

TRANSvisions

Contract A2/78-2007: Report on Transport Scenarios with a 20 and 40 Year Horizon

Task 1 Report – Qualitative Analysis

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1. Introduction

This report describes the approach and the contents of the TRANSvisions qualitative scenarios, or “visions”, of transport in Europe up to 2050. How difficult is to envision the distant future based on our perception of the current context can be shown with a thought exercise, by imagining that we were based in 1905 and trying to forecast the human-environment relationship over the next century.¹ In 1905, if you were European or North American, you might see the world as characterized by:

- Remarkable technological and economic progress with very few misgivings about progress
- Political stability based on colonial administration and a sense of that among the great powers. War had become obsolete because national economies had become too interconnected.²
- Modest anxiety about urban pollution and landscape change in Europe, America, and Australia but very little conservation awareness: for the great majority of people in industrial countries pollution was seen as an inevitable consequence of what makes employment and comfortable lifestyle.
- A power system operated by elites that did not include women, developing countries, and other marginal groups.

Technologies that are commons in 2005 were almost inconceivable in 1905, including contemporary computing and electronics, biotechnology, and space flight. For many people, decolonisation, universal suffrage, and mobility were unattainable and the devastation of World War I and II as well as the Cold War were unimaginable.

The message we learn by placing ourselves in 1905 is that the human part of the Earth system may be highly unpredictable. Indeed, there is in reality an exponential decay of reliability of predictions with time. This is because there is an increasing probability of high impact/low probabilistic events with time. The least predictable process can feedback strongly in a non-linear fashion to “more” predictable processes in an unpredictable manner. The usual suggestion for providing projections of the distant future is therefore not to predict but rather to produce scenarios or, as we name it, visions of possible futures.

In order to produce such visions, we use the following approach:

- First, making an **analysis of main drivers of change** of the transport system. The first category of “drivers” to be considered are phenomena which develop outside the transport system and have a direct impact on it, usually with manifold influences. This category includes five main drivers: energy, economy, population, technological change (in particular the diffusion of ICT technologies) and social change. A second category of drivers are phenomena which develop within the transport sector itself – e.g. the continuous development of new transport infrastructure, vehicle and fuels technologies

¹ This storyline is presented in Costanza R., Graumlich L.J., Steffen W. (eds.) Sustainability or Collapse? An Integrated History and Future of People on Earth, Dahlem Workshop Reports, 2007, pag. 372.

² Although this may seem perhaps a too complacent view of the geopolitical situation in 1905, as the Anglo-Boer war had just ended in 1902 and the Spain-USA war was still very recent (1898). The colonial question was also one of the reasons behind the arms race that was taking place at that time.

which make transport easier and faster, contributing to shape transport demand patterns - or where the transport system produces an impact on the environment and society contexts – e.g. the contribution to climate change, environment degradation and safety concerns. Finally, a third category of drivers include broad policy responses which affect the evolution of the transport system, and in particular the governance of the transport sector at EU, Member States and local level which may enable different policies in the transport sector (e.g. charging, harmonised EU taxation etc.) or in related fields (e.g. trade, security, etc.). These different categories of drivers are named respectively “external drivers”, because they act on the transport system from the outside, “internal and impact drivers”, because they originate in the transport sector or as a consequence of the transport impacts, and “policy drivers”, because they refer to institutional factors which enable the adoption of policy responses that contribute as well to shape the evolution of the transport system. The different drivers are described in chapter 2 of the report.

- Second, describing the relationship between the main drivers and transport, separately for passenger and freight transport. This is done in chapter 3 of the report.
- Third, developing scenarios for a European transport future. This has been done with the support of a preliminary literature review, a DELPHI survey and a workshop where invited experts have discussed four alternative visions of the future of transport in Europe at 2050. Qualitative scenarios for a European transport future are presented in chapter 4 of the report.
- Fourth, making the connection between the drivers, their impact in the four qualitative scenarios and the meta-analysis of key quantitative indicators developed in Task 2. The analysis of the main drivers and their impact (in qualitative and quantitative terms) on the different scenarios is presented in chapter 5 of the report.

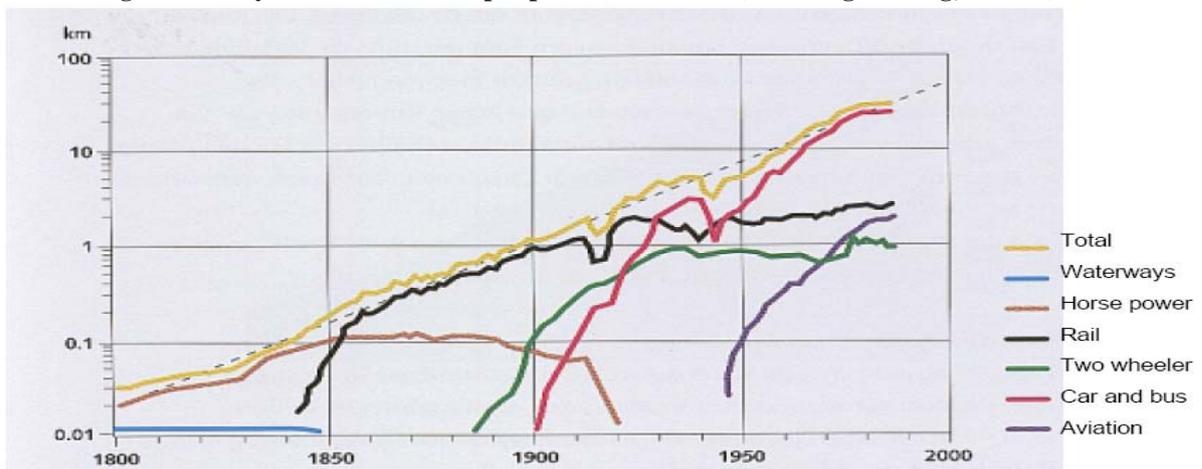
2. Analysis of main drivers

A conventional view, largely shared among transport experts, of the driving forces behind transport growth was provided at the International ECMT Seminar “Managing the Fundamental Drivers of Transport Demand” by Arie Bleijenberg, of the Netherlands Ministry of Transport, Public Works and Water Management (ECMT, 2002). The intervention looked into the history of transport over the last two centuries and projected the fundamental drivers for the coming half a century, neglecting all sorts of temporary and minor influences.

According to this conventional view, supported by a clear past evidence, the history of transport over the last two centuries can be described as a continuous reduction in the friction of distance. Travelling or transporting goods, has become faster, cheaper, more comfortable and reliable. This allowed for the impressive mobility growth we have experienced. Cheap and abundant energy, mainly in the form of fossil fuels, was the single most powerful reason for such impressive development of mobility, as it was also for the take off of economic development. However, the ECMT paper give us a more detailed overview of the drivers influencing separately passenger and freight transport, which is summarised below.

As it concerns **passenger transport**, the average distance travelled per person per day increased from a few kilometres to 40 kilometres in the period from 1800 to 2000. The dominant mode of transport shifted from walking and horse power to the train and then to driving by car. Technological developments, such as the internal combustion engine, in combination with growing income, allowed people to buy faster modes of transport over time. Figure 1 below two centuries of growth in distance travelled in France:

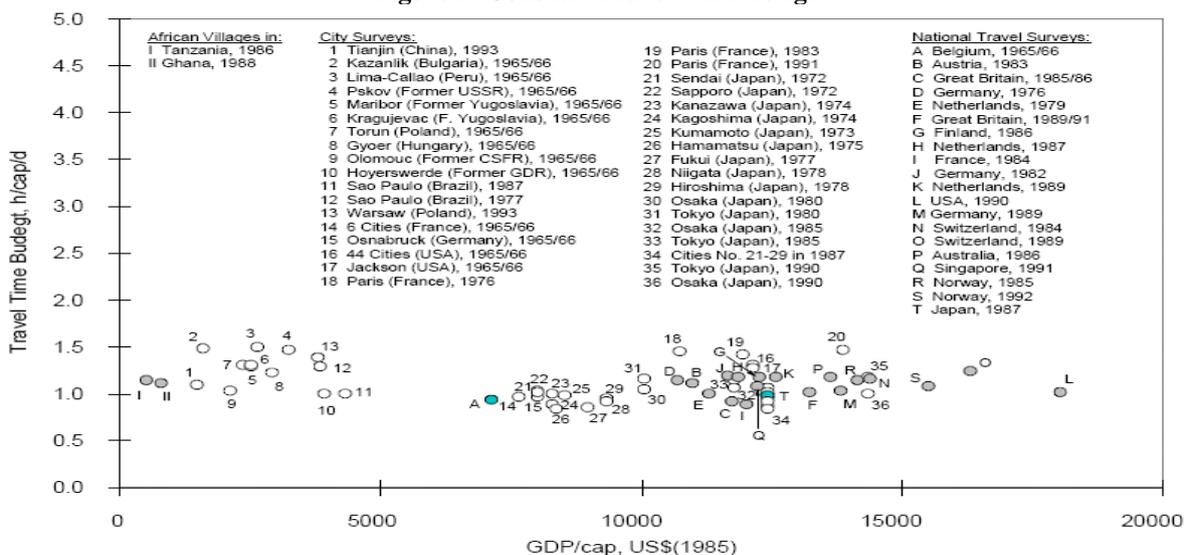
Figure 1: Daily distance travelled per person 1800-2000 (excluding walking; France)



Source: ECMT, 2002

Next, there is robust evidence that the daily amount of time spent on travelling only slightly changed over time. Figure 2 shows that the average time budget lies around 1,1 hour a day and more importantly this does not depend on income level or historic period. The investigated values differ roughly between 0,8 and 1,2 hours a day. Because total mobility (pkm) equals travel time (h) multiplied by travel speed (km/h), the impressive growth in mobility can only be explained by an equally impressive growth in speed.

Figure 2: Constant Travel Time Budget



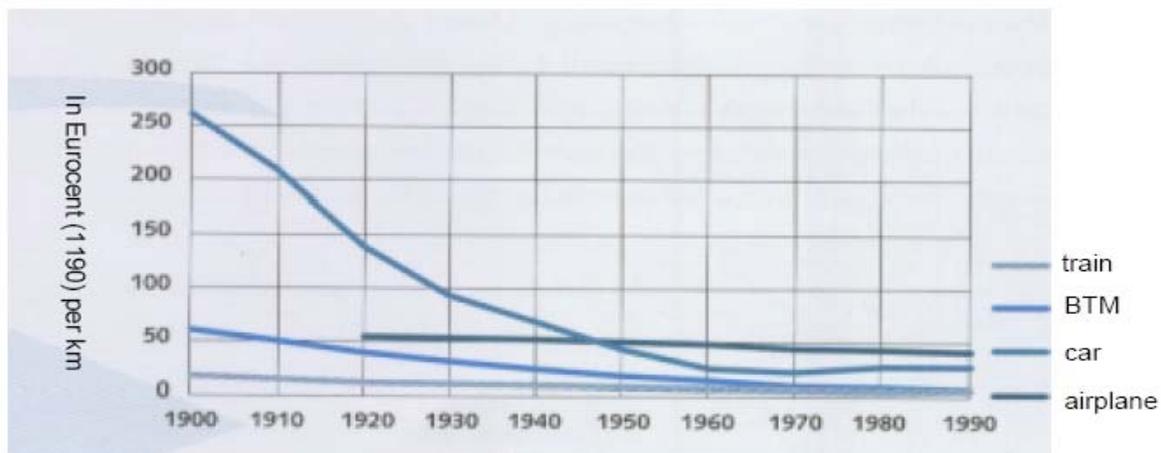
Source: ECMT, 2002

Travelling speed has increased from between 5 and 10 kilometres an hour – horse power – to an average of close to 70 km/h now. The train with steam engines reached a speed of around 30 km/h and replaced horse power in the second half of the 19th century. Next, the passenger car improved its speed from 15 km/h in 1900 to an average of 45 km/h now at which level it seems to stabilize. This improvement is achieved by building an extensive network of motorways and by the manufacturing of more powerful and convenient cars. The car became the dominant mode of passenger travel around 1960. After 1980 the continuing increase in travel speed is mainly caused by aviation. The modal share of aviation has increased to around 10% and at the same time the average door-to-door speed of air travel is improving.

So, the main driver of the growth in passenger travel appears to be the increase in average speed. However, this shift to faster transport modes in its turn is caused by different forces:

- The first is technological improvements. Each travel mode has become faster, cheaper and more comfortable by innovations such as the internal combustion engine, airplanes and building motorway networks.
- In addition to this technological driver, there is a strong economic driver. Increasing purchasing power, as a result of economic growth, allowed people to buy faster transport modes, increasing car ownership. Rising incomes generate also the current increase in the modal share of air travel. Nowadays, many people can afford to fly long distance (partly because of new low cost flight routes, see the point below)
- Not only economic growth, but in addition a reduction in costs of travelling, promoted the shift to faster modes. Figure 3 below shows this reduction in costs for the past century. Especially car driving experienced a sharp cut in costs in the period 1900-1960. This explains partly the success of the car.

Figure 3: Average costs of passenger travel (in 1990 euro per km)

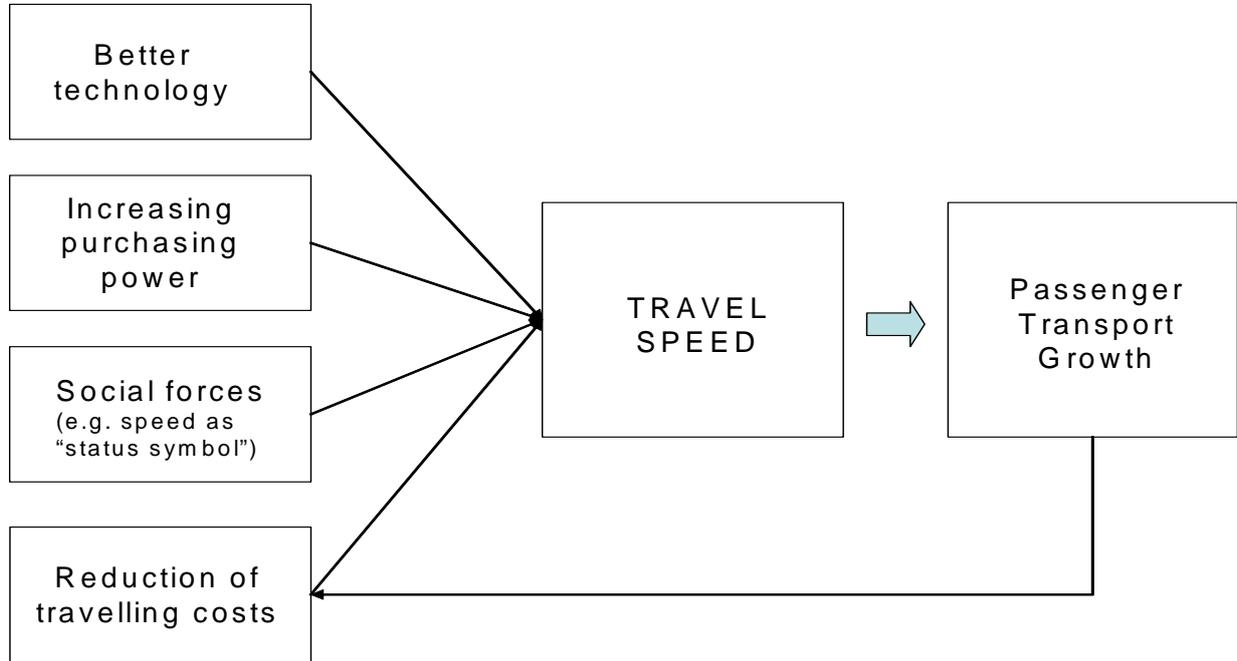


Source: ECMT, 2002

- Finally, social forces influence the shift to faster travel. It generally takes time before new (transport) technologies are accepted and fully adopted. In addition, the social acceptance and emotional attitude might influence somewhat the modal choice of people. For instance, car ownership has been a symbol of status, and it continues to be for some segments of the population, as the recent growth of SUVs' purchases demonstrates.

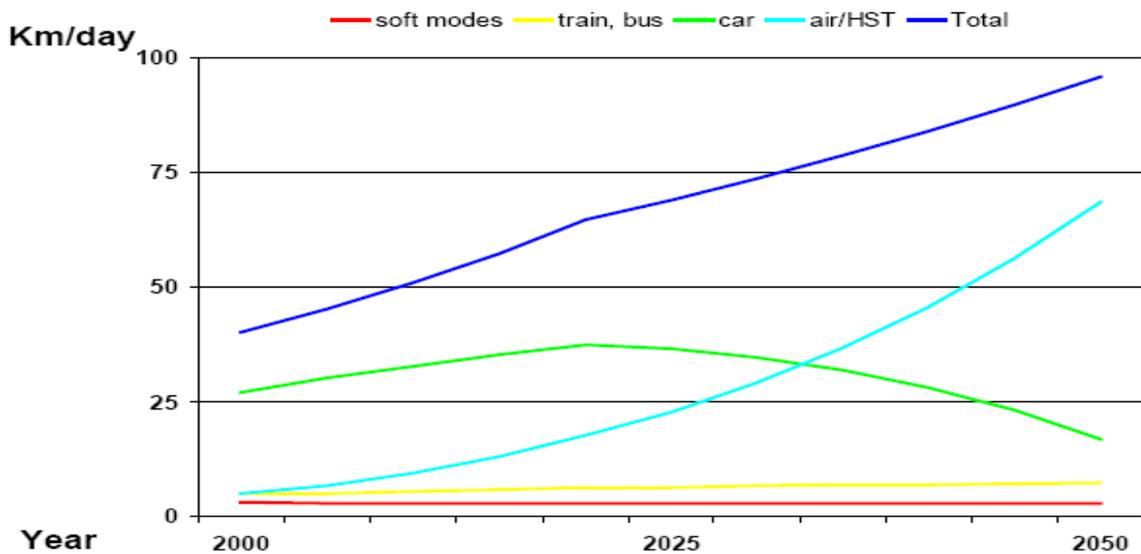
The view focusing on travel speed as the main driver of passenger transport growth, and the underlying drivers of the observed transport speed increase, is illustrated in the figure below:

Figure 4: Transport speed as a driver of passenger transport growth



Following this “travel speed” approach, a projection for the future has been made in the ECMT paper. As it is shown in the figure below, passenger mobility will continue to grow and aviation – the faster mode of transport – is projected to contribute decisively to the mobility growth between 2030 and 2040:

Figure 5: Projected mobility growth 2000-2050 (Western Europe)



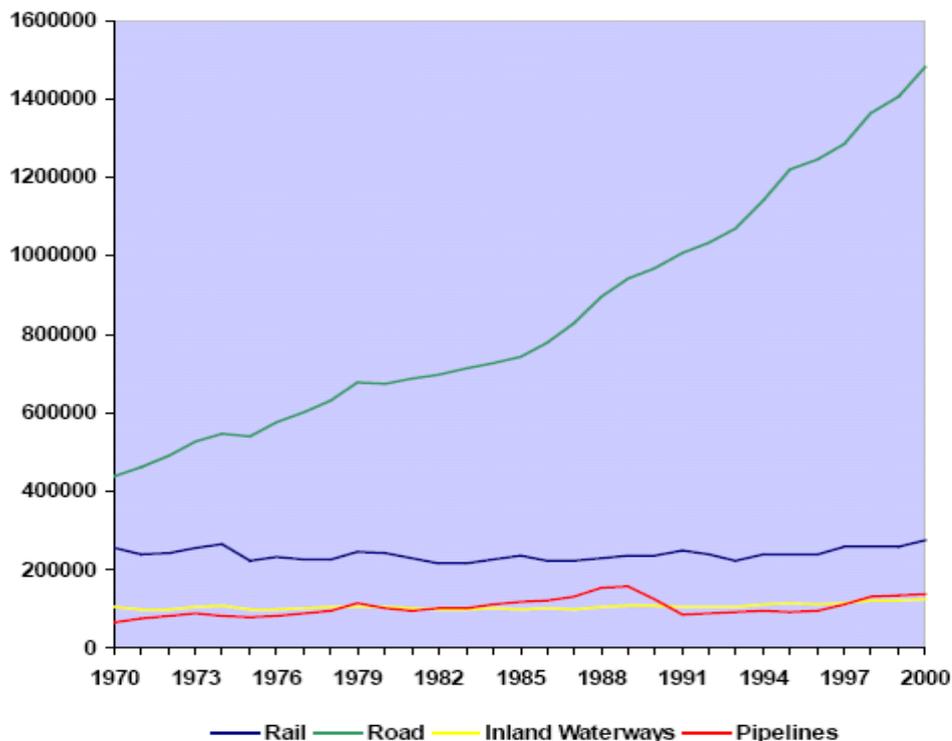
Source: ECMT, 2002

As it concerns **freight transport**, it is often assumed that the growth in goods transport is directly linked to economic growth. However, this seems to be half of the story. Western economies grow on the long run with an average 2.5% a year in money terms. This, however, does not equal the growth in physical terms (tonnes). The physical growth of our economies is roughly estimated at 1% a year. The divergence between economic growth and physical growth reflects the structural changes in western economies: from industrialization towards services and a knowledge based economy. The phenomenon is known as “dematerialisation” of the modern economies.

If it is not the physical growth of our economies that cause the high growth rates in freight transport, what is then the cause? Two separate factors explain the growth: each tonne of final product is moved more often in the production chain leading to more hauls – as an effect of the diffusion of more efficient “just-in-time” production patterns in all sectors of the economy - and at the same time the average length of haul has increased – as an effect of the increasing concentration of production and inventories to exploit economies of scale in distribution.

Figure 6 shows the total growth in tonne kilometres in Western Europe and the split over different modes. The figure clearly shows that road freight transport has become the dominant mode.

Figure 6: Growth in freight transport (tonne kilometres) and modal split (Western Europe)
Goods Transport in Western Europe
Thousands tonne-kilometres



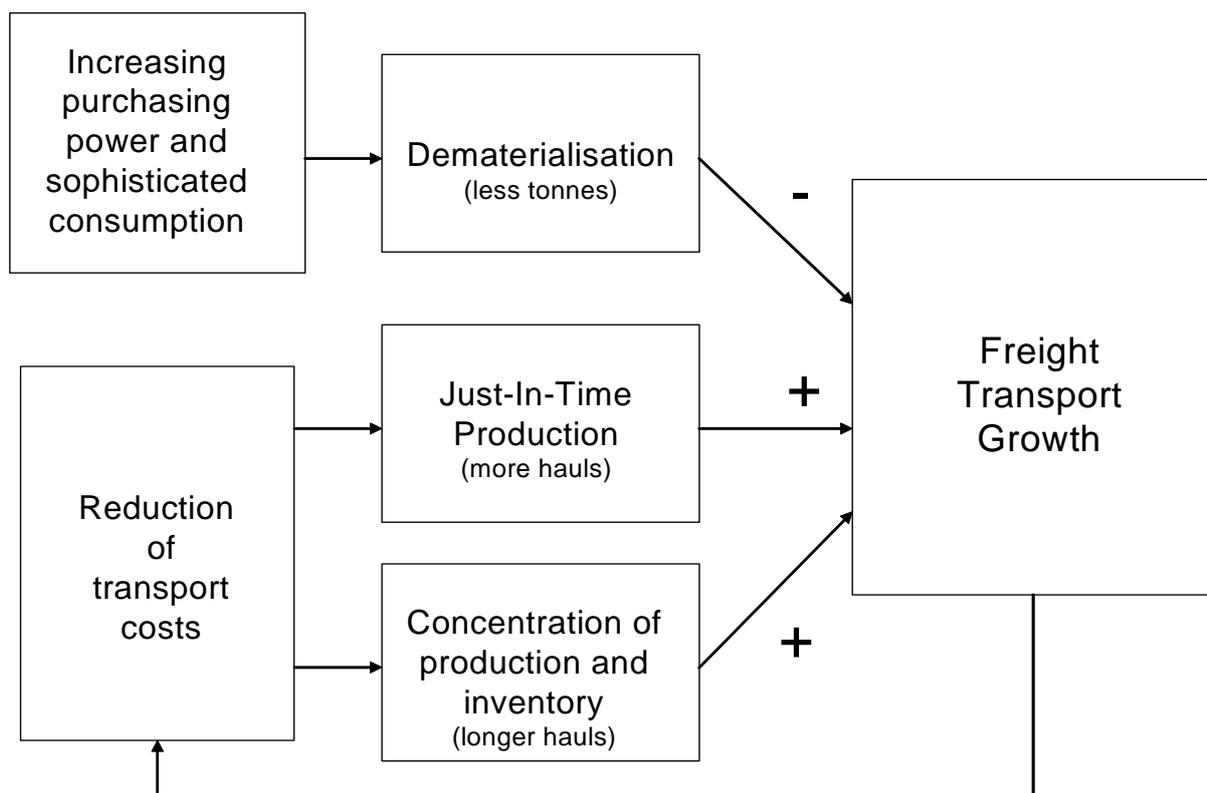
Source: ECMT, 2002

The driving forces behind these changes in logistics resulting in the strong growth in freight transport have been identified in the ECMT paper as follows:

- One driver is the increased purchasing power (income growth) to choose from a large variety of consumption goods. Furthermore, we can buy exotic products originating from all over the world. Both reflect economies of scope for the consumer and lead to more freight transport.
- The second driver lies within the logistics of the production process. Firms will minimize their total production costs, searching for economies of scale in production and distribution, locational advantages and reduced costs for warehousing – all factors which stimulate just-in-time deliveries and more freight transport activity. If transport becomes cheaper, companies will use more transport in the optimum and thus save money on warehousing and production costs. And this is exactly what happened: freight transport has become cheaper, faster and more reliable over the past centuries. In addition to cost reductions, road and air transport have managed to increase their speed substantially at the same time, thus lowering the generalised costs even more strongly. So, the realized reduction in transport costs is an important driving force behind the growth in freight transport. The reduction in costs of freight transport stimulated logistical changes resulting in lower total production costs while transport volume increased.

This view of the drivers influencing freight transport growth is illustrated in the figure below:

Figure 7: Proximate drivers of freight transport growth



Although well established among the transport experts, this conventional vision of the driving forces behind transport growth suffers of three drawbacks:

- It is limited in scope, because it focuses only on the most proximate drivers of transport growth, without analysing in depth the ultimate economy, demographic, energy, social and technological drivers which are behind the evolution of passenger travel speed and logistic changes affecting freight transport, whose past evolutions and possible future trends should be considered as well in a broader view.
- It is limited in spatial scale, because it refers to the experience of western economies. Although globalisation is generalising the passenger and freight transport growth patterns to the whole planet, it may also create new scenarios, e.g. a strong migration, that could radically change the past patterns.
- Although the centennial time scale of the analysis is clearly long-term, it ignores possible transitions and reversals of the steady transport growth trend that could be observed on wider (millennia) time scales. As a matter of fact, it cannot be given for granted that we are not near to a new major transition in the complexity of human society that could change significantly the transport landscape, as many other aspects of our society, in the next century or so (climate changes prospects are a relevant driver in this respect).

We will consider therefore also a broader view of the possible future of humankind - and of transport as one of the main activities of human beings – which starts from the assumption that we are experiencing in our times an historical transition. The view is based on the Stockholm Environment Institute and Global Scenario Group study (SEI-GSG, 2002) that produced global scenarios of the future of the planet in the twenty-first century.

Transitions, observe the authors of this study, are ubiquitous in nature. With the emergence of proto-humans some 5 million years ago, and especially Homo Sapiens about 200.000 years ago, a powerful new factor – cultural development – accelerated the process of change on the planet. A new phenomenon - human history - entered the scene in which innovation and cultural information drove a cumulative and accelerating process of development. With the advent of historical time came a new type of transition, that between the phases of human history that demarcate important transformations in knowledge, technology and the organization of society.

Naturally, the course of history is not neatly organized into idealized transitions. Real history is an intricate and irregular process conditioned by specific local factors, serendipity and volition. The historic record may be organized in different ways, with alternative demarcations between important periods. Yet, a long view of the broad contours of the human experience reveals two sweeping macro-transformations—from Stone Age culture to Early Civilization roughly 10,000 years ago, and from Early Civilization to the Modern Era over the last millennium. According to the GSG view, we are now in the midst of a third significant transition toward what can be referred to as the Planetary Phase of civilization. In this phase:

- First, planetary space is shrinking, as the integration of nations and regions into a single Earth system proceeds.
- Second, historical time is accelerating as the pace of technological, environmental and cultural change quickens.
- Third, the increasing complexity and scale of the human project has reached a planetary scale, and planetary dynamics operating at global scales increasingly govern and

transform the components of the earth system. Global climate change influence local hydrology, ecosystems and weather.

- Fourth, globally connected information and communication technology penetrate to the furthest outposts, changing values and cultures. Excluded, marginalised and inundated with images of affluence, the global poor seek immigration and a better global bargain. A complex mix of despair and fundamentalist reaction feeds the globalisation of terrorism.
- Fifth, the stability of the global economy becomes subject to regional financial disruptions. New global governance mechanisms, such as the World Trade Organisation (WTO) and international banks, begin to supersede the prerogatives of the nation-state.
- Sixth, and most important, although the increasing imprint of human activity on nature and the expanding reach of dominant nations were necessary antecedents of globalisation³, the essence of this new planetary transition is that the transformation of nature and the interconnectedness of human affairs has reached a qualitatively new stage: growing human population and economies inevitably must butt against the resource limits of a finite planet. The increasing complexity and extent of society over hundreds of millennia must at some point had to reach the scale of the planet itself, and this point in history is now.

In the past, new historical eras emerged organically and gradually out of the crises and opportunities presented by the dying epoch. The possibility to conquer new territories and contend them to the indigenous civilizations – think for instance to the colonisation that European did of the North and South America – was a strong opportunity in the race to exploit new land and natural resources. In the current planetary transition – this is the main message conveyed by the Global Scenario Group – reacting to historical circumstance is insufficient. With the knowledge that our actions can endanger the well-being of future generations, humanity faces an unprecedented challenge—to anticipate the unfolding crises, envision alternative futures and make appropriate choices. The question of the future, once a matter for dreamers and philosophers, has moved to the core of the development and scientific agendas.

Scientific forecast are usually based on some form of modelling approach. The key steps in this approach are description, analysis and modelling—data are gathered on current conditions, factors are identified that drive change, and future behaviour is represented as a set of mathematical variables that evolves smoothly over time. This is a powerful approach when the system under study is well understood and the time horizon is limited. But predictive modelling is inadequate for illuminating the long-range future of our stunningly complex planetary system. Global futures cannot be predicted due to three types of indeterminacy - ignorance, surprise and volition. First, incomplete information on the current state of the system and the forces governing its dynamics leads to a statistical dispersion over possible future states. Second, even if precise information were available, complex systems are known to exhibit turbulent behaviour, extreme sensitivity to initial conditions and branching behaviours at critical thresholds - the possibilities for novelty and emergent

³ Of course human activity has always transformed the earth system to some extent, and the tentacles of global connectedness reach back to the great migrations out of Africa, to the spread of the great religions, and to the great voyages, colonialism and incipient international markets of a century ago. At the end of the nineteenth century, the international integration of finance, trade and investment was comparable to contemporary levels when taken as a percentage of the much smaller world economy.

phenomena render prediction impossible. Finally, the future is unknowable because it is subject to human choices that have not yet been made.

In this context, scenario analysis is the only way of exploring a variety of long-range alternatives. Global scenarios draw on both science - our understanding of historical patterns, current conditions and physical and social processes - and the imagination to articulate alternative pathways of development and the environment. Rather than prediction, the goal of scenarios is to support informed and rational action by providing insight into the scope of the possible. Their aim is to illuminate the links between issues, the relationship between global and local development and the role of human actions in shaping the future.

Scenario analysis concerning the future of transport in Europe, in the context of the world development, is the specific aim of the TRANSvisions project. While the global trajectory may branch in very different directions – as it is illustrated in the four exploratory scenarios presented in chapter 4 of this report – the point of departure for all scenarios is a set of driving forces and trends the currently condition the planetary systems shortly summarised below:

- **Demographics:** Populations are growing larger, more crowded and older. In typical projections, global population increases by about 50 percent by 2050, with most of the additional three billion people in developing countries. If urbanization trends continue, there will be nearly four billion new city dwellers, posing great challenges for infrastructure development, the environment and social cohesion. Lower fertility rates will lead gradually to an increase in average age and an increase in the pressure on productive populations to support the elderly.
- **Economics:** Product, financial and labour markets are becoming increasingly integrated and interconnected in a global economy. Advances in information technology and international agreements to liberalize trade have catalyzed the process of globalization. Huge transnational enterprises more and more dominate a planetary marketplace, posing challenges to the traditional prerogatives of the nation-state. Governments face greater difficulty forecasting or controlling financial and economic disruptions as they ripple through an interdependent world economy. This is seen directly in the knock-on effects of regional financial crises, but also indirectly in the impacts of terrorist attacks and health scares, such as mad cow disease in Europe.
- **Social Issues:** Increasing inequality and persistent poverty characterize the contemporary global scene. As the world grows more affluent for some, life becomes more desperate for those left behind by global economic growth. Economic inequality among nations and within many nations is growing. At the same time, the transition to market-driven development erodes traditional support systems and norms, leading to considerable social dislocation and scope for criminal activity. In some regions, infectious disease and drug-related criminal activity are important social factors affecting development.
- **Technology:** Technology continues to transform the structure of production, the nature of work and the use of leisure time. The continued advance of computer and information technology is at the forefront of the current wave of technological innovation. Also, biotechnology could significantly affect agricultural practices, pharmaceuticals and disease prevention, while raising a host of ethical and environmental issues. Advances in

nanotechnologies could revolutionize medical practices, material science, computer performance and many other applications.

- **Environment:** Global environmental degradation is another significant transnational driving force. International concern has grown about human impacts on the atmosphere, land and water resources, the bioaccumulation of toxic substances, species loss and the degradation of ecosystems. The realization that individual countries cannot insulate themselves from global environmental impacts is changing the basis of geo-politics and global governance.
- **Governance:** There is a significant trend toward democratization and decentralization of authority. On an individual level, there is increased emphasis on “rights,” such as women’s rights, indigenous rights and human rights broadly conceived. In the private sector, it is reflected in “flatter” corporate structures and decentralized decision-making. Some entities, such as the Internet or NGO networks, have no formal authority structure. The emergence of civil society as an important voice in decision-making is a notable development.

A more detailed analysis of the drivers which affect transport is provided in the following sections, distinguishing:

- **External drivers**, i.e. those driving forces which act on the transport system from the outside: energy, economy, demographic change, technological change, social change. The past and future trends and projections found in the current literature are described for each of these drivers in section 2.1, while impacts on the transport system are illustrated in chapter 3.1.
- **Internal and impact drivers**, i.e. those driving forces which originate in the transport sector or as a consequence of the transport impacts on the environment are discussed in section 2.2, again showing past trends and future tendencies.
- **Policy drivers** are finally discussed in section 2.3, taking into account the current global and EU context and possible future evolution of global and EU governance issues

2.1 External drivers

2.1.1 Energy

One of the central reasons why human numbers could grow 4-fold in the 20th century, and why urban population could grow 13-fold, was the phenomenal success our species enjoyed in harnessing fossil fuels. Cheap and abundant energy, mainly in the form of fossil fuels, was the single most powerful reason why the 20th century was so environmentally turbulent. By about 1890, half the energy deployed around the world came from fossil fuels, mainly coal. In the 20th century the crucial development in energy history was the emergence of cheap oil. Over the past 100 years, energy systems have undergone a transition from solid fuels such as coals to oil and gas, as well as from the distribution of high-quality processed fuels (e.g. liquids, gases and electricity) to dedicated energy infrastructure grids. However, the next 100 years or so are unlikely to unfold as a simple extrapolation of these past trends. Although

there is considerable agreement that high-quality processed fuels supplied to the consumers via energy grids will continue to grow, there is much uncertainty surrounding energy projections to 2100. The link between income level and quantity and type of energy is changing, large differences in regional pathways exist now and will likely increase, and the transition toward more efficient and environmentally friendly energy sources is far from complete – as it is just starting to take place and can as well unravel towards a higher use of coal, including coal to liquid uses. Technology and innovation will be the key, but are highly uncertain, leading to the possibility of surprises and sharp shifts in the energy transition process.

2.1.1.1 Energy prices

The oil price is surely one of the most important drivers in the world, as has been stressed by the recent sudden rises in prices. The figure below points out the crude oil price trends as far as from 1861, in real and nominal terms, pinpointing also the major world events that were deemed to influence the oil price:

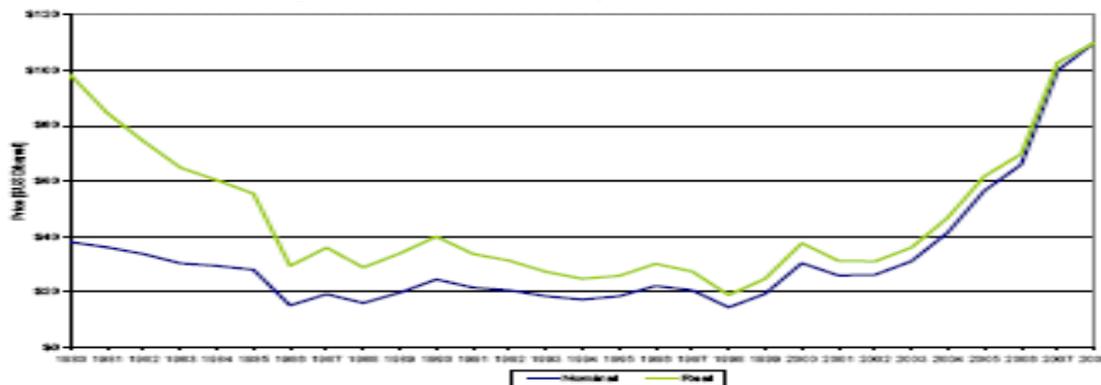
Figure 8: Oil price



Source: BP Statistical Review of World Energy, June 2008

The oil price continued to increase until the record figure of 150 \$/bbl in July 2008. The figure below illustrates the most recent trend, including early 2008 figures:

Figure 9: Nominal and Real price of Oil 1980-2008



Source: BP 2007

The recent increases have driven the real price of oil above that experienced in the early 1980s. Recent prices are notable both for the size and the rate of the increase – they have increased five fold over the last decade.

Discussions on future oil prices centre around two divergent views – commonly referred to as “peak oil” and “mainstream” perspectives. Peak oil proponents maintain that world oil production will soon plateau or decline, causing increasingly high and unstable prices (EWG, 2007, Hirsch et al., 2005, USGAO, 2007). Peak oil projections are based on geological models of the historical performance of oil and gas fields, such as the United States and North Sea, which have exhibited sharp peaks in production. At the other end of the spectrum, mainstream proponents maintain that high oil prices will drive exploration, discovery, production, and innovation at a rate that is sufficient to offset the drawdown in geological reserves, subsequently avoiding sustained high prices (Lynch, 2001). Mainstream sources agree that a peak in conventional oil production is likely to occur within the next two decades (Biro, 2008), but argue that innovation will ameliorate or mitigate the impacts of this peak.

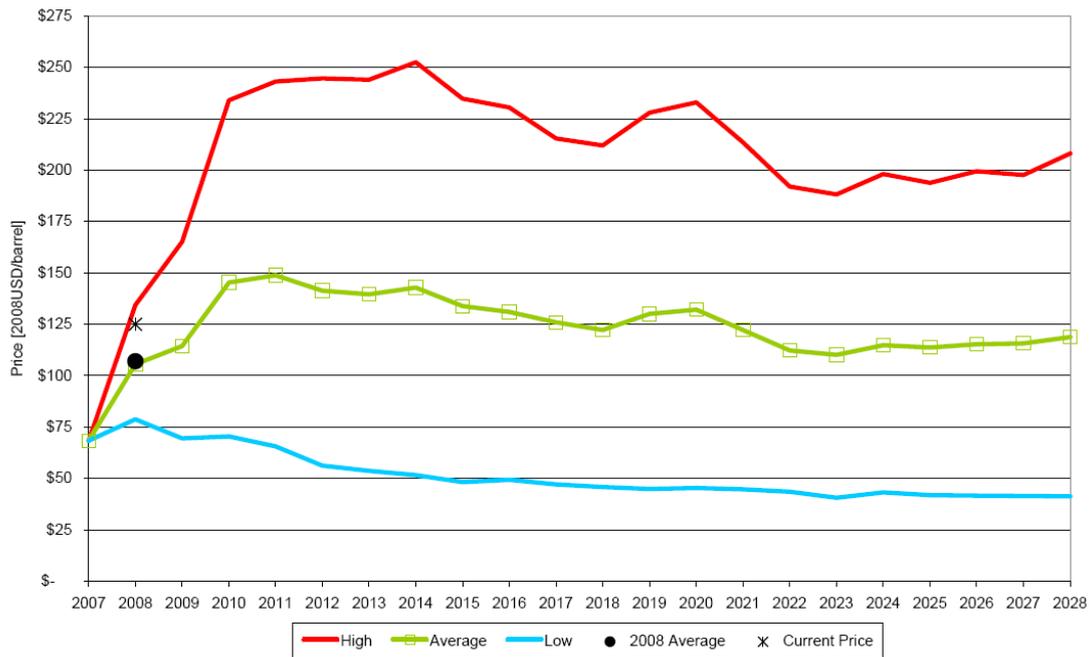
Future oil prices have been the subject of several oil price forecasts. However, recent experience has demonstrated the uncertainty around such forecasts. For example, the US Energy Information Administration's official 2007 prediction indicated that even in the high-price scenario, oil prices would not exceed \$100 USD/barrel until 2030, and in early 2008 predicted that oil prices would not exceed \$100 USD/barrel until 2018 (EIA, 2007). Forecasters seem to predict on a “business as usual” basis – a number of hardly predictable risk factors do not appear to be accounted for even though they clearly have a significant effect on the price.

A recent study for New Zealand (NZ Transport Agency, 2008) has modelled the future of world oil prices on the bases of several oil prices forecasts. The forecasts generated by this study will be taken as reference, as one of the most recent and robust sets of forecasts available for the future evolution of international oil prices.⁴

The figure below illustrates the average, high and low oil price projections (the black circle and star indicate the 2008 average price and the current price respectively):

⁴ The study uses a “meta-model” which generates future price projections on the basis of a number of individual forecasts, including NYMEX (2008), Goldman Sachs (2008), EIA (2007), MED (2006), CSIRO (2008) and LOPEX (Rehrl and Friedrich, 2005). The individual forecasts are highly variable, as the predictions of the price of oil in 2028 go from a low of 70 US\$/barrel to a high of 240 US\$/barrel. Naturally the accuracy of the individual forecasts is expected to reduce at longer time periods. The “meta-model” is based on a Monte Carlo simulation that moulds individual forecasts into a statistically representative distribution of prices over time. The “average” forecast generated by the Meta Model represents the mean of the distribution of prices generated by the Monte Carlo simulation, rather than the simple average of the sample forecasts. The advantage of this approach is that it considers all the information associated with the individual forecasts, and it provides also insight into extreme possible price scenarios that may eventuate under rare circumstances (NZ Transport Agency, 2008).

Figure 10: Oil price scenarios generated by the NZ Transport Agency meta model 2007-28



Source: New Zealand Transport Agency Research Report 357

This figure illustrates that the current price is substantially higher than the average price predicted for 2008. This suggests that a short term drop in the price of oil is likely – indeed, the last few weeks of July 2008 have seen a drop of approximately \$15 USD/barrel. Results suggest that the average price for 2008 will lie around \$110 USD/barrel, which aligns well with the current average for 2008 of \$107 USD/barrel. Looking ahead, the oil price is projected to increase rapidly to exceed \$150 USD/barrel by 2010, with the rate of increase almost as steep as that experienced in 2008. After 2010 the average price plateaus and gradually declines – suggesting that a combination of demand destruction and technological substitution may cap the price around \$150 USD/barrel.

In contrast with the more updated forecasts above, the EU-27 Energy Baseline Scenario to 2030 (EC DG TREN, 2007) projections seem now clearly outdated, as they were based on a moderate oil price environment with oil prices of 54,5\$/bbl in 2005 rising to 62,8 \$/bbl in 2030, at constant 2005 currency. This means that the price in nominal terms could be over 100\$/bbl in 2030 if it is assumed that the inflation target of the European Central Bank (ECB) of 2% per annum would be achieved.⁵

The baseline price assumptions for the EU are the result of world energy modelling that derives price trajectories for oil, gas and coal under a conventional wisdom view of the development of the world energy system. Fossil fuel import prices in the baseline scenario develop as follows:

⁵ The policy that matters most for the prices of oil in dollars and inflation is of course that of the US Federal Reserve rather than that of the ECB. However, both policies contribute to determine the \$/€ exchange rate which also important to calculate future oil prices in Europe.

Figure 11: Energy price trend

\$'2005/boe ¹⁴	2005	2010	2015	2020	2025	2030
Oil	54.5	54.5	57.9	61.1	62.3	62.8
Gas	34.6	41.5	43.4	46	47.2	47.6
Coal	14.8	13.7	14.3	14.7	14.8	14.9

Note: Assumed dollar exchange rate equal to 1.25 \$/€

Source: DG TREN, *European Energy and Transport Trends to 2030 Update 2007*

Natural gas prices are projected as linked with oil prices, as existing long term gas procurement contracts index gas prices to oil and the long term market dynamics point to the persistence of this linkage. Coal prices are projected to rise at far lower rates than oil and gas as a result of high coal resources and more favourable geopolitical conditions.

2.1.1.2 Energy supply

Two factors have the potential to bring about fundamental changes in the energy systems in the timescale up to 2050.

The first is the availability of energy resource supplies. Scarcity of resources occurs rarely at a global level, when demand growth cannot be met because resources are limited or the costs of new production capacity are too high. **Coal** will not become scarce within this timescale, though resources are concentrated in a few countries and will become increasingly complex and distant from markets. In addition, increasing CO₂ emissions constraints will require increased use of clean coal production and consumption techniques including carbon sequestration, and increased costs of exploiting and using coal will eventually affect its competitiveness. **Oil** production has long been expected to peak. Some think this is now imminent. For others the scarcity of oil supplies – including unconventional sources and natural gas liquids – is very unlikely before 2025. This could be also extended further by enhancing oil recovery from fields through better technology. In addition, oil consumption can be curbed by adopting measures to increase vehicle efficiency and focusing oil demand on the transport sector. **Gas** resource uncertainty is significant. Scarcity could occur as early as 2025, or well after 2050. The key issue is whether there can be timely development of the infrastructure to transport remote gas economically. **Nuclear energy** expansion has stalled in the past in OECD countries, not only because of safety concerns but because new nuclear power was often uncompetitive. However, the recent increase of oil and other fossil fuel prices is changing the prospects for the nuclear sector, improving its competitiveness significantly. In addition, measures to reduce carbon emissions, such as the EU Emissions Trading Scheme (ETS) encourage greater use of zero carbon energies including nuclear. Further ahead, technology advances could make a new generation of nuclear supplies more competitive. Finally, **renewable energy sources** are adequate to meet all potential energy needs, despite competing with food and leisure for land use. But widespread use of solar and

wind will require new forms of energy storage, and also for this reason renewable energy has made so far few inroads into primary energy supply. Although the costs of wind and photovoltaic sources have fallen dramatically over the past two decades, this is also true for conventional energy, although the recent surge in fossil fuel prices puts strong upward pressure on the costs of using these energy sources.

The second driving force for discontinuity in energy patterns is technology. A technology that offers superior or new qualities, even at higher costs, can dramatically change lifestyles and related energy use. Widespread introduction of electricity in the early 20th century prompted fundamental changes in production processes, business organisation and patterns of life. Coal-fired steam engines powered the early stages of industrialisation, replacing wood, water and wind. The internal combustion engine provided vastly superior personal transport, boosting oil consumption. The combined cycle gas turbine has become the technology of choice for power generation – greatly increasing the demand for gas, already the preferred heating fuel. Two potentially disruptive energy technologies are now **solar photovoltaics**, which offer abundant direct and widely distributed energy, and **hydrogen fuel cells**, which offer high performance and clean final energy from a variety of fuels. Both will benefit from economies of scale but both presently have fundamental weaknesses. Fuel cells require new fuelling infrastructure, while photovoltaics need new forms of storage as well as significant cost reductions. Nowadays, with oil prices at historic highs, China is moving full steam ahead with the **coal-to-liquid (CTL)** technology to turn its vast coal reserves into barrels of oil. A CTL plant will start to operate in 2008 in Inner Mongolia and is expected to convert 3.5 million tonnes of coal per year into 1 million tonnes of oil products such as diesel for cars.⁶ CTL is also being considered by a number of coal-rich countries such as the US, Australia and India, as the relatively low cost of CTL produced oil – compared with current oil prices – plus the chance to be more self-sufficient is a powerful incentive. But CTL is highly controversial. Experts say the whole lifecycle releases about twice as much CO₂ as fossil fuel. Carbon capture and storage would alleviate the environmental impact of CO₂ being released into the environment, but this is still the subject of much technological research. Liquefying coal also requires large amounts of energy and drain waters supplies. In conclusion, CTL might be very significant in future and would in general represent an environmental “nightmare”, as even CTL with carbon capture and storage has CO₂ emissions at least 4% higher than the use of oil based fuels.

Current oil supply trends are particularly relevant. Oil supply is typically broken into conventional, unconventional, and synthetic sources. Unconventional sources include oil produced from oil sands, heavy oil, and oil shale, while synthetic fuels includes coal liquefaction, gas to liquids, and bio-fuels. Production costs associated with unconventional and synthetic oil are substantially higher than that of conventional oil, particularly if carbon emission charges are included (Biro and David, 2001, MED, 2007a).

Not only are the costs of oil production increasing, but spare capacity within the oil supply chain is tight by historical standards. Research by Goldman Sachs (2008) indicates that the

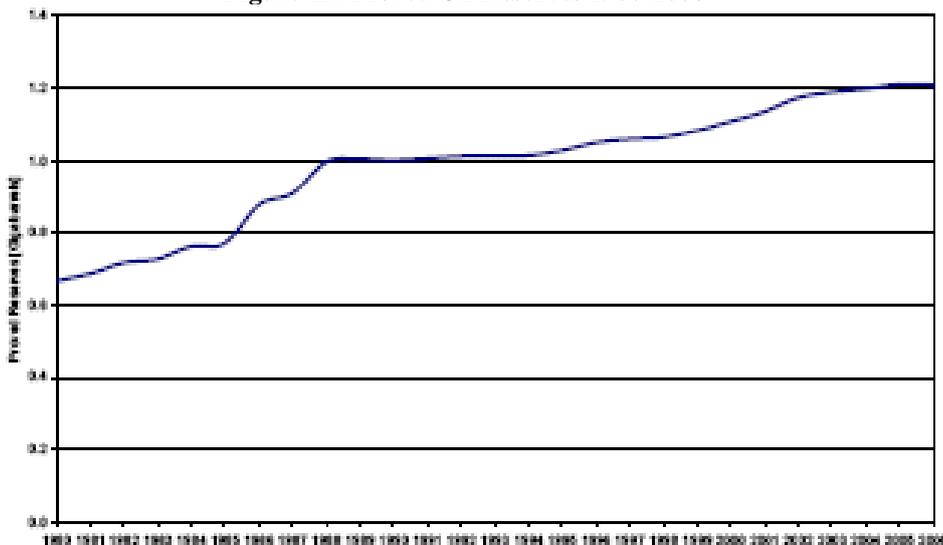
⁶ That's the equivalent of about 20,000 barrels a day, a tiny percentage of China's oil needs as oil consumption in China is around 7.2 million barrels a day. However, Inner Mongolia, a region as big as France, Germany and England put together (but by far less densely populated), hopes CTL will propel development while contributing to the China plan to have CTL capacity of 50 million tonnes by 2020 (equivalent to about 4 percent of China's energy needs based on current consumption).

immediately deliverable spare capacity of OPEC is expected to remain at approximately 2 Million Barrels Per Day (MBPD) until 2010 – in comparison to the average of 6 MBPD spare capacity that existed during the 1980s and 1990s. The already limited supply response is therefore pushing up against the physical limitations of the supply chain. In other words, the ability to pump more oil is even tighter than normal. The risk posed by tight supply chains is noted by the IEA in their World Energy Outlook 2007:

“Although new oil-production capacity additions from greenfield projects are expected to increase over the next five years, it is very uncertain whether they will be sufficient to compensate for the decline in output at existing fields and keep pace with the projected increase in demand. A supply-side crunch in the period to 2015, involving an abrupt escalation in oil prices, cannot be ruled out (IEA, 2007).”

As it concerns oil resources availability, approximately 1 Giga Barrels (GB) of oil has been produced thus far, with another 1-2GB of conventional oil sources remaining (MED, 2007a). Proved reserves are defined as the amount of oil that is economic to extract using existing technologies. The figure below indicate that proved reserves have increased since 1980, although recently appear to have reached a plateau.

Figure 12: Proved Oil Reserves 1980-2006



Source: BP (2007)

It is worth distinguishing between proved reserves and ultimately recoverable reserves (URR). The latter describes, quite simply, the amount of oil considered to exist in the ground that is able to be recovered and produced. This includes unconventional sources, such as oil sands, heavy crude, and oil shales. Studies have indicated that URR may be up to five times greater than proved reserves – approaching 5-6GB (SAUNER, 2000, MED, 2007a). Thus URR are an effective upper bound on total oil production, while proved reserves represent what is known to exist and feasible to extract under current conditions. Over time, the amount of oil that becomes proved reserves may be expected to increase until URR is reached. Estimates of URR are, of course, highly uncertain. There is no way to know how much oil is in the ground without actually drilling for it.

As it concerns the future trends of energy supply in Europe, according to the EU-27 Energy Baseline Scenario to 2030, total EU-27 energy requirements continue to increase up to 2030, with primary energy consumption in 2030 11% higher than in 2005. The 11% increase in the primary energy consumption by 2030 is much lower than the GDP growth assumed over the same baseline period (71%). Thus, energy intensity – i.e. the ratio between primary energy consumption and GDP – improves by 1,7% per year up to 2030. Energy intensity improvements are assumed to be driven by structural change towards services and lighter industries as well as by efficiency improvements in all sectors.

The EU-27 Energy Baseline Scenario assumes that the primary energy consumption increase of some 200 Mtoe between 2005 and 2030 will be overwhelmingly met by renewables and natural gas, which are the only energy sources that increase their market shares. Oil remains the most important fuel, although its consumption in 2030 exceed the current level by only 6%. Renewables increase most, growing by over 90% from today to 2030, accounting for nearly 60% of the increase of energy demand. Natural gas demand is expected to expand considerably by 71 Mtoe up to 2030, continuing the current trend, while solid fuels are projected to exceed their current level by 5% in 2030, following high oil and gas prices and the nuclear phase-out in certain Member States. Nuclear energy is assumed to be 20% smaller in 2030 than it was in 2005, as a result of political decisions on nuclear phase-out in certain old Member States and the closure of plants with safety concerns in some new Member States. In summary, the shares of energy sources in total primary energy in the baseline scenario develop as follows:

Figure 13: Share of Energy sources

%	1990	2000	2005	2010	2020	2030
Solid fuels	27.3	18.8	17.7	17.2	17.4	16.7
Oil	37.9	38.0	36.7	36.4	35.7	35.3
Gas	17.9	23.0	24.6	24.9	25.7	25.7
Nuclear	12.3	14.2	14.2	13.2	11.3	10.3
Renewables	4.5	5.9	6.8	8.2	10.0	11.8

Source: DG TREN, European Energy and Transport Trends to 2030 Update 2007

The share of fossil fuels (solid fuels, oil, gas) in total energy consumption falls only marginally by 2030, reaching 78% (compared with 79% in 2005). The nuclear share falls to about 10%, while the renewables share in primary energy consumption is assumed to rise throughout the projection period from less than 7% in 2005 to 8% in 2010, 10% in 2020 and 12% in 2030 (this means that achieving the 20% renewables target for 2020 will require a substantial additional effort compared with baseline developments, which include only those measures implemented in the Member States by the end of 2006).⁷

⁷ It should be noted that the 20% renewables target is expressed in terms of final energy demand, while the above shares relate to primary energy consumption. The renewables share in final energy is higher than in primary, e.g. 8,5% in 2005.

The framework conditions in the EU-27 Energy Baseline Scenario do not provide for the deployment of new energy carriers, such as hydrogen and methanol, taking into account that the time horizon is too short for these options to make significant inroads. The Carbon Capture and Storage (CCS) technologies are among the candidate power technologies but their deployment depends heavily on the development of CO₂ transport and storage infrastructure which, in the absence of a strengthening of climate change mitigation policies is not justified in the context of the baseline scenario.

2.1.1.3 Energy demand

The discussion in the previous section was mainly concentrated on the energy supply side, focusing on primary energy production. On the demand side, **final energy demand** matters most. This is driven by economic activity of non-energy firms as well as the living and working conditions of individuals. The corresponding end-use consumers, such as industry, services, residential and transport, purchase final energy products, such as fuels, electricity and distributed steam or heat, and transform them through appliances and equipment into useful energy forms, that is the services provided by energy at end-user level. The final consumers combine energy and non energy inputs to achieve production or get utility. The mix depends on relative prices, the technical possibilities and the consumer's income. **Energy savings** correspond to various combinations of actions such as: substituting non energy inputs for energy (e.g. insulation); optimizing the use of energy products in their transformation into energy services (e.g. choosing technological advanced appliances); rationalizing the use of energy services per unit of activity or revenue (e.g. less driving private cars or not letting appliances at stand-by mode). Another important indicator is **energy intensity**. This is defined as the ratio of energy consumption of a consumer or a sector divided by a volume index of the relevant driver, i.e. industrial output, transportation activity, income or GDP. Energy efficiency gain corresponds to a reduction of the energy intensity indicator.

The following is an overview of energy demand and intensity past and future trends in different sectors of the EU economy, based on the EU-27 Energy Baseline Scenario to 2030 results (EC DG TREN, 2007):

- **Industry** has been greatly influenced by the increasing globalisation and integration of the world economy after 1990 as well as the enlargement of the EU economy. Industrial firms address their product to a broader market which is subject to more intense competition but at the same time offers opportunity for increasing return to scale. In this context the industrial firms restructure, seeking higher productivity of production inputs and improvement in product quality. Energy is an input to industrial production and seeking productivity gains has always been among the basic goals of industrial firms. Energy consumption in industry, taken as a whole and excluding use of energy products as feedstock in petrochemicals, accounted for 27.8% of total final energy demand in 2005, down from 34.3% in 1990. Industry restructuring that took place in the '90s, especially in Central and Eastern European countries, has driven a considerable reduction of energy intensity of industrial value added: 2.74% per year during 1990-2000, followed by 1.13% per year during 2000-2005. The EC DGTREN Baseline scenario projects a continuation of the decrease in energy intensity of industrial value added, by 1.4% per year on average during 2005-2030. This is driven by the use of more efficient technologies and by increased electrification of processes. It is also explained by projected changes in the

composition of aggregate industrial value added reflecting a shift in favour of less energy intensive products.

- **Agriculture** has a relatively small weight in economic activity (2.7% of value added in 2005). It has grown at nearly half the rate of GDP growth. The EC DGTREN Baseline scenario includes a continuation of this trend, albeit with a small acceleration of value added growth in agriculture. Agriculture in the EU uses substantial amount of energy to produce heat in greenhouses and other heat applications (e.g. drying). This accounts for 73% of total energy consumption of agriculture. Energy is also used for pumping and agricultural machines (23% of total). The rest of energy consumption in agriculture corresponds to specific electrical equipment and electric motor drives.⁸ Energy intensity of agriculture has decreased substantially between 1990 and 2005 (1.5% per year), as a result of a restructuring of activities towards higher value added products and an increasing trend towards industrialisation of production, which involves optimisation of inputs to production at a larger scale. The EC DGTREN Baseline scenario takes the view that further energy efficiency progress is possible in the future but at lower rates than in the past. Energy intensity is shown to decrease on average by 0.9% per year in the period 2005 to 2030, and energy consumption in agriculture is projected to grow by 0.3% per year, in contrast with the decrease of 0.7% per year experienced in the period 1990- 2005.
- The **services sector** accounts for 12% of total final energy demand and produces 70% of total value added in the EU economy. During the last fifteen years services were the fastest growing activity in the EU economy, growing at a rate above GDP. Industrial specialisation of the EU towards knowledge-based and technology-based industries, which takes place increasingly in the context of a broad EU and global market have boosted the development of services, such as engineering, finance and trade. New services have emerged, enabled by high income elasticity of consumers, such as leisure services, information technology and telecommunications, driving further the development of the services sector. These trends are likely to prevail also in the future growth pattern of the EU economy and are assumed to continue in the EC DGTREN Baseline scenario. The working conditions, as for example the office space per employee, the degree of comfort enjoyed in the office (including heating and cooling) and the access to electricity based office facilities, have improved considerably over the last fifteen years. The construction of new office buildings offering high quality working conditions is among the fastest growing sectors in the EU economy. This trend has consequences for energy consumption, both regarding the level of energy needs per employee and the structure of energy uses. Similar trends are experienced in other market services and trade supporting services: their infrastructure became larger and more energy demanding, new energy uses have emerged which were generally facilitated by proliferation of electricity applications. The EC DGTREN Baseline scenario takes the view that these trends towards higher comfort and growing needs for energy services are not yet saturated and will continue in the future. However, energy consumption in the services sector will also depend by the energy efficiency progress. Indeed, the fast turnover of capital in offices buildings during the period 1990 to 2005, marked by the massive construction of modern structures, enabled significant progress of energy efficiency in the services sector, with a steady decrease of

⁸ Liquid fuels used in vehicles by farmers are accounted for the transport sector, according to Eurostat definitions.

energy intensity (final energy per unit of value added) by 1.47% per year in that period of time. The EC DGTREN Baseline scenario projects a continuation of this trend. In the projection period to 2030, useful energy follows the evolution of services output at an output elasticity of 0.8 given the importance of energy for quality and productivity in the services sector. The ratio of final energy per unit of useful energy is found to decrease at an average yearly rate of 0.88%. The combined result of these two effects is a decrease of energy intensity in the services sector by 1.32% per year over the period 2005 to 2030.

- Energy is used in the **residential sector** for space conditioning (heating and cooling), cooking, water heating, lighting and for electric appliances. The appliances are usually classified in "white" appliances such as refrigerators, washing machines, dishwashers and freezers, and other appliances that serve for entertainment, telecommunications, education, etc. New habits are emerging which need energy consumption, for example mobile phones and battery driven devices which are charged at home. Energy consumption in households is shaped by the characteristics of energy using equipment as well as the thermal integrity characteristics of houses. The dynamic change of equipment and housing stock is driven by the investment behaviour of households. Houses present a low capital turnover rate, whereas other appliances are replaced more frequently, even before the end of their technical lifetime. Technological progress concerning energy efficiency is embedded in new vintages of equipment and houses. Retrofitting of houses for energy purposes, often as part of other modernisation work, also impacts on energy consumption. The residential sector consumed 26% of total final energy consumption in the EU in 2005. This is slightly up from 25% in 1990 and is projected to attain 24% by 2030. The EC DGTREN Baseline scenario projects an increase in energy consumption in the residential sector by 0.4% per year, down from a rate of 1.0% per year experienced in the period 1990-2005. As a result of rising income, dwellings are becoming larger with greater comfort levels for heating. Ownership of appliances increases and new energy uses such as cooling or more advanced communication equipment emerge. It is likely that these trends offset part of the considerable energy efficiency gains that have been observed concerning both the thermal integrity of houses and the specific energy consumption of appliances and equipment. Indeed, the energy efficiency improvements were brought about by more efficient new buildings and appliances. The impact of new buildings on total consumption is gradual since capital turnover in the housing sector is low, but the ownership of appliances in the 1990-2005 period has grown considerably. The ownership of refrigerators and TVs approaches 100% and a significant percentage of households own multiple appliances of the same kind. The ownership of washing machines exceeds 80%. The penetration of small appliances is also important. The new appliances are increasingly complying with high energy efficiency standards: for example in 2004 the sales of certain A class white appliances accounted for more than 70% of total sales. As a result, energy intensity in the residential sector, measured as the ratio of final energy consumption over disposable income, decreased by 1.1% per year in the period 1990-2005. Considerable decoupling of energy demand from growth of households' income has already taken place in the EU. The EC DGTREN Baseline scenario projects a continuation of this decoupling and shows a decrease of energy intensity in the residential sector by 1.6% per year between 2005 and 2030. In summary, the residential sector undergoes considerable progress in energy efficiency. Energy demand is mainly driven by the increase in the number of households, the growing degree of comfort and the important proliferation of appliances and services enabled by electricity.

The **transport sector** is worth of a deeper analysis, as it is one of the most important sectors for the development of energy consumption and the related environmental emissions (and it is obviously the main focus of the TRANSvisions study). The analysis of transportation activity by transport mode and the projections for the EC DGTREN Baseline scenario are presented in section 3.1.3 below, which includes a full examination of the impact of economy drivers on passenger and freight transport. Here the focus is on energy consumption in the transport sector, which accounted for 31% of total final energy consumption in 2005, up from 26% in 1990. This increasing share of transport in total energy consumption is projected to persist in the EC DGTREN Baseline scenario, achieving a share of 32.9% in the year 2030.

Road transport is the dominant transport mode and consumed 82% of total energy in the transport sector in 2005, down from 83.7% in 1990. Aviation displays the fastest growth consuming 13.8% of total energy for transportation in 2005, up from 10.4% in 1990. The EC DGTREN Baseline scenario projects aviation transport to account for 18.6% in total sector's energy consumption in 2030. The railway part in transport energy consumption was 2.7% in 2005, down from 3.4% in 1990. The projection shows a further decrease to 1.7% in 2030, which is linked to increasing electrification. Inland navigation accounted for 1.5% of total energy consumption by the sector in 2005 and this part remains rather stable in the future.

Private cars represent the dominant transport mean in road transport, accounting for 55.9% of total energy consumed in road transport in 2005. This share was 60.6% in 1990 and it was rather stable during the decade 1990-2000. In the period 2000-2005 transport by trucks grew very fast, as a result of the increasing freight transport in the enlarged EU. Therefore, energy used by trucks accounted for 39.4% of total energy consumed in road transport in 2005, up from 34.5% in 1990. Energy consumption by buses accounted for 1.5% of total energy in road transport in 2005 and motorcycles accounted for 3.3%.

Energy efficiency of cars improved at a slow pace during the decade 1990 to 2000. The trends in the car market were dominated by sales of larger, more powerful and more comfortable cars (as for example with the widespread use of air conditioning), which use more energy per unit of activity, offsetting the effects from improved engines in terms of energy efficiency. However, the period 2000 to 2005 showed a significant improvement in terms of cars energy efficiency: specific energy consumption of cars measured in litres/100 km was 10.3 in 2005, down from 11 litres/100 km in 2000. This improvement is a combined effect of increasing fuel prices, motivating prudent behaviour in car driving and use, and the design of more energy efficient engines (also following voluntary agreements with ACEA, JAMA and KAMA associations). The penetration of cars with higher energy requirements, such as the SUV car types, did not offset the downward trend of car's specific energy consumption. As it concerns future trends of energy efficiency of cars, the EC DGTREN Baseline projection shows further decrease of specific energy consumption at a rate of 1.25% per year in the period 2005 to 2030, which implies that average consumption of cars will be 7.5 litres/100 km by 2030.

Energy consumption by road transport is projected to increase by 0.8% per year in the period 2005 to 2030, which is substantially lower than the rate of 1.76% per year experienced in the period 1990 to 2000. A smaller rate of increase in energy consumption in road transport was observed already in the period 2000 to 2005 (1.3%). Energy intensity of road

transportation is projected to decrease by 0.8% per year for passenger transport and by 0.38% per year for freight transport, in the period 2005 to 2030.

As it concerns **energy consumption by rail transport**, the EC DGTREN Baseline scenario assumes a recovery of transportation by rail manifested by a significant increase in rail activity. This is considered to be a consequence of infrastructure development, low relative cost of transportation and increasing congestion in road transport.⁹ Diesel oil has still an important market share in rail transport within the EU, accounting for one third of total energy inputs to rail. The rest is covered by electricity. Electrification of rail transport is assumed to further proliferate in the Baseline scenario, diesel train remaining the only mean of rail transport in remote areas with less frequent travelling. In terms of primary energy, which takes into account energy conversion and losses of electricity, the electric train is 25% more energy efficient than the diesel train per unit of transportation activity. The high speed electric trains are consuming more energy than conventional trains but usually have higher occupancy rates. Taking into account these considerations, the EC DGTREN Baseline scenario shows significant decline of diesel consumption in rail transport and also a decrease of energy consumption measured in terms of final energy.

Energy consumption by aviation has grown by 4.6% per year in the period 1990 to 2000; the rate of increase was lower between 2000 and 2005: 1.86% per year. Transportation activity handled by aviation, measured in passenger.km grew faster during the same period. The average energy intensity of flights, measured in toe per passenger-km decreased considerably during 1990-2005. Improved design of engines and aircrafts in terms of energy efficiency led to a reduction of specific energy consumption of aircrafts by 1.3% per year in 1990-2000 and 0.87% per year in 2000-2005. The EC DGTREN Baseline scenario projects a continuation of growth of aviation transportation activity at a fast pace in the short and medium term and at a slower pace in the long term. Aviation activity measured in passenger-km is projected to become 4.4 times higher in 2030 than it was in 1990. Energy consumption is projected to increase significantly but less than the activity level, continuing past trends. This is driven by energy efficiency progress of engines and aircrafts which is projected to provide during 2005 2030 energy intensity gains of 1.2% when measured per year per flight and of 0.84% per year when measured per passenger-km. Energy consumption by aviation grows by 2.21% per year in the period 2005 to 2030, down from 3.68% per year in 1990-2005. Nevertheless, total volume of energy consumed by aviation is projected to triple in 2030 compared to 1990.

Inland navigation is traditionally important in the EU for freight transportation and keeps a small share of the market, showing a slow but steady positive rate of growth of activity (around 0.5% per year). The EC DGTREN Baseline scenario projects a continuation of this trend and also growing energy efficiency. **Energy consumption for inland navigation** is projected to increase at a slow pace in the medium term and to stabilise in the long term.

Finally, the EC DGTREN Baseline scenario provides projections concerning the fuel mix for the transport sector taken as a whole. This is projected to be dominated by oil products, which account for 91% in 2030, down from 97% in 2005. The small loss in market share is exclusively due to the penetration of biofuels. Electricity is used almost exclusively in rail

⁹ However, the projection shows still declining market shares for both passenger and freight transportation by rail, as the activity of other modes, such as road and aviation, increase faster than rail.

transport and does not penetrate in road transport in the context of the Baseline scenario assumptions (new energy carriers and technologies do not develop under these assumptions). The vehicles serving road transportation are based on internal combustion engines and are mainly using gasoline and diesel oil. Other fuels, such as LPG and CNG have small shares of total energy for road transportation in 2005, namely 1.5% and 0.2%, respectively. The share of gasoline in road transport has continuously decreased during the period 1990 to 2005: 38.5% in 2005 down from 57.9% in 1990. This trend is due to relative prices and car's specific energy consumption which have both favoured the penetration of diesel cars.

2.1.1.4 Role of biofuels

A special issue worth of mention here, in relation to energy and transport prospects, is the role of **biofuels**. Bioenergy and biofuels are of growing public and private interest at a time of rapidly rising world energy demand and high oil prices. Biofuels are liquid fuels for road vehicles and include bioethanol made from crops such as cereals and sugar cane and biodiesel originating mainly from rapeseed-, palm- and soya oil. Higher demand for these crops to supply the biofuels industry is good news for farmers who produce them, but perhaps not for intermediate and final consumers who will face higher feed costs and increased food bills. There are also questions as to whether higher demand will cause new land to be given over to biofuel crops, with a negative impact on the environment. Research is looking for ways to produce fuels from other crop sources and waste, but the required technology is still some years away. Indeed, technologies are being developed that make it possible to use cellulosic material, such as wood and plant stems and leaves, to produce so-called "second generation" bioethanol and to enable the use of any type of biomass to produce synthetic fuels. While at present such technologies are prohibitively expensive for transport use, there is a potential for their commercial application over the long term.

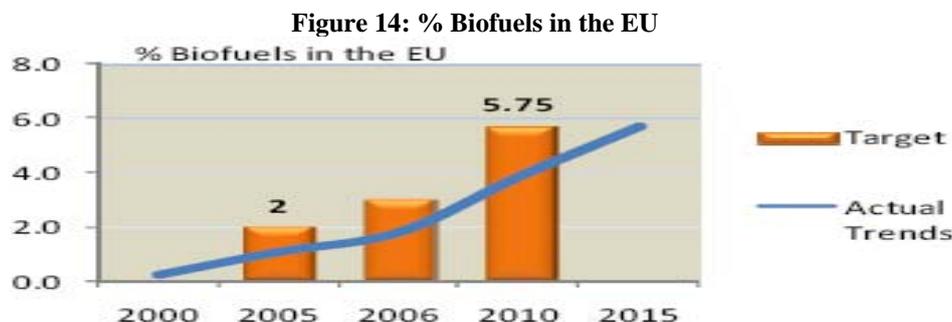
All in all, (first generation) biofuels can only make at present a modest potential contributing to address transport and energy problems, for a number of reasons:

- First the potential for biofuels to replace fossil energy is relatively small and the scope to improve energy security in this way is limited. The crops used in present-day biofuel production have a very low energy density compared with fossil energy sources (in other words, large amounts of agricultural land would be needed to replace a moderate amount of fossil energy). The International Energy Agency (IEA) estimates that by 2030 biofuels may account for only 4% to 7% of road transport fuels. According to the IEA, the amount of arable land needed for biofuels to meet just 4% of the world transport demand in 2030 is equal to more than that of France and Spain (IEA 2006).
- Second, assessing the environmental impact of biofuel production in the northern hemisphere is not as simple as it is often suggested. Life Cycle Analyses that take into account the entire production chain suggest that there is potential for fossil energy savings through the use of first-generation biofuels. However, these savings are relatively limited and vary between different situations in different locations. In addition, as growing demand from increased biofuel production raises prices for cereals, oilseeds and sugar, this may result in fragile land being brought back into production or currently forested land being cleared. Also, increased demand for biofuels may lead to an increase in more intensive and single-cropping practices, reducing water levels and damaging soil quality, and bridging increased quantities of pesticides and fertilizers into the environment. The latter are themselves produced through energy intensive processes.

- Third, food consumers will face higher prices resulting from increased raw commodity prices. In most OECD countries where costs of agricultural raw materials are only a small part in the final costs of food in the shops and where food represent only a small share of total expenditures, this issue should not be over-emphasised. But for poorer consumers in many developing countries, even a modest price increase could make the difference between being able to buy food or not. In addition, the results of the price changes will be mixed for farmers. Crop farmers will certainly benefit from the higher prices coming from increased demand for biofuels. But with contemporary technologies and current public support policies these are mostly cereals and oilseed producers in OECD countries.

Future generations of biofuels feedstocks and production processes are likely to have lower greenhouse gas emissions and may be more cost-effective. Such biofuels may be able to meet up to 10% or 20% of current transport energy demand, but no more than this without major advances in technology (Jones 2007). Ligno-cellulosic ethanol produced from some feedstocks in pilot plants already performs much better than most conventional biofuels in terms of greenhouse gas emissions and performs as well as the best Brazilian sugar cane ethanol. However, the economics are unproven and for large-scale production the potential supply of lingo-cellulosic ethanol is limited by cost and the land available for energy crops. It is true, indeed, that using waste products as the raw material for biofuel production would avoid many of the problems associated with cultivating biofuel crops. For instance, the potential value of diverting wastes from landfill has to be stressed against a background of rapid growth in the generation of household waste. Producing fuels from some kinds of waste reduces land use impacts to zero, but the potential volume of production from these kinds of waste remains to be quantified. In addition, many agricultural wastes have an opportunity cost and sustainable agricultural practices would see them returned to the soil to maintain organic matter content. However, producing biofuels from wastes that would otherwise be dumped in landfill sites might be expected to show net environmental benefits given a shortage of suitable landfill sites. The 2007 IPCC 4th Assessment Report on climate change mitigation policies foresees a potential for biofuels from agricultural crops and wastes to replace 5% to 10% of road transport fuels by 2030.

As it concerns Europe, the EU-27 Energy Baseline Scenario shows that the market for biomass and biofuels is likely to develop substantially. The baseline conditions presuppose investment and infrastructure development in sectors such as agriculture, forest, waste management and in sectors performing pre-treatment, transport and processing of biomass and waste resources. The Biofuels Directive sets an indicative target of 5,75% by 2010, for the share of biofuels in petrol and diesel for transportation purposes. The baseline projections are shown below:



Source: DG TREN, *European Energy and Transport Trends to 2030 Update 2007*

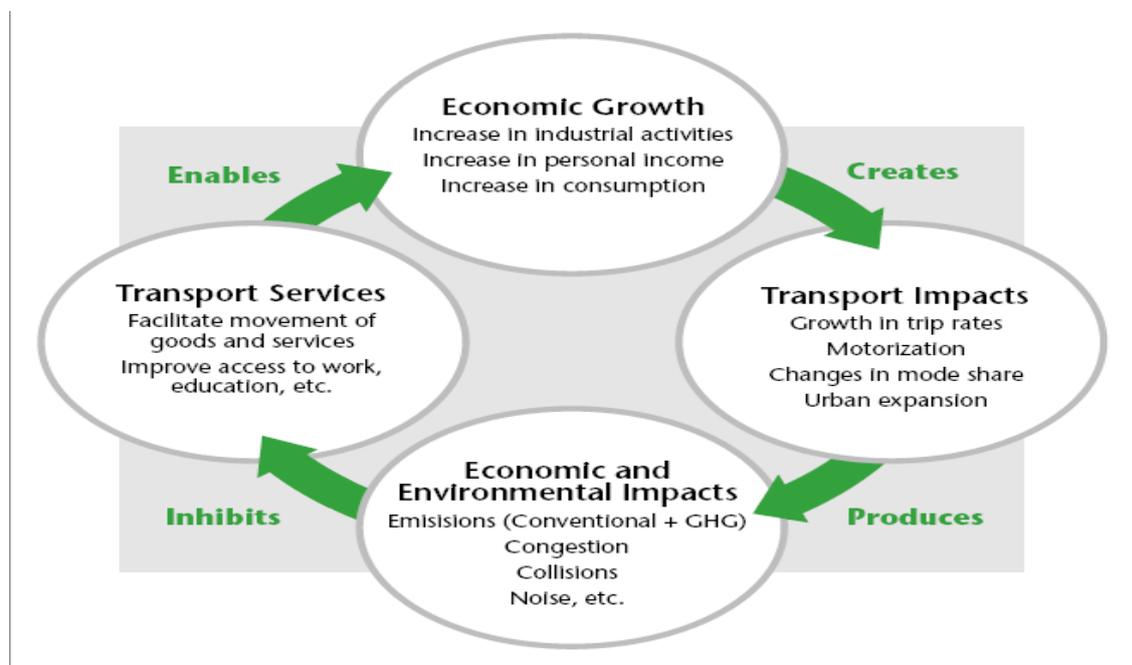
According to these projections, the overall EU target is likely to be achieved only in 2015, as the development of supporting infrastructure and changes in agriculture seem lower than initially expected. This result is achieved assuming that support schemes to biofuels are applied in all Member States and are determined so as to render them competitive, *vis-à-vis* the competing fuels. For the period beyond 2015, it was assumed in the baseline that subsidies gradually decrease, but that both economies of scale and maturity of infrastructure allow for further penetration of biofuels in transportation.

2.1.2 Economy

The relationships between economy and transport have been analysed in several studies¹⁰, and the conventional wisdom is that economy is one of the main driver of transport activity. However, despite the straightforward relationships between the two domains, the determination of causal relationships may be difficult to disentangle, due to the presence of complex feedbacks. For example, the relationship between the volume and quality of transport activity and the growth of an economy certainly exists. But does increased transport activity “cause” economic growth? Or does economic growth “cause” the increase in transport activity?

The following is a scheme aiming to establishing causal relationships produced by the WBCSD’s Sustainable Mobility Project at 2030¹¹:

Figure 15: Economy and Transport



Source: WBCSD: *Mobility 2030: Meeting the challenges to sustainability*

¹⁰ For an overall introduction to the issue, OECD *Decoupling the Environmental Impacts of Transport from Economic Growth*, Paris, 2006

¹¹ World Business Council for Sustainable Development “The Sustainable Mobility Project, 2004

The picture shows that the industrial activities and macroeconomic variables (GDP per capita, consumption, etc) are the main economic drivers causing directly transport impacts, in terms of increasing trip rates, motorization and urban expansion. At the same time, transport services enable economic growth, by making available better and faster passenger and freight transport services to be applied to facilitate trade, labour mobility, and human capital formation, allowing the division of labour and economies of scale. The environmental impacts, congestion and safety problems may inhibit the quantity and quality of transport activities.

In the following we will analyse in detail globalisation and trade patterns (sections 2.1.2.1 to 2.1.2.5), the logistic trends associated to an increasingly complex industrial activity (section 2.1.2.6) and EU economic growth trends, including their impact on personal income and consumption patterns (section 2.1.2.7).

2.1.2.1 Globalisation

Globalisation is a term mostly used to describe a set of processes that has transformed the world over recent decades. As put forward by J.R. Saul “since 1950 world trade has multiplied – depending on whose numbers you use – between twelve- and twenty-two fold. Worldwide foreign direct investment has grown fifteen-fold since 1970. For foreign direct investment to developing countries, the multiple is twenty. The daily turnover in foreign exchange markets was \$15 billion in 1973. Now is over \$1.5 trillion. Technology production has multiplied six times, the international trade in technology nine times. In 1956 it was possible to have eight-nine simultaneous transatlantic telephone conversations by cable. Today, by satellite and fibre optics, there are one million, plus faxes and e-mails”.¹²

However, according to Saul, what made “globalisation” an original phenomenon in the recent decades was not its internationalism or its international economics. History is full of both. From the Sumerian empire to United Nations, we have had every form of political, military and religious arrangements. And international trading arrangements, even international production integration systems, have always existed.¹³ So the remarkable originality of “globalisation” lay nowadays elsewhere: in its assertion that all civilizations from now on were going to be led by commerce, and free trade and unfettered markets would directly – according to the most optimistic – and indirectly – according to the more moderate – shape the key economic events on the globe, which in turn would shape the rest. The result would be a growth of wealth and general well-being through a multiplication of players, situations and factors.

Indeed, there have been hundreds of definitions of globalisation. The most technical is simply that the reduction of transport and communication costs would lead to an international integration of production and consumption. But the intent has always been grander than that. Alfred Eckes, the former chair of the US International Trade Commission, described that

¹² John Ralston Saul, 2005, *The Collapse of Globalism and the Reinvention of the World*, Atlantic Books London, pag. 21. The numbers are drawn from a variety of sources, mentioned in a note by the author.

¹³ Rome had all these for centuries across a territory so large that it included most of Europe as well as today’s Islamic world, with the exception of the Asian part.

intent in a speech given in October 1999 as a “process in which technology, economics, business, communication and even politics dissolve the barriers of time and space that once separated a people”.¹⁴

However, this vision of inevitable progress created by market leadership is increasingly becoming controversial. Today, by and large, there is (at least among economists, if not among politicians) an understanding of the limitations of markets. Take for instance the revolutionary explosion in money markets. Most of the foreign exchange movements are about speculation, not investment in wealth creation. The amounts involved are forty or sixty times that of real trade. The 1997 Asia meltdown included \$100 billion abruptly invested from abroad and then abruptly withdrawn within a year. Those countries had long had enough local capital for their own investment needs. Their economies were artificially inflated and then deflated – a classic boom-and-bust cycle, but imposed from the outside.

More rarely discussed is the lack of a sensible relationship between the spectacular growth in trade and the modest growth in wealth. Measuring success by gross domestic product is the standard, yet increasingly dubious approach to life. But if you do, you discover that GDP growth per head over the last three decades has been quite modest. It has been particularly subdued in the Western democracies, disastrous in both Latin America and Africa, and remarkable only in large parts of Asia (where most of the world population is however concentrated).

All in all, there is a growing recognition that there is not just one form of capitalism, not just one “right” way of running the economy. There are, for instance, other forms of market economies – such that of Sweden, which has sustained robust growth – that have led to quite different societies, marked with better health care and education and less inequality (Stiglitz, 2006). The globalisation debate in the Western democracies is still divided more or less in two categories of experts: economists who place less importance on reducing income inequality are more prone to think that the actions governments might take to reduce that inequality are too costly, and may even be counterproductive. These “free market” economists are also more inclined to believe that markets, by themselves, without government intervention, are efficient, and that the best way to help the poor is simply to let the economy grow – and, somehow, the benefits will trickle down to the poor. On the other hand, those who think that markets often fail to produce efficient outcomes (producing too much pollution and too little basic research, for instance) and are disturbed by income inequalities and high levels of poverty, also believe that reducing that inequality can cost less than the conservative economists predict. Those who worry about inequality and poverty also see the enormous costs of not dealing with the problem: the social consequences, including alienation, violence, and social conflict.

Meanwhile, a growing number of highly respected figures speaking outside of the Western democracies are turning their backs on theoretically scientific interpretations of global success such as trade statistics and cumulative GDPs. What they see are real people whose actual standard of living apparently must drop in order for them to appear to rise in global

¹⁴ Alfred E. Eckes, “Is Globalisation Sustainable?” speech given at CMRE meeting, Charlotte, N.C., 27 October 1999.

statistics.¹⁵ The Jordanian Prince Hassan now calls for a redefinition of “poverty in terms of human well-being rather than in terms of monetary wealth”.¹⁶ Malaysia has developed a Growth with Equity model. The Bhutanese work behind something called GNH – Gross National Happiness. And China – a giant actor in the global economic scene – is now increasingly focusing on a quality-of-life approach in the place of GDP, including a more locally appropriate manner of tackling their explosive levels of poverty and environmental problems. And if all this sounds like an anti-Western point of view, we can quote Vaclav Havel, the Czech writer and political leader, strongly pro free market, calling on Europe to act “as inspiration for other parts of the world in order to counter the dangers of globalisation”. As Havel puts it: “I don’t understand why the most important deity is the increase of gross domestic product. It is not about GDP. It is about the quality of life, and that is something else”.¹⁷

In conclusion, globalisation, like development, is no more seen as inevitable – even though there are strong underlying political and economic forces behind it. By most measures, between World War I and World War II, both the pace and extent of globalisation slowed, and even reversed. For example, measures of trade as a percentage of GDP actually declined. If globalisation leads to lower standards of living for many or most of the citizens of a country, and if compromises fundamental cultural values, then there are – and there will increasingly be – demands to slow or stop it.

2.1.2.2 Global production and trade patterns

While the globalisation process itself is not new, the present phase has witnessed a significant acceleration over the last 1-2 decades, with the integration of China, India and the former Soviet block countries into the world economy and trade. This acceleration in integration has resulted in a 50% increase in the world’s non-agricultural labour force, with a large proportion of these additional 700 million workers comparing well in human capital terms with the low skilled workers of the “developed” world. This labour supply boost has also coincided with a period rich in technological progress, most notably in the ICT area, with positive effects from the sharp reduction in communication costs being reflected in the growing tradability of many traditionally sheltered service sectors.

This dramatic intensification of the globalisation process is already transforming the economic structures of the developed and developing worlds, with India emerging as a global power in services, China consolidating its position in manufacturing and with the developed world as a whole searching for an appropriate response. In particular, recent media coverage has reinforced cognizance that China has become a world centre of production, producing innumerable discussions about where the world is headed. Chinese production as percentage of world production for several commodities in 2001 was already (Friedman, 2008):

- tractors: 83%

¹⁵ For example, these people may have been living a life beyond such measurements – perhaps rural lives where market transactions are almost inexistent. They are therefore technically existing on zero “income”. Then they move to a desperate urban slum where dirty water, sewage and alienation are the norm. But in such place, even a dollar’s worth of income can be measured, and so global GDP measurement systems say that they have taken a step forward and upward (Saul, 2005).

¹⁶ Prince El Hassan bin Talal, 2004, *To Be a Muslim: Islam, Peace and Democracy*, Brighton: Sussex Academic Press.

¹⁷ Vaclav Havel, interviewed in the International Herald Tribune, 22 October 2004, quoted in Saul 2005.

- watches/clocks: 75%
- toys: 70%
- penicillin: 60%
- cameras: 55%
- vitamin C: 50%
- laptop computers: 50%
- telephones: 50%
- air conditioners: 30%
- televisions: 29%
- washing machines: 24%
- refrigerators: 16%
- furniture: 16%
- steel: 15%

The current perspective is that China will overtake the US as the world's largest producer of manufactured goods as early as by 2009, according to forecasts by the economics consultancy firm Global Insight Inc., done on behalf of the Financial Times.¹⁸ China will account for 17% of the world's manufacturing value-added output next year, versus the United States 16%: in 2007, the US accounted for 20% of manufacturing output worldwide, while China made up just 13,2%. Also, last year, Global Insight predicted the US would hold its top position until 2013, but a severe economic downturn has expedited China's rise to the top. These Global Insight forecasts are based on current-year figures of manufacturing production for countries – including the activity of foreign-owned companies and local ones – measured as value-added output.¹⁹

Trade flows are a crucial indicator of the degree and pace of worldwide economic integration. **Global trade** is therefore examined in detail below, taking three different time-scale perspective:

- An historical perspective, showing world trade mega-trends over the period 1870-1998.
- A decadal perspective, showing the consequences on trade of the post-1990 acceleration in the global integration process.
- The current perspective, which shows now – in the year 2007 and 2008 - signals of world trade deceleration.

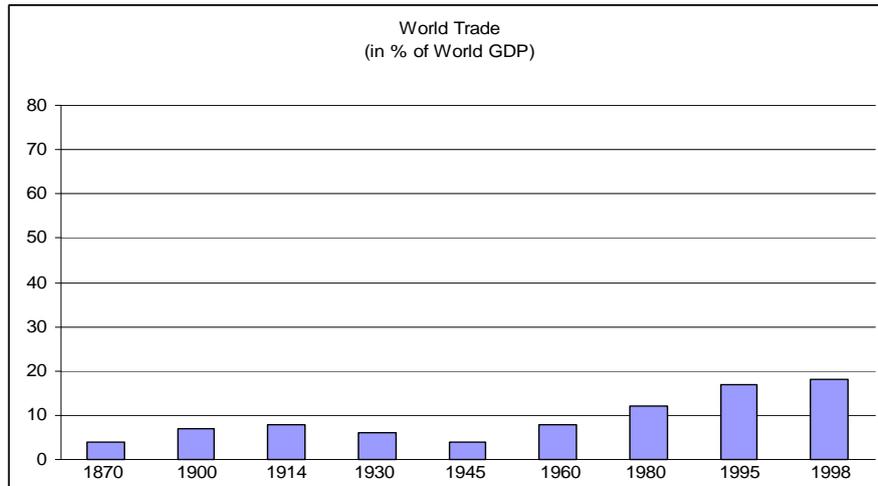
2.1.2.3 Historical world trade mega-trends

The figure below gives an overview of the importance of world trade as a percentage of world GDP over time and of the respective shares of world trade by the OECD and non-OECD economies.

¹⁸ Jason Simpkins, "China to Supplant US as World's Largest Manufacturer by Next Year", Financial Times, 11 August 2008.

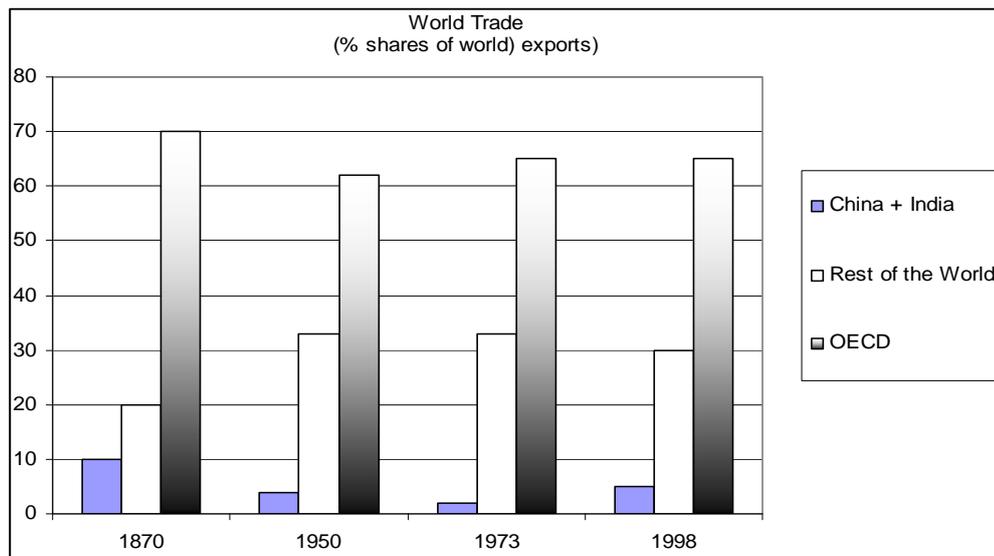
¹⁹ If inflation adjustments are used to put the numbers in constant prices, the expected US position looks better, because its inflation over this period is predicted to be lower than China's. Measured in real value-added terms, China's share in global manufacturing is forecast to overtake that of US by 2016-2017, boosted by rapid gains in market share of textiles, basic metals, computer equipment and mineral product manufacturing. However, again according to Global Insight, the US will continue to lead in certain high-value industries, such as aerospace, pharmaceuticals and specialized equipment.

Figure 16: World Trade as % of GDP



Source: EC Globalization: Trends, Issues and Macro Implications for the EU

Figure 17: Shares of World Exports (1870 – 1998) China/India, OECD and Rest of World



Source: EC Globalization: Trends, Issues and Macro Implications for the EU

The most important points to note at the centennial time scale are as follows:

- Firstly, if one uses world trade flows as a % of GDP as a proxy for the globalisation process as a whole, one can see clearly from the figure that this process is by no means inevitable and is subject to considerable setbacks at the hands of policy makers. While the overall trend since 1870 has been upwards, the interwar years was a timely reminder of the reversibility of the process, with world trade as a % of GDP15 being cut in half over these years as the tide of protectionism took hold in the major trading powers.
- Secondly, the shift in the post-war WWII period to more open policies ensured that trade integration has been a striking feature of the world economy over recent decades, with the

volume of goods presently traded being more than 15 times greater than in 1950 and with its share in GDP tripling.

- Thirdly, the growing integration of national economies into the world's trading system over the post-war period was driven not only by trade liberalisation but also by falling transportation and communication costs, rising income levels, higher productivity growth rates in tradable compared with non-tradable, and more recently by an ICT-enabled acceleration in the international division of labour linked with the development of increasingly global production systems. All these developments have led to a sharp increase in overall trade flows, underpinned by an expansion in both intra-industry flows and in a range of internationally tradable services.
- Finally, in terms of shares of world trade, the figure above highlights the dominance of the OECD countries in the global trading system, with the OECD's world share consistently in the 60-70% range over the whole period 1870 to the late 1990's. While the rest of the world, most notably China, have been making large gains in terms of their world market shares over the most recent years, the graph underlines the extent of the gap to be made up by these countries over the coming decades.

This analysis of broad trends for globalisation for the last 150 years is useful to understand the basic determinants and the fundamental fragility of the process – with the year of “Great Depression” showing that growing trade and capital integration is not an irreversible phenomenon. Indeed, although the long run trend shown by the graphs is towards closer economic integration at global level, the threat of economic and nowadays environmental anti-dumping protectionism is always present.

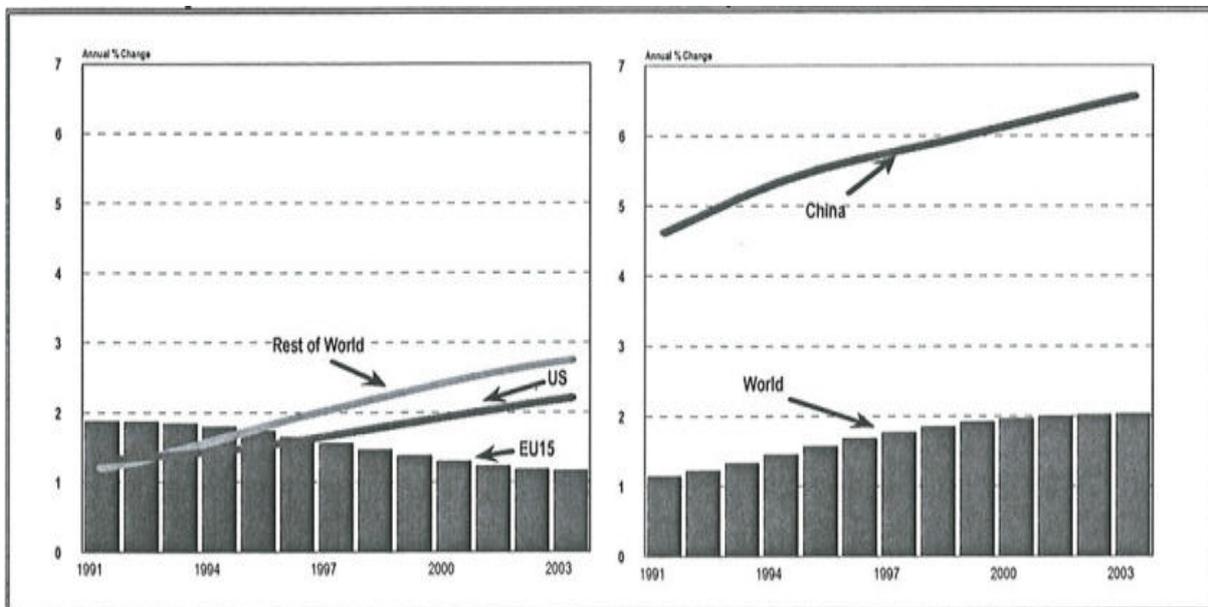
2.1.2.4 Last decade world trade trends

The decadal time scale perspective allow us to focus on the post-1990 acceleration in the global integration process. Three key features distinguish this phase:

- Firstly, **a further expansion in both trade and capital market integration**: The fall of the iron curtain in Europe and the opening up of China, India and parts of central and Latin America have led to a further increase in international trade and capital flows. World trade grew at rates well in excess of world output and flows of private capital have expanded rapidly.
- Secondly, **an ICT induced and ICT enabled acceleration in the global relocation of production processes**: The increase in international trade has not been confined to the exchange of finished goods and services since there has also been an expansion in the share of intermediate inputs which are traded internationally. This intermediate trade forms part of a growing trend towards the internationalisation of production. This pattern has been ongoing for decades but has accelerated since the early 1990's with the growth in the relocation of labour intensive manufacturing and business-related services to lower cost locations around the globe. This was mainly driven by multinationals seeking to take advantage of changes in global specialisation patterns and by the need to focus their developed world activities on the higher value added parts of the production process.
- Thirdly, **a worldwide income and technological convergence process**: In addition to the integration of economies through trade and financial flows, economic globalisation was also driven by the movement of knowledge (technology) across borders. The emerging

economies, especially the EU's new Member States, India, China and other south east Asian countries have exhibited strong productivity growth. As it is shown in the figure below, on average productivity growth in the rest of the world (world excl. EU15 and US) was about ½ % point higher than in the EU over the last 10-15 years. The “rest of the world” grouping includes the emerging economies which are making big strides in terms of productivity growth rates. The US on the other hand has managed to boost its productivity growth rate over this period and to restrict the gap to less than ½ % point, even over recent years. This process of income convergence is likely to continue over the coming decades, underpinned by a persistence of the existing Total Factor Productivity (TFP) growth rate differentials. As indicated by many growth studies, a country's level of long run income per capita is strongly related to human capital. Amongst many of the emerging economies in Europe and Asia, human capital is available in relative abundance.

Figure 18: World Trend Labour Productivity Growth Rates: 1991-2003



Note : China is also part of "Rest of World" grouping

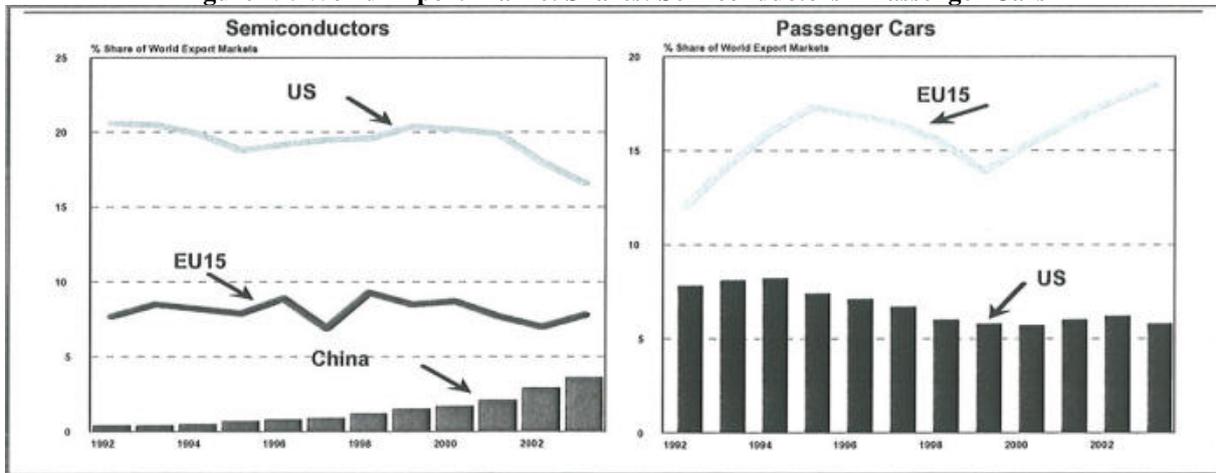
Source : World Bank (World Development Indicators) and own calculations

The EU was and still is the market leader in a wide range of medium technology and capital intensive goods industries. Despite this, there are a number of areas of concern regarding the future trends for the EU. In terms of new competitors, China and the Asia region in general pose a considerable competitive threat to the EU. Over the 1990's, the EU has experienced large and rising deficits with Asia in its overall trade and has experienced sharp turnarounds in its trading performance in a number of product areas which have traditionally been EU strongholds. In terms of a skills-based breakdown of product groupings, while the EU has a strong specialisation in the medium-high technology area, it is exceptionally weak in a large number of high technology export markets, especially in the ICT area.

According to the DG ECFIN 2004 study, if one examines the evolution of the world market shares over the period 1992-2003 for the EU, US and China for the top 6 products (see figure below), two important conclusions emerge:

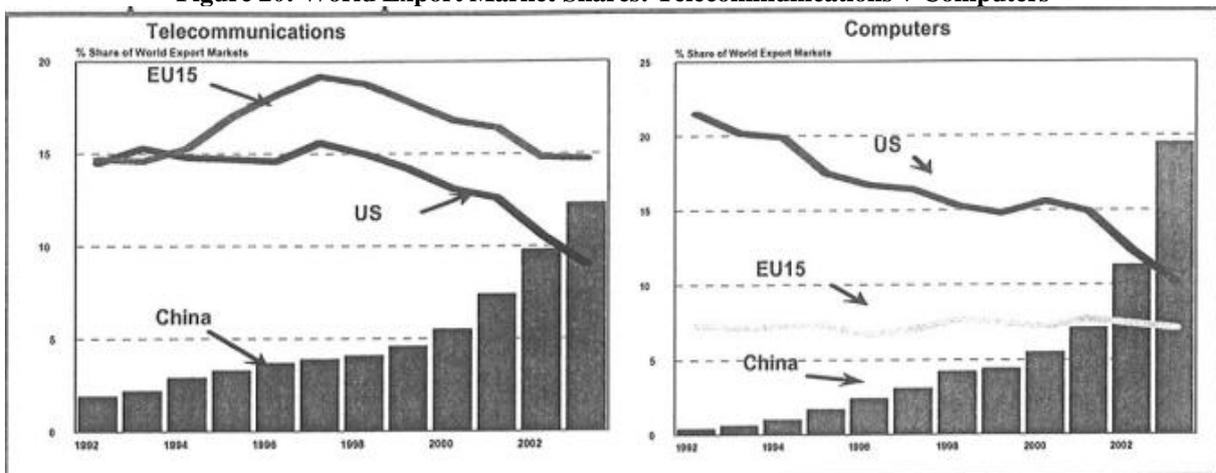
- firstly, that while the EU was broadly holding its own in many of these markets, its share of ICT related product markets (i.e. semiconductors; computers; and parts and accessories for computers) was often relatively small; and
- secondly, that China was largely absent from the passenger cars and pharmaceuticals markets, areas where the EU is very strong. China would appear to be more of a competitor to the US in many of the ICT related areas where the US has traditionally held a strong comparative advantage. One exception however is telecommunications where China was gaining market share from both the US and the EU.

Figure 19: World Export Market Shares: Semiconductors + Passenger Cars

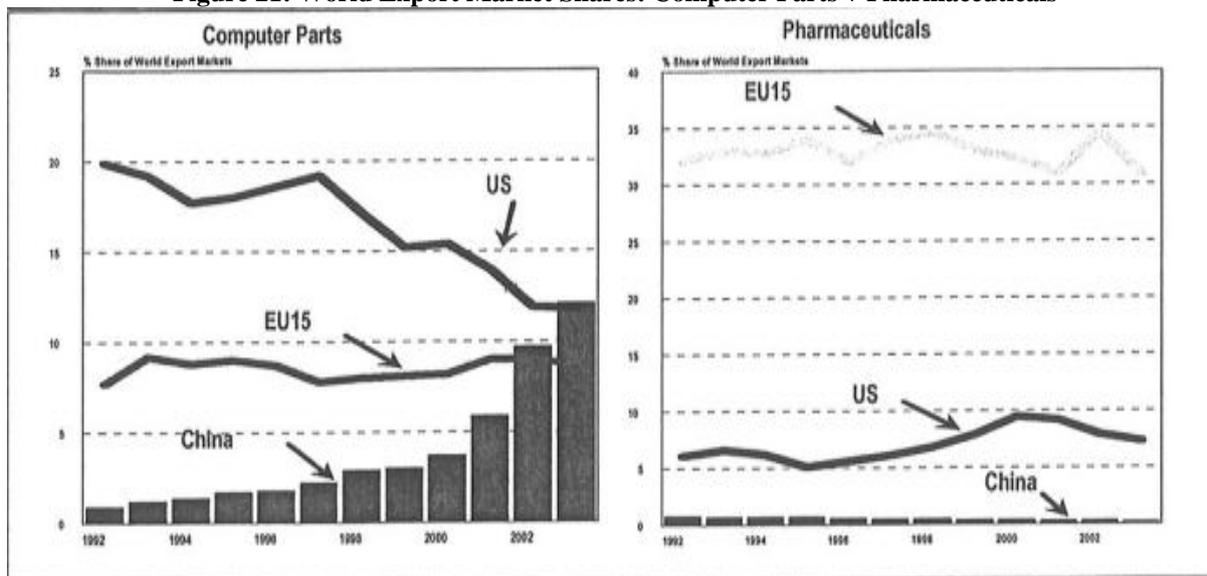


Source: EC Globalization: Trends, Issues and Macro Implications for the EU

Figure 20: World Export Market Shares: Telecommunications + Computers



Source: EC Globalization: Trends, Issues and Macro Implications for the EU

Figure 21: World Export Market Shares: Computer Parts + Pharmaceuticals

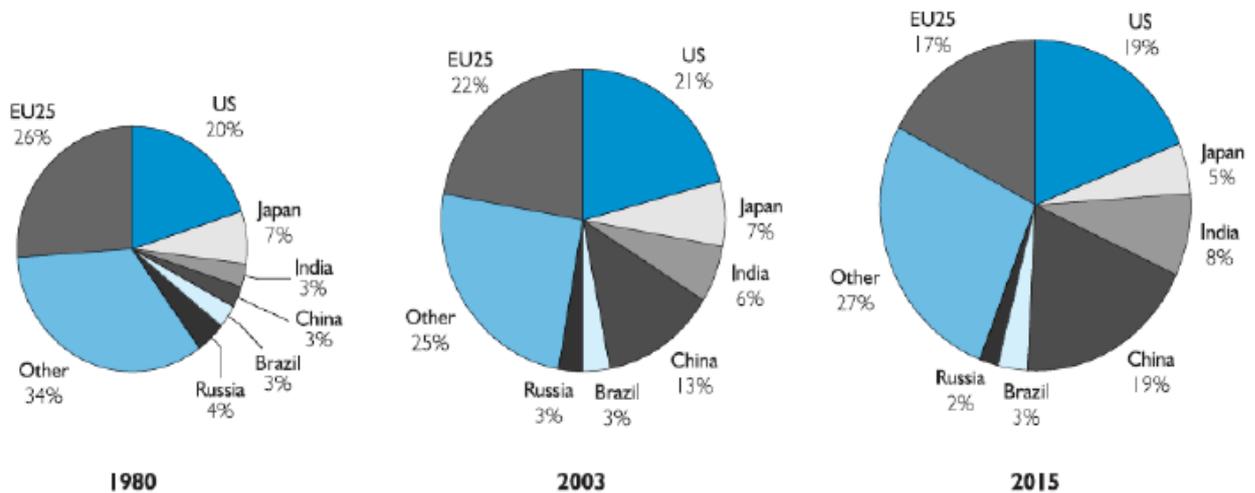
Source: EC Globalization: Trends, Issues and Macro Implications for the EU

In summary, as the DG ECFIN 2004 study pointed out, there were already a number of potential risks for the EU in the post-1990 accelerated wave of globalisation:

- Firstly, while the EU has done reasonably well over the last 10-15 years in maintaining its leading role in world trade, this performance could have been partially facilitated by the fact that the initial, investment intensive, phase of the global catching-up process tends to benefit those capital goods industries where the EU is relatively strong.
- Secondly, the EU's exceptionally poor performance in the high technology sector, and ICT in particular, was and still is a major source of concern especially given the evidence that China is anxious to rapidly move up the value added chain (and is investing heavily in R&D and education to hasten this process).
- Thirdly, given the estimates of over 100 million low skilled agricultural workers in China needing to move into the manufacturing sector over the coming decades, it appears that China's comparative advantage is likely to remain in labour intensive products for many years. Given that the EU has a relatively high share of its exports in the low technology / labour intensive categories compared with the US or Japan, it is particularly vulnerable to a possible world domination by China (or other low cost producers) in these industries.
- Finally, unlike the last 10-15 years when China tended to focus its export strategy on ICT related products as well as textiles / clothing, it is likely that in future phases of their development they may well target some of the industries where the EU is presently dominant, such as cars, chemicals or pharmaceuticals.

The realization of these trends in the short-medium period (up to 2015) would undermine the position of the EU economy in terms of their share on world economic output (in purchasing power parity), as shown in the following graph.

Figure 22: U Share on world economic output



Source: IMF, Consensus Forecast, HM Treasury

Note: Areas indicate size of global economy

Looking ahead to the future in a long-term horizon, the same DG ECFIN 2004 study has provided simulations for alternative global relocation patterns, from the perspective of EU, until 2050. Two extreme options emerged from the DG ECFIN study simulation results:

- The most favourable globalisation scenario:** If one allows for the possibility of more dynamic effects from globalisation in terms of restructuring from heightened competition levels and from technological spill over from the rest of the world, the EU has the potential to achieve significant efficiency gains from a continued global convergence process and from the associated reallocation of productive resources. On the basis of the most optimistic scenario, the level of EU GDP per capita was estimated to increase by about 8% over the next 4-5 decades which is roughly equivalent to 0.2 on the annual average per capita income growth rate over this period. In absolute terms an 8% increase in per capita income levels amounts to a permanent annual gain in living standards of about €2000 in 2004 prices for every EU citizen (over €5000 per EU household).
- The unfavourable anti-globalisation scenario:** Regarding the effects of actions to slow down or even reverse the trend towards greater global integration, the results of the simulations were unambiguously negative, with the most pessimistic scenario suggesting that the level of living standards in the EU could be up to 5% lower. The main conclusion was that, while the protectionist route may appear initially alluring to politicians relative to the alternative of global competition, in the long run this would be a policy which will be highly negative for EU citizens in terms of efficiency levels and overall welfare.

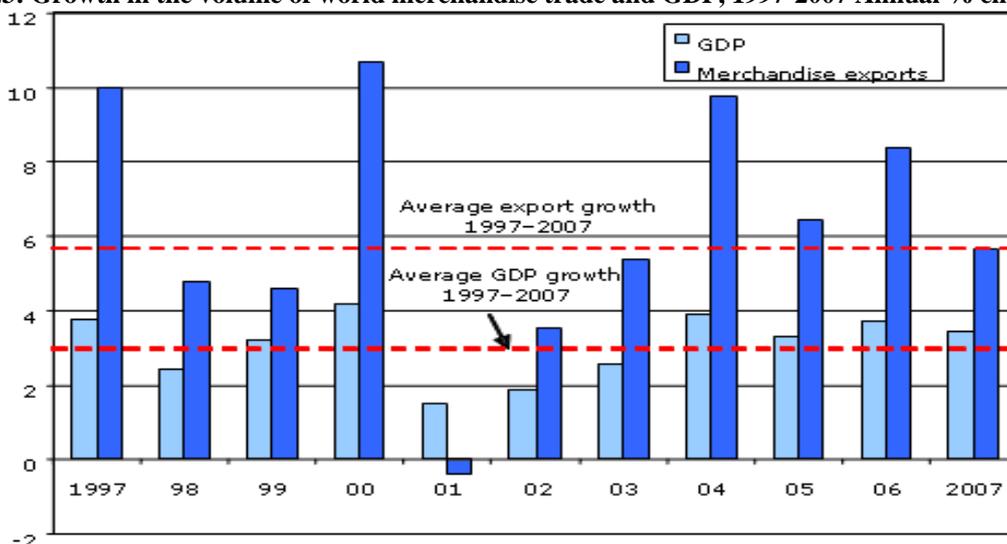
2.1.2.5 Current world trade trends

Growth in world output and trade decelerated in 2007. According to the last World Trade Organisation (WTO) outlook, weaker demand in the developed economies reduced global economic growth to 3.4% from 3.7%, roughly the average rate recorded over the last decade. At some 7%, growth in the developing regions was nearly three times the rate recorded in the developed regions. The whole Europe recorded GDP growth of 2.8% — a somewhat better performance than both Japan and the United States. Stimulated by sharply higher export earnings and rising investment, Russia's economic growth of 8% was the strongest annual rate since 2000. The most populous developing countries — China and India — continued to report outstandingly high economic growth.

World trade growth slid to 5.5% from 8.5% in 2006 and may grow even more slowly in 2008 — at about 4.5% — as sharp economic deceleration in key developed countries is only partly offset by continuing strong growth in emerging economies, according to World Trade Organization (WTO) economists. Among the leading traders, China's real merchandise (goods) trade expansion remained outstandingly strong in 2007 as lower export growth to the US and Japanese markets was largely offset by higher export growth to Europe and a boom in shipments to the net-oil-exporting regions.

According to the WTO outlook, the slowdown in economic activity in developed countries was the major factor in the reduced expansion of global trade in 2007. However, as illustrated in the figure below, the real merchandise export growth, estimated at 5.5% in 2007, is still close to the average rate of trade expansion over the last decade (1997-2007), which exceeded global output growth by 2 percentage points.

Figure 23: Growth in the volume of world merchandise trade and GDP, 1997-2007 Annual % change



Source: WTO Outlook

Europe's real merchandise export and import growth of 3.5% in 2007 continued to lag behind the global rate of trade expansion, as has been the case since 2002. Within Europe, individual countries' trade performances differed widely in 2007. Three groups can be distinguished. First, most of the new EU members and Turkey expanded exports and imports by more than 10%. Second, Germany, the Netherlands, Austria, Belgium and Switzerland registered trade

growth of about 5%. The third group's trade was almost stagnant (eg, France, Spain, Ireland and Malta).

As it concerns the nominal growth, Europe was the only region reporting a stronger increase in the dollar value of its exports in 2007 than in 2006 (16% and 13% respectively). Import growth was only slightly less than export growth, and also somewhat faster than in the preceding year. This acceleration in nominal trade growth is entirely due to the strong appreciation of the European currencies vis-à-vis the US dollar in 2007. The real appreciation of the Euro had differing consequences for the export performances of Euro-zone economies. Some countries reported stagnation in their trade (e.g. the United Kingdom) while most of the new EU members recorded dollar value growth rates in excess of 20%. Thanks to a 20% increase in its exports, Germany remained the world's leading exporter of merchandise. These more dynamic traders benefited also from their proximity to the booming CIS region.

The sharp rise of commodity prices — particularly fuels and metals — greatly improved the financial situation of most developing regions and boosted imports. But, higher energy and food prices translated into inflationary pressures worldwide. At the end of 2007 consumer prices in developed and developing economies were increasing faster than at the beginning of the year, by about 1 and 2 percentage points respectively. Major terms-of-trade gains could be observed now in countries and regions exporting primarily fuels or minerals. More recently net-food exporters have also enjoyed gains from favourable terms-of-trade movements. Unsurprisingly, thanks to their faster income growth and increased international purchasing power, net exporters of mining products (fuels and minerals) recorded a double-digit rise in their imports, while exports tended to increase less than the global average.

World commercial services exports rose by 18% to \$3.3 trillion in 2007. The acceleration in services exports could be observed in all major regions and in all three services categories - transportation, travel and "other commercial services" - with the last of these being the fastest growing category over the last seven years and accounting for slightly more than one half of total services exports. Higher fuels cost contributed to the relatively sharp rise in the dollar value of transportation services. Much of this acceleration is due to exchange rate movements and in some cases also to higher costs of transportation fuels. It can be assumed that exchange rate changes played a stronger role in the dollar value change of services trade than in merchandise trade, as Europe (with its appreciating currencies) accounts for a larger share of services than merchandise exports.

2.1.2.6 Logistic trends

Globalisation is leading to a world that is increasingly homogenised economically, with significant implications for the past and future trends in logistic and supply chain management. These trends are summarised in the table below and further discussed thereafter.

Table 1: Trends in logistics

Level of logistical decision making	Trend
Restructuring of logistics systems	Spatial concentration of production and inventory
	Development of break-bulk / transshipment systems
	Creation of hub-satellite networks
Realignment of supply chains	Concentration of international trade on hub ports
	Rationalisation of the supply base
	Vertical disintegration of production
	Wider geographical sourcing of supplies
	Wider distribution of finished products
	Postponement / local customisation
	Increased direct delivery
Rescheduling of product flows	Time-compression principles applied in retail and manufacturing
	Increase in retailers' control over supply chain
	Growth of 'nominated day' deliveries and timed delivery systems
Management of distribution	Changes in freight modal split
	Reduction in international transport costs
	Impact of legislation and regulation
	Increased use of information and communications technology
	Developments in vehicle and handling technology
Changes in product design	Complexity, Packaging, Modularity
	Globalisation, growth of E-commerce and dematerialisation of freight

Source: *COMPETE "Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States", Annex 5*

Nowadays industrial companies have an increasing incentive to concentrate production in a smaller number of factories. Each firm wants to enlarge its market area from just one distribution point. In many sectors the focus has moved from nationally based production to single locations producing a particular product for the world market. Concentration of inventory has been another main logistic trend over the last decades. A reduced number of stockholding points can yield a financial benefit much bigger than the additional transport cost they usually cause due to longer trips. This has been facilitated by the decline of international transport costs because carrying capacities have expanded and transport operators could take advantage of larger economies of scale. Other important drivers enabling companies to operate central warehouses are the advances in information technologies and supply chain integration. In some sectors the increase in direct deliveries supported by the diffusion of Internet enables manufacturers to bypass wholesale and retail channels and therefore reduce costs. The wider geographical sourcing of suppliers (upstream) and the wider distribution of finished products (downstream) are extending the companies' supply lines

upstream and downstream, and this facilitates outsourcing and delocalisation strategies as well, as the companies seek to reduce purchasing and manufacturing or labour costs.

The geographical concentration of production and inventory is depicted in the figure below:

Figure 24: Geographical concentration in logistics



Source: *COMPETE "Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States", Annex 5*

2.1.2.7 Future EU macroeconomic trends

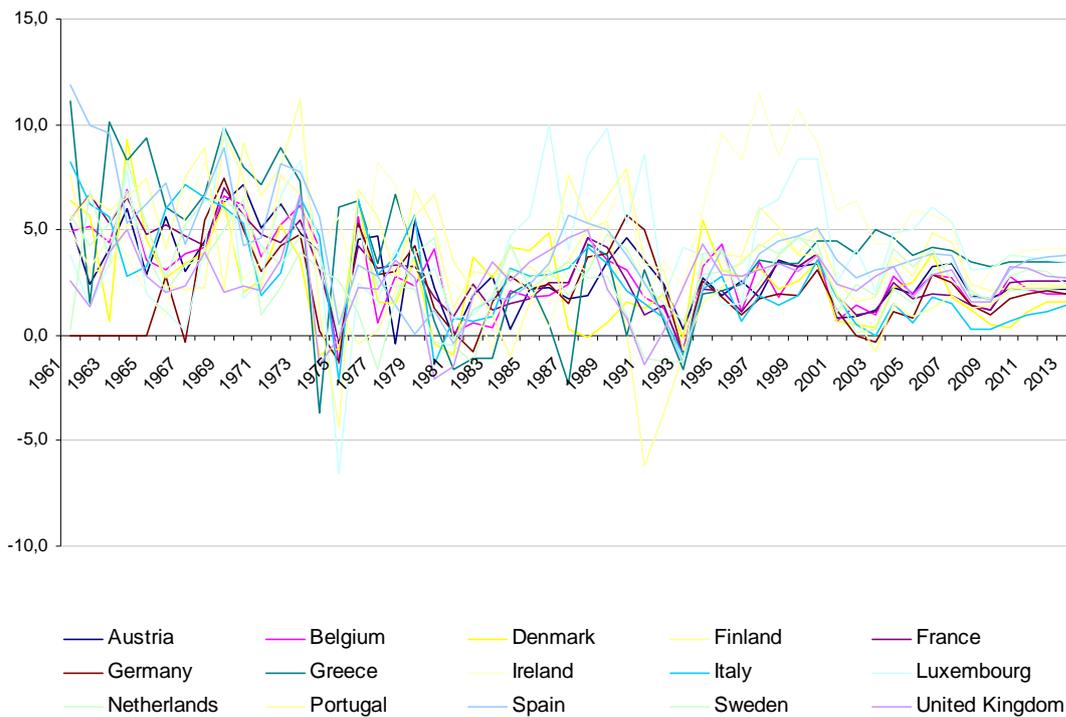
An outlook of the future EU macroeconomic trends up to 2030 is provided by the EU-27 Energy Baseline Scenario. This scenario can be considered optimistic, as the EU economy is projected to steadily grow at an average rate of 2.2% per year until 2030. The GDP projections for EU-27 Member States are based on pertinent long term studies of DG ECFIN for the period up to 2030²⁰, and additional inputs from Member States' stability programmes and other national long-term projections. A basic assumption is that the level of economic prosperity of the Member States will tend to converge, as the integration of the new Member States into the European Union is assumed to generate accelerated growth in these economies, although convergence will not be completed before 2030.

The baseline economic outlook of EU-27 is dominated by the evolution of the EU-15 economy. This is because the contribution of new Member States, despite their much faster growth over the projection period (+ 4.1% per annum in 2005-2030 compared to + 2,0% per annum in EU-15) remains rather limited in terms of overall EU-27 GDP. By 2030, new EU-12 GDP reaches 9,6% of EU-27 economic activity compared to 6.0% in 2005 and, consequently, overall economic growth of EU-27 (+ 2,2% per annum) follows closely that of EU-15.

²⁰ European Commission, DG ECFIN "Long Run Labour Productivity and Potential Growth Rate Projections for the EU25 countries up to 2050" ECFIN/50485/04-EN

The growth of about 2% per annum is also in line with long term trends convergence in the European economies (EU 15), especially from the beginning of 1980, as can be seen in the graph below.

Figure 25: GDP growth rate
GDP growth (yearly %)



Source: Our elaboration from IMF data

The European economy progressively changes its structure as sectors with higher value added develop more rapidly than sectors that are energy and material intensive, reflecting the long established trend of structural changes in developed economies, away from the primary and secondary sectors and towards services and high value-added products. However the pace of change is expected to decelerate in the long run. The share of industry in total value added slightly decreases from 19.6% in 2005 to 19.3% in 2030. Also, energy intensive industry is projected to grow at rates slightly below the average. Agriculture is projected to grow at rates will below the average (+ 1.2% per year in the period 2005-2030). The sustained growth of the EU industrial output, as projected for the baseline scenario, rely on global demand for manufactured goods which are projected to grow driven by economic development in the emerging economies (e.g. China's growing demand for metal and non metal materials). Value added produced by the services sectors increase over the projection period at rates above average, implying a slow but steady increase in the share of services in total economic activity (71% in 2030 up from 69% in 2005). Finally, the EU-27 Baseline macroeconomic scenario projects consumer expenditure per capita to increase steadily by 2% per year.

The development of macroeconomic drivers, population and passenger and freight transport activity assumed in the baseline scenario up to 2030 are shown in the table below:

Table 2: EU macroeconomic trend

	1990	1995	2000	2005	2010	2015	2020	2025	2030	Annual Growth		
										1990-2000	2000-2010	2010-2030
GDP of EU-27 (in 000 M€ '05)	8109	8712	10046	10949	12430	14059	15687	17266	18687	2.17	2.15	2.06
Value Added at Factor Prices (in 000 M€ '05)												
Energy Intensive Industry	353	375	416	448	503	566	628	685	734	1.67	1.91	1.91
Non Energy Intensive Industry	1227	1232	1426	1500	1692	1911	2133	2345	2527	1.52	1.72	2.03
Services Sector	4806	5274	6176	6857	7844	8925	10003	11050	12001	2.54	2.42	2.15
Agriculture Sector	241	245	269	272	289	311	332	350	367	1.08	0.72	1.21
Consumer Expenditure (€/capita)	10057	10634	12208	13230	14748	16452	18202	19955	21622	1.96	1.91	1.93
Population (million)	470	476	481	489	493	495	496	496	495	0.21	0.26	0.02
Passenger transport activity (Gpkm)	4785	5222	5820	6245	6784	7350	7897	8413	8861	1.98	1.54	1.34
Freight transport activity (Gtkm)	1879	1929	2175	2464	2770	3061	3321	3546	3717	1.47	2.45	1.48

Source: DG TREN, European Energy and Transport, Trends to 2030 – Update 2007

It is important to consider that as a household's income rises, its demand for personal transport also increases. Some of this growth may be reflected in greater demand for long-distance travel. But it is also reflected in the increased probability that the household will own more than one motorized vehicle. In fact, real per capita disposable income seems to be the most important determinant of vehicle ownership, explaining as much as 90% of cross-national variation in vehicle ownership per capita. However, it should be considered that differences in motorization rates among urban areas with similar per capita incomes are due to factors such as: different population density, different level of public services, strong car ownership and traffic restraint policies.

ECFIN has investigated in another study (see Annex II, "The impact of ageing on public expenditure: projections for the EU25 Member States on pensions, health care, long-term care, education and unemployment transfers (2004-2050)") the effect of ageing on the economic development in EU25 in a long-term perspective. From a start the forecasts assume a convergence towards a lower growth in GDP than has been experienced for the last 5 decades. The long term forecasts for EU15 indicate a convergence towards a growth in GDP of about 1.3 % in 2050, and of 0.6 % for NMS10.

The ECFIN analyses indicate that the economic growth can be affected by the ageing of population with about ± 10 % depending on assumptions on how shortages in working age population are handled. In terms of GDP per capita growth rates, income levels in EU10 are projected to increase from 50% of EU15 average in 2004 to 78% in 2050, as shown in the table below.

Table 3: GDP growth rate by EU 25 country – forecast at 2050 -

	GDP per capita growth rates (%)			GDP per capita (EU15=100)			Productivity levels (EU15=100)		
	2004-10	2011-30	2031-50	2004	2030	2050	2004	2030	2050
BE	2.1	1.6	1.6	108	107	109	122	115	115
DK	1.8	1.5	1.7	110	107	111	98	100	100
DE	1.6	1.4	1.5	101	94	95	94	88	88
GR	2.6	1.6	1.1	72	72	68	84	79	79
ES	2.0	1.9	0.9	85	90	81	91	88	88
FR	1.7	1.5	1.6	105	101	103	113	110	110
IE	4.2	2.5	1.2	132	177	167	128	161	161
IT	1.6	1.6	1.3	100	97	94	116	108	108
LU	3.1	2.1	2.4	194	226	270	129	135	135
NL	1.3	1.3	1.7	108	98	103	93	92	92
AT	1.9	1.5	1.4	116	113	112	109	106	106
PT	1.5	2.1	1.1	68	73	68	60	71	71
FI	2.4	1.6	1.7	108	110	115	104	112	112
SE	2.3	2.0	1.7	112	123	129	104	116	116
UK	2.4	1.8	1.5	104	111	113	95	107	107
CY	2.9	2.7	1.6	81	107	110	77	94	97
CZ	3.6	2.8	1.3	64	89	86	59	87	90
EE	6.6	3.5	1.6	46	86	87	46	82	86
HU	3.9	2.8	1.4	54	76	75	61	81	85
LT	7.0	3.7	1.5	43	86	87	46	80	84
LV	8.3	3.9	1.5	42	93	94	42	88	92
MT	1.3	2.2	1.7	68	73	76	80	81	84
PL	4.7	3.4	1.3	45	75	73	54	76	79
SK	4.7	3.6	1.0	48	83	77	52	76	80
SI	3.6	2.5	1.4	73	94	94	71	96	100
<i>EU25</i>	2.2	1.8	1.4	92	97	97	93	97	98
<i>EU15</i>	1.9	1.7	1.4	100	100	100	100	100	100
<i>Euro area</i>	1.8	1.6	1.4	99	97	96	101	98	98
<i>EU10</i>	4.6	3.2	1.3	50	80	78	56	80	83

Source: EPC and European Commission (2005a)

The macroeconomic assumptions assume a real interest rate of 3%, an inflation rate by 2% for all countries, and a growth of real wages in line with labour productivity.

Comparing the future European macroeconomic trends to 2030 and to 2050, it can be argued that between 2031 and 2050 a general decrease of economic growth maybe expected. For the EU25, the annual average potential GDP growth rate in the period 2004 to 2010 is in fact projected to decline from 2.4% to 1.2% in the period 2031-2050. The projected fall in potential growth rates is much higher in the EU10 due to their less favourable demographic projections .

2.1.3 Demographic change

The relationships between demographic change and transport activities are complex. Population growth is in itself a driver of transport. Generally, as the population grows, travel tends to rise proportionately. Population growth, the increase in the number of households and their location may affect the number and average length of journeys made. Other linkages are

to be assessed in relation to the most important demographic changes expected in Europe, i.e. population ageing, growing number of immigrants from outside Europe, decreasing household size and urbanisation

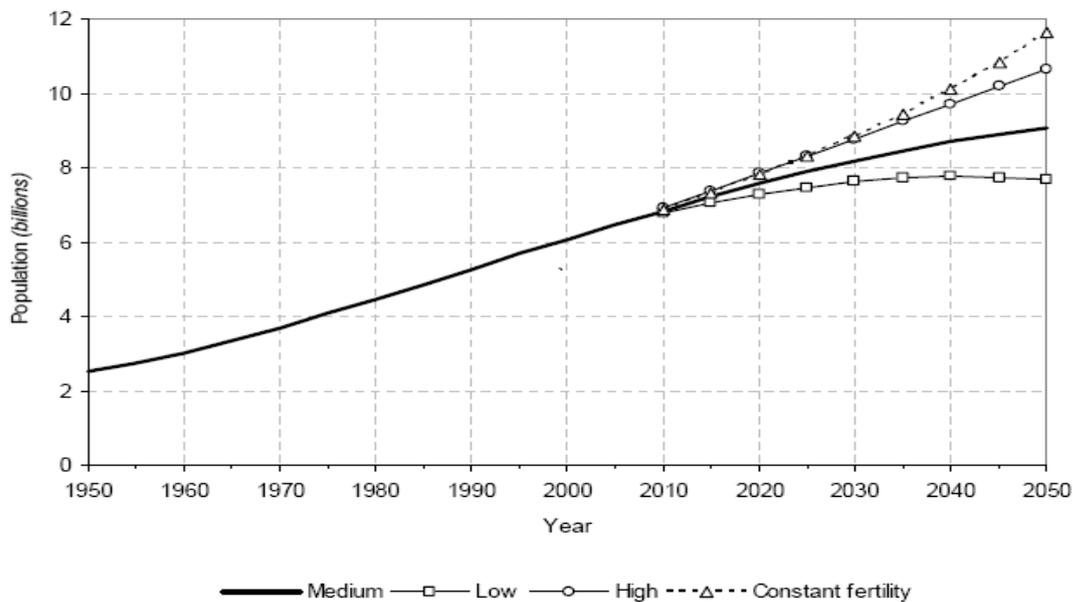
The next sections address separately the population growth, ageing, migration, household size and urbanization trends.

2.1.3.1 Population growth

Global population began a strong secular increase in the mid-1700s, with the maximum rate of increase occurring around 1970 with a current growth rate of about 77 million people per year. Since then, fertility rates have been generally declining: from an average of 5 children per woman in 1955 to 2.65 children per woman in 2005. This decline is significant, especially in east Asia. By 2005, in sub-Saharan Africa as well as in parts of south Asia, fertility decline progressed quite unevenly. Contemporary rates of population growth are largely attributable to increased medical and human health knowledge, science and technology, as well as the reduction of the impact from epidemics and infant mortality on global population size.

According to the UN World Population Prospects, despite the declining fertility levels projected over 2005-2050 the world population is expected to reach 9.1 billion in the medium variant and will still be adding 34 million persons annually by mid-century.

Figure 26: Population of the world, 1950-2050, by projection variants



Today, 95 per cent of all population growth is absorbed by the developing world and only 5 per cent by the developed world. By 2050, according to the medium variant, the population of the more developed countries as a whole would be declining slowly by about 1 million persons a year and that of the developing world would be adding 35 million annually, 22 million of whom would be absorbed by the least developed countries.

Because of its low and declining rate of growth, the population of developed countries as a whole is expected to remain virtually unchanged between 2005 and 2050, at about 1.2 billion.

In contrast, the population of the 50 least developed countries is projected to more than double, passing from 0.8 billion in 2005 to 1.7 billion in 2050. Growth in the rest of the developing world is also projected to be robust, though less rapid, with its population rising from 4.5 billion to 6.1 billion between 2005 and 2050.

In this global context, Europe is facing radical demographic change: **life expectancy** is increasing and at the same time the number of children being born is steadily falling. The aggregate population trends for the EU-15, the New Member States (EU-12) and the EU-27, according to the low fertility, medium fertility and high fertility variants, are shown in the following table.

Table 4: Population (thousands) by EU-15, New Member States and EU-27 for different scenarios 2000 to 2050

		2000	2005	2010	2015	2020	2025	2030	2040	2050
EU-15	Low Variant	377335	386878	389844	388856	385538	381515	376748	363493	343864
	Medium Variant	377335	386878	392982	396838	399371	401014	401825	401113	397524
	High Variant	377335	386878	396100	404805	413068	420465	426769	440955	458383
NMS	Low Variant	104807	103543	101268	98354	95024	91449	87577	78752	68882
	Medium Variant	104807	103543	102226	100755	99034	96864	94291	88339	81940
	High Variant	104807	103543	103184	103142	102996	102205	100996	98776	97194
EU-27	Low Variant	482142	490421	491112	487210	480562	472964	464325	442245	412746
	Medium Variant	482142	490421	495208	497593	498405	497878	496116	489452	479464
	High Variant	482142	490421	499284	507947	516064	522670	527765	539731	555577

Source: World Population Prospects, 2006 Revision

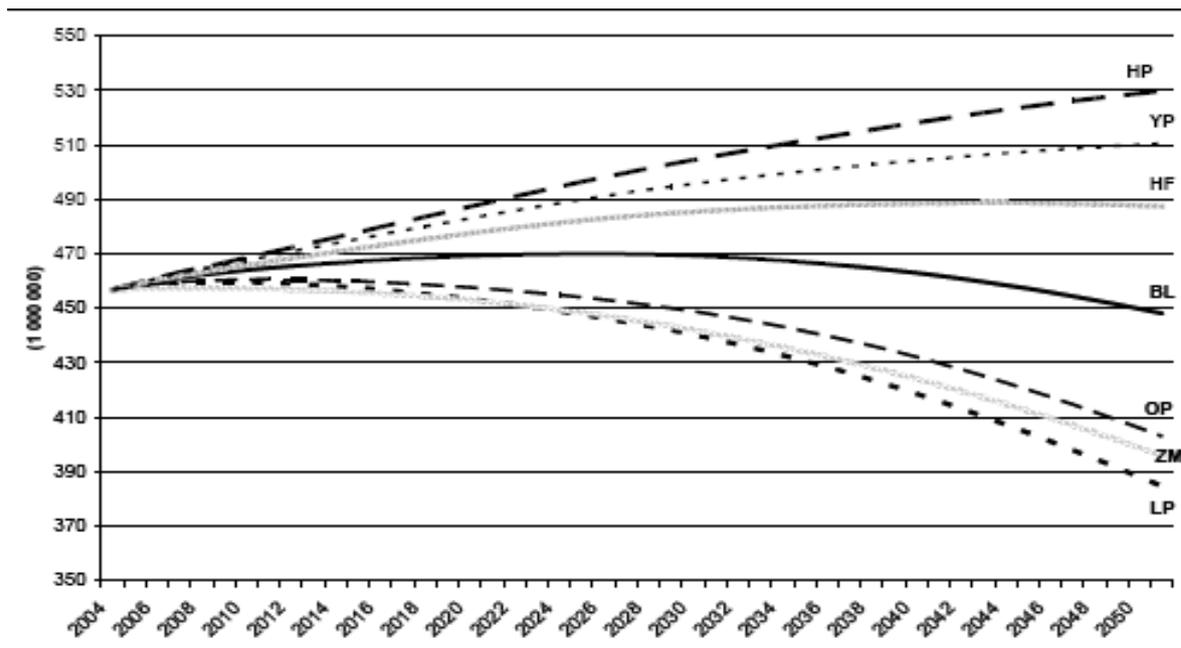
Population growth is projected to fall further in the future: both *Low and Medium Variant* scenarios show a decline across EU-27 over the next 45 years, in particular in most NMS for which all scenarios show a decline. Across EU-15 population is also expected to slowly decrease in the *Low Variant* scenario and to remain stable in the *Medium Variant* scenario. Total population in the *High Variant* scenario is also foreseen to remain stable as in the EU-15 it shows an annual growth rate of 0.4% against the annual reduction foreseen in NMS (-0.1%) until 2050. It is worth noting that the NMS account for 17% of the EU-27 population by 2050 compared to 21% in 2005.

According to the most recent EU-27 Energy Baseline Scenario up to 2030, which includes a demographic outlook, EU-27 population is projected to remain rather stable, peaking in 2020 at 496.4 million. However, the population in new Member States (EU-12) is projected to decline by 7.5 million people or 7.2% between 2005 and 2030: the EU-12 will account by 2030 for 19.4% of the EU-27 population, down from 21.2% in 2005.

The EUROSTAT projections at 2050 (EU-25) confirm the population decline. The scenarios include several demographic trends and comprises seven variants: 'baseline' (BL), 'high population' (HP), 'low population' (LP), 'younger age profile population' (YP), 'older age profile population' (OP), 'high fertility' (HF) and 'zero migration' (ZM). The assumptions underlying each scenarios are summarised in the following table:

		Total Fertility Rate	Life Expectancy	Net Migration
Baseline	BL	Base	Base	Base
High Population	HP	High	High	High
Low Population	LP	Low	Low	Low
Younger Age Profile Population	YP	High	Low	High
Older Age Profile Population	OP	Low	High	Low
High Fertility	HF	High	Base	Base
Zero Migration	ZM	Base	Base	Zero

Figure 27: Population projection EU 25 to 2050



Source: Eurostat Population Projections 2004-based. Statistics in focus, 3/2006

According to the different scenarios the EU-25 population will vary between levels of about 390 m and 530 m inhabitants. However, significant differences will affect specific countries. Taking the ‘baseline’ variant as a reference, 12 of the 27 Member States are expected to have population growth at the end of the projections period. Of those, France, Ireland, Cyprus, Luxembourg and Sweden will also have positive natural change, which for the first two is even higher than assumed net migration. Eastern and Baltic countries, as well as Romania and Bulgaria, are expected instead to show a considerable decrease in their populations.

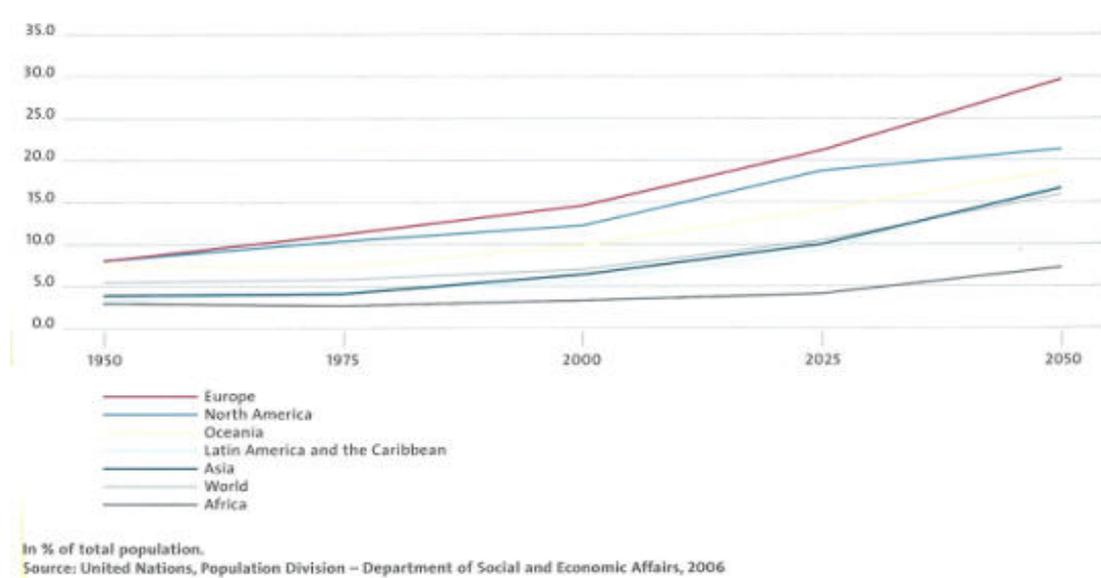
The updated EUROSTAT projections have been recently released in March 2008, the EUROSTAT 2008 scenario, assuming convergence of fertility rates in all European countries

in 2150 to 1.85. The fertility rates in the 2008 forecast are slightly higher than in EUROSTAT 2004 Trend Baseline forecast.

2.1.3.2 Population ageing

The primary consequence of fertility decline, especially if combined with increases in life expectancy, is **population ageing**, whereby the share of older persons in a population grows relative to that of younger persons. Indeed, global life expectancy at birth, which is estimated to have risen from 47 years in 1950-1955 to 65 years in 2000-2005, is expected to keep on rising to 75 years in 2045-2050. In the more developed regions, the projected increase is from 76 years today to 82 years by mid-century. Among the least developed countries, where life expectancy today is 51 years, it is expected to be 67 years in 2045-2050. As a consequence, globally the number of persons aged 60 years or over is expected almost to triple, increasing from 672 million in 2005 to nearly 1.9 billion by 2050. An even more marked increase is expected in the number of the oldest-old (persons aged 80 years or over): from 86 million in 2005 to 394 million in 2050. In developed countries, 20 per cent of today's population is aged 60 years or over and by 2050 that proportion is projected to be 32 per cent. The elderly population in developed countries has already surpassed the number of children (persons aged 0-14) and by 2050 there will be 2 elderly persons for every child. In the developing world, the proportion of population aged 60 or over is expected to rise from 8 per cent in 2005 to close to 20 per cent by 2050. The figure below shows a growing proportion of older people in all the regions of the globe, with a more accentuated increase in Europe:

Figure 28: Percentage of total population aged 65+ in selected regions of the globe (forecast to 2050)



Aggregate figures showing the population ageing in the EU-15, New Member States and EU-25 as a whole, according to the low fertility, medium fertility and high fertility variants, are presented in the following table:

Table 5: Percentage distribution of the population in selected age groups by group of countries (EU15, new Member States, EU25) for different scenarios - 2005 and 2050

		2005			2050		
		0-14	15-64	65+	0-14	15-64	65+
EU-15	Low Variant	0.16	0.67	0.17	0.11	0.56	0.33
	Medium Variant	0.16	0.67	0.17	0.15	0.56	0.29
	High Variant	0.16	0.67	0.17	0.19	0.56	0.25
NMS	Low Variant	0.16	0.70	0.14	0.08	0.56	0.35
	Medium Variant	0.16	0.70	0.14	0.13	0.57	0.30
	High Variant	0.16	0.70	0.14	0.19	0.56	0.25
EU-25	Low Variant	0.16	0.67	0.17	0.10	0.56	0.33
	Medium Variant	0.16	0.67	0.17	0.15	0.56	0.29
	High Variant	0.16	0.67	0.17	0.19	0.56	0.25

Source: World Population Prospect. 2004 Revision

In 2050, Europe will represent the world's major area with the highest share of older persons (more than 65 years old) in its population. By 2050 the elderly people will increase in all the assumed scenarios: in particular, in the *Medium Variant* scenario the percentage of older people on the total EU-25 population will pass from 17% in 2005 to 29% in 2050, whereas in the *Low Variant* scenario it will reach the higher level (+33%).

The ageing trend will be reinforced by the expected improvements in health services and technologies. Gene therapy will help eradicate inherited diseases, enormous advances in science and medicine will bring vigorous health at 80 and 90 years of age. Old people will travel more. Retirement age is expected to be postponed – perhaps of another 5 or 10 years - thus working force will increase with highly experienced contingents. More flexible and personalized working activities will be predominant. More and more people are moving into so-called “*encore careers*” instead of retiring, a new stage of work after the end of their midlife careers. New efforts are needed particularly to tap the idealism and experience of the baby boomer generation – the largest and healthiest generation to enter retirement in history. Senior associations may connect people over 55 years with organizations looking for skilled volunteers. With rising wages and a chance to benefit the community, nursing will become increasingly attractive as a second career option. Senior workers are more likely to understand the needs of elderly customers, which makes them attractive for positions in anything from personal training to guiding tours.

2.1.3.3 Migration

In this situation, **immigration flows** from outside Europe will continue to grow, as they will contribute to fill employment gaps especially in the low-skilled jobs. Such immigration may create social tensions, but at the same time will contribute to lessen the problems that an older European workforce would create for the viability of the pension systems.

Concerning the migration flows, during the period 2005-2050, the net number of international migrants to more developed regions is projected to be 98 million or an average of 2.2 million annually. The same number will leave the less developed regions. For the developed world, such a level of net migration will largely offset the expected excess of deaths over births during 2005-2050, which amounts to a loss of 73 million people. For the developing world, the 98 million emigrants represent scarcely less than 4 per cent of expected population growth. In terms of annual averages for the period 2005-2050, the major net receivers of international migrants are projected to be the United States (1.1 million annually), Germany (202.000), Canada (200.000), the United Kingdom (130.000), Italy (120.000) and Australia (100.000). The major countries of net emigration are projected to be China (-327.000 annually), Mexico (-293.000), India (-241.000), the Philippines (-180.000), Indonesia (-164.000), Pakistan (-154.000) and the Ukraine (-100.000).

The aggregate yearly average of net migration over the period 2005-2050 for the EU-15, New Member States and the EU-25 as a whole is presented in the table below:

Table 6: Yearly average Net Migration 2005-2050 (000 persons)

	EU-15	NMS	EU-25
Scenario	808	45	853

Source: World Population Prospects, 2004 Revision

Over the next decades, Europe is expected to be one of the primary recipients of international migration patterns, with a net migration projected to be more than 800 thousands of persons per year. EU-15 represents the major receiving area; in particular Germany, Italy and United Kingdom are foreseen to absorb the greater share of migrations by 2050. On the contrary several NMS such as Estonia, Lithuania, Latvia and Poland, are expected to have a negative average net migration.

More in general, we may wonder just how significant is international migration in the light of other globalisation developments. One obvious starting point for answering this question is to ask how many of the current world population of 6.7 billion people are international migrants, defined as persons living outside their country of birth. The last UN estimates put this at close to 185 million in 2005, or 2.9% of the global population. This can be compared with an equivalent share of 2.2% in 1970. At first sight, these seem rather small numbers, suggesting that international migration is only a small player in the globalisation saga. But there is an issue of comparing apples and oranges when one compares the immigrant population stock data with data on, say, trade and GDP which measure imports, exports, annual output and Foreign Direct Investment flows (see the section on globalisation trends below). If we were to put the immigrant data on a similar footing, say by relating inflows of working-age immigrants to new additions to the working-age population, the resulting measure would average 30-40% for the OECD area, not so far from the trade-to-GDP ratio of 45% for OECD countries. In sum, while migrants account for only a tiny fraction of the global population, international migration appears to be an important contributor to the working-age population in OECD countries in general, and in EU countries as well.

2.1.3.4 Households size

A key demographic factor driving energy and transport demand in households is the household size, i.e. the number of persons per household. Following UN projections²¹ and information from Member States, the average household size in the EU-27 is expected to decline from 2.4 persons in 2005 to 2.1 persons in 2030. Rising life expectancy, combined with declining birth rates and changes in societal and economic conditions, explain the reduction of average household size both in the EU-15 and in EU-12. This trend implies a significant increase in the number of households, adding 28.9 million households between 2005 and 2030 in the EU-27, despite stability of total population.

2.1.3.5 Urbanisation

The 20th century witnessed the rapid urbanisation of the world's population. The global proportion of urban population increased from a mere 13 per cent in 1900 to 29 per cent in 1950 and, according to the 2005 Revision of World Urbanisation Prospects, reached 49 per cent in 2005. Since the world is projected to continue to urbanise, 60 per cent of the global population is expected to live in cities by 2030. This overall trend, however, obscures striking differences in urban population change between the more developed regions and the less developed regions. Whereas a majority of the inhabitants of the less developed regions still live in rural areas, in the more developed regions the population is already highly urbanised.

In 2005, 74 per cent of the population of the more developed regions was urban, compared to 43 per cent in the less developed regions. Because urbanisation tends to rise as the level of development increases and socio-economic development is expected to continue in all countries, the levels of urbanisation are generally projected to rise in the future. Thus, by 2030 the less developed regions are expected to have 56 per cent of their population living in urban areas, nearly triple the proportion they had in 1950 (18 per cent). In more developed regions the proportion urban is projected to reach 81 per cent by 2030.

In Europe the proportion of the population residing in urban areas is expected to rise from 72 per cent in 2005 to 78 per cent in 2030. The aggregate percentage of population residing in urban areas of EU-15, New Member States and EU-25 as a whole is presented in the following table:

Table 7: Percentage of population residing in urban areas – 2005-2030

	2005	2010	2015	2020	2025	2030
EU-15	73,8%	74,8%	76,0%	77,3%	78,7%	80,2%
NMS	63,0%	63,6%	64,4%	65,5%	66,8%	68,1%
EU-25	72,1%	73,0%	74,1%	75,4%	76,9%	78,4%

Source: World Urbanization Prospect, the 2005 Revision

On average, the urban population is projected to increase by 0.3 percentage points each year until 2030.

²¹ United Nations: Global Urban Observatory and Statistics Unit of UN-HABITAT (UN Centre for Human Settlements): Human Settlement Statistical Database version 4 (available at <http://ww2.unhabitat.org/programmes/quo/statistics.asp>)

Urban populations have a less direct perception of “nature” than rural residents, and higher consumption levels. Urbanisation affects ecosystems due to the high “ecological footprint” of the production and consumption processes concentrated in the cities. However, urban population may have a greater environmental awareness as well, due to greater access to education and information. There are tendencies towards the revitalisation of urban centres as attractive places where to live, and land use in urban compact settings is generally thought to be more efficient, given economies of scale. In addition, urban lifestyles have been associated with a decrease in fertility rates and, therefore, contribute to slowdown of world population growth. Finally, urban centres are the home of “nodal” interactions that contribute to rapid developments in knowledge, science and technology. Indeed, urban contexts are richer in cognitive dimensions than rural contexts, if only because urban contexts contain more people and a greater range of ideas all within a dense setting.²²

2.1.3 Technological change

The breaks, regime changes, and/or points of inflection in accelerated knowledge, science, and technology are much less well defined than, for instance, demographic changes. Gradual increases that set the stage can be found from the origins of the modern scientific method in the 16th or 17th century (e.g. Galileo). As the 19th century progressed, industrial R&D developed in Europe and North America from 1850-1880. After World War II, “big science” increased greatly. Between 1945 and 1960, science and technology was mostly contained within national borders. As of 1960, better international scientific cooperation and communication evolved rapidly. Changes in technologies may contribute to decelerate the exploitation of the environment, e.g. by means of improved water treatment, air pollution controls, and the de-materialisation and de-carbonisation of some economies. There are many examples of such technology-driven deceleration: motor cars have become fuel efficient and the amount of emission per kilometre driven has dropped significantly. In term of production of energy itself, some forms of renewable energy, such as wind power, are now reliable producers of electricity and have been integrated into national power grids in many areas of the world. Improved management techniques can also power the trend towards deceleration of the excessive nature exploitation. For instance, management of traffic in urban areas is being streamlined by using network approaches to the flow of vehicles, leading to further gains in fuel efficiency.

2.1.4.1 Information and Communication Technologies

The great technological shifts in communications and transport in the 1800s (steamships, railroads, telegraphs) helped knit the world together more tightly, but some aspects of life remained untouched. The great distinction of the communication and transport technologies that shaped the 20th century (telephone, radio, television, movies, automobile, airplane, Internet) was that they altered the everyday lives of billion of people, enlarging their range of experience and their access to information. These new technologies democratized the

²² Although the diffusion of Internet may reduce this difference, especially in relation to fast accessibility to information sources and services from remote locations as the wireless connectivity will continue to develop and spread in the rural contexts, urban agglomerations will continue to be a more stimulating environment because they facilitate face-to-face meetings, large gathering and cultural events, etc.

transmission of information in prosperous countries, and until 1950 helped narrow gaps between rich and poor within them. But at the same time, because they conferred wealth and power upon those who used them, they helped widen the gap between the prosperous and the poor around the world. In 2000, about 60% of the US population regularly used the Internet and about 35% in South Korea. But in Brazil only 6% did and in Nigeria less than 0.1%.

All of these new technologies worked as networks, which mean they were slow to catch on but once over a threshold they spread very rapidly. So these technologies, once established, transformed daily life very quickly. The cumulative effect of all these changes (and some others such as mass circulation newspapers) was to bombard people with new information, impressions, and ideas, and to allow more of them to travel further, faster, and more frequently than ever before. This proved disconcerting and disorienting, as well as seductive. It invited people to suppose that their circumstances need not be as they were, but could be improved – through emigration, revolution, education, hard work, crime, or some other initiative. With radio, movies, and television in particular, hungry illiterates could catch a glimpse (accurate or not) of how more fortunate people lived.

Indeed, digital communication was initially expected to reduce travel and paper use and to facilitate the diffusion and linking of scientific ideas, environmental activism, and technologies; however, business travel and paper production have increased as never before. Similarly, an increasing global media has been blamed for the spread of environmental damaging consumption preferences and the loss of indigenous traditional knowledge of environmental stewardship. Finally, the movement of people around the globe – as migrants and tourists – has increased pollution from transportation.

The economic development wave since 90s - due to the emergence of personal computers, software and telecommunication – is continuing to produce the convergence of increasingly capable wireless technology with expanding network infrastructure and miniaturized electronics. As a consequence, the proliferating digital information had radically refashioned the relationships of individuals to their constructed environments and to one another. The effects will continue to strongly influence the businesses of the involved players. Cheaper transmission of information via many more communication outlets as a result of convergence will mean that ICTs will transform governments, industries and society, by giving just-in-time interactive access to information and user-friendly knowledge-base services. Productivity and well-being produced by ICT convergence is expected to increase; on the other hand new risks will emerge, in the area of intimacy, for instance. ICT produces simultaneously processes of concentration (in time and space) and dispersion (more individualization).

1.2.4.2 Nanosciences and nanotechnology

The end of the 20th century witnessed a major scientific and technological development, the consequences of which are only now beginning to become apparent. Three factors – a better understanding of the properties of matter at the atomic level, progress based on the molecular approach to the way living organisms operate, and the rise of information processing – have led to the increasing unification of condensed state sciences (physics, chemistry, biology) on the nanometer scale, forming what we now know as the **nanosciences**. Rather than the emergence of a fundamentally new discipline, the nanosciences can be considered the result of the convergence of various disciplines on the molecular level, or even as a new way of

looking at old questions. At the same time, propelled by new and ever increasing number of applications, the world of technology is undergoing a similar evolution. During the 1990s there was increasing awareness of the potential of hybrid applications bringing together microelectronics, biology, and information technology, particularly in the form of communicating objects, biochips, and miniature mechanical systems. Nowadays **nanotechnology** encompasses the study and manipulation of materials at the nanometre scale.²³ The fact that at this scale materials exhibit different properties to larger bulk materials is being exploited by researchers to develop new products with new functionalities. There is a wide ranging speculation on the potential uses of nanotechnology in areas from cosmetics though to solar cells.

The coming-together of different disciplines on the molecular level is sometimes referred to as NBIC convergence (for nanoscience, biology, information technology and cognitive sciences). This evolution – sometimes considered a truly new technological revolution that will show its full effects in the 21st century – can be seen already to herald major innovations, the implications of which could in certain cases profoundly affect our way of life. All fields are concerned, and huge investments (billions of euros) have been approved in the US, Europe and Japan. In the short term, these have been directed to sectors such as information technologies, medicine, sustainable development, and the energy sector, for all of which there are significant research programmes and already products on the market.

Taking a long term perspective, scientific and technical progress is traditionally considered a factor that improves our quality of life, in particular when it leads to the development of new products and services that meet society's expectations. In more general way, we tend to see scientific and technical progress as one of the major factors influencing the development and competitiveness of modern economies. In this context, mastery of nanotechnology is considered by the leading industrialised countries as vital to their economic and technological competitiveness in the 21st century. The size of the potential nanotechnology market (Rocco & Bainbridge, 2001) is measured in thousands of billions of euros per year. Nanotechnology is indeed what is know as a “generic” or “pervasive” technology, able to pave the way for a new industrial revolution equal to those ushered in by the introduction of the steam engine, electrification and computer technology. Nanotechnology is expected to have an even greater impact on the development of society than did the introduction of semiconductor chips, as it will find important use in many other areas of application besides electronics and IT. Examples of future applications of nanotechnology include: drugs without side effects dosed from nanostructures; new biocompatible material for implants; optical nanostructures for ultra-high-speed communication; biological production of materials; and new catalysts for environmental and energy technology.

It is evident that nanotechnology is not a single technology but a suite of different products and functionalities which are working on objects in the nanometre scale. Most nanotechnologies will need to be incorporated into a larger system or product or may require end user behavioural changes in order to be implemented. The barriers to adoption of these technologies may be system changes rather than specific technology changes, therefore the barriers are likely to include system and social issues besides the more specific technology development issues. Currently there are important fears concerning possible adverse impacts

²³ One nanometre is one billionth of a metre and is the width of approximately ten atoms.

of the diffusion of nanotechnologies, which are worth of consideration. A list of such fears is include:

- **Toxicity of nanomaterials and nanoparticles:** there are well publicised concerns surrounding the toxilogical impacts of nanomaterials on human and environmental health. The risk most often mentioned is the commercialization of nanomaterials or harmful components that could crumble during their use or finally degrade in the environment. Certain crumbs, nanometric in size, could build up in the environment without degrading, disturbing ecosystems or even having toxic effects on humans. Claims are often made about either the indestructibility of certain types or, on the contrary, their extreme reactivity, their capacity to absorb and transport dangerous molecules, and their extreme mobility. The key question is: how can a product be labelled as potentially dangerous on account of the nanoparticles that it might throw off in the environment during its life-cycle ? To answer it there is a growing need of research to better understand the physical and chemical properties of the material, how emitted nanoparticles will evolve in the atmosphere, and the behaviour of these particles in the organism (it is even likely that this kind of research will cast a new light on the issue of urban pollution)
- **Identification devices and privacy concerns:** nanotechnology potentially plays an important role in enabling the development of new sensors, miniaturization and the possible design of systems with low energy consumption and an autonomous information processing power. A particularly important example is the development of RFIDs (Radio Frequency Identification Devices) that contain a transmitter and a logical circuits. When queried, they can transmit information, often an “electronic product code” with enough bits to identify every individual object manufactured in the world. Their size, which has tended to be measured in millimetres, has been reduced in the sub-millimeter scale in the most recent examples. These devices were perfected during the 1970s and have gradually been implemented in a series of contexts such as access systems (badges, toll-booths) and short-range identification (goods in stock, anti-theft, identification of animals). The unit prices of the devices is still in the 10 cents to a few Euros range, but prices are expected to fall in the next few years, making RFIDs hardly more expensive than a label. They would seem to have limitless potential for use as they provide considerable advantages: stock monitoring systems in companies; objects capable of informing their environment of their presence; authentication systems (access badges, means of payment, etc.). Moreover, a technique exists for implanting RFIDs or “smart dust” in the human body. This is already routinely done to identify pets, and could easily be extended to humans, e.g. for marking individuals for surveillance purposes, or as implanted chips which cannot be lost or easily stolen like badges (these could be used as a means of access to secure premises). However, there are privacy concerns and sometime a strong opposition against the potentially uncontrolled diffusion of such devices (RFIDs can easily be hidden and, as long as they are active, provide information on the persons carrying them).

Besides the specific fears mentioned above, it is important to note that the new nanosciences technological revolution has the potential to drastically affect the relationship between humanity and Nature, for good or bad. The long-term goal of nanosciences is the understanding of how Nature works at the molecular level, and the mastering of this new knowledge will pose serious ethical problems as the following:

- Nanoscience could lead to the manipulation of life. Traditional biotechnology is already capable of this, but the new factor would be a vast increase of human manipulation of living matter in an unprecedented way, that may go as far as the creation of hybrids and “unnatural” beings.
- Another question is the limit of humankind. The questions already arises with issues such as stem cells or human cloning that are both related to the control of DNA configuration in a cell. More generally the body could eventually be considered as a complex machine that can be fixed in case of failure and modified or even enhanced. Similarly the impact of understanding and modifying the brain will raise new issues such as the meaning of responsibility and feelings when they are understood in terms of circuitry and “wetware”.
- Progress in nanotechnologies and their convergence with other techniques may offer various occasions of abuse. This may concern privacy, and the spread of biometric techniques and DNA tests. For instance, last century’s eugenics may return through new biotechnologies, perhaps in another form that replaces the concept of race with predisposition to a given disease.

Notwithstanding the increasing controversies and fears in the scientific community itself and the larger public, as a matter of fact nanosciences and nanotechnologies are developing at an incredibly rapid pace, promising a true revolution in a wide variety of fields where the capability to manipulate matter at the atomic or (supra)molecular scale is essential. Later in section 3.1.5 we will discuss the impact that this new technological revolution is expected to produce on the transport sector, directly or indirectly.

2.1.5 Social change

2.1.5.1 Time use and lifestyle change

Our work is more than just what we do in our jobs, it is also what we do without pay, in our households, for our families, and for members of the wider community. And what we do for other people’s living is, we use our non-work time, to consume the products of their work. Each of these activities – the paid work, the unpaid work, and the consumption – is a distinct category of **time use**. So if we can measure how the members of a society spend their time, we have the elements of a certain sort of account of how that society works.

Change in time-use patterns is not a mere indicator of social change: it is itself part of the essence of socio-economic development. A “poor” society is one which must devote the bulk of its time to low-value-added activities which go to satisfy “basic” wants or needs. The work of such a society is largely concerned with the provision of food and energy supplies; its consumption is accordingly limited for the most part to eating and taking shelter from the elements. Economic development is the process in which the growing technical efficiency of provision for basic wants allows the society to shift its time progressively towards production and consumption activities relating to more sophisticated wishes. This process is indeed commonly referred to as “economic” development, but this is a misleading term. **Cultural change**, change in habits and beliefs and values, is an integral part of the process. The developing society does not just engage in new forms of production, but also in new sorts of consumption. Its members can do new things with their time, different sorts of leisure emerge (and also new sorts of activity – e.g. learning and life-long learning – which share some characteristics of leisure and some of work).

Failing to recognise the cultural change dimension of development can lead modern societies to fall into traps of time use. Opportunities to consume can be severely limited by lack of time. Overworked labourers may receive an adequate wage, but they often work long hours and are denied the opportunity of regular leave. Women frequently face a triple constraint that severely affects their consumption choices. Not only is much of their work unpaid, but their domestic obligations on top of their responsibilities for bearing and raising children leave them with little time to do much else. And families in the industrial world find that their over-busy lifestyles prevent them from enjoying leisure time activities, despite their high incomes. Even though the choice to work long hours is often voluntary, many workers also face the pressure to do so. And they may be motivated by a perception of need for money that can only be met by working so many hours that they end up with little time and opportunity to use the money they earn. On the contrary, acknowledging the needed cultural dimension of development, we can share and promote a virtuous relation between time use and progress (Gershuny, 1999). Jobs are created by leisure. Some jobs involve the production of goods which enable the reduction of time spent in undesired menial work activities. Other jobs produce the leisure services used in the extra spare time thus liberated. More people have more of their basic wishes satisfied using less of the society's time, which in turn means that more time can be spent satisfying more of people's more sophisticated wishes. Both the increasing efficiency of provision of basic wishes, and the growth in demand for the satisfaction of sophisticated wishes, mean a requirement for more skilled labour. So there are more high-value-added jobs and fewer low value jobs. This is clearly a line of economic growth that improves human living conditions.

But the above line of progress is by no means necessary or predetermined, public policy here matters. A first important area of public policy is the framework of regulations and arrangements determining when and for how long a worker is expected to work, the so called "work-time regime". Crucial in determining the consumption effect of extra-free time is the nature of this work-time regime, affecting as it does both the individual's availability for consumption and the availability of services to be consumed. These are some key questions to be answered to forecast the consumption effects of extra leisure time:

- When are service facilities open, and where? (e.g. half an hour of extra free time per day between 5.30 p.m. and 6.00 p.m. provides no more service consumption if all the service facilities close at 5.30 p.m., or if they are open but located at a distance of more than 14 minutes travel-time)
- Who is available to join in prospective activities ? (if you take your leisure with your partner and your partner's employer insist on a work regime which conflicts with your own, shorter work hours will not mean extra leisure consumption)
- Must the extra free time be taken each day, or might it be taken in larger lumps on a weekly, monthly, or yearly basis ? Must it be taken every year ? (e.g. 12 extra minutes per day might mean more TV; an hour per week might mean an extra restaurant meal; five days per year might mean an extra week of holiday; parental leave associated with the presence of small children in the household, built up over time or borrowed against future work, might allow a partner to stay in employment who might otherwise have left it.)

The more constraint that is placed on the temporal location of free-time – on the detail of its placing in the day and the month and the lifespan – the less is the potential for stimulating consumption. **Time regulation** is therefore a major area of public policy to be better

exploited: it concerns not just work hours, but also such matters as, on the employment side, statutory family-related leave allowances and employment protection, vacation requirements, retraining and retirement provisions; on the consumption side it concerns the regulation of opening hours and closed periods. Scheduling constraints may keep people (women in particular) out of the workforce, and potential consumers away from services. So public regulation promoting flexi-time, and the right of employees to vary their weekly work hours, can have positive effects on both labour supply and consumption levels. There other more general lines of public policy which also contribute to influence time-use and consumption levels. The most important of these is education policy. Education is what initially equips workers to work; the value of the services that are produced is to some extent a function of the education provided for those that produce them. So much is obvious. But is less obvious the parallel importance of **education for consumption**. As the range of services provided by a society grows, so its members must develop new consumption skills, including those related to the sustainability of their consumption choices.

Another policy area of great potential impact is **infrastructure provision**. There are arguments for public provision (or direct or indirect subsidy for private provision) of cultural facilities which parallel those for public provision and subsidy of transport facilities. One strong argument is the complementarity with the time-use policy: if there is to be a public policy promoting the use of time for leisure consumption, there might equally be public encouragement for the provision of space and facilities for this. And transport policy itself forms a substantial part of these arguments. Since much of leisure service consumption takes place outside the private homes, and private motor transport is inappropriate for many leisure consumers (e.g. children and the elderly), dangerous for tired people, and environmentally questionable, so this line of policy argument may involve promotion of public transport systems, to respond to an increasingly flexible 24 hours/7 day travel demand (e.g. to serve city centres at evening and night hours).

2.1.5.2 Tourism

Besides the need of more flexible transport options to serve the everyday travel demand of an increasing share of leisure consumers in our cities, the most evident consequence of the growing leisure society and availability of free-time is the fast growth of **tourism**.

Leisure is estimated to account for 75 per cent of all international travel. The World Tourism Organisation (WTO) estimated there were nearly 900 million international tourist arrivals in 2007 from 846 million in 2006, an increase of about 6 per cent. This represent nearly 52 million more arrivals than in 2006 and they are expected to reach 1.6 billion by 2020. To appreciate these figures we may consider that international tourist arrivals in 1950 were only 25 million. Domestic tourism (people going on holiday in their own countries) is generally thought to be 4-5 times greater than international arrivals.

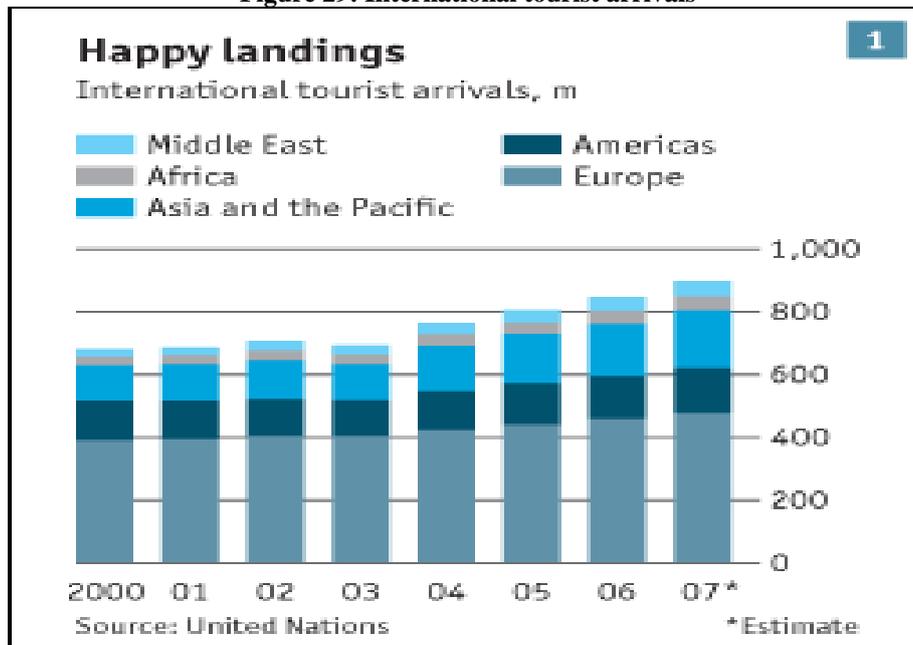
Globally, tourism accounts for roughly 35 per cent of exports of services and over 8 per cent of exports of goods (WTO). Tourism is said to be the world's largest employer. In 2001, the International Labour Organisation (ILO) estimated that globally over 207 million jobs were directly or indirectly employed in tourism. The latest long term forecasts by the industry's World Travel and Tourism Council (WTTC) point to a steady phase of growth for world travel and tourism between 2009 and 2018 with an average growth rate of 4.4 per cent per annum, supporting 297 million jobs and 10.5 per cent of global GDP by 2018.

Factors in tourism growth include:

- **Increasing leisure time:** In 1936, the International Labour Organisation convention provided for one week's leave per year for workers in developed countries. In 1970, this was expanded to three weeks, and in 1999 to four weeks.
- **Increased disposable income:** the strong economic growth of Asian economies such as China, India and Singapore has resulted in greater disposable income resulting in increased demand for foreign travel.

Some stylized facts illustrate the boosting growth of global tourism in the recent decades. In 1950, 97 per cent of international tourists went to Europe or North America (in fact, to just 15 countries). By 2003 this had fallen to 78.8 per cent. In the mid-1970s, 8 per cent of all international tourists were from the North visiting the South. By the mid-1990s, this had risen to 20 per cent. In 1999, more than 70 countries received over a million international tourist arrivals. As it is shown by the figure below, Europe maintains and consolidates the leading position in terms of absolute numbers of international tourist arrivals.

Figure 29: International tourist arrivals



In recent years, domestic and intra-regional tourism has grown rapidly in emerging economies such as China, Thailand, India, Korea and Mexico. Tourists originating in Asia and the Pacific increased from 114.8 million in 2000 to an estimated 166.5 million in 2006, a total of 19.3 per cent of the world total and with an average growth of 6.4 per cent between 2000 and 2006. In 2007 the number of visits abroad by the Chinese reached 47 million, 5 million more than the number of foreign visitors to China. The Chinese also made 1.6 billion trips at home – a staggering total, but not much more than one each. According to WTTC forecasts, Chinese demand for travel and tourism will quadruple in value in the next ten years. At

present China ranks a distant second, behind United States, in terms of demand, but by 2018 it will have closed much of the gap.²⁴

This rise of emerging economies marks the third revolution the travel industry has undergone in the past 50 years. The first came in the 1960s, in the shape of cheap air travel and package tours. Rising incomes enabled people of modest means to travel more, to farther-flung parts of the globe, and to take advantage of “all-in” offers that may have included sightseeing trips, scuba diving or camel rides. The second was the advent of the Internet, which has allowed millions to book flights, hotels, hire cars and package tours without going near a high-street travel agent. Now fast-growing emerging economies - the BRICs (Brazil, Russia, India and China) and others, such as Dubai, South Korea and Vietnam - are changing the world of travel once again, either as destinations or as sources of newly affluent travellers.

However, any forecast for growth is less reliable than in other industries, partly because tourism is vulnerable to shocks such as natural disasters or terrorist attacks. Developed countries are not strangers to terrorism, but the danger in emerging economies are greater. Another possible obstacle is growing concern, especially in Western countries, with the environment. The industry, which contributes 5-6% of all carbon emissions, seems worried. Green strategies are multiplying, as for instance “Carbon Trackers” which allows travel agencies and companies to measure and analyse carbon emissions and hence to help “sustainable travel decision-making”. Hotels are keen to show that they conserve water, recycle rubbish, and save electricity by using low-energy light bulbs.

2.1.5.3 Sustainable consumption

There is around a growing perception that the consumption patterns that characterise modern Western society are unsustainable. They rely too heavily on finite resources and they generate unacceptable environmental impacts. They are also unfair. The richest nations enjoy the benefits of material affluence, while the poorest still suffer from inadequate access even to the basic necessity of life. To make matters worse, the poorest sometimes bear more than their fair share of environmental impacts from the consumption patterns of the richest. Inequities in the present are compounded by our debts to the future. In many cases, the worst impacts from activities of today will only transpire later on. The running down of finite resources may not matter much until they are gone. The pollution of pristine environments may not bother us unduly until the soil is toxic and the water unsafe. The worst of the changes of our climate may not materialize for another 50 years. But none of this diminishes our responsibility for the effect consumption today might have on well-being tomorrow.

Perhaps surprisingly, there is also evidence to suggest that consumer society may have failed even in its own terms. After a certain point, material wealth has not delivered consistent improvements in well-being, even for those who benefit from its cornucopia of modern goods and services. Having more stuff doesn't always make us happy. Material aspirations don't necessarily deliver well-being. And a society dedicated to materialist values sometimes undermines the conditions on which well-being depends.

²⁴ To speed up the development of tourism and other industries, the Chinese government is racing to build roads, railways and airports. In January 2008 it said that it planned to add 97 airports by 2020 to the 142 China had at the end of 2006.

These are some of the contentions that have given rise to the emerging discourse on “sustainable consumption”. The discourse is an increasingly relevant one for many reasons. In the first place, it requires policy to engage in areas it has traditionally been far from comfortable engaging in: the values, expectations and aspirations of ordinary people. It forces us to confront not just the hidden driving forces of human behaviour but the limitations on our goals and intentions – the place where agency stops and social structure begins. In addition, the whole discourse embodies a profoundly ethical dimension in which rights and responsibilities are deeply entwined, in which both present and future generations are implicated.

By the late 1990s, a decade of initiatives placed the language of sustainable consumption firmly on the policy agenda. But agreement on what sustainable consumption is or should be about proved more difficult to negotiate, as a number of different definitions have been adopted by different institutions (see the box below for some of them).

Defining sustainable consumption

“The use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic material and emissions of waste and pollutants over the lifecycle, so as to not jeopardize the needs of future generations.” (Ofstad, 1994)

“Sustainable consumption is not about consuming less, it is about consuming differently, consuming efficiently, and having an improved quality of life.” (UNEP, 1999)

“Sustainable consumption is an umbrella term that brings together a number of key issues, such as meeting needs, enhancing the quality of life, improving efficiency, minimizing waste, taking a lifecycle perspective and taking into account the equity dimension; integrating these component parts in the central question of how to provide the same or better services to meet the basic requirements of life and the aspiration for improvement, for both current and future generations, while continually reducing environmental damage and the risk to human health.” (UNEP, 2001)

Some controversy lies in the extent to which the different positions imply consuming more efficiently, consuming more responsibly or simply consuming less. While some definition insist that sustainable consumption implies consuming less, others assert that it means consuming differently, and in particular consuming more efficiently, and that it categorically does not mean consuming less. The dominant institutional consensus has tended to settle for a position which is closer to this latter kind of definition (consume efficiently) than it is to the former (change lifestyles). A case in point was the Plan of Implementation signed at the Johannesburg Summit in 2002: far from cementing the focus on lifestyle issues implicit in Agenda 21, the Plan appeared to retreat from the idea of lifestyle change altogether. Instead, the focus was placed firmly on improvements in technology and the supply of more eco-efficient products, services and infrastructures. Essentially, this institutional view is one in which sustainable consumption means (more) consumption of more sustainable products.

Nonetheless, this position against consuming less is also problematic for a number of reasons. In particular, the concentration on efficiency and productivity tends to obscure important questions about the scale of resource consumption patterns. In fact, it would be entirely possible, under this framing of the problem, to have a growing number of ethical and green consumers buying more and more “sustainable” products produced by increasingly “efficient”

production processes, and yet for the absolute scale of resource consumption – and the associated environmental impacts – to continue to grow. Indeed, there is little doubt that economic consumption has historically relied heavily on the consumption of material resources; that improvements in resource productivity have generally been offset by increases in scale; and that the goods and services that people actually buy continue to be inherently material in nature.

Almost inevitably, then, policy-makers have been brought back to the idea that engaging in the complex terrain of lifestyle and behavioural change is going to be essential to make progress on sustainable consumption. At the heart of this new focus is the idea that lifestyle change is not only desirable but essential if key sustainability goals are to be met. This is particularly true for far-reaching emission reduction targets such as those required for climate change mitigation. Lifestyle change is fast becoming a central issue for environmental and social policy. How can we persuade people to behave in more environmentally and socially responsible ways? How can we shift people's transport modes, appliance choices, eating habits, social drinking, leisure practices, holiday plans, lifestyle expectations (and so on) in such a way as to reduce the damaging impact on the environment and on other people? How can we encourage "sustainable living" and discourage unsustainable living? These questions lie now at the hearth of the emerging policy debate.

However, to consider realistic the idea that it is possible to live better consuming less – which is behind this policy debate – we would need to answer some searching questions about the underlying nature of consumption itself and about the driving forces behind modern lifestyle, which are from being simple. There is a social competition dimension and status-seeking behaviours behind our levels of material consumption. Moreover, there is one underlying feature of consumption which has much wider connotations than the issue of status-seeking behaviours. This is the insight that consumer goods play vital symbolic roles in our lives. Drawing inspiration from anthropology and social philosophy, this idea also has a popular resonance. From wedding dresses to sport cars (and recently the SUVs), from children's toys to the colours of our favourite team, material goods convey important signals about our lives, our social standing and our allegiances. We value goods not just for what they can do, but for what they represent to us and to others.

Consumption of material goods plays therefore key social and psychological roles in our lives: behind providing the material basis for human well-being and quality of life, ownership or use of goods and services convey a social meaning. However, the insight that a certain amount of consumer behaviour is dedicated to the pursuit of meaning opens up to the tantalizing possibility of devising some other, more successful and less ecologically damaging strategy for creating and maintaining personal and cultural meaning. This is not in any sense a simple task, nor one that can easily be pursued by any given individual or set of individuals. On the contrary, it is a fundamentally social and cultural project, which will require sophisticated policy interventions at many different levels.

At the EU level, the Renewed EU Sustainable Development Strategy (EU SDS) - issued by the European Council on 26 June 2006 - while defining the policy guiding principles and key sustainable development challenges for the whole Europe recommends, as one overall objective, "to promote sustainable consumption and production patterns". In addition, there are other overall SD objectives: climate change and clean energy; conservation and

management of natural resources; public health; social inclusion, demography and migration; global poverty and sustainable development challenges; and finally – the most interesting SD objective for our purposes – **sustainable transport**. The EU sustainable transport objective is defined as: “To ensure that our transport systems meet society’s economic, social and environmental needs whilst minimising their undesirable impacts on the economy, society and the environment”. Sustainable transport can be considered as a specific form of sustainable consumption activity as well.

2.1.5.4 Security

Modern society is heavily dependent on transport and energy networks. When transport networks shut down, employees cannot go to work and goods cannot reach their destination. When energy networks shut down, economic activity stops. In both cases, all sorts of essential services become unavailable. This has an immediate and severe impact on society at large. Transport and energy networks may shut down for a variety of reasons: extreme weather conditions or major accidents are but two examples. The interdependence of networks can also result in shutdown, as when electrical power fails and all public transport services come to a halt.

Recently, the additional threat of terrorist attack against critical infrastructures has emerged. The vulnerability of passenger rail transport has been demonstrated in Madrid and London. When the safety of people and the integrity of critical infrastructures are involved, reducing the risk of terrorist attack and its consequences is paramount. Recently, the European Commission has funded COUNTERACT (www.counteractproject.eu), a research project set up to improve security against terrorist attacks aimed at public passenger transport, intermodal freight transport and energy production and transmission infrastructure. The project will review existing security policies, procedures, methodologies and technologies to identify the best practices which in turn will be promoted throughout the relevant security community in the EU.

Although terrorism is important, security is also an issue in respect of common criminal acts such as thefts or physical aggressions in public transport vehicles. These security problems contribute to making private transport more attractive due to the privacy it offers.

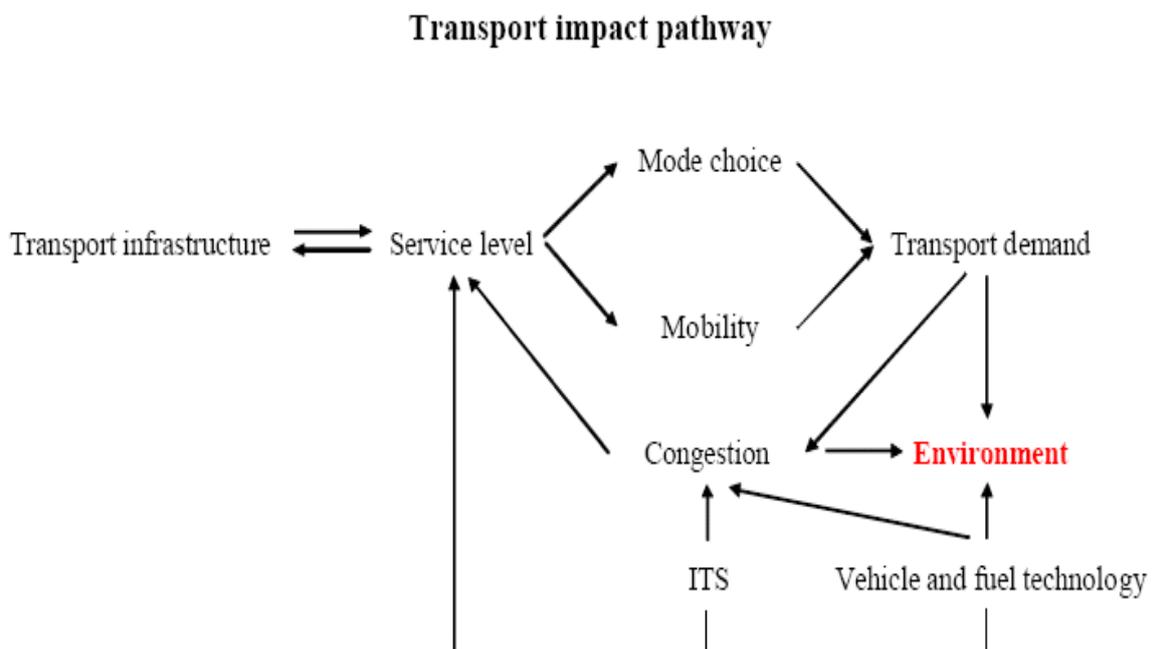
2.2 Internal and impact drivers

2.2.1 Transport infrastructure, vehicles and fuel technologies, ITS

Changes in the transport infrastructure most often influence the service level of a given or more transport modes, e.g. if a new high speed railway line is built, the speed of the train is increased, which can influence both the overall mobility and the mode choice and hence the transport demand as such. An increase in transport demand can lead to congestion, e.g. on a motorway. Both the increase in transport demand and a resulting congestion can influence the environment. The air pollution, the CO2 release and the noise level can increase as a result. The congestion itself can lead to a poorer service level, e.g. lower speed and thereby influence the mobility, the mode choice and the transport demand. A poorer service level can increase the demand for new infrastructure – starting the process once more. New vehicle and fuel technology can influence the environment directly, e.g. by changing to a more environmental friendly fuel like bio or hydrogen fuels. New vehicle technology can also together with Intelligent Transport Systems (ITS) help solving or relieving a congestion problem, e.g. by establishing variable speed limits on motorways or electronic toll collection. Satellite navigation (GPS) coupled with ITS can create better possibilities of managing transport, the utilisation of the infrastructure, interface between transport modes, the paperwork related to freight transportation and thus create a better overall service level.

The transport impact pathway relating to transport infrastructure, vehicle and fuel technology and ITS is shown in the following figure.

Figure 30: Transport Infrastructure and Technology Impact Pathway

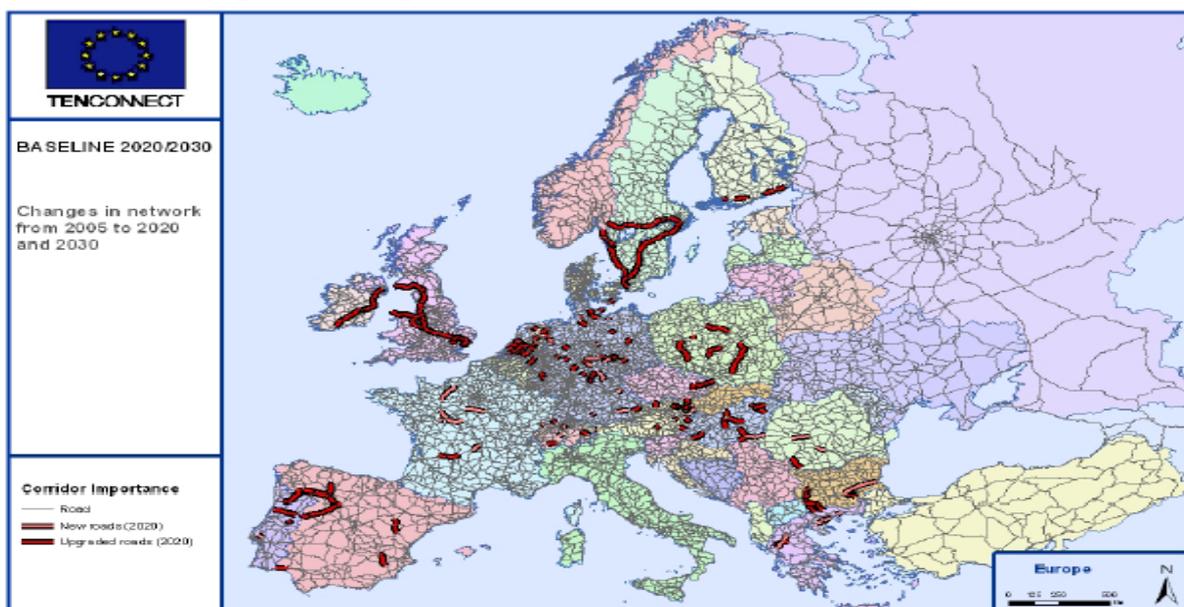


2.2.1.1 Transport infrastructure

Transport infrastructure is established for serving the demand for transport, and the investment in new transport infrastructure is a key driver of technological progress in the transport sector. Infrastructure forms homogeneous networks that multiply destination possibilities and offer routing alternatives. Infrastructure creates opportunities for mobility for people and goods. But the availability of new transport infrastructure also has the ability to serve as a driver for transport development. The construction of the Suez and Panama channels changed the main routes of sea borne trade. The development of the Öresund fixed link has created new opportunities for the citizens in Denmark and Sweden resulting in an integrated housing and employment market. The invention of the airplane and the airports network has changed the possibility for fast travel, and more recently has the introduction of the High Speed Trains in France and in other European countries changed long-distance travel. Building of motorways has made it possible to travel fast and safely from one end of a country to another and between countries.

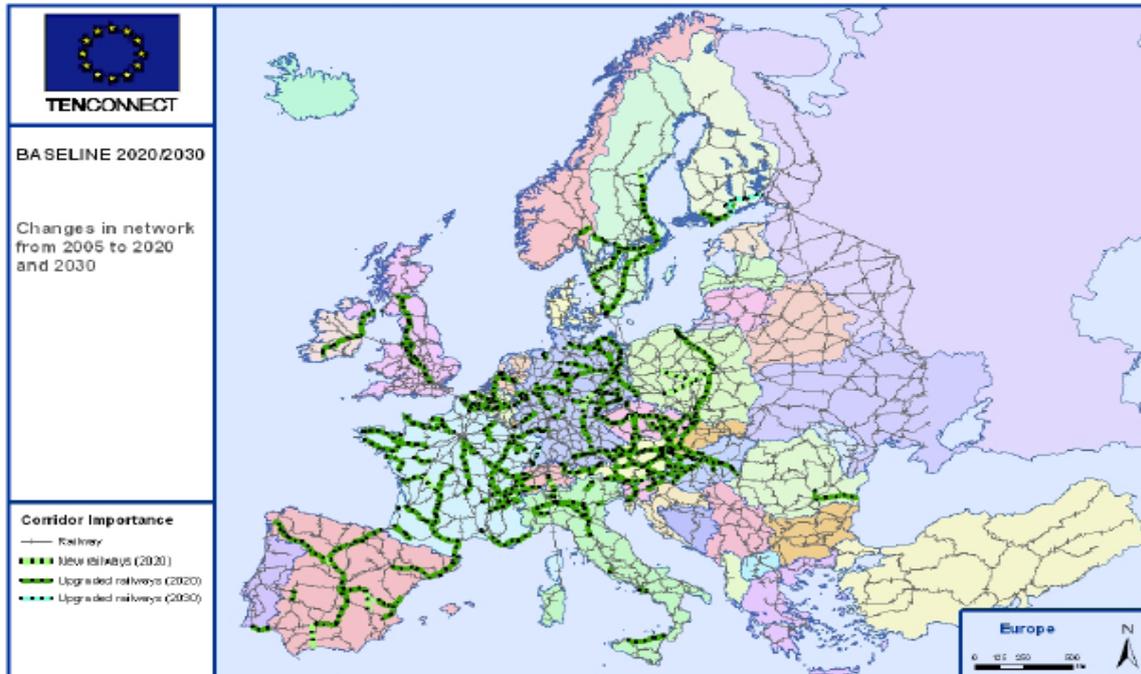
From 1990 to 2005 the length of the motorways in the 27 EU countries increased by nearly 50 %. In the same period the length of railway lines in use was almost constant, but the length of the high speed rail network grew more than four times. The length of the motorways was 61.565 km compared to 4.400 km of high speed lines in 2005. But since then more than 1.000 km high speed lines have been opened and approximately 1.200 km are under construction. 372 airports are in use of which 147 handle more than 1 million passengers and 28 more than 10 million passengers a year. More than 40.000 km of canals, rivers and lakes serve as inland waterways. (Source: EU Energy and transport in figures 2007/2008). TEN-policy deals with the infrastructure development in the EU. The infrastructure and its planned implementation is the main question for the current TENCONNECT study. The following figures show the planned changes to road network and rail network in Baseline scenario 2020/2030.

Figure 31: Changes to road network in Baseline scenario 2020/2030



Source: Traffic flow: Scenario, traffic forecast and analysis of traffic on the TEN-T, taking into consideration the external dimension of the Union, TENCONNECT, Intermediate Report 2, May 2008.

Figure 32: Changes to rail network in Baseline scenario 2020/2030



Source: *Traffic flow: Scenario, traffic forecast and analysis of traffic on the TEN-T, taking into consideration the external dimension of the Union, TENCONNECT, Intermediate Report 2, May 2008.*

When building new infrastructure you can either let the users pay for the investment themselves or you can let the taxpayers pay. Public-private partnership (PPP) describes a government service or private business venture which is funded and operated through a partnership of government and one or more private sector companies. In some types of PPP, the government uses tax revenue to provide capital for investment, with operations run jointly with the private sector or under contract. In other types capital investment is made by the private sector on the strength of a contract with government to provide agreed services. In projects that are aimed at creating public goods like in the infrastructure sector, the government may provide a capital subsidy in the form of a one-time grant, so as to make it more attractive to the private investors. In some other cases, the government may support the project by providing revenue subsidies, including tax breaks or by providing guaranteed annual revenues for a fixed period.

But infrastructure has inherited weaknesses. Infrastructure can be congested, that is a situation where vehicles compete for scarce capacity and some form of rationing is needed. Congestion implies time based rationing. Paying for capacity according to marginal cost pricing will be more efficient and will allow for the financing of extra capacity. Scheduled modes of transport do not experience the same kind of congestion as access to the infrastructure is controlled (apart from buses which are accessing the road infrastructure in competition with other road vehicles). However, overcrowding may take place inside the vehicles.

Whereas road transport can be carried out in principle over all Europe's borders, taking into account that there are certain limitations on weights and dimensions which are not uniform in all EU countries, the problems are much more complicated in the rail sector. Rail infrastructure has for historical reasons not been integrated across borders. And although the standard gauge is used in the majority of EU member states, there still exist other gauges, which hampers the easy transfer of trains across borders. But gauges are not the only problem. The European railways have for some time been urged to improve interoperability between the different networks. And there is a process ongoing trying to establish more interoperable networks. This relates to safety systems, signaling, ATC, loading gauges, driver's education, collective employment agreements, current systems, etc. The target is to be able to send a train across Europe with the same locomotive, the same driver and without unnecessary stops at borders. This would improve the competitiveness of the rail transport mode. Improving interoperability between the different networks is therefore most important, but some stakeholders have an economic interest in preserving the present differences.

Transport companies are devoting much energy in developing optimal supply solutions for satisfying the demand as efficient as possible. Hub and spoke systems are well known in logistics and freight transport but they are also applied in the air transport sector, in order to have sufficient amount of travelers to fill the major airplanes on the long legs of the travel. Hub and spoke systems have an inherited weakness related to the change of transport vehicle. Travelers need to be content with the system. Therefore transfer time should be kept at a minimum and without any effort. This is valid for both freight and passengers. A complicated transfer system in a huge intermodal node will make both people and goods search for other alternatives. Well functioning transfer systems will also maintain an efficient cost regime, which is also of major importance for making transport chains competitive. Problems meeting the demand for swift and comfortable transfer systems can make point to point transport popular again. An efficient transport system is a prerequisite for an efficient freight transport system where the infrastructure, the transport modes, warehousing and logistics all together create a system for efficient handling of goods. Central distribution from one or two warehouses in Europe has become the order of the day, because the efficiency of the transport system. And all transport modes are playing a vital part in the freight transport system.

2.2.1.2 Vehicles and fuel technology

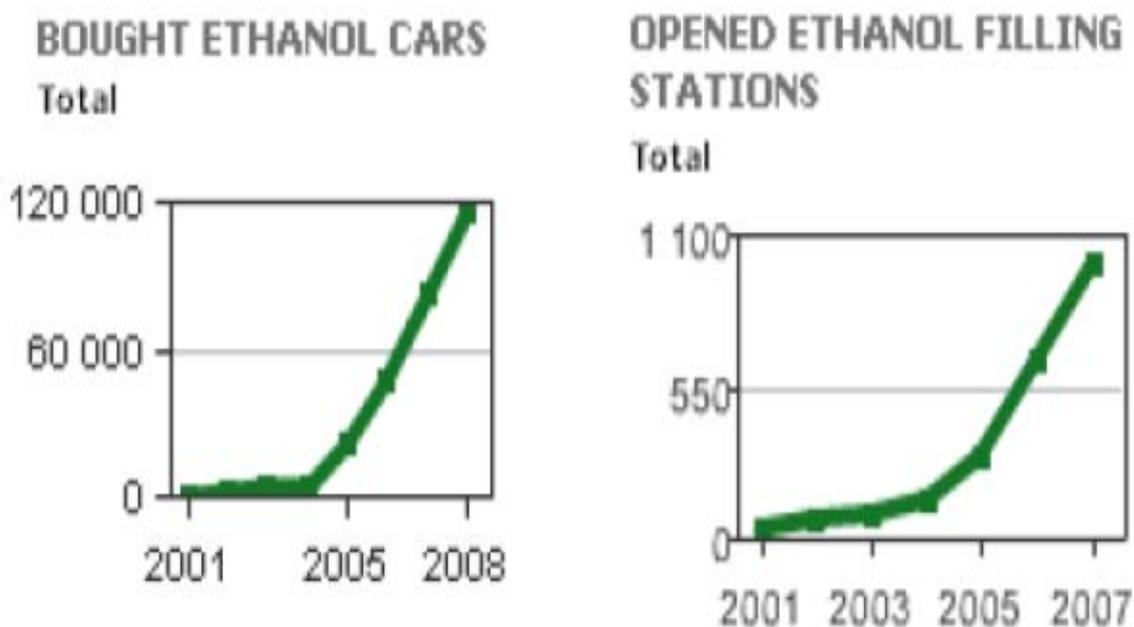
In the transport sector, technological development opens up a wide variety of options in particular for improving car technology from the power source and fuel sides. However, the effective implementation and diffusion of these technologies will require a number of conditions to be fulfilled. This is particularly relevant for the take up of radically new technologies, to overcome introductory barriers such as costs, infrastructure and public acceptance; and to avoid additional side effects elsewhere. The introduction of improved and in particular radically new technologies into the manufacturing process is very slow because of the inertia of the industry, inflexible organization and established ways of thinking. With regard to the automobile industry, it constitutes a considerable share of the overall economic activity and generates without any doubts both employment and wealth. Additionally, the system of transportation presents a very large inertia due to its production and distribution infrastructure and user acceptance.

The research and development of **new fuel options** in the transport sector includes biofuels and hydrogen technologies.

The EU has been and continues to be a leader on *biofuels*. However, based on their production costs biofuels are currently not competitive with diesel or gasoline in the EU. Even the recent increases in the crude oil price has not changed this as increased demand for vegetable oil has driven up biofuel feedstock prices at the same time. Consequently, the EU biofuels market largely depends on mandates and incentives. (Source: EU-27 Bio-Fuels Annual 2008, GAIN Report Number: E48063, May 2008). Sweden is today considered to be at the very forefront of the push toward renewable fuels. It all began in 1986, where ethanol was introduced on a trial basis as the fuel for two buses in Örnköldsvik, and by 1989 30 ethanol-operated buses were in service in Stockholm. Today there are over 600 ethanol-operated buses in service in Sweden.

In 1983 the Bio Alcohol Fuel Foundation (BAFF) was founded under the name of The Swedish Ethanol Development Foundation (SSEU) and it began lobbying other municipalities to invest in ethanol. It was a difficult start. Who was going to make the leap to set up ethanol pumps when there were no ethanol-operated cars on the roads? And conversely, who was going to buy an ethanol-operated car if there was nowhere to re-fuel it? But obviously there was a market for ethanol cars amongst the environmentally conscious Swedish population. Since then, Ford Sweden and Saab have become leaders in fuel-flexible ethanol cars, and Volvo currently markets several ethanol-operated models. The increased number of cars and ethanol pumps, although modest at the outset, has grown almost exponentially. It took 10 years to establish the first 100 E85 pumps, whereas today pumps are erected at the rate of close to 100 every two months. At present there are more than 1000 E85 pumps found throughout the country, a number which will increase to more than 2,400 by 2009. The number of fuel-flexible cars in Sweden currently approaches 120,000.

Figure 33: Forecasts on ethanol cars (Sweden)



Figures from Sweden

Source: BAFF (BioAlcohol Fuel Foundation) in Sweden

Biofuels as a share of all transport fuels is trending upwards within the EU, based on current conditions. The share in 2007 is estimated to 3,5 %. In January 2007 the EC proposed to introduce a binding 10 % target for biofuels in transport by 2020. (Source: EU-27 Bio-Fuels Annual 2008, GAIN Report Number: E48063, May 2008).

With ethanol and biodiesel coming under increasing criticism for driving up food prices and putting biodiversity at risk, the EU has committed to 'second-generation' biofuels as a clean alternative for transportation - but many challenges remain before they find their way into our cars.

Fuel cell vehicles typically use *hydrogen*—a gaseous fuel—stored in onboard fuel tanks. When you fill the tank with hydrogen fuel, it basically recharges the vehicle. Inside the fuel cell, hydrogen and oxygen combine to produce electricity. The electricity is then stored in a battery, which powers the vehicle's electric motor and other electronics. Fuel cell vehicles aren't yet commercially available because of their cost, but in the future they could provide us with a pollution-free transportation fuel option. Fuel cells vehicles are already competitive in terms of efficiency, emissions, silent driving and acceleration (OECD, 2006), but their deployment is hindered by the high cost of production, distribution and refuelling infrastructure for hydrogen. Additionally, the efficiency of fuel cells vehicles is at least twice that of standard combustion engine cars, but cars are not ready to be commercialized because of high costs related to fuel cell stack and hydrogen storage system.

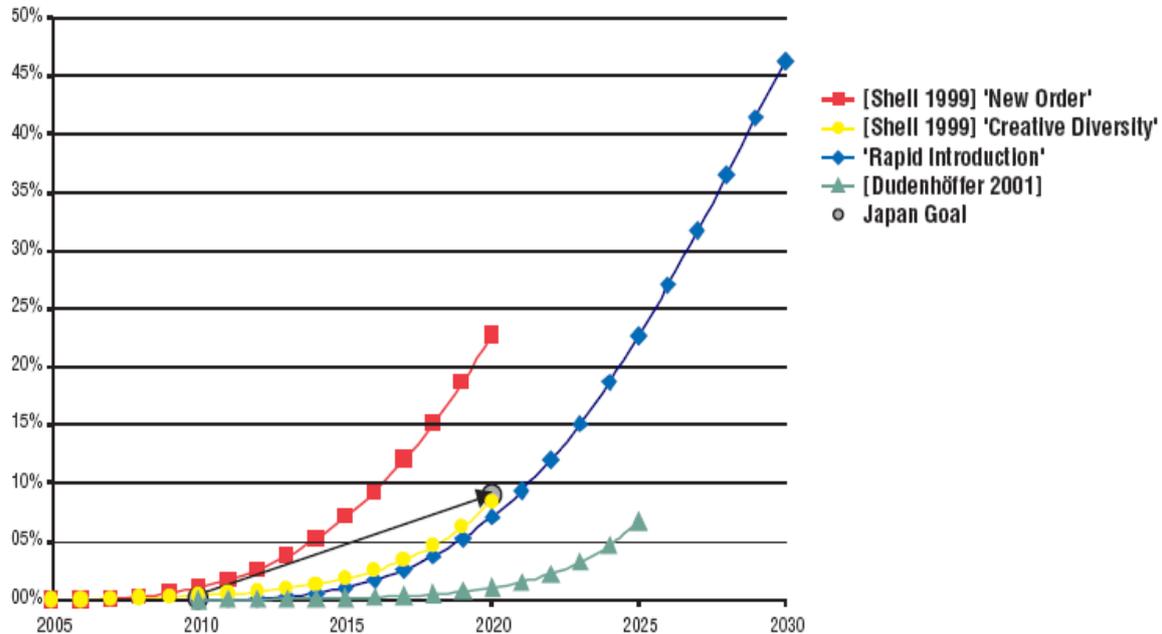
Many companies are currently researching the feasibility of building hydrogen cars and most of the automobile manufacturers have begun developing hydrogen cars. Fuel cell buses (as opposed to hydrogen fuelled buses) are being trialled by several manufacturers in different locations. Companies such as Boeing and Smartfish are pursuing hydrogen as fuel for airplanes. Unmanned hydrogen planes have been tested, and in February 2008 Boeing tested a manned flight of a small aircraft powered by a hydrogen fuel cell. (Source: NREL National Renewable Energy Laboratory).

Hydrogen is often seen as the most promising option to replace fossil fuels in the long term. In the transport sector, it can be a suitable energy carrier and under certain conditions improve the environmental performance. A study carried out by Ludwig Boelkow System Technik on behalf of the Joint Research Centre, Institute for Prospective Technological Studies in 2004 concluded that, it seems that year 2020 is too early for a wide scale introduction of hydrogen or fuel cells; it is questionable whether even year 2030 is a feasible time horizon. But it is also clear that even if the goal is the shift to hydrogen after year 2030, the preparation needs to start already.

The following figure shows different car fleet penetration scenarios for hydrogen fuel cell cars. The scenarios denoted [Shell 1999] assume commercialization to start in 2005, which seems unrealistic today. Delaying them by five years they become very similar to the scenarios denoted "Rapid Introduction" and [Dudenhöffer 2001], respectively. With market introduction starting in 2010, scenarios show car market shares of 4% to 22% until 2020, and up to 70% car market share and fleet penetrations of up to 46% until 2030. Hydrogen fuel

may replace from 1% up to 7% of conventional fuels in 2020 exponentially growing thereafter.

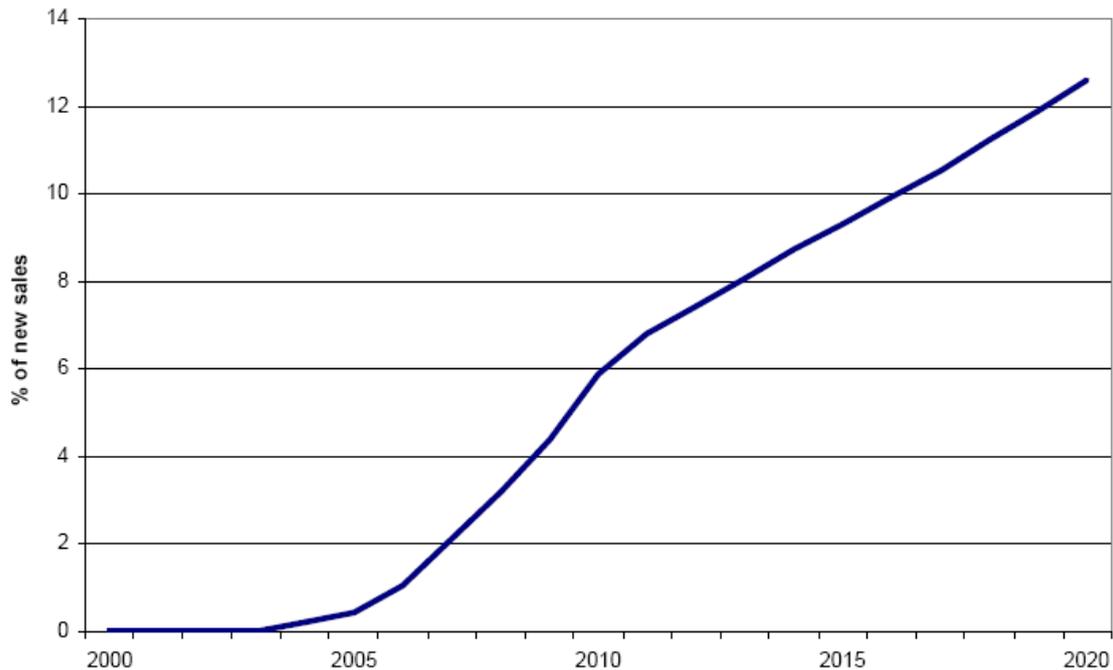
Figure 34: Scenarios for the development of the fleet penetration of hydrogen fuel cell passenger cars



Source: *Potential for Hydrogen as Fuel for Transport in the Long Term (2020-2030)*, Joint Research Center and IPTS, March 2004.

New road vehicles technologies include different types of technologies which improve vehicle fuel economy and related CO₂ emissions. The *hybrid and electric vehicles* are particularly efficient in urban drive cycle, but their high commercial costs are the most important barrier for their market penetration. Additionally, their mass diffusion depends on the evolution of their technology, namely battery technology, but also on their availability (much more models and sizes) to reach a full mass market deployment. Hybridisation will happen fastest where it makes most sense. The pros and cons must be weighted up carefully: hybrid drive makes sense for short-distance operation but not for long distances, where the negative factors like weight and costs have more of an impact, while the positive effect from better energy management in the power-train is lost. So hybrids cannot be regarded as a final solution, but as one step on the way to an ever higher level of electrification. A point will eventually be reached when the electrical component of the full-hybrid power-train becomes the dominant partner and the internal combustion is relegated to the role of “assistant”.

Even though hybrids have attracted a lot of attention and Toyota Prius is already in its second generation, the projections suggest that hybrids are not expected to reach a 2% market share before 2007 or 2008. As with all new technologies, an S-curve market penetration can be expected, that according to the baseline projection could lead to a 6% market share in 2010 and slightly above 12% by 2020. Increasing oil prices would certainly favour hybrid penetration in the long term. If prices, however, exceed US\$ 80 per barrel and if industry expectations prove right, fuel cells become competitive and start entering the market by 2020.

Figure 35: Potential market share of hybrids in EU-25

Source: Hybrids for road transport - Status and prospects of hybrid technology and the regeneration of energy in road vehicles, IPTS and Institute for Energy, February 2005).

The latest development in oil market with prices up to US\$ 145 per barrel will make the hybrids much more attractive. At the same time China has started producing hybrids. In 2009 cheap hybrid cars from the BYD Auto is expected to be introduced on the European market.

As nearly all car crashes are caused by human driver error, **driverless cars** are to effectively eliminate nearly all hazards associated with driving as well as to enhance traffic flow. The driverless car concept embraces an emerging family of highly automated cognitive and control technologies, ultimately aimed at a full "taxi-like" experience for car users, but without a human driver. Together with alternative propulsion, it is seen by some as the main technological advance in car technology by 2020. Dual mode transit will combine the flexibility of a private automobile with the benefits of a rail system: privately-owned cars will be built with the ability to dock themselves onto a public monorail system, where they become part of a centrally managed, fully computerized transport system. Congestion in roads and safety will increase by the implementation of such a system.

Besides new road vehicles, an important development that has revolutionized freight transportation is the introduction of containers. Use of **standardized containers** has made it faster, more reliable and efficient to transport goods around the world. Swift transshipment of goods has become very important and will become even more important in the future. Around 30 % of main commodities traded in the world by sea are transported in containers/other dry (source: UNCTAD).

The most dynamic development will continue to be in the field of container ships. The economies of scale are highly relevant to this ship type, and that is why we will see

increasingly larger ocean carriers and feeder ships. Limitations on the development of mega containerships are more likely to arise from the capability of port cargo handling facilities and inadequate depth of water, along with the maximum available size of propulsion plants. Speed is also the driving force in the development of container feeder ships, with orders for fast cargo cats probably imminent. There are already several projects for **fast transocean shipment of containers** with speeds up to 40 knots and more. With the continuing containerization regarding various cargo of all types, we will see the further introduction of specialized containers and containerships such as fully containerized reefer vessels.

More in general, there is a trend both in freight and passenger transport towards **bigger vehicles and vessels**, in order to improve competitiveness by lowering the price for transport unit whether passenger or ton. The application of the big vehicles and vessels requires a sufficient demand. Therefore the **A380 airplane** is developed only to serve heavy traffic long distance routes. And the 12,000 TEU containerships and in a smaller scale the double stack trains are only used on the routes between the main production and consumption sites in the world. The multitude of different transport modes ensures there will be a transport mode available which can almost fulfill every need to the most adequate price. But the price is obviously higher the less the load.

In October 2005, JAXA, the Japan Aerospace eXploration Agency, undertook aerodynamic testing of a scale model of an airliner designed to carry 300 passengers at Mach 2. If pursued to commercial deployment, it would be expected to be in service around 2020 – 2025. The British company Reaction Engines Limited, with 50% EU money, are engaged in a research programme called LAPCAT, which is examining a design for a hydrogen fuelled plane carrying 300 passengers, capable of flying nonstop from Brussels to Sydney at Mach 5+ in 4'6 hours. The development of economically viable and environmentally acceptable commercial **supersonic aircraft** will require continuing advances in many disciplines. Five areas of critical importance: approaches to sonic boom reduction, new aerodynamic concepts to improve efficiency and reduce environmental impacts, methods for dealing with highly coupled aircraft dynamics, strategies for the design of complex systems, and the continued development of variable cycle engines.

The **maglev train** is a vehicle without a motor—thus, without combustibles aboard—and without wings and wheels, which is suspended magnetically between two guardrails, that resemble an open stator of an electric motor. It is propelled by a magnetic field that, let's say, runs in front and drags it. If room-temperature superconductors succeed, a braking vehicle could also almost totally recover its kinetic energy. The energy consumption of the trains would then basically result from pushing air out of the way. The aerodynamic losses of maglevs running in evacuated tubes, as in a Swiss plan, would decrease with lower air pressure and make the energy efficiency of high-speed transport zoom.

2.2.1.3 ITS

Use of ITS (Intelligent Transport Systems) in road traffic management to fight congestion and improve safety has increased rapidly in the last few years and will do even more so in the future years. Highways of the future will utilise intelligent infrastructure which interacts with the vehicles and people using it. Intelligent systems will establish variable speed limits on motorways in order to enhance traffic flow. GPS will distribute traffic on the network according to traffic congestion levels. Variable fees and tolls are going to be set on major

infrastructure to distribute traffic along different times of the day and prevent uncontrolled use of road network. Cordon zones have already been implemented in Singapore, Stockholm, and London, where a congestion charge or fee is collected from vehicles entering a congested city center. Cordon zones will spread in most European cities in the next years to enhance traffic flow. Electronic toll collection (ETC) makes it possible for vehicles to drive through toll gates at traffic speed, reducing congestion at toll plazas and automating toll collection.

Advantages of satellite navigation is coupled with other ITS applications creating better possibilities of managing transport, managing the utilisation of infrastructure, manage the interface between transport modes and manage the paperwork related to freight transport. Travel cards covering the whole of Europe and all transport modes offer an easy way to purchase tickets, calculation of rebates and ensure also the seamless journey across borders and transport modes. The digital tachograph and more efficient enforcement of driving and resting time have lead to other ways of arranging transports.

The three main areas of the world where the largest part of adoptions of ITS have taken place (i.e. USA; Europe and Japan) have already **developed a reference architecture for ITS systems**. Like any other highly complex system, integrated ITS applications need a strategic framework as a basis for choices concerning their design and deployment, as well as for investment decisions. Such a framework is generally called a System Architecture. In the ITS context, the architecture will cover not only technical aspects, but also any organisational, legal and social issues involved. ITS architectures may be drawn up at a national level, a regional level, a city level or for the provision of specific services. The ability to integrate systems greatly increases their potential, and also means that they will be interoperable at European level, a factor of growing importance. Inter-operability includes not only technical, but also operational and organisational aspects. It ensures harmonious and/or complementary functioning of the overall system.

2.2.2 Climate change

Climate change is not just a problem for the future. Recent global climate changes, such as warming temperatures and rising sea levels, likely reflect the effects of Green House Gases (GHG) emissions into the atmosphere over the past century. Even if drastic measures were taken today to stabilise or eliminate GHG emissions, the effects of climate change would continue to be experienced.

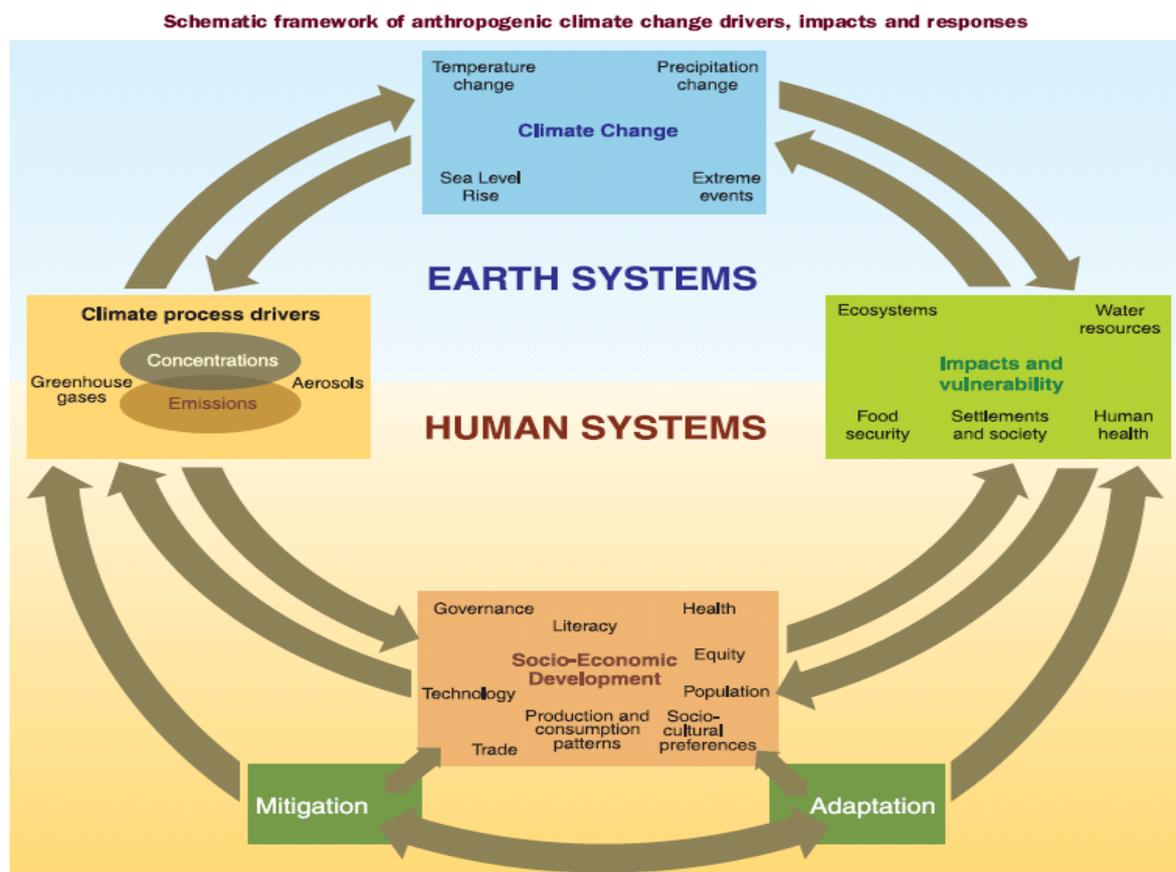
Climate is a key part of natural systems, and fluctuations in climate influence the delivery of goods and services provided by natural systems (ecosystem services). Surface water supplies, the biogeography of species, growing seasons, fish and animal populations, and consequently human welfare can all be significantly influenced by fluctuations in climate. On the basis of current knowledge, climate scientists have identified **five climate changes** of particular importance to transport and estimated the probability of their occurrence during the 21st century:

- **Increases in very hot days and heat waves:** it highly likely (greater than 90 percent probability of occurrence) that heat extremes and heat waves will continue to become more intense, longer lasting, and more frequent in most regions during the 21st century.

- **Increases in Arctic temperatures:** Arctic warming is virtually certain (greater than 99 percent probability of occurrence), as temperature increases are expected to be greatest over land and at most high northern latitudes. As much as 90 percent of the upper layer of permafrost could thaw under more pessimistic emission scenarios.
- **Rising sea levels:** it is virtually certain (greater than 99 percent probability of occurrence) that sea levels will continue to rise in the 21st century as a result of thermal expansion and loss of mass from ice sheets. The projected global range in sea level rise is from 0,18 m to 0,59 m. by 2099, but the rise will not be geographically uniform. Nor do the global projections include the full effects of increased melting of the Greenland and Antarctic ice masses because current understanding of these effects is too limited to permit projection of an upper bound on sea level rise.
- **Increases in intense precipitation events:** it is highly likely (greater than 90 percent probability of occurrence) that intense precipitation events will continue to become more frequent in widespread areas of the globe, especially in the Northern hemisphere.
- **Increases in hurricane intensity:** increased tropical storm intensities, with larger peak wind speeds and more intense precipitation, are projected as likely (greater than 66 percent probability of occurrence).

A schematic framework representing anthropogenic drivers, impact of and responses to climate change, and their linkages, is shown in the figure below.

Figure 36: Anthropogenic climate change drivers, impacts and responses



Source: IPCC, 2007, *Climate Change 2007: Synthesis Report*

The scheme describes the linkages clockwise, i.e. starting from climate process drivers (concentrations and emissions of greenhouse gases and aerosols) to derive climatic changes and the direct impacts on vulnerable ecosystems, water and food resources, human health, settlements and society, and the subsequent indirect impacts on socio-economic development, which in turn has an influence on climate process drivers (the so named anthropogenic causes, which co-exist with natural causes of climate change not explicitly represented in the scheme).

The same scheme describes also the linkages counter-clockwise, i.e. starting from the evidence of climate changes which induces global emissions constraints and possible new development pathways that would reduce the risk of future impacts that society may wish to avoid. The scheme illustrates the two strategic options societies have to respond to climate change: **adaptation** to its impacts, by reducing the vulnerability of ecosystems and human settlements to the climate change impacts, and **mitigation**, by reducing anthropogenic GHG emissions and therefore the rate and magnitude of climate change. These responses can be complementary.

Within the transport sector the main adaptation options are the realignment/relocation of main infrastructure, and the adoption of more severe design standards and planning for roads, rail and other infrastructure to cope with warming and drainage. Key mitigation technologies and practices currently commercially available include instead: more fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; modal shift from road transport to rail and public transport systems; non-motorised transport (cycling, walking); sustainable land use and transport planning. Looking ahead, key mitigation technologies projected to be commercialised before 2030, according to the IPCC 2007 report, include: second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.

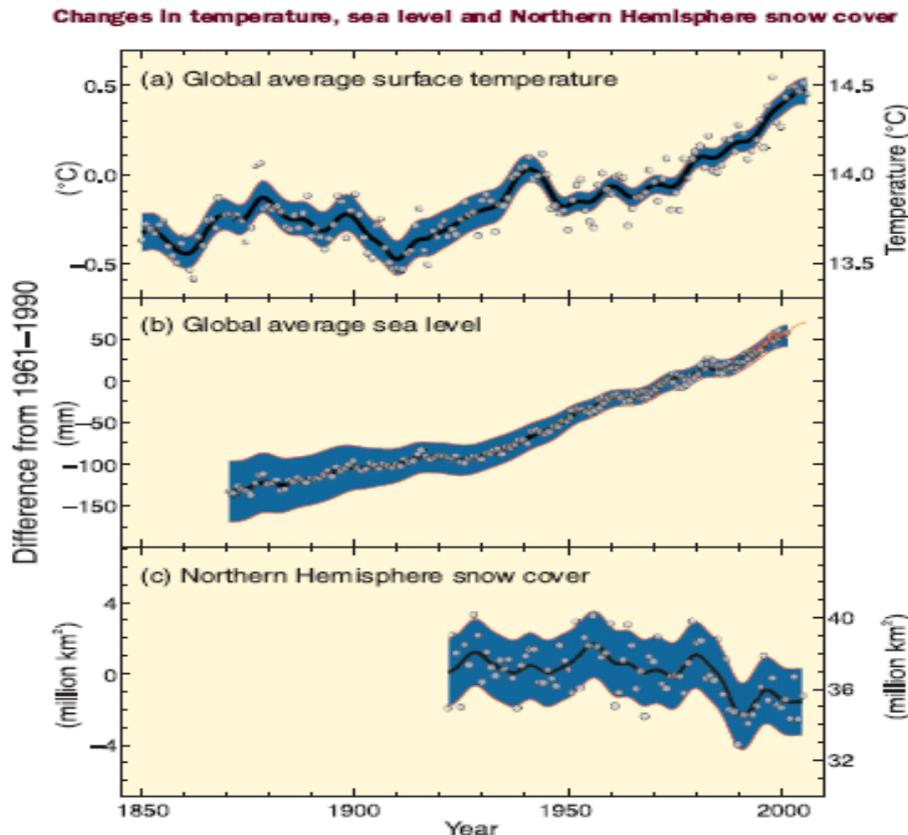
2.2.2.1 Past trends

Climate varies across a broad continuum of timescales in response to a wide variety of influences. For instance, subtle changes in the geometry of the Earth's orbit around the sun have been identified as a peacemaker for the glacial-interglacial cycles that have characterized Earth's climate over the past few million years. Century-to-century changes in the intensity of the sun have been linked with the multi-century Medieval Warm Period and subsequent Little Ice Age (from 14th to the late 19th centuries). More familiar, but equally dramatic, year-to-year shifts in global weather patterns are caused by El Nino and the Southern Pacific Oscillation, which are the results of naturally occurring interactions between the tropical pacific ocean and atmosphere.

According to the definition given by the Intergovernmental Panel on Climate Change assessment (IPCC, 2007), climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persist for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (see the figure below):

Figure 37: Changes in temperature, sea level and Northern Hemisphere snow cover



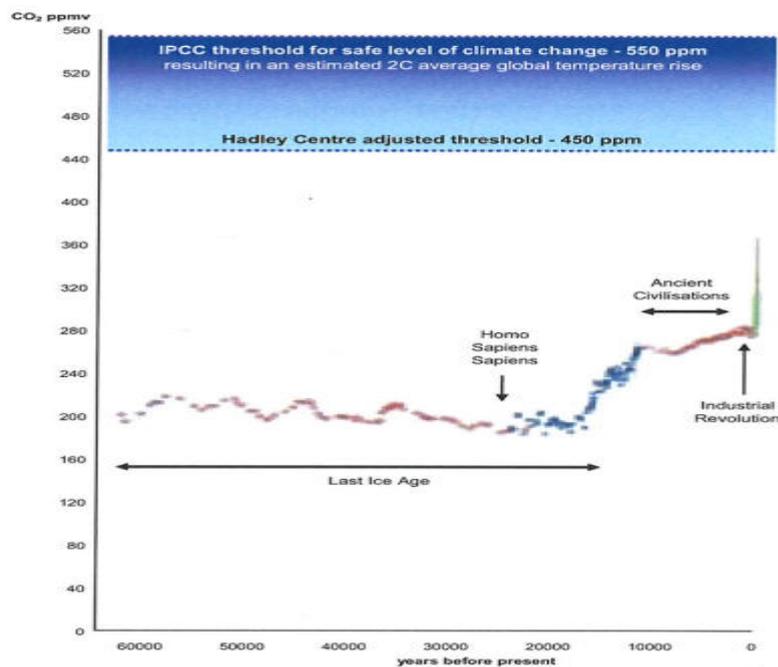
The temperature increase is widespread over the globe and is greater at higher northern latitudes, due to the greater concentration of continental lands, which have warmed faster than the oceans. Increases in sea levels are consistent with warming. Global average sea level rose at an average rate of 1.8 (1.3 to 2.3) mm per year over 1961 to 2003 and at an average rate of about 3.1 (2.4 to 3.8) mm per year from 1993 to 2003. Whether this faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer term trend is unclear. Observed decreases in snow and ice extent are also consistent with warming. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 (2.1 to 3.3)% per decade, with larger decreases in summer of 7.4 (5.0 to 9.8)% per decade. Mountain glaciers and snow cover on average have declined in both hemispheres.

At continental, regional and ocean basin scales, numerous long-term changes in other aspects of climate have also been observed. Trends from 1900 to 2005 have been observed in precipitation amounts in many large regions. Over this period, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia whereas precipitation declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.

Summarising the findings of current research on the subject, the IPCC 2007 synthesis report comes to the clear conclusion that a leading factor in the world's climate warming has been anthropogenic emissions of greenhouse gases, particularly CO₂ from the combustion of fossil fuels.

The trend in atmospheric CO₂ concentrations is shown in the figure below. This is now at levels never recorded in over half a million years. According to the IPCC an increase of more than two degrees Celsius in the global average surface temperature – which is estimated to correspond to a CO₂ concentration of 550 ppm – has the potential to cause significant damage to the eco-systems on which we are directly dependent.

Figure 38: IPCC thresholds for safe level of climate change



Source: School of Environmental Science, UEA.

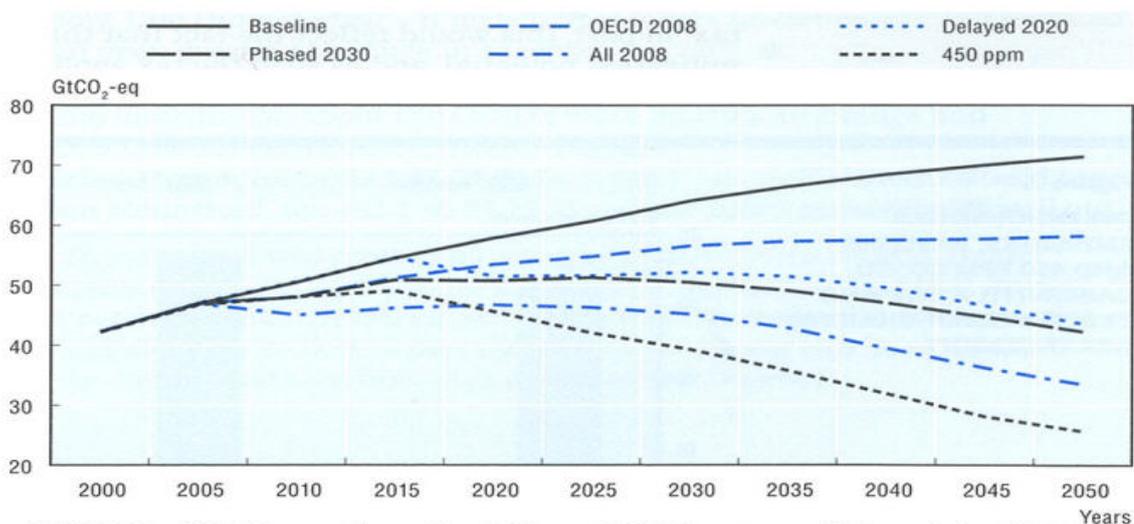
The principal gases associated with GHGs are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Carbon dioxide is the dominant GHG, accounting for 76% of global emissions and about 83% of emissions from OECD countries in 2005. Global human-caused GHG emissions grew 28% between 1990 and 2005. But the increase was far larger in major developing countries – 70% in Brazil, India and China – than in OECD countries, where emissions grew 14%. Despite this, the per capita GHG emissions in BRIC (Brazil, Russia, India and China) countries were only about one-third of those in OECD countries in 2005 (the equivalent of 5.1 tonnes of CO₂ per person in BRIC countries compared with 15 tonnes of CO₂ per person for OECD countries) and this pattern continues.

2.2.2.2 Future projections and challenges

Climate scientists have the greatest confidence in projected changes in mean temperature and other climate factors at the global and continental scale; confidence in these projections diminishes as the geographic scale is reduced. Nevertheless, climate scientists are now able to

project climate changes for large sub-continental regions, a scale better suited to transport infrastructure, which is regional and local. Projections of future climate are often shown as gradual changes, such as the rise in global temperatures projected over this century. However, these changes are unlikely to be experienced in such a smooth manner because those induced by human activity will be amplified in some years by naturally fluctuating conditions, reflected in potentially sudden and dramatic changes at the regional or local level. For example, many climate scientists caution that warming temperatures may trigger weather extremes and surprises, such as more rapid melting of the Arctic sea ice or more rapid rises in sea levels than are projected by current models. Based on baseline climate model projections, without wide-ranging measures to reduce greenhouse gas emissions, the IPCC scenarios predict ever-accelerating warming, which by the end of the century would have therefore dramatic consequences, such as longer heat-waves and more frequent flooding. By the same token, OECD simulations comparing the likely effects of different policies to mitigate climate change suggest two key messages: doing nothing is not an option as the consequences of inaction are high; and achieving ambitious climate stabilisation goals could be affordable – costing roughly a half a per cent of GDP by 2030 – but only if we start today and implement the least-cost solutions already available. If nothing is done, global GHG emissions are projected to increase by 52% by 2050 (see figure below). This would raise mean temperature by 1.7° C – 2.4° C, compared to pre-industrial levels, in 2050. And there is a risk of a “snowball” effect. Factors like reduced sea ice cover, which would change the regional albedo (reflectivity of the Earth’s surface) and increased methane emissions from melting permafrost soil, could accelerate climate change even more.

Figure 39: OECD simulations of climate change mitigation policies



Note: OECD 2008 = all OECD countries apply a GHG tax of USD 25 per tonne of CO₂-eq; Delayed 2020 = all countries apply the tax, starting only in 2020; Phased 2030 = OECD countries apply the tax in 2008, BRIC in 2020 and ROW in 2030; All 2008 = all countries apply the tax, starting in 2008; 450 ppm = scenario to stabilise GHG concentrations in the atmosphere at 450 ppm CO₂-eq; For all USD 25 tax cases, the tax is escalating by about 2% per year after the initial year of introduction.

Source: OECD Environmental Outlook, 2008.

But if the international community were to take action now, these trends could be slowed and limited overall. According to a first OECD policy scenario, if all the major GHG emitters phased-in over several years a tax of USD 25 (escalating at roughly 2% a year) on every tonne of GHG produced, global emissions would be established at 2000 levels by 2050. Putting in

place an immediate tax of USD 25 per tonne of CO₂ – eq imposed by all nations today would see global emissions fall to about 21% below 2000 levels by 2050. A more ambitious scenario was also simulated, reflecting a phased-in tax set at the level necessary to limit atmospheric concentrations to 450 ppm of CO₂ – eq. in the atmosphere in the long term. This would lead to a reduction in global emissions by about 40% in 2050 compared to 2000 levels. There is a difference of roughly 0.6° C in the predicted temperature rise by 2050 between the OECD baseline and the “most challenging” mitigation case examined that would stabilise atmospheric concentrations of CO₂ – eq. at 450 ppm. Drastically reducing GHG emissions can create a virtuous circle that has significant co-benefits in other areas as well. Measures taken to significantly reduce GHG emissions would likely also reduce air pollution and improve human health.

According to the OECD simulations, the global economic costs of limiting climate change are not insignificant, but they are manageable, even for the most ambitious case, which stabilises concentrations at 450 ppm CO₂ – eq. in the long term. Total loss of GDP worldwide, compared to a “no action scenario”, would be equivalent to losing less than 0.1 percentage points of global GDP growth per year through to 2050, with an aggregate loss of 0.5% of GDP in 2030, and just under 2.5% in 2050. This may be compared with the current estimates of the damage cost of climate change. For instance, in his 2006 report, the former Chief Economist of the World Bank, Nicolas Stern, put the costs of unchecked climate change at five to over 20% of world domestic product (GDP).

However, the real problem is not the total cost of action, but how it would be distributed around the world, since many developing countries may face far bigger GDP losses than the industrial world if a straightforward global tax policy was used. For example, in the 450 ppm case, the OECD would lose 0.2% of GDP in 2030, and 1.1% in 2050, but the BRIC countries would lose five times as much – a loss of 1.4% of GDP in 2030, and 5.5% in 2050. The OECD policy simulations suggest therefore a need for a mechanism for sharing the burden of the costs of global GHG emissions reduction action (e.g. by enforcing a world-wide emission trading permit system).

2.2.3 Environmental and safety concerns

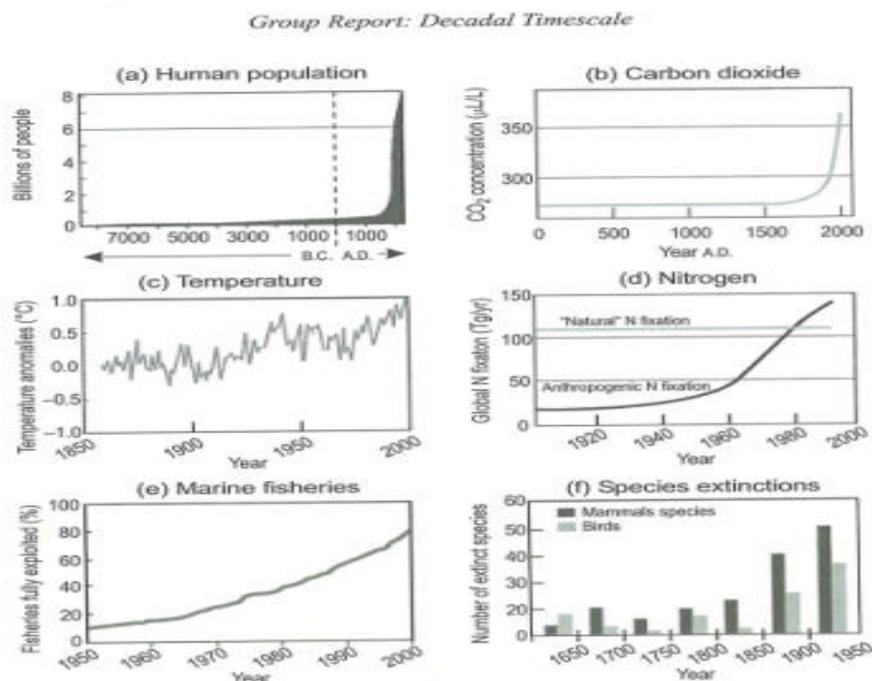
The primary finding reported by the Millennium Ecosystem Assessment (MEA 2005) is that “over the past 50 years, human have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth.” The trends in carbon dioxide (CO₂) emissions and associated temperature changes also suggest a rapid acceleration of human impacts on the atmosphere over the last 50 years. These and many other changes demonstrate a distinct increase in the rates of change in many human-environment interactions as the result of amplified human impact on the environment after the World War II – a period that has been termed the “Great Acceleration”. The scale of the environmental change from the 1890s to 1990s and some of the driving forces behind the change are illustrated in the following table (after McNeill 2005)²⁵:

²⁵ McNeill, J.R. 2005. Modern Global Environmental History: A Turbulent and Dramatic Scenario. IHDP – Update. *Newsl. IHDP Global Environment Change*

Environmental change	Coefficient of increase
Freshwater use	9-fold increase
Marine fish catch	35
Cropland	2
Irrigated area	5
Pasture area	1,8
Forest area	(20% reduction)
CO ₂ emissions	17
Lead emissions	8
Cattle population	4
Driving Forces	
Population	4-fold increase
Urban population	13
World economy	14
Industrial output	40
Energy use	13

These secular changes are mainly the results of the Great Acceleration, which can be characterised through a suite of global indicators that show dramatic increases over the last few decades (see figure below).

Figure 40: Global indicators of the Great Acceleration



McNeill, J.R. 2005. *Modern Global Environmental History: A Turbulent and Dramatic Scenario*

For example, human populations have increased from 1972 to 2000 from 3.85 to 6.1 billion (UNFPA 2001). Over the second half of the 20th century, human activities have expanded rapidly and have led, for example, to non linear increases in global atmospheric CO₂ concentrations. Although some correlations can be found between population and CO₂ growth rates in the 20th century, increased CO₂ is also associated with a rapid rise in per capita consumption by a relatively small fraction of the human population. The rapid accumulation

rate of atmospheric CO₂ has placed the Earth system in a domain with unknown consequences and feedbacks that are unprecedented over at least the last 730,000 years (EPICA 2005). Coincident with increased atmospheric CO₂ concentration, average global temperatures have risen as a result of long residence times of CO₂ and the greenhouse effect.

Nitrogen serves as a further indicator. The use of nitrogenous fertilizers has negatively impacted global terrestrial and freshwater ecosystems. The rate of resource extraction and harvest is a direct result of increased population and technology. In term of marine fisheries, the FAO (2000) reports that up to 80% of possible fish populations have been exploited. In addition, the exponential extinction rate of species highlights unforeseen and unpredictable consequences coupled with resource degradation.

The contribution of transport activities to adverse environmental conditions is clearly significant. Transport systems are nowadays almost entirely dependent on fossil fuel sources. This dependence is the main reason of the environmental unsustainability of the sector. On one hand, transport is unsustainable in terms of use of oil resource which is a non-renewable resource and its production is in a state of permanent decline. On the other hand, the use of fossil fuels to provide energy for the transport sector causes several kinds of air emissions which have impacts on human health, ecosystems, materials, etc. Indeed, emissions from transport represent a very high share of the overall emissions. The main components of transport emissions include: Carbon Dioxide (CO₂), Particulate matters (PM), Nitrogen Oxides (NO_x), Sulphur Dioxide (SO₂) Carbon Monoxide (CO), lead (Pb), benzene and volatile components (CmHn). The contribution of harmful emissions (acidifying substances, particulate matter and ozone precursors), has decreased by 30% to 40% from the 1990 to 2004 with exclusion of maritime transport and aviation contributions (EEA, 2007). Nevertheless, air quality in the areas immediately adjacent the transport activity, particularly in urban areas, is still a central problem mainly on account of adverse impacts for human health of pollutants such as particulate. However, transport activity causes also environmental impacts due to:

- noise pollution, mostly connected to road traffic and aircraft movements;
- congestion, that takes place from an inefficient use of transport infrastructures scarcity, and spread in time, space, fuel, more pollution;
- emissions from upstream and downstream processes, namely fuels production, vehicle production and maintenance;
- accidents, which cause lost of human lives, as well as release of hazardous goods and materials during their transport, such as crude oil into the sea;
- provisions and utilizations of transport infrastructures (roads, rails tracks, dams, bridges, airports, etc.). In particular, the provisions of infrastructures are connected to the landscape fragmentation, loss and disturbance of habitats and species, as well as the long term influence of partitioning and isolating ecosystems and species population. Additionally, in urban areas, the use of urban space for transport leads to a scarcity of space for other uses.

A major part of the problem with environmental degradation lies in the fact that many of the costs associated with economic production – and in particular those associated to the categories of impacts listed above for transport - are external to the market system. In terms of environment, the market sends out the wrong signals, and producers and consumers engage in “over-consuming” environmental resources. One way to correct this problem and create the

appropriate deceleration of environmental degradation is to “internalize” these external costs. This could be done by taxing environmental degradation (i.e. Pigouvian taxes), establishing cap and trade systems, or estimating the true external costs (including life-cycle impacts) and using that information to fix criteria for green public procurement. The transport sector is clearly a key area where the internalisation of external costs would bring important benefits.²⁶

Another important social impact of transport is caused by road accidents and fatalities. In *Road Safety: a public health issue* (2004), the World Health Organisation (WHO) reports that every year 1.2 million people are killed and more than 50 million people are injured in road accidents. The EU countries, with about 40.000 road fatalities in the year 2006, made and are continuing to make their way towards increasing levels of road safety, with a number of policy measures implemented at EU and national level. However, according to the WHO’s *Global Burden of Disease*, over the period from 2000 to 2020 we are likely to see a further 60% worldwide increase in the total number of fatalities and injuries due to road accidents. While the industrialised nations are set to see the number of road accident victims fall by 30%, this is more than offset by an increase of 80% in developing countries, and of as much as 144% in South-East Asia.

The positive trend in the industrialised nations proves that the connection between the increasing number of automobiles and the number of road traffic fatalities is merely an indirect one. Further evidence is provided by the fact that the majority of accident victims in developing countries are among the group of vulnerable road users (children, pedestrians, cyclists, etc.). The root causes here are deficiencies in planning, designing and financing infrastructure and in the drafting and enforcement of standards, i.e. an area where EU countries have learned a lot in the last decade or so. In developing countries there is also insufficient information and training for drivers, as well as lack of effective emergency service provision to mitigate the consequences of accidents.

2.3 Policy drivers

2.3.1 Overview

It is clear that policy (on various levels of governance) is an important factor affecting transport, and it is in this sense that we can talk about “policy drivers”. It can be argued that all the drivers described in Sections 2.1 and 2.2 above are susceptible to change by policy. The issue of policy will become increasingly important in the TRANSVISIONS project (and will become central in Task 3), given that one of the end results of the project is to make recommendations for future EU transport policy. This section outlines a number of key policy drivers in order to initiate this discussion, concentrating mainly on world and EU governance levels.

When considering policy drivers that will affect transport in the EU, a natural starting point is to consider EU transport policy, and for this reason the next subsection (2.3.2) is devoted to this subject. Subsequent subsections deal with various (non-transport) policy drivers that are important for transport: EU enlargement and cohesion policies (2.3.3); world and EU environmental policy (2.3.4); world and EU trade policy (2.3.5); and world and EU security

²⁶ Transport infrastructure charging initiative at the EU level is discussed in section 3.2.5 below.

policy (2.3.6). Each of these subsections will open with a discussion as to why the particular policy-type is relevant to transport, and hence can be defined as a “policy driver for transport”. The final subsection (2.3.7) examines possible future directions for transport-relevant policies on a variety of different governance levels.

However, before describing all these different types of policy, it is worthwhile mentioning the overall framework in which they need to evolve, as defined in the “EU Sustainable Development Strategy (EU SDS)”. The SDS was first adopted by the European Council in Göteborg (2001), with a Renewed Strategy being agreed at the European Council in June, 2006. The text of the Renewed SDS (<http://register.consilium.europa.eu/pdf/en/06/st10/st10917.en06.pdf>) includes various definitions of principles relevant to TRANSVISIONS. Firstly, sustainable development is defined as follows:

“Sustainable development means that the needs of the present generation should be met without compromising the ability of future generations to meet their own needs. It is an overarching objective of the European Union set out in the Treaty, governing all the Union’s policies and activities. It is about safeguarding the earth’s capacity to support life in all its diversity and is based on the principles of democracy, gender equality, solidarity, the rule of law and respect for fundamental rights, including freedom and equal opportunities for all. It aims at the continuous improvement of the quality of life and well-being on Earth for present and future generations. To that end it promotes a dynamic economy with full employment and a high level of education, health protection, social and territorial cohesion and environmental protection in a peaceful and secure world, respecting cultural diversity.” (p2)

Given this definition, the overall aim of the renewed EU SDS is “to identify and develop actions to enable the EU to achieve continuous improvement of quality of life both for current and for future generations, through the creation of sustainable communities able to manage and use resources efficiently and to tap the ecological and social innovation potential of the economy, ensuring prosperity, environmental protection and social cohesion.” (p3).

With reference to the relation between the SDS and the Lisbon Strategy, the text states that “[t]he EU SDS forms the overall framework within which the Lisbon Strategy, with its renewed focus on growth and jobs, provides the motor of a more dynamic economy. These two strategies recognise that economic, social and environmental objectives can reinforce each other and they should therefore advance together.....In this context the EU SDS recognises that investments in human, social and environmental capital as well as technological innovation are the prerequisites for long-term competitiveness and economic prosperity, social cohesion, quality employment and better environmental protection.” (p6).

Two points can be made here that will help guide the further methodological development of TRANSVISIONS:

1. It can be seen that, in general, there are three primary “axes” of sustainable development, comprising economic, environmental and social dimensions. Such thinking is in fact made explicit in the overall objective for sustainable transport within the SDS, which is to “ensure that our transport systems meet society’s

economic, social and environmental needs whilst minimising their undesirable impacts on the economy, society and the environment” (p10).

2. The SDS uses the language of “human, social and environmental capital”. In fact, the SDS uses the term “social capital” three times within the document.

2.3.2 EU Transport Policy

The following discussion of EU transport policy will focus upon the White Paper “EU Transport Policy, a Time to Decide” (CEC, 2001), referred to below as the “2001 White Paper”. However, subsequent developments will also be mentioned such as the Mid-term Review of the White Paper, “Keep Europe Moving” (CEC, 2006), and the Green Paper “Towards a New Culture of Urban Mobility” (CEC, 2007a), referred to below as the “2007 Green Paper”.

A concise history of EU transport policy is provided in an opening section of the 2001 White Paper. Essentially it describes how, “[f]or a long time, the European Community was unable, or unwilling, to implement the common transport policy provide by the Treaty of Rome. It was only in 1985, when the Court of Justice ruled that the Council had failed to act, that the Member States had to accept that the Community could legislate”. (CEC, 2001: p6). The story continues to the publication of the Commission’s first White Paper on the future development of the common transport policy in 1992, with the “guiding principle” of the document being “the opening-up of the transport market”. A fuller description of the history of EU transport policy, paying particular attention to the Trans-European Networks (TENs), is provided by Turró (1999), who emphasises the importance of the 1992 Treaty on European Union (the “Maastricht Treaty”) in establishing the legal and financial basis for the TENs. The TENs are, to date, the flagship transport infrastructural policy implementation of the EU.

The 2001 White Paper is a comprehensive document covering a large amount of transport topics, structured according to the following policy issues:

1. Shifting the Balance Between Modes of Transport (subdivided between “Regulated Competition” and “Linking up the Modes of Transport”)
2. Eliminating Bottlenecks (subdivided between “Unblocking the Major Routes” and “the Headache of Funding”)
3. Placing Users at the Heart of Transport Policy (subdivided between “Unsafe Roads”, “The Facts Behind the Cost to the User”, “Transport with a Human Face” and “Rationalising Urban Transport”)
4. Managing the Globalisation of Transport (subdivided between “Enlargement Changes the Name of the Game” and “The Enlarged Europe Must be More Assertive on the World Stage”).

As a very simple summary, the White Paper covers, in (1) and (2), transport policy-making in traditional terms as an economic activity (putting emphasis upon congestion and bottleneck problems), albeit with a heightened emphasis upon the negative environmental impacts of transport (and thus stressing the need for switching to more environmentally-friendly modes). On the other hand, “new” directions (or at least less prominent directions within traditional transport thinking) are opened up in (3) and (4), which cover the human dimension of transport and the EU’s place in the world respectively. In fact, it could be argued that the

policy-thinking in (1) and (2) represent the state-of-the-art for a well-established “economic plus environmental” way of thinking about transport, whilst future innovative policy development will come with increased thinking along the lines suggested by (3) and (4) (though building of course upon the wisdom embedded in (1) and (2)).

One of the key policy thrusts of the White Paper is summed up in the statement “we have to consider the option of gradually breaking the link between economic growth and transport growth, on which the White Paper is based” (referred to as “decoupling” elsewhere in the document). The White paper then dismisses a “simplistic solution” for accomplishing decoupling “which would be to order a reduction in the mobility of persons and goods and impose a redistribution between modes”, stating this to be against subsidiarity principles and “dirigiste”. Three alternative options are then provided for attaining decoupling, the chosen option comprising:

“a series of measures ranging from pricing to revitalising alternative modes of transport to road and targeted investment in the trans-European network. This integrated approach would allow the market shares of the other modes to return to their 1998 levels and thus make for a shift of balance from 2010 onwards. This approach is far more ambitious than it looks, bearing in mind the historical imbalance in favour of road for the last 50 years. It is also the same as the approach adopted in the Commission's contribution to the Gothenburg European Council which called for a shift of balance between the modes by way of an investment policy in infrastructure geared to the railways, inland waterways, short sea shipping and intermodal operations..... By implementing the 60-odd measures set out in the White Paper there will be a marked break in the link between transport growth and economic growth, although without there being any need to restrict the mobility of people and goods. There would also be much slower growth in road haulage thanks to better use of the other means of transport (increase of 38% rather than 50% between 1998 and 2010). This trend would be even more marked in passenger transport by car (increase in traffic of 21% against a rise in GDP of 43%)”.

As an example of the “broadening out” of traditional transport thinking mentioned above, an important recognition of the 2001 White Paper is that transport policy needs to be consciously integrated with other policy areas (and this integration will provide a continuing theme of the TRANSVISIONS project). It is worthwhile quoting at length the relevant text in the initial section on “Policy Guidelines of the White Paper”:

“The objective - never yet achieved - of shifting the balance of transport involves not only implementing the ambitious programme of transport policy measures proposed in the White Paper by 2010, but also taking consistent measures at national or local level in the context of other policies:

- economic policy to be formulated to take account of certain factors which contribute to increasing demand for transport services, particularly factors connected with the just-in-time production model and stock rotation;
- urban and land-use planning policy to avoid unnecessary increases in the need for mobility caused by unbalanced planning of the distances between home and work;
- social and education policy, with better organisation of working patterns and school hours to avoid overcrowding roads, particularly by traffic departing and returning at weekends, when the greatest number of road accidents occur;

- urban transport policy in major conurbations, to strike a balance between modernisation of public services and more rational use of the car, since compliance with international commitments to curb CO₂ emissions will be decided in the cities and on the roads;
- budget and fiscal policy to achieve full internalisation of external - in particular environmental - costs and completion of a trans-European network worthy of the name;
- competition policy to ensure that opening-up of the market, especially in the rail sector, is not held back by dominant companies already operating on the market and does not translate into poorer quality public services;
- transport research policy to make the various efforts made at Community, national and private level more consistent, along the lines of the European research area.

Clearly, a number of measures identified in this White Paper, such as the place of the car, improving the quality of public services or the obligation to carry goods by rail instead of road, are matters more for national or regional decisions than for the Community.”

Three important inter-linked issues arise from this list, which will be of particular relevance in TRANSVISIONS:

1. The question arises “how are these policies made?”, and in particular what level of public participation is involved with making them. This question can be considered in two different ways, depending upon different levels of policy-making. Firstly, in formulating high level EU policy (for example the 2001 White Paper), the European Commission has always gathered the opinions of stakeholders, notably through their organisations at European level. Furthermore, the EC has more recently carried out extensive public consultations on such policies via the internet. On the other hand, the 2001 White Paper does not itself give suggestions concerning how the public might be involved in the further development or implementation of such policies at a lower level.
2. Very much related to (1) is the issue of subsidiarity, which is explicitly recognised in the final sentence of the quotation given above (and which was the reason for the EU not to adopt “dirigiste” policies). In particular, many questions arise of the role of the EU in urban transport policy, given, on the one hand, subsidiarity norms, but, on the other hand, the need to harmonise EU transport policy with (locally-determined) urban transport policy. This issue will be raised below in the context of the 2007 Green Paper. In general, though, it can be argued that it is not against subsidiarity principles for the EU, in its high level policy documents (such as the 2001 White Paper) to make helpful suggestions about public participation at a local level, giving examples of good practice (without dictating what measures should be used in any particular location). Furthermore, it can be argued that the perception of most citizens of the EU with respect to transport policy will be based more upon the implementation of policy on a local level than on the formulation of policy at a high level. Thus it is in the interests of the EU to emphasise its democratic credentials by being seen to provide support to local participation exercises (whilst at the same time not appearing “dirigiste”).
3. The comments above about public participation are consistent with the EU Sustainable Development Strategy. In particular, the SDS has the following two “policy guiding principles” concerning “open and democratic society” and “involvement of citizens”.

The first of these principles is given as “Guarantee citizens’ rights of access to information and ensure access to justice. Develop adequate consultation and participatory channels for all interested parties and associations”. The second principle is given as “Enhance the participation of citizens in decision-making. Promote education and public awareness of sustainable development. Inform citizens about their impact on the environment and their options for making more sustainable choices.” In line with these principles, it would be consistent for the EU to take a role as “facilitator” for helping local communities for making socially-inclusive decisions about transport, and that suggestions for the mechanisms for doing so might be included in future transport white papers and other high level policy documents.

In 2006, the EC published its Mid-Term Review of the 2001 White Paper. This publication was preceded by an impact assessment of the White Paper, carried out by the ASSESS project, and a number of consultation exercises, including a public consultation about the internalisation of external costs. Further information about these preparatory activities can be found at:http://ec.europa.eu/transport/white_paper/mid_term_revision/index_en.htm

Of particular interest in the consultation process was a conference on the mid-term review held in Brussels in December 2005. In opening the conference, Mr Jacques Barrot (Vice-President of the Commission in charge of transport), made three observations:

- Mobility cannot be restrained; even if one wanted to, economic growth implies a growth of transport. The road traffic of goods has to double between now and 2020, as well as air traffic. In the new Member States, the use of cars increases at a rapid pace. Therefore, there is no question of restraining mobility.
- Mobility is a major asset for competitiveness. One must break with the dogma of the decoupling of the growth rate of transport with the growth rate of GDP. The transport strategy is an essential element to achieve the Lisbon objectives.
- The negative effects must however be averted: traffic congestion, the cost of which is estimated at 1% of the GDP of the EU; environmental pollution (26% of the CO₂ emissions come from transport); insecurity on European roads (44,000 deaths per year) and the increased risks of air transport related to continuous traffic growth.

These observations provide a sound introduction to the thinking of the mid-term review, as discussed below. Given that the conference was made up of a very wide range of stakeholders, it is not surprising that the views expressed were rather diverse, and in many cases conflicting. Of relevance to the issues of social impacts of transport the conference, as mentioned above in the context of SDS, it is clear from the conference participants’ comments that there is a very wide range of views as to exactly what “social” means (with respect to transport), let alone what policies should be adopted in this respect. In closing the conference, Mr Barrot stated that “[t]here must be a social dimension in transport. There are however many difficulties; the social dialogue is not the same in all the sectors, but it must progress in certain areas.”

With regard to the mid-term review itself, a number of commentaries and analyses have been made, such as that by Stead (2006). In summary, it can be said that the mid-term review maintains that the objectives of the Transport White Paper of 2001, and even the objectives of its predecessor, the 1992 Transport White Paper, remain valid. Nevertheless, the mid-term

review indicates something of a change in direction and focus in European transport policy largely as a response to the very low economic growth with which the century started, far below the 3% increase of GDP aimed at the Lisbon strategy. This is quite explicitly recognised in the mid-term review, which for example refers to the ‘need to re-adjust policy measures’ and the need for ‘a broader, more flexible, transport policy toolbox’ (p6) which will lead to more emphasis being paid to efficiency linked issues such as logistics, urban transport, and innovation on ITS and energy technology. The mid-term review asserts that the measures put forward in the 2001 European Transport White Paper ‘will not be sufficient on their own to continue achieving the fundamental objectives of EU policy, in particular to contain the negative environmental and other effects of transport growth whilst facilitating mobility as the quintessential purpose of transport policy’ (p6). The previous sentence introduces the concept of decoupling from the negative effects of transport rather than between transport and GDP. The mid-term review introduces also the concept of co-modality defined as the efficient use of the different modes on their own and in combination thus stressing the fact that modal balance has to be accompanied of modal performance in all modes, starting by the bigger one. Clearly, the prevailing view in the Commission is that transport policy should facilitate mobility rather than manage it: the emphasis on mobility as a precondition for competitiveness appears to take precedence over sustainability. Demand management as such does not feature in the mid-term review, although more work on pricing which is one of the main demand management tools is announced. The mid-term review contends that the focus of transport policy needs to be revised because of a combination of emerging issues and developments like for example the substantial enlargement of the European Union in 2002 which increases the heterogeneity of the Union (e.g. in respect of congestion), recent changes in the transport industry, evolving technologies and new innovations, and energy supply and security issues (New York, London and Madrid terrorist attacks).

As might be expected, given that large amount of research funding devoted to urban transport by the EU, the 2007 Green Paper on urban mobility represents state-of-the-art thinking about the subject. An intriguing aspect of the Green Paper is that, throughout, the question “What could be the potential role of the EU?” is repeated. One answer to this question could be to strengthen the role of “EU as facilitator” outlined above. Furthermore, although the Green Paper itself does not put much emphasis upon public participation issues, a sister “Commission Staff Working Document” (CEC2007b), accompanying the Green Paper, is based around a consultation exercise. It is worth pointing out here that it has traditionally been easier to arrange public participation for urban planning than for interurban planning, due simply to the “local” nature of the former and given that public participation has generally involved face-to-face meetings (which for practical reasons need to be “near to home”). Thus urban transport planning provides the most suitable stage in which new public participation approaches can be tested. On the other hand, with the coming of the internet age, various other possibilities are opened up for public participation.

2.3.3 EU Enlargement and Cohesion Policy

As indicated above, when listing the sections of the 2001 White Paper, the connection between transport policy and EU enlargement policy was made in the White Paper. In fact it is self-evident that enlargement, accompanied by the removal of barriers to movement and the encouragement of an internal market, has and will have a significant impact on mobility. The

relation between transport and cohesion policy is, however, more subtle. Both issues will be discussed in this subsection.

The expansion of the EU has until now proceeded as follows:

- 1957: Founding members: Belgium, France, West Germany, Italy, Luxembourg and the Netherlands
- 1973: + Denmark, Ireland and the UK
- 1981: + Greece
- 1986: + Portugal and Spain
- 1990: + East Germany (as part of unified Germany)
- 1995: + Austria, Finland and Sweden
- 2004: + Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia
- 2007: + Bulgaria and Romania

Currently, two categorisations exist for states who are involved in formal processes that could lead to EU membership. Those with a most advanced status in this respect are the “candidate countries”: Croatia, the Former Yugoslav Republic of Macedonia, and Turkey. The Western Balkans states of Albania, Bosnia and Herzegovina, Montenegro and Serbia are not yet recognised as candidate countries but are in the enlargement process and are classified as “potential candidate countries”. Other states with aspirations to join the EU, but without any formal status in this respect, are Armenia, Belarus, Georgia, Moldova and Ukraine.

Some see enlargement as a relatively straightforward process, with a number of states “queuing up” to join the EU and being accepted as long as they meet the following “Copenhagen criteria” established by the European Council in 1993:

- Stability of institutions guaranteeing democracy, the rule of law, human rights and respect for and protection of minorities.
- The existence of a functioning market economy as well as the capacity to cope with competitive pressure and market forces within the Union.
- The ability to take on the obligations of membership including adherence to the aims of political, economic and monetary union.

However, others see the process in much more problematic terms, particularly with reference to the accession of Turkey. Although many points of view exist on these issues, disagreement often is reduced to two alternative visions of the EU: a “competitive” EU versus a “cohesive” EU. Whilst many would claim that the EU should be both competitive and cohesive (and this is in fact the stance of the Lisbon Strategy), the disagreement surfaces if it is considered that, for a specific policy decision, there is a need to choose between the two alternatives. As a general rule, those favouring a competitive EU over a cohesive EU would support greater enlargement, one reason being to be able to exploit the opportunities for cheaper labour that would result. Those favouring a cohesive EU would tend to be less supportive towards further enlargement, in order to concentrate on resolving equity problems that exist in the current EU.

Faludi (2007) provides a comprehensive overview of EU cohesion policy, describing the importance of Jacques Delors, European Commission President from 1985 to 1995, in pursuing such a policy. Faludi describes the terms “cohesion policy” and “territorial cohesion policy” as follows:

“[Cohesion] policy is about compensating least favoured regions and member states for disadvantages suffered from the widening and deepening of the EU. Territorial cohesion policy is its latest offshoot. The rationale behind it is to be found in the Third Cohesion Report: “. . . people should not be disadvantaged by wherever they happen to live or work in the Union” (CEC, 2004, p. 27). Accordingly, territorial cohesion is about a just distribution of opportunities in space. However, the idea is that this will also unlock much dormant potential. As Allen (2005, p. 238) puts it: “The logic assumes that economic convergence among countries and among regions will deliver cohesion, which in turn will deliver growth, competitiveness, employment, and sustainable development, and thus the Lisbon and Gothenburg objectives”.

Two points can be made here:

1. Cohesion policy in the transport field is orientated to increase the accessibility of the countries and regions which benefit from that policy. Better accessibility means indeed less transport costs, less "peripherality" and therefore more traffic. European cohesion policy has been quite active in the provision of transport infrastructure, in particular as the Cohesion Fund was obliged to provide grants only for environmental and transport projects.
1. The final sentence in the above quotation stresses that cohesion and competition are not necessarily in conflict, and that there exists the possibility of a “win-win” situation which emphasises both. However, although this might be happy general approach, there will frequently be situations (such as whether a particular state gains accession to the EU, as mentioned above) in which discrete choices need to be made, and such choices will often involve emphasising competitiveness over cohesion or vice –versa.

Various future consequences associated with a competitive EU or a cohesive EU are described further in 2.3.7 below.

2.3.4 Global and EU changes in environmental policy

Over the past 50 years, there has been an growing awareness of environmental issues worldwide, leading to the emergence of environmental governance and institutions on various differing governance levels. Given the well-established environmental impacts of transport (as emphasised in the 2001 White Paper) it is clear that environmental policy is an important “policy driver” for transport. The 1972 UN Conference on the Environment in Stockholm and the 1992 Earth Summit in Rio are frequently identified as key events that signalled the emergence of environmental policy and sustainable development on national and international agendas. National governments have initiated environmental management strategies that include measures to control air and water pollution. International environmental organisations and regimes have also played major roles including, but not limited to, the United Nations Environment Programme (UNEP), the Montreal Protocol (concerning substances that deplete the ozone layer), the United Nations Framework Convention on Climate Change (UNFCCC), and the Kyoto Protocol (concerning CO₂ emissions). Arguably, the environmental factor that has been of most importance to the long term future of transport has been climate change, and so more information is here given about the UNFCCC and the Kyoto Protocol.

The UNFCCC was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its

ultimate objective is the “stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”. It contains commitments for all Parties. Under the Convention, Parties included in Annex I (all OECD member countries in the year 1990 and countries with economies in transition) aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The Convention entered in force in March 1994.

The Kyoto Protocol to the UNFCCC was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most Organization for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005.

As of May 2008, 182 parties have ratified the Kyoto Protocol. Of these, 36 developed countries (plus the EU as a party in its own right) are required to reduce greenhouse gas emissions to the levels specified for each of them in the treaty (representing over 61.6% of emissions from Annex I countries), with three more countries intending to participate. 137 developing countries have ratified the protocol, including Brazil, China and India, but have no obligation beyond monitoring and reporting emissions. The United States has not ratified the treaty. Given the importance of the USA as greenhouse gas emitter, this situation is clearly problematic. However, with the change in presidential leadership due early in 2009, it is hoped that there will be improvements in this regard.

An important contribution by the EU for meeting climate change targets is provided by the European Union Emission Trading System (EU ETS), which is the largest multi-national, emission trading scheme in the world, and is a major pillar of EU climate policy. The ETS currently covers more than 10,000 installations in the energy and industrial sectors which are collectively responsible for close to half of the EU's emissions of CO₂ and 40% of its total greenhouse gas emissions. Under the EU ETS, large emitters of carbon dioxide within the EU must monitor and annually report their CO₂ emissions, and they are obliged every year to return an amount of emission allowances to the government that is equivalent to their CO₂ emissions in that year. In order to neutralise annual irregularities in CO₂-emission levels that may occur due to extreme weather events (such as harsh winters or very hot summers), emission allowances for any plant operator subject to the EU ETS are given out for a sequence of several years at once. Each such sequence of years is called a Trading Period. The 1st EU ETS Trading Period expired in December 2007; it had covered all EU ETS emissions since January 2005. With its termination, the 1st phase EU allowances became invalid. Since January 2008, the 2nd Trading Period is under way which will last until December 2012. Currently, the installations get the allowances for free from the EU member states' governments. Besides receiving this initial allocation on a plant-by plant basis, an operator may purchase EU allowances from others (installations, traders, the government.) If an installation has received more free allowances than it needs, it may sell them to anybody.

In January 2008, the European Commission proposed a number of changes to the scheme, including centralized allocation (no more national allocation plans) by a EU authority, a turn

to auctioning a greater share (60+ %) of permits rather than allocating freely, and inclusion of other greenhouse gases, such as nitrous oxide and perfluorocarbons. These changes are still in a draft stage; the mentioned amendments are only likely to become effective from January 2013 onwards, i.e. in the 3rd Trading Period under the EU ETS. Also, the proposed caps for the 3rd Trading Period foresee an overall reduction of greenhouse gases for the sector of 21% in 2020 compared to 2005 emissions. It is also under consideration whether or not to extend the EU ETS to other industries. The Commission adopted a proposal to extend it to aviation which is now being discussed by the Institutions which have already reached an agreement.

2.3.5 Global and EU trade policies

International trade is clearly linked to transport, and so world and EU trade policy will both act as policy drivers for transport. This subsection makes a brief description of world and EU trade policy, including definitions of the organisations and treaties involved.

The World Trade Organisation (WTO) is an international organisation designed to supervise and liberalize international trade. The WTO came into being on January 1, 1995, and is the successor to the General Agreement on Tariffs and Trade (GATT), which was created in 1947, and continued to operate for almost five decades as a *de facto* international organisation. The WTO deals with the rules of trade between nations at a near-global level; it is responsible for negotiating and implementing new trade agreements, and is in charge of policing member countries' adherence to all the WTO agreements, signed by the majority of the world's trading nations and ratified in their parliaments. Most of the WTO's current work comes from the 1986-94 negotiations called the Uruguay Round, and earlier negotiations under the GATT. The organisation is currently the host to new negotiations, under the Doha Development Agenda (DDA) launched in 2001.

With respect to the EU, Dür and Zimmerman (2007) claim that “[w]ithout a doubt, foreign trade negotiations are among the most important and consequential manifestations of the EU as a global actor”. A summary recent developments describing the EU's common trade policy ("Common Commercial Policy": CCP) can be found at http://ec.europa.eu/trade/issues/newround/index_en.htm and is here reproduced. As a result of the CCP, where trade, including WTO matters, are concerned, the EU acts as one single actor, with the European Commission negotiating trade agreements and representing the European interests on behalf of the Union's 27 Member States. The legal basis for the EU's trade policy is Article 133 of the European Community Treaty. On this basis, the Commission negotiates on behalf of the Member States, in consultation with a special committee, "the Article 133 Committee". The 133 Committee is composed of representatives from the 27 Member States and the European Commission. Its main function is to coordinate EU trade policy. The Committee meets on a weekly basis, usually on a Friday in Brussels at the headquarters of the Council of Ministers. It discusses the full range of trade policy issues affecting the Community, from the strategic issues surrounding the launch of rounds of trade negotiations at the WTO to specific difficulties with the export of individual products, and considers the trade aspects of wider Community policies in order to ensure consistency of policy. In this Committee, the Commission presents and secures endorsement of the Member States on all trade policy issues. The major formal decisions (for example agreement to launch or conclude negotiations) are then confirmed by the Council of Ministers.

The current WTO trade round, the Doha Development Agenda, provides a good example of how trade policy is coordinated in practice. The Commission sets and carries forward the priorities and aims of the EU as laid down in guidelines given by the Council of Ministers. Officials from the Commission's Directorate General for Trade, under the authority of the Commissioner are charged with actually conducting the negotiations, and speak on behalf of the EU as a whole. Coordination with Member States is assured at all times through the 133 Committee, while the Commission regularly informs the Parliament. At the end of the Round, the Council has to agree formally the outcome.

The issue of trade and the EU is a well-researched subject, and there are a number of published papers about it in a variety of journals, in particular in the *Journal of Common Market Studies* (JCMS). In fact, a special issue of JCMS in 2007 was devoted to “the EU in International Trade Negotiations”, with an introduction by Dür and Zimmerman (2007). Much of the details described in the papers in this special issue concern the operational characteristics of recent trade negotiations carried out by the EU (such as with Chile, China, Mexico, Russia and South Africa). However, underlying this detail are a number of highly strategic long term issues which are of particular importance to TRANSVISIONS. In a nutshell, these cover alternative future visions for world trade, and consider how current and future trade policy might enhance or hinder such visions.

A further task to be carried out by TRANSVISIONS (in Task 3) will be to examine the extent that there is a conflict between increasing world trade and environmental factors (particular concerning greenhouse gas emissions), and the extent to which integrated policy can resolve such conflicts.

2.3.6 Global and EU changes in security policy

In the aftermath of various terrorist incidents since 2000, security has become a high profile policy issue. Given that many of the targets of terrorist attacks are transport-related, security policy has obvious overlaps with transport policy. Furthermore, there is a connection since operational measures to enhance security are likely to put barriers in the way of mobility, either by actually stopping certain flows of people or goods, or at least by adding time to journeys (as can be currently seen with the extra time need for air travel due to airport security measures). As with many other of the policy drivers considered in this section, it is important that transport and security policy are fully integrated with other types of policy. Along these lines, the Mid-term Review of the 2001 White Paper (CEC, 2006) stated the following policy on security (providing a conscious recognition of the need for transport security policy to take into account competition issues):

“The sustained terrorist threat keeps us aware that transport is both a target and an instrument of terrorism. Following the events of 11 September 2001, the EU reacted swiftly with legislation and quality control inspection regimes to enhance security in aviation and maritime transport. This *acquis* will be refined on the basis of experience. A level playing field needs to be stimulated where the cost of security measures is likely to distort competition. Security rules may need to be extended to land transport, including urban transport and train stations and the intermodal logistics chain. Moreover, an in-depth analysis has to be carried out concerning critical transport infrastructure within the framework of the ‘European programme for critical infrastructure protection’ (EPCIP). On the basis of EPCIP, ongoing work

concerning critical transport infrastructure may result in specific protection measures being proposed taking into account all risks and in particular terrorism. Careful consideration needs to be given to international cooperation in order to improve worldwide standards and avoid unnecessary and costly duplication of controls.”

For understandable reasons, much of the emphasis of security policy since 2001 has been upon short-term measures to resolve immediate threats, and there has arguably been less focus upon long term strategic security issues (of the type that are consistent with the long term future thinking of TRANSVISIONS). Before considering such issues, it is worthwhile stating the current legal basis of the EU with respect to formulating security policy. According to the Treaty on European Union, Article 11, (the 1992 Maastricht Treaty), the European Union defines and implements a common foreign and security policy covering all areas of foreign and security policy, the objectives of which are:

- to safeguard the common values, fundamental interests, independence and integrity of the Union in conformity with the principles of the United Nations Charter;
- to strengthen the security of the Union in all ways;
- to preserve peace and strengthen international security, in accordance with the principles of the United Nations Charter, as well as the principles of the Helsinki Final Act and the objectives of the Paris, including those on external borders;
- to promote international cooperation;
- to develop and consolidate democracy and the rule of law, and respect for human rights and fundamental freedoms.

A benefit of considering these founding aims of EU foreign and security policy is that it reminds the reader that long term security is very much tied up with the existence of a peaceful world, and that a peaceful world is in turn tied up with concepts of justice (as provided in the final bullet point above). Hence a long term security policy needs to be integrated with other long term policies to promote such justice.

In future work within TRANSVISIONS (in Task 3), there will also be need to examine potential conflicts between globalisation policy and security policy, and how such conflicts affect transport policy, or alternatively how transport policy might help resolve such conflicts.

2.3.7 Future governance issues and their impact on transport

The subsections above have been mainly concerned with a description of the role of policy drivers in the present day, although at times mention has been made of potential future developments. If one specific message comes out from this discussion, it is that, from the point of view of the transport sector, policy-making needs to be integrated with policy-making for other sectors of relevance to transport, such as the environment, enlargement, territorial cohesion, trade and security. This confirms the spirit of the statement about the need for integrated policy contained in the 2001 White Paper that is quoted above in 2.3.2.

The current subsection takes up these policy issues, putting a more conscious future orientation on them, and thus helps in further work in TRANSVISIONS in developing future scenarios and pathways towards such scenarios. Rather than try to “predict” policies (which, if one is not careful, can be rather an ad-hoc exercise), the approach taken here is to consider basic alternative trends in governance, since governance is the determining factor underlying

much policy-making. A number of important issues arise when considering governance in the future: these issues can be distinguished by geographical scale (world, EU and local), although of course an issue on one geographical level will have impacts on the other levels.

With respect to the world scale, the IPCC Scenarios (described in Annex II) distinguish between two scenarios (A1 and B1) in which there is a convergent world, so that the issue of world governance becomes increasingly central. On the other hand, in Scenarios A2 and B2, the world becomes more heterogeneous and divergent than at present. Given the fact that transport is the mechanism by which different parts of the world are physically connected, and due to the global nature of some of the negative impacts of certain forms of transport (for example climate change and the overuse of limited supplies of fuel), there is a clear benefit to transport planning in attaining a system of world governance. This point appears to be consistent with the thinking underlying the SEI Scenarios (also described in Annex II), which define the world as currently being in a “Planetary Phase” which could potentially evolve into a utopian future (“Great Transition”) in which there is worldwide equality and justice, or could descend into a dystopian world (“Barbarization”) involving war and general global breakdown. The utopian future would clearly need a system of world governance, though this would be democratic rather than authoritarian. With respect to the policy drivers described above, the Great Transition represents a cohesive and environmentally-friendly world in which security concerns (and hence security policy) do not play a major role. On the other hand, security policy would arguably be the most important policy driver in Barbarization, reducing other policy drivers to minor significance.

On the European level, a basic question can be asked “what will be the EU in the future?”, and this issue has already been discussed above in terms of enlargement and cohesion. Following this discussion, two initial stereotypical scenarios for the future can be identified: a “Cohesive Europe” and a “Competitive Europe”. In a Cohesive Europe, there will be no great degree of enlargement from the current 27 member states (though probably the Western Balkan states will join): development of the EU will be concerned with integrating the populations of these member states to form a cultural and social homogeneity which emphasises (within the overall EU boundary) concepts of equality and justice. On the other hand, a Competitive Europe will grow to take in neighbouring countries such as Turkey, Ukraine and perhaps even Russia and parts of North Africa. The intention of such enlargement would be to attain high economic growth, emphasising very much the “market aspect” of the European Union, without a strong attempt at social cohesion. Both scenarios have obvious problems in the social dimension. Whilst a Cohesive Europe might reach levels of equality and justice within Europe, the question arises as to what is the relationship between the EU population and those outside the EU, particularly those from poorer countries. In particular, there is a risk of Europe descending into a “Fortress Region” and becoming increasingly obsessed with issues of immigration which, by definition, would be “illegal”. In short, for a Cohesive Europe to succeed, it needs to be part of a “Cohesive World”, which would be similar to the Great Transition Scenario devised by SEI (mentioned above). On the other hand, a Competitive Europe would, by its nature, have less watertight boundaries. Whilst at first sight this might reduce the “us and them” distinction between Europeans and non-Europeans, the existence of inequality between citizens within the boundaries of the EU could lead to social conflict between the European rich and poor, and a tendency to “blame outsiders” for such conflict (as can be currently observed with the popularity of a number of far right movements in Europe). In the consideration of all these

issues, transport is obviously an important factor. Firstly, transport is the mechanism by which people cross borders, and the issue of ease or difficulty in making such crossings is a fundamental transport issue. Secondly, an inequitable distribution of mobility possibilities between citizens of Europe is one of the potential sources of conflict in an unequal Europe.

Probably the most interesting governance issue on the local level with respect transport policy-making concerns city governance, and the possibilities of citizen control of transport decision-making on both a city level and on a sub-city level. Initial discussion on this issue was provided above (particularly in the context of the 2007 Green Paper on urban mobility (CEC, 2007a)), where it was claimed that urban transport policy-making provided an appropriate stage for testing various forms of public participation. However, it needs to be recognised that transport is frequently a particularly polemical issue so that “the public” in public participation should not be seen as a homogenous block. It follows, therefore, that mechanisms need to be developed for providing opportunities for people to resolve (or at least explicitly recognise) fundamental conflictual interests in transport planning and that, arguably, the EU can take a lead in helping to develop such mechanisms. Part of this development will need to include research on conceptualising such conflicts, and it can be further argued that an important step in such conceptualisation is to make explicit theoretical recognition of the “social dimension” of transport, focussing upon social, cultural and political dimensions of transport and mobility. This dimension, which has historically been played down at the expense of viewing transport as an “economic activity with environmental impacts”, has been the subject of increased interest in academic research over the past 10 years, particularly associated with thinking within the “New Mobility Paradigm” (Sheller and Urry, 2006).

Finally, the question arises as to how the policy drivers will develop at different levels of governance in the long term future. The approach to answering this question will be to investigate the governance and policy implications of each of the future scenarios being proposed by TRANSVISIONS (described in Chapter 4 of this report). Once this step has been taken, it will be important to investigate, for each scenario, the pathways as to how various transport-relevant policies will develop between now and the (2050) time horizon considered in the scenarios. All this will be tackled within Task 3 of the project, making use of the quantitative predictions being produced by Task 2 of the project.

This analysis will then in turn feed into the analysis of the main issues being considered in Task 3, which are:

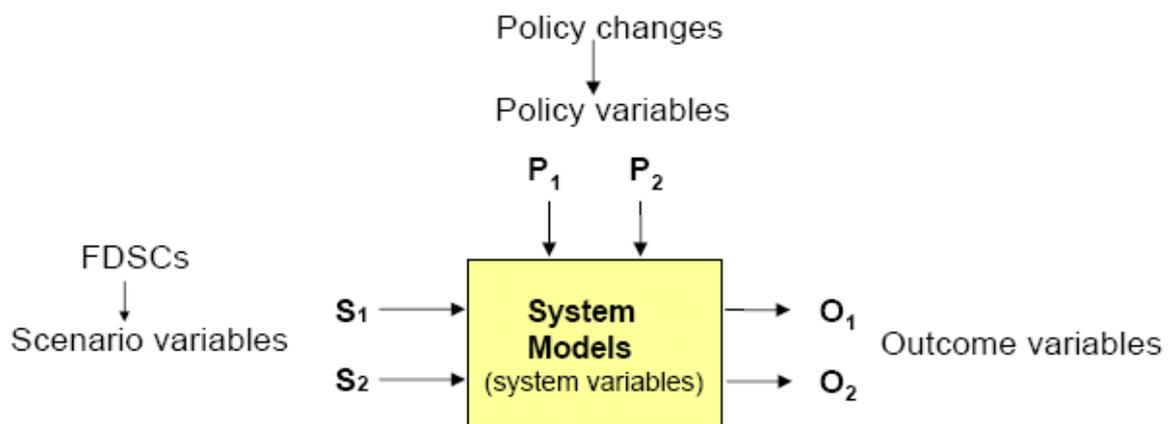
- Identification of main structural trends
- Challenges for transport policy
- Long-term objectives for the European Transport Policy
- Division of labour between political jurisdictions
- Impacts on productivity/competitiveness, environment and well-being

2.4 Modelling of transport systems and “data gap” problems

Figure 41 below specifies how models formally conceptualize the operation of the transport system subject to external and policy influences, and its effects. Outcome variables measure

the performance of the transport system internally as well as externally, for instance on the environment, the economy or employment. The system models represent the parts of the transport system, such as transport costs or network characteristics, the performance of which determines the values of the outcome variables. Two sets of forces act on the system and can lead to changes in the structure of the system and its elements: external forces driving structural change (FDSCs) and policy changes. The external forces are highly uncertain. Scenarios are the analytical tools used to represent and deal with these uncertainties. Policy changes are described in terms of the values of policy variables.

Figure 41: Overview of how to formalise impacts on transport system in transport modelling



Source: THINK-UP Deliverable 10, 2002

System models are designed to use the values of the scenario and policy variables as inputs. When the system models are run, the changes that the external scenarios and the policies produce in the structure of the system produce changes in the outcome variables. This is the basic theory behind the operation of transport models, which rests however on several assumptions that should be adequately understood in order to appreciate what transport models can and cannot do but also for correctly interpreting the projections or analyses they deliver.

In addition, an important requirement to use effectively any quantitative modelling approach to the study of transport system is the availability of a sufficient quantity and quality of data to estimate the values of variables and parameters over time.

Indeed, the modelling of transport flows well into the future rests on a range of statistical time series, such as GDP, external trade, and transport statistics. While some of these, such as GDP, have shown very stable trends in the past so that even disruptive events such as terror attacks or military conflicts may appear as mere blips in the overall curve, there are also a number of exogenous drivers that will undoubtedly affect the overall development of transport in the future. One of the most obvious drivers is energy supply, especially the anticipated scarcity of fossil fuel reserves progressively translating into higher fuel costs and in turn, transport costs.

2.4.1 Data gaps in freight transport

In a very broad definition, a “data gap” in modelling and forecasting the future development of transport is the lack of particular parameters or ratios due to

- Lacking harmonisation of reporting and data collection schemes.
- lack of data coverage / availability in the underlying statistical reporting systems
- breaks in statistical reporting systems
- the value/weight problem
- significant uncertainty of parameter values
- stochastic disruptive input parameters

2.4.1.1 Lacking harmonisation of reporting and data collection schemes.

There are two fundamentally different approaches for capturing and classification of goods flows, which are difficult but not impossible to map onto each other: the trade-oriented and the transport-oriented approach.

Trade statistics.

Since the introduction of the European Single Market in 1993, a two-tier system for trade statistics exists for intra- and extra-community trade respectively, giving existence to two observation methods: the INTRASTAT²⁷ system (direct observation) and the EXTRASTAT system (indirect observation).

In EXTRASTAT reporting of extra-community trade, companies still declare (as before 1993) only to the customs authorities and a copy of the customs documents is processed by the statistical authorities, while intra-community trade activities of companies above a certain threshold must be declared *directly* to the respective national statistical authorities. Important aggregated sources for non-EU trade statistics are the UN Comtrade database and the OECD data base. Not all European countries are members of the OECD.²⁸

The INTRASTAT system is based on the concept of movement of goods between Member States. It is linked to the VAT system of the respective tax authorities to maintain a current, continuously updated register of the relevant EU trading enterprises. In INTRASTAT reporting, goods are classified according to the Combined Nomenclature (CN) regime used by EUROSTAT, and Member states for customs classification. Standard, unambiguous translations exist between the CN and the UN’s Standard International Trade Classification (SITC) used in EXTRASTAT customs reporting. The CN provides an eight-digit detailed hierarchical code for all types of goods and commodities traded which is revised annually and is legally binding for external trade reporting of all member states. The Intra-EU trade statistics record the arrival (import) and dispatch (export) of goods as recorded by each Member State. These statistics do not include goods in transit, i.e., goods that are merely passing through a Member State. A threshold obliges just the larger enterprises to report,

²⁷ System for collection statistics on the trading of goods between Member States, cf Council Regulation No 3330/91 of 7 November 1991 (OJ L 316 of 16.11.91).

²⁸ While data sets still can be completed when one of the trading countries is a member of the OECD, this data source will not disclose any information about trade between, for example, Russia and Slovenia.

easing the statistical response burden on SMEs. Since 1993, the threshold has been raised in several Member States, thus reducing the number of companies obliged to declaring to about 20-30 % of the total number of companies trading in the single market. However, depending on the respective member state, these companies account for between 93% and almost 100% of intra-community trade. Collected by national statistics offices, these data are then sent to EUROSTAT for compilation into EU-wide trade statistics. The monthly reports involving about 500.000 enterprises across the community provide a breakdown of 10.000 products by partner countries and include value, quantity and other variables.

While common Community-wide trade reporting system should ensure consistency, the fact is that trade statistics, even between EU Member states and even between countries with a high harmonisation standard, sometimes do not match. For the past years, for example, the Swedish exports to Finland reported by Swedish authorities do not match the figures for Finnish imports from Sweden reported by Finnish authorities. The Dutch export figures to other European countries are extremely high, due to the fact that the Netherlands, in contrast to Germany, count overseas cargo handled in the Dutch ports as Dutch cargo when it is transhipped abroad. Sometimes these discrepancies are a result of clerical errors (mis-reporting) but in others they are due to a genuine measurement difference (such as using different CN8 codes for classifying goods). The clerical errors can be highly significant, but the “normal” measurement differences are usually manageable. It is common to see the adoption of a convention to handle discrepancies, such as giving priority to importing countries, or regarding some countries’ reporting as more reliable than others.

While intra-EU trade statistics are concerned with the commodities themselves (weight and value) they are not concerned with the transport flows and transport modes used in the physical transport.

Community transport statistics.

The EU transport statistics, on the other hand, are based on the NST/R resp. the NST nomenclature and classification²⁹ which is different from the classification system used for capturing external trade. Transport data are collected by the national authorities responsible for the different transport modes. The ordering principle of NST/R reflects the need of the transport industry to categorise cargo in terms of its transport characteristics (kind of goods, raw/ semi-finished/ finished, transport conditions and volumes). It also reflects the issue that sometimes the true nature of the cargo is unknown to the transport company or that it operates aggregated traffic that mixes different kinds of goods. Therefore the NST/R group 99 “miscellaneous articles” is chosen quite often by transport companies to report what they actually transport.

In its actual use, of NST/R has a three digit structure with 10 top-level chapters (first digit), 52 groups (first two digits) and 176 individual goods (first three digits).³⁰ NST is to be revised to reflect the Classification of Products by Activity (CPA) which is used by the European Union in national and regional accounts for input-output analyses. The CPA classification in turn reflects the criterion of economic origin, with the framework (and thus the definition of

²⁹ The NST largely follows the „Classification des marchandises pour les Statistiques de Transport en Europe (CSTE) created by UNECE (United Nations Economic Commission for Europe).

³⁰ The revised current version NST/R consists of 24 groups of goods and 176 individual goods, the revision NST/2000 which was published in 2006, reorganises the classification into 20 groups of goods.

the economic activities) being based on NACE Rev. 2, the statistical classification of economic activities in the European Community.³¹

4.2.1.2 Lack of data coverage/availability in the underlying statistical reporting systems

For purposes of predicting the impact of trade on the transport infrastructure, it is vital to be able to derive an estimate of the actual distribution of interregional trade flows across the transport network and the different transport modes. Trade data, however, generally does not exist on a regional level. For example, INTRASTAT reports (dispatch) record the region of origin (but only for some Member States), but just the destination Member State.³² Some member states may choose to capture this aspect, but most do not. Transport data for road is generally regionalised in EUROSTAT, but usually not for other modes, such as rail.

In combining different national sets of INTRASTAT statistics, regionalised transport flows may be generated, as has been done in ETIS base on which the TransTools model depends. The allocation takes into account the relative economic strength of regions in countries to estimate their share of the national demand for transport. Regional keys might be based on data about inhabitants, regional GDP and employment figures.

Such secondary data to ‘fill data gaps’ may be generated through approximate recoding, or derived from simulations on the basis of a general equilibrium model. This however is fraught with problems, as can be seen when verifying secondary data against, for example, transport data. Selected comparisons and cross-checks often show that estimates can be wide off the mark. The reason for that may be different decisions as to the category allocation of particular goods under a particular classification system, depending on the choices of the reporting agent or intermediate places such as national statistical offices where data have been harmonised.

Unavailability can also arise through changes in the system to be modelled. The past has shown that new variables (units of measurement) come into being which are not accounted for in the original systems of statistical data collection. The container, for example, which today dominates intercontinental transport, sits uneasily with the traditional commodity classifications. Many and diverse things can be transported in a container, even bulk commodities such as recycled paper, steel or cement. The introduction of containers has led to the situation that while figures are available about the numbers of boxes moved in ports³³, knowledge as to their weight and value must be derived, for example, by mapping inland-bound (i.e. excluding sea transshipment) TEU figures onto the relevant classes in the NST/R based transport statistics.

The capturing and classification of commodity, containerisation, and mode of transport as three separate attributes can help associating trade flows to transport routes. Within extra-EU trade this is often done, so it is possible to estimate containerisation quite well. In this way, trade tonnes can be converted to estimated container TEUs, and compared with port statistics.

³¹ NACE conforms with the International Standard Industrial Classification of all economic activities (ISIC).

³² http://help.sap.com/saphelp_40b/helpdata/en/2b/274520995111d1b4e30000e82d81b0/content.htm

³³ Here, another uncertainty occurs in that containers (TEU) are often counted twice, one when unloaded and another time when reloaded.

The transport statistics, on the other hand, do not differentiate the wide range of containerised goods, which are lumped together as “general cargo” or “other goods”. Some share of these categories will be containerised, others may be break bulk.

In EUROSTAT's port statistics, the commodities handled are broken down into liquid bulk goods (4 subgroups), dry bulk goods (4 subgroups), Large freight containers (4 subgroups), RoRo (7 subgroups) and Other cargo not elsewhere specified (3 subgroups). The share of goods transhipped (i.e. goods that never enter the hinterland) is not treated separately from goods transported towards the hinterland. For countries such as Belgium and the Netherlands, which have a high share of transit traffic towards other European countries, the mode-specific transport statistics are especially hard to relate to genuine import and export trade flows. An overall modal split can be estimated or may, for some ports, be available, but does not exist on the level of commodity groups. This is why it is necessary to construct transport chains from the trade data in order to estimate routeing patterns. Without this modelling step it is usually not possible to harmonise port data and trade data – particularly in transit countries or countries using transit countries.

A significant data gap relevant for the development of the EU economic area is trade between non-EU partners. A Framework 6 research project, WORLDNET,³⁴ focuses on improving the representation of medium and long distance flows, the multi-modal aspects and the relationships between trade and the development of trans-national transport corridors. This should lead to a better representation of trade flows between non-EU partners and their impact on the EU's external and internal trade and transport.

Non-EU trade data is widely available, however, it is mostly reported in values. Often, non-EU countries actually produce better data because they are not part of the Community's 2-tier intra/extra system. However, it is time-consuming to harmonise trade data from more than a few countries. In practice, the use of a single harmonised source (UN Comtrade) is a better option, and key external countries such as USA, China, Japan can then be collected in addition.

4.2.1.3 Breaks in reporting systems

There are changes over time which cause changes in national and EU-wide statistics and data collection systems. These may be political changes such as the introduction of the European single market in 1993, or changes brought about by the EU enlargements where a high share of the external trade of accession countries suddenly had to be reported via INTRASTAT. Another example is the German unification producing a steep change in GDP, population and trade statistics. Revisions of statistical reporting systems often also react to changes over time in the relative importance of goods transported, transport modes, and transport units (e.g. the growing role of the container as a dominant load unit).

Harmonisation efforts by EUROSTAT have also changed national time series, by e.g. defining the minimum distance of long distance transport or changing weight limits in the definition of HGVs. Another example is the somewhat failed reformation of the transport

³⁴ <http://www.worldnetproject.eu/>

statistic classification in the mid 90s with the SAEG groups, which caused a large disruption even down to national transport statistics.³⁵

Whenever such breaks in reporting systems take place, data time series are interrupted, limiting or complicating the extrapolation of future data on the basis of historical data as much as the ‘backcasting’, i.e. the validation of forecasting models by using as input a historical situation for which point onward the future development is already known. While one would prefer to work with time series of more than a decade, it is generally difficult to do this with statistics from more than one country.

4.2.1.4 The commodity value/weight problem

Another aspect that is not available through the current way of trade and transport statistics are changes in the relation between cargo volume and value. To translate trade into transport by assigning trade volumes to transport links and nodes requires trade statistics in weight.

International trade data generally can be obtained primarily in value from customs reporting, and sometimes also in tonnes. EUROSTAT and OECD are exemptions to this rule since they also publish trade in weight. This derived weight parameter may prove wrong due to improper conversion, which would have to be indexed to time to be accurate. As could be seen with prices for steel and industrial minerals, manifold increases of price can occur within very short time periods.

The necessary value-to-weight conversions to arrive at trade flow volumes are therefore fraught with problems and can mislead the data analysis at an early stage. For once, different trade relations may have different value/weight ratios, even if the commodity classification code may be the same (an example, there is the huge span of value across different types of wood). Forecast models that convert value to weight also need to make assumptions regarding future price developments, an exercise that may quickly invalidate results.

If available, the value measurement is often useful as a way of cross-checking weights, since values are subject to far more scrutiny and revision compared to weights. National data and transport data rarely record weight on a detailed level, but since it often groups commodities into broad categories it would be fairly safe to convert using simple value densities. These would not necessarily be the same as the ones that could be derived from trade statistics, but they should not differ by a large margin.

4.2.1.5 Significant uncertainty of parameter values

Certain exogenous factors introduce uncertainty to modelling the future of transport. The prediction of energy reserves is a good example of a significant long term model parameter exhibiting a high degree of uncertainty. Coal reserve estimates, for example, have been rapidly shrinking³⁶ since the year 2000, and some experts now predict ‘coal peak’ as early as 2025³⁷. Other sources doubt that.³⁸ Oil peak is imminent or has already happened, depending

³⁵ KBA transport statistics, 1990-1998, Flensburg, Germany

³⁶ The rapid increase in demand especially in China and other emerging economies has meant that the EU Institute of Energy estimate of the reserves /production ratio of coal has dropped from 277 years in 2000 to just 144 in 2006.

³⁷ Experts at Energy Watch predict that coal will peak as early as 2025 at 30% above 2007 production and then fall into terminal decline

on the source chosen. For transport with its heavy reliance on oil, the increasing cost of fossil fuels may profoundly affect global distributed production patterns, which may follow a new imperative of minimising transport distance. The increasing scarcity of oil may lead to a qualitative or steep change that may no longer be suitably modelled based on known models of fuel price elasticity.³⁹ A similar impact may occur in the tourism sector, especially affecting aviation.

Depending on the respective set of vested interests, there are political reasons both for the overestimation and the underestimation of economically recoverable reserves. The very price development may make reserves economically recoverable that were seen as unattractive at a lower price level. At the same time, it also increases the competitiveness of alternative fuel sources which do not rely on fossil fuels, such as bio fuel-, photovoltaic- or hydrogen-based propulsion. It is hard to predict at what point of scarcity a steep change towards a large-scale development of vehicles based on such alternative energies would be likely, and what the consequences would be in terms of ecological and economic systems.

The turmoil within the US financial market and the onset of a possible recession in the US has recently impacted on GDP growth expectations for most first world countries. As a consequence, long-term growth projections have also eased compared with other long-term trends previously extrapolated. In the US, the ongoing depression of the housing market coupled with the deepening credit crunch, weak job market and inflationary pressures is lowering consumer spending. Forecasts suggest that expenditure might not immediately bounce back to previous strong rates of expansion. Indeed, while the US downturn itself is expected to be rather shallow, the recovery may take longer to gather momentum, and GDP forecasts over the next 5-10 years point to growth below 3% (the US trend rate). Germany as the largest European economy is forecast to have GDP growth rates in the range of only about 2 %.

The decade-long era of strong activity and benign inflation – fuelled by the integration of China into the world economy and some technological inventions that lifted GDP and productivity growth rates – may have just ended. The United Kingdom faces similar challenges given that it, too, is reliant on an influential financial sector and a vulnerable property market. Other countries are somewhat less exposed to US volatility. Recent inflation forecasts suggest a rise of inflation rates for most countries.

A big unknown are emergent changes likely to affect the household incomes and consumer demand, and in turn, demand for goods transport. While gradual, these changes are dependent on the cyclical development of the world economy. Another factor is the development of new, yet unknown, technologies the impact of which is hard to predict (note the erroneous predictions of the paperless office and virtual work environments which may still turn out to be correct but happen much later than originally predicted). Changes of lifestyles and consumption will affect the composition of the basket of consumer goods and in turn, the future types of cargo to be transported. These changes will affect the value/weight ratio, the

³⁸ Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) Hannover, Germany 2006

³⁹ Rizet, C. & Hemery, C. 2008: Fuel price elasticity of road freight transport demand in France (INRETS) http://cost355.inrets.fr/article.php3?id_article=233

granularity/shipment size of cargo, and consequently, the mode of transport to which it gravitates.

4.2.1.6 Stochastic disruptive input parameters

In making predictions of the future transport development, the basic assumption must be that of the validity, in the absence of better knowledge, of modelling a ‘business as usual’ (BAU) scenario which extrapolates currently known trends. This will ensure the best realism possible. It is obvious that the BAU scenario might be far from what will actually happen; it is even likely that even the most conscientious forecast will omit some vital factors that with hindsight will have had a crucial impact on developments. For example, most past forecasts have underestimated the growth of goods transports on the major EU corridors, despite predicted growth rates of some 30-50% - growth rates which were criticised as too high when they were published.

There is a range of potential external events that would profoundly impact on the BAU scenario and future economic (and in turn, transport demand) development. These events include natural and man-made catastrophes, epidemics, and future conflicts, not least in the context of ever scarcer natural resources (fossil fuels, water). However, none of these external events are amenable for inclusion in equilibrium models. Their unpredictability implies that they cannot be treated as ‘data gap’ to be filled for modelling. While the disruption they might cause is useful for consideration considered in qualitative ‘extreme case’ scenarios, they cannot be factored into approximate forecasts of future transport flows.

The iTREN 2030 project⁴⁰ is addressing some of these questions through a modelling approach in which an energy model (POLES) is linked to an economic model (ASTRA), a transport model (TransTools), and an impact model (TREMOVE). The idea is attempt to reduce the dependence upon exogenous assumptions, and to focus upon the inter-dependencies – analogous to the thread of the argument set out above. The approach is also similar i.e. trying to remove areas of genuine uncertainty and statistical improbability. This however, leaves a gap because the approach cannot determine which unlikely events matter. Nevertheless it has been informative to debate the importance of factors such as diverging population growth, migration, and technical change in this context – aspects which are not typically considered in the analysis of transport.

4.2.1.7 New data collection opportunities

The technological development opens up new opportunities for collecting data that may lead to better forecasting of future development of transport. However, not all data that can be recorded can actually be used for statistical purposes. For example, concerns about data protection currently prevent the use of recorded data about truck movements on German motorways. The on-board units of the trucks are already tracked by the system, recording when they pass which control bridges. A number plate recognition system has been widely implemented on the German motorway system, but the automatic recognition of all number plates has been stopped by German courts. Mobile phone providers track the movements of mobile phones on the road network to know first about congestion. Even if none of these examples offer a direct link between commodities shipped and vehicle movements, one

⁴⁰ <http://www.isi.fraunhofer.de/projects/itren-2030/index.htm>

however could construct such links through the clear identification and mutual mapping of the truck and its cargo.

In the future, more cargo (especially high-value and perishable goods) is likely to transmit radio signals permanently, making it possible to read cargo, truck or wagon ID and related information through RFID sensors. While these data sources have not yet proved suitable substitutes for more traditional approaches to data collection, they offer new possibilities, e.g. vehicle routing, or assessing demand by time of day. Problems include the lack of harmonisation / interoperability, statistical biases, and the inability to track cargo trip ends – instead, current approaches are vehicle oriented.

A key concern is data ownership, i.e. the question whether the telematics companies or the operators own the data. In practice, the solution to this dilemma is usually to maintain privacy. Data can be sought with permission but this is often biased by the relatively small sample of operators that one might engage. Roadside surveys would not be biased in this way. Another problem is the sheer quantity of data as telematics systems produce vast amounts of real-time data.

2.4.2 Data Gaps – Passenger Transport

This chapter is twofold by the two sections statistics and networks. While statistics form the base for all kind of analysis and consulting in transport data, the networks of the distinct transport modes (air, rail, road – private car, road – coach, urban passenger transport (UPT) and waterborne transport) are a prerequisite for the topic of modelling and forecasting transport flows and impedances. Both type of information together provide the base for the development of scenarios and are essential to run scenario simulations.

2.4.2.1 Statistics

This section describes mode by mode the data available for passenger transport statistics in Europe, the gaps and what data would be useful to access in addition to complement the information needed to reflect the transport modes realistically and to encounter or circumvent shortages in the data.

Air transport

Air transport is the best monitored mode in Europe. Following EU regulation 437/2003 all member states in principle report the data mentioned below to Eurostat since 2003. Exceptions exist for airports below 150,000 and 1.5 mill. passengers per year concerning the year and the figures which have to be reported to Eurostat. Since 2007 figures for all airports exceeding a volume of 15,000 passengers p.a. should be available. Beside the exceptions stated by the regulation there are numerous, country specific exceptions which unfortunately are not described in a central document displaying which information are not reported for which countries due to data security reasons, e.g. figures of monopolistic routes below an annual demand of 30,000 passengers.

In general the following data are available:

- Passengers by segment, differentiated by the total number of passengers and those who are embarking or disembarking at one of the two airports,
- Passengers by airport, embarking, disembarking, in total,

- Aircraft movements per segment and per airport.

The information is documented on a monthly and yearly base and in various forms of aggregation (domestic, international intra, EU, international extra EU, ...).

In practice some problems occur in certain cases when using these data. For example if the passengers figures reported by airport A for a segment between airport A and an airport B differ from those which are reported from airport B for the same segment. While these two airports are within one country these data usually are harmonised before they are handed out to Eurostat by the distinct national statistics office, data for international segments should be harmonised at Eurostat to be consistent. Member states also report a lot of data for routes which Eurostat does not publish as they just focus on the most important routes (i. e. with highest passenger figures), but to reflect the overall picture of the air transport and to analyse for future scenarios the optimal usage of existing capacities or the competitive environment all data are relevant.

Another problem with the accuracy / validity of these data occur in cases where there is more than one airport existing with the same city code. Every airport has its distinct unique airport code in the IATA nomenclature (three letters) or in ICAO- nomenclature (four letters). Furthermore an airport has a City Code to identify the City it serves (IATA nomenclature). In most cases of small and medium sized airports this City Code is identical to the IATA airport code. In some cases, e.g.

Town	City Code	Airport Name	Airport Code
London	LON	London Heathrow	LHR
London	LON	London Gatwick	LGW
London	LON	London Stansted	STN
London	LON	London City Airport	LCY
London	LON	London Luton	LTN

there are several airports existing with the same city code. When analysing the statistics of the recent years it has been observed that in such cases of multi airport cities frequently there were mismatches at segment statistics (see as well Paris and Berlin).

Another problem is the offset between the time period data are valid and the moment of their publication by Eurostat. Depending on the origin of the data, they arrive quite different at Eurostat. For this reason Eurostat publishes statistics for a distinct year before all statistics for this year are transmitted to them. In cases of international air transport, all information in principle has to be reported from the country of origin and the one of destination. To circumvent the time gap due to delayed reporting of one country this can be compensated by data already available from the other but in cases of domestic air transport this does not work. Thus Eurostat publishes frequently an incomplete set of data instead of waiting until the whole data set is consistent and comprehensive. In consequence one has to be aware that some figures already published may be updated when they got harmonised with data from another country reporting data delayed. This offset in publishing data is very unsatisfying especially if data have already been published or at least partly published by national sources but are still not delivered to Eurostat.

Finally there are a lot of information which would help to cope with actual questions of interest for the transport policy and the definition of future scenarios. The main data interests in view of transport planning, modelling and consulting are the following:

- a) the routing the passengers actually take,
- b) the regional origin and the regional destination of the travel,
- c) airline specific figures, per segment, per airport, in total,
- d) data about the costs, the passenger had for their trip.

Information belonging to a) is available at every airport through the passenger transfer message (SITA message) and some EU member states already monitor the information but do not publish the information. Data referring to b) are at least partly published by a few member states (statistics about the true final destination of passengers). Airline specific figures as mentioned in c) are collected in principle in most countries, but are only published by a few of them in line with national data privacy regulations.

Finally consumer relevant price data are not collected systematically. Just by infrequent passenger surveys for distinct airports or groups of airports such information is monitored. In general the data of such passenger surveys are not public. When looking at the United States this kind of information is collected comprehensively and published freely with a well defined offset by the Bureau of Transportation Statistics (see <http://www.transtats.bts.gov/>).

These data include (extract):

- Financial Schedule consists of financial information on large U.S. certified air carriers,
- Monthly data reported by certificated U.S. and foreign air carriers on passengers, freight and mail transported. The data set includes as well aircraft type, service class, available capacity and seats, and aircraft hours ramp-to-ramp and airborne.
 - T-100 Market (All Carriers)

This table combines domestic and international market data reported by U.S. and foreign air carriers, and contains market data by carrier, origin and destination, and service class for enplaned passengers, freight, and mail. For a uniform end date for the combined databases, the last 3 months U.S. carrier domestic data released in T-100 Domestic Market (U.S. Carriers Only) are not included. Flights with both origin and destination in a foreign country are not included.
 - T-100 Segment (All Carriers)

This table combines domestic and international segment data reported by U.S. and foreign air carriers, and contains non-stop segment data by aircraft type and service class for transported passengers, freight and mail, available capacity, scheduled departures, departures performed, aircraft hours, and load factor. For a uniform end date for the combined databases, the last 3 months U.S. carrier domestic data released in T-100 Domestic Segment (U.S. Carriers only) are not included. Flights with both origin and destination in a foreign country are not included.
- Origin and Destination Survey (DB1B) contains a 10% sample of airline tickets from reporting carriers. Data include origin, destination and other itinerary details of passengers transported.
 - DB1Bcoupon

This table provides coupon-specific information for each domestic itinerary of the Origin and Destination Survey, such as the operating carrier, origin and destination airports, number of passengers, fare class, coupon type, trip break indicator, and distance.
 - DB Market

This table contains directional market characteristics of each domestic itinerary of the Origin and Destination Survey, such as the reporting carrier, origin and destination airport, prorated market fare, number of market coupons, market miles flown, and carrier change indicators.

Applying the collection of such data on a EU wide base would be very useful to set up scenarios, nevertheless it could be considered as critical concerning data privacy issues. In this context it should be noted that in the research community some doubts exist concerning the method of data collection for the U.S. In some cases there seems to be a lag of accuracy, as these figures are reported by the carriers one can find segment-specific inconsistencies when comparing transatlantic figures from Eurostat with those from the US Bureau of Transportation Statistics.

Rail transport

Beside Eurostat for rail there is mainly one central source available for statistics at the 'Union International de Chemin der Fer' (www.uic.asso.fr). The annual statistics concerning their members contains the statistical indicators for UIC member railway companies. 28 tables cover the main areas of railway activity: network, transport stock, staff, operations, passenger traffic, freight traffic, financial results, energy, safety and high speed. While there is information available within this tables e. g. dealing with the rolling stock of the specific railways in depth (e. g. the line length differentiated by single /double track, by running generally on the right / left, by gauge, by type of electrification), passenger transport is mentioned only in global figures, without any regional differentiation.

In detail passenger figures (volumes and mileage) for every railway company are differentiated by:

- Season ticket holders,
- International traffic (as a total),
- Domestic traffic,
- Road traffic,
- Shipping services.

Eurostat publishes country specific extracts of those data. In addition passenger figures for international transport between the EU member states are available at Eurostat. Also Eurostat in principle supplies the numbers of passengers between European countries – in principle, as there are a lot of gaps, some of the figures are considered 'confidential' in a distinct country, some are not delivered or for some there is no information available, as direct tickets between some country pairs are not sold, so that there is no information about such passenger flows.

There is neither information available about the regional origin or destination of passengers, nor any link loads published. Also figures published by the specific national statistic offices do not offer information about flow patterns in passenger rail transport more differentiated than country wide. There may be some slightly more differentiation (e. g. in Germany figures are published for long distance and regional trains) but there are no data available which at least come close to the details applying for air transport.

As the situation concerning origin-destination of passenger flows is already poor, when it comes to link loads (e. g. how many passengers are using a distinct line) the situation is even worse. There do not exist any link load data, neither in differentiation by type of trains (long-distance, regional), nor in total.

It has to be stated, that:

- due to the different volumes between rail transport when comparing with air transport (e. g. passenger rail volumes in Germany come at roughly one power of ten higher than air transport) and
- due to the fact that using railways in general does not require any check-in procedures and
- finally season tickets for the whole or even a part of the network of a railway company exist

It is clear that monitoring of flow pattern in rail passenger transport is not feasible in similar detail as for air transport. Nevertheless the most railway companies do actually have such kind of data, but just refuse to publish them, as long as they are not forced to do so by a regulation. In the light of the upcoming privatisation of railway companies and the importance of competition within and across the transport systems for future scenarios it is a matter of urgency to work out a regulation facing the problem to overcome the data gaps in passenger rail transport.

The costs for travelling by rail are also not available. Although information exists about the specific standard fares in 1st and 2nd class per railway company, there is only rare information available about the actual prices the consumers paid, as most passengers ride trains on discounted tariffs. In some cases it is possible to derive figures for the external sales of railway companies from their annual reports, in a few of them even differentiated slightly (e. g. for Deutsche Bahn, Germany, for long-distance and regional trains). Combining such figures with the passenger-mileage allows at least to calculate the average fare per kilometre and gives a rough idea for the average price for a train trip from A to B, when the distance is known. As the railways tend more and more to apply 'market prices', i. e. a discount is not a fixed percentage for a distinct group of consumers (e. g. like 50% off for children), but refers to a yield-management policy as used by airlines, using average costs per kilometre may become more and more inaccurate, when looking on a distinct railway line or corridor. Therefore a 10% ticket sample may encounter this information shortage as anyhow the data are in most cases anyhow already available in electronic form.

Road transport

For road transport the only two figures published by Eurostat are the passenger mileage - differentiated by private car, bus & Coach and motorised two-wheelers - and the motor vehicle movements per country. In addition there are numerous countries for which even this information is not available (not reported to Eurostat), in fact for 2004 only for seven countries the vehicle mileage is published by Eurostat. Finally the few numbers which are available at all, are relatively outdated, as 2004 data are the latest available for the time being (sept.2008).

There is no information about the number of passenger trips, no regional reference concerning origin and destination of trips, nor does there exist any information about the link loads from this source. For the latter one can apply the UNECE database of links counts. These link counts are published every five years, data for 2005 will be available within the next months.

The data are collected mainly for motorways in Europe, for some countries complemented by information about selected main roads. The data available consist of figures of the average number of vehicles per day. For some countries the numbers are differentiated by the type of

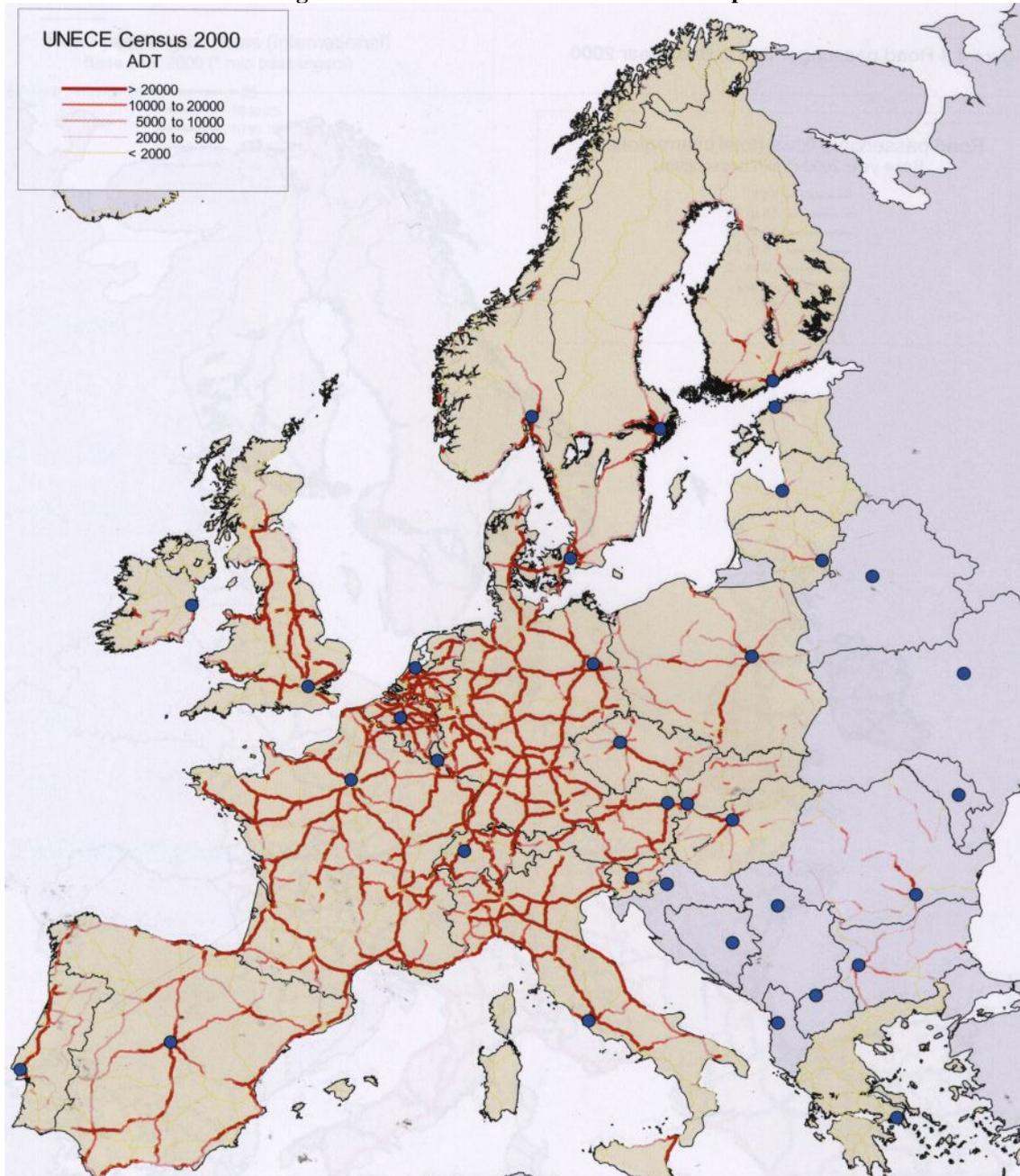
vehicle, while for others only total figures are available. The map below (taken from the ETIS Statistical Handbook) shows the road network for which data is available.

Although these data are quite valuable for transport modelling, forecasting, scenario set up and consulting, these data represent only a small part of the information, which is available in every country. E. g. for Germany data for all main roads aside motorways are collected as well and published annually with an offset of less than two years (see www.bst.de => 'Statistik'). On the level of the Bundesländer data for selected secondary roads is collected additionally. This holds as well for other countries like the Netherlands, Switzerland, Denmark, UK and Belgium. In other countries like France, Italy and Spain the highway companies monitor the flows already in detail but neither publish nor report the data to Eurostat.

Again there is no regulation to help EUROSTAT to capture the major information. So the challenge remains as to collect, harmonise and publish these data from all over Europa at a central place, forming a one-stop-shop (for at least road) transport information. Of course the new member states should be assisted or guided to build up such a monitoring system.

Concerning bus transport it is essential to collect basic information allowing to monitor and analyse the competitive situation with other transport modes and within the bus transport system. For some countries such information is vital for scenario and policy formulations. In this context as well the price question should be elaborated by a 10% survey.

Figure 42 Link loads from UNECE for Europe



Inland Waterways and maritime transport

Referring to Eurostat data just for the latter one date are available. Eurostat lists the number of passengers embarking at debarking at Sea harbours aggregated on country level as well as for all harbours covered. One can further obtain passenger flows differentiated by harbour of origin or destination. The data are available on a quarterly base, as well as aggregated per year. In comparison to the information available for road and rail transport, the details are quite good.

A data-source offering similar information (on yearly base) is the statistical yearbook published by Shippax. These statistics covers nearly all ship and ferry routes all over the

world and provides data about the number of passengers, carried vehicles and the number of trips on the distinct routes.

What is missing for this mode is any information about the real origin or the final destination of the passengers which could be obtained by passenger surveys on a regular base. In addition no information about consumer prices is available, where again a 10% sample would help to encounter the data gap.

Concerning the passenger transport on inland waterways a reporting system has to be established from scratch whereby the transport volumes are quite small so that the policy has to evaluate the trade off between bureaucracy and the relevance of such information for transport policy. Concerning the future scenarios to be developed within this study the relevance / importance is negligible.

2.4.2.2 Network

For any analysis and forecast qualified network information are a prerequisite as they provide the backbone for any scenario simulation. Especially if scenarios have to be developed for a wide time horizon one needs to know how much, where and which type of capacity is available or whether already shortages / bottlenecks are obvious as these are major issues a future transport policy has to face.

Therefore a network data set should fulfil the following criteria:

- Public free availability of data to strengthen and widen the research and to provide a common data platform allowing for comparison of research and analysis results.
- Electronic format for further effective processing.
- Comprehensive by reflecting the network basics as realistic as possible, e.g. links and nodes, and by attributing all details necessary for reflecting the shipment procedures and to allow for quantified and qualified monitoring such as performance, punctuality, security, safety and level of service indicators.
- Consistent across the member states, the neighbouring countries and the intercontinental due to globalisation and general effects influencing the European transport system and the environment.
- Regular data update is obvious to allow for monitoring purposes, e.g. historic development, transport policy effects, as well as providing the decision makers actual analysis and to detect, investigate and encounter aberrations.

Within this section we want to highlight whether the European data landscape allows to withdraw all necessary data to build up mode specific network models or whether data gaps exists and if these gaps can be circumvented by a reasonable effort.

A first question about the public availability of a network data set can already be answered. The European Commission took note about the necessity of a solid data base and took as well action in December 2002 by contracting a consortium of consultants to develop a core database for the European Transport policy Information System (ETIS). This project called ETIS-BASE provided as proof of concept a first data set covering supply and demand information of all modes as well as numerous indicators for the policy decision makers. Besides the ETIS-BASE project of the European Commission there is no public, consistent

and partly comprehensive data source available in electronic format which allows researchers to withdraw the necessary network information.

Unfortunately the data set reflects upon the year 2000 and a regular update was not foreseen, neither concerning the year nor the new member states and intercontinental focus. In addition the ETIS-BASE data set still needs to be enriched by full or semi automatic data retrieval procedures and a permanent maintenance service ensuring the correctness and accessibility of the data. In addition the data gaps and work around routines lined out by the project have to be encountered by regulations, cooperation agreements with transport stakeholders, commercial reporting systems or other data collection projects. But beside the gaps identified this is the only existing source fulfilling most of the above criteria, so that the ETIS-BASE data set is widely used as basic data input in other research projects, e.g. the TRANS-TOOLS project which aims to produce a European transport network model covering passengers and freight, as well as intermodal transport. For further information about ETIS-BASE we refer to www.iccr-international.org/etis/base/index.html .

In the perspective of the coming years the European Commission wants to encounter some of the ETIS-BASE data gaps by other research activities but the projects foreseen do not cover the issue of monitoring and maintenance and they will not solve the severe information shortages in some areas as one want to avoid to stress member states by additional or extended regulations.

Air passenger transport

Concerning the passenger air network information can be withdrawn from commercial available sources like OAG (www.oag.com), HAFAS (www.hacon.de/hafas_e/air-win.shtml) etc. but for using the information as data base one has to negotiate a separate agreement. Of theoretical nature is the alternative to extract the information from the web sites of airports at the time being, whereby this solution is nearly impossible as nobody can scan all airports every month. Another problem of the commercial sources concerns the completeness of information. While nearly all scheduled air services of the legacy carriers are prompted the information, the charter services are partially available as they are often just published by the tour operators and the ones of low cost carrier may be just available on their and the airports web sites in some cases. These two data gaps can only be overcome by a lot of hand work. In addition there is a third data gap which concerns the validity of the commercial available information as these publications are not binding airlines to execute the announced flights. So often flights are listed to safeguard a slot or mislead a competitor but never take place in reality. It is also obvious that the announced aircraft used for a flight is not binding and any frequency, seat capacity, energy usage or emission analysis based upon such data is biased.

To encounter the three data gaps mentioned a solution exists as every flight in the EU is monitored by EUROCONTROL (www.eurocontrol.int/corporate/public/subsite_homepage/index.html). This dataset includes beside some sensitive data all required information to set up a comprehensive and consistent air service database. Moreover a Memorandum of Cooperation between the European Commission and EUROCONTROL is in place which fosters the exchange for research purposes whereby commercial sensitive data can easily be filtered out and airlines would welcome the additional publicity of their services. Installing a permanent exchange of such filtered air service data would as well allow for regular updates and ensure a correct analysis

for a wide range of indicators. Other information available at EUROCONTROL concern node information, respectively information about the airports concerning their technical equipment and capacity, whether they can be provided is a matter of negotiation and the willingness of EUROCONTROL to allow the research community to participate in a wide sense at the know how in contrast to a restrictive commercial business policy.

Various information about airports can as well be withdrawn from air transport associations like the IATA, ICAO, ACI or ATAG such as ‘Airport Capacity / Demand Profiles’ where for a lot of airports around the world runway, apron and terminal capacity details are available (see more details at

www.iata.org/NR/ContentConnector/CS2000/Siteinterface/sites/ps/file/ACDP2003_Infopack_YMQ.pdf), but again this are commercial information, the dataset is not comprehensively covering neither all airport classes in the EU nor all information to describe all details necessary for reflecting the shipment procedures and the data are not available in an open format for further electronic use as well as lacking regular published updates. Details to the source mentioned and other data items one can be found on the web sites

www.iata.org/ps/publications,

www.airports.org/cda/aci_common/display/main/aci_content07_c.jsp?zn=aci&cp=1-6662 or

www.icao.int/icao/en/m_publications.html and

www.atag.org/content/showlatestpublications.asp?level1=4&folderid=431 .

It has to mentioned that there are plenty of other organisations and associations who can be used to draw data from, but the problem is the amount of sources to be contacted to build up a homogeneous consistent database as mostly the distinct information available is not always compatible each other, available for the same year or covering the same attributes. To solve the data problem on the long run would imply that the European Commission co-operates with EUROCONTROL concerning the exchange of non-sensitive data as they have to monitor all the data anyhow due to their business and they are as well already in place doing so. As the European Commission is member of EUROCONTROL they should take the lead to ask all other members to allow for free data usage of non-sensitive data.

On purpose the question of air navigation has not been addressed but there is plenty of information available and published as text, maps on paper and in electronic format. Most these information are not considered directly within transport models as the major bottlenecks are with the airports although the single European sky is highly political and of major importance for this transport system.

Rail passenger transport

Building up networks for the rail mode consists of three elements. Beside the tracks with all their attributes, the nodes (railway stations and intersections) and the rail services including the potential transfer possibilities have to be reflected. While information for tracks can be withdrawn from national railway companies (whereby e.g. the attribute speed has to be made manually compatible), national transport ministries and diverse EU studies, information about nodes are not available in a comprehensive way but can be derived from track information. For some countries the electronic version of the data is as well not publicly available so that again much handwork is necessary to implement the information for electronic usage.

Concerning rail services the major sources are the regularly published schedules of the national railway companies. They contain all relevant information for reflecting reality in a consistent comprehensive way but the sources are not available as database and again a lot of hand work is required to extract the information for implementation. There are as well commercial sources like HAFAS (www.hacon.de) but they just provide software and no database for further electronic use.

Road by individual vehicles and bus

Due to the boom for navigation systems the data world for individual road transport became quite good, consistent and comprehensive. Detailed networks are regularly available about lanes, intersections, speed, tolls, slope, potential traffic jam risks etc. but also here the information are commercial and therefore it is a matter of negotiation to get access to the database and not just the software. A lot of member states already digitised their road networks or are in the process to do so, but their usage is not foreseen to be for free although financed by public money.

To reflect bus transport the road network has to be enriched by the services offered. A comprehensive and consistent schedule for Europe is not available and so one is lost with the fragmented data displayed at rail schedules, local and international operators. These information have to be enriched by the tour operators information which often offer bus and hotel as package deal.

Waterborne transport

The major waterborne services are published in co-operation with the rail services as connections from and to ferries are often part of the public transport chain. In this case the information are regularly updated, consistent and comprehensive. But smaller services, e.g. between the islands of Greece, are not displayed in a comprehensive way and only available from local operators. Nearly all information is available by internet but alike rail not as database for further electronic use.

There are as well certain water roads which have higher priorities to be developed and therefore are reflected within models but the volume of this information is small and available from the European Commission in the course of the roadmap for the development of the Trans European Network for Transport (see TEN-T www.ten-t.com).

Information about harbours is available very fragmented and not commonly published. There are associations displaying a variety of information, but a common source covering the whole of Europe is not available which might be a matter of the fragmented market of inland and deep sea harbours as well as the major differences concerning the passenger and freight business. Concerning modelling reasons and the simulation for future scenarios just the capacity matters, which can be drawn from the maritime web sites.

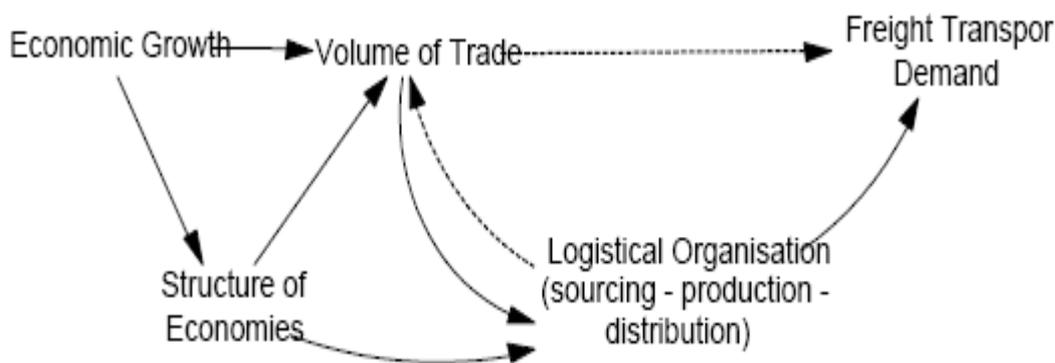
A quite good source of information about the waterborne transport for passengers is prompted by ShipPax which publishes regularly a yearbook displaying service figures and demand statistics for ferries, cruise and port statistics around the world (www.shippax.se). In addition this publication contains some data about the fleet and trade. Unfortunately the information is not in electronic format.

3 Relationship between main drivers and transport

An useful approach to analyse the relationships between the main drivers and transport impacts has been provided by the FORESIGHT for TRANSPORT study⁴¹. The **transport impact pathway approach** has been defined thereof, aiming to make explicit the relationship between a) the generating variable (or driver); b) the intermediate variables which mediate the effect between the causal variable (driver) and the transport impact and c) the transport-related impact.

The following picture clarifies the approach through the example of the relationships between economic growth (the driver) and freight demand (the impact). Despite the fact that the relationship is complex, involving feedback effects between the intermediate variables (logistics) and the impacts⁴², the FORESIGHT impact approach has the merit to identify the key intermediate variables providing the possible impacts on transport.

Figure 43: The transport pathway approach



Source: FORESIGHT project

The transport impact pathway approach requires the following information to be specified:

- Scope: to specify for what transport segment the impact pathway is more relevant, e.g. passenger/freight transport, short/long distance, etc.
- Specific drivers: to specify which variable / driving factor is considered as effecting possible changes on mobility and the transport system.
- Role of intermediate variables : to specify which variables may mediate the above link (between external determining variables and transport impacts).
- Transport impact: to specify what transport-related impacts can be expected from the external determining variables.

⁴¹ FORESIGHT for TRANSPORT, A Foresight Exercise to Help Forward Thinking in Transport and Sectoral Integration, Final Report, 2004

⁴² Such type of effect, in fact, should be taken properly into account using system dynamic transport models

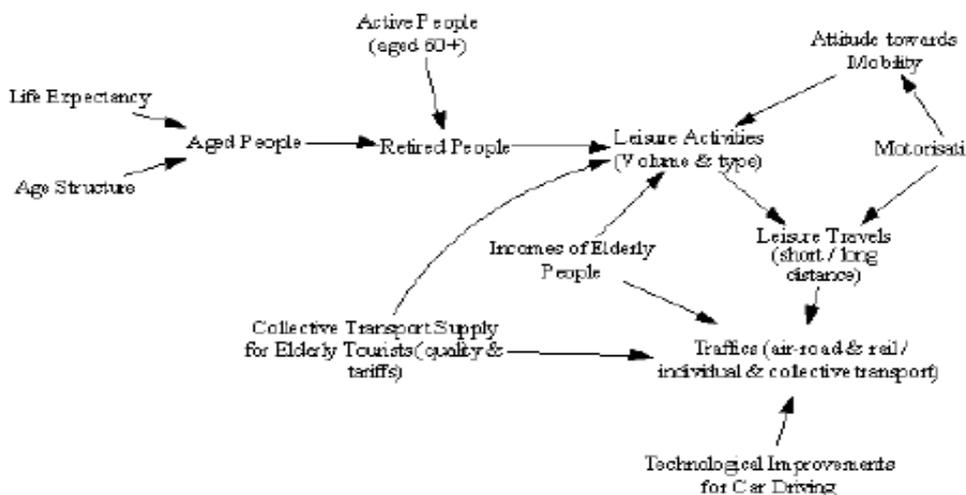
3.1 Impacts of external drivers on passenger and freight transport

3.1.1 Impacts of population drivers on passenger transport

Population is a key variable. The level and composition of the population in terms of person types, with considerable variation in trip making and trip distances between persons by age, sex, economic position, car availability and income, is clearly one of the factors that influences transport demand. Particular attention is paid to the way trip rates change for each person category, and especially in relation to age and income dependent behaviour. Related to that is the role of car ownership. It should be considered in fact that in the future older people will compose a larger share of the driving population than in the past. Older people will wish to retain their driving licence as long as possible and therefore licence holding among older people will reflect licence holding among younger and middle aged people now. Special mention should be made of female elder drivers. Data reveal that women are driving much more than in the past. However, female mobility presents very definite features. Their trips are normally shorter, and they travel less annual kilometres than men do. Therefore, the general conclusions may not be valid to the same extent as for men.

Besides car ownership and driving habits, the ageing of society will affect the transport system through its impacts on the structure and patterns of leisure activities. Nowadays older cohorts are more interested in travelling in their leisure time. In view of the current ageing trends, this will result in the future in an increase of demand for collective forms of transport by road and air. However, older people may show more variable habits in terms of mobility than in earlier times, possibly due to higher average income revenues and better health status of the elderly in the more distant future. In addition, even if collective public transport such as rail are not currently preferred by older people, this could change with significant improvements in terms of quality (comfort, accessibility, information) and adapted tariffs. A detailed representation of the impact pathway of ageing on traffic for leisure purpose is provided in the figure below:

Figure 44: Impact pathway of ageing on leisure traffic



Source: ICCR, Foresight for Transport, Final Report

In any case, the impact on leisure travel will be ensured by a growing segment of retired people.

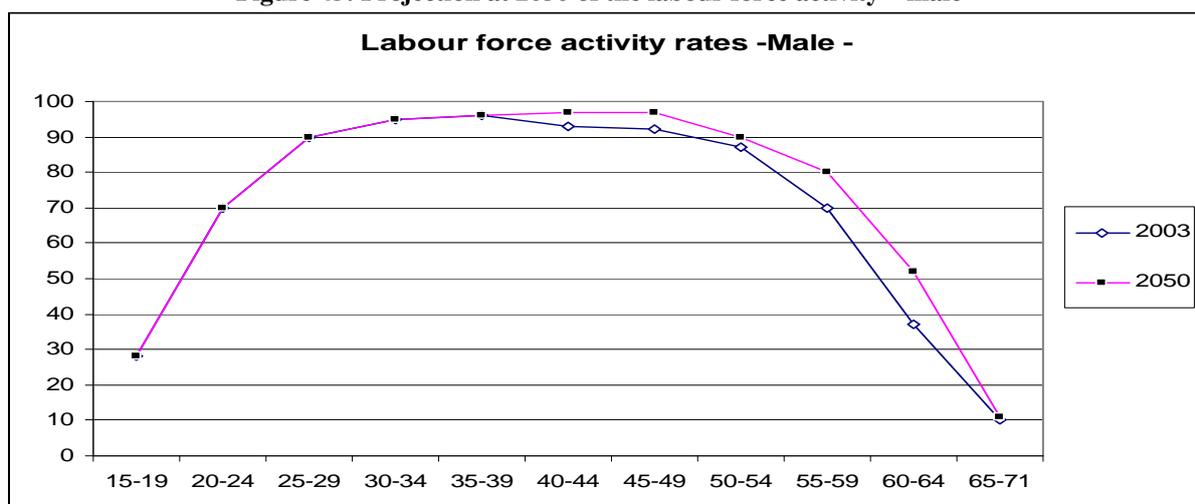
However, another increasingly important segment of elderly people will be constituted by persons aged > 60 still active in the labour market. By this way ageing will affect mobility also through its impact on the labour market. Assuming that labour market demand grows in the future - and technological developments are not such that this increase in labour supply is totally absorbed by teleworking – we can expect ageing to generate a higher transport demand for daily passenger transport of the growing segment of older workers.

Projections of the labour market participation rate of the older people in Europe have been provided in the EC study on the long-term labour force projections (EU 25)⁴³. The study takes account of the potential effects of recently enacted pension reforms in 17 EU Member States, which will be phased in more or less gradually, on the participation rates of older workers. The findings are clear: changing pension plan provisions would have large effects on the labour force participation of older workers

The following graphs show the future trends, namely:

- Looking at the profile of lifetime participation rates in 2003 and in 2050, it can be seen that an upward shift in the participation rates of older age groups (mainly from the age of 45) will occur.
- That is particularly strong for women while the participation rate profiles of the prime-age males and young (both males and females) are assumed to remain generally stable, or increase only moderately over time.
- As a result of these dynamics, the gap between male and female labour force participation rates is projected to narrow down gradually, especially in countries with higher a gap in 2003, such as Spain, where a gap of 25 percentage points in 2003 is projected to narrow down to 12 p.p. in 2050, Greece (from 26 to 16 p.p.) and Ireland (down from 21 p.p. to 12 p.p.).

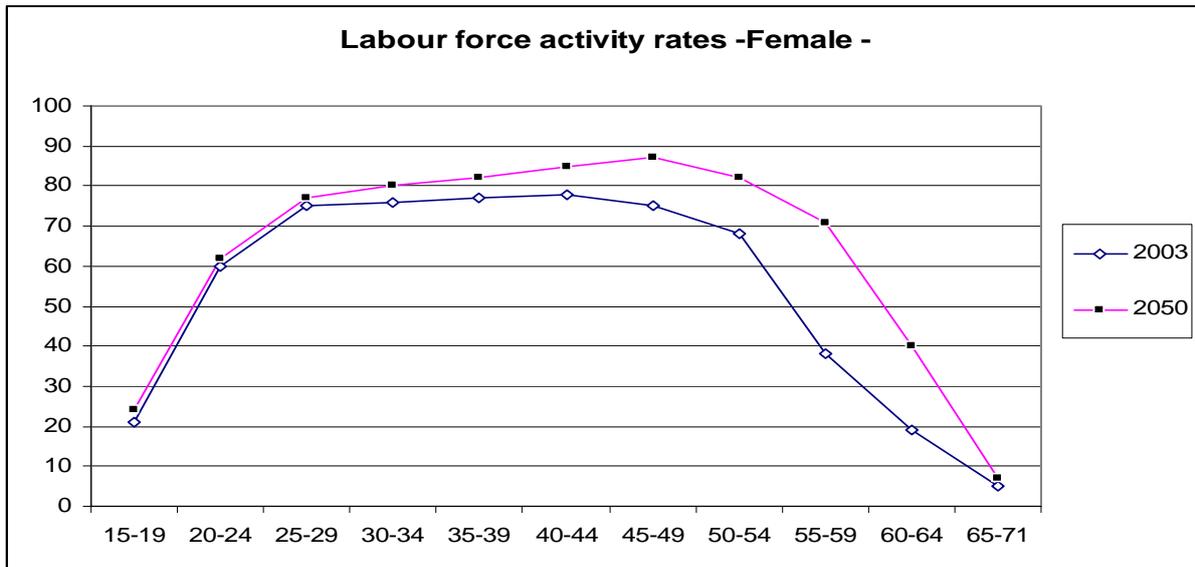
Figure 45: Projection at 2050 of the labour force activity – male -



Source: EC, Directorate-General for Economic and Financial Affairs

⁴³ EC, Directorate-General for Economic and Financial Affairs Long-term labour force projections for the 25 EU Member States: A set of data for assessing the economic impact of ageing, 2005

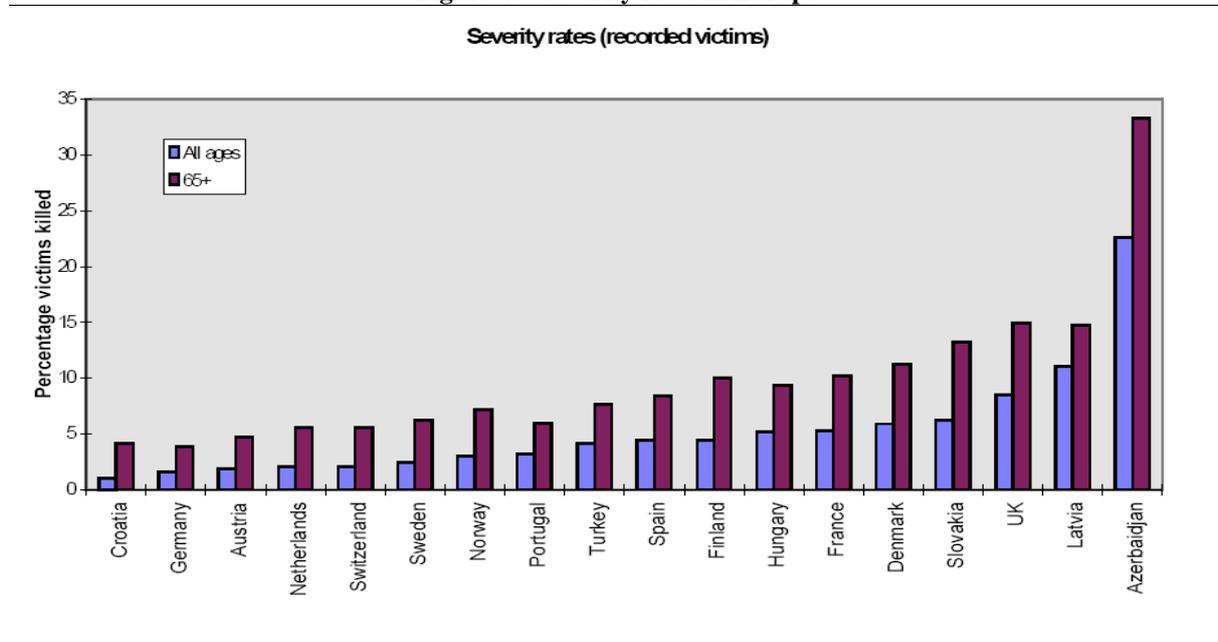
Figure 46: Projection at 2050 of the labour force activity – female -



Source: EC, Directorate-General for Economic and Financial Affairs

The population ageing will also have an implication on the safety side. Accident analysis throughout Europe show in fact that the elderly do not take more risks, but are more at risk⁴⁴, as shown in the following graph in which the percentage of victims over 65 years compared to the other ages. The growing number of frail elderly people will lead to more accidents that are serious or fatal, asking for transport policies ensuring that the mobility needs of elderly people are met in a safe, accessible and sustainable way.

Figure 47: Severity rates in Europe



Source: OECD, Transport and ageing of the population

⁴⁴ OECD, Transport and ageing of the population, February 2002

Concerning the urbanisation driver, urban growth is accompanied by **urban sprawl** – a relative shift in the location of activities (housing, industries, retail and other services) towards the peripheries of the urban agglomeration. This was and currently is an established trend that affects the growth of modern cities, which can be assessed by taking into account global trends in the housing, retail and business sectors, in order to understand why this phenomenon has steadily marked the development of urban areas over the last decades. It has also important consequences in terms of associated trends of increasingly land consumption and car dependent mobility.

With regard to the **housing sector**, lower housing prices at some distance from the city centres make more convenient for a growing share of households in Europe – and especially young couples and families – to rent or buy houses in the suburbs or even in satellite towns around large agglomerations, as the sum of housing prices and transport prices compare favourably for a given house quality (i.e. available space and comfort) to those derived from living downtown. From around 1960 on, the European **retail sector** has experienced an important development at the urban peripheries and in suburban areas. This evolution was basically spurred by the considerable emigration flux towards the outskirts of the agglomerations (suburbanisation of houses and workplaces), the increasing economies of scale in the retail sector, the changes in the shopping behaviour of consumers, problems in the inner city centres (congestion, parking, high ground prices, scarcity of parcels and buildings), the intention of urban planning to improve services in the urban agglomeration and, finally, the internationalisation of the retail sector (with the increasing presence in our cities of hypermarkets Carrefour, IKEA etc.). The new peripheral retail centres are the result of two tendencies, namely the introduction of new retail techniques - self-service and hard discount – and, secondly, the appearance of shopping centres, combinations of retail businesses and warehouses. New trends in the retail sector respond also to the intention of diversifying – shopping centres become also leisure centres, sports centres, cultural centres and congress centres. Current urban development – at least in Western Europe - has been characterised also by the shift of **business activities** to suburbs. Indeed, tendency for jobs to increase faster in the suburbs and on the urban fringes than in the centres and inner districts of metropolitan areas is characteristic of all developed countries. Nowhere this is more true than in the USA, but decentralisation of employment is also taking place in most European cities. The location of high-tech and often footloose enterprises is relatively independent of the location of raw materials and markets. Fast accessibility to regional, national and international markets is gaining importance at the expense of proximity. “Gates” - namely nodes of internationally oriented, multimodal and goods-intensive activities such as major airports and railway stations - are becoming increasingly strategic in the development of trans-national market networks. Nearby these nodes all kinds of economic activities locate themselves in order to have a fast connection to the rest of Europe or to be accessible for a big market. At the moment this trend is especially evident in the North West European area, where internationally oriented airports and railway stations are increasingly taking the status of urban poles re-shaping the spatial structure of the surroundings.

However, it is important to note also the signals of a reverse trend towards **re-urbanisation** and revitalisation of the inner cities, with a number of brownfield development projects creating a mixture of workplaces and residences in downtown areas, increasing the level of residential densities, combined with the realisation of attractive public spaces and the availability of efficient public transport systems. Active urban redevelopment and renewal

policies in many urban areas seem to be having some success in reversing the depopulation and decay of urban centres. This reverse trend is facilitated by the decline of household size – single or two-persons households have a higher propensity to locate in the urban centres – and by the growth of the creative knowledge intensive economy, with its strong preference for inner city environments. Urban centres have usually succeeded also in maintaining their position in the retail sector by specialising, offering a wider high-quality products selection.

As a main consequence of urbanisation, per capita urban **land consumption** is increasing, including the land that has been converted from rural to urban use to provide for jobs, recreation and entertainment, shopping, parking, transportation, storage, government services. Transport network and corridors are still the major consumers of space. Land resources in most of Europe are relatively scarce, and achieving a sustainable balance between competing land uses is a key issue for all development policies. Large-scale urban agglomerations and extended peri-urban settlements resulting from the increasing urban sprawl fragment large landscapes and threaten various ecosystem processes through near-complete reliance on importing material goods and unsustainable resource use.

Finally, there is an important relationship between the urbanisation driver and daily **commuting patterns**. Indeed, one of the consequences of urban sprawl is an increasing dependence on the automobile for intra- and inter-metropolitan travel. Urban sprawl entails building extensive transportation systems because houses are increasingly far away from workplaces and commercial centres. This new constructed infrastructure, in return, spurs further urban sprawl – investments made in new motorways or road connections attract new development along the improved transport lines. Growing car ownership and the concentration of work and shopping in out-of-town locations have resulted – and may continue to result - in continuing increases in journey length for all purposes, but particularly for commuting. Trends in trip lengths in some EU 15 countries (e.g. the United Kingdom, Denmark and Belgium) showed a growth in travel during recent decades, with people living further away from work, leisure activities, shopping centres and schools (EEA, Indicator Fact sheet – TERM 2001 14 EU). Increased average trip length and suburb to suburb trips increase fuel consumption and related emissions of air pollutants and greenhouses gases. This low-density living and car dependency creates also another major drawback, i.e. the difficulty maintaining a sense of community in a car-dependent society (Schiller, 2001).

A summary of the demographic impacts, separately on passenger and freight transport, is provided in the table below:

Table 8: Summary table on transport impacts from demography

Specific drivers	Role of demography intermediate variables	Impacts on passenger transport	Impacts on freight transport
Later retirement	People > 65 in labour market	Higher transport demand, short distance trips (road, rail, local public transport)	
Population Ageing	Higher life expectancy	Higher transport demand, short/medium distance trips (air/rail)	

Specific drivers	Role of demography intermediate variables	Impacts on passenger transport	Impacts on freight transport
	Older people aged 80 and over	Increase of accidents (road)	Increased home delivery of goods
	Reduction of household size	Higher transport demand, short distance trips (road, local public transport)	
Urbanization patterns	Urban sprawl	Higher transport demand, short distance trips (road, rail)	Higher transport demand, Long distance, optimization of transport chains

3.1.2 Impacts of fuel prices on passenger and freight transport

Oil currently plays an important role in the transport system in three primary ways. Firstly, and most obviously, oil provides the fuel that powers the majority of vehicles. Secondly, oil is the major input into the asphalt and bitumen used to construct and maintain road surfaces. Finally, the majority of public transport (PT) services are dependent on diesel – although to a lesser extent than private vehicles. Thus, when oil prices rise and consumers are faced with higher prices for petrol and diesel, government agencies are confronted with higher costs for maintaining and constructing road infrastructure as well as higher costs for operating public transport services. The price of oil is therefore a key driver of the cost of using, maintaining, constructing, and operating the transport network.

High oil prices affect all economic sectors and determine several macroeconomic impacts. A distinction shall be done in this respect between oil shocks and sustained high prices. A spike is defined as a large transient increase in price which subsequently subsides. Sustained high prices are, by contrast, a large and persistent increase in price. These two events differ in terms of what responses people are prepared to take and also in terms of what responses government agencies are able to provide.

The responses of individual households to an oil shock are likely to be dominated by short term measures, such as telecommuting. These decisions are typically made in the knowledge that reversion to standard travel patterns will be possible in the near future (IEA, 2005). In contrast, when exposed to sustained high fuel prices individuals are likely to opt for more permanent and enduring responses, such as locating closer to their usual destinations. Government responses to an oil shock are likely to be dominated by measures designed to manage the fuel supply so as to maintain the integrity of essential services and the rule of law. This may require the implementation of heavy handed measures, such as fuel rationing programmes (IEA, 2005). In contrast, government responses to sustained high oil prices may more reasonably focus on accommodating long term changes in demand for certain travel and land use patterns.

Improvements in vehicle technology may be also expected to mitigate the impacts of rising fuel prices, by reducing the sensitivity of travel demands to increasing fuel prices. Improvements in vehicle technology generally fall into one of two key categories: improvements in fuel economy and alternatives to oil.

Fuel economy describes the amount of transport fuel consumed to travel a certain distance, often in litres of fuel consumed per 100km travelled. Technological improvements have resulted in sustained improvements in fuel economy. Uptake of these vehicles tends to be related to the price of transport fuels – with the period immediately following the oil shocks of the late 1970s and early 1980s seeing hitherto unmatched improvements in average fuel economy of approximately 1.4% per annum (MED, 2006). Given that many new vehicles have fuel economies in the range of 5-6 litres/100km, increased uptake of existing technology will certainly assist consumers to offset the impacts of sustained high fuel prices. Mopeds and motorcycles provide even greater fuel economies and have indeed seen rapid growth in numbers in the wake of recent fuel prices. However, this trend has been somewhat counter-acted in recent times by the increased prevalence of large vehicles.

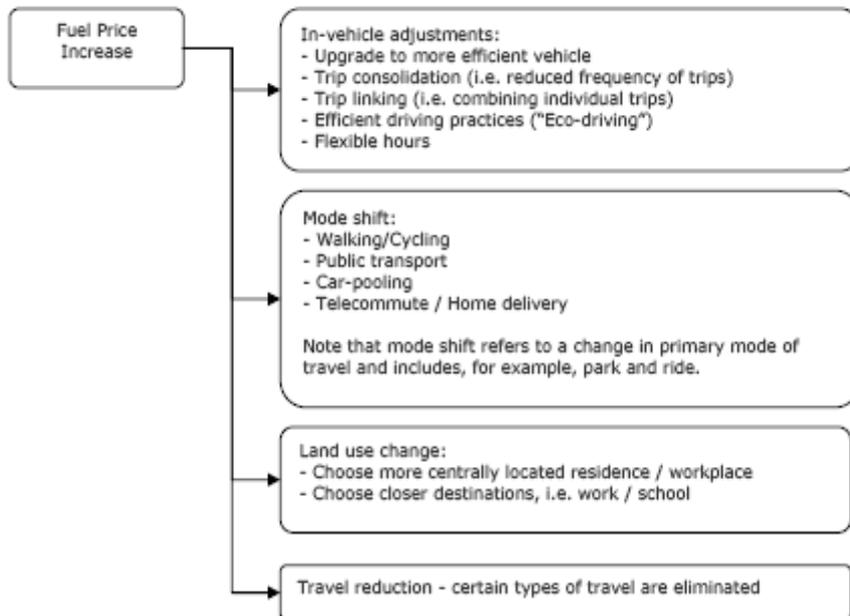
Alternative transport fuels are also receiving increasing attention as a means to decouple motorised travel from oil based transport fuels. These fuels include technologies such as electric vehicles (EV) and hydrogen fuel cells, which may allow for the substitution of oil based transport fuels with electrical energy.

All in all, nevertheless, the transport sector's demand for oil is less price sensitive than any other part of the economy. This is in part because demand for transport services is relatively insensitive to price and in part because substitutes for oil in road transport are currently far from cost-effective. In addition, the impact of international oil prices on transport is moderated by the role of excises, which for road transport represent on average about 40% of pump prices and which cushion the impact of oil prices rises. Excise duties, especially those on gasoline (Euro Super 95) still vary considerably across EU countries, from 300 €per 1000 litres in Cyprus up to more than 700 €per 1000 litres in the UK. Other countries where the excise duties are particularly high – i.e. 600 € per 1000 litres or more – are Belgium, Germany, France, Netherlands and Finland, while in Denmark, Italy and Portugal the excise duties are more than 500 €per 1000 litres.

In the passenger transport sector, consumer responses to changes in fuel prices are measured through elasticity. According with OECD (2008c) the price elasticity of fuel demand is fairly low, meaning that prices have no big impact on demand: a 1% increase of fuel price is estimated to lead to a 0.1% short term decrease in vehicle – km. In the long term the decrease is 0.3% per vehicle (EEA, 2007b). Since the absolute value of the elasticity is below one, fuel consumption declines when prices rise but expenditures increase. The resulting shifts in allocation of expenditures to travel from other goods and services depress consumption in other parts of the economy, and results in a transfer of wealth to domestic and foreign oil producers.

For the households that currently do have access to at least one vehicle, responses to higher fuel prices are likely to fall within one of the following four categories: in-vehicle adjustments; mode shift; land use changes; and travel reduction. These categories, and examples of the types of responses they include, are illustrated in the figure below. They provide a simple behavioural framework through which the effects of higher oil prices may be interpreted.

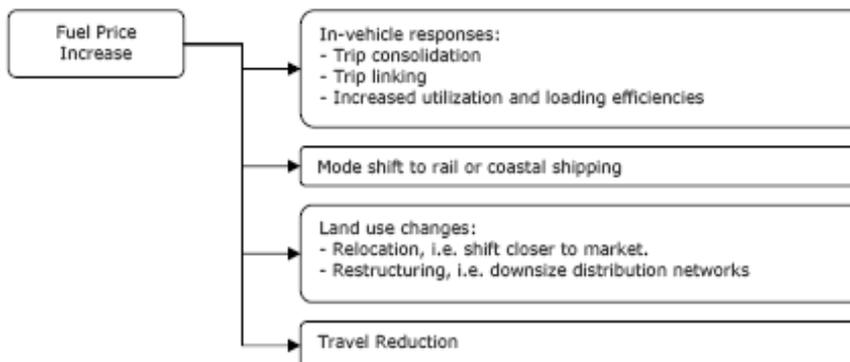
Figure 48: Personal Travel Demand Responses to Fuel Price Increase



Source: New Zealand Transport Agency, 2008

In the freight transport sector, commercial travel demands are expected to be less sensitive to oil prices than light passenger travel demands. This reflects the latter’s higher economic utility as well as the fact that fuel represents only a small component of overall operating costs. Commercial travel demands are thus more strongly linked to economic growth (Mackie et al., 2006). Commercial travel demand responses to rising fuel prices are summarised in the figure below. This is similar to that previously considered for passenger transport.

Figure 49: Commercial Travel Demand Responses to Fuel Price Increase



Source: New Zealand Transport Agency, 2008

As it concerns more in detail the international freight movements, high oil prices may be expected to give international shipping an increased price advantage over air for the movement of non-time critical international freight. This is likely to reinforce the importance of ports as the origin and destination of international freight movements, as well as increase

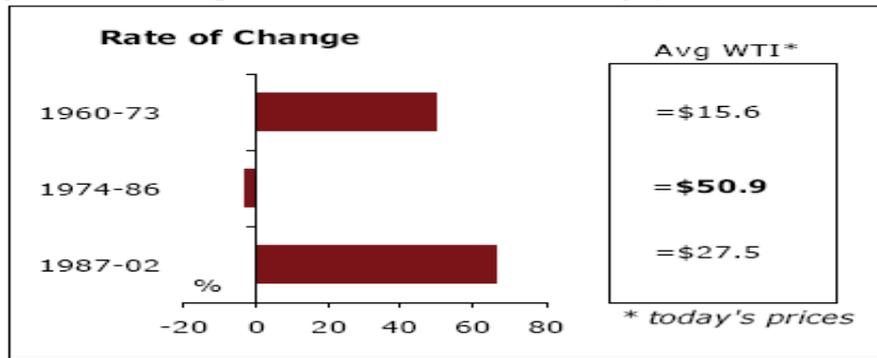
the importance of high capacity terminals able to both physically accommodate and rapidly unload large ships.

High fuel prices may also drive consolidation in international freight movements around fewer larger terminals located close to markets, increasing the potential benefits of coordination, cooperation, and specialisation between individual port companies. Sustained high oil prices may have specific implications for major airports, which may be expected to suffer from lower volumes of air passengers.

It may be even contended that the current trends towards a slower growth of world trade may be interpreted as a signal that globalisation is reversible. Indeed, this thesis is supported by a recent study of the Canadian Investment Bank (CIB; Rubin & Tal, 2008), based on the assumption that when high energy prices – as those currently experienced today (in 2008) - are impacting transport costs so much, the cost of moving goods, not the cost of tariffs, is the larger barrier to global trade. The issue is particularly sensible for world-wide long distance maritime transport, as according to the CIB study, the recent explosion in global transport costs, in tariff-equivalent terms, has effectively offset all the trade liberalisation efforts of the last three decades. Not only does this suggest a major slowdown in the growth of world trade, but also a fundamental realignment in trade patterns.

Indeed, recent developments in sea freight transport have led to increased sensitivity to higher energy prices. Most notable of these changes is the massive trend towards containerization that effectively makes shipping costs more vulnerable to swings in fuel costs. Container ships can be unloaded much faster than break cargoes so they spend much more time at sea than in ports. Another factor is speed, as the shift to container ships has increased the importance of ship speed. Over the past two decades, container ships were built to go faster than bulk ships and since container ships were steadily gaining share, the world's fleet speed picked up. But greater speed requires greater energy, as it does in all other modes of transport.

To show how higher energy costs translate directly into higher shipping costs, Rubin & Tal (2008) made an interesting computation. At today's oil prices, every 10% increase in trip distance translates into a 4.5% increase in transport costs. The duration of a typical sea voyage from China to North America is four weeks. Including inland costs, shipping a standard 40-foot container from Shanghai to the US eastern seaboard now cost \$8,000. In 2000, when oil prices were \$20 per barrel, it cost only \$3,000 to ship the same container. But at \$200 per barrel, it would cost \$15,000 in transport costs to ship from China to the US eastern seaboard. Such soaring transport costs suggest that world trade should be both dampened and diverted as markets seek shorter, and hence less costly supply lines. This is actually what happened in response to past OPEC oil shocks, as it is illustrated by high sensitivity of the rate of change of world exports as share of global GDP to oil prices in the figure below:

Figure 50: World Exports as a Share of Global GDP: Highly Sensitive to Oil Prices

Source: Rubin & Tal (2008)

Between 1960 and 1973, exports as a share of world GDP rose by over 50%, a function of both falling trade barriers and cheap transport costs when oil prices averaged less than \$16 per barrel (in today's prices). Similarly 1987-2002 saw another quantum leap in world trade, spurred not only by a 30% drop in tariffs but by still relatively cheap transport costs grounded by an average \$27 per barrel oil. In sharp contrast, exports as a share of world GDP slightly decreased between the first OPEC shock and the aftermath of the second, despite a 25% reduction in global tariffs. No doubt the 1974 and 1981/82 recessions dampened trade, but trade should have rebounded strongly on the back of healthy recoveries from those recessions. Annual world GDP growth averaged 3.5%, roughly the same rate as from 1987-2002 which saw world trade to grow again significantly. Trade failed to respond to a pick-up in global growth because transport costs were exploding due to soaring oil prices. Trade not only failed to grow as a share of global GDP but it also diverted along increasingly regional lines.

However, to what extent will steep increases in transport costs offset the huge (but shrinking) wage differential between Chinese labour and European labour remains to be seen. Indeed, exactly how much trade, soaring transport costs divert from China (or for that matter anywhere else) depends ultimately on how important those costs are in total costs. Goods that have a high value to freight ratio carry implicitly small transport costs, while goods with low value to freight ratios typically carry significant moving costs.

As a matter of fact, a high percentage of Chinese exports fall in the later category, and there is already some evidence that Chinese exports of freight-intensive goods are beginning to slow under the pressure of rapidly rising transport costs. Somewhat different considerations, however, may hold for the European context. For instance, the ECOTRA Study (IPTS, 2006) has computed the incidence of transport costs on overseas export and import flows from/to different regions of the world for six major sectors – medicinal and pharmaceutical products; iron and steel; road vehicles; ferrous metal ores and metal scrap; petroleum and petroleum products. These sectors constitute, in volumes, the majority of the trade flows between Europe and the rest of the world.

The table below shows the values of transport costs at destination⁴⁵ and share of sea transport cost for different long distance routes and products:

⁴⁵ TCD is computed as total transport cost/final price * 100 for specific products and origin-destination links.

Table 9: Transport costs at destination and share of sea transport costs

Indicator	Wheat		Oil		Pharmaceutical		Steel		Iron Ore		Road Vehicles	
	Europe to South Asia	US Gulf to South Asia	Russia to South Europe	Middle East to South Europe	Europe to East Coast US	China to East Coast US	West Europe to Far East	East Coast US to Far East	South America to Europe	Australia to Europe	Europe to East Coast US	Far East to East Coast US
TCD (%)	58.7	56.0	10.0	11.0	0.2	0.2	15.3	15.9	61.9	64,0	4.4	4.5
Sea transport (%)	78	74	29	87	69	89	43	50	51	68	90	93

Source: IPTS, 2006

It is interesting to note that:

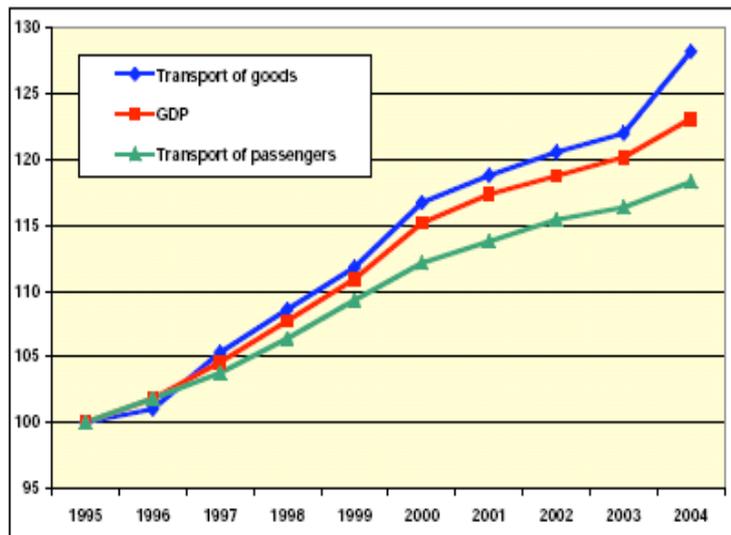
- The incidence of transport cost on final prices of goods (TCD) seems to be in line with the expectations, i.e. it declines with the value of goods; its values are very high for wheat and iron ore, between 10 and 15% for oil and steel, lower for road vehicles (4.5%) and pharmaceuticals (less than 1%).
- For all the commodities and almost all the routes (with the notable exception of the Russia to South Europe connection for oil) the main cost component is attributable to sea transport.

It is evident from the ECOTRA Study that transport is almost fully outsourced and transport prices are low as compared to the final product prices, despite the recent rocketing increase in maritime transport rates. The overall incidence of transport costs on the final prices of goods is on average in the range of 5-10% for processed food, 1-3% in the textile sector, 4% for automotive and negligible for pharmaceutical products. The influence of transport costs is also weakened by the growing demand for more sophisticated and expensive goods – even in sectors like food and agriculture – which reduce the incidence of transport costs. In addition, in the Euro area, the increase of oil prices and related transport costs are tempered by the Euro overvalue as compared to the US dollars. Finally, an important component of transport prices is fuel taxes, but this do not apply to maritime transport: transport from Frankfurt to Berlin pays more fuel taxes than from Shanghai to Hamburg.

All these arguments tend to reduce the importance of the variation of oil prices for the evolution of trade patterns, although it remains true that, depending on the level of energy prices, world merchandise trade patterns may evolve rather differently. In principle, when energy prices are high – in the order of 3-digits per barrel – proximity matters, and regional trade will grow faster than long distance trade, while the contrary will happen when the energy prices are low.

3.1.3 Impacts of economy drivers on passenger and freight transport

The overall consequence of global trade patterns on transport is seen over the decoupling between GDP and freight transport growth. Indeed, the last thirty years of unprecedented growth of world trade, and in particular the post-1990 acceleration, has seen a growing share of long distance trade. Until today more goods were and are still transported over long distances than before. As a result the freight transport volume, as shown in the figure below, grew in recent years faster than the GDP.

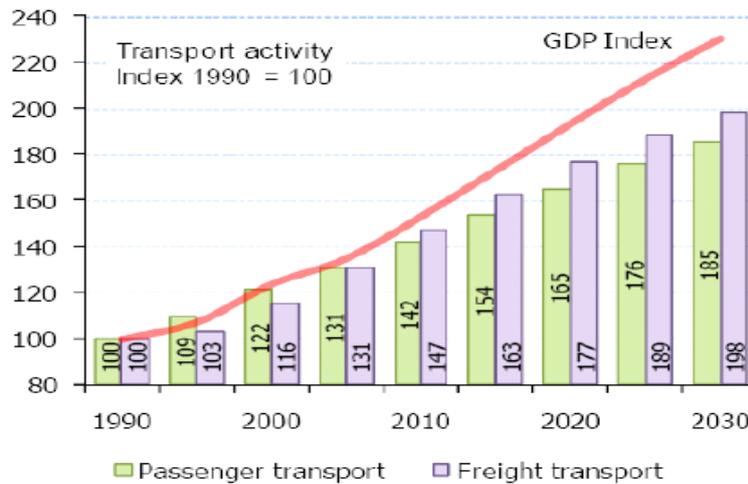


Source: DG TREN: Mid-term review of the European Commission's 2001 White Paper on Transport

According to the analysis presented in the EC DGTREN Baseline scenario to 2030, in the period 1990 to 2005, the GDP elasticity of transportation activity was estimated at 0.90 for both passenger and freight transport. This is a remarkably high value indicating great dependence of economic and social activity on transportation. A closer look at the period 2000 to 2005 shows that the GDP elasticity of passenger transport remained constant at a level just below one, but for freight transportation it became as high as 1.45. This reflects the considerable increase in commodity trading following the EU enlargement and the market integration.

The projections for the EC DGTREN Baseline scenario show values of the GDP elasticity of transportation activity that remain stable over time as far as passenger transport is concerned and decreases over time for freight transport reflecting saturation and productivity gains. For passenger transport, the GDP elasticity is equal to 0.65 on average for the period 2005 to 2030. For freight transport, the GDP elasticity of activity is projected to decrease gradually, first down to 0.92 in 2005-2010, and then further down to 0.72 between 2010 and 2030. As the values of GDP elasticity of transportation activity are lower than one, the Baseline scenario displays therefore a gradual decoupling of transportation from GDP growth (see figure below).

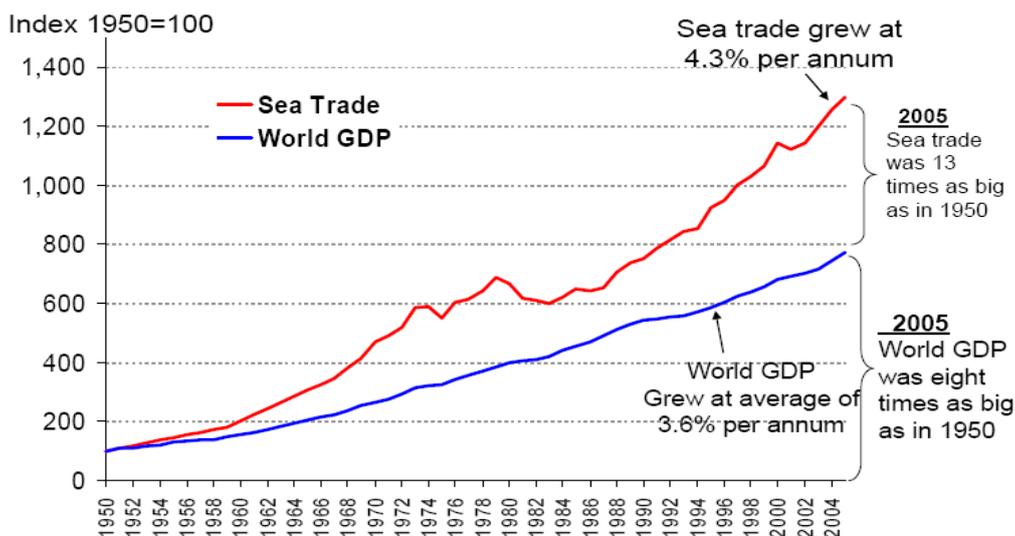
Figure 51: Transport activity growth, 1990-2030



Source: DG TREN, European Energy and Transport, Trends to 2030 – Update 2007

The volume of transportation of passengers is projected to increase at a rate of 1.4% per years between 2005 and 2030 while the volume of freight transport is projected to increase by 1.7% per year during the same period. One of the possible reasons for the decoupling of freight transport could be the dematerialisation of the economy. Decoupling may be greatly facilitated also by growing regional trade patterns, as they could be stimulated by a future persisting high energy prices context. For passenger transport decoupling is already taking place due to low demographic growth, the saturation of the car park in some countries and congestion. Past evidences have shown a tight correlation between maritime trade growth and GDP growth rates.

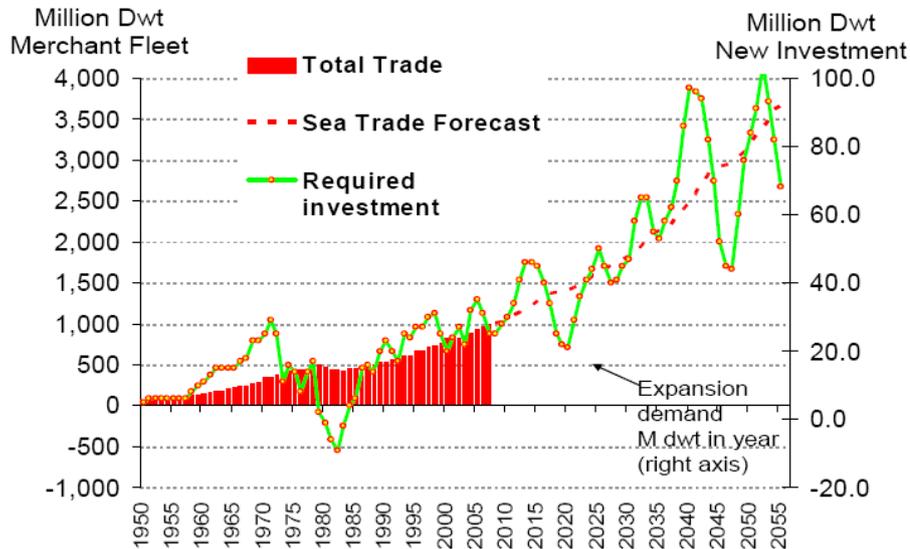
Figure 52: Maritime trade growth rates and GDP



Source: Martin Stopford, Hong Kong Shipowners Association, Will the next 50 years be as Chaotic in Shipping as the Last, 18th January, 2007

If the globalization process is going to continue, the growing demand and supply from China India; Central Asia; Russia; the Baltic states; South America; and Africa may be expected. Sea trade and investment are expected to growth, as in the below forecasts⁴⁶.

Figure 53: Ship demand scenario 2007-2057



Source: Martin Stopford, Hong Kong Shipowners Association, *Will the next 50 years be as Chaotic in Shipping as the Last*, 18th January, 2007

Literature review of recent analysis on the decoupling of transport activity with economic growth⁴⁷ allows to stress the following trends:

- Transport activity is still closely correlated with economic development (GDP growth), despite the emergent trend of weak decoupling is occurring, i.e. the elasticity of transport volume in relation to GDP growth is between 0.5 and 0.8. However, more evidences are needed for deriving long-term stable trends. For example, evidences in the UK (Lenthonen, 2006) warn that the apparent decoupling in road freight transport (Mc Kinnon, 2006) might be at least partly a statistical illusion, due to the non inclusion of freight activity by foreign vehicles.
- The decoupling should be particularly evident in relation to passenger transport. Local mobility flows, characterised by short-medium distance trips, may be considered in fact uncorrelated to growth trends in household income⁴⁸, depending on land use factors. Demographic components as later retirements, population ageing, etc (see infra, section 3.1.1) may act as counteracting factors. The opposite trend may be found

⁴⁶ Martin Stopford, Hong Kong Shipowners Association, *Will the next 50 years be as Chaotic in Shipping as the Last*, 18th January, 2007

⁴⁷ In particular, Markku Lehtonen, “Decoupling freight transport from GDP – conditions for a ‘regime shift’”, 2006, Jérôme Verny “The importance of decoupling between freight transport and economic growth”, 2007 and Alan C. McKinnon “The Decoupling of Road Freight Transport and Economic Growth Trends in the UK: An Exploratory Analysis”, 2006

⁴⁸ As in the French scenarios at 2050 (Ministère des Transports, de l’Équipement, du Tourisme et de la Mer, 2006)

for long-distance passenger flows, in particular by cars and airlines, heavily affected by economic growth and higher disposable income.

- Concerning freight transport, the higher economic growth realized according to the current logistic and industrial developments in the industrialized countries, i.e. outsourcing, warehousing concentration, frequent deliveries, consumption patterns, etc, is going to increase the average distance and frequency of freight movements, increasing the long and short distance freight trips by road, sea and air.
- The possibility to widen the decoupling trends between economic growth and transport activity (in particular for freight transport) in a long-term horizon depends on two factors: a) the reverse trends in logistics processes, through the diminishing rate of spatial concentration and domestic supply chains; b) change in GDP composition, in the direction of a diminishing weight of economic sectors producing and distributing tangible goods⁴⁹.

A summary of the transport impacts from the economy, separately on passenger and freight transport, is provided in the table below:

Table 10: Summary table on transport impacts from economy

Specific drivers	Role of economy intermediate variables	Impacts on passenger transport	Impacts on freight transport
GDP growth	Volume of trade Infrastructure Investment	Higher Transport demand	Higher Transport demand
GDP per capita growth	Disposable income	Spending power in transport services, motorization, long distance trips	Higher Transport demand
Globalization	World trade integration EU integration (e.g. € membership)		Higher Transport demand, long distance trips
	Transport costs reduction	Growth in long term trips, air transport, High Speed train	Growth in long term trips, maritime (container), air cargo
	Outsourcing, delocalization		Growth in logistic services, higher long distance trips, mainly by road
	E commerce, dematerialisation		Growth in parcel shipments, creating an increase in demand for small package delivery as more consumers shop on the Internet, increase in short distance by road (urban) and long distance trips

⁴⁹ Adapted from the UK review carried out by McKinnon (2006)

3.1.4 Impacts of ICT on passenger and freight transport

The impact of Information and Communication Technologies (ICT) on transport is a much debated and still somewhat controversial issue. Indeed, ICT technology is enormously influential in transport, and perhaps this is its main role, namely to influence the operation of transport systems, to provide in-vehicle monitoring and control systems, and to provide information to users of all transport systems (i.e. by means of widespread diffusion of ITS). This role may be more important than that on transport. The latter is usually categorized by means of two possible contrasting effects:

- Stimulation of more travel as new opportunities become available
- Substitution for travel as activities can now be carried out remotely rather than by travel

These two elements are often combined, taking place simultaneously, and the net effect may be for instance, in relation to work trips, that fewer journey to work take place each week, but these journeys may be much longer and so the total distance has increased.

More in detail, it is useful to divide the impact of ICT on transport into three types: production, living and working (Banister and Stead, 2004):

- As it concerns **production**, the impacts affect both the manufacturing systems and logistic and freight distribution. There are two main aspects affecting manufacturing systems. One relates to the direct selling of goods and services over the Internet (e-commerce), which can be business to business or business to customer, and the other relates to changes in the production processes themselves (mainly business to business, such as just-in-time production). The main advantages of ICT is that it provides the potential to cut costs and increase efficiency (by some 20–30%) through electronic transactions that allow the use of computer-aided manufacturing and electronic data interchange. Another aspect relates to production schedules that can be changed weekly according to the variability in demand patterns, with suppliers increasingly acting as retailers. Such developments have led to a reduction in the transport requirements as orders are now processed electronically from the supply of goods to the invoicing of customers. However, as requirements become more demanding, there may be an increase in the number of deliveries required to meet production deadlines with smaller loads. Logistics and freight distribution have been revolutionized by the increased use of ICT. This is perhaps the area in which the impact of ICT on transport is greatest. The structure of the supply chains has changed as the location and size of production, processing and warehousing sites have adapted to the new technology. This has affected the spatial concentration of production and inventory activities, the development of new break/bulk and transshipment systems, and hub satellite networks. The alignment of supply chains has also been altered with the concentration of international trade on hub ports and airports, the rationalization of the supply base, the vertical disintegration of production, the wider geographical sourcing of supplies, customization and the increase in direct delivery. Such changes have been reflected in the increased use of road freight vehicles, as these can be more easily adapted to the new logistics. Transport costs have been further reduced through improved design, the use of containers, and an increase in the freight capacity of ships and aircraft. New automated handling for freight at distribution centres, airports and ports, together with greater modularity and reductions in packaging, have all helped to revolutionize freight systems. ICT has played an instrumental role here in information exchange, tracking and tracing, in enabling new concepts for production and services to be introduced, in cutting turnaround

time, and in determining shipment size and improving loading factors (e.g. according to Mansell, 2001, 28 per cent of lorry distance in the UK involves empty running, and this has been reduced by 20% through freight exchanges).

- As it concerns **living**, a number of activities can be done now through the Internet (e-Everything): these include e-shopping, e-medicine, e-education, e-banking and e-entertainment. In each case, there is a potential substitution effect for existing activities, but the intention is to allow 'low-level' activities to be carried out remotely (e.g. self-diagnosis of minor illnesses or primary-school education). Higher-order activities would still have to be carried out through face-to-face contact, involving travel. The intention is also to encourage greater participation in activities and so generate new customers and revenues. Initially, this should not result in more travel, but there would be increases as new people become involved, and the need for face-to-face contact increases. The direct effects on transport may be some replacement of existing travel, but in the longer term new patterns of longer distance travel may take place as the ICT becomes embedded in lifestyles. Indeed, The indirect effects are likely to be far more fundamental as the new activity and location patterns emerge. It may allow people to live in remote parts of the European Union and to develop locally based travel patterns with occasional longer distance journeys to the city. Other activities will be carried out remotely, and so the traditional problems of rural inaccessibility of isolation may be overcome. However, such futures still leave many questions open about the importance of social interaction. Travel is not only undertaken for functional reasons (e.g. shopping and work), but also it also has been instrumental in establishing social networks. In the city, the need to own a car may be reduced as the quality of public transport and information services is enhanced and as there will be severe restrictions on pollution emissions. Car sharing and innovative forms of leasing may result in less city car ownership. Online booking and debiting systems can be combined with personal digital assistants with embedded intelligence to ensure that high-quality options are presented to allow customized mobility. Finally, another important effect on long-distance passenger travel will be provided by the increasing opportunities of last-minute deals done through the Internet. These have become increasingly important as the flexibility of the Internet has been used to sell excess capacity, particularly for flights, hotels and holidays. The direct effects have been higher occupancy rates on airlines, railways and hotels, as space is sold at costs slightly above the margin. At one level, this may just be using up excess capacity and so there is little additional travel, but in the longer term it may result in additional capacity being designed as new markets are developed. In this case, the growth in long-distance travel is likely to be substantial.
- As it concerns **working**, much of the debate has concentrated on the potential of teleworking to reduce commuting travel. Indeed, much of the evidence is limited (Banister and Stead, 2004), and it seems that there is a substantial potential for substitution of travel to work for home working, but that potential has not been fully realised so far. The increased flexibility has resulted in many self-employed and other workers spending more time working from home, typically 1–2 days a week. The social dimensions of real contact with colleagues are important, and this is also reflected in the need for face-to-face meetings. New dispersed patterns of work may develop as people continue to live further from their workplace and as firms also disperse their activities (internationally and locally). All in all, work-time regimes and tele-working cannot be estimated in the future

as it has been traditionally done. In 2050 there won't be tele-workers and non-teleworkers, but just partial time tele-workers, more flexible work in relation to time (when it is carried out) and place (where). Pretty much everyone is going to tele-work to some extent. People will work at home, in the office, in their weekend apartments. People are going to tele-work some days of the week, they will tele-work as they travel, but they will still be into office work due to human relationship requirements, which are fundamental in business. The net result will be fewer journeys to work, but each journey is likely to be longer. Another result will be the possibility for people to be more flexible in the choice of when moving around during the day, as for instance some activities can be easily done before leaving from home – e.g. e-mails etc. – postponing the trips to workplaces at off-peak times. In this way congestion could be significantly smoothed.

In conclusion, the main question which remains controversial about the impact of ICT on transport is whether ICT acts as a brake or as an accelerator in what currently seems a relentless growth in the demand for travel. The existing evidence suggests there is substantial scope for reducing some types of (less valued) travel demand, like the journey to work, but equally it might encourage other (higher valued) longer distance travel, like leisure travel.

A summary of the ICT impacts, separately on passenger and freight transport, is provided in the table below:

Table 11: Summary table on transport impacts from ICT

Specific drivers	Role of ICT intermediate variables	Impacts on passenger transport	Impacts on freight transport
Global markets	Improves communication, assists global marketing	More long-distance travel for business meetings and services	More long-distance transport for goods
Flexible work-time regimes; e-Office	Technology for flexible and remote working	Reduction in travel frequency; but perhaps longer distance travel (when individuals move further from work) and also substitution of work travel with other travel (with time saved by not travelling to work)	
24-hour economy	Improves one's ability to carry out transactions automatically and in real time	Reduce the need to travel for many transactions, but requires more people to work outside "regular" work hours, with implications for transport modes	
e-Commerce	Internet, sms, e-mail etc.		May reduce the need for the movement of goods in certain cases, e.g. music is downloaded from the web, and orders are transmitted electronically
e-Everything: shopping, medicine, education,	Internet, sms, e-mail, etc.	Reduces the need for individuals to travel for	

Specific drivers	Role of ICT intermediate variables	Impacts on passenger transport	Impacts on freight transport
banking, entertainment, chat rooms, network games, etc.		many transactions, but may also lead to new journeys to replace the ones that would have been necessary in the absence of the e-activity or to completely new demand resulting from social networking. e-ticketing may increase the convenience of public transport	
Just-in-time production	Technology for stock control, ordering and tailored production		More frequent deliveries. Smaller loads, faster delivery, more air movements
Logistic and freight distribution	Real-time route guidance, track and trace technology optimizing delivery vehicles and routes		Savings in reliability and travel time, but may add to journey distance. Possibilities for trip chaining and load matching. Also savings in terms of vehicles and route choice
Public transport planning	Integrated public transport planning information (e.g. real time information on bus schedules)	Modal shift in favour of public transport	
Road transport planning	Real-time route guidance and hazard warning	Saving in congestion and travel time, but may add to journey distance	Saving in congestion and travel time spent by road haulers, but may add to journey distance
“Last minute” deals: flights, hotels, holidays	Internet, sms, e-mail etc.	Assist companies providing transport or other services to increase capacity and revenues; create additional travel	

Source: adapted from Banister and Stead, 2004

3.1.5 Potential impacts of nanotechnology on the transport sector

Nanotechnology can be described as a “platform” technology whose impacts are potentially wide and pervasive, affecting several fields of the economy and society.

As it concerns the impacts affecting the transport sector, we can make a distinction between general impacts which will have implications for the transport sector as well and specific impacts in the transport field.

General impacts of the nanotechnology revolution (see chapter 1.2.4.2 above) include:

- **The expected impact of the new technological wave on growth and labour productivity:** nanotechnology is in a state of rapid growth and has excellent prospects in a number of areas as a catalyst for dynamic industrial development, creating new opportunities of enhanced competitiveness for existing enterprises and brand new enterprises and industries that can help increase growth and labour productivity in the coming decades.
- **Increasing efficiency of production and dematerialisation of intermediate and final products:** until 20 years ago, it had not been thought that it would become possible to “see” individual atoms, let alone move them about. Today the situation is different. With the latest scanning probe microscopes, it is now possible both to “see” individual atoms and molecules and to move them around, thereby creating new nanostructures in a controlled manner. This has led to a paradigm shift, as today we are in principle in a position to construct new materials atom by atom and molecule by molecule, analogously to building a model out of Lego bricks. Although there are a number of major challenges on the path from being able to perform such operations in the research laboratory to being able to use them in large-scale industrial production, it is clear the potential of future nano-production processes of reducing the need of raw materials and resources, thanks to the optimisation of production. In addition, identification devices will help to optimise the logistic supply chain and freight transport.
- **The impact of molecular medicine on people health and life expectancy:** cure at molecular level may produce a rapid increase in life expectancy. Molecular medicine is a broad field, where physical, chemical, biological and medical techniques are used to describe molecular structures and mechanisms, identify fundamental molecular and genetic errors of disease, and to develop molecular interventions to correct them. The molecular medicine perspective emphasizes cellular and molecular phenomena and interventions rather than the previous conceptual and observational focus on patients and their organs. Health care and remedies will be more easily customized, contributing to make elderly life longer and healthier. To some extent, molecular medicine can have an impact also on fertility rates of women in the later stages of their reproductive life, increasing the number of those that could have babies later in their life.
- **The impact of nano-technologies on security:** the impact of nano-technologies on security could be controversial. On one hand, it is clear that identification devices, and especially implanted chips, may help to mark individual for surveillance purposes (for instance, anti-kidnapping systems have been already proposed in countries where the disappearance of children is a serious problem) and/or can make the access control to secure premises more easily done. On the other hand, as far as forms of potentially hazardous nano-materials will develop, there could appear new types of criminal use of new technologies including terrorism (the distribution of strains of anthrax at the end of 2001 in the US is a good example of this).

These general impacts will affect transport as well as other sectors of society. Increased GDP growth and productivity is usually coupled with higher people and goods mobility. However, especially goods mobility may be less intensive as the trend towards increasing trade of high value-added and low weight intermediate and final products and services will be reinforced by the diffusion of nano-technologies in the production processes. The increasing life expectancy, and the greater number of aged people in good health conditions, thanks to the benefits achieved by molecular therapies, will make such segment of population much more dynamic and mobile than today, with influences on leisure and even business travels (as a

consequence of the expected increasing number of older workers). Finally, security checks at airports, ports etc. will be greatly facilitated by the adoption of identification devices, i.e. one of the most likely future applications of nanotechnology.

Besides the above general impacts, there are some specific nano-technology developments which promise to strongly affect the transport sector in the more distant future. They include in particular:

- **Hydrogen economy:** Hydrogen powered vehicles could eliminate all noxious emissions from road transport, which would improve public health. If the hydrogen were generated via renewable means or using carbon capture and storage, all CO₂ emissions from transport could be eliminated. The hydrogen economy is estimated to be 40 years away from potential universal deployment. Nanotechnology is central to developing efficient hydrogen storage, which is likely to be the largest barrier to wide scale use. Nanotechnology is also a lead candidate in improving the efficiency of the fuel cells and in developing a method for renewable hydrogen production.
- **Batteries and supercapacitors:** Recent advances in battery technologies made the range and power of electric vehicles more practical. Issues still surround the charge time. Nanotechnology may provide a remedy to this problem by allowing electric vehicles to be recharged in much more quickly. Without nanotechnology, electric vehicles are likely to remain a niche market due to the issue of charge time.
- **Fuel additives:** nanoparticles additives have been shown to increase the fuel efficiency of diesel engines by approximately 5%, which could result in a substantial saving of CO₂ emissions. This could be implemented immediately across diesel powered fleets. However this must be tempered by concerns about the health impact of free nanoparticles in diesel exhaust gases.

3.1.6 Impacts of social drivers on passenger transport

The OECD has recently explored the relationship between tourism and transport. Most tourism travel is made by car. However, tourism travel – especially international - is also driven by the growth in availability of inexpensive air transport. Tourism is estimated to account for about 75% of the demand for aviation, which is growing rapidly. Low cost carries have been moving passengers over longer distances for shorter and more frequent holidays with 10-20 times environmental impact per trip compared with tourism by road and rail. According to the WTO, air transport generated 46 per cent of all tourist arrivals followed closely by transport overland. The trend in the last three years has been for air transport to grow at a faster pace than other means of transport. According to the International Air Transport Association, international passenger demand rose 9.3 per cent in November 2007, the fastest growth rate recorded in 18 months.

European travellers benefit from a strong euro. Within the continent, there are other pluses. The expansion of low-cost airlines is boosting short-break travel. The extension of the passport-free Schengen area to nine more countries makes trips within Europe easier. This will help the European Union remain the biggest contributor to global travel and tourism, with 27.5% of the share of the world market and more than 10% of the industry's total workforce. Even so, Europeans are likely to feel the slowdown of the economy and the impact of the high price of oil. For instance, easyJet, a low-cost airline, experiences increasing troubles from the

rising cost of fuel, which now accounts for 28% of easyJet's cost per seat. All this means tourism in the EU will grow by only about 2% this year, reckons the WTTC, compared with worldwide growth of 3-4%. For faster growth, the industry will have to look to emerging economies. These are becoming increasingly well established as places to visit. Now they are starting to provide more visitors too. According to McKinsey, a consulting firm, by the middle of the next decade almost a billion people will see their annual household incomes rise beyond \$5,000 - roughly the threshold for spending money on discretionary goods and services rather than simple necessities. Consumers' spending power in emerging economies will rise from \$4 trillion in 2006 to more than \$9 trillion - nearly the spending power of western Europe today.

The impact of an emerging “sustainable consumption” culture on transport could be important. Car ownership could be affected most, with owning a car starting not to be seen more as a status symbol and the only provider of “mobility freedom” in the younger generations. A new sustainable mobility freedom concept could take ground, especially in the urban environment, with a greater attention of people towards active travel (walking and cycling) combined with the use of high quality public transport and information services as the main way to ensure freedom of movement. On the other side, distributed energy and information systems could lead to a pattern of distributed human settlements as a superior way of organisation, giving rise to a landscape of scattered new homogeneous motorized neighbourhoods which would pay as many charges as needed to keep down congestion and CO₂ emissions.

A summary of the transport impacts from the social factors, separately on passenger and freight transport, is provided in the table below.

Table 12: Summary table on transport impacts from social factors

Specific drivers	Role of social factors intermediate variables	Impacts on passenger transport	Impacts on freight transport
Tourism	Leisure society, availability of free time	Higher Transport demand, long distance trips by air, rail, shipping	
Lifestyle change	Sustainable consumption	Lower motorization rates, higher short distance trips, use of public transport	Local consumption, shorter long term distance trips

3.2 Impacts of transport infrastructure, vehicle and fuel technologies on transport demand patterns

Relationships between new infrastructure and mobility are many and complex. Transport infrastructure, whether for travel by road or rail, has no inherent significance. Its efficiency in terms of shifting mobility depends on all of the conditions in which it operates, i.e. access and usage costs, degree of availability and technical effectiveness in terms of travel speed. It is the combination of these parameters which correlate mobility with infrastructure. (Source: Infrastructure-induced mobility, Round Table 105, page 134, OECD, November 1996).

3.2.1 Past trends

After the introduction of TGV in France the overall rail traffic between Paris and south-eastern France rose from 12 to 18 million passenger between 1980 and 1984. The induced traffic which came to light was the result of an increase in two parameters: individual mobility and the number of persons who travelled.

Table 13: Number of annual business trips per capita between Lyons and Paris

	Plane	Train	Car	Total
1980	6.9	5.9	1.7	14.5
1985	4.3	12.9	2.0	19.2

The figures in the table show that the rise in individual mobility for business trips far exceeded the growth in number of travellers. While trips rose by 56 % overall, individual mobility was up by 34 % and the combined number of air and rail passenger by 16 %.

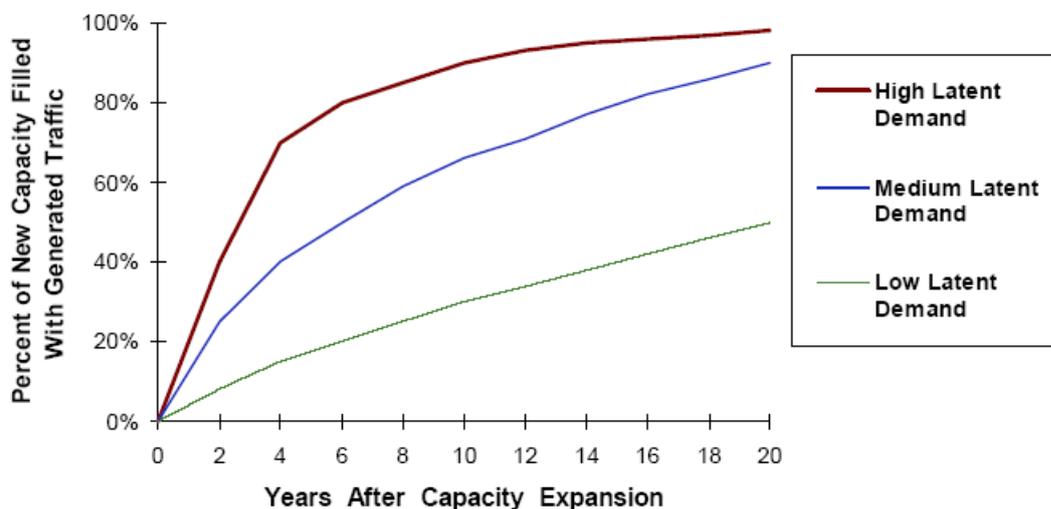
The introduction of new high-speed rail services not only triggered a sharp rise in mobility, it also altered travel behaviour by causing train passengers to adopt the practice of air travellers. Before TGVs started running between Lyons and Paris, only 25 % of train travel between the two regions took place without a night away from home, versus nearly 60 % for travel by air. High speed rail caused airline customers to transfer their travel behavior to the trains since, in 1985, 62 % of return trips by TGV were completed in a single day. One cannot help question the economic efficiency of these new travel patterns. Studies on the consequences of high speed rail have shown that certain business travellers on the TGV, instead of making a single trip between Lyons and Paris to meet with two or three different contacts, were now making two or three trips involving just one contact; trips have been getting shorter and shorter and easier to arrange. As a result, it is not possible to associate this sharp growth in travel with high economic efficiency of mobility. On the other hand, the TGV has made greater flexibility possible. (Source: Infrastructure-induced mobility, Round Table 105, page 122, OECD, November 1996).

In the case of new road infrastructure, as several independent forecasts show, mobility can be expected to increase on average by 10 % in the short term and by 20 % in the longer term, although the spread is extremely large in that induced traffic can vary, according to circumstances, from 0 to 40 %. However this evidence does not offer reliable means of determining the volume of induced traffic. The volume of such traffic varies substantially according to local circumstances and factors of a primarily macroeconomic nature. In the long term, induced traffic can be influenced by higher wages, the cost of using private cars, and the price and attractiveness of other modes. At the local level, the volume of induced traffic will depend upon the size of the new investment in capacity (i.e. the higher speed it allows), existing congestion, local geographical conditions (land use for different activities) and the existence and attractiveness of alternative roads. It should also be noted that the smaller the network, the greater the impact which new infrastructure will have. (Source: Infrastructure-induced mobility, Round Table 105, page 293, OECD, November 1996).

Particularly in congested cases it is doubtful whether an expansion of infrastructure will improve the mobility in the long term. Todd Litman at Victoria Transport Policy Institute concludes in 2007 that expansion of infrastructure in uncongested cases has a limited effect

on mobility, whereas expansion of road infrastructure in congested cases leads to a fast development of mobility, and a possible change of landuse encouraging urban sprawl along the expanded infrastructure. His particular point is the tendency to underestimate or even neglect the negative consequences of induced traffic in circumstances where relief of a congested situation based on infrastructure expansion is generating a new congested situation at a higher level. He therefore advocates strongly for the use of pricing policies or improvement of alternative transport modes as an alternative to infrastructure (road) expansion. His analysis concerning elasticities related to improved infrastructure leads to the following figure:

Figure 54: Elasticity of Traffic volume with respect to Road Capacity



Source: Todd Litman, *Generated Traffic and Induced Travel*, Victoria Travel Policy Institute, Sept. 2007

3.2.2 The influence of infrastructure on trade

Infrastructure is a significant determinant of both trade costs and trade volumes. Transport infrastructure is important not just in determining direct shipping costs, but also in determining time in transit and the flexibility of trade. (Source: Transport and international trade, Round Table 130, OECD, October 2004).

3.2.3 The "capacity crunch"

The scarcity of infrastructure creates congestion as transport continues to increase. The state of road congestion across Europe differs between countries and regions. The Randstad and Ruhr areas take an outstanding position as here the density of large urban areas causes considerable congestion on the entire trunk road network. But also other European countries perceive congestion problems mainly around the bigger cities. The congestion on the road network is due to increase in the future. The same goes for congestion in aviation with capacity shortages at the London airports being much more critical than at other major hubs, such as the Paris airports, Frankfurt or Madrid. The major rail bottlenecks include the French high speed lines, French and German lines which have not been upgraded for high speed trains (e.g. East-West connections in France and the Rhine axes), and the connections from

Dutch seaports to the German border. Further, capacity shortages on the German network reach out to Switzerland and to the Netherlands. Concerning the waterborne transport EU ports and inland navigation networks do not operate under full capacity utilisation and thus are ready to take the strong increase in container movements expected for the coming decades. (Source: COMPETE Final Report, Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States).

To day congestion costs the equivalent of 1 % of GDP. Even if transport becomes clean, congestion will remain an important issue in the years to come.

3.2.4 Optimising existing infrastructure or building more?

Traditionally, bottlenecks in transport infrastructure have been addressed by building extra capacity. However, in many urban areas – where the demand for transport is highest – possibilities for the further expansion of infrastructure are limited.

What's more, a number of reports have found that the construction of new roads and airports to relieve congestion is ineffective because it only serves to induce new traffic. On the other hand, a study undertaken by a Norwegian research organisation (Source: Environmental consequences of better roads, SINTEF Technology and Society, February 2007), claims that infrastructure capacity increases are directly linked to decreases in polluting emissions from motor vehicles. Using a traffic micro-simulation, it showed, for example, that upgrading narrow, winding roads or adding a lane to a congested motorway can yield decreases of up to 38 % in CO₂ emissions, 67 % in CO emissions and 75 % in NO_x emissions, without generating substantially more car trips (Source: EurActiv 11/04/07).

Bigger and better roads contribute to cutting pollution by removing bottlenecks, states a report commissioned by the EU Road Federation. The study follows criticism from green groups that investing in roads is contrary to Europe's sustainable development goals. "More investment in road infrastructure is needed to remove bottlenecks, avoid city centres and complete missing links which together cost billions every year in lost fuel and undoubtedly contribute to the transport sector's environmental footprint," said the European Union Road Federation (ERF), in a paper published on 10 April 2007.

The paper by Todd Litman referred to above indicates that Cost Benefit Analysis (CBA) of infrastructure capacity expansion needs to be carried out taking into account the long-term effect of the expansion. He points out that particularly in urban congested infrastructure expansion of the capacity may lead to only limited positive benefits in terms of savings in travel time and vehicle operating costs, but particularly social and environmental costs may develop in a negative way. This is indicated in the table below and enhances the importance of a correct project appraisal through CBA.

Table 14: Cost impacts of Roadway Capacity Expansion

Costs Reduced	Costs Increased		
	Diverted Trips	Longer Trips	Induced Trips
Travel Time	Downstream congestion	Downstream congestion	Downstream congestion
Vehicle Operating Costs		Road facilities	Road facilities
Per-mile crash rates (if implemented in conjunction with roadway design improvements, but these are often offset if traffic speeds increase).		Traffic services	Parking facilities
Per-mile pollution emissions (if congestion declines, but these may be offset if traffic speeds increase).		Per-capita crash rates	Traffic services
		Pollution emissions	Per-capita crash rates
		Noise	Pollution emissions
		Resource externalities	Noise
		Land use impacts	Resource externalities
		Barrier effect	Land use impacts
			Barrier effect
			Transit efficiency
			Equity
			Vehicle ownership costs

Source: Todd Litman, Generated Traffic and Induced Travel, Victoria Travel Policy Institute, Sept. 2007

Todd Litman concludes that very often would implementation of efficient pricing schemes have a higher return than provision of new infrastructure capacity. Evidently, infrastructure expansion schemes for other transport modes will also require solid and comprehensive Cost Benefit Analysis in order to assess the viability of these schemes.

A report on airport capacity, adopted by the European Parliament on 11 October 2007, also warns that tackling growing congestion levels cannot be done simply by "optimising existing capacity" and that additional airports will "necessarily" have to be built. It adds that building new capacity would help avert "unnecessary air pollution caused by en route or ramp congestion" (Source: EurActiv 11/10/07). The European Parliament has warned the Commission that Europe could be short of 3.7 million flights each year by 2025 if it fails to dramatically increase the capacity of its airports in the face of growing demand for air travel. A Parliament report, (Source: MEPs call for 'Master plan' for enhanced airport capacity, October 2007), warns the Commission that its plan to tackle congestion at European airports simply by "optimising existing capacity" will be insufficient to address the large rise in demand for flights.

With air travel growing at a rate of 5.2 % per year, flight demand will be 2.5 times bigger in 2025 than it was in 2003, rendering at least 60 European airports unable to handle the daily traffic without encountering delays or unaccommodated demand. This shortage of capacity "will necessarily open a market for new major airports (up to ten, according to a Eurocontrol study) and medium-sized airports (up to 15, according to Eurocontrol)", states the report.

While acknowledging the importance and urgency of boosting existing capacity, notably by improving slot allocation and ground-handling services in airports, as suggested in the Commission's proposal, Parliament urges the EU executive to "take a further step" and come up with a "Master plan for enhanced airport capacity in Europe" before 2009, containing measures to "promote and coordinate any national and cross-border initiatives for building new airport capacities". "Airports are so congested that if one flight gets slightly delayed, it

affects many other airports. The lack of airport capacity is therefore not just a national problem - it is a European problem", pointed out Danish Liberal MEP Anne Jensen, who drafted the report.

The report adds that building new capacity would also be a first step towards averting unnecessary air pollution caused by en route or ramp congestion, but says that additional measures to limit greenhouse gas emissions and noise - such as including aviation in the EU's Emissions Trading Scheme, taxing kerosene or differentiating airport charges according to environmental performance - would be necessary.

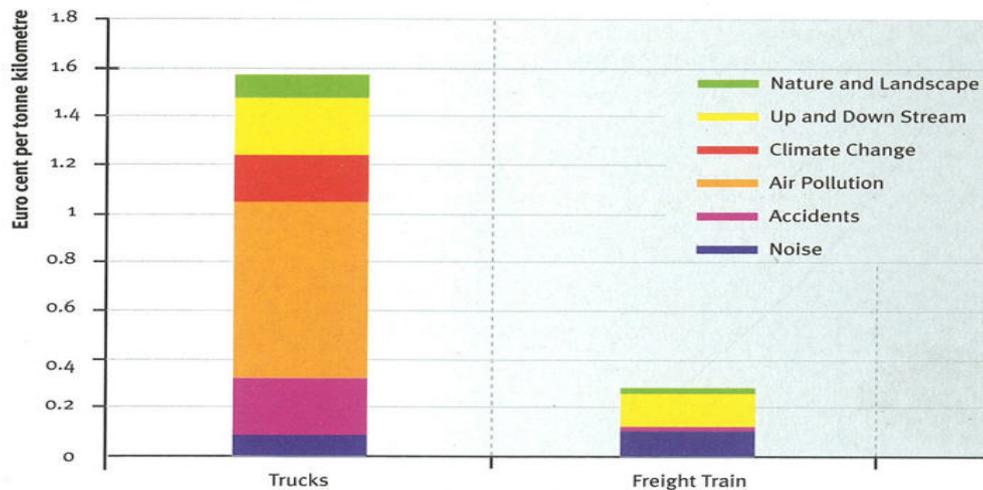
3.2.5 Developing infrastructure charging

Because most transport modes fail to fully cover their external costs, users currently pay a much lower price for their mobility than the real cost to society and the environment, keeping demand artificially high. It is thought that confronting users with these costs by imposing charges on infrastructure could ensure a more efficient usage of transport, while addressing some of its negative consequences and, at the same time, raising funds for investing in new or optimised infrastructure and alternative transport modes.

At EU level, the only directive on charging so far covers only the use of road infrastructure by heavy freight vehicles which may be asked to pay to recover the costs of infrastructure construction and operation. However, this so-called 'Eurovignette Directive' excludes the possibility of adding any environmental and health costs into toll prices until a "common methodology for the calculation and internalisation of external costs that can be applied to all modes of transport" is agreed upon and a strategy for the stepwise implementation of the internalisation model is proposed.

The idea of establishing a uniform 'user-pays' system for all forms of transport is not new, but it has usually been brushed under the carpet due to the complexity of calculating external costs. The question of which costs should be considered as transport-related externalities – whether it should just be congestion, CO2 emissions, or also factors like the hospital costs of people involved in traffic accidents – is the main bone of contention, including the derived aspect of how to measure these costs. Another issue is what to do with the money raised from internalising these costs: Taking them to the general budget, subsidisation of new infrastructure for the taxed transport mode or cross-subsidisation of cleaner transport alternatives?

To address these issues the European Commission initiated a study (IMPACT) producing the "Handbook on estimation of external costs in the transport sector". Drawing on existing research, it has identified the same seven cost categories as INFRAS/IWW 2004. As an example, the marginal external costs of interurban freight transport at day time are shown in the figure below: the costs from Heavy Duty Vehicles are more than five times higher than of an electric freight train.

Figure 55: Comparison of marginal external costs for road and rail

Source: CE Delft, Handbook on estimation of external costs in the transport sector (2007)

Note: Values for Day Interurban travel. Rail refers to electric traction. Average load factors used.

The internalisation of external costs is possible and an important process that not only would set the prices right but also would send a signal to the market actors of the real cost of transport. According to the Commission internalisation proposal, revenues from internalisation should remain within the transport sector to be used to promote sustainable mobility. The use of such revenues should not be exclusive to one mode but rather favour combination of modes, with the aim of minimizing the overall negative external effects of transport.

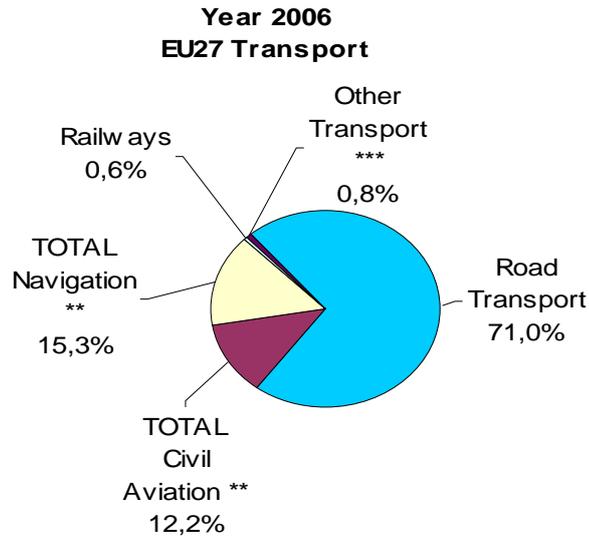
3.3 Relationship between climate change and transport

3.3.1 CO₂ emissions from transport

CO₂ emissions from the transport sector attract the attention of both transport and climate change policymakers because of their share of overall emissions and their persistently strong growth. Over the past three decades, carbon dioxide emissions from transport have risen faster than those from all other sectors and are projected to rise more rapidly in the future. From 1990 to 2004, the carbon dioxide emissions from the world's transport sector have risen by 36.5%. For the same period, road transport emissions have risen by 29% in industrialised countries and 61% in the other countries (mainly developing countries or countries in transition, IEA 2006).

According with EEA analysis (2008), after the stationary energy sector, transport is the second largest growth sector in EU-27 green-house gases emissions. In 2005, it has accounted for 23.4% of EU-27 greenhouse gas emissions, with vast majority of these emissions produced by road transport sector, freight and passenger transport, and the increasing contribution of aviation, as it is shown in the figure below (data at 2006).

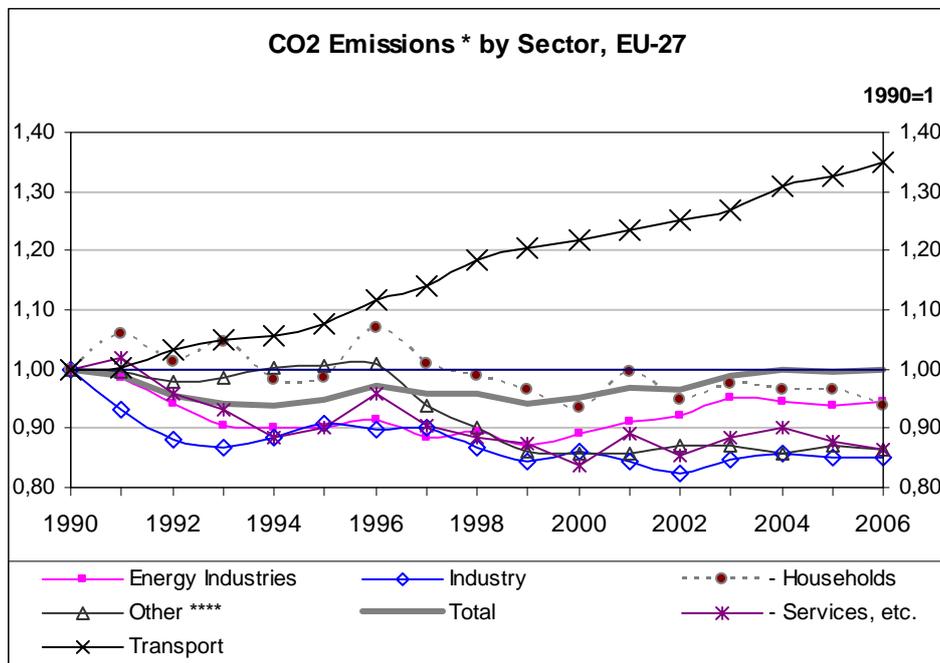
Figure 56: Green-house gases emissions by transport modes – 2006 (source EC 2008)



Source: European Environment Agency (EEA), June 2008

Additionally, between 1990 and 2006, CO2 emissions from transport had the highest increase in percentage terms of all energy related sectors, as illustrated in the figure below (source EC, 2008):

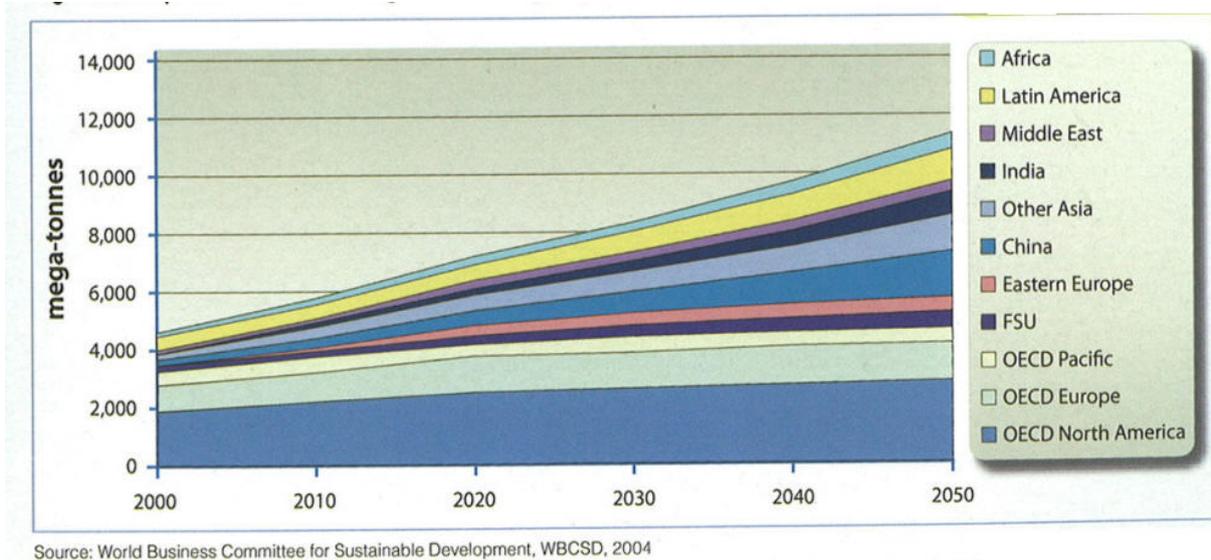
Figure 57: Green-house emissions by sector EU-27 (index number)



Source: DG TREN Energy and transport in figures 2007-2008

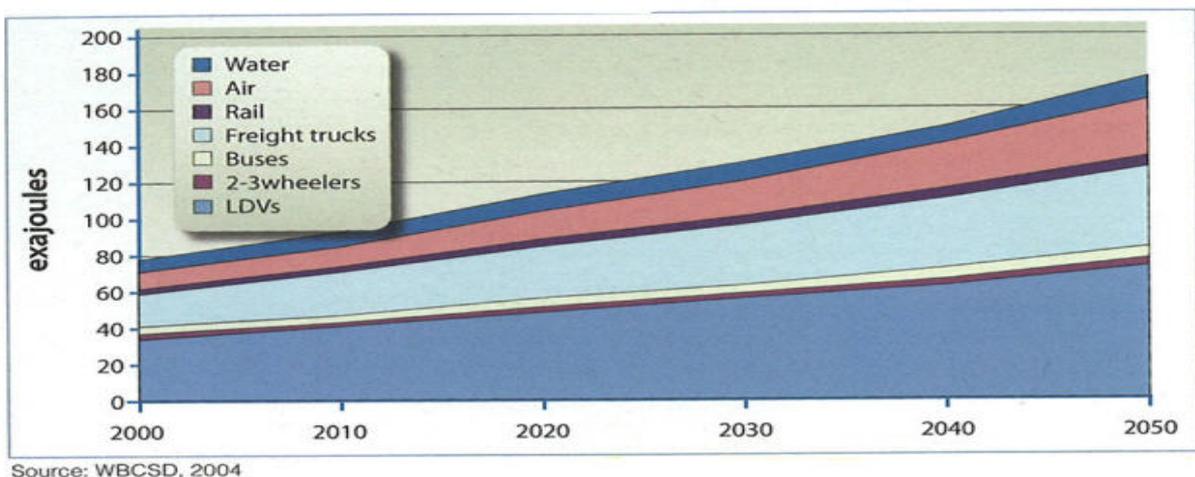
Taking into account expected long-term future development in a global perspective, the figure below shows the projected increase in transportation CO₂ emissions by world region for 2050 (source WBCSD, 2004).

Figure 58: Transport vehicle CO₂ emissions by regions



At present industrialised countries are the main sources of transport emissions. However, the proportion of emissions being produced in developing countries is increasing rapidly, particularly in countries such as China and India. World CO₂ emissions from the transport sector are projected to increase by 140% from 2000 to 2050, with the biggest increase in developing countries. The figure below shows the increase in world fuel by transport mode.

Figure 59: Global transport fuel use by mode



The majority of transport fuel emissions (76%) are from road transport. Light Duty Vehicles (LDVs) – i.e. four-wheeled vehicles, including cars, sport utility vehicles (SUVs), small passenger vans (up to 8 seats), and personal pickup trucks – are the most important source. Air travel produces around 12% of transport CO₂ emissions and its share is growing rapidly. Various transport modes contribute to global warming by more than their direct emissions of

CO₂, e.g. via the upstream CO₂ emissions from oil refineries, electricity used by electric trains, and for aviation the enhanced climate forcing as a result of contrails and other effects.

A more detailed Reference Scenario to 2050 has been estimated for the EU-27, based on the European Commission estimate of energy and transport trends to 2030 (EC 2008). The table below shows the estimated CO₂ emissions projections by end users in the EU 27 to 2050. Maritime transport and International Aviation have not been considered. For the future, growth in CO₂ emissions of these two sectors is expected at a large degree. This is due to the growth in world trade for the increasing contribution of shipping and increasing tourism by low cost carries with regard to the aviation.

Table 15: CO₂ emissions projection by end-users in the EU-27, in Millions tonnes of Carbon

End user Category	1990	2000	2010	2020	2030	2050
Road transport	695	825	905	980	1002	1018
Rail	29	29	27	27	21	20
Domestic Aviation	86	134	179	206	237	244
Inland navigation	21	16	16	17	17	17
Total	810	988	1110	1213	1260	1299

Source: Backcasting approach for sustainable mobility, JRC-EC, 2008

Although not included in the table above, greenhouse gas emissions from international aviation increased in the EU by 73% (+ 47 Mt CO₂e) from 1990 to 2003, corresponding to an annual growth of 4,3% per annum. In the longer run, aviation emissions will become a major contributor if current trends continue. Furthermore, the IPCC has estimated that the total impact of aviation on climate change is currently about 2 to 4 times higher than what stems from CO₂ emissions alone, notably due to aircrafts' emissions of Nitrogen Oxides (NO_x) and water vapour in their condensation trails. Recent EU research results indicate that this ratio may be somewhat smaller (about 2 times).

3.3.2 Potential impacts of climate change on transport

Climate change will affect transport primarily through increases in several types of weather and climate extremes, such as very hot days; intense precipitation events; intense hurricanes; drought; and rising sea levels, coupled with storm surges and land subsidence. The impacts will vary by mode of transport and regions, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning design, design, building, operation and maintenance of transport infrastructures.

Another main impact will be mediated through the transport-environment pollution chain, as for example increasing hot days will augment the occurrence of critical pollution levels in high sport areas, e.g. the large urban conurbations in Europe (main capital cities or even entire regions as the Randstat in Netherlands and Po Valley in Italy).

In the following we will concentrate on the potential impact of climate change on transport infrastructure. This will be affected most by those climate changes that cause environmental conditions to extend outside the range for which the system was designed. Illustrative impacts of key climate changes are summarised in the table below (TRB 2008).

TRANVisions

Table 16 : Summary table on transport impacts and climate change

Potential Climate Change	Impacts on Land Transport (highways, rail, pipelines)		Impacts on Water Transport		Impacts on Air Transport	
	Operation	Infrastructure	Operation	Infrastructure	Operation	Infrastructure
<i>Temperature: Increases in very hot days and heat waves</i>	Limitations on periods of construction works due to health and safety concerns. Vehicle overheating and tire deterioration	Impacts on pavement and concrete construction practices. Thermal expansion on bridge paved surfaces. Impacts on landscaping in highway and street rights-of-way. Concerns regarding pavement integrity. Rail-track deformities.	Impacts on shipping due to warmer water in river and lakes		Delays due to excessive heat. Impact on lift-off load limits at high-altitude or hot-weather airports with insufficient runway lengths, resulting in flight cancellations and/or limits on payload (i.e. weight restrictions). More energy consumption on the ground.	Concerns regarding pavement integrity. Heat-related weathering of vehicle stock.
<i>Temperature: Decreases in very cold days</i>	Regional changes in snow and ice removal costs. Fewer cold-related restrictions for maintenance workers.	Decreased utility of unimproved roads that rely on frozen ground for passage.	Less ice accumulation on vessels, decks and docks; less ice fog; fewer ice jams in ports.		Regional changes in snow and ice removal costs. Reduction in need for de-icing. Fewer limitations on ground crew at airports.	
<i>Temperature: Increases in Arctic temperatures</i>		Thawing of permafrost, causing subsidence of roads, rail beds, bridge supports and pipelines. Shorter season for ice roads.	Longer ocean transport season and more ice-free ports in northern regions.			Thawing of permafrost, undermining runway foundations

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Potential Climate Change	Impacts on Land Transport (highways, rail, pipelines)		Impacts on Water Transport		Impacts on Air Transport	
	Operation	Infrastructure	Operation	Infrastructure	Operation	Infrastructure
<i>Temperature: Later onset of seasonal freeze and earlier onset of seasonal thaw</i>	Changes in seasonal weight restrictions Changes in seasonal fuel requirements Improved mobility and safety associated with a reduction in winter weather. Longer construction season.	Reduced pavement deterioration resulting from less exposure to freezing, snow and ice, but possibility of more freeze-thaw conditions in some locations.	Extended shipping season for inland waterways due to reduced ice coverage (more important for North America, less so for Europe).			
<i>Sea level rise, added to storm surge</i>	More frequent interruptions in travel on coastal and low-lying roadways and rail service due to storm surges. More severe storm surges, requiring evacuation.	Inundation of roads and rail lines in coastal areas. More frequent or severe flooding of underground tunnels and low-lying infrastructure. Loss of coastal wetlands and barrier shoreline. Land subsidence.	More severe storm surges, requiring evacuation.	Changes in harbour and port facilities to accommodate higher tides and storm surges. Reduced clearance under waterway bridges. Changes in navigability of channels; some will be more accessible (and farther inland) because of deeper waters, while others will be restricted because of changes in sedimentation rates.	Potential for closure or restrictions for several airports that lie in coastal zones, affecting air transport services.	Inundation of airport runways located in coastal areas.

TRANSvisions

Potential Climate Change	Impacts on Land Transport (highways, rail, pipelines)		Impacts on Water Transport		Impacts on Air Transport	
	Operation	Infrastructure	Operation	Infrastructure	Operation	Infrastructure
<i>Precipitation: Increase in intense precipitation events</i>	Increases in weather-related delays Increases in traffic disruptions. Increased flooding of evacuation routes. Disruption of construction activities. Changes in rain, snowfall and seasonal flooding that affect safety and maintenance operations.	Increases in flooding of roadways, rail lines and subterranean tunnels. Overloading of drainage systems, causing backups and street flooding. Increases in road washout, damages to rail bed support structures, and landslides that damage road-ways and tracks. Impacts on soil moisture levels, affecting structural integrity of roads, bridges and tunnels. Adverse impacts of standing water on the road base. Increases in damages to pipelines.	Increases in weather-related delays.	Impacts on harbour infrastructure from wave damages and storm surges. Changes in under-water surface and silt and debris build-up, which can affect channel depth.	Increases in weather-related delays. Storm water runoff that exceeds the capacity of collection systems, causing flooding, delays and airport closings.	Impacts on structural integrity of airport facilities. Destruction or disabling of navigation aid instruments. Runway and other infrastructure damage due to flooding. Inadequate or damaged pavement drainage systems.
<i>Precipitation: Increases in drought conditions for some regions.</i>	Increased susceptibility to wildfires, causing road closures due to	Increased susceptibility to wildfires that threaten transport	Impacts on river transport routes and seasons.		Decreased visibility for airports located in drought-susceptible areas	

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Potential Climate Change	Impacts on Land Transport (highways, rail, pipelines)		Impacts on Water Transport		Impacts on Air Transport	
	Operation	Infrastructure	Operation	Infrastructure	Operation	Infrastructure
	fire threat or reduced visibility.	infrastructure directly.			with potential for increased wildfires.	
<i>Precipitation: Changes in seasonal precipitation and river flow patterns</i>	Benefits for safety and reduced interruptions if frozen precipitation shifts to rainfall, depending on terrain.	Increased risk of floods from runoff, land-slides, slope failures and damage to roads if precipitation changes from snow to rain in winter and spring.	Periodic channel closings or restrictions if flooding increases. Benefits for safety and reduced interruptions if frozen precipitation shifts to rainfall.	Impact on long-term viability of some inland navigation routes.	Benefits for safety and reduced interruptions if frozen precipitation shifts to rainfall.	Inadequate or damaged pavement drainage systems.
<i>Storms: More frequent strong hurricanes</i>	More debris on roads and rail lines, interrupting travel and shipping. More frequent and potentially more extensive emergency evacuations.	Greater probability of infrastructure failures. Increased threat to stability of bridge decks. Increased damage to signs, lighting fixtures and supports. Decreased expected lifetime of highways exposed to storm surge.	Implications for emergency evacuation planning, facility maintenance and safety management.	Damages to harbour infrastructure from waves and storm surges. Damages to cranes and other dock and terminal facilities.	More frequent interruptions in air service.	Damage to landside facilities (e.g. terminals, navigation aids, fencing around perimeters, signs).

4 Scenarios for a European transport future

The scenario method has become rather widespread over the last few decades. The many practitioners have given a large array of definitions.⁵⁰ Common elements are:

- Scenarios are a tool for better strategic decision making
- The scenario method emphasizes the construction of alternative futures in order to prepare for divergent plausible futures
- To this purpose, existing mental models should be challenged, and qualitative (“storytelling”, narrative) as well as quantitative (“modelling”) approaches are to be used.⁵¹
- It is important to know for whom scenarios are made and for which purpose. Credibility, legitimacy, and creativity are important aspects, then, of process and product.
- Scenario construction is a training in finding key trends, recognising prevalent myths, and imagining attitudes of key players.

One should not make more than three or four scenarios because people cannot handle more due to cognitive limitation. The identification of driving forces (i.e. what makes it going), of predetermined elements (in particular slow changing variables), and of critical uncertainties provide the structure or logic of scenario (Schwartz 1991).

The scenarios do not set out to predict what will happen or to suggest a preferred future. They are stories that offer various possible, even extreme, outcomes. The scenarios shall be designed therefore to stimulate thought, to highlight some of the opportunities and threats we might face in the future and to inform today’s decisions.

For the purpose of the TRANSvisions project, our first task was to define “a maximum of four extreme scenarios to outline the scope of transport development and at least include a priority to competitiveness and a priority to environmental protection scenarios and cohesion” (TRANSvisions inception report, page 13). These are qualitative scenarios which should take the form of alternative visions of the future of transport in Europe at the 2050 horizon. The definition of the qualitative scenarios was supported by internal and external experts that have been involved in a DELPHI survey exercise, and a subsequent discussion at the seminal TRANSvisions workshop held on 9th July 2008 in Brussels.

The four “extreme” scenarios have been defined following a pragmatic approach according to which:

- We have taken as background information for some key drivers – climate change, population growth and ageing, migration, urbanisation, and the effects of globalisation on

⁵⁰ See, e.g., van Notten et al. (2003) for a recent overview of the scenario literature and scenarios. Some foresight and scenario building exercises related to transport are also presented in the literature review annexed to this report.

⁵¹ In TRANSvisions Task 1 we follow the qualitative storytelling approach. The quantitative approach is considered in Task 2.

EU economy and trade, technological development, etc. – the outcomes of existing scenarios, analysed in the relevant “main drivers” sections of this report.

- We have chosen to consider the need to comply with the 50% CO₂ emission reduction target by the year 2050 in respect of 2005 values as an “invariant” for all the four alternative scenarios. The assumption behind this is that, whatever will be the future developments in Europe, they need to finally comply with the climate change mitigation targets in any case. Later in Task 2 of the project the CO₂ emission reduction targets will be considered again to build up a quantitative back-casting scenario, while now in Task 1 the four scenarios aim to show different contexts (with different key drivers evolutions) in which the same CO₂ emission targets shall be achieved by 2050.
- We have chosen to adopt two “axes of uncertainty” that reflect two important dimensions of uncertainty:
 - A. *Vertical axe: The economy and - as far as technological development is the engine of economic growth especially in the long term – technology dimension: will Europe become the most competitive knowledge economy in the world at one (positive) extreme, or will the global economy collapse at the other (negative) extreme ?*
 - B. *Horizontal axe: The society and – as far as institutions and people behaviour are key aspects of the future society – behavioural change dimension: will societal development – as measurable in terms of the human well-being and quality of life for all, and the environmental quality as well - be fairly better in a future Europe post-carbon society at one (positive) extreme, or will become substantially worse in a still carbon-dependent Europe at the other (negative) extreme.*
- Along these axes of uncertainty we have provided to the DELPHI survey and workshop participants a first preliminary description of four “extreme” scenarios, taking inspiration from four scenarios towards 2055 produced in a recent Foresight project of the UK Office of Science and Technology (OST, Intelligent Infrastructure Futures. The Scenarios Towards 2055, 2006).⁵² The four extreme scenarios have been then validated with the support of the stakeholders DELPHI survey and an interactive workshop. Starting from the analysis of the four extreme scenarios, the experts have been asked to provide their comments, to set a priority ranking for the most important drivers, and to give their educated guesses about the plausible ranges for some key indicators related to the drivers of change.

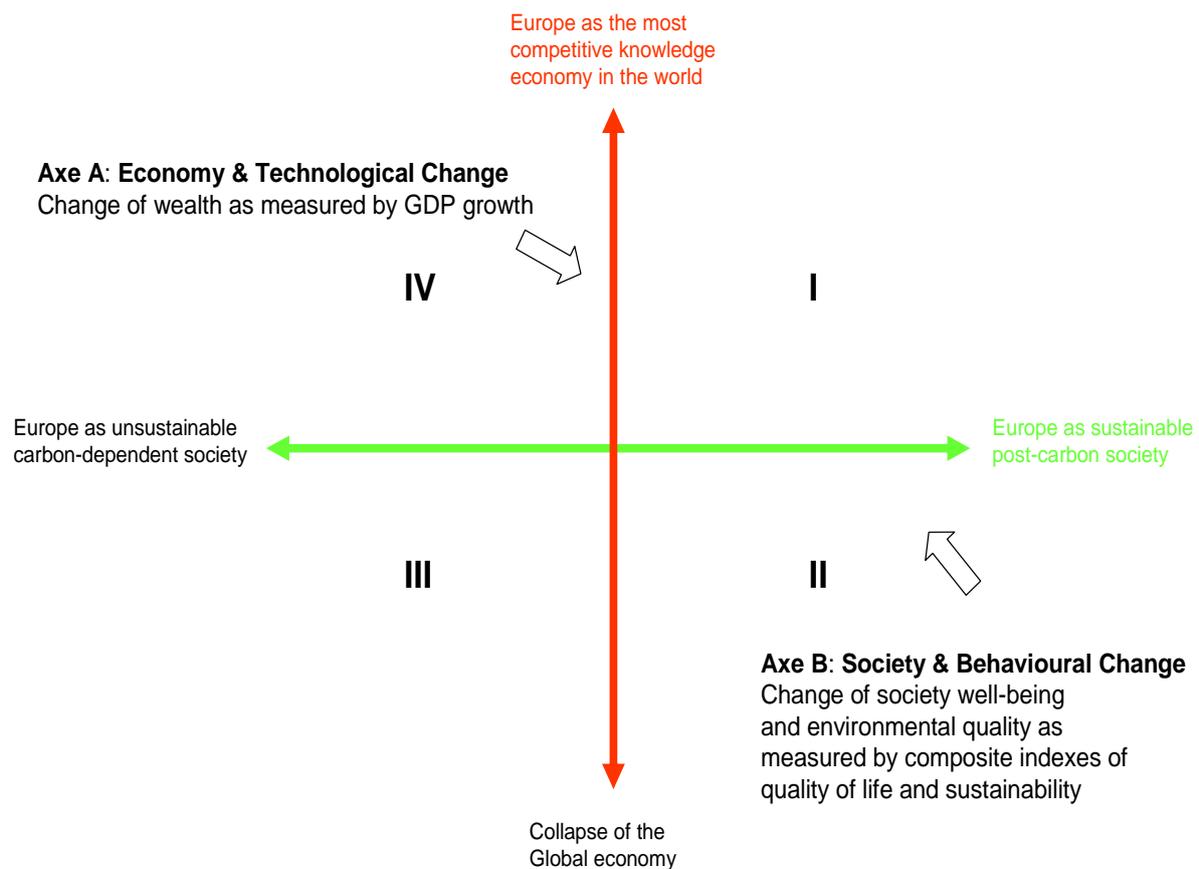
With the first dimension of uncertainty we wonder mainly about future market trends, economic development and the solutions provided by technology to the today problems. With the second dimension we wonder about the role that social values may have in shaping the behaviour and the effects on the human well-being and ecosystems’ health in the more distant future. The first dimension includes the belief that technology – e.g. new clean engines – and

⁵² This study has been selected within a number of scenarios studies reviewed in the Annex to this report, as that proposing the more provocative and stimulating visions of the future of transport up to 2055. Although limited to the UK, the four scenarios of this study – named “perpetual motion”, “urban colonies”, “tribal trading”, and “good intentions” – are inspiring and provide a good basis for building up similar scenarios adapted to the whole Europe.

growth may ensure an increasing standard of living, while the second dimension recognise that income growth and technological innovation – although needed and desirable – will be not enough to ensure a better quality of life for the present and future generations: there will be an important role for societal factors and change of values and lifestyle too.

It is important to note that beneath the societal and behavioural change dimension there is a strong role to be played by institutions and government. People behaviour – e.g. consumption habits – is routinized, while motivated behavioural change – e.g. people spontaneously changing their mobility habits as a result of an awareness campaign – is infrequent and marginal to the patterns of everyday life. Right government incentives, e.g. in the form of right prices reflecting the external costs of people choices, are needed to induce consistent changes in the direction of more sustainable behaviour. Of course governments in our democratic society are elected by people, so it is important to raise also the awareness of citizens on the needed policy actions and, in so doing, increase their public acceptance (changes that are not understood by the users are easily seen as an unnecessary disturb).

The two proposed dimensions of uncertainty are represented in the figure below, the first as a vertical axe that could be measured with the total increase or decrease of GDP up to 2050, and the second as a horizontal axe that could be measured with the increase or decrease of the quality of human well-being and ecosystem health up to 2050 (using a composite index).



Moving clock-wise we meet first quadrant I, where both GDP and well-being increase, then quadrant II, where an increase of well-being is associated to a decline of GDP (this would be

the result of the so-called “happy economy decrease” pattern), quadrant III with the worst situation (GDP and well-being decline) and finally quadrant IV where an increase of GDP is associated with a decrease of societal well-being and environmental quality (in practice any kind of unsustainable growth pattern will be shown in this quadrant).

Societal well-being and ecosystems health can be hardly measured in practice, because it includes many aspects related to sustainable consumption and production, human well-being and environmental quality, etc.. However, we need here to retain at least the theoretical distinction, by understanding why human “well-being” is a different dimension from “wealth” as measured by the standard GDP index (see the box below).

The relationship between consumption and well-being

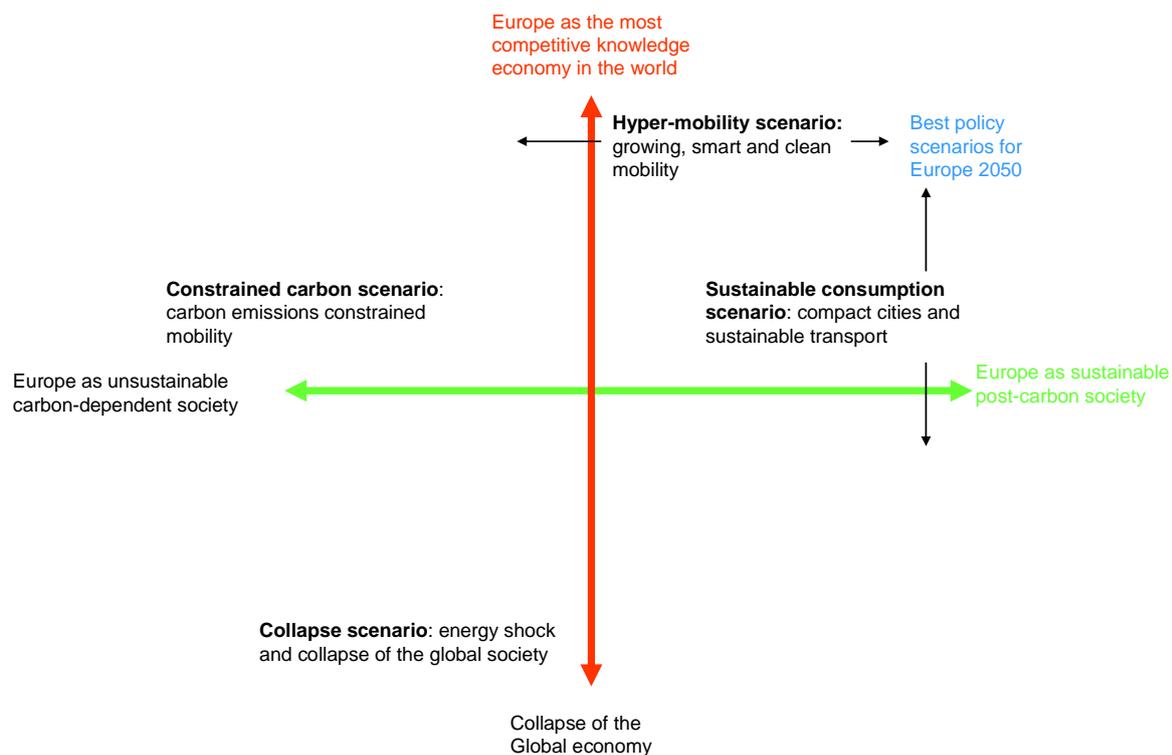
In some simple sense, consumption can be seen as an attempt to provide for individual and collective well-being. Consumer goods and services are to be seen, in this view, as a proxy for the well-being that people derive from them. Since the sum of consumption expenditures is equivalent (under certain conditions) to the value placed by consumers on the goods they consume then – according to the conventional argument – the national income (or gross domestic product - GDP) can be taken as some kind of proxy for the well-being derived from our consumption activities. And since the GDP rose more or less consistently over the last 50 years in most Western countries, the comforting logic of this view suggests that rising levels of consumption have been pretty successful in delivering an increasing standard of living and, by proxy, improving our collective well-being over recent decades. But this equation of economic growth with increasing quality of life has come under considerable scrutiny over the last few decades, for a variety of reasons. Not least among these is the realization that conventional measures of economic progress fail to account for the depletion of natural resources, and for the environmental and social impact of consumption and production. In addition, this conventional view is faced with what is perhaps the most striking ambivalence involved in understanding modern lifestyles: the so-called “life-satisfaction paradox”. This phenomenon was clearly detected by Inglehart and Klingemann (2000): when they plotted survey data on life satisfaction and happiness against data on national income they found a strong correlation between the two only at low incomes. Across most developed countries, however, the correlation between increased income and reported well-being is weak at best. And for countries with average incomes in excess of US\$ 15,000 there is very little correlation at all between income and happiness. Data across time are equally striking. Incomes in the UK (for example) have almost doubled since the early 1970s. Yet reported life satisfaction over the same period has scarcely changed at all (e.g. Jackson, 2006).

Explanations for this life-satisfaction paradox have been sought in a variety of different places. Some authors highlight the fact that relative income has a bigger effect on individual well-being than absolute levels of income. Some commentators point also to the impact of “hedonic adaptation”. As I get richer, I simply become more accustomed to the pleasure of the goods and services my new income affords me. Humanistic psychologists (and some ecologists and philosophers) have argued that the entire project of income growth rests on a misunderstanding of human nature. Far from making us happier, according to this critique, the pursuit of material things damages us psychologically and socially, entrenching us in unproductive status competition, disrupting our work-life balance and distracting us from those things that offer meaning and purpose to our lives. In a recent attempt to construct an international index of quality of life, the Economist’s Intelligence Unit suggested the explanation for the paradox was that “there are factors associated with modernisation that, in part, offset its positive impact”, including for instance: a marked rise in various social pathologies (crime, and drug and alcohol abuse); a decline in political participation and of trust in public authority; and the erosion of the institutions of family and marriage. The point about these changes – which have occurred hand in hand with the rise in incomes and the expansion of individual choice – is not that income growth is irrelevant to individual quality of life; all the evidence suggest the contrary. Rather it is that the pursuit of income growth – beyond a certain level that in Europe (or at least in the most

affluent member states) has been widely overcome – appears to have undermined some of the conditions (family; friendship; community) on which we know that people’s long-term well-being depends.

In conclusion, and if any of this kind of critique is right, consumer society appears to be seriously adrift – not just in terms of its impacts on the environment, but even in terms of its own pursuit of well-being. We might perhaps be tempted to put up with a little environmental degradation if it was the only way of increasing human well-being. But damaging the environment and at the same time failing to deliver consistent improvements in well-being is potentially tragic. For these reasons, while thinking at the distant future of Europe, it is important to distinguish the two directions, towards increasing wealth and towards increasing well-being and environment health. Finding a way to conciliate these two dimensions is the core issue for “sustainable development” of the European society.

Coming back to the TRANSvisions task of featuring visions for transport at the year 2050, it was important to introduce a first sketch of the four extreme visions, inspired by those explored in the UK foresight study. They are mentioned below, positioning them on the “axes of uncertainty” diagram.



The “**Hyper-mobility scenario**” (inspired by the UK study “Perpetual motion” scenario) is featured by continued economic growth, increasing competition, use of intelligent technologies and globalisation, a mix of nuclear energy, clean coal and renewable energy supply, high travel demand, the diffusion of cleaner fuel technologies (e.g. hydrogen fuel cells), 24/7 “always on” society, intensive work and a lot of stress. Depending on the share of carbon-based fuels (e.g. gas used to produce hydrogen) the scenario can move to the quadrant of the carbon-dependent society. If the share of centralised nuclear energy supply is decreased

and that of renewable energies increased (also to produce hydrogen used as energy vector for transport), the same scenario can move to a better position in the sustainable post-carbon society quadrant.

The “**Sustainable consumption scenario**” (inspired by the UK study “Urban colonies” scenario) is featured by compact urban settings, distributed power generation with an high share of renewable energy, restricted car use (still energy expensive) and increased sustainable transport modes, concentration of high-value knowledge business in competitive, attractive and environmentally sound cities, diffusion of biofuels, sustainable consumption. When the latter is intended as (more) consumption of sustainable goods and services, the scenario is located in the quadrant of the diagram with a moderate economic growth. More optimistic variants of the same scenario could deliver a higher economic growth as well, fuelled by increasingly competitive European cities. However, a more radical concept of sustainable consumption as “consuming less” may cause the scenario to shift back to the quadrant with a moderate reduction of GDP (a kind of “happy decline”).

The “**Collapse scenario**” (inspired by the UK study “Tribal trading” scenario) is featured by a sharp and savage energy shock, a global recession that has left millions unemployed, a world after that stabilised at lower level of complexity, with infrastructure falling into disrepair, declined cities and increased rural settlements, long-distance travel which is a luxury for few people, freight transport mainly using canals and sea-going vessels. By 2030 “Peak Oil” came and went, and the reserves figures turned out to be as fragile as the critics had insisted. Oil and gas prices have spiked and then spiked again. Attempts to secure supplies from Russia failed as the Russians have turned instead to their customers in the East: for a short while, the BRIC countries (Brazil, Russia, India, China) hold the balance of trade and diplomatic power.

The “**Carbon-constrained scenario**” (inspired by the UK study “Good intentions” scenario) is featured by a world in which the market has failed to provide a realistic energy alternative to the use of carbon fossils fuels, and in which the need to reduce carbon emissions constraints personal mobility. Carbon surveillance systems ensure that people only travel if they have sufficient carbon quotas; intelligent car monitor and report on the environment costs of journeys; and in-car systems adjust speeds automatically to minimise emissions. Business has adopted energy-efficient practices for freight transport and traffic volumes have fallen while mass transportation is used more widely. Economic growth is constrained as well, showing only a moderate increase.

As mentioned above, these scenarios have been assessed by means of:

- A DELPHI survey in which internal and external experts have been asked to assess the key drivers presented in the four extreme scenarios, and give their expert judgement about the predictability of the single drivers, the plausibility of the different scenario events, and the relevance of the drivers for the transport sector.
- A workshop to discuss the results of the DELPHI survey, collecting recommendations from the experts on how to adjust the scenarios if and as appropriate, and to identify a shorter list of the more relevant drivers.

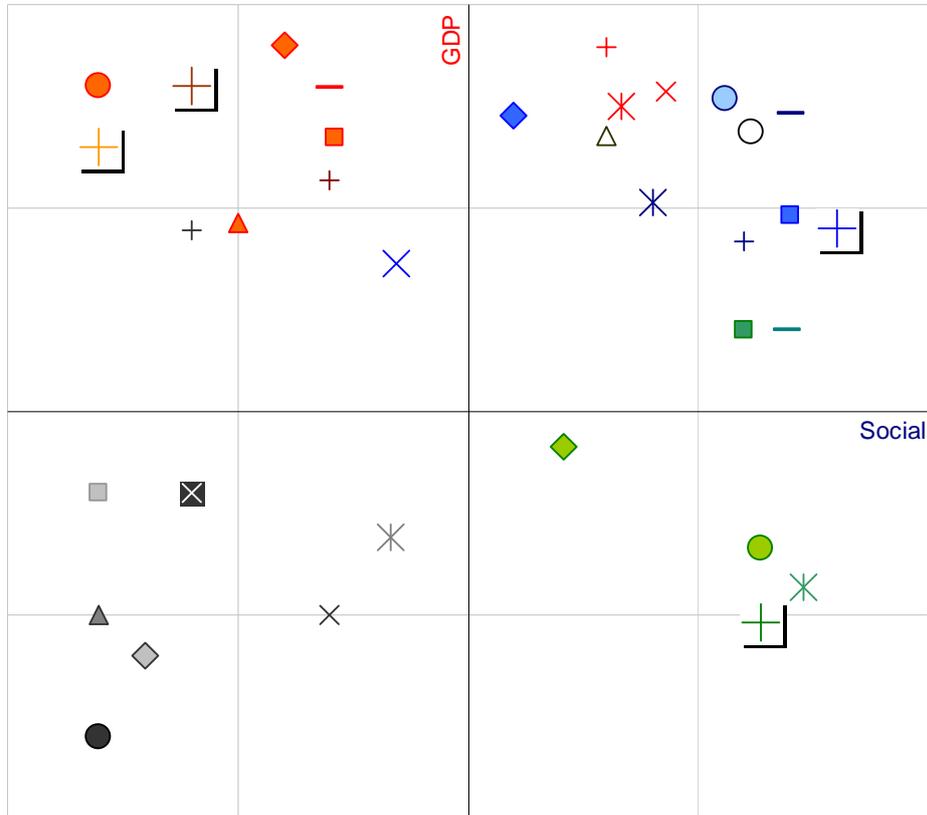
In order to give a context to these four scenarios, scenarios defined in recent studies have been reviewed; most of them are related to the European context, though some are broader.

UK OFFICE SCIENCE & TECHNOLOGY	Perpetual Motion
	Urban Colonies
	Tribal Trading
	Good Intentions
FORWARD STUDIES UNIT "Five different futures for Europe"	Triumphant Markets
	The Hundred Flowers
	Shared Responsibilities
	Creative Societies
	Turbulent Neighbourhoods
CPB, "4 FUTURES 4 EUROPE"	Strong Europe
	Transatlantic Market
	Regional Communities
	Global Economy
EMCC. "Trends and drivers of Change in the EU transport and logistics sector:scenarios" 2008	Take the A-Train
	I'm in love with my car
	Riding the rainbow
ESPON 3.2.	Moonlight ride in a Diesel
	Pro-active Europe
	Cohesion-oriented (Danubean Europe)
UN GEO-3	Competitiveness-oriented (Rhine-Rhone Europe)
	The Markets First
	Policy First
	Security First
MEDACTION	Sustainability First
	Knowledge is King
	Big is beautiful
GLOBAL SCENARIO GROUP	Convulsive Change
	Market Forces
	Policy Reform
	Great Transitions
MILLENIUM PROJECT SCENARIOS	Fortress World
	S&T develops a Mind of its Own
	The World Wakes Up
	Please, turn off the Spigot
JAMES MARTIN	Backlash
	Fortress America
	The Strong Nation Clubs
	Triage
GLOBAL FUTURE ANALYSIS	Compassionate World
	Doing nothing
	Extending the past
	Reinventing prosperity

Next two tables maps these scenarios in terms of economic performance versus social welfare and equity standards in one case, and environmental awareness on the other. Different scenarios are coloured similarly according to affinities between them: technology and

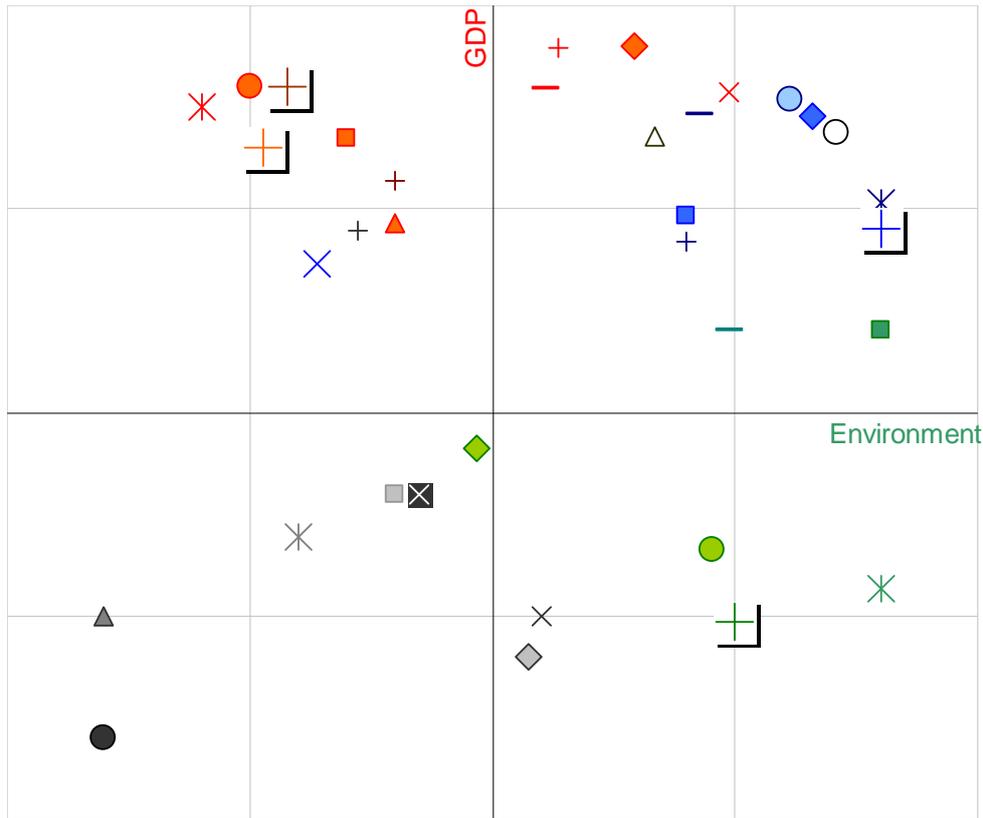
economic performance driven scenarios in red, ecologically driven scenarios in green, welfare scenarios in blue and decadence scenarios in grey.

Scenarios on economic and social axes



- Triumphant Markets
- Shared Responsibilities
- Turbulent Neighbourhoods
- ◆ Urban Colonies
- ◆ Good Intentions
- Policy First
- Sustainability First
- × The World Wakes Up
- × Backlash
- × I'm in love with my car
- × Moonlight ride in a Diesel
- + The Strong Nation Clubs
- + Compassionate World
- Cohesion-oriented (Danubean Europe)
- △ Knowledge is King
- △ Convulsive Change
- + Transatlantic Market
- + Global Economy
- The Hundred Flow ers
- Creative Societies
- ◆ Perpetual Motion
- ◆ Tribal Trading
- Market Forces
- Security First
- × S&T develops a Mind of its Ow n
- ⊠ Please, turn off the Spigot
- × Take the A-Train
- × Riding the rainbow
- + Fortress America
- + Triage
- Pro-active Europe
- Competitiveness-oriented (Rhine-Rhone Europe)
- ▲ Big is beautiful
- + Strong Europe
- + Regional Communities

Scenarios on economic and environmental axes



- Triumphant Markets
- Shared Responsibilities
- Turbulent Neighbourhoods
- ◆ Urban Colonies
- ◆ Good Intentions
- Policy First
- Sustainability First
- × The World Wakes Up
- × Backlash
- × I'm in love with my car
- × Moonlight ride in a Diesel
- + The Strong Nation Clubs
- + Compassionate World
- Cohesion-oriented (Danubean Europe)
- △ Knowledge is King
- △ Convulsive Change
- + Transatlantic Market
- + Global Economy
- The Hundred Flowers
- Creative Societies
- ◆ Perpetual Motion
- ◆ Tribal Trading
- Market Forces
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- × S&T develops a Mind of its Own
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- Pro-active Europe
- Competitiveness-oriented (Rhine-Rhone Europe)
- △ Big is beautiful
- + Strong Europe
- + Regional Communities

4.1 The DELPHI survey

The DELPHI survey has been done by means of a questionnaire shared on-line by the internal and external experts. For the purpose of the DELPHI survey, scenarios are defined as a representation of visions/images of the future and courses of development organised in a systematic and consistent way (a distinction can be made between scenarios and visions or images of the future: the latter are often static “snapshots” in time, whereas the former are dynamic, logical sequences of events).

Generally speaking, a DELPHI analysis involves the survey of experts’ opinion – sometime consecutively over a number of waves and a period of time – for identifying developments and/or trends and reaching gradually a convergence of opinion without physically getting together. The essence of the technique comprises questionnaires sent out to the same group of experts (sometime several times, each time adding the results of the previous rounds). The concept behind the DELPHI method is to facilitate an experts “discussion” – in contrast to a simple survey – and at the same time allowing for independent and in principle anonymous contributions of the participants.

More specifically, the TRANSvisions DELPHI survey focused on thinking about possible futures, asking to the question *what might happen* for the transport sector in Europe until 2050 by defining four “extreme” description scenarios (these list a set of possible events without taking into account their desirability). The objective of the DELPHI survey was therefore to elicit expert judgement on the plausibility of alternative futures.

The experts have been asked to read and react upon the following sequences of key events, each one describing a different story-line related to the four scenarios named “hypermobility”, “sustainable consumption”, “collapse” and “carbon-constrained”.

*Key events of the "hyper-mobility" scenario*Reference trends

- **Growing EU population:** the UN high variant population scenario issued in 2004 is confirmed by the actual evolution of EU-27 population, which grew from about 490 millions inhabitants in 2005 to 523 millions in 2030 and 550 millions in 2050. The proportion of elderly people (over 65) increased from 16% to 25%. Net immigration from outside Europe is more than 800 thousand of persons per year, mostly concentrated in EU-15 countries.
- **Convergent economic growth and soft climate change policy:** the world experienced convergent economic growth with rapid changes in economic structures towards a service and information economy, with reduction of material intensity, and the introduction of clean and resource-efficient technologies. The EU GDP growth has been in the order of magnitude of 2% per annum in the period 2010-2030 and 1,5% per annum in the period 2030/2050. A global climate change mitigation policy aiming at reducing the GHG emissions in the year 2050 at 2000 level (corresponding to a atmospheric concentration of about 550 ppm of CO₂-eq) caused a reduction of about 0,1% of the indicated annual GDP growth rates. Key mitigation strategies in the transport sector included more fuel-efficient vehicles, hybrid vehicles, cleaner diesel vehicles, and as from 2030 second generation biofuels, advanced electric and hybrid vehicles with more powerful and reliable batteries.
- **Continuous growth of world trade:** in the decade after the oil shock of the years 2007-2008, both developed and emerging economies diversified further their energy sources (with more electricity from nuclear plants, solar plants and wind power) and greatly improved their energy efficiency in all sectors. This contributed to reduce the energy prices and the trend was consolidated towards 2050 by the full adoption of hydrogen in the transport sector. With relatively low energy prices, the world trade continued to growth, again with a fast increase after 2010 of long distance trade of manufactured goods, mainly from China and India. Terms of trade continued to evolve, with EU maintaining the lead in some high technology products (e.g. those stemming from the application of nanotechnologies) and in the export of commercial services. China and India were producing a growing share of high tech, high value added products too.
- **Continuous growth of world tourism:** world travel and tourism grew as forecasted by the industry's World Travel and Tourism Council (WTTC) between 2009 and 2018 with an average growth rate of 4,4 per cent annum, and this was followed by a steady phase of more moderate growth, leading the tourism sector to represent more than 10 per cent of global GDP.

Key events until 2030:

1 – Wireless connection: the foundations of hyper-mobility were laid down in UK as early as in 2009, with the development of a range of intelligent miniature devices that connected consumers directly, and continuously, to the first national area wireless network. A similar development occurred later in the rest of EU, with the spreading on national areas wireless networks to other countries as well.

2 – Drivers assistance: governments and local authorities worked with car manufacturers to integrate disparate vehicle management systems (on-board driver assistance, automated driving) designed to even out traffic flows and reduce congestion. Integration was patchy at first, but the integration of advanced ground-based global positioning systems (GPS) receivers with wide area augmented systems (WAAS) capability in 2018 enhanced reliability and range of coverage significantly in the UK. In Europe, with the support of the EU and the European industries, the Galileo system took up ensuring the critical advance and independence in technology for Europe and its partners, including also US by means of the interoperability ensured with GPS. As early as from 2013, Galileo has created more than 100.000 new jobs and a market for equipment and services worth some €10 billion per annum. Besides helping to avoid traffic jams and therefore reducing drivers' waste of time, fuel consumption and pollution, driver assistance supported by the interoperable Galileo and GPS systems

helped to curb the number of road accidents.

3 – Increasing carbon emissions: if driver assistance systems helped people to manage their way around congestion, more people bought bigger cars and travelled further using the new systems, increasing carbon emissions. By 2030, 40% of CO₂ emissions came from transport emissions (instead of 30% of CO₂ emissions indicated in the latest 2007 revision of European Energy and Transport Trends). Aviation was doing little to help the situation, as the Emission Trading Scheme proposed as early as in 2006 was enforced only in 2025.

4 – Hybrid/electric vehicles and hydrogen cell applications: Starting from a relatively modest level, a steadily increasing proportion of motive power has been supplied electrically. A growing proportion of engines has been equipped with electric starter/generator systems (hybrid vehicles), thereby improving emissions and fuel consumption. Hybridisation happened faster where it made most sense, i.e. for short-distance operation but not for long distances, where the negative factors like weight and costs have more of an impact, while the positive effect from better energy management in the power-train is lost. A point has been reached where the electrical component of the full-hybrid power-train became the dominant partner and the internal combustion engine was relegated to the role of “assistant”. Some purely electric vehicles, including scooters, became also more popular in the urban environment. Some hydrogen cell applications were already being tested on the street financing full fleet of guided buses across pilot regions (e.g. the London region) from the proceeds of road pricing schemes. As from 2020 in the UK and by 2030 in other countries of EU, central governments developed complex sets of sanctions and incentives to encourage oil companies and car firms to invest seriously in the development of consumer cell hydrogen applications. Gradually, complete hydrogen cars can be seen on the EU roads, but they remain restricted to urban areas due to the infrastructure required to support them, which is not available in rural areas.

5 – Growing air transport: progress on the cleaner plane has been far slower than on the cleaner car. Energy efficiency improved by 20% through the first decade of the century but these gains were more than offset by a strong rise in demand over the same period. The trends highlighted as from the 2007 revision of European Energy and Transport trends (109% of air transport growth for EU-15 from 2005 to 2030 and almost 200% for NMS-12 in the same period) were continuing unabated. While the airport capacity already in place or planned at the outset of the 21st century in Western Europe revealed to be enough to accommodate this growth, some new airports have been built until 2030, mainly in the NMS. The aviation market has also benefited largely from the safe services offered by Galileo: by 2020 about 120.000 aircraft use satellite navigation in conformity with international aviation standards. However, as early as from 2006, when the European Commission proposed the adoption of an European Emission Trading Scheme (ETS) to curb the still small but fast growing greenhouse gases emissions of the aviation sector, became apparent that growth in this sector needed to be curbed if the EU countries were to meet its CO₂ obligations. However, and although the plan was to include international flights in the scheme and to start as early as 2010, the agreement entered into force later, and was initially limited to domestic EU aviation (due to the strong opposition of the US, threatening trade sanctions if the EU made any attempt to force foreign airlines to comply with its emission trading system). Only by 2025 the ETS became fully effective, covering domestic and international aviation.

6 – Nuclear energy: Several new nuclear plants reactors are being built in UK and EU other countries with nuclear plants already in operation in 2005. Plans to develop new generation nuclear energy plants have been adopted also in other countries where nuclear energy was previously banned.

7 – High Speed Trains (HST): with air travel seen as a less viable option to get to Europe, the HST system has become a popular option.

8 – Telepresencing: the first real-time tele-presencing technology was launched in 2020. While adequate technology had been in use – on a very limited scale – for several years, the system is now finally of a standard that business finds acceptable, making the concept of remote working from different parts of Europe a reality.

9 – Life stress: in this highly connected world, life and work are intense, and the boundary between them is blurred. Some thrive on the buzz of activity that results, but early burn-out is common and stress is a way of life for the vast majority of the EU population. Not everyone finds it easy to “keep

up” with the growing competition for the most desirable, highly paid jobs. The use of prescription and non-prescription drugs to manage stress continues to boom, even in the face of increasing evidence, and knowledge, of side-effects.

10 – Urban sprawl: while a significant number of, mainly younger, people thrive on the buzz of living in the urban hubs, telepresencing and ever more powerful miniature communication devices are increasingly allowing the more affluent to move to the outskirts of towns or to rural areas.

Until 2050:

11 – ID devices: by 2042, ID devices were well and truly embedded in people’s live across EU. Since then, a raft of new services has been added: the LifeServe agent-based software can alert parents when their children leave the schools grounds, calculates the most cost-effective transport route for every journey and automatically schedules telepresence meetings with colleagues, family, friends or whoever.

12 – Energy transition: the hydrogen economy has now become the reality. The combination of increased nuclear capacity and the development of renewables had reduced dependence on carbon-based fuels. Clean-coal technology, combined with effective carbon sequestration, smoothed demand at power stations and mitigated much of the carbon impact by dealing with it at the top of the supply chain rather than at the end of the exhaust pipe. The vision for the whole Europe is that, by 2050, non-fossil energy sources (excluding nuclear) will account for more than 35% of the total energy supply, with biomass, wind and solar energy taking leading roles. Considerable attention will be paid to energy conservation. About half of the EU member States will support the use of nuclear energy. Coal with CO₂ capture will be applied on a large scale for the production of both electricity and hydrogen. The hydrogen will be used in the transport sector. Biomass will be used as fuel for freight transport – with the availability of second-generation biofuels - and as feedstock in industry, as there are few other substitutes for oil products in these sectors. The energy needs of dwellings and other buildings will have been greatly reduced, and will primarily be met with solar energy and electricity.

13 – Increasing waste footprint: what to do with the nuclear waste remains an issue, despite the fact that the amount of waste produced by the modern reactors is significantly less than those from plants in the past. It’s not just nuclear waste that is a potential future problem. Ever increasing consumption of goods and high-impact services means that society’s waste footprint is growing inexorably and unsustainably.

14 – Increasing long-distance transport: with ID devices the only means of making reservations and paying for a seat on all High Speed Trains, long-distance journeys are seamless and quick, as well as relatively low cost in environmental terms. Further rail routes continue to be added across the continent. Long-distance guided vehicles systems have also helped. Some travellers simply lock their car into the guided lane of a motorway and go to sleep while the vehicle takes them there, sometimes overnight – a phenomenon that’s known as “night-riding”. In the freight transport sector, Galileo has enabled road and rail operator to increasingly monitor the movements of their lorries, wagons and containers more efficiently, and combat theft and fraud more effectively.

15 – Flexible local public transport: more locally, public transport has mostly been replaced by the Swarm, a type of integrated mass taxi system. These as well as more traditional taxi companies are using as from 2013 the Galileo system, and thanks to this they offer a faster and more reliable service to their customers. Local people-carrier vehicles despatched into specific areas of city, and are alerted to user locations and journey request through their positionally enabled mobile phones. The network calculates the most efficient way of collecting and delivering multiple passengers, and allocates the fare. In a world of integrated intelligent technology, security for the traveller is ensured because the identity and provenance of each passenger is known as soon as they make their journey request. Passenger can get on any bus that contacts them, rather than having to wait for a particular number. However, the biggest barrier to take-up is the reduced anonymity – the vehicles are closer to cars than buses in size and the proximity between passenger is increased.

16 – Increasing volumes of traffic: growing home working and telepresencing have not reduced levels of travel as much as some had hoped. It seems individuals still enjoy the sense of leaving the

home, as well as the desire to explore. Demand for travel has remained strong in this “always on” world – transport is now well connected, semi-automated and (mostly) friction free. However, with new technologies – which combine low or zero emissions with energy “vectors” that ensure efficient energy capture and storage – ensuring that environmental curbs on car use are unnecessary, traffic management remains a critical problem. Cyclist and pedestrians continue to have a tough time – even without the afterburn of diesel and petrol in the air, the volume and speed of traffic still means that many urban environments are not pleasant and safe places to cycle and walk in.

17 – Rampant consumerism: a raft of developments in ICT and intelligent transport throughout the 2010s and 2020s has helped to fuel the “always on” society of the past 50 years. Intelligent positioning systems, encryption technology, real-time telepresence and a shift towards a low-carbon economy have boosted the economy and accelerated consumerism that shows few signs of abating. If energy issues have been addressed, other sustainability problems have not. Europe’s waste footprint is still far larger than Europe is; we are still a “three-planet” society, sustained only because, globally, the poorest are poorer than ever. In a far richer society, there is a vast service sector, increasingly offering high degrees of personalisation.

18 – Rising stress: high-intensity work experiences are matched by high-intensity leisure, in the form of multi-user games and designer stimulants. However, the need to maintain their skills in such a competitive environment, along with fewer opportunities to switch off from work, has taken its toll on many. The use of some specific drugs, by that time legal and free of secondary effects, to enhance intellectual performance of an ageing population continue to rise.

19 – Increasingly automated delivery of services (self-servicing): as a society, we are richer than ever, more than twice as affluent as we were in 2005, and one consequence is that is increasingly hard to fill jobs that involve working anti-social hours. With fewer people needing the pay from such jobs, and a growing realisation of the social costs of such work on family life and social relationships, many service deliverers have been forced to put in place sophisticated auto-delivery systems in order to continue to provide the levels of service and frequency of delivery their customers have come to expect. However, other personal services (e.g. home elderly care) continue to be increasingly provided in the richer EU countries by low-skilled immigrants from less well-off European countries or poorer countries outside Europe.

*Key events of the "sustainable consumption" scenario*Reference trends

- **Slight decline of EU population:** the UN medium variant population scenario issued in 2004 is confirmed by the actual evolution of EU-27 population, which slightly increased from about 490 millions inhabitants in 2005 to 494 millions in 2030 and then declined to 480 millions in 2050. The proportion of elderly people (over 65) increased from 16% to 29%. Net immigration from outside Europe is less than 800 thousand of persons per year, mostly concentrated in EU-15 countries.
- **Low economic growth and strong climate change policy:** the world experienced intermediate levels of economic development, and less rapid and more diverse technological change, with an emphasis on local solutions to economic, social and environmental sustainability. The EU GDP growth has been in the order of magnitude of 1% per annum in the period 2010-2030 and 0,5% per annum in the period 2030/2050. A global climate change mitigation policy aiming at reducing the GHG emissions by about 40% in 2050 compared to 2000 levels (corresponding to a atmospheric concentration of about 450 ppm of CO₂-eq) caused a reduction of about 0,1% of the indicated annual GDP growth rates. Key mitigation strategies in the transport sector included modal shift from road transport to rail and public transport systems, non-motorised transport (walking and cycling), land-use and transport planning, use of biofuels.
- **Shift to regional world trade patterns:** in the decade after the oil shock of the years 2007-2008, gains of energy efficiency in all sectors and the shift to more sustainable consumption and lifestyles in Europe and elsewhere in the developed countries contribute to reduce the impact of triple-digit oil prices. However, world trade continued to be dependent on highly priced fossil fuels, and this contributed to stop the growth of long distance trade increasing the share of regional trade of manufactured goods. Intra-EU trade increased, as well as the trade with CIS and middle-east countries, while the delocalisation of production in China and India was partially reversed.
- **Reduction of world tourism:** world travel and tourism was dominated by forms of domestic eco-tourism and less long-distance air travelling.

Until 2030:

1 – Road pricing: at the end of the first decade of the 21st century, the EU Member States have realised that meeting its international emission reduction targets wouldn't be done by technology alone, and that it was necessary actively to encourage people to travel less; and that this in turn required public policy intervention to help households and individuals to change their lifestyles, and business to change their expectations. Even before nationwide road pricing was introduced in the great majority of EU countries in the period 2015 - 2020, charges and tax penalties were imposed on motorists' benefits such as "free" parking. As early as in 2013, the Galileo system started to support the road pricing pilot schemes, making customized road tolling in the urban and interurban transport context a reality.

2 – Mobility rights enforced: political culture was increasingly interested in the problems of social, economic and political exclusions, of which access to transport was now strongly identified as a main cause. "Mobility rights" were argued to be a principal barrier to economic and social participation in society. As with other services where universal provision was deemed to be important, it was simpler to design them to be accessible, whether or not the end-user had personal access to a car.

3 – Accelerated urbanisation: the global trend to urbanisation has been reinforced in the EU countries, as planning guidelines were increasingly adopted along the lines of the ABC location policy used in the Netherlands, to encourage greater building density and co-location of business. So it was that the UN estimate that the EU-25 urban population would hit 78,4% by 2030 was passed in 2022!

4 – City transport infrastructure and innovation: changes in infrastructure have had a significant part to play as cities have invested in public transport and cycle paths, and more people are getting out of their cars as the overall image of public transport improves. Transport innovation came at the local level rather than the national: local agencies were simply more responsive to innovation. Their relative diversity helped. Pilot local authorities across Europe were the first to replace their city centre bus fleet with hybrid electric/NPG buses, and install the fuel infrastructure needed to do so – and opened up that infrastructure to private motorists with similarly powered vehicles.

5 – Drive away from automated public transport: not all public transport innovations were successful. Within outlying urban areas more flexible and demand-responsive public vehicles evolved as a hybrid between buses and taxis. Although early results had shown a significant reduction of congestion, pilot testing of fully automated hybrid vehicles halted when newspapers reported that in trials a car had hit a pedestrian. The Unions welcomed the re-introduction of drivers, and their warnings about over-reliance on autonomous systems struck a general chord. Plans for a dual-mode long-distance commuting system using hybrid vehicles linking larger conurbations were shelved indefinitely.

6 – Competitive and sustainable cities: globally, competition is increasing between cities, not states, and the winners are those that are able to link high-value knowledge assets with a desirable workforce, good quality of life, and appropriate public assets such as cultural and educational resources. Cities are changing, driven by the twin pressures of competition and the national, regional and local governments’ continued push to make it safer and easier to access jobs, shopping, leisure facilities and services by public transport, walking and cycling. Society embraced this new world where people do not travel as extensively. Population, housing density and employment in big cities are rising faster than before. Cities are more compact, widening the range of local opportunities and activities that are accessible without using the car.

Until 2050:

7 – Sustainable buildings: as from 2040 sustainable buildings are the norm, rather than the exception, especially commercially and public buildings. This didn’t happen overnight; but the replacement cycle – whether being rebuilt or refurbished – on commercial buildings is about 30 years, and legislation introduced across EU countries in 2020 to mandate “the new sustainability” has now had its effect.

8 – Distributed energy power (microgrids): an effect of the diffusion of sustainable buildings has been to transform the energy supply model: once a centralised model, built by the state and later privatised, now it is a distributed one, as the economics of energy production have been transformed by microgrids. These are small community networks that integrate wind and solar power into the electricity network – and now generate over 50% of household electricity in cities.

9 – Zero-waste society: the notion of “waste” has almost disappeared from the vocabulary. Instead, everything either gets recycled as a raw material for another production processes or returned, clean, to the earth or water. Every municipality runs its own “freecycle” scheme to help people who have things they want to dispose of to find a willing recipient. And because resource use is now a fundamental part of the tax base, people prefer not to buy disposable items any more. The legal requirement for goods to be repairable, which manufacturers had lobbied hard against, is now regarded as a source of competitive advantage.

10 – Full cost accounting and resource taxation: full-cost accounting has become the standard accounting convention, and GNP and other economic growth indicators are no longer used as shorthand for an indication of social benefit. Materially, fewer good, but more services, are consumed than in 2005. And people value possessions that will last more than they did then, not least because the tax system has been fundamentally redesigned so that people are taxed principally on the resources they use up, rather on the money they earn or what they spend.

11 – Slow passenger and freight transport: people travel, but not so far, and often by foot or cycle. Transport is permitted if it is “clean and green”, but not otherwise. Local electric vehicles are ubiquitous, and local light rail schemes are common. In the long-distance world, speed is less important than energy conservation. Even if transport is no longer fuelled by oil, clean energy is still

far more expensive than petrol or diesel ever were. Large slow-moving “road-trains” are a common sight in their own guided tracks in motorway lanes, controlled by their own information network as they leave the ports for their inland destination. The lack of integration of systems means that generally transport is poorly integrated, with different systems controlled by different organisations. Freight, perhaps, was lucky that it was valuable enough to justify the infrastructure investment; for individual drivers, the mass traffic management systems which were widely predicted in the late 20th century were too unreliable to work, and were abandoned after a succession of mass pile-ups. Individual satellite navigation systems seem only to move congestion to new bottlenecks.

12 – A “knowledge hubs” economy: globally, most economic value resides in “knowledge hubs”, which emphasise the importance of attracting the best people to learn, and to work, in your city. Competition between cities is about quality of life. In this respect, Europe has done well, developing its cultural resources to create cities that are envied everywhere. The judiciously applied migration policy of free movement in Europe, with a proportion of “investment visas” for those from elsewhere, has helped to manage its ageing population while attracting the best young talent from the countries of the south and east.

13 – Mixed situation for rural areas: the story in rural areas is mixed. There is more agricultural work than there was in the 20th century and more people are employed on the land. This is also due to a growing production in response to demand for more local crops, food and biofuels. But rural work is still poorly paid and few want to do the work. As with city service infrastructure, many of those who are employed are migrants. Rural areas also suffer from poorer communications. Generally, it is expensive and inconvenient to live in the countryside and work in the city, unless the regional government is one of the few that has invested in light rail links.

*Key events of the "collapse" scenario*Reference trends

- **Strong reduction of EU population:** the UN low variant population scenario issued in 2004 is confirmed by the actual evolution of EU-27 population, which decreased from about 490 millions inhabitants in 2005 to 465 millions in 2030 and then further declined to 415 millions in 2050. The proportion of elderly people (over 65) increased from 16% to 33%. Net immigration from outside Europe is nearly stopped.
- **Collapse of the world economy:** the global economy collapsed and the EU GDP level fell back to the 1995 level (which is about 50% of the 2030 baseline level projected in the last 2007 revision of European Energy and Transport Trends).
- **Collapse of world trade:** world trade was drastically reduced as a consequence of the global collapse of the economy. Local production of food and other non-energy products prevailed.
- **Collapse of tourism:** both international and domestic tourism collapsed, as leisure travel was reduced to almost pre-industrial levels.

Until 2030:

1 – The energy shock: it is 2025. The energy shock has been sharper and more disrupting than anyone except the pessimists imagined. The Peak Oil came and went, and the reserves figures turned out to be as fragile as the critics had insisted. Oil and gas prices have spiked and then spiked again. Attempts to secure supplies from Russia failed as the Russians have turned instead to their customers in the East. And the problems were not only with energy supplies: the increasingly common “freak” weather conditions have stretched the infrastructure beyond its limits. With energy shortages and repair costs have come higher prices, unemployment, and a depression as sharp as that in 1930s (and perhaps sharper). Millions are unemployed, and with little prospect for improvement.

2 – Hard travel: travel is hard, within and between EU countries and outside Europe as well. The national governments have adapted the existing congestion charging technologies simply to prevent travel where necessary, at least when power cuts allow.

3 – Self-help communities: the picture is not one of unremitting gloom. In the face of food and energy shortages, self-help communities have started, tentatively, to emerge. Cities have declined, but local food production and services have increased. Even as the grid has become more erratic, small self-powered communities have started to emerge, especially in the countryside, using wind, water and solar power. Millraces are running again. Local food production is also on the up; even if production is sparse, it makes work for people who would otherwise be workless.

4 - Low-powered communications: the same spirit has been seen in the emergence of low-powered communications technologies. Wireless mesh networks, tried and tested in places like Nepal, work fine in Europe too. And the world has been turned upside-down in other ways: communities which are used to hardship, and where people still have mechanical and technical skills, seem to be doing better than those that had become part of the knowledge economy. Social cohesion matters, more than ever (wireless mesh networks are point-to-point-to-point networks: each node can send and receive messages and can function as a router relaying messages for its neighbours).

5 – Social breakdown: but in the areas hit hardest, with fewest resources in the lower-energy economy, social breakdown is rapid. Armed gangs roam the roads and the army and police do little other than containment, unless officers are shot at. They are spread too thin. Gated communities are no longer just for the more affluent.

Until 2050:

6 – A fragmented polity: borders are important in the world of 2040, for reasons of security and of revenue; tariffs on transport are one of the most reliable ways of raising taxes. The power of the state has eroded, because it can no longer guarantee security or stability. Instead, the world has fragmented into smaller communities, often delineated by natural landmarks, and barriers, and by local resources.

7 – An eroded information infrastructure technology: much of the 20th century infrastructure has

been eroded now (much of it was already old in 2005), but that doesn't mean that communities have retreated to a new mediaeval brutalism. Much of the knowledge of the technology which drove the 'Great Economy' of the 20th century is still in people's heads. If some components are no longer viable (the last chip fabrication plant closed a decade and a half ago), invention has found ways of adapting. Some of the models already existed: that the computer network, with the central server and 'dumb' (or simple) terminals used far less energy and generated far less waste than the proliferating personal computer, was well understood in 2005. Short-hop wireless systems have proved to be resilient. Above all, the groups who make communications function are highly valued, and highly incentivised. This is an area of constant innovation. The huge clean microchipmaking plants of the early 21st century have long closed, but there is still a supply of chips, and other technology fragments, from the so-called 'chip monkeys', who forage in waste tips for them, stripping cars and toys. It is a lucrative business, if an unhealthy one.

8 – Slow transport patterns: Transport is slow: energy efficiency matters far more than speed. Canals and sea-going vessels are used for freight; the rail network still exists, but is worthwhile only for high-value, long-distance cargoes and trips. The few remaining airplanes in their last few years of life have become the preserve of the 'super-rich', as they were in the 1930s. Small point-to-point flights are more common than the vast 'hub-and-spoke' systems which were once thought to drive economic growth, at significant environmental cost. But the airship entrepreneurs seem to be making progress with new models. Some cars still function, although most have had to be rebuilt after their electronics failed; some have been adapted to steam. Local transport, typically, is the preserve of the bike (sometimes electric-aided) and the horse.

9 – The remnants of globalisation: distance matters, but less than it might. The world that fragmented when the energy collapse came was already diverse and multicultural, and those social links produced social value. The groups which had the largest diasporas (especially Asian groups) gained influence because – in a low-trust world where identification was important – they were more likely to know what was happening elsewhere, and who was likely to know about it. Such social groups were also more likely to be involved in trade between communities. But there are still high degrees of mistrust in this world, and with good reason. These problems are to be found across the globe. The growth of the Chinese economy came to an abrupt halt in the face of falling demand and the rising costs of its manufactured products, and has since succumbed further to the environmental impact of water shortages in the south, the spreading deserts of the north, and food shortages everywhere. India has been overwhelmed by the spread of millions of environmental refugees from Bangladesh and other low-lying neighbours.

10 – Local lifestyle: the world now is more local than it was. The world awash with cheap energy is a distant memory, and lifestyles have changed accordingly. If people travel as much as they ever did, they do it more slowly; they don't travel so far. Work is closer to the home; indeed, in some places, living patterns have reverted to the pre-industrial, with the home and the workplace being the same. People – certainly in Europe and the United States – are colder and hungrier than they were 50 years ago. But more appropriate building design has compensated for some of the cold, and diet is better. Less energy means that there is more physical work to be done, so people are fitter too.

11 – Contracted carbon emissions: Carbon emissions have contracted, mostly, simply because far less energy is used than in the later 20th century, although coal is burnt again for heat and some power, at least where it can be recovered. Vehicles for local use combine human power with electricity, for those who desire such luxury; the fastest vehicles on the road are steam-powered; although there are precious few of those, they are well-suited to the wide, if battered, roads that remain from the later 20th century. Air travel is a luxury for those few still employed by global enterprises, mostly energy companies enjoying the last profits from their lucrative oil and gas reserves, flitting between expensively maintained and well-defended airport compounds. For those who do not have such luxury, life is simpler. This is a world in which the 'energy cost' of everything, goods or services, has to be paid for. People own less than they used to, and they repair more than they used to. Waste is minimal, not out of ideological concern but simply because it is a luxury; when things reach the end of their functional lives, they are re-used or recycled. People also trade less than they used to; however, they do trade the things they can't make locally.

Key events of the “carbon-constrained” scenario

Reference trends

Slight decline of EU population: the UN medium variant population scenario issued in 2004 is confirmed by the actual evolution of EU-27 population, which slightly increased from about 490 millions inhabitants in 2005 to 494 millions in 2030 and then declined to 480 millions in 2050. The proportion of elderly people (over 65) increased from 16% to 29%. Net immigration from outside Europe is less than 800 thousand of persons per year, mostly concentrated in EU-15 countries.

Slow economic growth: economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in the hyper-mobility and sustainable consumption scenarios. The EU GDP growth has been in the order of magnitude of 0,5% per annum in the period 2010-2030 and 0,3% per annum in the period 2030-2050. A global climate change mitigation policy aiming at reducing the GHG emissions by about 40% in 2050 compared to 2000 levels (corresponding to a atmospheric concentration of about 450 ppm of CO₂-eq) caused a reduction of about 0,1% of the indicated annual GDP growth rates. Key mitigation strategies in the transport sector included more fuel-efficient vehicles, cleaner diesel vehicles, biofuels, modal shift from road transport to rail and public transport systems, non-motorised transport (walking and cycling), land-use and transport planning.

Shift to regional world trade: in the decade after the oil shock of the years 2007-2008, gains of energy efficiency in all sectors and the enforcement of tight carbon emission regulations contribute to reduce the impact of triple-digit oil prices. However, transport continued to be very costly, and this contributed to stop the growth of long distance trade increasing the share of regional trade of manufactured goods. Intra-EU trade increased, as well as the trade with CIS and middle-east countries, while the delocalisation of production in China and India was partially reversed.

Reduction of world tourism: world travel and tourism was dominated by forms of domestic eco-tourism and less long-distance air travelling.

Up to 2030:

1 – Limited change of the transport infrastructure: the past 20 years have seen limited changes to the EU’s transport infrastructure. Few long-term infrastructure projects have had the political commitment or investment required to become a reality. The ageing infrastructure is becoming an increasing financial burden on the state and business has become concerned about the impact on the EU’s long-term economic competitiveness. Successive governments have been reluctant to tackle the growing threat posed by climate change, fearing the consequences from an electorate that still wants the right to travel where, when and how they want.

2 – Fuel efficiency: vehicles are now 90% efficient at energy conversion. Use of alternative fuels and ultra-light materials – such as aluminium, plastics, magnesium, carbon fibre, and metal matrix composites – are two key ways that fuel efficiency is increased. Car manufacturers have overcome the challenges of hydrogen storage, and are working towards hydrogen fuel-cell vehicles, as well as biodiesel and SVO (straight vegetable oil) engines. The constraining factor remains the fuel infrastructure.

3 – Dynamic traffic flow management: The first large-scale dynamic traffic flow management system pilots – introduced as from 2010 for some EU regions (e.g. UK West Midlands, Stockholm, Barcelona, Warsaw) – was initially hailed as a success but quickly ran into technical problems. It was some years before these pilot systems were declared a success by governments – speeding travel times, smoothing flows on the network and reducing accident rates by up to 30% – but their endorsement was not sufficient to placate the growing numbers of citizens who were becoming increasingly vocal about the perceived threat to their right to mobility. These concerns were related in particular to the use of Pay As You Drive (PAYD) elements of the pilot schemes (with this system

vehicles fitted with electronic vehicle identification chips calculate and assign premiums based on actual vehicle use. The driver's monthly bill is calculated according to their driving data – distance travelled, premium toll roads chosen and emission level). It is still too early to tell how effective dynamic traffic flow management will be. The technology remains susceptible to system failure and vulnerable to attack. Problems with interoperability and inefficiency – the result of unresolved issues around standards and exchange protocols between operators – remain. So too does the question of ownership of the personal data that is collected through the system.

4 – Increasingly priced air transport: airline passengers suffered a huge price hike nearly a decade ago and have watched prices continue to rise constantly ever since. On top of that, environmentally driven passenger airport landing taxes – introduced across the EU in 2020 for all planes with CO₂, CO, NO_x or VOCs emissions above Clean Air Standard (CAS) and collected at the point of arrival regardless of point of departure – have resulted in increased costs, delays, re-scheduling and complaints as airlines seek to offset costs by utilising cheaper regional airports. The growth of the aviation sector was started to be “carbon constrained” as early as 2010, when the ETS proposed by the Commission in 2006 and then approved, entered fully into force, covering domestic and international aviation, and with a total amount of emission certificates capped at just 75% of the average emissions in 2004-2006.

5 – Increasingly priced rail transport: railway passengers aren't happy either; years of rising fuel costs and underinvestment in public transport mean that the networks are – still – stretched to their limits. Public pressure for investment in public transport is growing and there is mounting concern about the continued use of old, high-SO₂-emission electric traction on regional (and some long-distance) journeys.

6 – Carbon Contraction Agreement: across the transport infrastructure, the rhetoric may have been there, but there has been little substantive action. It is therefore hardly surprising that the G10 and the EU Member States governments are now feeling the political heat on climate change. The Contraction and Convergence Agreement (CCA) signed by the G10 in 2024, could be now the best chance to tackle the problem. The agreement was for a full-term contraction budget for global emissions consistent with stabilising atmospheric concentrations of greenhouse gases at a level of 450 parts per million by volume. The intent was that all countries converge around more sustainable emissions targets.

Up to 2050:

7 – Carbon decoupled growth: in the year 2040 the economic, environmental and social consequences of signing up to the CCA are clear. The economy has continued to grow, despite a significant reduction in the amount of travel being undertaken, much to the surprise of some economists; GDP and transport growth are not as closely coupled as they were once believed to be. Under the terms of the CCA, individuals each received a carbon entitlement, which had been negotiated and agreed between the regions of the world. The entitlements, in the form of international energy-backed currency units (EBCUs), operate as a parallel currency. The G10 nations have all successfully met the CCA targets on carbon emissions and some of the most pessimistic outcomes of climate change have been avoided. This is a cause for celebration among the world's political leaders, but the carbon measurements in the atmosphere are still rising, probably because of inaction a generation ago, and it is hard to gauge whether contraction and convergence will be enough.

8 – Strong social impact of carbon entitlements: a picture of Europe in 2035 showed the social impacts of CCA to be more dramatic than anyone had predicted. Notably, the gap between the poorest 10% of the population and the rest narrowed significantly as individuals who used little carbon successfully traded their entitlement – allocated as UCEs, or ‘Units of Carbon Entitlement’ – for cash. Carbon entitlements have affected middle-income families too, forcing many to change their lifestyles in order to make best use of their EBCUs. Two-car families are in decline, bicycle sales continue to soar, home working is increasing and many families are rediscovering the need to budget carefully in order to purchase the travel credits required to go on holiday.

9 – Better local infrastructure and services: the renaissance of homeworking has created demand for better local infrastructure and services. Many local authorities have responded with extensive

carbon-free infrastructure development programmes. Biodiesel buses have been a particular success in the face of insufficient carbon credits. Rural areas with strong communities and local leadership have fared better than expected due in large part to the pooling of community carbon credits for local transport provision, such as school buses. Less-cohesive rural communities are, however, struggling and many face an uncertain future as residents are forced to consider relocating closer to the jobs.

10 – Biofuel buses: biodiesel and also bioethanol buses circulate freely and are starting to become more popular, although they remain ‘niche transport’. The biggest limit on the growth of biodiesel is its agricultural impact, reducing the amount of land available for producing food closer to where it is eaten. The declining numbers of fast-food restaurants have long since entered into agreements to recycle all their surplus cooking oil into the vehicle network.

11 – Increasing public transport commuting: a growing number of commuters are willing to suffer long bus journeys during the week, in order to spend their carbon entitlements on enjoying themselves at the weekends. Using the trains is more pleasant and efficient than it used to be after increased investment in latest-generation fuel cells (reducing pollution and improving performance) and satellite positioning systems (improving safety and efficient movement on low-density routes). However, train operators are once more complaining that they are at capacity, despite the increased volumes of traffic afforded by network technology.

12 – More rational freight transport: the now widely spread national traffic flow management systems and the CCAs have forced many businesses and freight companies to seek more cost-effective and energy efficient means by which to transport their goods across Europe. Highly sophisticated wireless identification devices have allowed them to optimise logistics and distribution with the large EU ports, and many now use the existing EU’s waterways as their key means of distribution. Supermarkets have faced many challenges too – they have a maximum allocation of non-local and non-seasonal stock, enforced by ubiquitous wireless stock-tagging schemes, which are monitored in real time. It is no longer viable to fly produce in from further afield.

13 – Intelligent speed control: London and Paris have led the way for further reducing speed limits in cities – and have threatened to impose legislation in this area if car manufacturers do not commit to building intelligent speed adaptation systems (ISAS) into all models. Increasingly, cars are restricted to 30 kph in residential zones and 50 kph on the outskirts of towns and villages, and the technology is integrated with national digital speed maps. Vehicles download the latest version of the speed maps as part of their daily software update and automatically limit their speed when entering or exiting different zones. In addition, sensors in the vehicle can send a distress signal to the police if the vehicle is involved in a crash while travelling at over 50 kph.

14 – Drastically reduced transport volumes: after half a century of contention, the ‘road wars,’ which have dominated transport policy since the early part of the century, finally seem to be over. The largely unrestricted personal mobility that people enjoyed in the early years of the century is now a distant memory. After bitter political conflicts, sometimes violent, a tough national surveillance system means that people only travel if they have sufficient carbon quotas – and these are increasingly tightly rationed. Traffic volumes have shrunk hugely, and will fall further as the carbon ration continues to be reduced. There are even days when people have insufficient carbon credits to get to work, or so they say. As it concerns the long-distance transport, flying is increasingly becoming a luxury for the rich; and for a growing number of citizens, it is socially unacceptable even if it is affordable; frequent flyers are demonised in the same way that smokers were at the turn of the century.

15 – Inescapable carbon regulation and control: those commentators who argue that government policy has assailed individual freedoms are right – but unfair. Governments across the world have finally found the will to act, in the face of increasingly savage environmental projections, but they have had to do so because individual citizens and consumers who had access to all the same climate information as their governments did, had chosen not to act on it, or at least not to act fast enough. At a national level, much of the implementation is based on satellite surveillance and a huge processing capacity, which can monitor every car on the road, if need be. This is coupled with a carbon credits smart card, which is needed by any citizen who wishes to use any kind of carbon resources, from having a shower, to driving, to eating out, to listening to a digital music system. Those who are short

of credits have to buy them; those who have changed their lifestyle sufficiently and have credits to spare, or who are financially poor and who have little need for travel, have prospered by selling their excess credits. Since the individual carbon level continues to be cut each year, there are always willing buyers, at increasingly attractive prices. New in-car technology is having an impact too – the two green dials on every dashboard tell the driver both the environmental cost of each journey and the true economic cost.

16 – Taxation of resource consumption: one of the biggest incentives to change behaviour and reduce carbon consumption was the change in the tax system, which started to have a significant effect from the early 2030s. Instead of being taxed mostly on earning and spending, as under the old income tax and VAT systems, most tax is now raised against resource consumption. The EU led the way by replacing VAT with RUT (resource-use tax). The result has proved to be far more progressive, with far greater distributional effects, than the old system ever was, and far easier to police.

17 – Climate change effects continuing: despite the strong environmental enforcement in place, the scientific community remains pessimistic. Antarctica continues to shrink, and there are new stories, constantly, about carbon released into the environment as the ice retreats in the north. The sustained unpredictability of global weather patterns continues to have huge social and economic consequences. The parts per million are continuing to rise, ever closer to the critical levels that could take us into uncharted and unpredictable climatic territory.

In order to enable the consultation at a glance of the key changes expected in each of the four alternative scenarios, these have been also rearranged in **Table A** (shown in Annex I to this report), where the key events have been classified in relation to six main drivers of change:

1. Society
2. Economy
3. Energy
4. Technology
5. Environment
6. EU Policy context

Based on the information provided and their own expertise, the experts have been asked to answer to six questions, presented in Annex II to this report.

4.2 The results of the DELPHI survey and main outcomes of the workshop discussion

4.2.1 Qualitative results of the survey

The DELPHI survey has produced in total 23 responses. However the number of experts answering to different questions of the DELPHI questionnaire was variable. Here we will analyse the responses to the questions concerning qualitative aspects of the TRANSvisions drivers and scenario analysis.

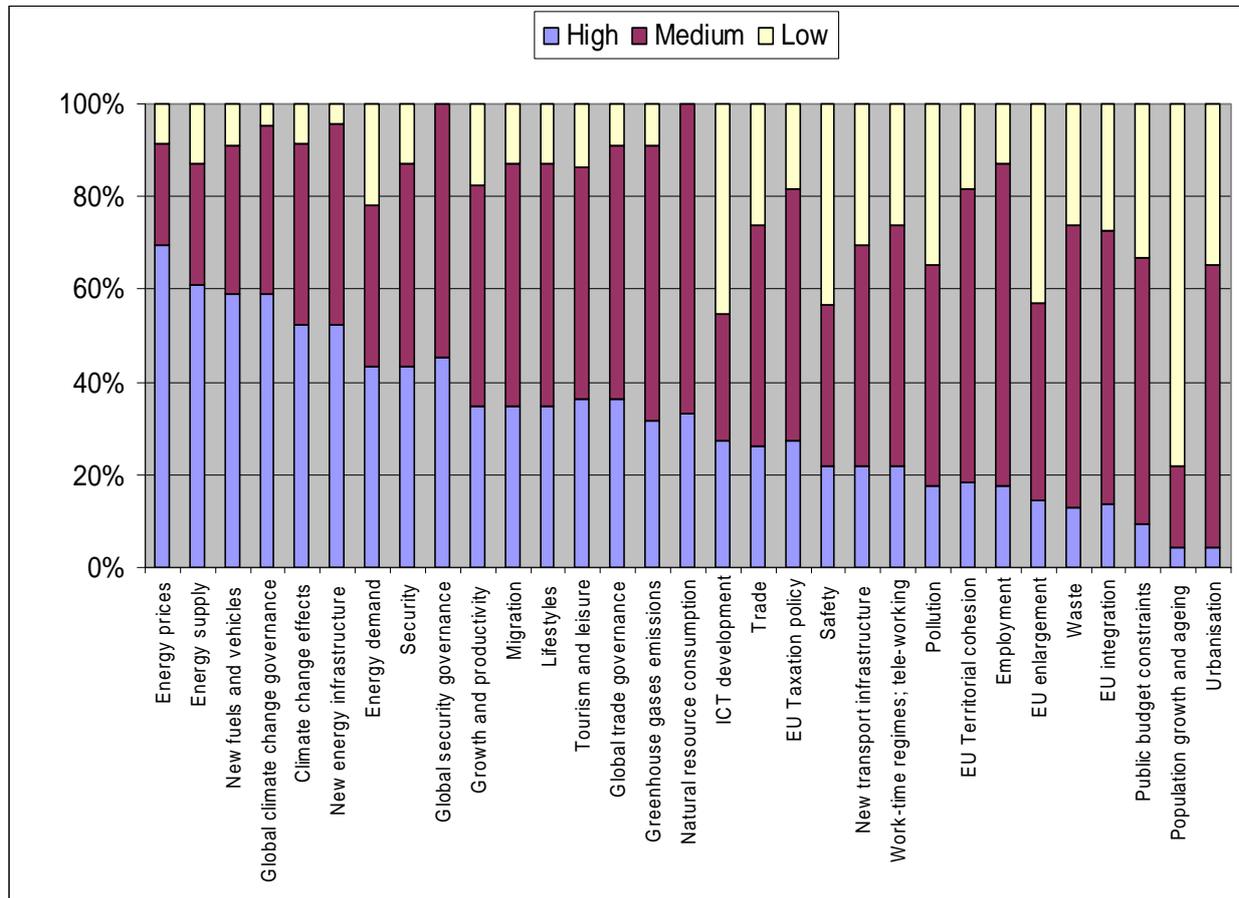
Question 1 – Any driver related feature to add or change in the scenarios of “hyper-mobility”, “sustainable consumption”, “collapse” and “carbon constrained” future? (9 responses).

The following are the answers received to this question:

- The absolute and relative change in the **price of energy sources** play a major role in all the scenarios by impacting behaviour and triggering innovation and market penetration of new technologies as well.
- **Life expectancy**, which is deemed to be different in the four alternative scenarios, will strongly influence the structure of the population in 2050 and the related mobility patterns.
- A drive towards atomistic **labour market** relationships – with an increasing individualisation of working contracts – is to be considered both in the hyper-mobility and sustainable consumption scenario. High level of unionisation is instead more likely in the other two scenarios, “collapse” and “carbon-constrained”.
- **Health impacts** linked to stress and obesity are likely in the hyper-mobility scenario, due to the lion share of passive forms of travel (as apposed to active travel by walking or cycling), while in the other scenarios population can gain health thanks to a greater share of active transport.
- Poor opportunities for interaction and **social life** should be considered as a feature of the hyper-mobility scenario, together with increasing problems of social inclusion and crime. In the sustainable consumption scenario it is most likely a drive towards growing importance of local identity and family & friends close by.
- **Global issues** that need to be considered include also: high price of energy and problems of security in the hyper-mobility scenario; a trend towards globalisation which is ineluctable also in the sustainable consumption scenario; the role of European and world-wide governance in mitigating the adverse impact of the worst scenarios (collapse and carbon-constrained)
- The possible occurrence of a **catastrophic nuclear accident** in Europe stopping further deployment of nuclear power, in the “collapse” and “carbon constrained” scenarios.
- Other key drivers should be also considered, such as: continuing **reduction in travel time** and increase of travel comfort in the hyper-mobility scenario; the increasing role of **security** control checks at airports, etc., which will make more difficult any kind of travel especially in the collapse scenario; the presence of a black market in the carbon-constrained scenario

Question 2 – Which drivers are the most affected by uncertainty? (23 responses)

This was a closed question, where the experts were asked to evaluate the level of uncertainty of each driver as “high”, “medium” or “low”. The answers are summarised in the following graph:



As expected, the category of “low” uncertainty drivers includes population growth and ageing, and also ICT development and safety, while drivers that more than 50% of the respondents classified in the category of “high” uncertainty include energy prices, energy supply patterns, the diffusion of new fuels and vehicles, global climate change governance, climate change effects and the realisation of new energy infrastructure.

Question 3 – How easy is it to assess the impacts of drivers on transport? (23 responses)

This question was strongly correlated with the previous one. The answers are summarised in the following table:

Easy assessment	Not so easy assessment	Difficult assessment
Population growth and ageing	Urbanisation	Public budget constraints
Safety	Trade	New energy infrastructure
	New transport infrastructure	ICT development
	Pollution	Natural resource consumption
	Tourism and leisure	EU enlargement
	Energy demand	EU integration
	EU taxation policy	Global trade governance
	Migration	Global climate change governance
	Work time regimes; teleworking	Global security governance
	Growth and productivity	Lifestyles
	Greenhouse gas emissions	Security
		Energy prices
		Energy supply
		New fuels and vehicles
		Climate change effects

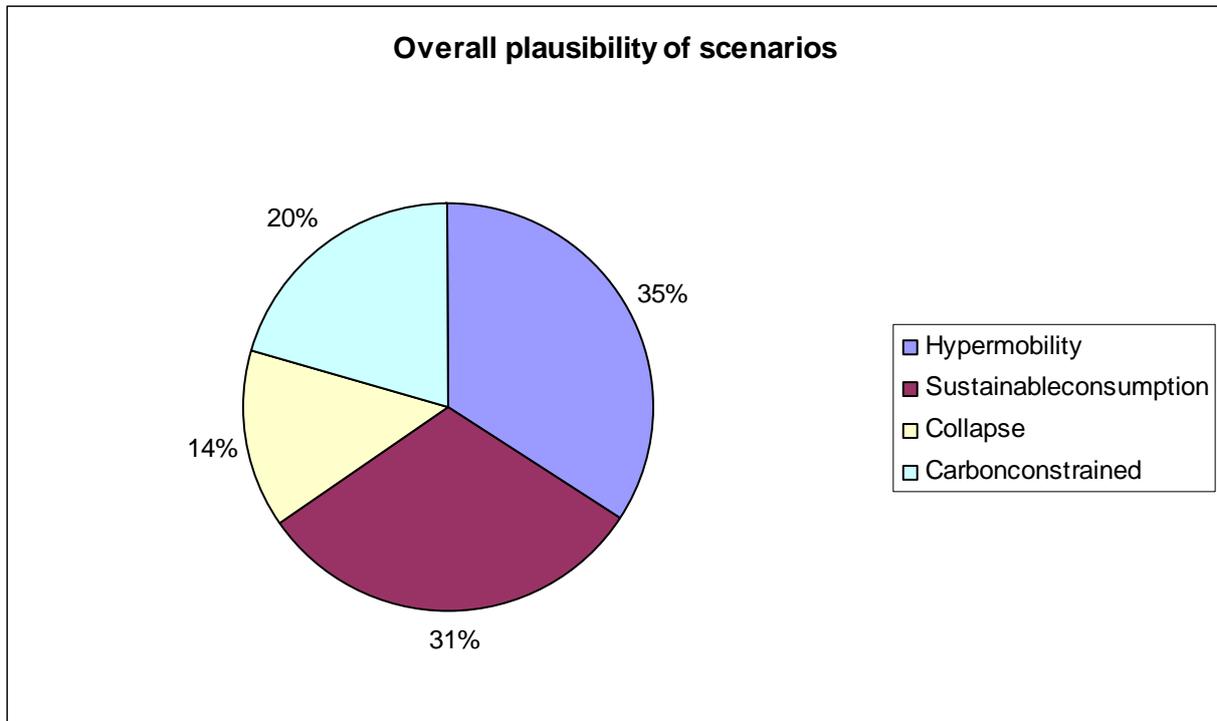
Question 4 – Which drivers have the most relevant impact on transport? (23 responses)

The experts were asked to indicate which was respectively the 1st, 2nd and 3rd more relevant driver among those listed in the questionnaire. Considering the aggregate score – i.e. the total number of 1st, 2nd or 3rd ranking positions got by each drivers – we gathered the following priority list:

1. **Energy**, and in particular the evolution of energy prices
2. **Economy**, and in particular the evolution of globalisation and trade patterns
3. **Infrastructure and technologies**, and in particular the building of new transport infrastructure in Europe and the evolution of fuel and vehicle technologies
4. **Demography**, and in particular the impact of ageing trends and the related structure of working/retired population; urbanisation is also considered an important trend
5. **Climate changes**, their impacts and the related mitigation/adaptation policies
6. **Innovation**, i.e. the diffusion in society of new ICT or other frontier technologies (e.g. nanotechnologies)
7. **Society**, and in particular change of working/leisure time regimes and consumption lifestyle

A final question in the DELPHI survey concerned the plausibility of the four scenarios at the 2050 horizon. The experts were asked to indicate what was the most likely scenario among

the four alternative scenarios presented to them. We got 17 responses and the shares of likelihood of the scenarios are illustrated in the figure below:



The most likely scenarios, in the opinion of the experts, are “hyper-mobility” (35% of responses) and “sustainable consumption” (31%). However, it is important to note that also the “carbon-constrained” (20%) and “collapse” scenarios (14%) are considered as most likely by a consistent minority of the experts group.

4.2.2 Quantitative results of the survey

The quantitative results of the survey basically concern question 5 of the DELPHI survey. The experts have been asked to give their educated guesses about the evolution at 2050 of a number of key indicators (39), related to five main transport drivers (society, economy, energy, technology and environment).

The Annex III to this report illustrates the experts’ responses about the evolution at 2050 of all the 39 indicators. This paragraph summarises the experts opinion for a short list (21) of most important indicators:

Society

1. Total Population
2. Ageing as % > 65
3. Net immigration (thousands people/year)
4. Urbanization %
5. Work-time regimes (tele-working %)
6. Tourism (Num. of tourists)
7. Safety (Number of injured people)

Economy

8. GDP growth
9. Trade
10. Employment %

Energy

11. Energy supply (Gross electricity generation Renewables share)
12. Energy supply (Gross electricity generation Nuclear share)
13. Energy supply (Gross electricity generation Coal share)
14. Energy supply (Gross electricity generation Oil share)
15. Energy supply (Gross electricity generation Gas share)
16. Share of biofuels in total final consumption of petrol/diesel for transport
17. Prices of fuel €/litre

Technology

18. Share of hydrogen fuelled cars
19. Share of electric cars

Environment

20. CO2 emissions
21. CO2 emissions from transport

The analysis of the experts answers must consider that for particular indicators the evolution at 2050 has been available from BAU (Business as Usual) projections taken from statistics and research projects. In such a case, the experts evaluations provide an indication about how much the future changes will affect (in positive or in negative) the “do nothing” trends of the indicators. In case of non availability of BAU estimates, the individual responses are compared with the average guesses given by the experts’ group.

The indicators for which BAU estimates are available include: Society (Total Population; Ageing as % > 65; Net immigration; Urbanization %), Economy (GDP growth and Employment rate), Energy (Gross electricity generation, Renewables share, Nuclear share, Coal share, Oil share, and Gas share) and Environment (Co2 emissions).

The following conclusions can be drawn:

- The experts evaluations for the Society indicators (basically demographic indicators) indicate that at 2050 the impact of net immigration will exert an upward pressure on the total EU population. In fact, 94% of the answers consider the future net immigration at level higher more than 20% of the BAU trends (from the Ageing Working Group of the EU Economic Policy Committee). This will imply higher EU population (61% of the answers consider the future EU population higher more than 20% of the BAU trends) and, it may be guessed, younger than the BAU forecasts (72% of the respondents consider the share of future people > 65 years living in Europe lower than more than 10% of the BAU trends). Concerning urbanization trends, the experts evaluations basically agree with the BAU trend at 2050 (from the UN World Urbanization Prospects). In fact, 90% of the respondents ranges between +- 10% from the BAU trend.
- The experts evaluations for the Economy indicators reflect the major uncertainties underlying the assessment of the future economic situation compared to the most predictable demographic projections. The indications about the future GDP growth

rates show in fact both a component of pessimistic evaluation of the future situation (35 % of the experts consider possible a reduction higher than 20% of the forecasted value) and elements of optimism (41% consider an increase by 10% of the forecasted growth rates). Where the pessimistic approach is dominant is in the future employment rates, with all the respondents considering possible a reduction between 10% and 20% of the forecasted levels.

- The experts evaluations for the Energy indicators provide the following picture: the gross electricity generation at 2050 will be supplied by less gas and oil, as indicated by about 80% of the respondents at values more than 20% lower the forecasted shares (from the World Energy Technology Outlook project). There will be more use of renewables (about 80% of the respondents consider their share at values higher than 20% of the forecasted values), while no clear patterns can be identified for the use of nuclear and solid fuels sources. Optimistic evaluations have been provided for the share of biofuels in transport fuel consumption, considered higher than 20% compared to the BAU share (from the IEA Energy Technology Perspectives 2008 – Scenarios at 2050)
- Concerning the environment, the experts evaluations about the future CO2 emissions are optimistic. About 64% of the respondents consider possible to reduce the emissions at 2050 by a percentage higher than 20% compared with the BAU forecasts (from the World Energy Technology Outlook project). It's interesting to consider that with reference to the CO2 emissions from transport, the opinions are more pessimistic (60% of the respondents consider the share of future CO2 emissions from transport higher than 20% of the forecasted value).

Concerning the indicators for which no BAU forecast are available, the experts guesses are evaluated comparing the individual responses with the average value for each indicator. A consensus about future evolutions can only be found for the following indicators:

- Trade flows as share of GDP, with 80% of the respondent ranging from -10% (the majority) and + 10% from the average value.
- Total GDP nominal value, with 80% of the respondent ranging from -10% (the majority) and + 10% from the average value.

4.2.3 Outcomes of the workshop discussion

The discussions at the TRANSvisions workshop of 9th July 2008 was mainly focused on the following drivers and key issues:

- Technology (vehicles, intelligent traffic management, new energy sources...)
- GDP growth trends / personal income evolution
- Infrastructure availability
- Population / employment evolution
- Transport prices (energy prices / other logistic prices / e-commerce)
- Urbanization: distribution of people in the territory // accessibility
- Environmental constraints
- Policy regulation (free market // institutional framework...)

The following are the considerations emerged in the debate with regard to the issues, drivers and trends that have been reputed most important by the participants:

- **Policy making.** Policies and taxation have minor effect on Long Distance traffic in comparison to large megatrends. ESPON policy oriented scenarios showed that differences between Cohesive and Competitive Scenarios were very limited. Demography or urbanization trends have small impacts as well, as their effects on transport can only be seen on the very long term. Other factors, such as improvement of technology or changes in infrastructure stock have much more accelerated effects. Some radical policies, however, can change the status quo. 250 years ago, the British Government passed laws on land expropriation in order to grant adequate construction of infrastructures. In the 1900s government forbid to build in green belts. Nowadays, people need to ask for permission prior to building in a certain place. All these policies were then radical but assumed normal nowadays. Could the Commission moderate transport through radical policy making, mainly on city morphology design regulations and integrated transport modes?
- **Energy Prices.** Transport costs are very sensitive to energy prices, especially to oil. However, traffic flows are less sensitive to transport costs. For passengers, the key element in transport is its cost in relation to people's personal income. If personal income rises, rising transport costs are not a substantial problem. For freight, 90% of traffic flows in Europe are less than 100km long. In this interval, there are no alternatives to road traffic (oil fuelled transport), neither there will be in the next 20 years. 80% of traffic is not price sensitive. Transport prices may be internalized in goods' prices, but transport flows are not reduced. Technology is to provide a solution to increasing energy prices.
- **Passenger traffic** is very much related to both personal income and travel time. People are willing to travel, and are disposed to spend a certain amount of their income (ie. 10-15% personal income) and of their time (ie. 1h per day) for that. Passenger mobility will thus react to growth of GDP per capita and to transport speed changes. As transport means have gotten faster in cities people have moved farther away from downtowns (TGV commuters); the success of low-cost air companies has boomed air traffic flows, and has allowed new relations that didn't take place in the past, mainly in tourism.
- **Evolution of logistics.** Current goods' costs are much more influenced by production costs rather than distribution costs. That is why producing in China and then shipping to the EU is nowadays cheaper than producing directly in Europe. However, should distribution costs rise in a dramatic way (rise of transport prices), or EU production costs diminish substantially (EU productivity increasing strongly, protectionist policies), the balance between production costs and distribution costs could be altered significantly. Delocalization of production towards Asia could diminish, as it could grow in closer EU countries such as Maghreb countries, or even come back into Europe again. Japan has actually succeeded in keeping a quite important share of industrial production due to high productivity indexes.
- **Migrations.** Europe's population is to pick up regressive patterns in about 20 to 30 years according to current forecasts, with more than 40% of people being 65 or more. No society can afford such a worn out population; new immigrants will have to come to cover up jobs that are not being taken by local population, just because of physic laws of equilibrium. By 2030, it is estimated that some 200 million immigrants will be needed to fulfil the economic system needs. It's a matter of Europe's survival. There is still the possibility of "invited workers", who come to Europe to work for a period of time and

then leave back to their origin countries. The dynamics of this phenomenon are related on border permeability policies, as weak borders allow people to easily come in and leave, but strong borders encourage people to stay due to the difficulty in re-entering later on.

- **Tourism** is to grow steadily. As millions of people are to become middle-classes in Asia in the next 20 years, Europe will become a theme park for extra-EU visitors. Between 300 and 600 million Asian tourists will be travelling yearly to Europe. This fact implies a large growth of transcontinental flights, especially towards consolidated touristy areas such as Paris and London, but also towards Italy, Barcelona, Berlin... Internal air traffic is to grow as well, as new tourists move according to itineraries between major destinations, and new touristy transport channels are to appear such as long distance high speed rail services targeted on tourism. North – South EU tourism is to grow steadily as well. As air travel is cheap and weather conditions in the South are milder than in Northern countries, thousands of northerners are to travel southwards for leisure, medical, shopping purposes. Population ageing and their increasing well-being conditions are to increase flows even more. Residential tourism in Spain, Italy, Croatia is already booming, as Northern Europeans are purchasing second residences there, either retired people spending winters in the south or liberal professionals spending 3 or 4 days per week thanks to their work flexibility.
- **Integration and/or more segregation?** These two driving forces interrelate to generate different transport trends, not always in the same directions. Tendency to homogeneity (GDP per capita equity, regional GDP equity) is to prioritize many to many transport fluxes (intercities, interregions...), increased mobility for everybody... Tendency to heterogeneity (few are rich and lots are poor; regional disparity) means to prioritize a few nodes over all the others, few people able to travel, exclusive transport services, more segregated networks... Gregariousness together with increased mobility fluxes may bring transport segregation according to travel purpose (touristy trains vs business trains, charter flights vs private jets...), while individuality may increase car use.
- **Tele-working** cannot be estimated in the future as it has been traditionally done. In 2050 there won't be tele-workers and non-teleworkers, but just partial time tele-workers. People will work at home, in the office, in their weekend apartments. People are going to tele-work some days of the week, they will tele-work as they travel, but they will still do presential work due to human relationship needs, which are fundamental in business. Tele-work indicators should be rather based on full equivalent tele-workers.

Concerning the definition of the four qualitative and “extreme” scenarios – “hyper-mobility”, “sustainable consumption”, “collapse” and “carbon-constrained” – there was a general consensus on using them as embryonic descriptions for producing more consolidated exploratory scenarios, in which:

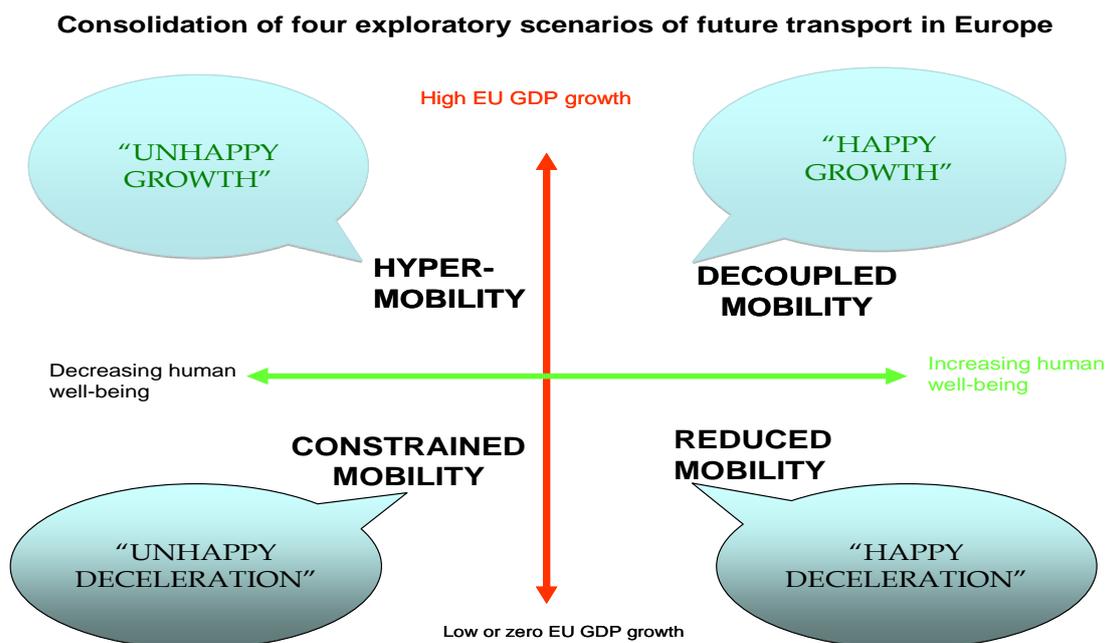
- The collapse scenario should be transformed in a less dramatic decline scenario
- The description of all the four scenarios should be improved with a more complete narrative and a more coherent identification of what different evolutions are assumed for the single drivers and related impacts in the four exploratory scenarios.
- The relationship of the four exploratory scenarios with the backcasting scenarios planned in Task 2 of the project (to achieve a 50% CO₂ emission target reduction in 2050) should be clarified

4.3 The four exploratory scenarios of future transport in Europe

Predicting long-run developments is impossible. What is possible and useful is to develop scenarios. These are feasible and consistent views of the future. They do not aim to predict the future, but rather to sketch alternative futures. These future states of the world form the background against which strategic decisions can be explored.

We will present therefore in this chapter four **exploratory scenarios** of future transport in Europe which:

1. Are developed from the four “extreme” scenarios – hypermobility, sustainable consumption, collapse, carbon constrained – presented in the previous sections and discussed at the TRANSvisions 9th July workshop and at the 24th July steering committee meeting. Following the suggestions collected from the experts at those meetings, the new “exploratory” scenarios are less extreme in character, as in particular the “collapse scenario” is transformed in a more realistic (and useful for strategic analysis purposes) EU stagnation scenario. The scenarios are also more clearly defined in relation to two axes of uncertainty adopted for featuring the alternative paths in the future (see point 3 below).
2. Are all developed as alternative paths with reference to the same **global reference scenario**, which is derived as mere extrapolation of the trends in place when we entered the third millennium. Some of these trends (e.g. population ageing and growing pressure on the public sector) are common to all the alternative scenarios. The differences among the scenarios originate in the responses to the these common trends by national and international organisations. In addition, the scenarios diverge in relation to the most uncertain tendencies (e.g. concerning consumption behaviour, international and EU policy context, etc.).
3. Are differentiated mainly in relation to two “axes of uncertainty” as described in the scheme below:



The axes of uncertainty are derived from those used to feature out the four “extreme” scenario – presented in section 4.1 above - introducing two important differences:

- the “economy/technology/market” dimension (red vertical axe) spans from an high growth of EU GDP to low or zero growth. The extreme case of global and EU recession, and even more the case of a global collapse of the world economy, is netted out from this analysis not because reputed impossible⁵³, but because it doesn’t provide a useful background against which strategic decisions can be explored.
- the “society/environment” dimension (green horizontal axe) refers now only to the change of human well-being and happiness - as long as is demonstrated that over a given income threshold this change is no more coupled with personal income growth – excluding the environmental dimension. Indeed, in this new conceptual framework, the need for tackling with environmental challenges is consider an invariant for all the four exploratory scenarios, although the scenarios responses to this common need are different. The green axe represent accordingly the uncertainty about the future standard of living of the EU population.

The four exploratory scenarios are now identified with the help of the new conceptual framework as follows:

- **Hyper-mobility scenario**, in a context of “unhappy growth” where the growth of income is decoupled by human well-being improvement and happiness for all. The scenario is mostly derived from the same scenario presented at the 9th July workshop. The response to the common climate change and environmental sustainability challenges in this scenario is mainly technology-driven (clean technologies).
- **Decoupled mobility scenario**, in a context of “happy growth” where mobility needs are decoupled from the growing income and people standard of living. The scenario is mostly derived from the “sustainable consumption” scenario presented at the 9th July workshop. This scenario envisions a world with more active people travel, and a “quality of life”-led development in which the distribution of income is more equitable, and people have more time and propensity to taste life experiences, aesthetic values, etc. The response to the common climate change and environmental sustainability challenges in this scenario is mainly planning-driven (e.g. modal shift to environmentally friendly modes).
- **Reduced mobility scenario**, in a context of “happy deceleration” of EU growth (or even zero-growth) where the focus is on more radical changes of consumption lifestyles, entailing a drastic reduction of mobility needs. This scenario considers some elements of the “collapse scenario”, but without the most dramatic disruptions: it is a world of economic stagnation and less consumerism partially as a choice of life. The response to the common climate change and environmental sustainability challenges in this scenario is mainly behavioural-driven (e.g. change of people consumption lifestyles and values resulting in less transport demand).
- **Constrained mobility scenario**, in a context of “unhappy deceleration” of EU growth where the growth of income and quality of life is severely limited by the environmental

⁵³ Indeed, 14% of the experts involved in the DELPHI survey have considered the “collapse scenario” the most plausible.

constraints of a society still heavily dependent on fossil fuels. The scenario is mostly derived from the same scenario presented at the 9th July workshop. The response to the common climate change and environmental sustainability challenges in this scenario is mainly regulation-driven (e.g. strict and pervasive carbon emission regulation, not always cost-effective).

In the following sections we will provide a qualitative description of the global reference scenario and narratives of the four exploratory scenarios which will describe the evolutions of the key institutional, economic, demographic, energy, technology and societal drivers of change in the distant future (at the 2050 horizon).

These qualitative stories will be then complemented in Task 2 by a quantitative sketch of the scenarios, simulated with the help of the TRANSvisions meta-model.

4.3.1 Global reference scenario

At the turn-around of the 2nd millennium, a wide group of experts has been involved in the FORESIGHT for TRANSPORT project, producing with the help of a DELPHI Survey and a number of workshops a global reference scenario⁵⁴ based on the projection in the third millennium of the trends in place at the year 2000. This scenario still provides a useful reference against which to contrast the alternative exploratory scenarios developed in TRANSvisions. According to the Foresight for Transport group of experts, in 2000 you might have seen the world, and more specifically the European Union, as characterised by (ICCR, 2004):

- **Demographically**, an ageing society with a comparatively high regional variation at the global level (less so within the European space). The total population of the EU is growing very slowly, and over the last 30 years the share of persons in the age range 60+ in the EU has grown by over 40 per cent, representing an average 1.3 per cent annual increase. A similar fast ageing trend can be observed in the new Member States since 1996. Immigration to EU 25 is expected to amount to about 38 million people until 2050, mainly directed towards EU15 countries. On the contrary, several EU12 countries experience a net emigration towards the old member states, although this trend could reverse assuming convergence has been attained in EU27 in the next 50 years of time.
- **People lifestyle and behaviour** which tends towards individualism with an emphasis on consumerism, self-interest and a positive view of technology. With regard to mobility preferences, European citizens prioritise high-speed and subsequently high-speed travel. This is evidenced, among others, by car manufacturing. Between 1990 and 2000, the average power of new passenger car registrations in the EU rose from 52.3 KW to 62.8 KW in 2000 which represents an increase by 20 per cent. Another indicator of preference for speed is the success of high-speed train (HST). HST lines traffic tripled during the 1990s.

⁵⁴ The same group of experts produced alternative scenarios, which have been considered together with those elaborated in other studies to build the TRANSvisions policy scenarios illustrated in the subsequent sections.

- Trends with regard to the **social agenda** which point towards a predominance of the laissez-faire approach with increasingly flexible labour markets, decreasing welfare expenditures and higher levels of inequality. The increase of the flexibility of labour markets is reflected in the increase of part-time work. In the EU the number of employees working less than 30 hours per week has increased from 13.3 per cent in 1990 to 16.4 per cent in 1999.
- **Institutionally** an EU which finds itself at a key turning point, with enlargement and institutional reforms underway. The success and impacts of the latter remain unclear. The gradual emergence of the European supra-national polity means that more than 50 per cent of national legislation follows European directives. However, key areas for statehood like fiscal policy, social expenditures, justice and security as well as cultural affairs, continue to be national competencies.
- A continued **technological progress** and incremental changes and improvements. The problem appears to lie more with the diffusion and uptake of new technologies rather than with innovation, whereby the low expenditures in RTD, both from government and business, are in part to blame for this. From 1991 to 1999 R&D Expenditure in EU15 stabilised between 1.5% and 2.0% of the GDP per year. In most countries it remained far below the minimum target of 2.0%, the preferred one being 2.5 to 3.0%. Between 1995 and 2000 in the EU15, the percentage of people employed in high-tech and knowledge intensive services was increasing at an average rate of 2.9%. From 1990 to 1995, high tech patents in EU15 grew by an average of 22 percent annually, albeit from a very low starting point.
- Improvements with regard to the **environment** which are sought through both economy and technological instruments. However, the low uptake of new technologies, on the one hand, and the low economic growth, on the other, make the introduction of strong ecological policy measures difficult. Final energy consumption grew by 16 per cent between 1985 and 1998 in the EU15. This corresponds to an average annual increase of 1.2 per cent. The share of energy consumed by the transport sector increased from 28 to 36 per cent between 1985 to 1998. This corresponds to an average annual increase of 0.6 per cent. Between 1990 and 2000, the transport share of CO₂ emissions in the EU-15 increased from 21.6 to 25.2 per cent which corresponds to an annual average rate of increase of 1.7 per cent. In the new Member States, the respective share increased from 10.1 to 13.4. This corresponds to an annual average rate of increase of 3 per cent. Between 1990 and 2000 NO_x emissions in the EU15 decreased by 27 per cent which corresponds to an annual average rate of decline of 2.7 per cent. In the new Member States there was a decrease by 41 per cent, albeit from a higher starting point. The share of renewable energies in the total primary energy consumption increased from 4.8 per cent in 1990 to 5.7 per cent in 2000 in the EU15. This corresponds to an average annual rate of increase of close to 2 per cent.
- In terms of the **economy**, a tendency to a low level of EU GDP growth with stagnation in terms of international trade and the economic structures. This is however not a stable situation. A turn-around towards economic growth is possible.

- An unclear situation at the **political** front. At the crossroads of the European project of integration it remains unclear whether we are moving towards the consolidation of an open democratic system where politics are the arena for active citizenship or whether we are more likely to witness the beginning of an era of political polarisation, elite closure and technocracy.
- Against this background, the **transport** situation was characterised by high transport demand with the trend pointing towards: further growth; high levels of congestion and external negative effects; an increasing trend towards motorisation and, associated with this, a high level of injuries and fatalities.

4.3.2 Hyper-mobility or Induced mobility scenario

The storyline of the Hyper-mobility scenario presented here is based on:

- The extreme “Hyper-mobility scenario”, which was in turn inspired by the “Perpetual motion” scenario in the UK Office of Science and technology study (OST, 2006), and the subsequent discussion with internal and external experts at the TRANSvisions 9th July and 24th July meetings.
- The “Global Economy” scenario elaborated in the context of the CPB “Four Scenarios for Europe” study (CPB, 2003).

In short, this scenario is the more optimistic in terms of technologic improvements and market self-organisation capabilities. Public policies aim to support research and development, use the most cost-effective technologies to reduce emissions, and liberalise and regulate markets allowing healthy competition. The most cost effective path to achieve the 50% reductions is to start by improving the efficiency of existing cars, make use of biofuels and a variety of alternative fuel options, including hydrogen batteries, and then move to a second generation of biofuels and electricity. Intelligent traffic management systems may have a significant importance releasing congestion.

The following is a deeper discussion of the scenario features for the different key drivers.

4.3.2.1 Global governance and policy context

European countries find a new balance between private and public responsibility. Institutions are increasingly based on private initiatives and market-based solutions. European governments concentrate on their core tasks, such as the provision of pure public goods and the protection of property rights. They engage less in income redistribution and public insurance, so that income inequality grows. Political integration and cooperation in non-trade areas is not feasible, as government assign a high value to their national sovereignty in many areas. Economic integration becomes broader, however, as countries find it in their mutual interest. The European Union finds relatively easy to enlarge further eastwards. The negotiations in the WTO lead to a successful liberalisation of global trade, including intellectual property and services.

European institutional reform is successful after the enlargement. Further integration is, however, primarily focussed on a proper functioning of the internal market. Political integration is not an issue. Cooperation in foreign policy is intergovernmental and

fragmented. As a successful economic and (partly) monetary union, the EU finds it easy to enlarge further eastwards. Turkey, Ukraine and some smaller of the former Commonwealth of Independent States become EU members. Despite the abolishment of European Cohesion policy, the Eastern member states converge gradually to the EU average. This is because rapid institutional reform in these countries and a catching up of technology take place. Indeed, a surge of foreign direct investment flows into the Eastern regions of Europe.

International cooperation is limited to economic issues. The WTO focuses solely on free trade, and manages to find an agreement among all participants. Free trade in agriculture and services is fostered. This calls for substantial industrial restructuring in Europe. For instance, agricultural sectors with little value added contract, while the same holds true for textile in a number of countries. Whereas economic cooperation between the EU and other continents is successful, cooperation in non-trade issues fails. For instance, political cooperation via the United Nations is cumbersome. More generally, the failure of international political cooperation increases the risk of conflicts.

4.3.2.2 Economic and social milieu

International integration and market-oriented domestic policies stimulate labour productivity which grows by 2.1% per year up to 2020 and by 2.0 thereafter. High economic growth stimulated investment, which implies an increase in the real interest rate until 2020. After 2020, a lower pace of economic growth leads to a slight decrease in the real interest rate. Successful liberalisation boosts international trade. Until 2020, world trade shows an increase of about 6% per year. After 2020, growth falls somewhat since GDP growth levels off. In 2000, almost 54% of all exports by EU countries have destinations within the European countries. Slightly more than 18% is shipped to non-OECD countries (mainly to Asia) while the remaining 28% flows more or less equally to the United States, the rest of the OECD, and the Eastern part of Europe (the Central and Eastern European countries, Russia and Turkey). The direction of trade changes drastically in the future scenario. Asia will become a much more important trading partner for Europe during the coming decades, also due to the consistent growth of Asian economies (and primarily China and India). In 2040, about 60% of all European exports have a destination outside Europe, compared with less than 50% in 2000.

Capital is relatively mobile internationally as capital markets become better integrated. Accordingly, the European Union finds it easier to attract foreign capital, causing a net inflow of foreign assets – especially after 2020 when savings decline. Most foreign assets originate from Asia, where saving rates are higher than elsewhere. The opportunity to import capital from abroad implies that the impact of savings and investment on the interest rate is smaller.

Despite the ageing of population, GDP grows rapidly due to significant employment growth. This is because participation among the elderly generations increases due to various reforms. Immigration reinforces the positive effect on labour supply. The EU follows a selective immigration policy by allowing each year a fixed number of immigrants, which ensures that immigrants are high-skilled and they easily enter the European labour market.

Indeed, immigration is facilitated by the reformed, flexible European labour markets, which can easily absorb new workers. Labour mobility increases, especially of high-skilled workers. Governments engage in competition to attract these skilled workers as well as mobile firms.

Intense policy competition in a large Europe contributes to an efficient government, but also reinforces the trend towards downsizing the scope for income redistribution. Reforms in the labour market, income taxation and social security encourage labour force participation. This applies particularly to elderly workers. Their incentives to participate increase because of reforms in early retirement provisions, tougher eligibility criteria in social security and an increase in retirement age. As ageing tends otherwise to reduce the supply of capital,⁵⁵ savings fall after 2020 by around 4% points. This is less than in the other scenarios, however, because governments increase national savings by prudent government budgetary policies and early reforms in pensions towards individualised defined-contribution schemes.

European governments take steps to limit their role in facilitating an efficient and productive economy. Societies have a strong preference for flexibility and diversity, which is best provided by the market. This applies in particular to private goods that are currently publicly provided as “Merit goods”, such as health care, higher education and so on. Moreover, government regulations to ensure uniformity in supply (e.g. in pensions, housing and so on), are relaxed so as to meet more diversity in lifestyles. Governments remain responsible for the production of pure public goods (basic education, defence, police, justice), but also use their regulatory powers to ensure effective competition on markets.

As it concerns the prevailing people lifestyle, in the Hyper-mobility highly connected world, life and work are intense, and the boundary between them is blurred. Some thrive on the buzz of activity that results, but early burn-out is common and stress is a way of life for the vast majority of the EU population. Not everyone finds it easy to “keep up” with the growing competition for the most desirable, highly paid jobs. The use of some specific drugs, by that time legal and free of secondary effects, to enhance intellectual performance of an ageing population and to manage stress continues to boom. While a significant number of, mainly younger, people thrive on the buzz of living in the urban hubs, tele-presencing and ever more powerful miniature communication devices are increasingly allowing the more affluent to move to the outskirts of towns or to rural areas, accelerating the trend toward urban sprawl.

World travel and tourism grow as forecasted by the industry’s World Travel and Tourism Council (WTTC) between 2009 and 2018 with an average growth rate of 4,4 per cent annum, and this was followed by a steady phase of more moderate growth, leading the tourism sector to represent more than 10 per cent of global GDP.

Toward the year 2050, intelligent positioning systems, encryption technology, real-time tele-presencing and a shift towards a low-carbon economy have boosted the economy and accelerated consumerism that shows few signs of abating. If energy issues have been addressed, other sustainability problems have not. Europe’s waste footprint is still far larger than Europe is; we are still a “three-planet” society, sustained only because, globally, the poorest are poorer than ever. In a far richer society, there is a vast service sector, increasingly offering high degrees of personalisation. High-intensity work experiences are matched by high-intensity leisure, in the form of multi-user games and designer stimulants. However, the need to maintain their skills in such a competitive environment, along with fewer opportunities to switch off from work, has taken its toll on many. As a society, we are richer than ever, more than four times as affluent as we were in 2005, and one consequence is that is

⁵⁵ This follows from the life-cycle pattern of savings: people borrow when young, save when mature, and dissave when old.

increasingly hard to fill jobs that involve working anti-social hours. With fewer people needing the pay from such jobs, and a growing realisation of the social costs of such work on family life and social relationships, many service deliverers have been forced to put in place sophisticated auto-delivery systems in order to continue to provide the levels of service and frequency of delivery their customers have come to expect. However, other personal services (e.g. home elderly care) continue to be increasingly provided in the richer EU countries by low-skilled immigrants from less well-off European countries or poorer countries outside Europe.

4.3.2.3 Technology

Total Factor Productivity (TFP) is the most important driving force behind GDP growth. This underlines the critical importance of technology and, more generally, knowledge for level and growth of productivity. But TFP growth is more than technical change; for example, it also reflects changes in economic efficiency, that more or less public intervention may bring about, and changes in energy use. High TFP growth in the hyper-mobility scenario reflects an efficient functioning of markets, both nationally and internationally, which brings dynamic technology gains. Capital accumulation follows to some extent TFP growth. Higher productivity and income imply higher savings and investments, which in the hyper-mobility scenario – as said above – are further stimulated by early policy responses to the prospect of ageing populations (i.e. pensions reforms).

The share of services in the economy grows, and the EU maintains its comparative advantage in chemicals and minerals and business services, while the current comparative advantage in agriculture and food – somewhat artificially due to the Common Agriculture Policy – disappears. In contrast, the export pattern of EU becomes more specialised in trade and transport services.

As it concerns the development of specific IT and transport technologies, the foundations of hyper-mobility were laid down starting from 2009 with the development of a range of intelligent miniature devices able to connect consumers directly, and continuously, to national area wireless networks. The first real-time tele-presencing technology was launched in 2020. While adequate technology had been in use – on a very limited scale – for several years, the system will finally become a standard that business finds acceptable towards 2030, making the concept of remote working from different parts of Europe a reality. By 2050, ID devices are well and truly embedded in people's lives across EU, allowing since a raft of new personal services to be added: e.g. the LifeServe agent-based software can alert parents when their children leave the schools grounds, calculates the most cost-effective transport route for every journey and automatically schedules tele-presence meetings with colleagues, family, friends or whoever.

In the field of drivers assistance, governments and local authorities worked with car manufacturers to integrate disparate vehicle management systems (on-board driver assistance, automated driving) designed to even out traffic flows and reduce congestion. Integration was patchy at first, but in Europe, with the support of the EU and the European industries, the Galileo system took up ensuring the critical advance and independence in technology for Europe and its partners, including also US by means of the interoperability ensured with GPS. As early as from 2013, Galileo has created more than 100.000 new jobs and a market for equipment and services worth some €10 billion per annum. Besides helping to avoid traffic

jams and therefore reducing drivers' waste of time, fuel consumption and pollution, driver assistance supported by the interoperable Galileo and GPS systems helped to curb the number of road accidents.

As it concerns the future development of vehicle technologies, in the hyper-mobility scenario, starting from a relatively modest level, a steadily increasing proportion of motive power has been supplied electrically. A growing proportion of engines has been equipped with electric starter/generator systems (hybrid vehicles), thereby improving emissions and fuel consumption. Hybridisation happened faster where it made most sense, i.e. for short-distance operation but not for long distances, where the negative factors like weight and costs have more of an impact, while the positive effect from better energy management in the power-train is lost. A point has been reached where the electrical component of the full-hybrid power-train became the dominant partner and the internal combustion engine was relegated to the role of "assistant". Some purely electric vehicles, including scooters, became also more popular in the urban environment. Gradually, complete hydrogen cars can be seen on the EU roads, but they remain restricted to urban areas due to the infrastructure required to support them, which is not available in rural areas.

4.3.2.4 Energy and environment

Regarding global environmental issues, the European Union is unable to convince the United States to participate to the Kyoto Protocol. With rapid economic growth in combination with lax environmental policies, and notwithstanding the achievements in terms of fuel efficiency, hyper-mobility is a pollution-intensive scenarios, mainly due to the rebound effect of more intense volumes of traffic. Indeed, if driver assistance systems helped people to manage their way around congestion, more people bought bigger cars and travelled further using the new systems, increasing carbon emissions. Aviation was doing little to help the situation, as the Emission Trading Scheme proposed as early as in 2006 was enforced only in 2025.

International markets for energy being efficient and reliable, countries seem do not diversify enough their imports of energy; energy consumption is not only (relatively) high, but also still fossil-fuel intensive, notwithstanding the developments of nuclear energy and renewable sources. Several new nuclear plants reactors have been built in the EU countries with nuclear plants already in operation in 2005. Plans to develop new generation nuclear energy plants have been adopted also in other countries where nuclear energy was previously banned.

In 2050 the "hydrogen economy" has become a reality. The combination of increased nuclear capacity and the development of renewables had reduced dependence on carbon-based fuels, which however remain the larger share of energy sources. Clean-coal technology, combined with effective carbon sequestration, smoothed demand at power stations and mitigated much of the carbon impact by dealing with it at the top of the supply chain rather than at the end of the exhaust pipe. The vision for the whole Europe is that, by 2050, non-fossil energy sources (excluding nuclear) will account for more than 35% of the total energy supply, with biomass, wind and solar energy taking leading roles. Considerable attention will be paid to energy conservation. About half of the EU member States will support the use of nuclear energy. Coal with CO₂ capture will be applied on a large scale for the production of both electricity and hydrogen. The hydrogen will be used in the transport sector. Biomass will be used as fuel for freight transport – with the availability of second-generation biofuels - and as feedstock in industry, as there are few other substitutes for oil products in these sectors. The energy needs

of dwellings and other buildings will have been greatly reduced, and will primarily be met with solar energy and electricity.

What to do with the nuclear waste remains an issue, despite the fact that the amount of waste produced by the modern reactors is significantly less than those from plants in the past. It's not just nuclear waste that is a potential future problem. Ever increasing consumption of goods and high-impact services means that society's waste footprint is growing inexorably and unsustainably.

4.3.3 Decoupled mobility scenario

The storyline of the Decoupled-mobility scenario presented here is based on:

- The extreme “Sustainable consumption scenario”, which was in turn inspired by the “Urban colonies” scenario in the UK Office of Science and technology study (OST, 2006), and the subsequent discussion with internal and external experts at the TRANSvisions 9th July and 24th July meetings.
- The “Strong Europe” scenario elaborated in the context of the CPB “Four Scenarios for Europe” study (CPB, 2003).

In short, this scenario it is defined as the right combination of all set of policies over time, with the aim of reducing the adverse impacts of transport on human and ecosystems health while continuing to support a sustained economic growth of Europe. It aims to supply the basis for a normative scenario.

The following is a deeper discussion of the scenario features for the different key drivers.

4.3.3.1 Global governance and policy context

Reforming the process of EU decision making lays the foundation of a strong European Union. The enlargement is a success and integration proceeds further, both geographically, economically and politically. A strong Europe is important for achieving broad international cooperation, not only in the area of trade but also in other areas such as climate change. The transfers of powers to a supranational body reduces national sovereignty.

An institutional crisis is looming after EU enlargement in 2004, but the EU member states are willing to sacrifice their national sovereignty in order to obtain a solution to this crisis. Initiated by a core group of countries, European integration intensifies on the basis of reinforced cooperation. Countries that initially remain outside the core group step in at a later date, so that multi-speed Europe emerges. EU decision making is eventually reformed and acquires improved legitimacy through increased direct democratic mechanisms of participation, good governance and transparency.

Driven by its success, the EU opens its borders further eastwards. Turkey becomes an EU member and, although Ukraine and Russia do not become full members, they become more integrated with Europe. The bilateral association agreements with the Mediterranean countries are a success, and integration proceeds. Through economic cooperation, the European Union also exports stability to its Southern and Eastern borders. Even with faraway China, which

grows rapidly during the next decades, economic relationships become increasingly important for the European Union.

A strong Europe becomes one of the superpowers in the global arena, next to United States. Europe develops its own identity. Solidarity defines the European view on international cooperation. This refers to issues such as trade and poverty, environment and ethical questions around new technologies (e.g. biotechnologies). The next WTO round becomes a modest success, primarily regarding trade in agricultural products. International cooperation in non-trade issues also intensifies, driven by the leading role of the EU. The United States is granted some concessions for their participation in this cooperation (e.g. in the Kyoto Protocol).

Driven by the desire to obtain a strong position in the international political arena, Europe centralises its policies in Foreign and Security Policy. National sovereignty thus diminishes. Decentralised responsibilities remain in other fields. Enlargement increases heterogeneity in the EU which calls for diversity in institutions, e.g. in social security and taxation. The EU develops a framework in which policy competition between member states can take place. For instance, countries agree upon a minimum rate of corporate taxation and countries develop indicators on social targets which effectively operate as a floor for policy competition. Member States learn from each other's experiences, which creates a process of convergence of institutions among Europe.

4.3.3.2 Economic and social milieu

The outward orientation of Europe, the deepening of the internal market, and rapid growth in Central and Eastern Europe contribute to productivity growth in the EU. Labour productivity increases by about 1.5% per year, which equals the average figure during 1980-1999. Population growth does not change much during the coming decades. In light of ageing, however, employment growth falls, especially after 2020. Annual GDP growth, equal to the sum of productivity and employment growth, thus falls from 3.0% between 2005 and 2020 to 2.7% between 2005 and 2030, and to 2.4% between 2005 and 2050.

The integration of goods and services markets leads to large trade volumes and changing trade patterns. World exports increase by 4.8% per year until 2020, and by 4.1% thereafter. The larger in the period before 2020 is due to higher GDP growth and trade-liberalisation policies during that period. The combination of lower trade barriers and high growth in Asia redirect export flows towards Asia, the Central and Eastern European countries and Turkey. However, the growth of world trade is lower than in the past. Ageing population in OECD countries and lower population growth in developing countries can partly be held responsible. Also, the shift from agriculture and manufacturing towards services, especially in Asia, tends to moderate the growth in trade volume, because services are less tradable than commodities and manufactured goods. Indeed, in this scenario (as in the others) the service sector grows relative to other sectors.

European countries maintain social cohesion through various collective arrangements. These limit income disparities (e.g. between skilled and unskilled and between those inside and outside the labour force). Countries are to some extent able to accommodate trends that put the public sector under pressure. In particular, governments experiment with differentiation in the supply of publicly provided private goods, such as education, health care and social

security arrangements. This is done by using more information about individual characteristics (at the expense of privacy) and large-scale application of ICT. European governments also experiment with new incentive schemes for raising efficiency in the public sector, ranging from benchmarking and yardstick competition to outright privatisation of companies in the network industries.

Solidarity between young and old generations is maintained primarily through increases in the participation of the elderly in the labour force. Participation is encouraged by a gradual increase in the retirement age, which becomes linked to life expectancy. The financial incentives for early retirement are reduced and more flexibility is introduced for the elderly to work shorter hours. Although the measures to stimulate the participation rate of older workers have an important effect, they cannot prevent that ageing reduces the overall participation rate in Europe. Among the working population, unemployment drops slightly to an equilibrium rate of 5.8% in 2050. The generous social insurance system prevents a further reduction in unemployment because it strengthens the position of workers in wage negotiations and reduces the incentives for unemployed people to search for work or to accept a job offer.

Savings decline, especially after 2020. This is because the growing retired population disavows and policies to increase savings cannot fully compensate for this. Indeed, in some European countries, national savings are stimulated by redirecting pension systems toward more funding and/or by sustained surpluses on the government budget. Hence, the elderly partly pay the price for maintaining intergenerational redistribution. In addition, notwithstanding the decline of savings, the real interest rate in Europe decreases as well. The reason is that the demand for capital falls as well, due to declining employment.

Europe combines social cohesion with a fairly competitive and strong economy. It succeeds in deepening the internal market as intended to do (e.g. in energy, financial services, postal services, government procurement, and passenger transport), which intensifies competition and stimulates productivity growth. Also labour mobility is encouraged by the removal of institutional barriers to migration. Accelerating economic growth is reinforced by the completion of a successful European innovation strategy, which includes a European patent and joint policies to stimulate R&D. The budget for the Common Agriculture Policy and Cohesion Policy are maintained, but these policies become less distorting, as they are reformed and become effective instruments to benefit peripheral and rural region in the European Union – especially in the new member states.

Immigration policy is coordinated by the European Union. With a focus on international cooperation and solidarity with other regions, European immigration rules become less strict and immigration flows increase. The reformed, more flexible labour markets are able to integrate the majority of immigrants in European societies. As a result there is a counter-balance to the ageing of population and this leads to a somehow more balanced distribution of age cohorts within and across societies.

Globally, competition is increasing between cities, not states, and the winners are those that are able to link high-value knowledge assets with a desirable workforce, good quality of life, and appropriate public assets such as cultural and educational resources. Cities are changing, driven by the twin pressures of competition and the national, regional and local governments' continued push to make it safer and easier to access jobs, shopping, leisure facilities and

services by public transport, walking and cycling. Society embraced this new world where people do not travel as extensively.

Population, housing density and employment in big cities are rising faster than before. Cities are more compact, widening the range of local opportunities and activities that are accessible without using the car. The global trend to urbanisation has been reinforced in the EU countries, as planning guidelines were increasingly adopted along the lines of the ABC location policy used in the Netherlands, to encourage greater building density and co-location of business. So it was that the UN estimate that the EU-25 urban population would hit 78,4% by 2030 was passed already in 2020. Rural areas suffer from poorer communications. Generally, it is expensive and inconvenient to live in the countryside and work in the city, unless the regional government is one of the few that has invested in light rail links.

4.3.3.3 Technology

Total Factor Productivity (TFP) is the most important driving force behind GDP growth. This underlines the critical importance of technology and, more generally, knowledge for level and growth of productivity. But TFP growth is more than technical change; for example, it also reflects changes in economic efficiency, that more or less public intervention may bring about, and changes in energy use. The decline in the production of energy and raw materials is especially pronounced in this scenario, where global climate change policies are introduced.

The share of services in the economy grows, and the EU maintains its comparative advantage in chemicals and minerals and business services, while the current comparative advantage in agriculture and food – somewhat artificially due to the Common Agriculture Policy – disappears. In contrast, the export pattern of EU becomes more specialised in trade and transport services.

As it concerns the development of specific transport infrastructure and technologies, the leading factor is the renewal of urban transport infrastructure and technologies. Changes in infrastructure have had a significant part to play as cities have invested in public transport and cycle paths, and more people are getting out of their cars as the overall image of public transport improves. Transport innovation came at the local level rather than the national: local agencies were simply more responsive to innovation. Their relative diversity helped. Pilot local authorities across Europe were the first to replace their city centre bus fleet with hybrid electric/NPG buses, and install the fuel infrastructure needed to do so – and opened up that infrastructure to private motorists with similarly powered vehicles. However, not all public transport innovations were successful. Within outlying urban areas more flexible and demand-responsive public vehicles evolved as a hybrid between buses and taxis. Although early results had shown a significant reduction of congestion, pilot testing of fully automated hybrid vehicles halted. The Unions welcomed the re-introduction of drivers, and their warnings about over-reliance on autonomous systems struck a general chord. Plans for a dual-mode long-distance commuting system using hybrid vehicles linking larger conurbations were shelved indefinitely.

4.3.3.4 Energy and environment

A global climate change mitigation policy aiming at reducing the GHG emissions by about 57% in 2050 compared to 2005 levels (corresponding to a atmospheric concentration of about 450 ppm of CO₂-eq) caused a reduction of about 0,1% of the indicated annual GDP growth

rates. Key mitigation strategies in the transport sector included modal shift from road transport to rail and public transport systems, non-motorised transport (walking and cycling), land-use and transport planning, use of biofuels.

Indeed, at the end of the first decade of the 21st century, the EU Member States have realised that meeting its international emission reduction targets wouldn't be done by technology alone, and that it was necessary actively to encourage people to travel less; and that this in turn required public policy intervention to help households and individuals to change their lifestyles, and business to change their expectations. Even before nationwide road pricing was introduced in the great majority of EU countries in the period 2015 to 2020, charges and tax penalties were imposed on motorists' benefits such as "free" parking. As early as in 2013, the Galileo system started to support the road pricing pilot schemes, making customized road tolling in the urban and interurban transport context a reality.

In the building sector, as from 2040 sustainable buildings are the norm, rather than the exception, especially commercially and public buildings. This didn't happen overnight; but the replacement cycle – whether being rebuilt or refurbished – on commercial buildings is about 30 years, and legislation introduced across EU countries in 2020 to mandate "the new sustainability" has now had its effect.

The concept of "zero-waste" society has been fully implemented in 2050, as even the notion of "waste" almost disappeared from the vocabulary. Instead, everything either gets recycled as a raw material for another production processes or returned, clean, to the earth or water. Every municipality runs its own "freecycle" scheme to help people who have things they want to dispose of to find a willing recipient. And because resource use is now a fundamental part of the tax base, people prefer not to buy disposable items any more. The legal requirement for goods to be repairable, which manufacturers had lobbied hard against, is now regarded as a source of competitive advantage.

Ecological concerns and objectives determine economic goals and strategies rather than the other way round. Full-cost accounting has become the standard accounting convention, and GNP and other economic growth indicators are no longer used as shorthand for an indication of social benefit. Materially, fewer good, but more services, are consumed than in 2005. And people value possessions that will last more than they did then, not least because the tax system has been fundamentally redesigned so that people are taxed principally on the resources they use up, rather on the money they earn or what they spend.

In the transport sector, a significant decrease of transport demand can be observed and both for international and national transport as well as for passenger and freight transport, with technology substituting for mobility (through e-commerce and e-work). There is an increase in the demand for short-distance local mobility, both for work and for leisure. This is, however, primarily met through non-motorised transport. Non-motorised transport as well as shared modes of transport are explicitly supported through policy, i.e. tax-breaks, company transport plans, as well as RTD and ICT. Social inclusion as well as punctuality and reliability rather than speed are high on the transport policy agenda.

4.3.4 Reduced mobility scenario

The storyline of the Reduced-mobility scenario presented here is based on:

- The extreme “Collapse scenario”, which was in turn inspired by the “Tribal trading” scenario in the UK Office of Science and technology study (OST, 2006), and the subsequent discussion with internal and external experts at the TRANSvisions 9th July and 24th July meetings. However, this scenario has been radically changed from collapse of the world economy to Europe following a pathways of “happy” deceleration of the economy in the context of a society giving less value to consumerism and material accumulation of wealth. Therefore, only very few elements – the less dramatic features – of the collapse scenario are retained.
- The “Regional Communities” scenario elaborated in the context of the CPB “Four Scenarios for Europe” study (CPB, 2003).

In short, this scenario is based on behavioural and transport demand-management policies, combined with strict land-use policies able to take full advantage of the economic changes ahead (a service-oriented economy, with more flexible and decentralised workplaces, in a more compact and planned cities favouring public transport and limiting the use of cars).

The following is a deeper discussion of the scenario features for the different key drivers.

4.3.4.1 Global governance and policy context

The European Union cannot adequately cope with the Eastern enlargement and fails to reform her institutions. As an alternative, a core of rich European countries emerges. Cooperation in this sub-group of relatively homogeneous member states gets a more permanent character. The world is fragmented in a number of trade blocks, and multilateral cooperation is modest.

Indeed, enlargement with twelve new member states increases the heterogeneity of the European Union. These render cooperation between all EU member states more difficult. Governments are willing to cooperate internationally, but only if their countries are sufficiently homogeneous. A new club of countries is born within the European Union. The club intensifies cooperation in various policy fields, including taxation and social policy. This is done through the community method on the basis of “reinforced cooperation”. Although the intention was a two-speed Europe in which countries that lag behind would catch up with frontrunners after some time, reinforced cooperation ends up in a two-tier Europe that gets a more permanent character.

The less well off member states remain outside the core group because they are either unwilling or unable to join. While cooperation in the core group becomes more important, the European Union loses power. Further enlargement of the EU receives little interest from the core: Turkey does not accede to the European Union and a number of member states remain outside the Euro area. These member states shift their attention more and more towards other countries in order to expand its trade and income.

As the world is too heterogeneous to deliver global coordination, a fragmented pattern of trade blocks emerge on the international arena. The EU and the United States have different views on global trade and non-trade issues. The US agree upon a free trade area with other Americas. Europe suffers from this, due to trade diversion.

EU policies are only modestly reformed: the Common Agricultural Policy maintains distortionary components, especially with respect to outside countries, or is replaced by distorting national support measures. Cohesion policy remains ineffective. In fact, poor member states from the Central and Eastern European countries are unable to absorb funds because they cannot comply with the complex and demanding administrative procedures set by the EU. Moreover, a large part of the cohesion budget is transferred to richer member states that are unwilling to give up their share.

4.3.4.2 Economic and social milieu

In light of the barriers to international trade and the lack of competitive forces, which feature this scenario, labour productivity grows only mildly at a rate of 1.2% per year. In combination with the ageing of the population, which reduces the employment rate, this implies that GDP hardly grows after 2020, with a growth rate near to zero (0.4%) substantially smaller than the 2.2% that Europe experienced in the recent past.

European countries rely on collective arrangements to maintain an equitable distribution of welfare. At the same time, in this scenario are unsuccessful in modernising welfare-state arrangements. In the core of Europe, vested interests block reforms in social security systems, pensions, labour market institutions and product market regulations. Proposals to make collective arrangements more efficient or to introduce more differentiation in the public provision of private services fail. Governments largely maintain the welfare state in its original form, which suffers from moral hazard, a lack of incentives and uniformity in supply.

Many mature European industries are protected from outside competition through trade barriers. This holds in particular for agriculture, which is protected by the Common Agricultural Policy, but also for network industries. Trade unions in the core of Europe actively cooperate and minimise wage dispersion. They form a powerful lobby group in the European Union and its member states to hold up reforms in welfare state arrangements. Governments in Europe minimise the scope for policy competition through the harmonisation of social policies, such as employment protection legislation, minimum standards for social assistance, and disability insurance. The European core introduces a central unemployment insurance scheme with the aim to absorb asymmetric economic developments. The corporate tax system is harmonised, with a common base and a common rate. As a matter of fact, EU policy coordination goes beyond what is justified on the basis of subsidiarity.

The labour force participation rate falls from 46.7% of the population in 2000 to 40.2% in 2040 and beyond. Apart from ageing, this is the result of the adverse incentive effects of fairly generous social security systems and labour-market regulations. The unemployment rate among workers stays above 8%. Also the participation rate among older workers remains low.

Increasing expenditure on old-age benefits and publicly provided health care pushes European public sectors to their boundaries. Inefficient and large public sectors render sustainable public finance problematic. This puts pressure on the Stability and Growth Pact and challenges the independence of the European Central Bank. The fear for inflation raises the risk premium on interest rates and hampers investments. Aggregate savings fall substantially in light of ageing, and economic policies do little to offset this. Slow economic growth and

low employment also imply weak investment demand. As a result, the real interest rate decreases below 3%.

Migration is restricted within the European Union. Only a limited number of immigrants from the Central and Eastern European countries move towards the core of Europe.

As it concerns trade, this scenario will see the completion of the EU internal market, which implies a removal of all formal and informal barriers, but transitional periods for various aspects of the internal market will take on a more permanent character. The EU accession thus effectively boils down to a custom union, e.g. in agriculture and food, in which informal trade barriers remain. The scenario assumes also regional trade liberalisation between the Americas from 2015. In this situation, there will be only small changes in the trade patterns. The share of exports to non-OECD regions increases from 18% in 2000 to nearly 23% in 2040 (CPB, 2003). This comes at the expense of trade with the rest of the OECD. The share of intra-EU trade remains stable because of the elimination of non-tariff barriers between the EU15 countries (the core EU group).

On the global arena, the growth of the Chinese economy came to an halt in the face of falling demand and the rising costs of its manufactured products, and has since succumbed further to the environmental impact of water shortages in the south, the spreading deserts of the north, and food shortages everywhere. India has been overwhelmed by the spread of millions of environmental refugees from Bangladesh and other low-lying neighbours.

The world now is more local than it was. The world awash with cheap energy is a distant memory, and lifestyles have changed accordingly. If people travel as much as they ever did, they do it more slowly; they don't travel so far. Work is closer to the home; indeed, in some places, living patterns have reverted to the pre-industrial, with the home and the workplace being the same. More appropriate building design have reduced energy needs, and diet is better. Less energy means that there is more physical work to be done, so people are fitter too.

People lifestyle is therefore the major area of change in this scenario. Large cities environments declined, but self-help communities have started to emerge everywhere, in the urban and rural environment, to react to the staggering economy and the increasing inflation, which makes individualistic consumerist attitudes unaffordable for an increasing share of people. Local food production and services have increased. In particular, the share of local organic food production is significant, as the full external costs of conventional agriculture (water pollution from overuse of chemical fertilisers, pesticides, soil erosion etc.) were internalised and incorporated into the price, making conventionally grown food much more expensive. This has produced a significant shift in consumption patterns, from conventional to organic food, and because this produce mainly seasonal stocks of products which are consumed locally there is also a reduction of food transport and related emissions. Small self-powered communities have emerged, especially in the countryside, using wind, water and solar power. Millraces are running again, and local food production, even if sparse, makes work for people who would otherwise be workless.

4.3.4.3 Technology

Total Factor Productivity (TFP) is the most important driving force behind GDP growth. This underlines the critical importance of technology and, more generally, knowledge for level and growth of productivity.

However, in this scenario the lack of international competition in combination with extensive public intervention hurts economic efficiency and hinders development and diffusion of new technologies. The share of services in the economy continue to grow – although less than in the other scenarios - and the EU reinforces its comparative advantage in agriculture and food products, chemicals and minerals and business services. In addition, the export pattern of EU becomes somehow more specialised in the “other services” category than before.

A specific technological development which supports the change of people lifestyle is the diffusion of low-powered communications technologies. Wireless mesh networks, tried and tested in places like Nepal, work fine in Europe too. And the world has been turned upside-down in other ways: communities which are used to hardship, and where people still have mechanical and technical skills, seem to be doing better than those that had become part of the knowledge economy. Social cohesion matters, more than ever (wireless mesh networks are point-to-point-to-point networks: each node can send and receive messages and can function as a router relaying messages for its neighbours).

4.3.4.4 Energy and environment

Carbon emissions have contracted, mostly, simply because far less energy is used than in the later 20th century. Transport is slow: energy efficiency matters far more than speed. Economic production and development as well as transport are re-organised according to ecological principles supporting strong sustainability – in general and with regard to transport – and new forms of social organisation with less work, more leisure, strong voluntary sector and “togetherness” in consumption (e.g. co-housing, car-sharing, etc.) emerge. This contributes to reduce the overall impact of human activities on the environment.

In an effort to diversify their energy imports and to contain local environmental problems (e.g. air quality), countries opt for clean energy sources. The local environment thus fares rather well.

However, although these results have been the direct consequence of more sustainable consumption patterns, the attitude of people to consume less carbon-intensive products and services has been primarily facilitated by the introduction of carbon tax systems, in particular in North America and in the core group of EU countries (EU15). Carbon taxes are based on fossil fuel carbon content and therefore tax carbon dioxide emissions. Introduced as early as 2008 in British Columbia, Canada, they spread over North America, encouraging energy conservation also in the United States, formerly used to consume large amounts of relatively cheap energy. Since then, carbon taxes were applied progressively by all EU15 countries, in a revenue neutral fashion, as the taxes on labour and investments were reduced. In this way people started to perceive clearly that what is taxed is “what you burn, not what you earn”, and this perception helped them to shift to more energy behaviours in all their activities, including mobility. Carbon taxes are efficient and flexible because they support many energy conservation and emission reduction strategies, allowing households and business to choose the combination that works best for them, including more fuel efficient vehicles, more

accessible locations and destinations, more efficient modes (and more active travel), more resource-efficient goods (such as recycled products), shifts to alternative fuels etc.

4.3.5 Constrained mobility scenario

The storyline of the Constrained-mobility scenario presented here is based on:

- The extreme “Constrained mobility scenario”, which was in turn inspired by the “Good intentions” scenario in the UK Office of Science and technology study (OST, 2006), and the subsequent discussion with internal and external experts at the TRANSvisions 9th July and 24th July meetings.
- The “Transatlantic Market” scenario elaborated in the context of the CPB “Four Scenarios for Europe” study (CPB, 2003).

In short, this scenario is based on supply-oriented policies favouring public investments on environmentally friendly modes even when they are not so cost effective, and strict demand management, including environmental taxation. A breaking point in nowadays tendencies would be the implementation of on-line pricing systems for transport charging users according to the vehicle they are using, and the speed, the number of occupants, the place and the moment of the day. Short sea shipping and railways are increasingly used, as well as public transport in cities.

The following is a deeper discussion of the scenario features for the different key drivers.

4.3.5.1 Global governance and policy context

After enlargement of 27 member states in this scenario, EU governance is not reformed into decisive and legitimate institutions. Many countries do not regard this failure of reform in the European Union as problematic. The bureaucracy in Brussels is widely mistrusted and is seen as too technocratic, undemocratic and not transparent. Countries thus want to play down the power of supranational decision making. Integration comes to a halt – it reverses the fact in some areas. The European Union is primarily seen as an economic union with a focus on the internal market.

Multilateral cooperation via international institutions is not a primary concern for the EU and the United States: both are unwilling to sacrifice sovereignty to multilateral institutions. However, economic integration between the two continents is feasible at low coordination costs. Hence, whereas a global trade agreement fails, the European Union, the United States and Latin America agree upon a “backdoor free trade” agreement. The transatlantic economic integration actually goes beyond a free trade agreement: it leads de facto to a single market in which a large number of formal and informal barriers to trade are removed through mutual recognition. This holds in particular for the service sectors, and it fosters growth of the ICT sector in Europe.

The rich transatlantic economic block contrasts sharply with the poorest parts of the world. Less developed countries even suffer from trade diversion as a result of the free-trade agreement. There is little interest in Europe and the United States to actively fighting poverty in developing countries.

EU enlargement is not a success in this scenario: cohesion support is ineffective and the new member states have difficulty in adjusting to the increasingly competitive market. Poverty in rural areas in the Central and Eastern European countries is increasing, and there is slow convergence to the EU average. The new member states do not enter the Euro area, with the exception of two smaller countries (Slovenia and Malta). Turkey does not accede to the European Union, but instead shifts her attention more eastwards. China and Russia become more isolated, both politically and economically. Because of poor border controls in the East, EU member states suffer from an inflow of illegal immigrants. All in all, enlargement receives a low priority from the Western EU countries, as they fear the import or even more instability and more immigrants.

4.3.5.2 Economic and social milieu

Growth is concentrated in ICT-producing sectors, and in ICT-using service sectors such as the financial sector, business services and the public sector. The broad dissemination of ICT boosts labour productivity to 1.8% per year. GDP growth falls, however, as the result of declining employment due to ageing. Participation rates do not fall substantially, since lower social benefits and limited eligibility reduce unemployment and stimulate labour supply. This positive effect on employment compensates for the negative effect of an ageing population on labour supply.

European countries limit the role of the state and rely more on market exchange. This boosts technology-driven growth and at the same time increases inequality. The heritage of a large public sector in EU is not easily dissolved. New markets – e.g. for education and social insurance – lack transparency and competition which brings new social and economic problems. The elderly dominate political markets. This makes difficult to dismantle the pay-as-you-go systems in continental Europe.

Indeed, pressure on public sectors and strong preferences for individualised arrangements, rather than collective ones, leads to downsizing of European welfare state. Insurance against labour market risks is reduced and partly shifted to the market and social partners. Publicly provided welfare provisions are limited to social assistance. At the same time, the labour market becomes more flexible as employment protection legislation is relaxed, the power of trade unions deteriorates, minimum wages are reduced, and tax systems become less progressive. These reforms stimulate participation in the formal labour market and induce people to work longer hours.

As noted above, the “political market” becomes more and more dominated by the older generations. Hence, countries that have not switched early enough towards a funded system find it difficult to downsize the pay-as-you-go system. The high costs of public pensions, in combination with high expenditures on health care, crowd out the possibilities for inter-generational redistribution. Thus, we arrive at a less equitable income distribution between people inside and outside the labour market.

Income inequality increases also because of a rapidly rising skill premium. In particular, ICT-driven technical change raises the demand for skilled workers relative to unskilled workers. At the same time, the supply of skills does not increase at the same pace, especially since part of the population cannot afford higher education. As a result, income disparities between

skilled and unskilled workers rise considerably. Trade unions, which used to dampen wage dispersion, lose power and can no longer offset the increasing skill premium.

Increasing income disparities between rich and poor countries raise the potential immigration to the European Union. Europe, however, keeps its borders closed for immigrants. Illegal immigrants and asylum seekers who do enter the EU can be absorbed by the flexible labour market, but tend to increase the skill premium even further.

The real interest rate rises somewhat as, on the one hand, the elderly dissave while, on the other hand, GDP growth stimulates investments.

As it concerns trade, persistent trade barriers and relatively low economic growth outside the club of rich countries hamper world trade. World exports grow moderately. A large share of the European exports is intra-EU trade. The United States is an important destination for the exports to other regions because of the European-American internal market.

4.3.5.3 Technology

Total Factor Productivity (TFP) is the most important driving force behind GDP growth. This underlines the critical importance of technology and, more generally, knowledge for level and growth of productivity. More than in the other scenarios, GDP growth in this scenario is driven by technical change. Productivity increases are indeed concentrated in ICT-producing and ICT-using sectors, and this is mainly the result of more intense trade relations with the United States.

The share of services in the economy grows, and the EU maintains its comparative advantage in chemicals and minerals, while loses those in business services and in agriculture and food – the latter somewhat artificially due to the Common Agriculture Policy. In addition, the export pattern of EU becomes more specialised in trade and transport services.

As it concerns the development of specific IT and transport technologies, those connected to the boosting ICT sectors are obviously facilitated, including the extensive use of ITS in the transport sector, for both passenger and freight applications. The first large-scale dynamic traffic flow management system pilots – introduced as from 2010 for some EU regions – was initially hailed as a success but quickly ran into technical problems. It was some years before these pilot systems were declared a success by governments – speeding travel times, smoothing flows on the network and reducing accident rates by up to 30% – but their endorsement was not sufficient to placate the growing numbers of citizens who were becoming increasingly vocal about the perceived threat to their right to mobility. These concerns were related in particular to the use of Pay As You Drive (PAYD) elements of the pilot schemes (with this system vehicles fitted with electronic vehicle identification chips calculate and assign premiums based on actual vehicle use. The driver's monthly bill is calculated according to their driving data – distance travelled, premium toll roads chosen and emission level). Problems with interoperability and inefficiency – the result of unresolved issues around standards and exchange protocols between operators – remain. So too does the question of ownership of the personal data that is collected through the system.

By 2050 intelligent speed control is largely implemented in the European conurbations. London and Paris have led the way for further reducing speed limits in cities – and have

threatened to impose legislation in this area if car manufacturers do not commit to building intelligent speed adaptation systems (ISAS) into all models. Increasingly, cars are restricted to 30 kph in residential zones and 50 kph on the outskirts of towns and villages, and the technology is integrated with national digital speed maps. Vehicles download the latest version of the speed maps as part of their daily software update and automatically limit their speed when entering or exiting different zones. In addition, sensors in the vehicle can send a distress signal to the police if the vehicle is involved in a crash while travelling at over 50 kph.

It is also increasingly important the impact of ICT on transport, in terms of substitution and/or change of daily mobility patterns in the urban environment - as well as of substitution of trips with virtual meetings and/or induction of new business and tourism travel in the long distance transport segment. The renaissance of home-working has created demand for better local infrastructure and services, especially in the urban areas. Rural areas with strong communities and local leadership have fared better than expected in providing such infrastructure, while less-cohesive rural communities are struggling and many face an uncertain future as residents are forced to consider relocating closer to the jobs.

The change of EU's transport infrastructure have been limited up to 2030. Few long-term infrastructure projects have had the political commitment or investment required to become a reality. In 2030 the ageing infrastructure is becoming an increasing financial burden on the state and business has become concerned about the impact on the EU's long-term economic competitiveness. Successive governments have been reluctant to tackle the growing threat posed by climate change, fearing the consequences from an electorate that still wants the right to travel where, when and how they want.

4.3.5.4 Energy and environment

The potential developments of nuclear energy were stopped by social concerns about the risks associated to nuclear plants, exacerbated by a catastrophic nuclear accident occurred in Europe, and the unmanageable problem of nuclear wastes. The energy production remains therefore in this scenario mostly based on fossil fuels. As there has been also little substantive actions to renovate the EU transport infrastructure – including new infrastructure to distribute alternative fuels such as hydrogen in the road sector – or to incentive the fast adoption of fuel efficient technologies, it is hardly surprising that the G10 and the EU Member States governments are feeling the political heat on climate change, which forces a tight multilateral cooperation never seen in other sectors in this scenario.

A Contraction and Convergence Agreement (CCA) is signed by the G10 in 2020, and it appears to be the best chance to tackle the problem. The agreement is for a full-term contraction budget for global emissions consistent with stabilising atmospheric concentrations of greenhouse gases at a level of 450 parts per million by volume. The intent was that all countries converge around more sustainable emissions targets.

In the year 2050 the economic, environmental and social consequences of signing up to the CCA are clear. The economy has continued to grow, despite a significant reduction in the amount of travel being undertaken, much to the surprise of some economists; GDP and transport growth are not as closely coupled as they were once believed to be. Under the terms of the CCA, individuals each received a carbon entitlement, which had been negotiated and

agreed between the regions of the world. The entitlements, in the form of international energy-backed currency units (EBCUs), operate as a parallel currency. The G10 nations have all successfully met the CCA targets on carbon emissions and some of the most pessimistic outcomes of climate change have been avoided. This is a cause for celebration among the world's political leaders, but the carbon measurements in the atmosphere are still rising, probably because of inaction a generation ago, and it is hard to gauge whether contraction and convergence will be enough. Furthermore, a picture of Europe in 2050 shows that the social impacts of CCA are more dramatic than anyone had predicted. Notably, the gap between the poorest 10% of the population and the rest narrowed significantly as individuals who used little carbon successfully traded their entitlement – allocated as UCEs, or 'Units of Carbon Entitlement' – for cash. Carbon entitlements have affected middle-income families too, forcing many to change their lifestyles in order to make best use of their EBCUs. Two-car families are in decline, bicycle sales continue to soar, home working is increasing and many families are rediscovering the need to budget carefully in order to purchase the travel credits required to go on holiday. It is not surprising that in this context also a parallel back market of carbon entitlements flourished in some parts of Europe, and especially in Southern and Eastern countries.

Transport is strongly affected by this strict carbon regulation. Bio-diesel and bio-ethanol buses have been a particular success in the face of insufficient carbon credits. These buses circulate freely and are starting to become more popular, although they remain 'niche transport'. A growing number of commuters are willing to suffer long bus journeys during the week, in order to spend their carbon entitlements on enjoying themselves at the weekends. Using the trains is more pleasant and efficient than it used to be after increased investment in latest-generation fuel cells (reducing pollution and improving performance) and satellite positioning systems (improving safety and efficient movement on low-density routes). However, train operators are once more complaining that they are at capacity, despite the increased volumes of traffic afforded by network technology.

The now widely spread national traffic flow management systems and the CCAs have forced many businesses and freight companies to seek more cost-effective and energy efficient means by which to transport their goods across Europe. Highly sophisticated wireless identification devices have allowed them to optimise logistics and distribution with the large EU ports, and many now use the existing EU's waterways as their key means of distribution. Supermarkets have faced many challenges too – they have a maximum allocation of non-local and non-seasonal stock, enforced by ubiquitous wireless stock-tagging schemes, which are monitored in real time.

At the end of the day, the largely unrestricted personal mobility that people enjoyed in the early years of the century is in 2050 a distant memory. After bitter political conflicts, sometimes violent, a tough national surveillance system means that people only travel if they have sufficient carbon quotas – and these are increasingly tightly rationed. Traffic volumes have shrunk hugely, and will fall further as the carbon ration continues to be reduced. There are even days when people have insufficient carbon credits to get to work, or so they say. As it concerns the long-distance transport, flying is increasingly becoming a luxury for the rich; and for a growing number of citizens, it is socially unacceptable even if it is affordable; frequent flyers are demonised in the same way that smokers were at the turn of the century.

Besides carbon regulation and emission control, another big incentive to change behaviour and reduce carbon consumption was the change in the tax system, which started to have a significant effect from the early 2030s. Instead of being taxed mostly on earning and spending, as under the old income tax and VAT systems, most tax is now raised against resource consumption. The EU led the way by replacing VAT with RUT (resource-use tax). The result has proved to be far more progressive, with far greater distributional effects, than the old system ever was, and far easier to police.

5 References

- Allen, D. (2005) Cohesion and the Structural Funds: Competing pressures for reform?, in: H. Wallace, W. Wallace & M. A. Pollack (Eds) *Policy-making in the European Union* (5th edition), pp. 213–241 (Oxford: Oxford University Press).
- Banister, D. & Stead, D.; 2004, *Impact of Information and Communications Technology on Transport*, *Transport Reviews*, Vol 24, No 5, 611-632
- Beck, U; 1992, *Risk Society: Towards a New Modernity*, Sage Publications, London
- BIROL, F. (2008) *Seven Questions: The New World Energy Order*. Foreign Policy.
- BIROL, F. & DAVID, W. (2001) *Oil Supply Costs and Enhanced Productivity*. Energy Prices and Taxes, xvii-xxiii.
- BP (2007) *Statistical Review of World Energy 2007*. www.bp.com/statisticalreview
- BP (2008) *Statistical Review of World Energy*, June 2008
- Benedict, E.K., Heaps C., Raskin P., (2002) *Global Scenario Group Futures – Technical Notes*, Boston
- Cazzola, P (2007); *Vehicle Fuel Economy improvements*, EIA, October
- Commission of the European Communities (CEC) (2001). *White Paper. European transport policy for 2020: time to decide [COM(2001)370]*. Office for Official Publications of the European Communities, Luxembourg.
- Commission of the European Communities (CEC) (2004) *A New Partnership for Cohesion: Convergence, Competitiveness, Cooperation - Third Report on Economic and Social Cohesion*. Office for Official Publications of the European Communities, Luxembourg.
- Commission of the European Communities (CEC) (2006). *Communication from the Commission to the Council and the European Parliament. Keep Europe moving – Sustainable mobility for our continent. Mid-term review of the European Commission’s 2001 Transport White Paper [COM(2006)314]*. Office for Official Publications of the European Communities, Luxembourg.
- Commission of the European Communities (CEC) (2007a). *Green Paper. Towards a new culture for urban mobility [COM(2007)551]*. Office for Official Publications of the European Communities, Luxembourg
- Commission of the European Communities (CEC) (2007b). *Commission Staff Working Document Accompanying The Green Paper “Towards A New Culture For Urban Mobility” [SEC(2007)1209]*. Office for Official Publications of the European Communities, Luxembourg

Commission of the European Communities (CEC), DG ECFIN; 2006 “Long Run Labour Productivity and Potential Growth Rate Projections for the EU25 countries up to 2050” ECFIN/50485/04-EN

Commission of the European Communities (CEC), Directorate-General for Economic and Financial Affairs; 2005 “Long-term labour force projections for the 25 EU Member States: A set of data for assessing the economic impact of ageing”.

Community of European Railway (CER), (2008) Making Europe’s Mobility Sustainable,

Council of the European Union, (2006). Review of the EU Sustainable Development Strategy (EU SDS) – renewed Strategy, Brussels

CPB, 2003, *Four Futures of Europe*, R. de Mooj, A. Lejour. Central Planbureau, The Hague.

CSIRO (2008) *Fuel for Thought: The future of transport fuels - challenges and opportunities*.

Dür, A., and Zimmerman, H. (2007) Introduction: The EU in International Trade Negotiations. *Journal of Common Market Studies* 45(4) pp 771-787

European Energy Agency (2008) Annual European Community LRTAP Convention emission inventory report 1990-2006, Technical report No 7/2008

Easterbrook, G.; 2003, *The Progress Paradox: How life gets better while people feel worse*, Random House, New York

EC- European Energy and Transport, (2007) EU-27 Energy baseline Scenario to 2030

EC- European Energy and Transport, (2008) Energy and transport in figures 2007-2008

EC-JRC; IPTS – Institute for Prospective Technological Studies; 2003, *Impacts of ICTs on Transport and Mobility (ICTRANS)*, Technical Report

EC-JRC; IPTS – Institute for Prospective Technological Studies; 2006, *Energy Use and Cost in Freight Transport Chains (ECOTRA)*, Final Report, TRT

EC-JRC; IPTS – Institute for Prospective Technological Studies; 2007, *Global Climate Policy Scenarios for 2030 and beyond*

ECMT, (2002) The driving forces behind transport growth and their implications for policy, *International Seminar*, Brussels

EIA (2007) *American Energy Outlook 2008*. Washington, Energy Information Administration.

Eurocontrol, (2004) *Challenges to growth*. Report 2004 – CTG04)

EWG (2007) *Crude Oil - The Supply Outlook*. IN ZITTEL, D. W. (Ed.). Ottobrun, Energy Watch Group.

EWING, R. H. (2007) *Growing cooler the evidence on urban development and climate change*. Washington, D.C., Urban Land Institute.

Faludi, A. (2007) *Territorial Cohesion Policy and the European Model of Society*. European Planning Studies 15:4, pp 567-583

Friedman, J., 2007, *Toward a Comparative Study of Hegemonic Decline in Global Systems*, in Costanza, R., Graumlich L.J., Steffen W. (eds.) *Sustainability or Collapse? An Integrated History and Future of People on Earth*, Dahlem Workshop Reports, MIT & Dahlem University Press.

GOLDMAN-SACHS (2008) *\$100 oil reality, part 2: Has the super-spike end game begun?* , Goldman Sachs Global Investment Research: Global energy equity research team.

Goodwin, Phil, Joyce Dargay and Mark Hanly (2004); *Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review*, Transport Reviews vol. 24 no. 3 May

HIRSCH, R., BEZDEK, R. & WENDLING, R. (2005) *Peaking of World Oil Production: Impacts, Mitigation, and Risk Management*. US Government.

Hollins, O. (2007), *Environmentally Beneficial Nanotechnologies – Barriers and Opportunities – A report for the Department for Environment, Food and Rural Affairs*, May 2007

ICCR, FORESIGHT for TRANSPORT: 2004 “A Foresight Exercise to Help Forward Thinking in Transport and Sectoral Integration, Final Report

IEA (2005) *Saving Oil in a Hurry*. International Energy Administration.

IEA (2007) *World Energy Outlook 2007 - China and India Insights*. International Energy Agency.

IEA (2008) *Medium Term Oil Market Report*. World Petroleum Congress. Madrid.

IPCC-Intergovernmental Panel on Climate Change; 2007, *Climate Change 2007: Synthesis Report*.

IPTS (2006) ECOTRA “Energy use and Cost in freight TRANsport chains”, TRT

Litman, Todd (2007); “Generated Traffic and Induced Travel”, Implications for Transport Planning, Victoria Transport Policy Institute, 17. Sept.

Litman, T., 2008, *Carbon Taxes “Tax What You Burn, Not What You Earn”*, Victoria Transport Policy Institute

LYNCH, M. (2001) *Forecasting oil supply: theory and practice*. The Quarterly Review of Economics and Finance, 42, 373-389.

Martin, J. 2008, Migration, globalisation and gender – some key lessons, *OECD Observer*

Martin Stopford: 2007 Hong Kong Shipowners Association, Will the next 50 years be as Chaotic in Shipping as the Last, 18th January

MED (2006) *New Zealand's Energy Outlook to 2030*. Wellington, Ministry of Economic Development.

MED (2007) *Alternative Liquid Fuels: Global Availability, Economics and Environmental Impacts*. Wellington, Ministry of Economic Development.

Ministère des Transports, de l'Équipement, du Tourisme et de la Mer (2006) Long-Range Transportation Plan 2050 Conseil Général des Ponts et Chaussées

New Zealand Transport Agency, 2008, *Managing transport challenges when oil prices rise*, Research Report 357

NYMEX (2008) Light Sweet Crude Oil - Session Expanded Table.

http://www.nymex.com/lSCO_fut_csf.aspx?product=CL. New York, New York Mercantile Exchange.

Nuclear Energy Institute: Homesite www.nei.org

Oakdene Hollins Ltd; 2007, *Environmentally Beneficial Nanotechnologies: barriers and opportunities*, Report for the UK Department for Environment, Food and rural Affairs (DEFRA)

OECD, 2002, Transport and ageing of the population, Paris

OECD, 2006, Decoupling the Environmental Impacts of Transport from Economic Growth, Paris

OECD, 2007, Biofuels: Linking Support to Performance – *Discussion Paper No. 2008-7, February 2008*, Paris

OECD, 2007, Cutting Transport CO₂ Emissions: What Progress?, Paris

OECD, 2008, Climate Change: meeting the Challenge to 2050

REHRL, T. & FRIEDRICH, R. (2005) *Modelling long-term oil price and extraction with a Hubbert approach: The LOPEX model*. Energy Policy, 34, 2413-2428

Reuters, Publisher, ENN: Environmental News network (2008), China builds plant to turn coal into barrels of oil

Rocco, M & Bainbridge, W; 2001, *Societal implications of Nanoscience and Nanotechnology*, Kluwer, Dordrecht

Rubin J., Tal B. (2008) Will Soaring Transport Costs Reverse Globalization ? CIBC World Markets InC

SAUNER (2000) *Sustainability and the Use of Non-Renewable Resources*. Environment and Climate Change Programme. Brussels, European Commission DG XII

SEI – Stockholm Environment Institute, (2002) – Great Transition - The promise and lure of the Times Ahead

Sheller, M., and Urry, J. (2006) The New Mobilities Paradigm. *Environment and Planning* A38 pp 207-226

Simpkins, J. (2008) *China to supplant U.S. as world's largest manufacture by next year*

Stead, D. (2006) Mid-term review of the European Commission's 2001 Transport White Paper. *European Journal of Transport and Infrastructure Research* 6(4) pp 365-370

Stiglitz, J. (2006): *Making globalization work*

THINK-UP Network (2002), Deliverable 10, Vienna, ICCR

Transportation Research Board; 2008, *Potential Impacts of Climate Change on U.S. Transportation*, National Research Council, U.S.

Turró, M. (1999) *Going trans-European: Planning and financing transport networks for Europe*. Pergamon.

USGAO (2007) *Uncertainty about Future Oil Production Makes it Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production*. United States Government Accountability Office.

Volkswagen, (2007) Sustainability Report 2007/2008 – We are moving into the future responsibly , Germany

World Business Council for Sustainable Development; 2004 “ The Sustainable Mobility Project

Annex I – Table A: Deployment of future “extreme” scenarios by main drivers

Key drivers:	KEY EVENTS/FEATURES OF THE SCENARIOS AT THE YEAR 2050			
	“Hyper-mobility”	“Sustainable-decoupled mobility”	“Collapse-Reduced mobility”	“Carbon-constrained mobility”
SOCIETY				
- Population growth	Moderate increase of EU population	Growing EU population	Strong reduction of EU population	Low increase of EU population
- Population ageing	Marked ageing, but limited due to immigration	Moderate ageing	Strong ageing	Strong ageing
- Migration	High increase of immigration	Moderate immigration	Low level of immigration	Very low immigration
- Urbanisation	Urban sprawl	Accelerated (compact) urbanisation	De-urbanisation: smaller communities	Compact urbanisation
- Work-time regimes; tele-working	Telepresencing is almost a “lifestyle”	Diffusion of telework and flex-work regimes	Use of short-hop wireless systems	Diffusion of telework
- Tourism and leisure	Continuous growth of world tourism	Development of personal services related to “tourism” (business, health, etc)	Collapse of tourism	Reduction of world tourism
- Lifestyles	Rising life stress Rampant consumerism Increasingly automated delivery of services (self-service)	Increasing sustainable consumption and lifestyle	Social breakdown Local lifestyle	Strong social impact of carbon entitlements
- Safety	EU Road fatalities halved as compared to 2006 level (to 20.000 death per year) thanks to driver assistance	Reduction of road fatalities thanks to the increased use of sustainable modes	Reduction of road fatalities due to the drastic reduction of traffic	Almost-zero road accidents target achieved thanks to the drastic reduction of traffic and the diffusion of intelligent speed control
- Security	Private security on the rise. Market-led security provision (including part of defence tasks). Security offered by private cars much valued and improved.	Security enhanced through: i) private-public cooperation with public sector maintaining oversight and private sector sub-contracting, ii) positive and negative incentives for public to cooperate.	Security crisis. Transport becomes a highly hazardous activity, as high unemployment might cause increased crime levels also affecting transport.	Focus on enforcement, control and corrective action.

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Key drivers:	KEY EVENTS/FEATURES OF THE SCENARIOS AT THE YEAR 2050			
	“Hyper-mobility”	“Sustainable-decoupled mobility”	“Collapse-Reduced mobility”	“Carbon-constrained mobility”
ECONOMY				
- Growth and productivity	Marked economic growth, with GDP growth in the order of 2.6% per annum.	Lower economic growth (as compared to Hyper-mobility), with EU GDP growth in the order of magnitude of 2.4% per annum. Competitive and sustainable cities A “knowledge hubs” economy Mixed situation for rural areas	Collapse of the world economy, growing at 1.2 % per annum	Slow economic growth, with EU GDP growth in the order of magnitude of 1.3% per annum
- Trade	Continuous growth of world trade	Shift to regional world trade patterns	Collapse of world trade	Shift to regional world trade patterns
- Employment	The EU employment rate will increase at about 70%, with greater female participation and share of immigrant workers and elderly	The EU employment rate will remain around the current level (65%)	Reduction of employment rate; less working/hour per day	Reduction of employment rate
- Public budget constraints	Decrease in GDP share of public sector, also due to high growth and tax base extension due to immigrants. Pressure to lower taxes.	Unchanged or moderate increase in GDP share of public sector, pressure of ageing but outsourcing of tasks.	Government finances overburdened	Strong increase in GDP share of public sector, as major challenges are tackled by government.
ENERGY				
- Energy supply	Nuclear energy Diffusion of hydrogen as energy vector towards 2050	Distributed energy power (microgrids)	Energy shock	Still heavily carbon-dependent, but carbon regulation provides for a carbon decoupled growth pattern
- Energy demand	Higher efficiency but also high rebound effects of increased mobility	Sustainable buildings	Self-help communities	High fuel efficiency and heavily constrained demand by means of carbon entitlements
- Energy prices	Moderate energy prices increase.	High energy prices (e.g. triple-digit oil	Low energy prices as a	High energy prices (e.g. triple-

TRANSvisions

Key drivers:	KEY EVENTS/FEATURES OF THE SCENARIOS AT THE YEAR 2050			
	“Hyper-mobility”	“Sustainable-decoupled mobility”	“Collapse-Reduced mobility”	“Carbon-constrained mobility”
		prices)	consequence of falling demand	digit oil prices)
TECHNOLOGY				
- New energy infrastructure	Full exploitation of nuclear energy.	Full exploitation of distributed micro-generation from natural gas and renewable sources. Small energy community networks (microgrids).	Decaying energy infrastructure	Better local infrastructure and services
- New transport infrastructure	Full development of intelligent transport infrastructure, hydrogen distribution infrastructure. Market-led ITS.	City transport infrastructure and innovation. Government-steered ITS	Decaying transport infrastructure	Limited change of the transport infrastructure
- New fuels and vehicles	Drivers assistance Hydrogen cell application	Drive away from automated public transport	Research on new vehicles is nearly stopped.	Fuel efficiency Biofuel buses
- ICT development	Wireless connection ID devices	Use of ITS mainly in the urban environment	Low-powered communications An eroded information infrastructure technology.	Intelligent speed control
ENVIRONMENT				
- Pollution	More local pollution	Local pollution below air quality control targets	Reduced pollution due to reduced activity in the transport and other sectors.	Less pollution as a side-effect of strict carbon regulation
- Waste	Increasing waste footprint	Zero-waste society	Reduction of waste due to the reduction of production and consumption.	Decreased waste footprint
- Greenhouse gases emissions	Reduction of CO2 emissions to	Reduction of CO2 emissions to about	Reduction of CO2	Reduction of CO2 emissions

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Key drivers:	KEY EVENTS/FEATURES OF THE SCENARIOS AT THE YEAR 2050			
	“Hyper-mobility”	“Sustainable-decoupled mobility”	“Collapse-Reduced mobility”	“Carbon-constrained mobility”
	about 52% below 2005 level at 2050.	57% below 2005 level at 2050.	emissions to about 58% below 2005 level at 2050.	to about 35% below 2005 level at 2050.
- Climate change effects	At the atmospheric concentration of about 550 ppm of CO ₂ -eq, global average temperature increase is going to stabilise at about 3 C° by 2100 and the global average sea level rise at 1,2 metres	At the atmospheric concentration of about 450 ppm of CO ₂ -eq, global average temperature increase is going to stabilise at about 2,2 C° by 2100 and the global average sea level rise at 0,9 metres	Atmospheric concentration of CO ₂ -eq fall below 400 ppm, the global temperature increase below 2 C° and sea level rise below 0,4 metres	At the atmospheric concentration of about 450 ppm of CO ₂ -eq, global average temperature increase is going to stabilise at about 2,2 C° by 2100 and the global average sea level rise at 0,9 metres Climate change effects continuing
- Natural resource consumption	<i>Not specifically in focus within this particular scenario</i>	<i>Not specifically in focus within this particular scenario</i>	<i>Not specifically in focus within this particular scenario</i>	<i>Not specifically in focus within this particular scenario</i>
POLICY				
- EU enlargement & territorial cohesion	Broadened and extended EU, but not deep and maybe with divergent speeds. Market oriented and greater market convergence with US and MED countries. EU territory featured by competitive megalopolis and leisure landscapes.	Deepening EU, with divergent speeds; only small enlargements. EU territory featured by polycentric development in green towns, supported by cohesion funds.	EU rendered powerless by Member States acting on their own. EU territory featured by run down cities with slums, and migration back to rural areas	Deepening EU but with an “EU fortress” character. EU territory featured by compact green megalopolis
- EU integration (Single Market vs Political Union)	Prevalence of the “Competitive Europe” model	Prevalence of the “Cohesive Europe” model Increased cooperation at local level (between regions and municipalities)	A fragmented polity	Strong cooperation (Carbon Contraction Agreement)
- EU Taxation policy	Pressure to lower taxes, with national tax systems becoming less progressive GHG tax of \$25 per tonne of CO ₂ -eq applied in 2008 by OECD countries,	Pressure of ageing eroding tax bases, not enough compensated by immigrant workers GHG tax set at the level necessary to limit atmospheric concentrations to 450	Reduced tax revenues	National tax systems becoming less progressive (shift from labour to carbon taxation) GHG tax set at the level

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Key drivers:	KEY EVENTS/FEATURES OF THE SCENARIOS AT THE YEAR 2050			
	“Hyper-mobility”	“Sustainable-decoupled mobility”	“Collapse-Reduced mobility”	“Carbon-constrained mobility”
	2020 by BRIC and 2030 by the Rest of the World. Taxes on vehicle purchase, registration, use and motor fuels; road and parking pricing. Road tolling used to finance new clean transport technologies.	ppm of CO ₂ -eq in the long term. Full cost accounting and resource taxation		necessary to limit atmospheric concentrations to 450 ppm of CO ₂ -eq in the long term Taxation of resource consumption
- Global trade governance	Full liberalisation, including intellectual property and services.	Linked to global Emission Trading System and Clean Development mechanisms	Tariff and non-tariff outright protectionism	Tariffs re-emerge because of necessity to tackle carbon leakage. Likely regionalisation of world trade.
- Global climate change governance				
TRANSPORT				
- Interurban transport	Growing air transport High Speed Trains Increasing long-distance travel	Growing share of slow modes in passenger transport In freight transport punctuality and reliability are more important than speed. Increasingly priced air transport Increasingly priced rail transport Less passenger travel need. More rational freight transport	Hard travel Slow transport patterns Decline of long-distance trips	Inescapable carbon regulation and control Long distance traffic increases at a low rate
- Urban transport	Flexible local public transport Increasing volumes of traffic	Slower passenger and freight transport growth compared to GDP growth Road pricing More intensive use of public transport in urban areas	Slow transport patterns Markets grow mostly locally Average trip length decreases	Increasing public transport commuting Reduced volumes of traffic Inescapable carbon regulation and control Average trip length decreases

Annex II: DELPHI Survey questions

1. Are there driver related events/features you would like to add or change in relation to any of the four extreme scenarios ?

Hyper-mobility scenario:

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Sustainable consumption scenario:

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Collapse scenario:

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Carbon constrained scenario:

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2. Which drivers are most affected by uncertainty? Please tick one, and only one, box for each driver below

Uncertainty at 2050 horizon is:
Low Medium High

SOCIETY

Population growth and ageing

Migration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Urbanisation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work-time regimes; tele-working	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tourism and leisure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lifestyles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Security	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ECONOMY			
Growth and productivity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trade	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Employment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Public budget constraints	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ENERGY			
Energy supply	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy demand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TECHNOLOGY			
New energy infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New transport infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New fuels and vehicles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ICT development	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ENVIRONMENT			
Pollution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Waste	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Greenhouse gases emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Climate change effects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Natural resource consumption	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

POLICY

EU enlargement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EU integration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EU Territorial cohesion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EU Taxation policy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global trade governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global climate change governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global security governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. In your opinion, the impact of the drivers on transport is:

	Relevant and easy to assess	Relevant but uncertain	Not so relevant
SOCIETY			
Population growth and ageing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Migration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Urbanisation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work-time regimes; tele-working	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tourism and leisure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lifestyles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Security	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ECONOMY			
Growth and productivity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trade	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Employment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Public budget constraints	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

ENERGY

Energy supply	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy demand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

TECHNOLOGY

New energy infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New transport infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New fuels and vehicles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ICT development	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

ENVIRONMENT

Pollution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Waste	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Greenhouse gases emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Climate change effects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Natural resource consumption	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

POLICY

EU enlargement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EU integration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EU Territorial cohesion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EU Taxation policy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global trade governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global climate change governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global security governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. In your opinion which drivers have the most relevant impact on transport ? (Please indicate below up to three most important drivers in order of importance, and give any comment you may have on the nature of the impact on transport of these drivers. You may add comments related to other drivers too, if you think appropriate)

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5. The list below shows a number of key indicators for each drivers category and the related current reference values. Please give your best guesses of the most plausible evolution for the whole Europe at the year 2050:

Key indicators	Most plausible value at 2050
SOCIETY:	
Total EU population (493 millions)	
People > 65 old (16,7 %)	
Net migration from outside EU (1,4 millions)	
Urban population (80%)	
Teleworkers (10%)	
Tourists per year (190 millions)	
Single families (28,6%)	
Road fatalities (42.953)	
ECONOMY:	
Total GDP nominal (11.597 billions)	
Yearly GDP growth at constant 1995 prices (3%)	
\$/€exchange rate (1,56)	
Share of GDP in R&D activities (1,84%)	
Trade flows as share of GDP (63,3%)	
Total imports (3.720 billions €)	
Share of extra-EU imports (36,7%)	
Total exports (3.622 billions €)	
Share of extra-EU exports (32,8%)	
Inflation rate in the long run (2,3)	
Employment rate (64,5%)	

Unemployment rate (8,3%)	
ENERGY:	
Final energy consumption: solid fuels (4,6%)	
Final energy consumption: oil (42,4%)	
Final energy consumption: gas (24,6%)	
Final energy consumption: renewables + derived heat & industrial waste (8,2%)	
Final energy consumption: electricity (20,2%)	
Gross electricity generation: solid fuels (28,2%)	
Gross electricity generation: oil (4,2%)	
Gross electricity generation: gas (21,0%)	
Gross electricity generation: nuclear (30,2%)	
Gross electricity generation: renewables (14,0%)	
Gross electricity generation: other (pumped storage plants and other power stations) (2,3%)	
Automotive diesel oil prices all taxes included (1,028 €/litre)	
Unleaded petrol (95 RON) prices all taxes included (1,122 €/litre)	
TECHNOLOGY:	
Share of hydrogen fuelled buses (negligible)	
Share of hydrogen fuelled cars (negligible)	
Share of electric cars (negligible)	
Share of electric buses (negligible)	
Share of biofuels in total final consumption of petrol and diesel for transport (1,1%)	
ENVIRONMENT:	
Total CO ₂ emissions (4.554 million tonnes)	
Share of CO ₂ emissions from transport (27,4%)	
CO ₂ emissions per km cars/lorries	
Emissions of tropospheric ozone precursors from transport (TOFP - Tropospheric Ozone Formation Potential equivalent) (11.772 million tonnes)	

Emissions of particulate matter from transport (6.144 million tonnes)	
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6. OPTIONAL QUESTION: based on the summary description of the four extreme scenarios presented in Table A please indicate, for each driver, which is in your opinion the most plausible scenario (please tick one, and only one, box for each driver below):

	Scenarios at 2050			
	Hyper- mobility	Sustainable consumption	Collapse	Carbon constrained
SOCIETY				
Population growth and ageing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Migration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Urbanisation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work-time regimes; tele-working	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tourism and leisure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lifestyles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Security	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ECONOMY				
Growth and productivity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trade	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Employment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Public budget constraints	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ENERGY				
Energy supply	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy demand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

TECHNOLOGY

New energy infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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New transport infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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New fuels and vehicles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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ICT development	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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ENVIRONMENT

Pollution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Waste	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Greenhouse gases emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Climate change effects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Natural resource consumption	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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POLICY

EU enlargement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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EU integration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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EU Territorial cohesion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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EU Taxation policy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Global trade governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Global climate change governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Global security governance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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TRANSPORT

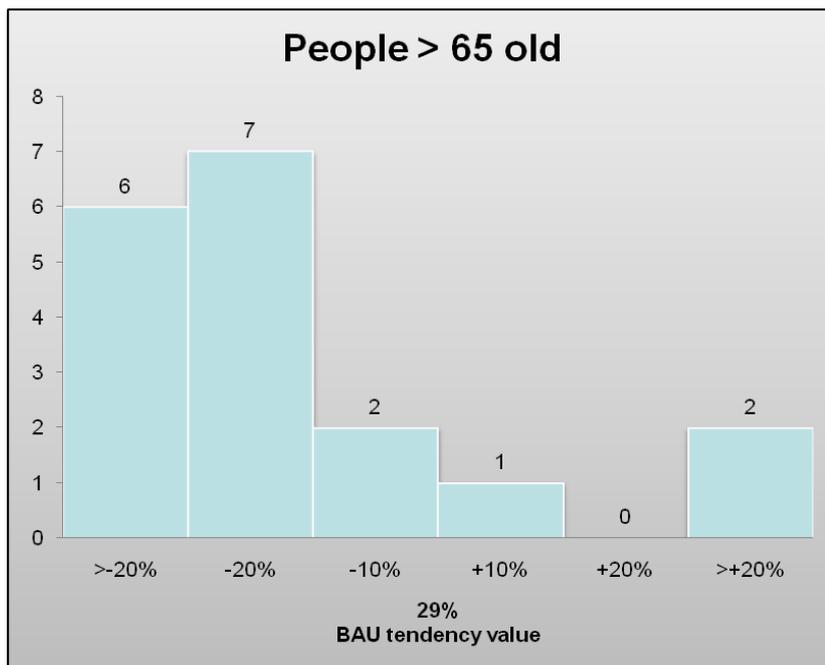
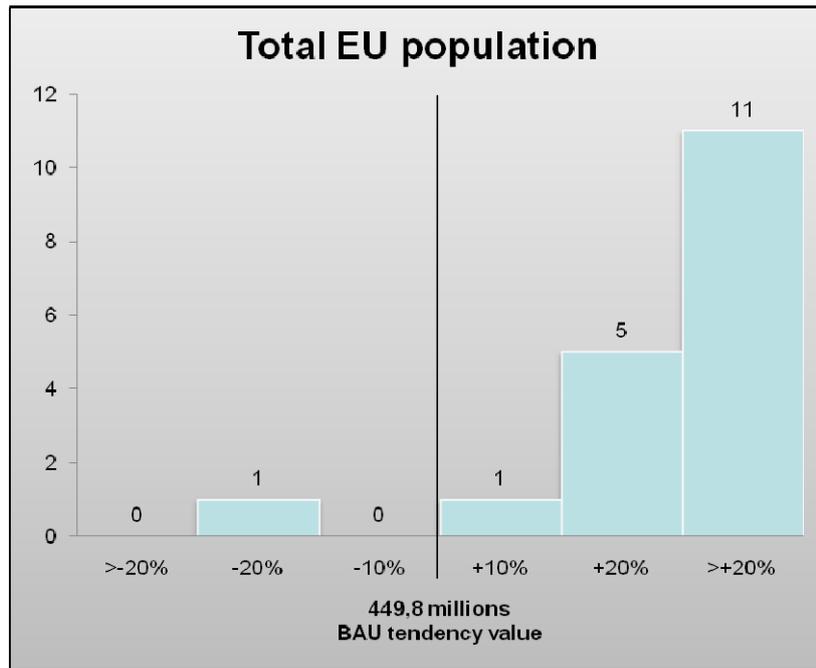
Interurban transport	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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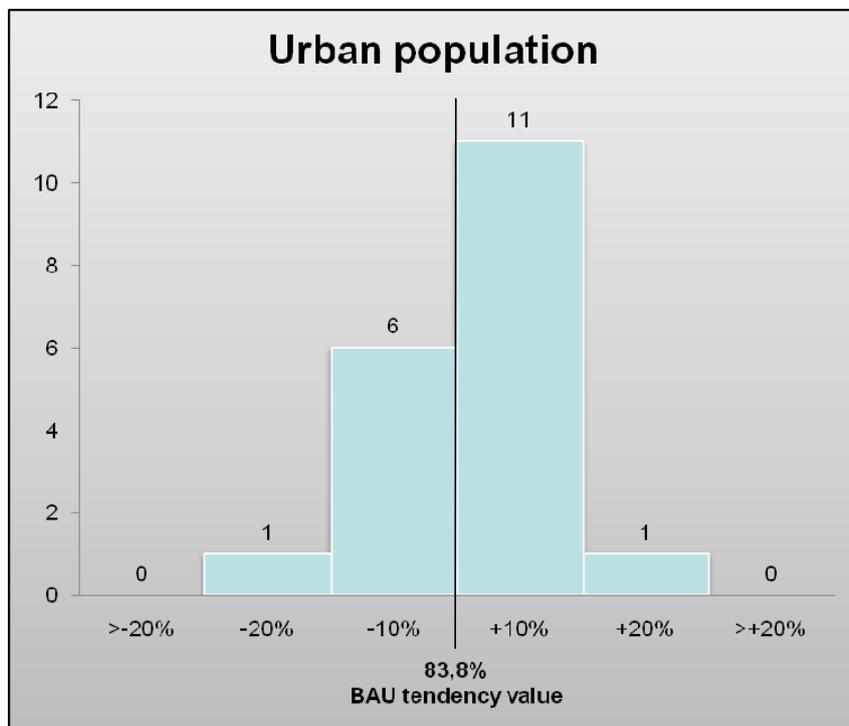
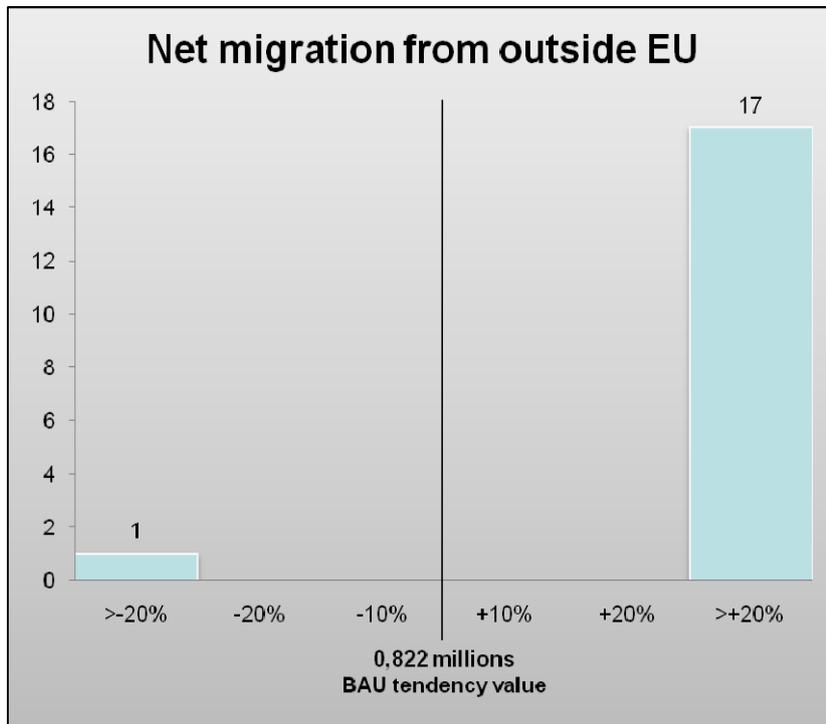
Urban transport	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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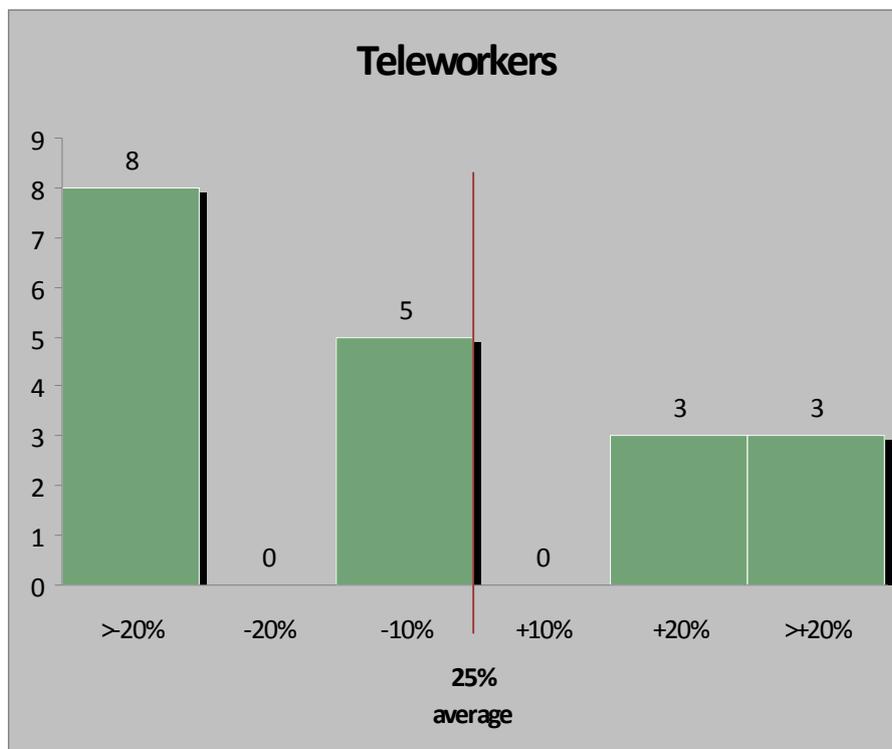
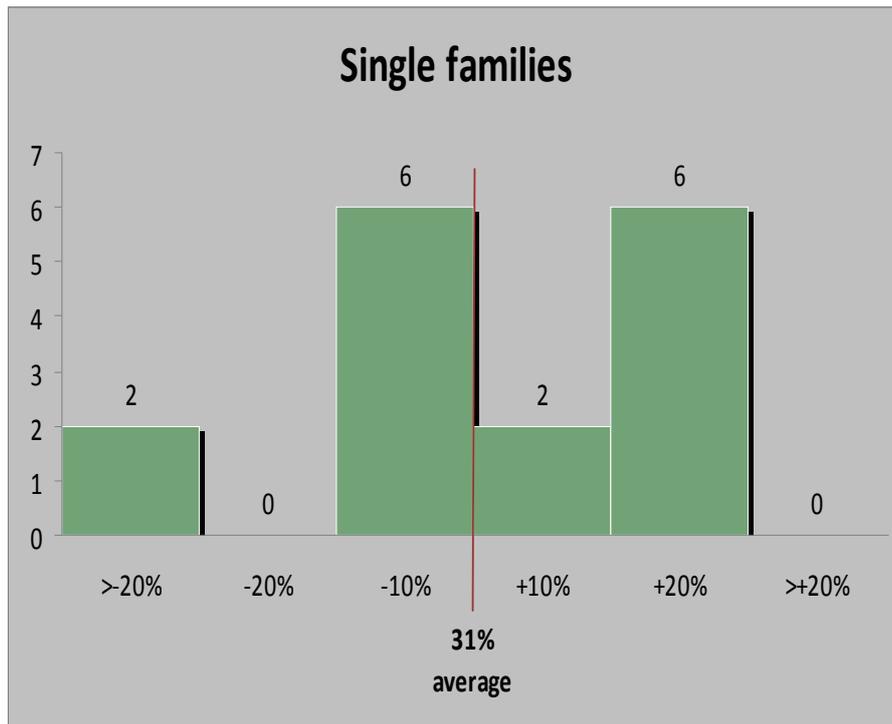
Annex III: Experts evaluations of the indicators

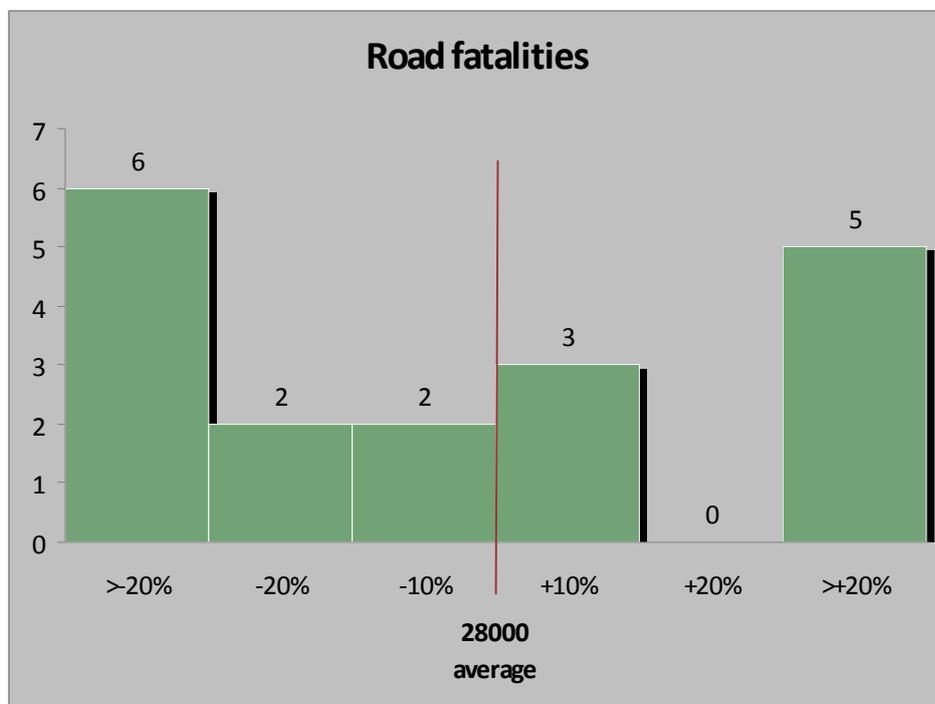
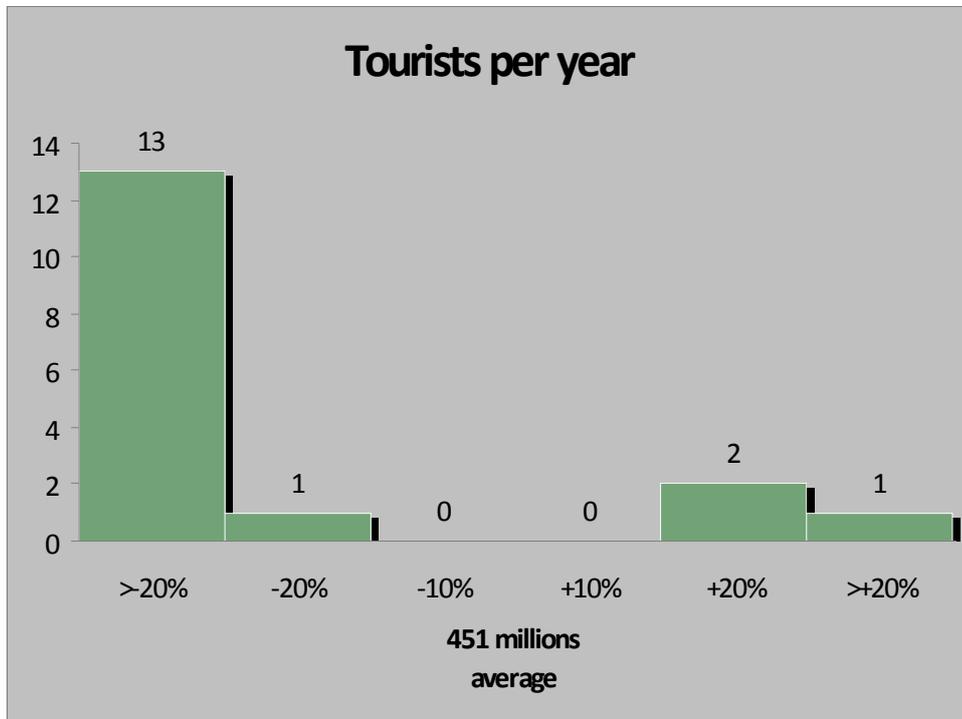
The following graphs show the experts evaluations for each indicator. On the axis are shown the ranges of variability from the central value, as resulting from BAU projections or as the average value emerging from each expert evaluation. On the vertical axis are shown the frequencies of the answers for range of variability.

SOCIETY

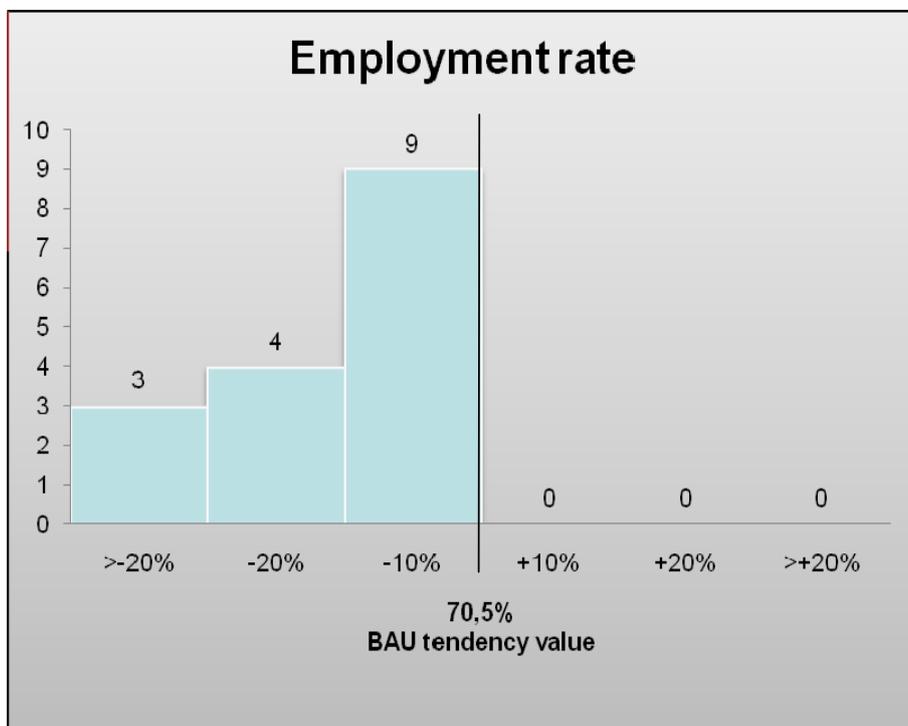
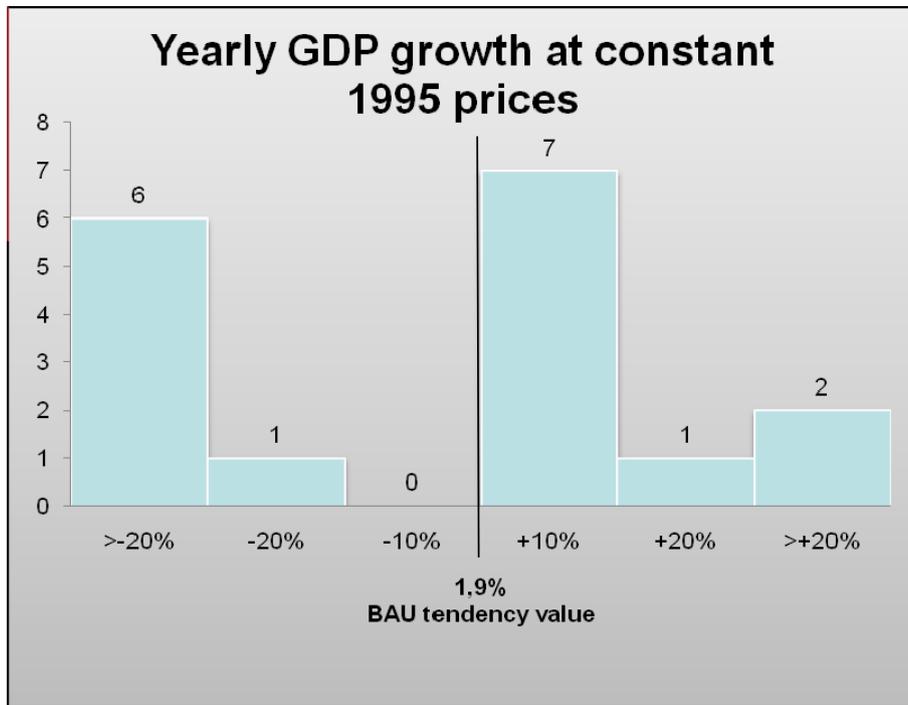


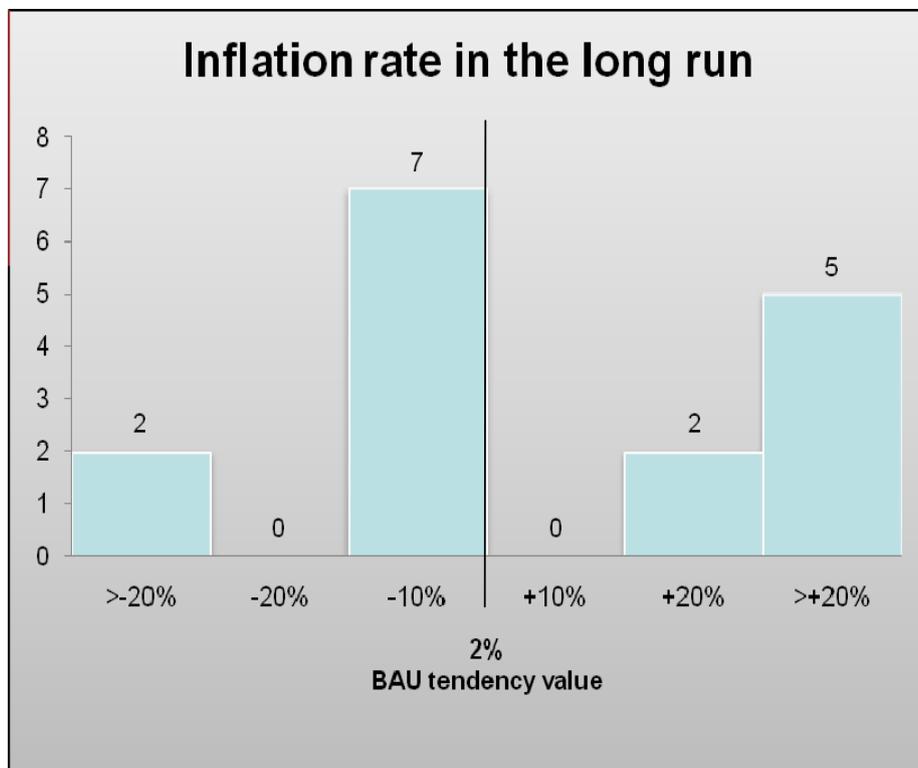
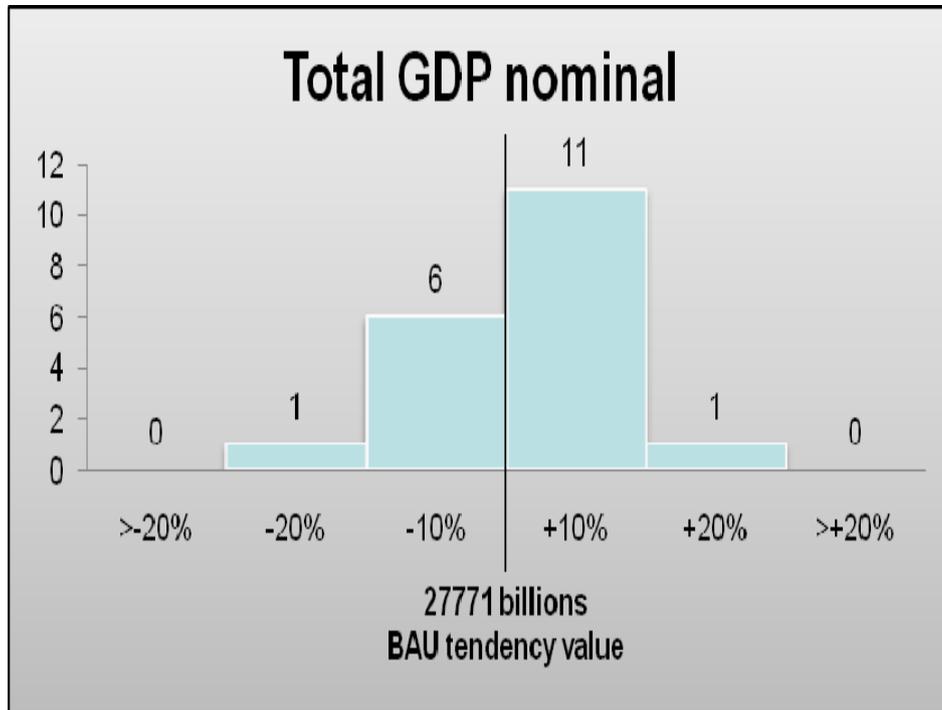


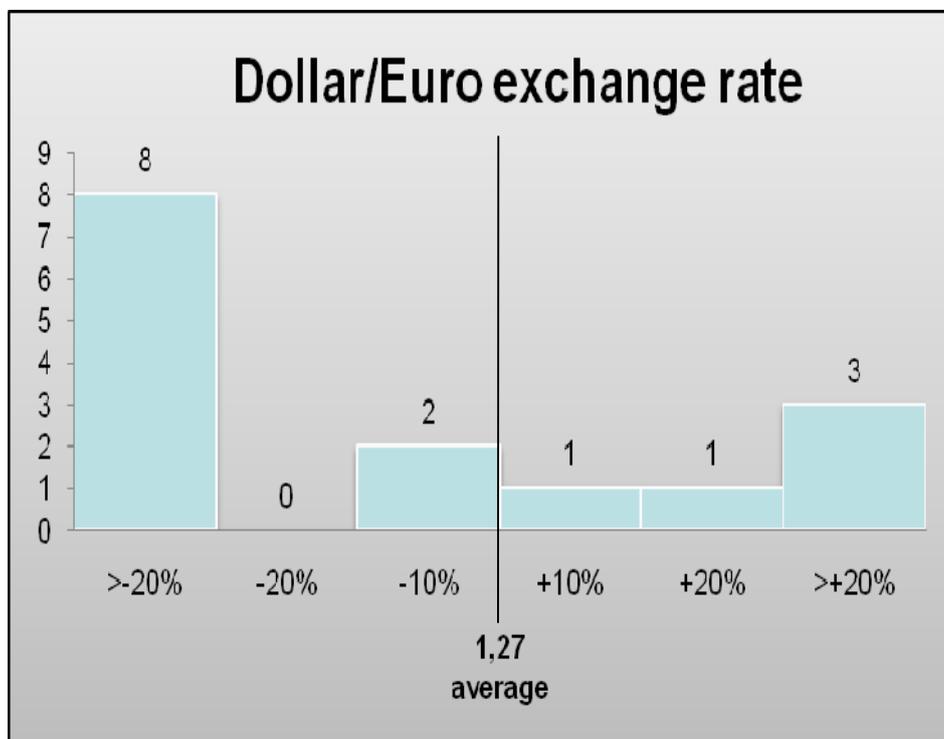
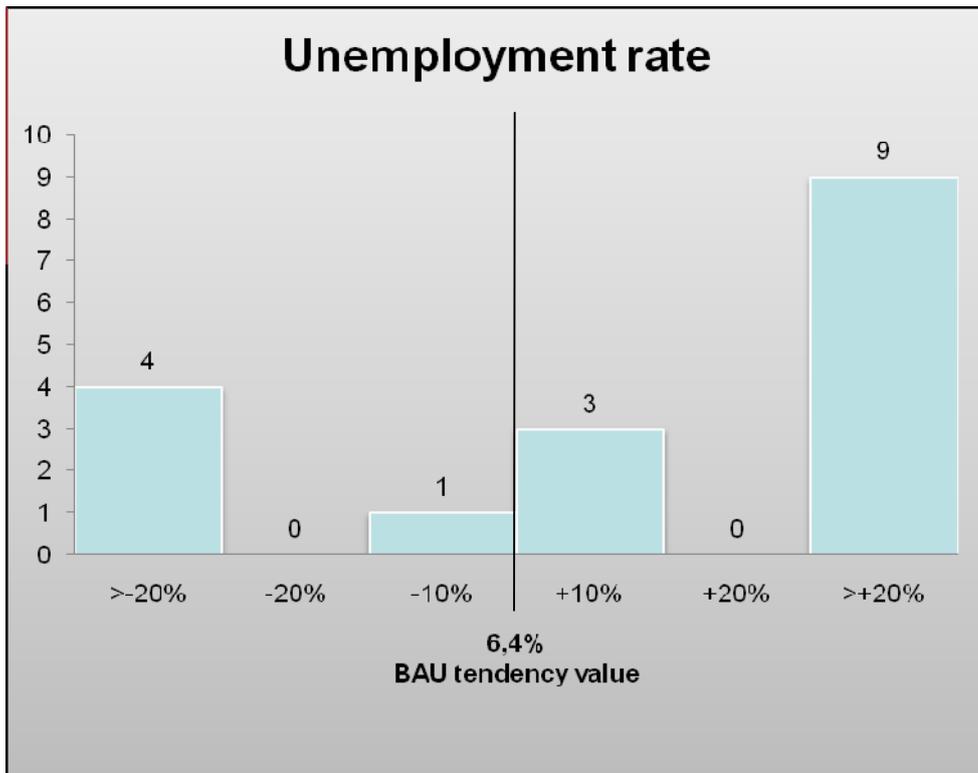


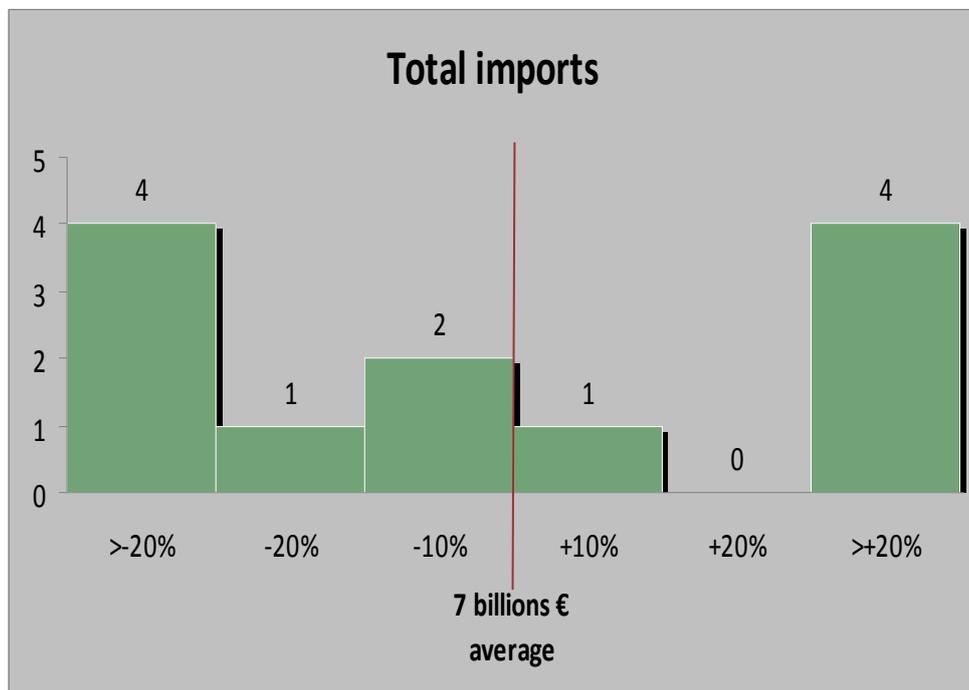
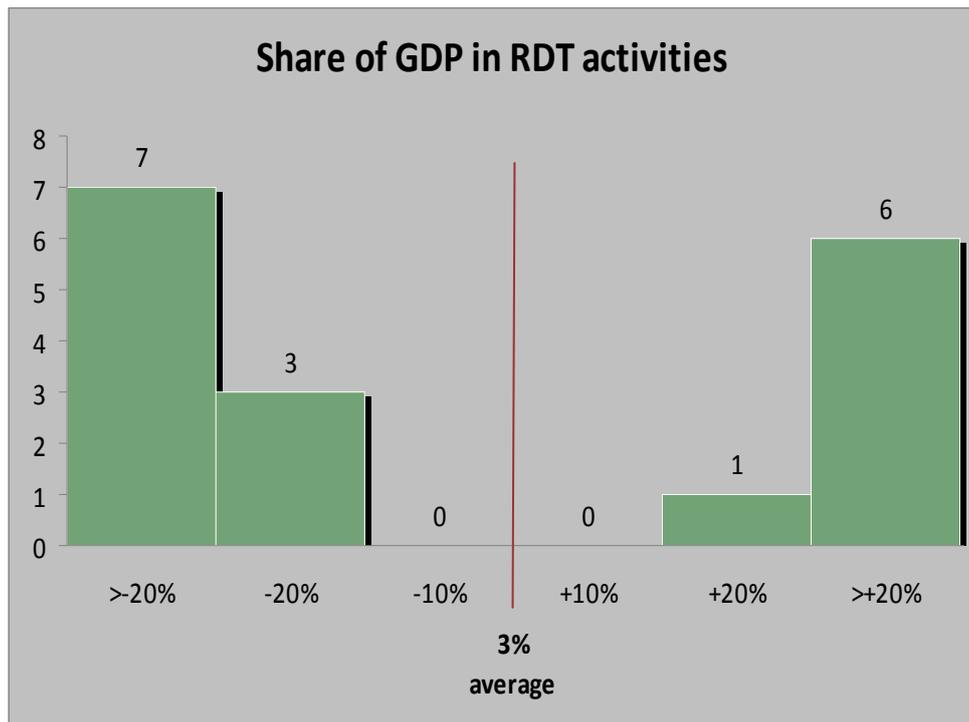


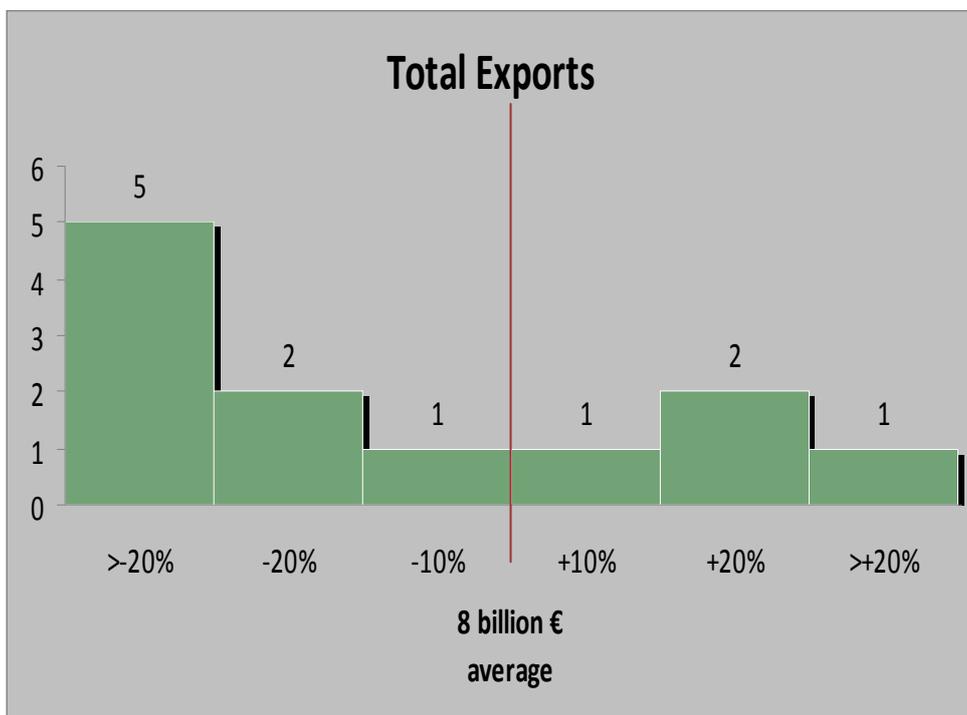
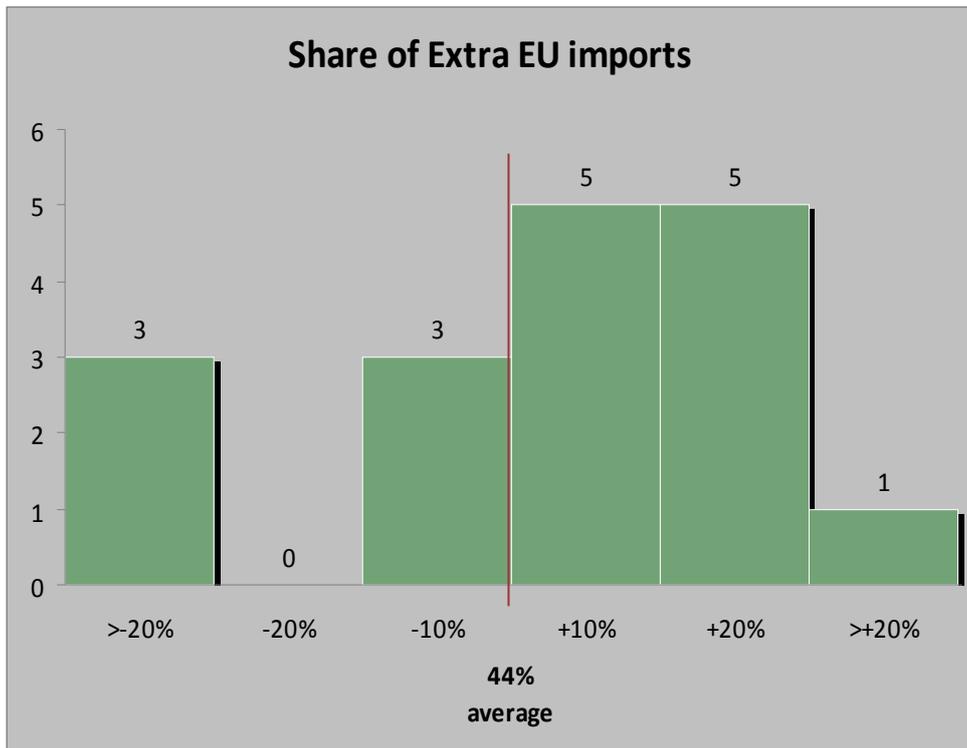
ECONOMY

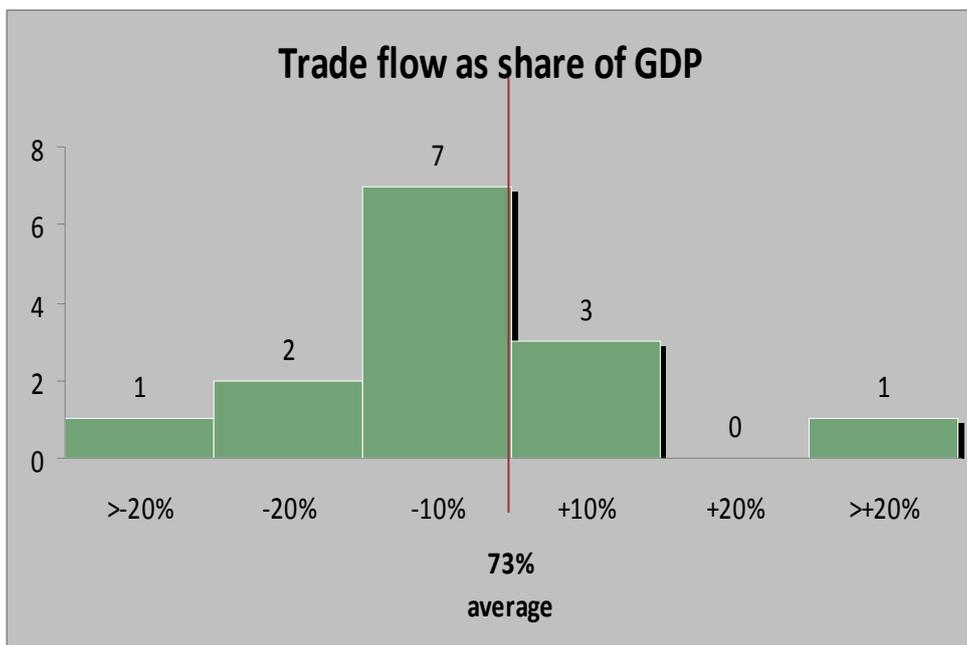
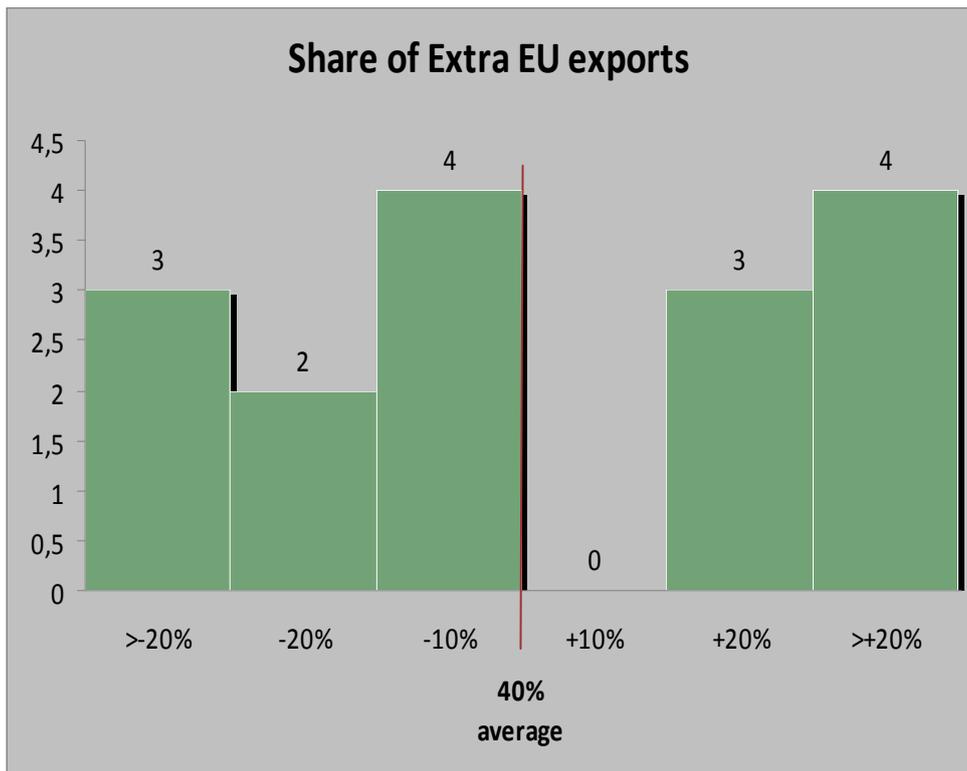




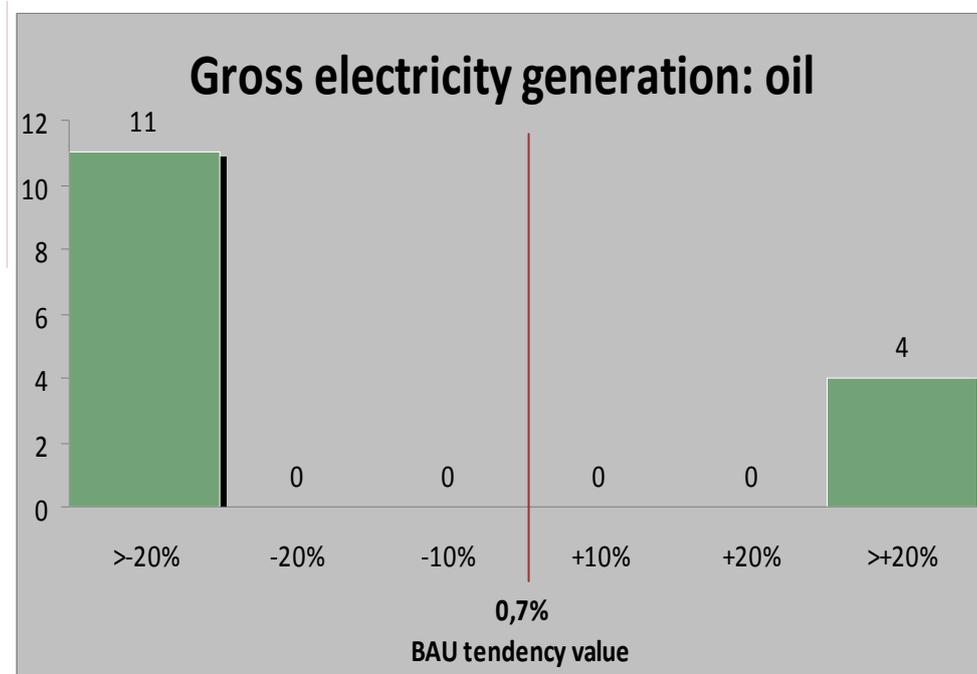
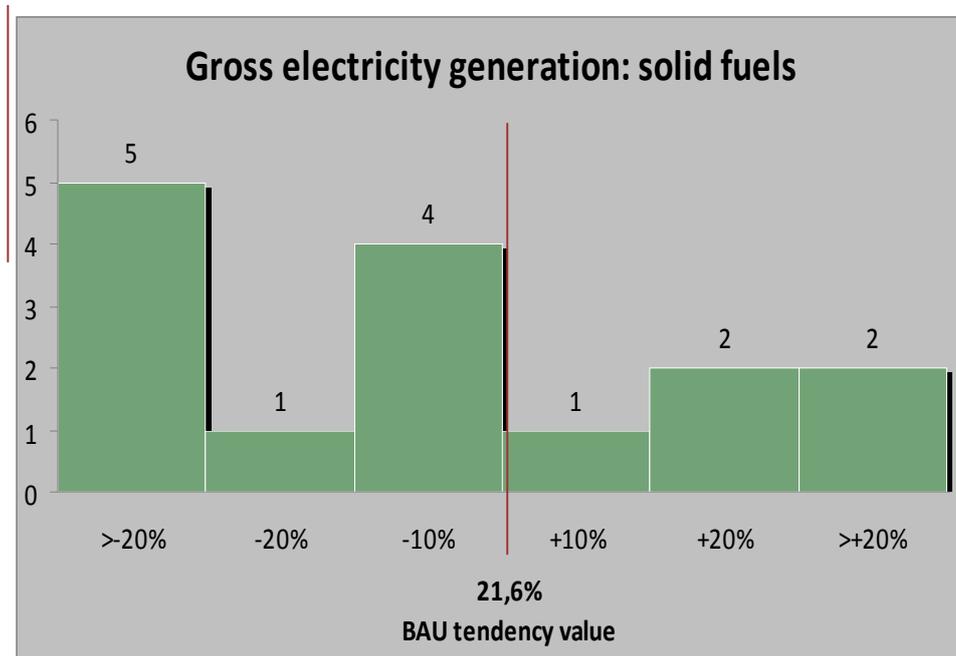


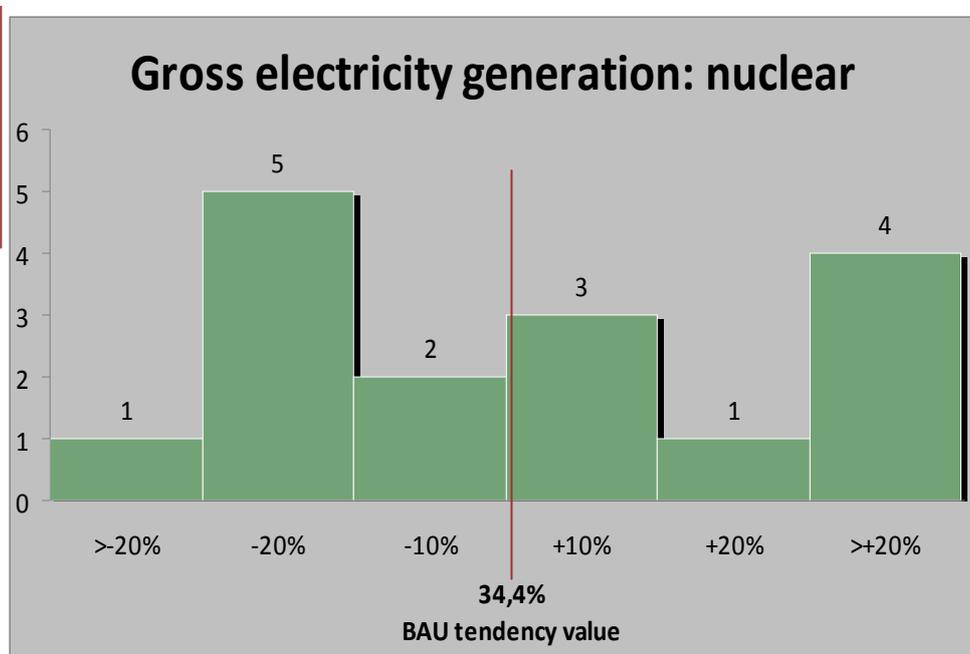
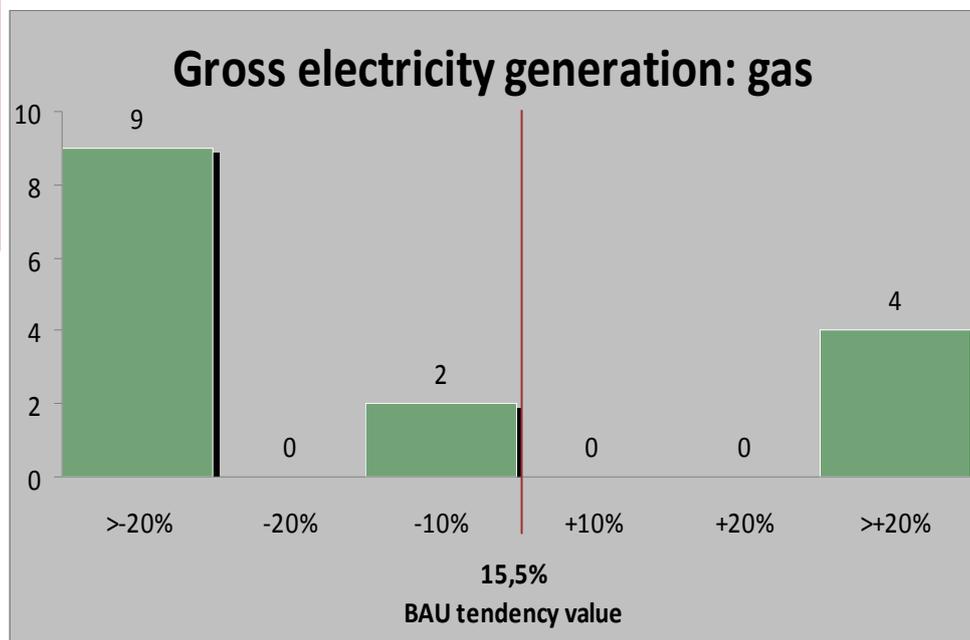


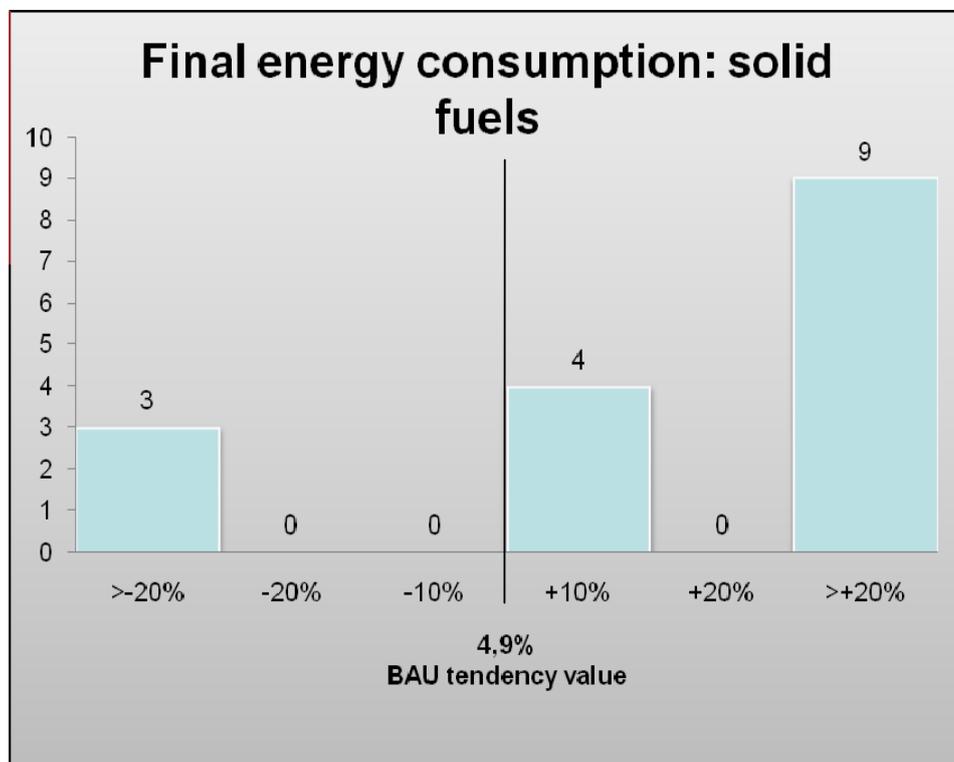
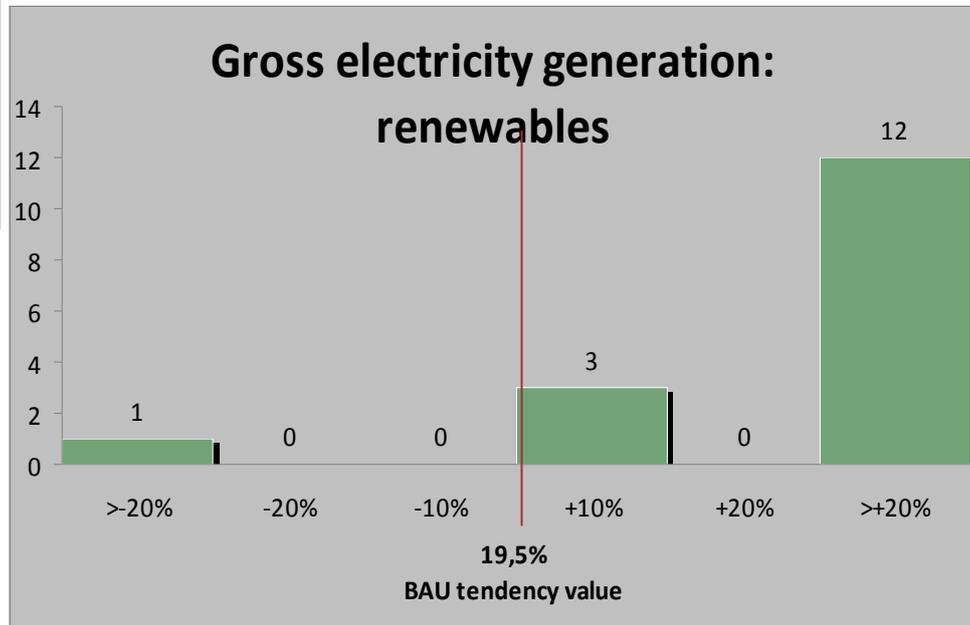


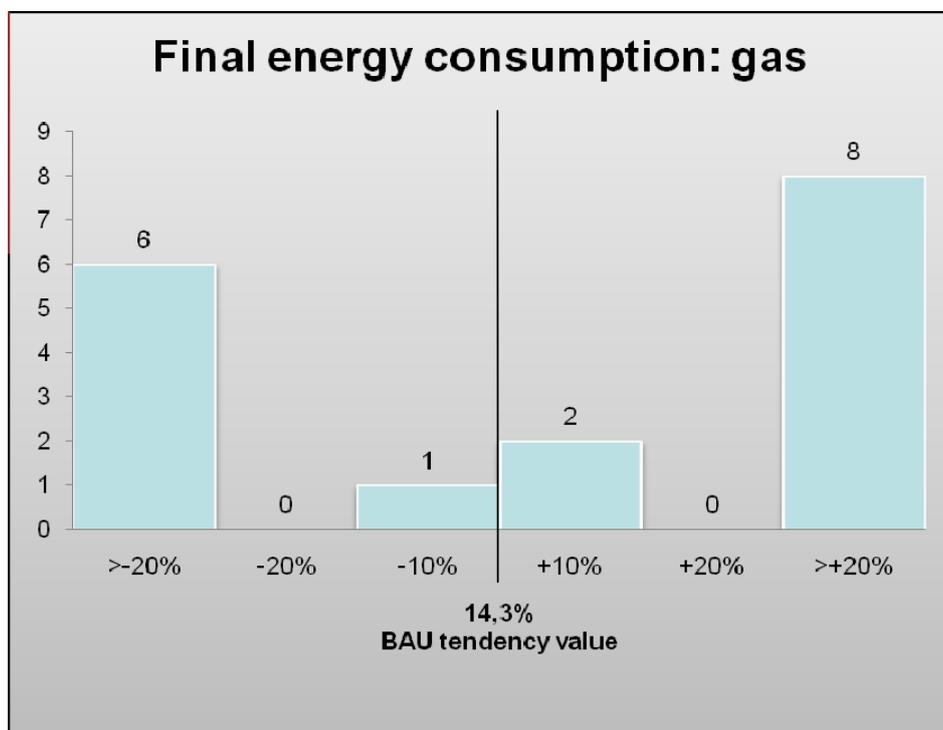
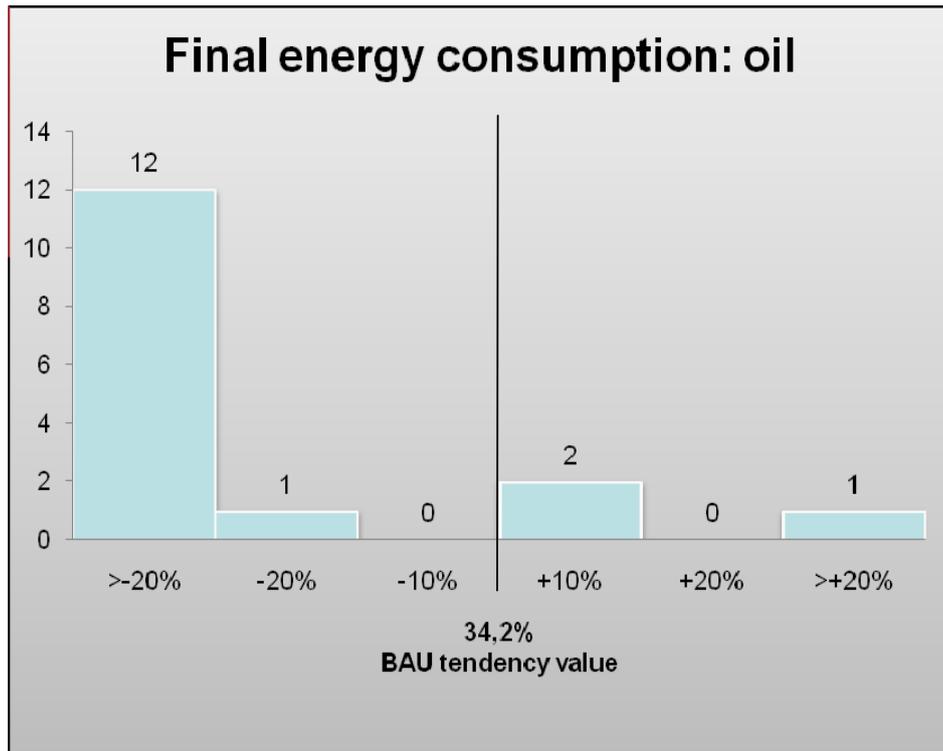


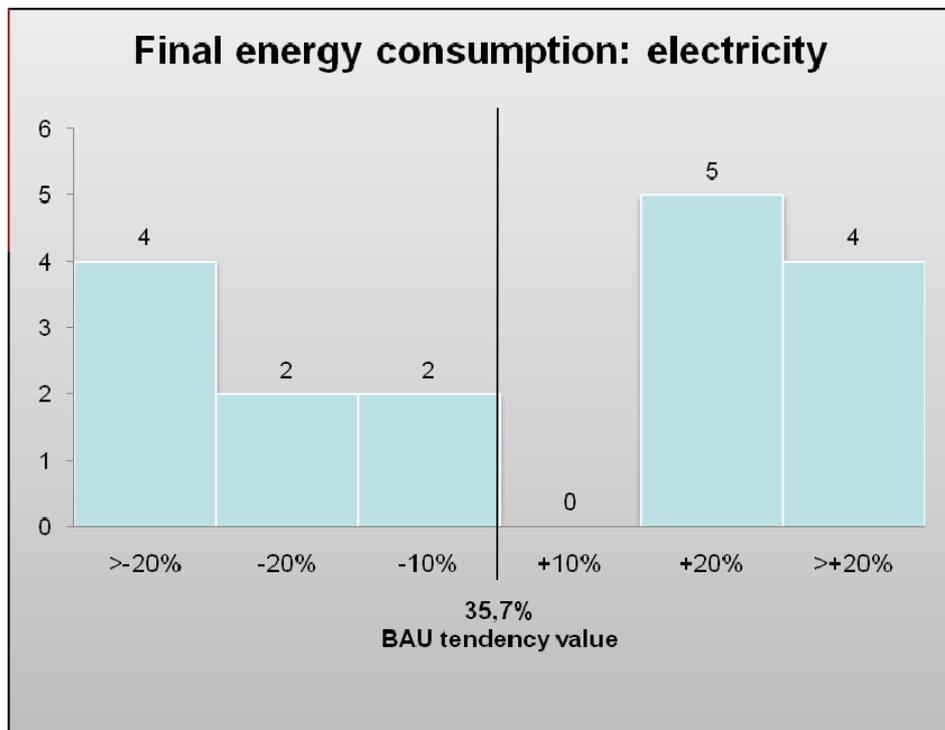
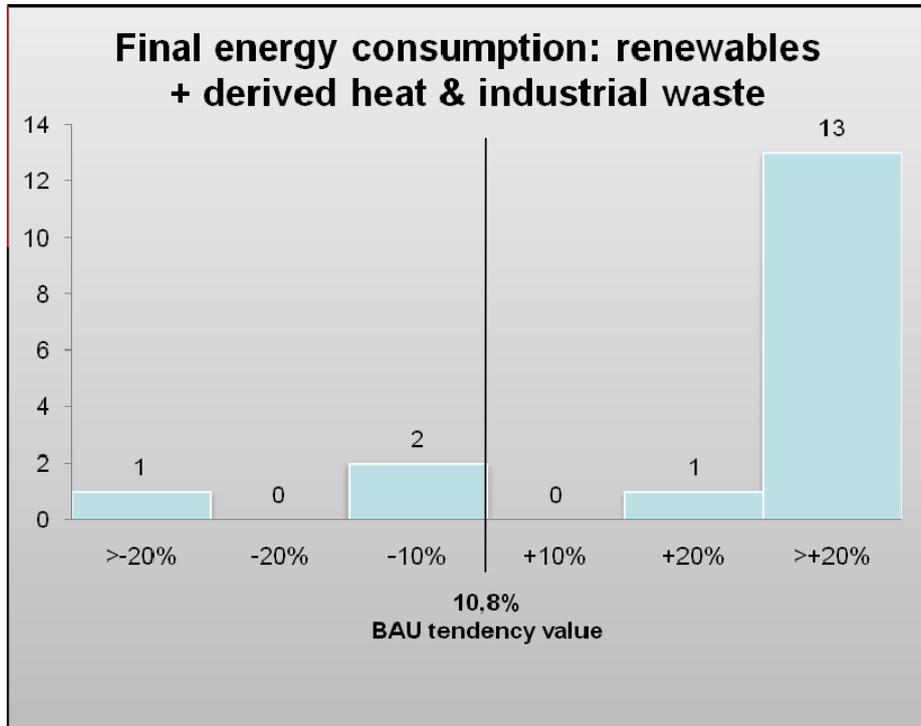
ENERGY

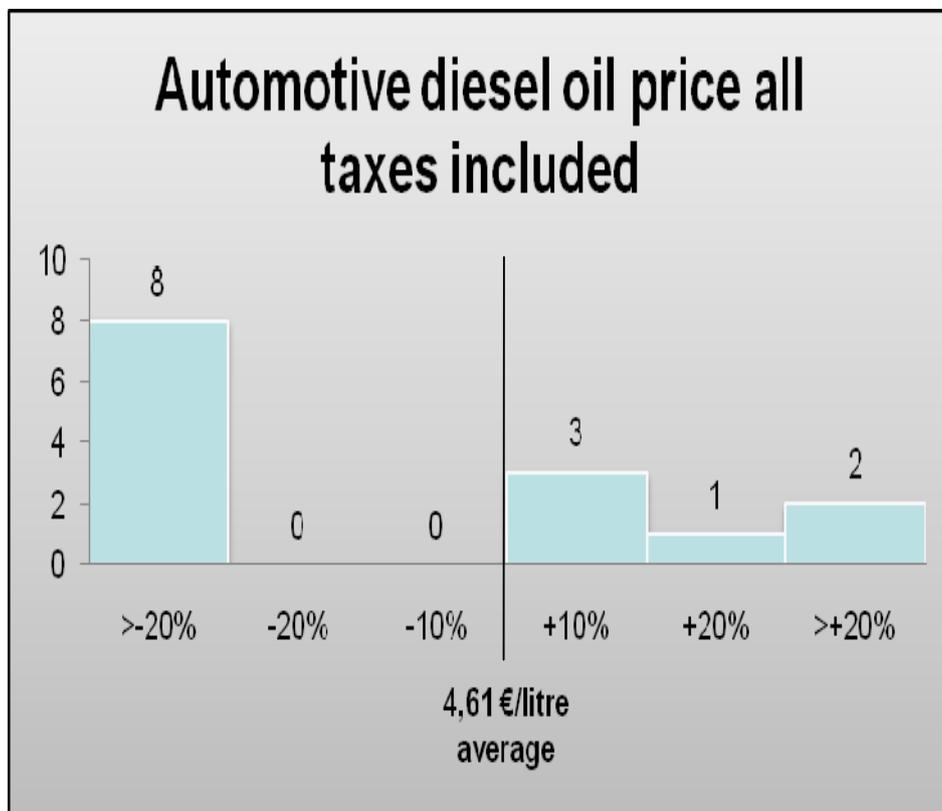
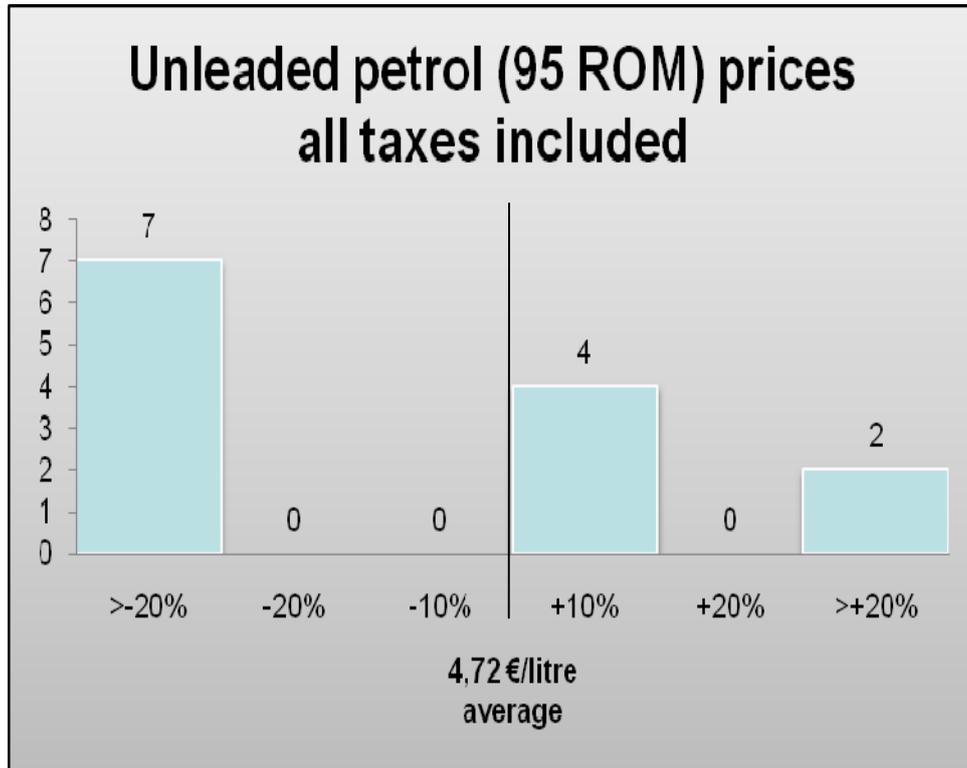


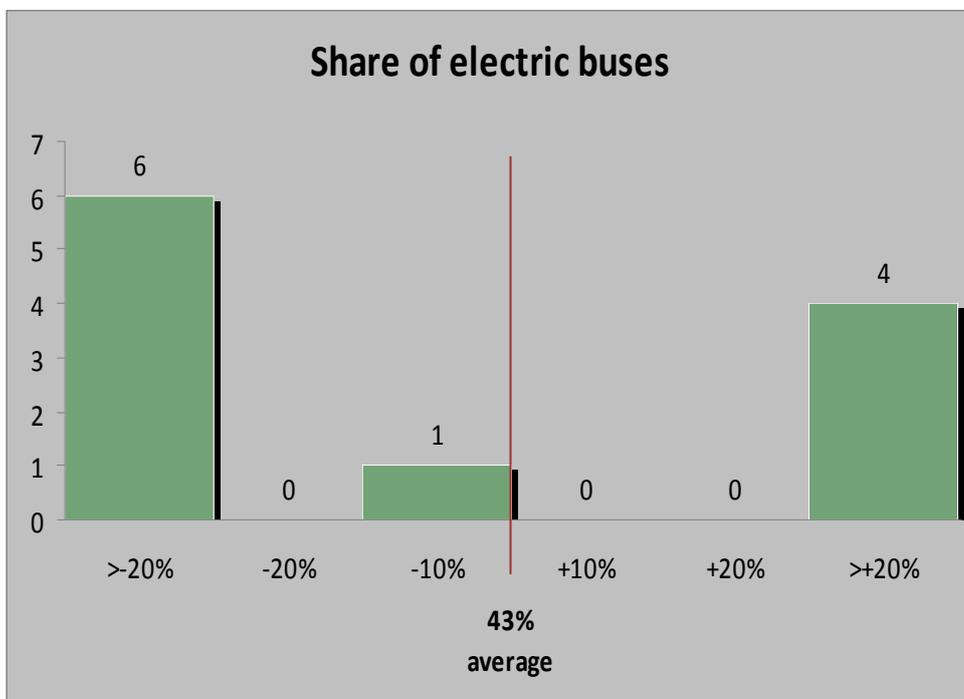
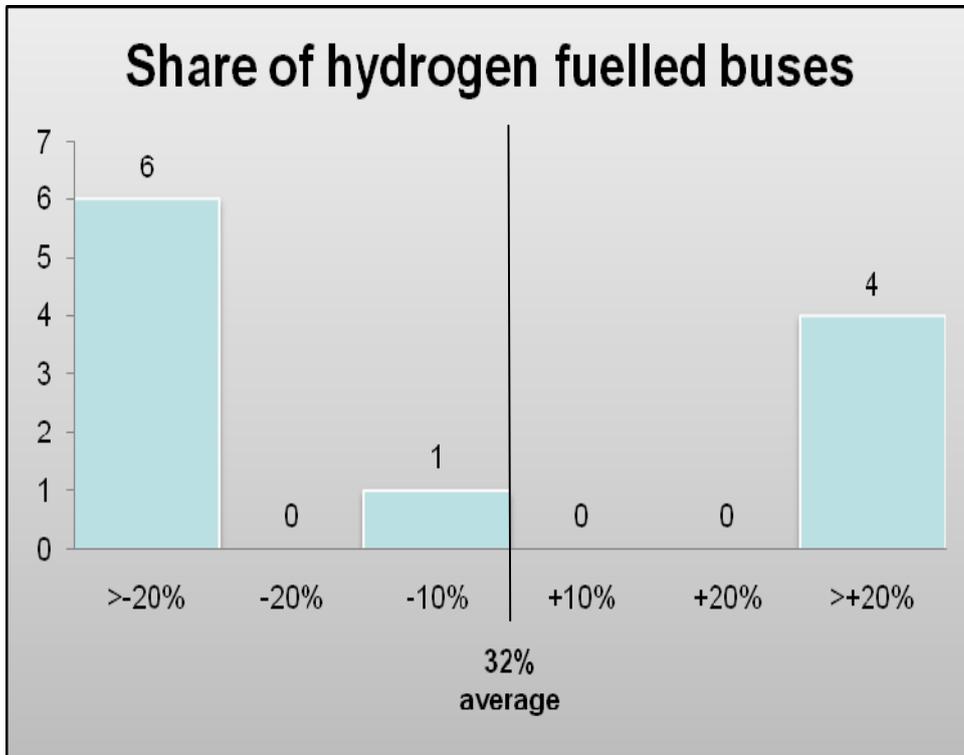


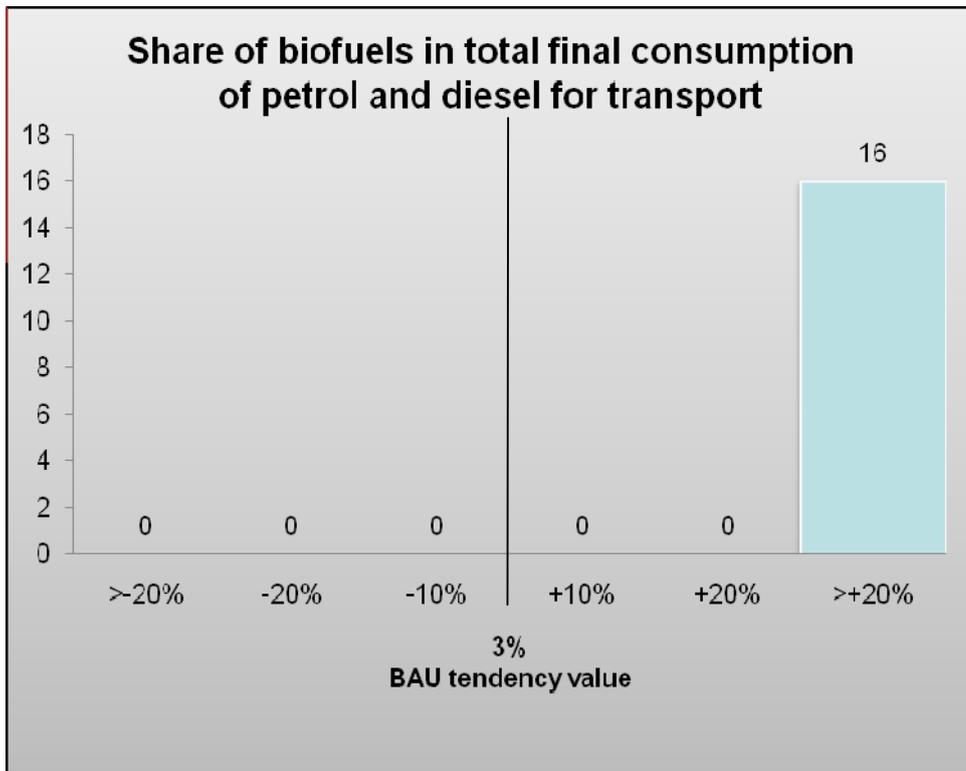




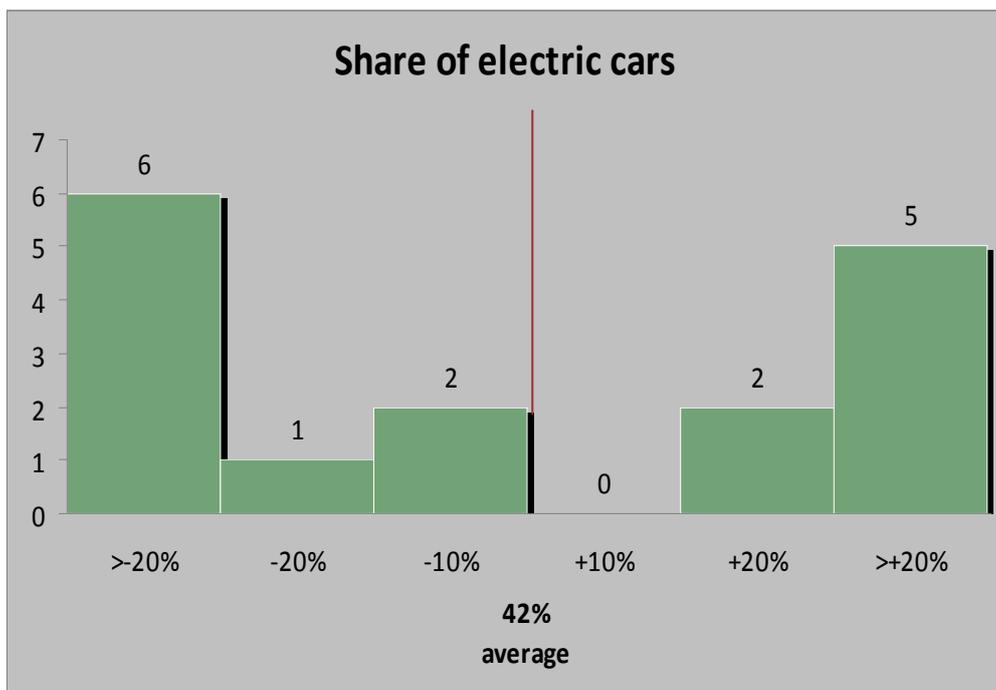


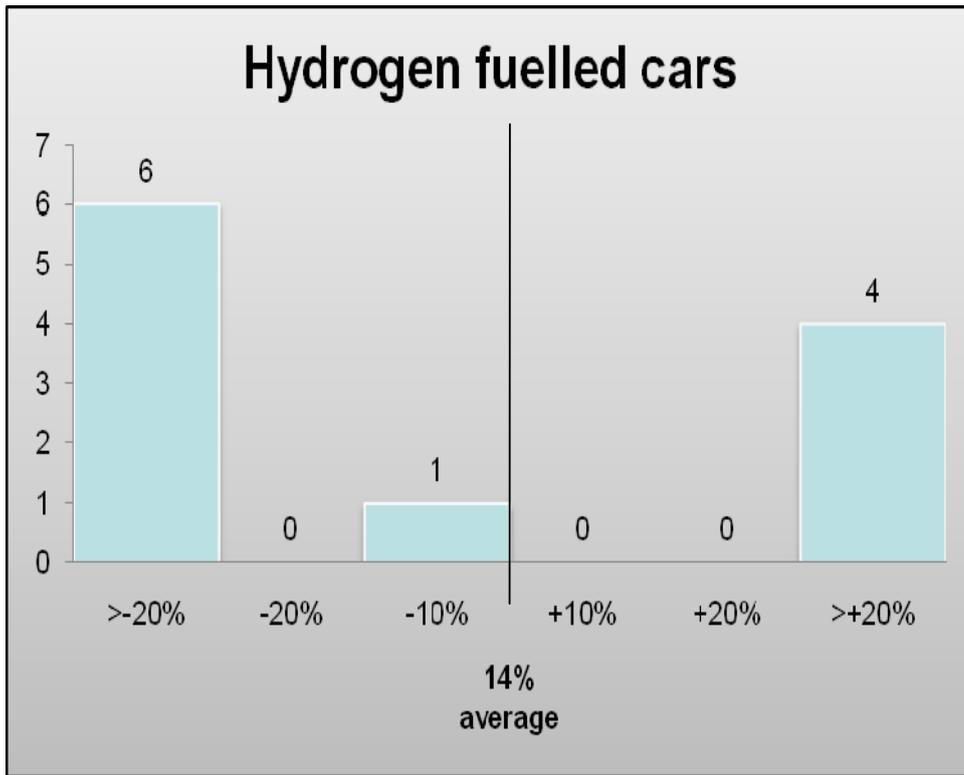




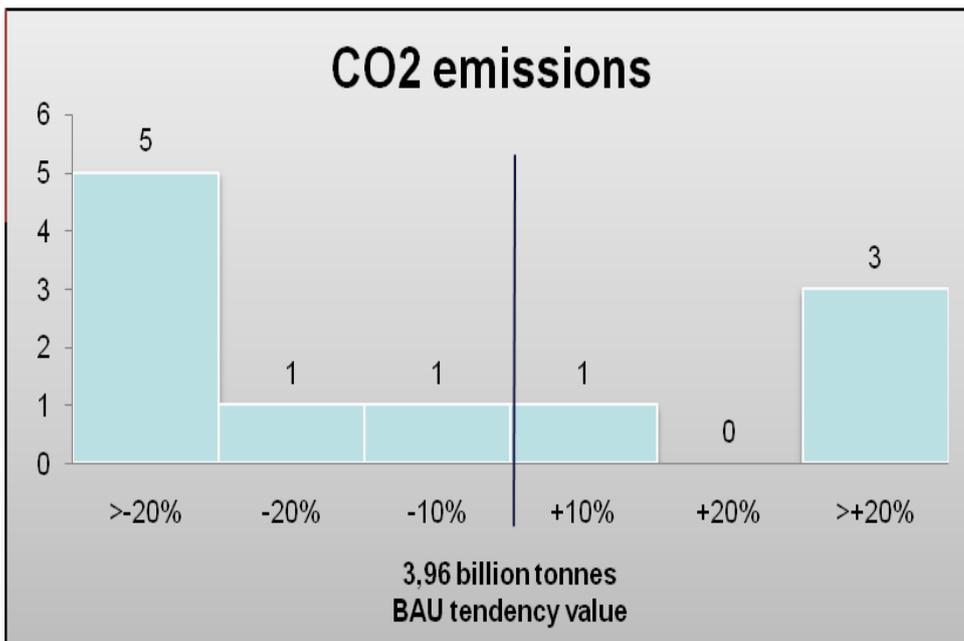


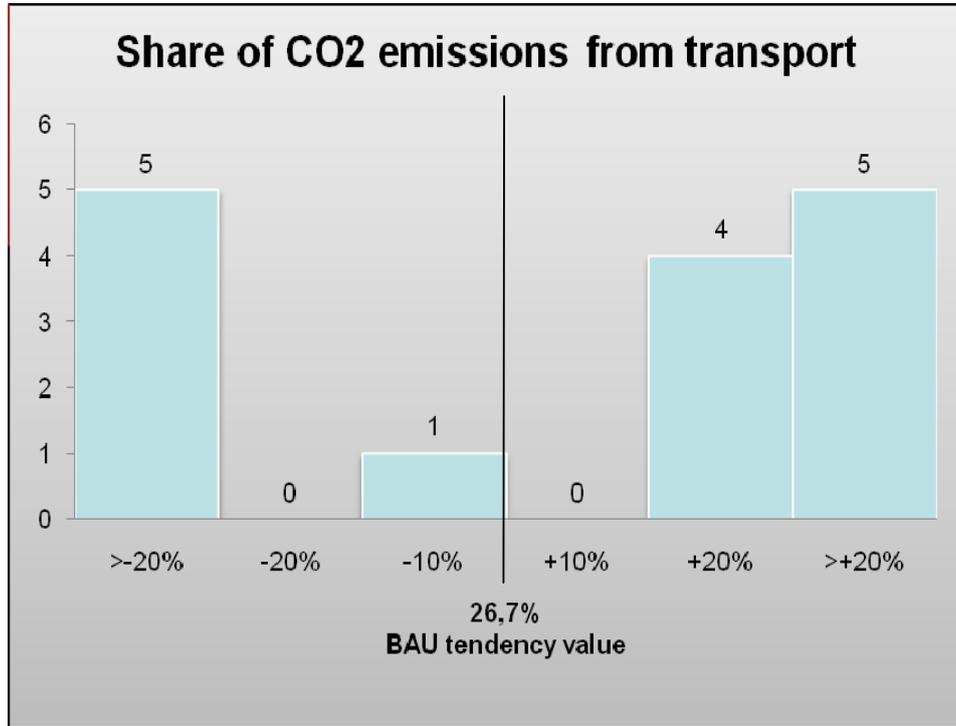
TECHNOLOGY





ENVIRONMENT





Annex IV: Literature Review

Time horizon: 2050

List of the studies and reports reviewed

Topic	Issuing Institution
1.1 International studies and data focusing on demographic and urbanisation changes	
World Population Prospects- The 2006 Revision	UNITED NATIONS
World Urbanization Prospects- The 2007 Revision	UNITED NATIONS
Long-term population projections at national level	EUROSTAT
1.2 International and EU studies focusing on macro-economic perspectives	
Globalisation: Trends, Issues and Macro Implications for the EU	Directorate-General for Economic and Financial Affairs
Long-term labour force projections for the 25 EU Member States: A set of data for assessing the economic impact of ageing	Directorate-General for Economic and Financial Affairs
The long-term sustainability of public finances in the European Union	Directorate-General for Economic and Financial Affairs
The impact of ageing on public expenditure: projections for the EU25 Member States on pensions, health care, long-term care, education and unemployment transfers (2004-2050)	Economic Policy Committee and the European Commission (DG ECFIN)
Pensions Schemes and Projection Models in EU-25 Member State	Economic Policy Committee and

Topic	Issuing Institution
	the European Commission (DG ECFIN)
1.3 International and EU policy outlooks	Directorate-General for Economic and Financial affair
Great Transition The Promise and Lure of the Times Ahead	Stockholm Environment Institute
Back casting approach for sustainable mobility 2008	Joint Research Centre
1.4 International and EU climate change and energy outlooks	
Climate Change 2007: Synthesis Report	IPCC
Very Long Term Energy-Environment Model	European Research Project EC/DG Research
World Energy Technology Outlook – WETO H2	EUROPEAN COMMISSION
Energy Technology Perspectives - Scenarios & Strategies to 2050	International Energy Agency (IEA)
1.5 Relevant foresight studies produced by EU Member States	
A sustainable energy system in 2050: promise or possibility?	ECN – Energy research Centre of the Netherlands
Foresight Intelligent Infrastructure Futures The Scenarios – Towards 2055	Department for Transport (UK), Office of Science and Technology
UK Air Passenger Demand and CO2 Forecasts	Department of Transport (UK)
Long range Transportation Plan – 2050 -	Conseil Général des Ponts et Chaussées
Four futures for Europe	CPB Centraal Planbureau
Perspectives énergétiques de la France à l’horizon 2020-2050	Centre d’Analyse

Topic	Issuing Institution
	Stratégique
1.6 Relevant foresight studies produced by business and other stakeholders	
Pathways to 2050: Energy and Climate Change	WBCSD
1.7 Relevant foresight studies produced by business and other stakeholders	
Shell energy scenarios to 2050	Shell International BV

International studies focusing on demographic and urbanization changes

Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	UNITED NATIONS Department of Economic and Social Affairs Population Division 2007
Title	World Population Prospects- The 2006 Revision
Main focus	Energy transition <input type="checkbox"/> Climate change <input type="checkbox"/> Technological change <input type="checkbox"/> Economic change <input type="checkbox"/> Social change <input checked="" type="checkbox"/> Policy change <input type="checkbox"/>

Summary

This report presents the highlights of the results of the 2006 Revision of the official world population estimates and projections prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat.

The underlying forces behind the varied patterns of population growth and changes in the age structure are distinct trends in **fertility and mortality**. Below-replacement fertility prevails in the more developed regions and is expected to continue to 2050. Mortality in the established market economies of the developed world is low and continues to decline, but it has been stagnant or even increasing in a number of countries with economies in transition, largely as a result of deteriorating social and economic conditions and, in some cases, because of the spread of HIV. **International migration assumptions** also influence the amount of resident population by geographical areas.

To project the population until 2050, the United Nations Population Division uses assumptions regarding future trends in fertility, mortality and international migration. Because future trends cannot be known with certainty, a number of projection variants are produced. The 2006 Revision includes eight projection variants and three AIDS scenarios. The eight variants are: low; medium; high; constant-fertility; instant-replacement-fertility; constant mortality; no change (constant-fertility and constant-mortality); and zero-migration. The first five variants, namely, the low, medium, high, constant-fertility and instant replacement-fertility, differ among themselves exclusively in the assumptions made regarding the future path of fertility. The sixth variant, named “constant-mortality”, differs from the medium variant only with regard to the path followed by future mortality. The seventh variant, denominated “no change”, has constant mortality and constant fertility and thus differs from the medium variant with respect to both fertility and mortality. The eighth variant, denominated “zero migration”, differs from the medium variant only with regard to the path followed by future international migration. Generally, variants differ from each other only over the period 2005- 2050. In addition to the five fertility variants, a constant-mortality variant, a zero-migration variant and a no change variant (constant-fertility and constant-

mortality) have been prepared. The following table summarises the assumptions behind the scenarios.

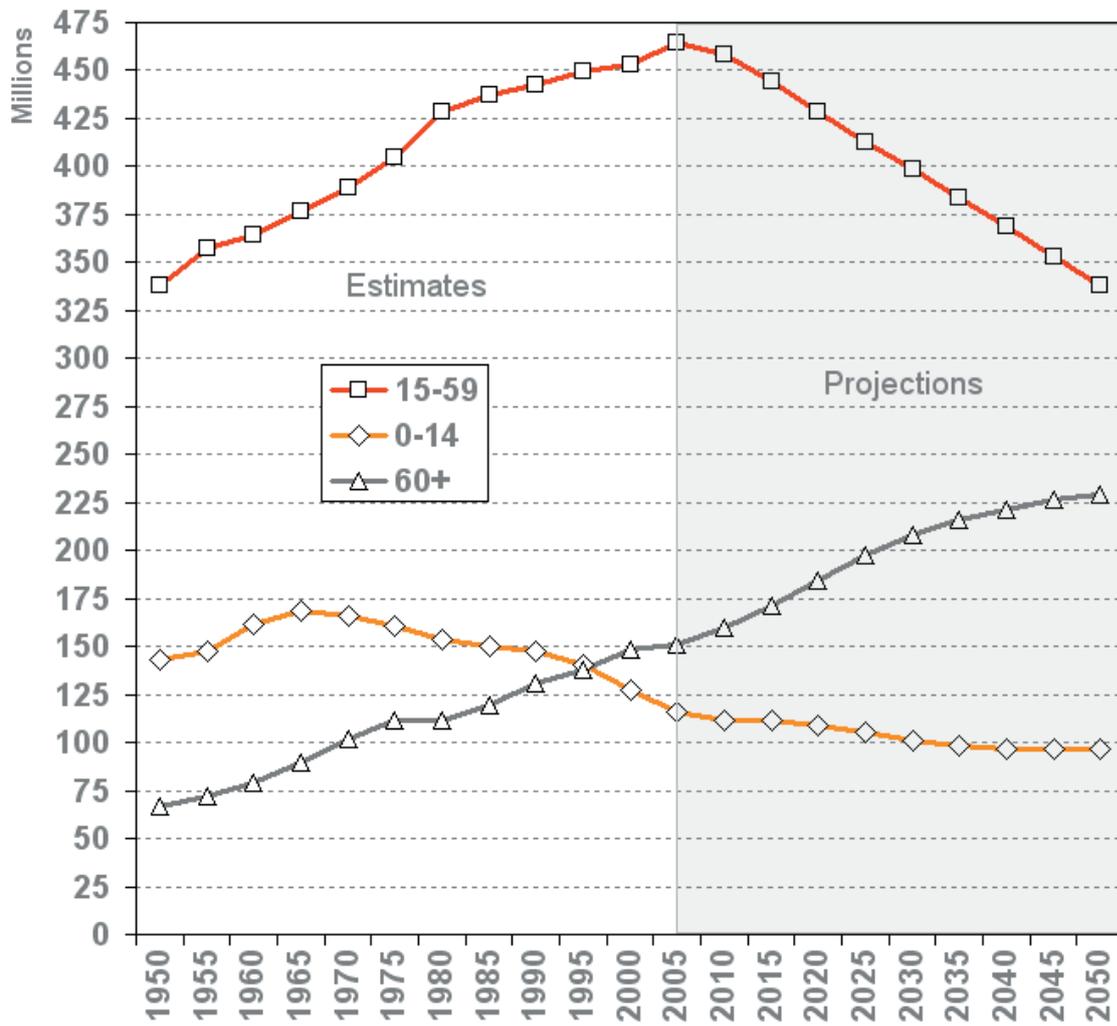
<i>Projection variant or scenario</i>	<i>Assumptions</i>		
	<i>Fertility</i>	<i>Mortality</i>	<i>International Migration</i>
Low fertility	Low	Normal*	Normal
Medium fertility	Medium	Normal*	Normal
High fertility	High	Normal*	Normal
Constant-fertility	Constant as of 2000-2005	Normal*	Normal
Instant-replacement-fertility	Instant-replacement	Normal*	Normal
Constant-mortality	Medium	Constant as of 2000-2005	Normal
No change	Constant as of 2000-2005	Constant as of 2000-2005	Normal
Zero-migration	Medium	Normal*	Zero
No-AIDS	Medium	No-AIDS since 1980	Normal
High-AIDS	Medium	High-AIDS as of 2005	Normal
AIDS-vaccine	Medium	AIDS-vaccine as of 2010	Normal

The impacts for Europe concerning **total population change by age groups according to the medium variant scenario between 2005 and 2050** are the following:

<i>Major area</i>	<i>0-14</i>	<i>15-59</i>	<i>60+</i>	<i>80+</i>	<i>Total population</i>
World.....	-0.03	0.65	2.43	3.38	0.76
More developed regions	-0.19	-0.36	1.13	2.16	0.05
Less developed regions.....	0.00	0.84	2.93	4.19	0.90
Least developed countries.....	0.96	2.14	3.39	3.97	1.82
Other less developed countries	-0.32	0.56	2.88	4.20	0.70
Africa.....	0.85	2.04	3.25	3.88	1.72
Asia.....	-0.34	0.48	2.74	4.04	0.65
Europe	-0.41	-0.70	0.93	2.02	-0.21
Latin America and the Caribbean	-0.41	0.59	2.92	3.91	0.71
Northern America	0.25	0.38	1.73	2.42	0.65
Oceania	0.17	0.68	2.08	2.97	0.84

The table shows that population ageing will be a trend particularly strong in Europe. In fact, the median age, that is, the age that divides the population in two halves of equal size, is an indicator of population ageing. At the world level, the median age is projected to increase from 28 to 38 years between 2005 and 2050. **Europe has today the oldest population, with a median age of nearly 39 years that is expected to reach 47 years in 2050.**

The following graph summarises the population ageing.



Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	UNITED NATIONS Department of Economic and Social Affairs Population Division 2008												
Title	World Urbanization Prospects- The 2007 Revision												
Main focus	<table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">Energy transition</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td style="text-align: right;"><input checked="" type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input checked="" type="checkbox"/>	Policy change	<input type="checkbox"/>
Energy transition	<input type="checkbox"/>												
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Technological change	<input type="checkbox"/>												
Economic change	<input type="checkbox"/>												
Social change	<input checked="" type="checkbox"/>												
Policy change	<input type="checkbox"/>												

Summary

The 2007 Revision presents estimates and projections of the **total, urban and rural populations of the world for the period 1950-2050**. The results are shown for development groups, six major areas (i.e., Africa, Asia, Europe, Latin America and the Caribbean, Northern America and Oceania) and 21 regions. Data are further disaggregated for the 229 countries or areas of the world. The 2007 Revision also provides estimates and projections of the population of urban agglomerations with 750,000 inhabitants or more in 2007 for the period 1950-2025. Estimates of the proportion of the population living in urban areas and the population of cities are derived on the basis of national statistics. The most common source of data on the proportion urban and the population of cities and urban agglomerations is the population census. For some countries, the basic data are obtained from population registers or administrative statistics. The 2007 Revision corroborates that the world population will reach a landmark in 2008: for the first time in history the urban population will equal the rural population of the world and, from then on, the world population will be urban in its majority. This event is a consequence of rapid urbanization in the last decades, especially in the less developed regions. Nevertheless, major parts of the world remain largely rural. In Africa and Asia, still six out of every ten persons live in rural areas.

The sustained increase of the urban population combined with the pronounced deceleration of rural population growth will result in continued urbanization, that is, in increasing proportions of the population living in urban areas. Globally, the level of urbanization is expected to rise from 50 per cent in 2008 to 70 per cent in 2050. More developed regions are expected to see their level of urbanization rise from 74 per cent to 86 per cent over the same period. In the less developed regions, the proportion urban will likely increase from 44 per cent in 2007 to 67 per cent in 2050.

In Europe, the following table shows the trends in the percentage of urban population and in the urbanization rate between 1950 and 2050

Major area	Percentage urban					Rate of urbanization (percentage)			
	1950	1975	2007	2025	2050	1950-1975	1975-2007	2007-2025	2025-2050
Africa	14.5	25.7	38.7	47.2	61.8	2.28	1.28	1.10	1.08
Asia	16.8	24.0	40.8	51.1	66.2	1.42	1.66	1.24	1.04
Europe	51.2	65.7	72.2	76.2	83.8	1.00	0.29	0.30	0.38
Latin America and the Caribbean	41.4	61.1	78.3	83.5	88.7	1.56	0.78	0.36	0.24
Northern America	63.9	73.8	81.3	85.7	90.2	0.58	0.30	0.29	0.20
Oceania	62.0	71.5	70.5	71.9	76.4	0.57	-0.05	0.11	0.24

In terms of population volume, the table below shows the decreasing growth rate of rural population in Europe, compared to the higher growth in the urban population.

Major area	Population (millions)					Average annual rate of change (percentage)			
	1950	1975	2007	2025	2050	1950-1975	1975-2007	2007-2025	2025-2050
Total population									
Africa.....	224	416	965	1394	1998	2.48	2.63	2.04	1.44
Asia.....	1411	2394	4030	4779	5266	2.12	1.63	0.95	0.39
Europe.....	548	676	731	715	664	0.84	0.24	-0.12	-0.30
Latin America and the Caribbean.....	168	325	572	688	769	2.65	1.77	1.02	0.45
Northern America.....	172	243	339	393	445	1.40	1.03	0.82	0.50
Oceania.....	13	21	34	41	49	2.03	1.49	1.05	0.65
Urban population									
Africa.....	33	107	373	658	1234	4.76	3.90	3.15	2.52
Asia.....	237	574	1645	2440	3486	3.54	3.29	2.19	1.43
Europe.....	281	444	528	545	557	1.84	0.54	0.18	0.08
Latin America and the Caribbean.....	69	198	448	575	683	4.21	2.55	1.38	0.69
Northern America.....	110	180	275	337	401	1.98	1.33	1.11	0.70
Oceania.....	8	15	24	30	37	2.60	1.44	1.17	0.89
Rural population									
Africa.....	192	309	592	736	764	1.92	2.03	1.21	0.15
Asia.....	1174	1820	2384	2339	1780	1.75	0.84	-0.11	-1.09
Europe.....	267	232	204	170	107	-0.57	-0.41	-1.00	-1.84
Latin America and the Caribbean.....	98	126	124	113	87	1.01	-0.06	-0.50	-1.08
Northern America.....	62	64	63	56	44	0.11	-0.02	-0.65	-1.00
Oceania.....	5	6	10	12	11	0.88	1.60	0.78	-0.04

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	EUROSTAT Statistics in focus 3/2006
Title	Long-term population projections at national level
Main focus	Energy transition <input type="checkbox"/> Climate change <input type="checkbox"/> Technological change <input type="checkbox"/> Economic change <input type="checkbox"/> Social change <input checked="" type="checkbox"/> Policy change <input type="checkbox"/>

Summary

The EUROSTAT population projections is just one among several scenarios of population evolution based on assumptions of fertility, mortality and migration. The current trend scenario does not take into account any future measures that could influence demographic trends. Next to the 'baseline' variant which is presented in this vision the trend scenario comprises other variants. All variants are available on the EUROSTAT website. It should be noted that the assumptions adopted by EUROSTAT may differ from those adopted by National Statistical Institutes (for example, assumptions about migration levels in Italy and Slovenia). Therefore, the results published by EUROSTAT can be different from those published by Member States.

The share of persons aged 65 and over was 17% of the total population in the EU25 in 2005, compared to 15% in 1995. The Member States with the highest proportions in 2005 were Germany and Italy (both 19%) and Greece (18%), while the lowest were Ireland (11%), Cyprus and Slovakia (both 12%).

Projections for 2050 indicate that, in the EU25, the number of persons aged 65 and over might rise from 75 million in 2005 to nearly 135 million in 2050 (1995: 66 million). Their share in the total population is projected to increase to around 30% at the EU25 level, with the highest shares in Spain (36%), Italy (35%), Germany, Greece and Portugal (all 32%) and the lowest in Luxembourg (22%), the Netherlands (23%), Denmark and Sweden (both 24%).

The following table shows the forecasts at European level, by country and geographical area (EU 25 and EU 15).

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	% of total population aged 65 and over			Expected healthy life years at 65, 2003*		Employment rates**, 2005, %	
	1995	2005	Projection 2050	Men	Women	60-64 years	65-69 years
EU25	15	17	30	:	:	26.7	8.2
EU15	15	17	30	10.1	10.7	27.8	8.1
Belgium	16	17	28	11.7	12.6	17.0	2.5
Czech Republic	13	14	31	9.5	10.0	22.3	7.9
Denmark	15	15	24	8.4	9.9	36.7	14.4
Germany	15	19	32	10.8	9.2	27.8	6.3
Estonia	13	16	26	:	:	43.9	(18.3)
Greece	15	18	32	9.9	10.5	30.8	9.4
Spain	15	17	36	11.3	12.5	31.8	4.4
France	15	16	27	8.2	8.9	13.0	3.0
Ireland	11	11	26	10.1	10.4	42.9	15.3
Italy	16	19	35	11.9	14.4	18.1	7.2
Cyprus	11	12	26	12.6	11.5	37.9	19.8
Latvia	13	17	26	:	:	31.9	18.7
Lithuania	12	15	27	:	:	36.9	(7.6)
Luxembourg	14	14	22	:	:	(12.6)	u
Hungary	14	16	28	6.1	7.2	15.0	3.6
Malta	11	13	25	9.9	10.3	(15.5)	u
Netherlands	13	14	23	9.2	9.5	25.0	10.3
Austria	15	16	30	10.2	12.2	13.7	5.2
Poland	11	13	29	9.2	11.4	18.3	10.2
Portugal	15	17	32	8.4	7.7	41.3	28.4
Slovenia	12	15	31	:	:	(15.5)	(11.1)
Slovakia	11	12	29	:	:	12.7	(2.4)
Finland	14	16	27	6.5	7.1	33.9	5.8
Sweden	17	17	24	8.9	10.4	56.8	14.6
United Kingdom	16	16	27	8.2	9.6	42.0	14.5

Based on past trends, an analysis of driving forces and expert opinion, EUROSTAT has produced internationally consistent population projections **from 1 January 2005 to 1 January 2051 by sex, year and age for each Member State plus Acceding Countries (Bulgaria and Romania).**

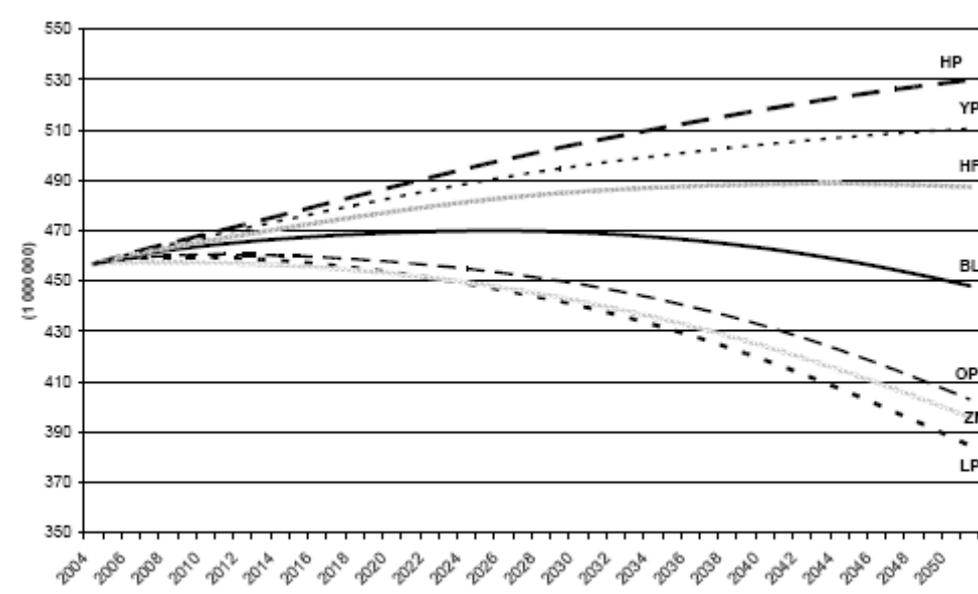
EUROSTAT's set of population projections is just one of several population change scenarios based on assumptions of fertility, mortality and migration. The current scenario, named Trend, does not take account of any future measures that might influence demographic trends and comprises seven variants: 'baseline' (BL), 'high population' (HP), 'low population' (LP), 'younger age profile population' (YP), 'older age profile population' (OP), 'high fertility' (HF) and 'zero migration' (ZM).

The combination of the different assumptions produces the variants shown in the table below. In the HP and LP variants, the assumptions all work together in the same direction for the growth or decrease of population; the other two variants (YP and OP) focus on the age structure of the population, while the HF and ZM variants highlight the impact of a specific component. No variant should be seen as a confidence limit in the statistical sense.

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		Total Fertility Rate	Life Expectancy	Net Migration
Baseline	BL	Base	Base	Base
High Population	HP	High	High	High
Low Population	LP	Low	Low	Low
Younger Age Profile Population	YP	High	Low	High
Older Age Profile Population	OP	Low	High	Low
High Fertility	HF	High	Base	Base
Zero Migration	ZM	Base	Base	Zero

Most of the variants show a decline in **EU population in the first half of the new century**. The starting year of the population decrease differs across variants: 2008 for the ‘zero migration’, 2009 for the ‘low population’, 2011 for the ‘older age profile population’, 2025 for the ‘baseline’ and 2043 for the ‘high fertility’ variants, while for ‘younger age population’ and ‘high population’ the population size never declines over the projections horizon.



The share of the population over the age of **65 will increase considerably in the European Union**. Indeed, the old age dependency ratio (persons aged 65 years and over compared with persons 15-64 years-old) is expected to approximately double in all the variants from the initial 25% in 2004. **Migration alone will not ensure EU population growth.**

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International and EU studies focusing on macro-economic perspectives**Visions for 2050 (abstracts)**

Issuing Project, Author(s)	Institution(s),	EUROPEAN COMMISSION Directorate-General for Economic and Financial Affairs Cécile Denis, Kieran Mc Morrow and Werner Röger, 2006
Title		Globalisation: Trends, Issues and Macro Implications for the EU
Main focus		Energy transition <input type="checkbox"/> Climate change <input type="checkbox"/> Technological change <input type="checkbox"/> Economic change <input checked="" type="checkbox"/> Social change <input type="checkbox"/> Policy change <input type="checkbox"/>

Summary

This vision estimates the impacts on the EU economy to 2050 arising from a set of channels; namely specialisation, economies of scale; technological spill-overs (i.e. diffusion of best technologies / practices) and finally the benefits of import competition in terms of consumer gains from reduced prices and increased varieties and the productivity gains from the reallocation of resources between firms. The ultimate target variable is productivity which in the long run is the key driver of **GDP per capita trends**. All the above impacts are caused by three developments taken together (i.e. trade and capital market integration, production relocation and global convergence trends), usually defined as globalisation. The quantification of impacts has been differentiated according to the following characteristics: a) static and dynamic effects of globalisation on the EU and the rest of the world; b) according to an optimistic and a pessimistic point of view concerning the long-term effects of globalization on the European standard of living. The static effects include shifts in comparative advantage / specialisation patterns of countries; gains in terms of economies of scale; and in the availability of new varieties of goods and services, while the dynamic effects go beyond the initial “first round” effects on consumers and firms, taking account of the benefits in terms of increased competition and from the dissemination of global technological advances. According to the optimistic view, productivity increases in the developing economies are welfare improving for EU citizens. The reason is that the goods and services produced in these countries (which are not perfect substitutes for goods and services produced in the EU) tend to be sold at a lower price in order for them to be absorbed by the world market. Thus domestic consumers and investors would benefit

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from increased productivity in the rest of the world (RoW). On the other hand, according to the more pessimistic view, productivity growth in the developing world will not simply be confined to the production of goods and services in which these countries were specialising in before the productivity take-off. Technological progress in the RoW will enable catching-up countries to increase the range of goods they produce and to enter markets which were previously dominated by industrialised countries. To the extent that increased supply is accompanied by increased demand for the goods supplied by the catching-up countries, the beneficial terms of trade and demand effects described in the optimistic view will be smaller and could even, under certain extreme circumstances, be reversed. The overview of simulation results is the following

	GDP per capita		Import shares		Export shares		Investment	
	2005	2050	2005	2050	2005	2050	2005	2050
Static effects of globalization								
Optimistic scenario	-0.3	1.6	4.8	14.7	0.0	-1.2	0.2	6.1
Pessimistic scenario	-1.1	-0.9	1.8	9.8	0.1	-2.0	-4.3	-1.6
Dynamic effects of globalization								
Optimistic scenario	1.8	8.0	3.4	10.5	0.0	-0.9	3.1	12.2
Pessimistic scenario	-1.6	-5.1	0.2	0.4	0.0	-0.1	-6.5	-10.7

All variables are expressed as % deviations from a baseline with a common technological trend, that it is assumed in the simulations to be equal to the average 1991-2003 growth rates. The results show that the pessimistic scenario (static effects) induces to losses of about **1% in GDP per capita** levels in 2050 (i.e. 0.02 off the annual average growth rate over the coming decades), while the optimistic scenario leads to permanent gains of 1.6% in levels (i.e. a gain of 0.03 in terms of growth rates). **Investments** at 2050 will be increased by 6.1% (optimistic scenario) and -1.6% (pessimistic scenario) compared to current trends at 2050 in the static assessment. The same values referred to the dynamic effects, will be +12.2% (optimistic) and -10.7% (pessimistic). Considering the dynamic effects, the pessimistic scenario shows a substantial negative impact on living standards in the EU, of the order of **5% in GDP per capita levels**, roughly 0.1 in annual growth rate terms. It is important to stress that the pessimistic scenario includes a series of **anti-globalization measures**, as an increase of 10% in tariff levels and trade barriers. On the other hand, the dynamic optimistic scenario leads to an 8% level effect translates into an **annual average gain in EU living standards of roughly 0.2 each year up to 2050**. In terms of **developments internal to the EU area**, the optimistic scenarios consider that the process of income and technological convergence is likely to continue over the coming decades. As

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indicated by many growth studies, a country's level of long run income per capita is strongly related to human capital. Amongst many of the emerging economies in central and Eastern Europe, human capital is available in relative abundance.

In conclusion, the simulations attempt to establish how the European economy will be affected, on a **no-policy-change basis**, by a continuation of current globalisation patterns both in static and dynamic terms. However, given the rise in protectionist sentiments in many developed economies, the globalisation model is used to look at the effects of an **anti-globalisation scenario which is characterised by increased trade tariffs and a reduction in capital mobility**.

As it concerns the **transport sector**, the variation in growth rates of the per capita GDP depending on the pessimistic or the optimistic globalization scenarios, will lead to corresponding **passenger and freight traffic growth rates**, given the continuation of the historic trends (1970-2003) concerning the relationships between GDP and traffic growth.

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	EUROPEAN COMMISSION Directorate-General for Economic and Financial Affairs Giuseppe Carone, 2005												
Title	Long-term labour force projections for the 25 EU Member States: A set of data for assessing the economic impact of ageing												
Main focus	<table style="width: 100%; border: none;"> <tr> <td>Energy transition</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td style="text-align: right;"><input checked="" type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input checked="" type="checkbox"/>	Policy change	<input type="checkbox"/>
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Social change	<input checked="" type="checkbox"/>												
Policy change	<input type="checkbox"/>												

Summary

The main objective of this vision is to provide estimates of labour force projections over the long term (until 2050) for each of the 25 EU Member States. The projections show the outcome for the labour force by extrapolating recent trends (1990-2004) in labour market behaviour (entry and exit rates from the labour market). These base case projections reflect the working assumption of “no policy change” and the authors warn that they are neither forecasts nor predictions in that they are not based on any assessment of more or less likely future changes in working patterns or economic conditions. However, the estimation of the long-term labour force participation involves a variety of factors (determinants), as outlined in the following bullet points:

- institutional factors, as the impacts of the recent pension reforms on participation rates of older workers, leading to an **expected postponement of the average retirement age in 2050 by 1.0 in EU25 (1.7 in the 10 New Member States)**

	Male		Female	
	2003	2050	2003	2050
EU25	61.9	62.9	61.1	61.9
EU15	62.1	63.0	61.6	62.1
Nms10	61.0	62.7	58.7	60.4
Eurozone	61.7	62.7	61.3	61.8

The pension reforms will also increase the participation rates of older people (aged 55-64) to labour market.

- demographic factors, including the decline of fertility rates and modifications of the age structure. The size and age structure of the EU25 population are projected to undergo dramatic changes in coming decades due to the dynamics of fertility, life expectancy and migration rates. The overall size of the

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population is projected to be both smaller and older than it is now. Under the baseline scenario, the **EU25 population is projected to increase slightly, by 3% until 2025, when it will peak at 470 million.** Thereafter, a steady decline occurs and, according to the projections, **the population in 2050 will be smaller than in 2004, at 449 millions.** **Reduction more important are projected in the 10 New Member States**

	Young (15-24)		Prime age (25-54)		Older (55-64)		Working age (15-64)		Total	
	2003/2025	2025/2050	2003/2025	2025/2050	2003/2025	2025/2050	2003/2025	2025/2050	2003/2025	2025/2050
EU25	-14.7	-10.5	-3.5	-13.8	35.9	-11.3	-2.5	-12.9	3.7	-3.7
EU15	-8.2	-10.4	-3.2	-12.0	37.5	-15.0	-0.8	-12.1	5.2	-3.0
Nms10	73.9	-12.3	-14.2	-13.5	36.4	-17.5	-1.6	-13.8	4.6	-4.0
Eurozone	-40.6	-10.8	-4.6	-23.5	26.3	12.9	-10.7	-17.7	-3.9	-8.1
% change										

The increased participation rate of the older people has only a limited impact on the aggregate participation rate. The shrinking of the young will also affected the old-age dependency ratio. **The old-age dependency ratio could increase to levels well above 50% in some southern European countries** largely on account of their very low fertility rates.

	Over 65 as % of 15-64 aged population	
	2003/2025	2025/2050
EU25	11.6	16.0
EU15	10.7	15.7
Nms10	11.1	17.2
Eurozone	13.3	17.7
% change		

- economic and social factors, as labour supply, employment projection and economic dependency ratios. Concerning labour supply, according to the baseline scenario projections, **the overall labour force (aged 15 to 64) in the EU25 is projected to increase by 7.5% from 2003 to 2015.** However, the positive trend, mainly due to increase in female labour supply, **is projected to reverse during the period 2015-2050** and, along with the drop in male labour supply, the overall EU25 labour force **is expected to decrease by as much as 14%.** In the medium run, most EU25 countries, except Denmark, Finland, the Czech Republic, Estonia, Hungary and Latvia, are projected to record an increase in labour supply. The negative impact of the demographic composition on the overall participation rate (the demographic effect is negative in all EU25 Member States), is clear; in particular for the 10 New Member States.

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	Peak year	Trough year	% change	% change
	Peak year	Trough year	From 2003 to peak	From peak to trough
EU25	2015	2050	7.5	-14.3
EU15	2017	2050	7.7	-12.5
Nms10	2016	2050	7.5	-25.0
Eurozone	2016	2050	8.0	-14.4

- under a no-policy change scenario, the unemployment rate assumptions and the labour force projection predict that **the overall employment rates (of people aged 15 to 64) in the EU25 are projected to increase from 63% in 2003 to 70% in 2025, and to stabilise at 70.7% in 2050.** The number of people employed (according to the European Labour Force Survey definition) is projected to record an **annual growth rate of 0.7% up to 2017, which will reverse to a negative annual growth rate of about -0.5% in the subsequent three decades (from 2018 to 2050).** As a result of these two opposite trends , the overall employment in the EU25 in 2050 is projected to be about 9 million below the level recorded in 2003 (- 600.000 women and -8.2 million of men). Rises in immigration levels in some countries and increases in labour force participation rates moderate the fall in employment owed to the ageing of the population and the negative population growth projected for the period 2025 to 2050.

	Peak year	Trough year	% change	% change
			from 2003 to peak	from peak to trough
EU25	2017	2050	0.7	-0.5
EU15	2017	2050	0.7	-0.4
Nms10	2015	2050	1.0	-0.7
Eurozone	2016	2050	0.8	-0.5

- Concerning the total economic dependency ratio, it is the ratio between total inactive population and employed person. Hence, it provides an indication of the average number of people that each economically active person supports, and thus is relevant when considering the prospects for **potential GDP per capita growth. The ratio is projected to decline in the first period of projection (up to 2025) in most EU 25 countries,** with the exception of Denmark, France, Netherlands, Finland and Sweden, while it is **projected to rise between 2025-2050** in all countries, with larger increases in Greece, Portugal and Italy.

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To summarise the outcome of projections, the baseline scenario indicates that, in the absence of major changes in the current policy and institutions setting (in a broader sense), **the pace of labour force and employment growth in the EU25 will be weakly positive over the next 15 years and will turn negative over the period 2018 to 2050.** For a given labour productivity growth rate, the negative effect of population ageing on labour supply is to slow economic growth.

The impacts on transport are manifold: a) slow economic growth in the long-term period may induce a reduction **in goods and passenger transport growth**; b) the same can be said considering lower population growth rates, c) on the other hand the increase in the share of the elderly, higher life expectancy, will most likely lead to an increase in **leisure and social travel**; d) potential public budget constraints may come from the public budget impacts of ageing, detrimental to the available resources for **infrastructure provision**.

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Visions for 2050 (abstracts)

Issuing Project, Author(s)	Institution(s),	EUROPEAN ECONOMY N°4/2006 Directorate-General for Economic and Financial Affairs Klaus Regling, 2006
Title	The long-term sustainability of public finances in the European Union	
Main focus	Energy transition	<input type="checkbox"/>
	Climate change	<input type="checkbox"/>
	Technological change	<input type="checkbox"/>
	Economic change	<input checked="" type="checkbox"/>
	Social change	<input checked="" type="checkbox"/>
	Policy change	<input type="checkbox"/>

Summary

This vision concerns the assessment of the budgetary implications of demographic change and the sustainability of public finances across Member States to 2050 and in a longer perspective. The central concept for the overall assessment is the calculation of sustainability gap indicators that measure the size of a required permanent budgetary adjustment (e.g. a constant reduction of non-age-related public expenditure as a share of GDP or a constant increase in public revenue as a share of GDP) that enables one of the following conditions to be met : (i) reaching a target of 60 % of GDP for the Maastricht debt in 2050 (the S1 indicator); and (ii) fulfilling the inter temporal budget constraint over an infinite horizon (the S2 indicator). Hence, the sustainability indicators provide a firm basis to identify the size and the main source of risks to public finance sustainability in the EU Member States. The sustainability assessment means that. the current public debt and the discounted value of future expenditure including the budgetary impact of ageing populations, should be covered by the discounted value of future government revenue. The visions to 2050 have been provided:

- a) under the current policies (the baseline scenario)
- b) under the fulfilment of the medium-term objective (MTO), as required by the Stability and Growth Pact, i.e. namely: (i) providing a safety margin with respect to the 3 % deficit limit; (ii) ensuring rapid progress towards sustainability; and, taking the first two objectives into account, (iii) allowing room for budgetary manoeuvre, in particular taking into account the needs for public investment. Country-specific MTOs in the current phase were set by the Member States themselves, taking into account: (i) the current government debt ratio (in 2004); (ii) potential economic growth (average 2005–50); and (iii) a measure of safety margin with respect to the reference value of 3 % of GDP.

Sensitivity analysis has also been carried out trying to address the main uncertainties behind the visions; as a) life expectancy trends, b) labour productivity growth; c) higher employment; d) higher interest rates and alternative scenarios in healthcare expenditures.

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In order to understand the meaning of the indicators, it should be considered that a positive value suggests that current policies are not sustainable while a negative value indicates that current policies are sustainable.

	Change in age- related expenditure GDP	Sustainability Indicator S1 % GDP
BE	6.6	0.4
CZ	7.7	2.5
DK	4.5	-4.2
DE	4.0	3.5
EE	1.2	-4.4
EL (2)	1.4	3.2
ES	8.9	0.2
FR	3.2	3.2
IE	7.8	-0.8
IT	2.3	3.4
CY	11.7	4.0
LV	1.6	-0.6
LT	2.1	0.3
LU	8.4	4.6
HU	7.1	7.9
MT	-0.6	0.4
NL	5.2	-0.2
AT	1.1	0.1
PL	-3.2	-0.4
PT	9.7	7.9
SI	9.9	3.9
SK	3.7	1.3
FI	5.0	-3.3
SE	2.4	-2.7
UK	4.2	3.4
EUR- 12	4.4	2.3
EU-25	4.1	2.1

(2) Possible underestimation of age-related expenditure for Greece

The change in age-related expenditure indicator reflects the large differences of the budgetary impact of ageing on public finances and notably the large differences between countries with regard to the change in pension expenditure to 2050 — **ranging from a reduction in Estonia, Malta and Poland to an increase of more than 10 % of GDP in Cyprus.**

The sustainability indicator implies that, based on the current budgetary position and with no changes in policies, an adjustment is necessary so as to render the public finances sustainable over the long term for most Member States. **In about half of the**

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Member States, a considerable adjustment, of more than 2 % of GDP, is required (2.3% in EU 12).

Another way to look at the prospects for long-term public finance sustainability is to project the debt/GDP ratio over the long term, to 2050. On the basis of current policies, 11 countries will have a debt/GDP ratio above the 60 % of GDP reference value by 2030 and by 2050; another seven countries will have been added to the list of high-debt countries, implying that more than two thirds of the Member States will be breaching the 60 % threshold. **In particular, the EU 12 countries are projected at 2050 with a debt development of 196% of GDP.**

The sensitivity analysis (medium-term objective scenario, MTO) has been carried out in case the member States reach by 2010 the MTO objectives. The table below shows that the sustainability gaps for the EU and the euro area can thus be reduced, in fact more than halved, if Member States reach their MTOs.

	Sustainability	
	Indicator	S1 %
	GDP	
BE	1.3	
CZ	2.2	
DK	0.7	
DE	0.1	
EE	-2.6	
EL (2)	-1.9	
ES	2.2	
FR	0.0	
IE	1.7	
IT	-1.0	
CY	2.3	
LV	0.6	
LT	0.3	
LU	3.9	
HU	1.7	
MT	-2.5	
NL	2.2	
AT	-0.7	
PL	-4.0	
PT	2.5	
SI	3.8	
SK	0.1	
FI	-0.7	
SE	-1.9	
UK	1.0	
EUR-		
12	0.3	
EU-25	0.2	

(2) Possible underestimation of age-related expenditure for Greece

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Impacts on the transport sector will be channelled through a) the **reduction of available resources for investment** in transport infrastructure, and b) **slow economic growth** in the long-term period in case of failure in the fulfilment of the medium-term objective, implying a reduction in goods and passenger transport growth.

Visions for 2050 (abstracts)

Issuing Project, Author(s)	Institution(s),	EUROPEAN ECONOMY N°1/2006 Economic Policy Committee and the European Commission (DG ECFIN)
Title	The impact of ageing on public expenditure: projections for the EU25 Member States on pensions, health care, long-term care, education and unemployment transfers (2004-2050)	
Main focus	Energy transition <input type="checkbox"/> Climate change <input type="checkbox"/> Technological change <input type="checkbox"/> Economic change <input checked="" type="checkbox"/> Social change <input checked="" type="checkbox"/> Policy change <input type="checkbox"/>	

Summary

The vision estimates the impacts on the economic (the potential GDP growth rates), budgetary (public age-related expenditure projections) and social (population ageing) impacts due to low fertility rates, continuous increases in life expectancy and the retirement of baby-boom generation. The projections are generally - and for the reference scenario in particular - made on the basis of “no policy change”, i.e. only reflecting enacted legislation but not possible future policy changes.

Europe’s population will be slightly smaller, and significantly older, in 2050. Fertility rates in all countries are projected to remain well below the natural replacement rate. Life expectancy at birth, having risen by some 8 years since 1960, is projected to rise by a further 6 years in the next five decades.. **The total population of the EU25 will register a small fall from 457 to 454 million between 2004 and 2050.** Of greater economic significance are the dramatic changes in the age structure of the population. **Starting already from 2010, the working age population (15 to 64) is projected to fall by 48 million (or 16%) by 2050. In contrast, the elderly population aged 65+ will rise sharply, by 58 million (or 77%) by 2050.** The old-age dependency ratio, that is the number of people aged 65 years and above relative to those between 15 and 64, is projected to double, reaching 51% in 2050. Inward migration flows will only partially offset these trends. In fact, the net inflows cumulate to close to 40 million people between 2004 and 2050, in particular at the EU 15 level.

Europe will go from having four people of working age for every elderly citizen currently to a ratio of two to one by 2050.

The impacts in terms of age-related expenditures are diversified in the EU25. For EU15 Member States, public pension spending is projected to increase in all countries, except

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Austria, on account of its reforms since 2000. Very small increases in spending on pensions are projected in Italy and Sweden due to their notional contribution-defined schemes where pension benefits are based on effective working-life contributions. Relatively moderate increases (between 1.5 and 3.5 percentage points of GDP) are projected in most other EU countries, with the largest increases projected for Ireland (6.4 p.p.), Spain (7.1 p.p.).

Concerning the EU 10 Member States, between 2004 and 2030, public pension expenditure is projected to decrease by 1 p.p. of GDP and thereafter to increase by 1.3 p.p., resulting in an overall increase of 0.3 p.p. of GDP on average between 2004 and 2050. However, the trends are very diverse across countries, ranging from a decrease of 5.9 p.p. of GDP in Poland and to an increase of 6.7 p.p. in Hungary, 7.3 p.p. in Slovenia and 12.9 p.p. in Cyprus. The projected decreases in Poland, Estonia and Latvia, as well as small projected increases in Lithuania and Slovakia, stem partly from pension reforms enacted during the last 10 years which involve a partial switch of the public old-age pension scheme into private funded schemes. Thus, the public provision of pensions will decrease over time while the private part will increase. The challenges faced by Cyprus, Slovenia, Hungary and the Czech Republic are among the biggest in the EU. While Slovenia and the Czech Republic have undertaken parametric reforms in their pension system during the 1990s, the systems remain fully pay-as-you-go public pension schemes. The total number of persons employed is projected to increase up to 2017, but after 2017, the demographic effects of an ageing population outweigh this effect. **After increasing by some 20 million between 2004 and 2017, employment will contract by almost 30 million by 2050**, i.e. a fall of nearly 10 million over the entire projection period. As a result of these employment trends and the agreed assumptions on productivity, **potential GDP growth is projected to decline in the decades to come. For the EU15, the annual average potential GDP growth rate will fall from 2.2% in the period 2004-2010 to 1.8 % in the period 2011-2030 and to 1.3% between 2031 and 2050. An even steeper decline is foreseen in the EU10, from 4.3% in the period 2004-10 to 3% in the period 2011-30 and to 0.9% between 2031 and 2050.** This is not only due to unfavourable demographic developments, but also to the underlying assumptions for these countries which assume productivity growth rates coming closer to those of EU15 countries as they complete the convergence process.

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	European Economy Occasional papers The Economic Policy Committee and Directorate-General for Economic and Financial affair November 2007												
Title	Pensions Schemes and Projection Models in EU- 25 Member State												
Main focus	<table> <tr> <td>Energy transition</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input checked="" type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

The background of this report lies in the work of the Ageing Working Group of the Economic Policy Committee, mandated by the ECFIN Council, that produced a new set of projections for age-related expenditure for the period 2004-2050, covering pensions, health care, long-term care, education and unemployment transfers, already reviewed in the present literature review (see the related abstract).

The purpose of the this report is to make the projections better understandable through country-specific descriptions of the pension systems and the models used for the projection exercise. Thus, the study aims at increasing the transparency in the exercise where one part was done by the Commission and another part by Member States.

An overview of the current type, presence of statutory private schemes, average retirement age and mechanisms of funding has been carried out at EU 25 level.

Concerning the **prevailing characteristics of the pensions schemes**, i.e. the type of benefit provided by public earnings-related schemes, the report stresses that most Member States provide defined-benefit pensions. This means that pension rights are defined in terms of earnings and service years, without a direct link to contributions and their real or notional accumulated capital. Only four Member States, namely Italy, Latvia, Poland and Sweden, apply a notional defined-contribution principle, according to which the notional accumulation of contributions (i.e. pension capital) is converted into an annuity at the time of retirement.

Concerning the presence of **statutory private funding schemes**, a part of the social security pension scheme has been switched to statutory private schemes in a number of countries. These arrangements are relatively recent innovations and, thus, they are not

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yet very apparent regarding the volume of pensions paid out but increase in importance over time. Such statutory shifts to private funded schemes are in place in Estonia, Latvia, Lithuania, Hungary, Poland, Slovakia and Sweden. Moreover, occupational pension schemes based on large-scale agreements between social partners are important in Denmark, the Netherlands, Ireland, Sweden and the United Kingdom.

In most countries, **early retirement** is arranged within the normal old-age pension scheme, while Ireland, Cyprus (for private sector employees), Malta and the United Kingdom do not have early retirement provisions and Denmark and the Netherlands have separated early retirement schemes. In addition, several countries provide more than one pathway to early retirement. In Belgium, Germany and Finland still in 2005, prolonged unemployment benefits or pensions provided an early exit from the labour market along the pension schemes. However, these arrangements are to be abolished in Finland and Germany within some years, while the eligibility conditions are tightened in Belgium. Possibilities to defer retirement beyond the normal retirement age exist in almost all countries. Only Ireland, Cyprus and Luxembourg do not have such provisions.

Concerning the **financing of public pensions**, In most Member States, there are specific pension contributions in place in order to earmark the financing of public pension schemes. Only in Denmark, public pensions are fully financed by general tax revenues.

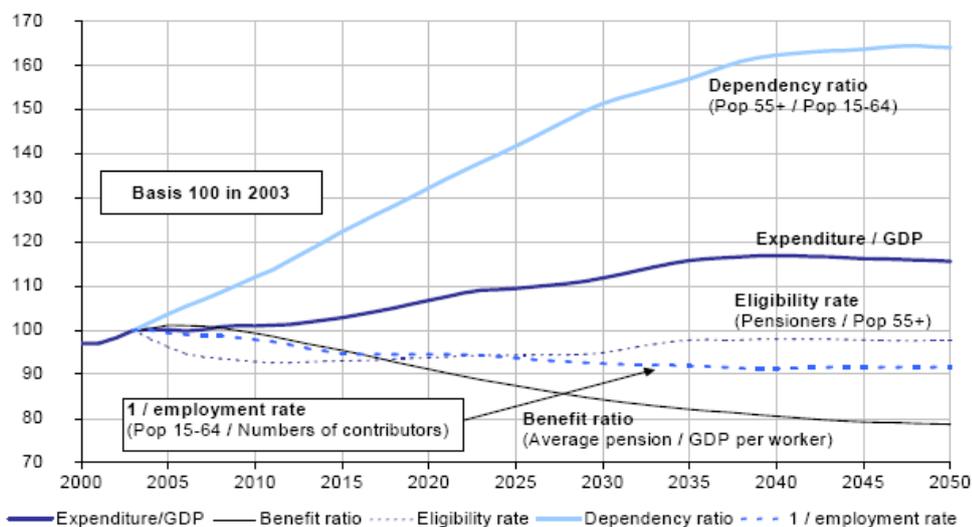
The results of the projections in terms of impacts on the financial balances are presented for all the Member States. The example below is related to France, showing trends similar to the European average.

(in points of GDP)	2000	2005	2010	2015	2020	2030	2040	2050
Contributions	12.6	12.8	12.9	12.9	12.9	12.9	12.9	12.9
Expenditures	12.4	12.8	12.9	13.2	13.7	14.3	15.0	14.8
Balance	0.2	0.0	0.0	-0.3	-0.8	-1.5	-2.1	-1.9

The table shows that **the global financial balance of the pension schemes** remains roughly constant until 2013. Between 2005 and 2013, the pension schemes deficit is around 0.1 of a point of GDP. After that, the balance decreases strongly towards -1.9 points of GDP in 2050.

In terms of ratio **pension expenditure/GDP**, the graph below summarises the main trends and the causing factors behind them.

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International and EU policy outlooks

Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	Stockholm Environment Institute - Boston Tellus Institute Paul Raskin, Tariq Banuri, Gilberto Gallopin, Pablo Gutman, Al Hammond, Robert Kates, Rob Swart 2002												
Title	Great Transition The Promise and Lure of the Times Ahead												
Main focus	<table border="0"> <tr> <td>Energy transition</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input checked="" type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input checked="" type="checkbox"/>
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Policy change	<input checked="" type="checkbox"/>												

Summary

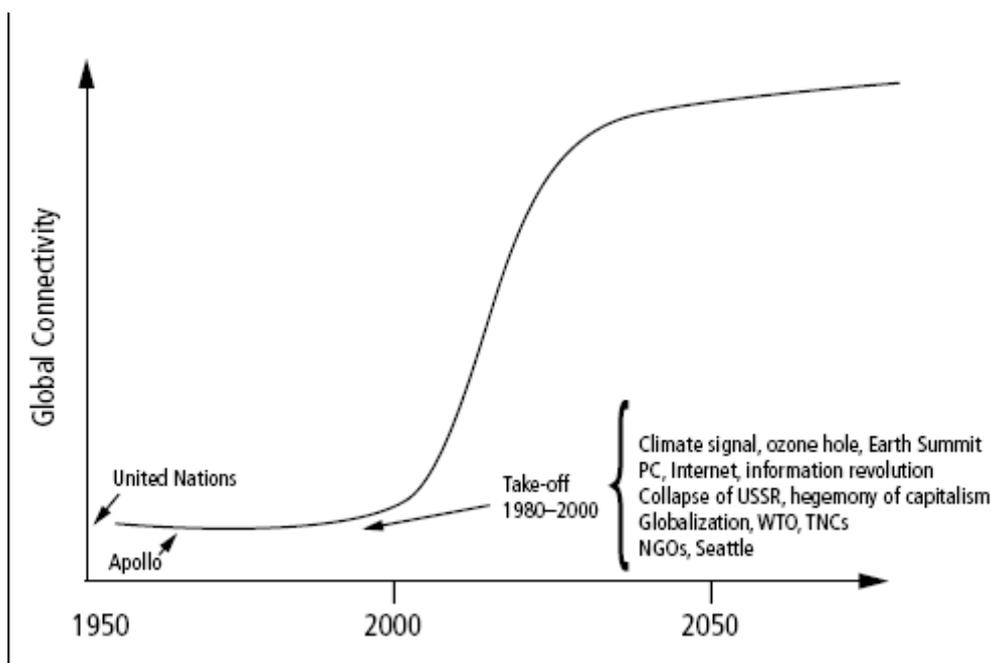
The visions elaborated in the report shape long-term future possible scenarios depending on how environmental and social conflicts are resolved. Four major agents of change have been identified. Three of them are global actors—intergovernmental organizations, trans national corporations and civil society acting through non-governmental organizations and spiritual communities. The fourth is the critical underlying element—wide public awareness of the need for change and the spread of values that underscore quality of life, human solidarity and environmental sustainability.

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The background of the analysis, i.e. the evolution of human development in historical ages, is the following:

	Stone Age	Early Civilization	Modern Era	Planetary Phase
Organization	Tribe/village	City-state, kingdom	Nation-state	Global governance
Economy	Hunting and gathering	Settled agriculture	Industrial system	Globalization
Communications	Language	Writing	Printing	Internet

The Planetary phase, i.e. the phase in which we are, can be outlined as follows:



The figure shows the global connectivity, loosely defined, characterised by the emerging global environment, economic integration, new global actors, etc, following the characteristic S-shaped curve of transition, with “take off” over the last two decades. The schematic suggests that we are in the early phase of an accelerating transition. In this turbulent period, the character of the global system that will emerge from the transition cannot be predicted. The ultimate shape of things to come depends to a great extent on human choices yet to be made and actions yet to be taken.

Three classes of scenarios are considered: — **Conventional Worlds, Barbarization and Great Transitions.** These scenarios are distinguished by, respectively, essential

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continuity, fundamental but undesirable social change, and fundamental and positive social transformation. The scenarios are distinguished by distinct responses to the social and environmental challenges. **Market Forces** relies on the self-correcting logic of competitive markets. **Policy Reform** depends on government action to seek a sustainable future. In **Fortress World** it falls to the armed forces to impose order, protect the environment and prevent a collapse into Breakdown. **Great Transitions** envision a sustainable and desirable future emerging from new values, a revised model of development and the active engagement of civil society.

The distinct paths of the scenarios depends on how the uncertainties of planetary transition are resolved. The figure below illustrates the main uncertainties. **Market Forces** are defined by counteracting tendencies. Technological innovation steadily reduces the environmental impact per unit of human activity, but the increase in the scale of human activity drives impacts higher. Economies in poor regions grow rapidly, but so do disparities between and within countries. The result is a continued erosion of environmental health and the persistence of poverty. **Policy Reform** “bends the curve” through the rapid deployment of alternative technology—eco-efficient industrial and agricultural practices, highly resource efficient equipment and renewable resources—and targeted programs to reduce poverty. **Fortress World** is a dualistic world of modern enclaves of affluence for the few, and underdeveloped areas of destitution for the many. **Great Transition** includes the rapid penetration of environmentally benign technologies, as does **Policy Reform**, but at a more rapid pace. A second major feature also supports environmental sustainability— the shift toward less materially-intensive lifestyles. Resource requirements decrease as consumerism abates, populations stabilize, growth slows in affluent areas, and settlement patterns become more integrated and compact. At the same time, poverty levels drop, as equity between and within countries rapidly improves.

The analysis suggests that the momentum toward an unsustainable future can be reversed, but only with great difficulty. The Great Transition in fact assumes fundamental shifts in desired lifestyles, values and technology.

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	European Commission Joint Research Centre Institute for Environment and Sustainability												
Title	Back casting approach for sustainable mobility 2008												
Main focus	<table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">Energy transition</td> <td style="text-align: right;">X</td> </tr> <tr> <td>Climate change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td style="text-align: right;">X</td> </tr> <tr> <td>Economic change</td> <td style="text-align: right;">X</td> </tr> <tr> <td>Social change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td style="text-align: right;">X</td> </tr> </table>	Energy transition	X	Climate change	<input type="checkbox"/>	Technological change	X	Economic change	X	Social change	<input type="checkbox"/>	Policy change	X
Energy transition	X												
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Summary

This vision applies through a literature review a back casting approach finalized to achieve a sustainable mobility toward a relevant cutting of CO2 emissions from EU transport sector by 2050. Following the OECD EST guidelines (OECD, 2002a) the main steps of this exercise will consist of:

- Definition of a long term vision of a desirable transport future that is sustainable for the environment (in our analysis abatement of CO2 emissions) and that provides benefits of access and mobility;
- Assessment of long term-trends considering all aspects of transport activity;
- Identification of packages of measures and instruments for reaching the targets.

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Following this approach, the main transport drivers have been analysed to identify their main trends to 2050 and to define the space of efficient transport policy measures. Finally, the back casting scenarios to 2050 are developed and policy strategies are designed.

The main drivers of transport demand considered are : **Demographic trends; Economic trends (i.e. GDP and sectorial production trends; World oil prices, the tourism sector); Technology progress**, for which the main trends at 2030 have been identified.

Demographic trends is one of the factors that influences transport demand in terms of its composition by person types, with considerable variation in trip making and trip distances between persons by age, sex, economic position, car availability and income.

The main trends of passenger and freight transport highlight the positive relationship between transport, on one hand, and economic activity, employment and welfare on the other. That emphasizes the “derived nature” of travel demand that implies **that increase in economic growth leads to greater demand for transport services.**

Concerning oil prices, transport is the one sector of the economy **where substitution with other fuels has been negligible.** Consumer responses to changes in fuel prices are often measured through elasticity. According with OECD **the price elasticity of fuel demand is fairly low**, meaning that prices have no big impact on demand.

According to OECD estimations, **tourism contributes up to 5.3% of global anthropogenic greenhouse gas emissions**, with transport accounting for 90% of this. **Travel for tourism purpose is expected to grow significantly to 2030 with international tourism growing by over 4% per year** accompanied by increasing environmental pressures. The OECD has recently explored the relationship between tourism and transport. Most tourism travel is made by car. However, tourism travel is driven by the growth in availability of inexpensive air transport.

Concerning the fuel option to 2050, the IPCC in the 4th Assessment Report on climate change policies has estimated a potential for bio fuels from agricultural crops and wastes to **replace 5% to 10% of road transport fuel by 2030** being competitive with oil.

On the technological side, the promising options are the following: **light weight material**, whereby OECD estimate that a weight reduction is technically possible, but only 5 to 10 % may be practical by 2015 and 11-16% by 2025 at reasonable costs. **Technologies to reduce the energy requirements of on board equipment such as air conditioners.** For these technologies has been estimated a maximum potentiality of conventional technology of 3 to 5 % by 2025. **Improvements in internal combustion engine technologies**, including engine technology potential in the short term (by 2015) with regard to 2-steo valve lift; continuous valve lift; Gasoline direct Injection, Friction reduction. Cam-less valve actuation are estimated very promising in term of technology potential in mid term (by 2030).

The Baseline Scenarios to 2050 assumes as reference the Baseline Reference Scenario performed by European Commission to estimate Energy and transport trends to 2030. This Baseline Reference scenario presents a projection on how it would be like in 2030 if currently existing policies were maintained and target achieved (namely, the legislation in place up to 2006 and implemented in the Member States or likely to be implemented before 2010. In 2030, it has been estimated 4267.7 Mt of CO2 emissions in EU-27 with a contribution of 30% from transport sector and the

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higher annual percentage change. The volume of **transportation of passengers** is projected to **increase at a rate of 1.4% per years between 2005 and 2030** while the volume of **freight transport is projected to increase by 1.7% per year during the same period**. At the same time it is estimated a **gradual decoupling** of transportation activity from GDP growth. **Road transport continue dominating passenger and freight transport** even if the share of road transportation of passengers is projected to decline (**79.7% of total activity in 2030 down from 84% in 2005**) and road freight transport activity is projected to increase (+1.8% pa in 2005-2030).

On the basis of the **above scenario to 2030, the Baseline Reference Scenario to 2050 has been estimated**. The table below shows the estimated CO₂ emissions projections by end users in the EU 27 to 2050.

End user Category	1990	2000	2010	2020	2030	2050
Road transport	695	825	905	980	1002	1018
Rail	29	29	27	27	21	20
Domestic Aviation	86	134	179	206	237	244
Inland navigation	21	16	16	17	17	17
Total	810	988	1110	1213	1260	1299

Two images of future have been elaborated to achieve the target of reduction CO₂ emissions from transport by 50% by 2050 in EU-27: the **technological and the behavioural vision**.

The underlying assumptions are the following:

	Technological vision	Behavioral vision
Population change	9%	9%
Economic growth (GDP)	3.5%	2%
World oil Price	160\$ a barrel	200\$ a barrel

The **technological vision** is based on the assumption of a full development of technologies which exist today and are likely to become commercially available in the years to achieve the CO₂ reduction target. The full penetration of new fuel options and more efficient energy technology are supported by the assumption of high GDP growth in presence of high oil price. **No assumption on decreasing travel demand and on change in transport users behaviour** (car ownership, shift to public transport, et cetera) have been done. The combination of technological solutions to

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reach the target by 2050 and their contribution is the most important driver to reach the target.

The **behavioural scenario corresponds to increasing importance of values such as community and social welfare and environmental quality**. It supports a radical change in travel user's behavior. Complementary assumptions are low GDP growth and very high oil prices increase. These hypotheses imply change in **travel demand which decreases with respect to Baselines Reference Scenario**. This decrease of travel demand is based on the assumption that the long-term elasticity to fuel prices is twice as large as short term elasticity. Land use policies are the most important policy measures in order to reach the target.

International and EU climate change and energy outlooks

Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	An Assessment of the Intergovernmental Panel on Climate Change IPCC Plenary XXVII Lenny Bernstein, Peter Bosch, Osvaldo Canziani, Zhenlin Chen, Renate Christ, Ogunlade Davidson, William Hare, Saleemul, Huq, David Karoly, Vladimir Kattsov, Zbigniew Kundzewicz, Jian Liu, Ulrike Lohmann, Martin Manning, Taroh Matsuno, Bettina Menne, Bert Metz, Monirul Mirza, Neville Nicholls, Leonard Nurse, Rajendra Pachauri, Jean Palutikof, Martin, Parry, Dahe Qin, Nijavalli Ravindranath, Andy Reisinger, Jiawen Ren, Keywan Riahi, Cynthia Rosenzweig, Matilde Rusticucci, Stephen Schneider, Youba Sokona, Susan Solomon, Peter Stott, Ronald Stouffer, Taishi Sugiyama, Rob Swart, Dennis Tirpak, Coleen Vogel, Gary Yohe
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	November 2007	
Title	Climate Change 2007: Synthesis Report	
Main focus	Energy transition	X
	Climate change	X
	Technological change	X
	Economic change	X
	Social change	<input type="checkbox"/>
	Policy change	<input type="checkbox"/>

Summary

This report is based on the assessment carried out by the three Working Groups (WGs) of the Intergovernmental Panel on Climate Change (IPCC). It provides an integrated view of climate change as the final part of the IPCC's Fourth Assessment Report (AR4). The topics are the following: Topic 1 summarises observed changes in climate and their effects on natural and human systems, regardless of their causes. Topic 2 assesses the causes of the observed changes. Topic 3 presents projections of future climate change and related impacts under different scenarios, while Topic 4 discusses adaptation and mitigation options over the next few decades and their interactions with sustainable development. Topic 5 assesses the relationship between adaptation and mitigation on a more conceptual basis and takes a longer-term perspective. Topic 6 summarises the major robust findings and remaining key uncertainties in this assessment.

The topics that are of particular interest in TRANSVISIONS are the third (future climate change) and the fourth (adaptation strategy with particular reference to transport).

Concerning the emissions scenarios, there is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.

The scenarios, in absence of additional climate policies, are the following:

The SRES scenarios are grouped into **four scenario families (A1, A2, B1 and B2)** that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. The main characteristics of the scenarios are the following:

The A1 storyline and scenario family describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into four groups that describe alternative directions of technological change in the energy system.

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), non-fossil energy resources (A1T) and a balance across all sources (A1B).

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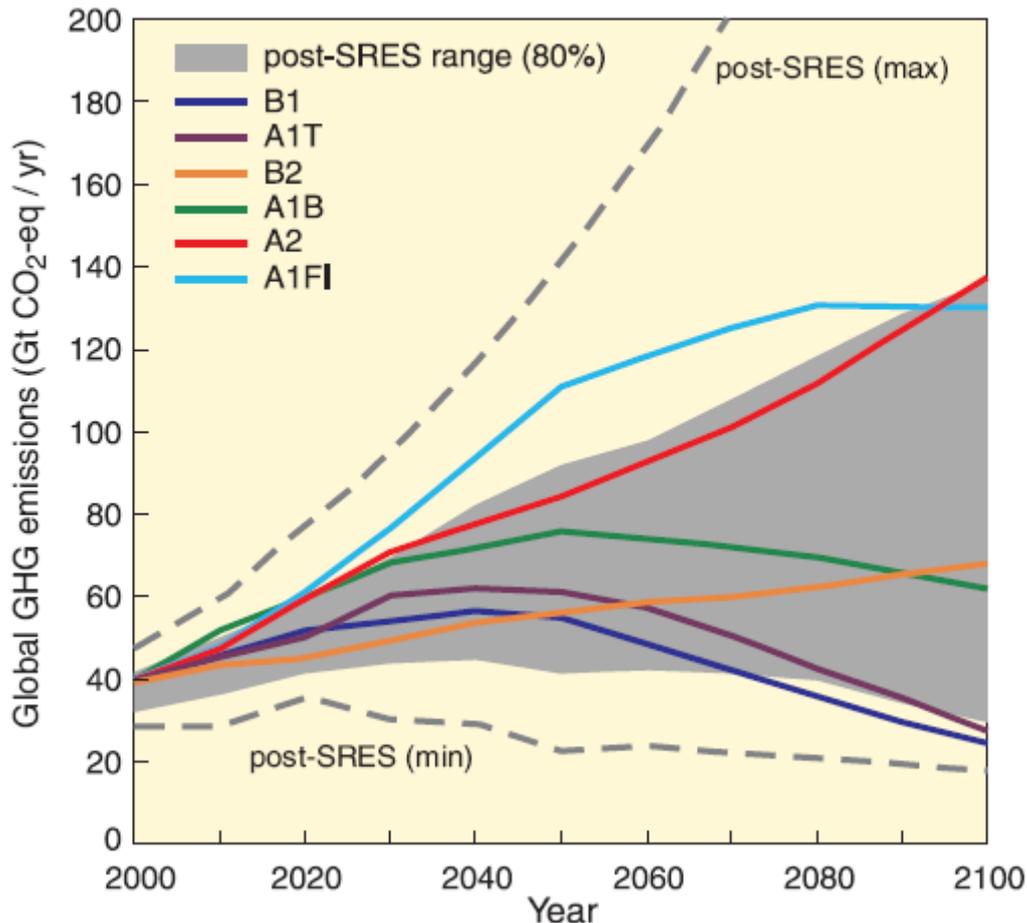
The B1 storyline and scenario family describes a convergent world with the same low population growth as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

The graph below shows the Global GHG emissions (in GtCO₂-eq per year) in the absence of additional climate policies according to the scenarios above described. The emissions include CO₂, CH₄, N₂O and F-gases. It can be derived that for the next two decades a warming of about 0.2°C per decade is projected for a range of emissions scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Afterwards, temperature projections increasingly depend on specific emissions scenarios.

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Scenarios for GHG emissions from 2000 to 2100 in the absence of additional climate policies



Concerning the examples of key sectoral mitigation technologies, policies and measures, with reference to the transport sector the following actions have been suggested:

- More fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning; second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.

From the policy side, the following measures have been recommended:

- Taxes on vehicle purchase, registration, use and motor fuels; road and parking pricing. Influence mobility needs through land-use regulations and infrastructure planning; investment in attractive public transport facilities and non-motorised forms of transport

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	European Research Project EC/DG Research Contract ENG1-CT 2002-00645 ENERDATA, ECN, Max-Planck-Institut, Univesiteit Utrecth, STE Juelich, Verbundplan 2005	
Title	Very Long Term Energy-Environment Model	
Main focus	Energy transition	X
	Climate change	X
	Technological change	X
	Economic change	<input type="checkbox"/>
	Social change	<input type="checkbox"/>
	Policy change	<input type="checkbox"/>

Summary

The 21th century will have to face tremendous challenges related to the climate change, the depletion of fossil fuel resources and the management of nuclear wastes. The development of the technologies necessary to face these challenges and the long reinvestment cycles especially for buildings, power generation and energy intensive manufacturing, require to consider all these issues over the whole century, in the broad context of sustainability. The VLEEM project has been designed to address these challenges, combining two methodological innovations which are imposed by the very long time-frame:

- an innovative approach of the very long term future, particularly suitable for RTD strategies elaboration in the context of sustainability: the back-casting approach;
- a re-foundation of the energy-environment modelling structures, in order to properly assess very long term modification of social and cultural preferences and technology evolution dynamics in relation to them.

In order to build up the long term visions (2050-2100) at world level in energy demand the fundamental driver of the social and economic context considered in VLEEM is **the demography**: population, age pyramids, urbanization, household structure, etc...Fertility, which drives the demography is indeed a matter of woman emancipation, which goes along with economic development, human rights and democracy. All visions built in VLEEM up to 2100 consider this movement towards woman emancipation as a key component of any future social development in which it make sense to investigate sustainable energy systems over the very long term. This movement can be faster or slower depending on the world region and the scenarios, but it is considered unavoidable. One of the consequence of this basic assumption is that, sooner or later, the world population will peak and then stabilize or even decrease.

Three "visions" have been elaborated accordingly.

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1. HiPop with high demography in 2100 with near 12 billion people, corresponds to a very slow demographic transition process towards a low fertility rate in developing countries where religious and cultural determinism remain very strong and change only very slowly: south Asia, conservative Muslim countries, sub-Saharan Africa. It corresponds also to a relative success of nativity policies in the industrialised countries where the demographic transition is now completed.

2. MidPop as middle storyline with a stabilization of the world population around 8 billion people (UN projection for 2050), which means that the demographic transition will be completed in most parts of the world by 2050, and that governments succeed in convincing educated women to get slightly more than two children in their life. This scenario also means that the transition to universal education and democracy has also been achieved everywhere, and that collective values, inspired by regional value systems, are stronger than the development of individualism.

3. LowPop storyline with little growth, same or less population than today (+/- 6 billion). The demographic transition will be completed by 2050, with a peak population around 8 billions at that time. After that, the trend towards a decreasing fertility rate continues in developing countries, and nativity policies, if any, fail to convince women to get more children almost everywhere. This scenario means that individual values take the lead over collective values.

Each of these scenarios involve the following set of key drivers, whose direction is conditioned by the different population trends, e.g.:

- Life styles and social links, with a growing need for extensive health services and facilities in the HighPop scenario
- Economic development, constrained in the LowPop scenario by population ageing
- Migration pattern, with pressures to migrate in the HighPop scenario
- Technological development, pushed up by high demand for tailor made product in the HighPop scenario

The impacts on transport arising from the above scenarios are the following:

Passenger mobility: In the Mid-Pop scenario, the model simulates a convergence of the mobility around the world in a range 12 000-20 000 km/cap per year because of the average speed increase. North America remains apart of the other regions with a very high mobility pattern: 29 000 km/cap per year. Household equipment in private vehicles is assumed to come soon to saturation in the industrialised countries of today, and to reach saturation before the turn of the century in most developing countries of today, because of the growth in affluence. The share of private vehicles in persons mobility is calculated to **decrease in industrialised** countries of today, down to **41% in the USA and 69% in Europe (75% in 2000)**. In the developing world of today, it is calculated to increase first (up to 85% in Latine America in 2100, 69% in 2000 for example) and, for some more advanced regions to start decreasing before the turn of the century.

Freight mobility. In the Mid-Pop scenario, there is a clear distinction among three groups of regions:

- A first group corresponding to regions with only one country of a very big size (USA, CIS, China), where the geographical dimension drives the freight mobility to high levels when the economic production develop (12 000 to 19 000 ton-km/cap per year in 2100)

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- A second group corresponding to regions either with one big dominant country or highly economically integrated, for which the model calculates a convergence around 8 000 ton-km/cap per year (South Asia, Europe, Latine America)
- A third group with the other countries, where the freight mobility is calculated to remain close or below 5 000 ton-km/cap per year.

The share of road in freight mobility ranges from 10% to 91% among the world regions in 2000: this reflects huge differences in the historical development of the infrastructures, from countries like the USA, the CIS or China, where rail infrastructures have been widely developed to cope with the transportation of natural resources over long distances, and countries with almost no rail infrastructures, where everything has to be moved by road. **In 2100, the model calculates a much reduced gap between the different world regions (33% to 96%),** in particular because of the development of fast modes imposed by the speed constraint.

Summing up, **transportation services (passenger and freight) are projected to more than quintuple from 2000 to 2100.** Most of the growth will occur in developing countries which a projected increase of transportation services by a factor of 13 while transportation in industrialized countries is expected to increase by 2 between 2000 and 2100.

Concerning the end-use energy efficiencies, for the period 2000 to 2100, it is projected that energy efficiency can be increased by up to two thirds for passenger transport by car and by air, by up to somewhat more than half for public transportation on roads and by 15-35% for passenger transport by rail (different values for high speed, medium speed and local rail). For freight, energy efficiency can be increased by somewhat more than half for freight transportation by road, by 10-25% for rail and by around one third for freight transport via waterways and overseas.

The largest fuel efficiency gains will be achieved by speeding up **the transition either to fuel cells or to electric vehicles. In both cases the well-to-wheel fuel efficiency in primary energy terms will depend on the efficiency of producing the combustible fuels (e.g. hydrogen).** Development and progress in the field of fuel cell systems indicate that there are a couple of unresolved technical problems, making it rather unlikely that fuel cells will be introduced to the market on a broad scale in the next 15 to 20 years. Concerning hydrogen, the report assumes the path to the hydrogen development in Europe as sketched out by the European Commission DG Research in 2003 “Hydrogen Energy and Fuel Cells A vision of our future” in which **by 2040 fuel cells become the dominant technology in transport, in distributed power generation, and in micro-applications and by 2050 there is the H2 use in aviation.**

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	EUROPEAN COMMISSION Directorate-General for Research Directorate Energy 2006												
Title	World Energy Technology Outlook – WETO H2												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
Energy transition	X												
Climate change	X												
Technological change	X												
Economic change	<input type="checkbox"/>												
Social change	<input type="checkbox"/>												
Policy change	<input type="checkbox"/>												

Summary

The WETO-H2 study has developed a Reference projection of the world energy system to test different scenarios for technology and climate policies in the next half-century; it has a particular focus on the diffusion of hydrogen as a fuel. This Reference projection adopts exogenous forecasts for population and economic growth in the different world regions and it makes consistent assumptions for the availability of fossil energy resources and for the costs and performances of future technologies. It uses a world energy sector simulation model – the POLES model – to describe the development to 2050 of the national and regional energy systems and of their interactions through international energy markets, under constraints on resources and from climate policy.

Two variant scenarios are considered: a Carbon Constraint case and a Hydrogen scenario. The Carbon Constraint case reflects a state of the world with moderately ambitious climate targets, aiming at an emission profile that is compatible in the long-term with concentration levels below 550 ppmv for CO₂.

The Reference projection describes a continuation of existing economic and technological trends, including short-term constraints on the development of oil and gas production and moderate climate policies for which it is assumed that Europe keeps the lead. **The total energy consumption in the world is expected to increase to 22 Gtoe per year in 2050**, from the current 10 Gtoe per year. Fossil fuels provide 70% of this total (coal and oil 26% each, natural gas 18%) and non-fossil sources 30%; the non-fossil share is divided almost equally between renewable and nuclear energy. **The size of the world economy in 2050 is four times as large as now**, but world energy consumption only increases by a factor of 2.2. **Conventional oil production levels off after 2025 at around 100 Mbl/d. Non-conventional oils provide the increase in total**

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liquids, to about 125 Mbl/d in 2050. Natural gas shows a similar pattern, with a delay of almost ten years. **The prices of oil and natural gas on the international market increase steadily, and reach 110 \$/bl for oil and 100 \$/boe for gas in 2050.** **The growth in electricity consumption keeps pace with economic growth and in 2050, total electricity production is four times greater than today.** Coal returns as an **important source of electricity** and is increasingly converted using new advanced technologies. **The price of coal is expected to reach about 110 \$/ton in 2050.** The deployment of non-fossil energy sources to some extent compensates for the comeback of coal in terms of CO₂ emissions, which increase almost proportionally to the total energy consumption. **The resulting emission profile corresponds to a concentration of CO₂ in the atmospheric between 900 to 1000 ppmv in 2050.** This value far exceeds what is considered today as an acceptable range for stabilisation of the concentration.

In Europe, the reference energy consumption trend increases only a little from **1.9 Gtoe / year today to 2.6 Gtoe / year in 2050.** **In 2050 non-fossil energy sources, nuclear and renewable provide 40%** of the primary energy consumption, much above the present 20%. This combination of modest climate policies and new trends in electricity supply results in CO₂ emissions that are almost stable up to 2030 and then decrease until 2050. **In 2050 CO₂ emissions in Europe are 10% lower than today.** Because of relatively strong climate policies, **European electricity production is 70% decarbonised in 2050; renewable and nuclear sources provide 60% of the total generation of electricity** and a quarter of thermal generation is equipped with CO₂ capture and storage

systems. **Hydrogen develops after 2030, with modest although not negligible results: it provides in 2050 the equivalent of 10%** of final electricity consumption.

The carbon constraint scenario explores the consequences of more ambitious carbon policies that aim at a long-term stabilisation of the concentration of CO₂ in the atmosphere close to 500 ppmv by 2050. In Europe, according to this scenario, three quarters of power generation is based on nuclear and renewable sources and half of thermal power generation is in plants with CO₂ capture and storage. **Hydrogen delivers a quantity of energy equivalent to 15% of that delivered by electricity.** **By 2050,** half of the total building stock is composed of low energy buildings and a quarter of very low energy buildings. **More than half of vehicles are low emission or very low emission vehicles (e.g. electricity or hydrogen powered cars).**

The hydrogen scenario is derived from the carbon constraint case, but also assumes a series of technology breakthroughs that significantly increase the cost-effectiveness of hydrogen technologies, in particular in end-use. The assumptions made on progress for the key hydrogen technologies are deliberately very optimistic. In Europe, **nuclear energy provides a third of the total energy demand in Europe. Oil, natural gas and renewables each provides roughly 20% and coal 6%.** The share of fossil fuels in power generation decreases steadily and significantly. **The use of CO₂ capture and storage systems develops strongly; by 2050, more than 50% of thermal electricity production is from plants with CO₂ capture and storage.** **The production of hydrogen increases rapidly after 2030 to reach 120 Mtoe by 2050, or 12% of world production.** **Hydrogen provides 7% of final energy consumption in Europe, against 3% in the Reference case.** In Europe, hydrogen is produced mainly from the electrolysis of water using nuclear electricity. The share of hydrogen produced from

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renewables is also substantial (40% in 2050). **About three quarters of the hydrogen produced in Europe go to the transport sector.**

Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	International Energy Agency (IEA)	
Title	Energy Technology Perspectives - Scenarios & Strategies to 2050	
Main focus	Energy transition	X
	Climate change	X
	Technological change	X
	Economic change	<input type="checkbox"/>
	Social change	<input type="checkbox"/>
	Policy change	<input type="checkbox"/>

Summary

This vision starts from the acknowledgment that secure, reliable and affordable energy supplies are fundamental to economic stability and development. The threat of disruptive climate change, the erosion of energy security and the growing energy needs of the developing world all pose major challenges for energy decision makers. They can only be met through innovation, the adoption of new cost-effective technologies, and a better use of existing energy-efficient technologies. Therefore, the Energy Technology Perspectives study presents the status and prospects for key energy technologies and assesses their potential to make a difference by 2050.

In the Reference Scenario the future is in line with present trends as illustrated by the World Energy Outlook 2005 Reference Scenario: **CO₂ emissions and oil demand will continue to grow rapidly over the next 25 years.** This is after taking account of energy efficiency gains and technological progress that can be expected under existing policies. **Extending this outlook beyond 2030 shows that these worrisome trends are likely to get worse. In the Baseline Scenario prepared for this study, CO₂ emissions will be almost two and a half times the current level by 2050. Surging transport demand** will continue to put pressure on oil supply.

However, The Accelerated Technology scenarios (ACTs) demonstrate that by employing technologies that already exist or are under development, the world could be brought onto a much more sustainable energy path. **The scenarios show how energy-related CO₂ emissions can be returned to their current levels by 2050** and how the growth of oil demand can be moderated. **They also show that by 2050, energy efficiency measures can reduce electricity demand by a third below the Baseline levels.** Savings from liquid fuels would equal more than half of today's global oil

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consumption, offsetting about 56% of the growth in oil demand foreseen in the Baseline scenario.

The backbone of the scenarios are the followings:

- Strong energy efficiency gains in the transport, industry and buildings sectors.
- Electricity supply becoming significantly decarbonised as the power-generation mix shifts towards nuclear power, renewables, natural gas and coal with CO₂ capture and storage (CCS).
- Increased use of bio-fuels for road transport.

Energy efficiency gains are a first priority for a more sustainable energy future. **In the ACT scenarios, improved energy efficiency in the buildings, industry and transport sectors leads to between 17 and 33% lower energy use than in the Baseline scenario by 2050.** Energy efficiency accounts for between 45% and 53% of the total CO₂ emission reduction relative to the Baseline in 2050, depending on the scenario. In a scenario in which global efficiency gains relative to the Baseline are only 20% by 2050, global CO₂ emissions increase by more than 20% compared to the other ACT scenarios. In particular:

In the ACT scenarios, Capture and Storage technologies contribute between 20% and 28% of total CO₂ emission reductions below the Baseline Scenario by 2050.

The share of natural gas in electricity generation remains relatively robust in all of the ACT scenarios, ranging from 23 to 28% of total generation in 2050.

An increased use of nuclear power can provide substantial CO₂ emission reductions. In the ACT scenarios, nuclear accounts for 16 to 19% of global electricity generation in 2050. **The increased use of nuclear power relative to the Baseline Scenario accounts for 6 to 10% of the emissions reduction in 2050.** In a scenario with more pessimistic prospects for nuclear, its share of electricity generation drops to 6.7%, the same level as in the Baseline. In the more optimistic TECH Plus scenario, nuclear power accounts for 22.2% of electricity generation in 2050.

By 2050, the increased use of renewables such as hydropower, wind, solar and biomass in power generation contributes between 9% and 16% of the CO₂ emission reductions in the ACT scenarios. **The share of renewables in the generation mix increases from 18% today, to as high as 34% by 2050.**

The increased use of bio fuels in transport accounts for around 6% of the CO₂ emission reductions in all the ACT scenarios, while the contribution from hydrogen is very modest. In the TECH Plus scenario, however, hydrogen consumption grows to more than 300 Mtoe per year in 2050 and accounts for around 800 Mt of CO₂ savings, while the fuel-efficiency impact of fuel cells adds another 700 Mt CO₂ of savings. **Hydrogen and biofuels provide 35% of total final transport energy demand in 2050 in the TECH Plus scenario, up from around 13% in the ACT scenarios and 3% in the Baseline scenario.** This returns primary oil demand in 2050 back to about today's level. From the point of view of **the implementation of the ACT scenarios**, it is important to stress that it will take a huge and co-ordinated international effort to achieve the results implied by the ACT scenarios. Public and private support will be essential. Unprecedented co-operation will be needed between the developed and developing nations, and between industry and government.

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Relevant foresight studies produced by EU Member States

Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	ECN – Energy research Centre of the Netherlands
Title	A sustainable energy system in 2050: promise or possibility?
Main focus	Energy transition <input checked="" type="checkbox"/> X Technological change <input type="checkbox"/> Economic change <input type="checkbox"/> Social change <input type="checkbox"/> Policy change <input type="checkbox"/>
Drivers affecting transport	Energy prices Energy sources Biofuels New infrastructure development New vehicles Application of ICT Teleworking Emissions Climate change Transport policy

Summary

The vision is that, by 2050, **renewable energy sources** will account for more than **35%** of the total energy supply, with biomass, wind and solar energy taking leading roles. Considerable attention will be paid to **energy conservation**. **Nuclear energy** will have a limited role, as only half of the EU member States will support the use of nuclear energy. **Coal with CO₂ capture** will be applied on a large scale for the production of both electricity and hydrogen. The **hydrogen** will be used in the transport sector. **Biomass** will be used as fuel for freight transport, and as feedstock in industry, as there are few other substitutes for oil products in these sectors. The energy needs of dwellings and other buildings will have been greatly reduced, and will primarily be met with solar energy and electricity. The authors have attempted to map out a consistent development path that leads to the reduction in **CO₂ emissions in**

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Europe to 60% below 1990 levels, as well as a significant decrease in oil and natural gas imports. The vision for 2050 is centred on the application of new technologies, new energy sources and a new energy infrastructure. However, these changes will be successful only if they are combined with new organisational forms and changes in behaviour patterns. Realistic time-to-market projections have been drawn up concerning such technological innovations as the development of **affordable solar cells**, the availability of **second-generation biofuels** and the **reliable capture & storage of CO₂**. The fuel prices below have been used. These are taken from the POLES model and are based upon a scenario in which increasing CO₂ taxes are levied, rising from €10 per tonne to €85 per tonne in 2050. It is assumed that an **“oil peak” will occur in Europe in about 2015**, after which consumption starts to decline.

Energy prices in the sustainable vision			
\$ ₂₀₀₅ /barrel	2000	2030	2050
Oil	27	61	97
Gas (Europe)	19	49	73
Coal (Europe)	10	18	23

As it concerns the **transport sector**, a transition towards alternative fuels and drive trains was hastened by the scarcity of oil products and a strict climate policy. Because **road charging** have made driving more expensive, **more use is now made of public transport**, which has become flexible and of good quality. Passenger cars are now much more efficient, thanks to efficient internal combustion engines and the use of hybrid concepts and lightweight materials. **Traffic jams are now rare**, as a result of the implementation of advanced ICT. Motorists are advised in good time about delays, and automatic distance sensors on motorways have led to a great reduction in the number of accidents. **Many people now telework** and thus avoid the rush hour and save fuel. In cities, a **large number of deliveries are made by vans powered by electric motors** that run on batteries or fuel cells, and this has improved local air conditions. **Hydrogen is available at the pump** in many areas of Europe. Initially, hydrogen was largely produced from natural gas with CO₂ capture, but, due to the high gas prices, coal with CO₂ capture is now preferred. Because of the **sharp drop in the price of fuel cells**, there is a rapid growth in the number of cars powered by such cells. This is partly a result of the European campaign in 2020 for “100.000 fuel cell cars”, which encouraged manufacturers to produce large series of these vehicles. Due to the high efficiency of the fuel cell, cars powered by such cells are as cost-efficient as cars that have petrol or diesel engine. **Approximately 50% of all passenger cars are now hydrogen-fuelled**; others still use biofuels, either pure or mixed with oil products. **Bicycles**, many of which have an auxiliary electric motor, **are used for travelling short distances**, facilitated by the many safe cycle paths that have been created across Europe. Freight transport that involves long distances and heavy loads is still reliant on diesel. **Most freight carriers opt for bio-diesel**, which is made from woody plants using such advanced processes as the Fisher Tropsch process. This also applies to buses, which are standardly fitted with a bio-diesel hybrid, except in a number of cities where hydrogen-fuelled buses are used. Shipping has also turned to bio-diesel. Only

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about 30% of the diesel used in Europe is made from mineral oil. Aviation is largely dependent on bio-kerosene.

Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	Department for Transport (UK), Office of Science and Technology Andrew Curry, Tony Hodgson, Rachel Kelnar, Alister Wilson, September 2007												
Title	Foresight Intelligent Infrastructure Futures The Scenarios – Towards 2055 2007												
Main focus	<table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">Energy transition</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td style="text-align: right;"><input checked="" type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td style="text-align: right;"><input type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input checked="" type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Technological change	<input checked="" type="checkbox"/>												
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Social change	<input type="checkbox"/>												
Policy change	<input type="checkbox"/>												

Summary

The Foresight Project on Intelligent Infrastructure Systems (IIS) set out to examine the challenges and opportunities for the UK in bringing ‘intelligence’ to its infrastructure – the physical networks that deliver such services as transport, telecommunications, water and energy. In particular, the project explored how, over the next 50 years, we can apply science and technology to the design and implementation of intelligent infrastructure for robust, sustainable and safe transport, and its alternatives.

The following four scenarios and related ‘systems maps’ have been developed to investigate how science and technology might be applied to infrastructure over the next 50 years.

- Perpetual Motion
- Urban Colonies
- Tribal Trading
- Good Intentions

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Perpetual Motion describes a society where the norm is constant information, consumption and competition. Instant communication and continuing globalisation have fuelled growth: demand for travel remains strong. New, cleaner, fuel technologies are increasingly popular: road use causes less environmental damage, although the volume and speed of traffic remains high. Aviation still relies on carbon fuels and remains expensive. It is increasingly replaced by telepresencing technology (for business) and rapid train systems (for travel). Increased nuclear capacity and the development of renewable energy sources have further reduced dependence on carbon-based fuels. Work, however, is intensive: stress is a growing problem in the developed economies. Many workers are considering ways to downshift, raising questions over the long-term viability of continued economic growth.

In the **Urban Colonies** scenario, technology investment and development is primarily focused on minimising environmental impact. Good environmental practice is at the heart of the UK's economic and social policies and sustainable buildings, distributed power generation and new urban planning policies have created compact, sustainable cities. Transport is permitted only if green and clean – and car use (still energy-expensive) is restricted. Different cities have developed their own public transport – electric or low energy – which is efficient and widely used. Competitive cities have the IT infrastructure needed to link high-value knowledge businesses, but poor integration of public systems means that private networks are most trusted. Rural areas have become more isolated, effectively acting as food and bio fuel sources for cities. Consumption has fallen – resource use is now a fundamental part of the tax system and disposable items are less popular.

Tribal Trading is a world that has been through a sharp and savage energy shock. The world has now stabilised, but only after a global recession that has left millions unemployed. The global economic system is severely damaged: infrastructure is falling into disrepair. Long-distance travel is a luxury that few can afford: for most people, the world has shrunk to their own community. Cities have declined: local food production and services have increased. Canals and sea-going vessels carry freight: the rail network is worthwhile only for high value, long-distance cargoes and trips. There are still some cars, but local transport is typically by bike and by horse. Local conflicts recur over resources: lawlessness and mistrust are high. The state does what it can – but its power has been eroded.

Good Intentions is a world in which the need to reduce carbon emissions constrains personal mobility. A tough national surveillance system ensures that people only travel if they have sufficient carbon quotas; intelligent cars monitor and report on the environmental cost of journeys; and in-car systems adjust speeds automatically to minimise emissions. Traffic volumes have fallen and mass transportation is used more widely. Businesses have adopted energy-efficient practices and use highly sophisticated wireless identification and tracking systems to optimise logistics and distribution. Some rural areas are able to pool community carbon credits for local transport provision, but many are struggling. There are concerns that the world has not yet done enough to respond to the human activity that has caused the environmental damage. Airlines continue to exploit loopholes in the carbon enforcement framework. The market has failed to provide a realistic alternative energy source.

The **impacts on transport at 2055** are the following, for each type of scenarios:

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Perpetual motions. The demand for travel and transport has remained strong. New technologies – which combine low or zero emissions with energy ‘vectors’ that ensure efficient energy capture and storage – are widely available ensuring that environmental curbs on car use are unnecessary, traffic management remains a critical problem. **Motor manufacturers’ success in developing hydrogen-fuelled vehicles** has helped to meet the desire for more cars, but they are not cheap. However, cyclists and pedestrians continue to have a tough time – even without the after burn of diesel or petrol in the air, **the volume and speed of traffic still means that many urban environments are not pleasant places to cycle or walk in.**

Urban Colonies. People travel, but not as far, and often by foot or cycle. **Transport is permitted if it is ‘clean and green’, but not otherwise.** For some transport, this has proved easier than others. Local electric vehicles are ubiquitous, and local light rail schemes are common. In the long-distance world, speed is less important than energy conservation. **Even if transport is no longer fuelled by oil, clean energy is still far more expensive than petrol or diesel ever were.** The lack of integration of systems means that generally **transport is poorly integrated, with different systems controlled by different organisations. Materially, fewer goods, but more services, are consumed than in 2005.**

Tribal Trading. **Traffic volumes are sensibly lower than in 2005.** If people travel as much as they ever did, they do it more slowly; they don’t travel so far. **Work is closer to the home;** indeed, in some places, living patterns have reverted to the pre-industrial, with the home and the workplace being the same. **Vehicles for local use combine human power with electricity,** for those who desire such luxury; the fastest vehicles on the road are steam-powered; although there are precious few of those, they are well-suited to the wide, if battered, roads that remain from the later 20th century.

Good Intentions. **Traffic volumes have shrunk hugely,** and will fall further as the carbon ration continues to be reduced. **Regions and local authorities have followed the lead of their governments and run local initiatives to reduce travel demand.** At a national level, much of the implementation is based on satellite surveillance and a huge processing capacity, which can monitor every car on the road, if need be. This is coupled with a carbon credits smart card, which is needed by any citizen who wishes to use any kind of carbon resources.

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	Department of Transport (UK) November 2007
Title	UK Air Passenger Demand and CO2 Forecasts
Main focus	Energy transition <input type="checkbox"/> Climate change <input checked="" type="checkbox"/> Technological change <input type="checkbox"/> Economic change <input type="checkbox"/> Social change <input type="checkbox"/> Policy change <input type="checkbox"/>

Summary

In December 2003, the UK Government set out a sustainable long-term strategy for the development of air travel to 2030. This was supported by forecasts of demand for air travel at UK airports and carbon emissions forecasts from UK aviation. These forecasts are used to inform and monitor long term strategic aviation policy, and wider Government policy on tackling climate change. They are also inputs to the appraisal of airport developments supported by the Air Transport White Paper, the results of which were set out in Passenger Forecasts: Additional Analysis.

The forecasts distinguish two time horizons: up to 2030 and beyond 2030. Demand forecast to 2030 have been provided using sophisticated statistical and other modelling techniques. For the purposes of the CO2 forecasts and airport development appraisal, further project demand to 2050 and 2080 (respectively) have been provided.

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From the methodological point of view, up to 2030, the key variables determining air travel demand varied by market segment, but in general included measures of economic activity (e.g. consumer spending, GDP, or international trade), air fares, and exchange rates. In the leisure sectors consumer spending, GDP, air fares, and exchange rates were identified as drivers. In the business sectors, a mixture of GDP, international trade, and exchange rate variables were shown to be the main drivers, with only limited price effects identified.

Beyond 2030, the CO₂ forecasts rely on the demand and fuel efficiency forecasts. These are available only to 2030, so the **CO₂ emissions to 2050** have been provided using simpler, yet still robust, methods.

Passenger demand is projected beyond 2030 by assuming demand growth at each airport between 2026 and 2030 continues but with no further passenger or runway capacity added after 2030. Passenger demand is converted into ATM demand using projections of **aircraft size and load factor trends. Growth at each airport continues**, until either terminal or runway capacity is reached.

By 2030 all the London area airports are forecast to be at capacity. There is no reallocation of demand away from constrained airports to unconstrained airports within these post-2030 projections.

The projections of **ATM size** are then combined with projections of average flight distance to obtain seat-kilometre projections by airport. These are then combined with a projection of the fleet fuel efficiency.

Fuel efficiency beyond 2030 has been provided on the basis of the IPCC forecast, assuming a 0.5% per annum improvement for the fleet as a whole from 2021 onwards, and IATA and Lee et al project only to 2020 and 2025 respectively. We have therefore based our post-2030 projection on the IPCC long-term assumption of 0.5% improvement per annum, but allowed a slightly higher rate of 0.75% between 2030 and 2050. This reflects the continued propagation of ACARE-consistent aircraft through the fleet after 2030, and allows a smooth transition from our pre-2030 efficiency forecasts to our post 2030 projections.

The **resulting fleet efficiency gain from 2030 to 2050** remains below the forecasts to 2030 by Lee et al and IATA. 3.65 This results in a forecast fleet efficiency improvement of 29.7% 2005- 2030 (1.0% pa), as shown in table 3.4, and 15.3% 2030-2050 (0.8% pa). The table below shows the CO₂ forecasts with the results of applying the methodology outlined above under the central case to 2050.

	Low	Central	High
2005	37.5	37.5	37.5
2010	40.9	42.0	43.0
2020	48.1	50.0	53.1
2030	54.8	58.9	62.7
2040	55.3	61.1	66.3
2050	53.2	60.3	66.9

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The table shows that central case emissions are forecast to rise from 37.5 MtCO₂ in 2005 to 58.9 MtCO₂ in 2030, after which their growth is projected to slow and slightly decline between 2040 and 2050. The post-2030, capacity constraints begin to bite again, so the growth in passenger demand slows. Fuel efficiency slows post-2030 as the scope for further improvements diminishes (without any step change technological developments), but post 2040 the balance of these two effects causes emissions to begin to decline. 3.70 Overall, aviation carbon dioxide emissions are projected to grow by some 1.8% per annum in aggregate over the period 2005-2030 slowing to an average of 1.1% per annum over the period 2005-2050 under the central case.

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	Conseil Général des Ponts et Chaussées Ministère des Transports, de l'Équipement, du Tourisme et de la Mer Claude GRESSIER, President of the CGPC's "Economics and Transportation" Unit, Head of Long-Term Planning et alt.	
Title	Long range Transportation Plan – 2050 - September 2006	
Main focus	Energy transition	X
	Climate change	<input type="checkbox"/>
	Technological change	<input type="checkbox"/>
	Economic change	X
	Social change	<input type="checkbox"/>
	Policy change	X

Summary

The Conseil Général des Ponts et Chaussées "Economics and Transportation" unit decided at the end of 2003 to undertake along-term planning study on the transportation system out to 2050 in France. The vision set forth four potential views of the transportation system in the year 2050, in the form of four exploratory scenarios established from socioeconomic criteria. The scenario building step includes a number of elements from the worldwide and European context that appear as determinant to shaping a long-term view; these would include:

- demographics, with a dual emphasis: aging of the population, and population migration patterns (increasing vs. decreasing concentrations within certain zones?);
- energy available over the upcoming decades, and the interrelationships existing between
- transportation and the greenhouse effect;
- the economic context (how will globalization play out? what kind of GDP growth rates can be expected?) likely to influence evolution;
- technological progress, especially that relative to enhanced vehicle engines and cleaner fuels.

No specific policy objectives or constraints were set out.

Four possible perspectives on the worldwide and European geopolitical context served as input to the four scenarios:

- **Scenario 1 - "Worldwide governance and environment-friendly industry"** is characterized both by worldwide cooperation for enhanced control over energy-production technologies, which allows for enhanced mitigation of the adverse effects due to greenhouse gases and by a pan- European policy favouring industrial development, especially through extensive R&D support;
- **Scenario 2 - "European isolationism and decline"**, with the world's major blocks engaging in a ferocious economic competition against a backdrop of

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energy supply crises; each European nation manages and protects its resources, and both demographic and economic growth rates remain low;

- **Scenario 3 - "A tightly-integrated, enlarged Europe"** is founded by virtue of the successful economic integration of the Mediterranean Region and Russia into the European Union, to ensure providing for their development and European security at the same time. This scenario reflects strong economic growth;
- **Scenario 4 - "Inward-looking European governance and regionalization"** lies within a context of worldwide energy crisis, as characterized by a decisive increase in the price of oil paid on the world market. In order to preserve security and employment, Europe pursues a more endogenous growth formula, with considerable emphasis on integration, yet only a limited opening onto the other world blocks.

The above visions are underpinned by the following **policy scenarios**

Scenario 1: strong world governance and strong European governance on climate issues, open trade and international relations;

Scenario 2: absence of either world or European governance; a rather protectionist stance;

Scenario 3: no world governance; moderate European governance; opening onto the world;

Scenario 4: no world governance; strong European governance; protectionism.

The transport and energy impacts of the scenarios are the following:

In the **Scenario 1 - "Worldwide governance and environment-friendly industry"** the local mobility flows (trips of up to 50 km), which had risen by nearly 90% between 1975 and 2002, **will only gain another 30% over the period 2002-2050**. While the private automobile will continue as the main mode, the share of public transit, which had fallen from 12% to 8% of all motorized trips between 1975 and 2002, will climb back to the 10% mark. **Between 2002 and 2050, long-distance mobility (50-1,000 km trips) will double**, while more local mobility will only rise by a third. Airport traffic within metropolitan France will reach a figure of 238 million passengers (less than a twofold increase through 2050, i.e. 1.4% annual expansion). **The freight growth scenario lies within the continuum of current trends (with a 1% annual increase in flows between 2002 and 2050**, a figure sharply lower than over the past several decades). Worldwide cooperation on energy prices, particularly via heavy carbon taxation (\$140 per ton of CO₂, equivalent to \$60 a barrel of oil), will engender technological leaps: **at 2050 a heavy decrease in per-vehicle consumption rates and emphasis on developing synthetic fuels (according to our scenario, biomass-derived fuels will constitute half of all liquid fuels consumed)**. A moderate demographic and economic growth (GDP rising by 1.5% a year) will underpin the scenario

In the **Scenario 2 - "European isolationism and decline"** is characterised by a weak demographic and economic growth (1% a year). **Passenger flows over short and medium distances (land-based) will be reduced, with automobile traffic out to 2050 rising by just 10% and public transit by 25%. Long distance will be more heavily affected, with a slow growth over the 2004-2050 period (+1.4%) for the air sector.** the dual effect of reduced economic growth and the absence of worldwide and European regulation will not enable the widespread development of alternative energies to replace petroleum and fossil fuels. Consequently, bio fuels will account for the smallest share

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(8%) of all four scenarios and will consist of agricultural by products (ethanol and ester from vegetable oil).

The **Scenario 3 - "A tightly-integrated, enlarged Europe"** assumes moderate demographic evolution and strong economic growth (2% a year). **The level of mobility for trips exceeding 50 km will double by 2050. Airline traffic offers the most substantial rise in the demand for airline transportation, i.e. on the order of +2.5% a year over the period 2004-2050, which works out to a 350% increase through 2050.** The strong economic growth will lead to an increased freight traffic volume (**with a 1% annual increase in flows between 2002 and 2050**). The energy assessment relative to this scenario is the least favourable of the four. The major gains experienced in transportation flows will be associated with an **11% jump in total liquid fuel consumption for transportation uses**.

The **Scenario 4 - "Inward-looking European governance and regionalization"** is characterised by a strong demographic evolution and a moderate economic growth (by 1.5% a year), intensive development of trade within the European zone and high energy costs. The passenger flows over short and medium distances will slow considerably. Given the rise in automobile operating costs coupled with a drop in travel speeds, the modal share attributed to public transit will edge up from 8 to 10%. **The long-distance flows will double by 2050**, despite the extremely high jump in energy prices. A significant rise in airline ticket prices (in direct correlation with oil prices - \$120 to 180 a barrel, including the carbon tax) will determine the **smallest annual growth in airline traffic (+1.1% over the study period)**, at 2050. With Europe's industrial base moving towards regional specialization favouring economic development at the local level, this scenario will foster employment while limiting growth. In comparison with Scenarios 1 and 3, **national transportation volumes will experience stronger growth**, even though total flow will remain within a moderate range. **Given the high price of oil (\$180 a barrel, with the carbon tax) and poorer energy performance than in Scenario 1, the per-km cost of running a vehicle will increase by more than 50%.** The long-term view associated with this set of input data will resemble that of the first scenario, with a total consumption of **liquid fuels used in the transportation sector dropping slightly (to 47 million eto vs. 52 at present) and a market share of 30% for biofuel**. Decisive results (although not as impressive as in Scenario 1) will be obtained herein for net **CO2 emissions within the transportation sector, with a 37% decrease in 2050 with respect to 2002**.

In general, the following common trends can be identified, regardless of the scenarios assumptions:

A moderate increase in day-to-day local mobility. These more limited gains, in the range of 10 to 40% over the period 2000-2050, depending on the preferred scenario, would be due to:

- slowing population growth;
- constraints in the amount of time available each day for transportation, whether this be commute trips and/or home-leisure trips, with travel speeds no longer increasing and trip distances remaining stable;
- regardless of the scenario, the proportion of non-discretionary local trips will drop as a result of expanded remote access services (e.g. banking, public administration, short-term ticketing), fewer trips should also be expected for

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medical purposes (telemedicine), shopping (e-commerce) and work (teleconferencing, telecommuting).

A stronger growth in long-distance passenger flows. (excursions or several-day journeys between 50 and 1,000 km), a twofold increase over the period, with the exception of Scenario 2 (the declining Europe scenario), for which the rise is limited to 50% as a result of slower household income growth. This increase will structurally benefit the road, which already holds the dominant position. Nonetheless, the rate of gains in public transportation will rise, and particularly so for high-speed rail (+100-200%), whose network will be considerably extended.

Contrasted trends for freight flows. The evolution in freight transportation will be structurally tied to industrial trade patterns, i.e. at a pace below that experienced over the recent past (recognizing that the share of bulk transport –ores/minerals, cereals, construction materials, etc., which heavily influence modal split - will be decreasing). Discrepancies across scenarios vary as a function of the type of growth envisaged (favouring industry vs. the tertiary sector):

- Scenarios 1 ("Worldwide governance and environment-friendly industry") and 4 ("Inward-looking European governance and regionalization") reflect a slowing in the expansion of intra-European flows (equally split between domestic transportation, trade and transit traffic), with an annual growth of approximately 1% (less for Scenario 4) **between 2002 and 2050**;
- According to Scenario 2 ("European isolationism and decline"), domestic transportation will drop
- beyond 2025 and wind up at a level just slightly higher than the situation in 2002;
- Scenario 3 will result in a strong global growth in freight flows along with a concentration onto major land transit corridors and Mediterranean ports. This additional transit traffic might be less than anticipated given the potential use of alternative maritime routes between Europe and North Africa.

A favourable outlook for non roads-modes. All scenarios indicate a favourable modal shift. Travel speeds will be capped by the road network to meet changes in road operating policy (for safety and smooth traffic flow). Fuel prices under most scenarios will substantially rise, mainly from introducing higher taxes. And yet the net effect from modal transfer will remain small.

But road will remain the most important mode. Despite a considerable local impact, the overall effect from modal transfer will remain marginal. With respect to personal travel patterns, mobility costs do not actually constitute an impeding factor for households, regardless of the scenario. The high price of energy exerts little influence on total transportation flows. A simulation was run raising the per vehicle-km price of energy in Scenario 1 by 50%, which is tantamount to applying Scenario 4's energy prices, and the result showed a net per vehicle-km drop of just 6.4%. The passenger car is destined to remain the predominant trip-making mode over the horizon 2050. According to the various scenarios, the public transit share of all motorized trips less than 50 km will represent 8 to 10%, even when adopting bolder hypotheses (upgrading the supply of public transit services coupled with a more restrictive policy regarding automobile use), with the exception of Scenario 2, which calls for a less marked trend change.

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A sizeable reduction in road generated CO₂ emissions. In Scenario 1, the most favourable, CO₂ emissions from transportation will be reduced (excluding energy transformation) in 2050 by a factor of about 2.5 compared with year 2000 values, which will significantly contribute to curbing greenhouse emissions, provided the passenger vehicles in circulation satisfy the following:

- a consumption efficiency on average of 3 liters per 100 km; and
- fueled one-third by biomass and another third by nuclear power.

The **technological breakthroughs** necessary to achieve this emissions reduction require a decisive step forward in worldwide governance, or at the very least from a consolidated European governance. They must be sparked by regulatory measures, such as the carbon tax, negotiable permitting and vehicle and fuel technical standards, for which the prospect of adoption by just a single country or by a regional group like Europe seems difficult to imagine: the risk of losing industrial competitiveness is crucial for both economic development and employment.

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	CPB Centraal Planbureau Ruud de Mooij, Paul Tang												
Title	Four futures for Europe 2006												
Main focus	<table> <tr> <td>Energy transition</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input checked="" type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input checked="" type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input checked="" type="checkbox"/>
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Summary

This vision set up for The Netherlands at 2040 four scenarios. They are built along the following two key uncertainties: **the first challenge is whether countries will succeed in international cooperation**, necessary to deal adequately with cross-border issues. In particular, this uncertainty derives from the difficulties in reforming current international organisations, such as the European Union and the WTO, and institutionalising new forms of cooperation to deal with global problems. International cooperation thus refers to cooperation both within the European Union and between the European Union and other regions. **The second key uncertainty refers to developments in the public sector in European economies.** It derives from developments that put the public sector under pressure, such as ageing, the divide between low-skilled and high-skilled, policy competition, individualisation and so on. The study also provides a quantification of the economic situation in 2020 and 2040 on the basis of the assumptions that underlie each of the four scenarios.

The four scenarios are the following: A) **strong Europe**, in which the outward orientation of Europe, the deepening of the internal market, and rapid growth in Central and Eastern Europe contribute to productivity growth in the European Union. **Labour productivity increases by about 1.5% per year**, which equals the average figure during **1980- 1999**. Population growth does not change much during the coming decades. In light of ageing, however, employment growth falls, especially after 2020. Annual GDP growth, equal to the sum of productivity and employment growth, thus **falls from 2.2% during last two decades to 1.8% between 2000 and 2020, and to 1.3% between 2020 and 2040**. B) **Regional communities**, for which in light of the barriers to international trade and the lack of competitive forces, labour productivity grows only **mildly at a rate of 1.1% per year**. In combination with the ageing of the population, which reduces the employment rate, this implies that GDP hardly grows after 2020: the growth rate of 0.2% is substantially smaller than the 2.2% that we

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experienced in the recent past. **The participation rate falls from 46.7% of the population in 2000 to 40.2% in 2040.** C) **Global Economy**, in which the international integration and market-oriented domestic policies stimulate labour productivity which grows by 2.1% per year up to 2020 and by 2.0% thereafter. Despite the ageing of the population, **GDP grows rapidly due to significant employment growth.** This is because participation among the elderly generations increases due to various reforms. Immigration reinforces the positive effect on labour supply. D) Transatlantic market, in which the **broad dissemination of ICT boosts labour productivity growth to 1.8% per year. Growth is concentrated in ICT-producing sectors, and in ICT-using service sectors such as the financial sector, business services and the public sector.** GDP growth falls over time, however, as the result of declining employment due to ageing.

The global view on the EU economy (EU 15) in the four scenarios is the following:

	Past	2000-2040			
	1980-2000	Strong Europe	Transatlantic Market	Regional Communities	Global Economy
annual growth rates					
GDP	2.2	1.6	1.9	0.6	2.5
labour productivity	1.5	1.5	1.8	1.1	2.1
employment	0.7	0.1	0.1	-0.5	0.4
population	0.3	0.3	0.0	-0.2	0.3
world exports	5.6	4.5	3.7	2.4	5.6
ratios	2000	Strong Europe	Transatlantic Market	Regional Communities	Global Economy
participation rate	46.6	41.6	45.2	40.2	45.8
unemployment	8.5	5.8	3.9	8.3	3.9
savings rate	18.8	15.1	13.0	12.7	15.6
interest rate	3.6	3.3	4.3	2.6	3.8
share intra-EU trade	53.5	47.3	49.3	52.8	39.4
GDP per capita (index)	100.0	162.9	210.4	134.6	234.5

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	Centre d'Analyse Stratègique Commission Énergie Thierry Chambolle, président du groupe 5 Hervé Pouliquen, rapporteur												
Title	Perspectives énergétiques de la France à l'horizon 2020-2050 2007												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

In early April 2007, the French Energy Commission presented the Prime Minister with an orientation report outlining historical facts, the present diagnosis and prospects that are medium-term (2020), in addition to proposals for immediate action or medium-term recommendations.

The Energy Commission's task is organised into six work groups dealing with complementary issues that made it possible to range across the broad spectrum of preoccupations within the energy field:

- The lessons of the past: drawing lessons from the past on the subject of energy forecasts, particularly with regard to the effects of prices and public policies as well as consumer behaviour patterns.
- Supply/demand prospects: studying the prospects of energy supply and demand in the world and their geopolitical consequences ("peak oil", reserves of renewable and non-renewable energy sources, etc.).
- Technological developments: Envisaging technological developments (nuclear, wind, solar, etc.), their implementation schedules and associated costs.
- European directions: identifying the opportunities and constraints to be taken into account by France within the European Union.
- Energy scenarios: proceeding with a variety of simulations to define the different possible scenarios.
- Energy policy: summarising the main points with a view to defining the components of an energy policy for France.

The assumptions concerning the transport sector are the following (Trend at 2030): According to the General Plan and Urban Development the collective transport increases the share by 25%. Rail traffic (TGV passengers should increase by 50%). **The implementation of the voluntary agreement with car manufacturers (ACEA) set the threshold of emissions at 140 gCO₂/km. Environmental efficient new vehicles are made available at an average consumption of 3,4 l/100km at 2010. Due to**

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efficient land use policies, the average travel distance is reduced by 15 %. Bio-fuels share is set at 5,75 % 2008 and 10 % at 2015.

- Transport demand forecasts are based on the following assumptions:
- Urban development favouring agglomeration of urban services and functions;
- Development of urban and peri-urban areas and zones in order to favour the provision of urban transport services
- Development for long-distance transport services, e.g. high speed train (both passenger and freight)

The impacts at 2050 on freight transport load factors (tonne*km) are the following:

Variables marchandises	2005	2025 Tendanciel	2025 Facteur 4	2050 Facteur 4
Total G.Tonnes x km	348	459 (+37 %)	459 (+37 %)	556 (+60 %)
<i>dont route</i>	300	390	369	392 à 412
<i>dont ferroviaire</i>	41	59	76	124 à 144
<i>dont fluvial</i>	7	10	14	20
G.PL. x km > 3,5 tonnes	35	44 (+26 %)	42 (+20 %)	46 à 48 (+33 %)
G.VUL. x km < 3,5 tonnes	45 (*)	63 (+40 %)	63 (+40 %)	75 (+70 %)

The table shows the shift towards more environmental friendly transport modes (rail and sea) at 2050.

As far as the passenger transport is concerned, the impact at 2050 are the following

Milliards de voy/km parcourus		dont tr. collectifs	Δ 2050/2002	dont VP	Trafic VP (G V x km)	Δ 2050 /2002	
Urbain de proximité (0 à 100 km)	<i>Total</i>	32	+45 %	140	<i>Total</i>	120	0 %
	<i>dont TCSP</i>	20			<i>dont électr</i>	100	
	<i>dont bus</i>	12			<i>dont carb</i>	20	
Périphérie et rural de proximité	<i>Total</i>	48	+85 %	420	<i>Total</i>	300	+30 %
	<i>dont fer</i>	32			<i>dont électr</i>	180	
	<i>dont bus</i>	16			<i>dont carb</i>	120	
Longues dist. (plus de 100 km)	<i>Total</i>	220	+140 %	360	<i>Total</i>	200	+75 %
	<i>dont fer</i>	160			<i>dont électr</i>	0	
	<i>dont aérien</i>	16			<i>dont carb</i>	200	
Ensemble	<i>Total général</i>	240	+70 %	920		620 (*)	+33 %

The collective transport on long distance is planned to grow by 140% between 2002 and 2050

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Relevant foresight studies produced by business and other stakeholders**Visions for 2050 (abstracts)**

Issuing Institution(s), Project, Author(s)	World Business Council for Sustainable Development (WBCSD), Facts and Trends Series Laurent Corbier (WBCSD), David Hone (Shell), Simon Schmitz, Lorenz Koch (WBCSD)												
Title	Pathways to 2050: Energy and Climate Change 2005												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Economic change	<input type="checkbox"/>												
Social change	<input type="checkbox"/>												
Policy change	<input type="checkbox"/>												

Summary

This vision provides an overview of the potential pathways necessary to stabilize CO₂ concentrations in the atmosphere at no more than 550-ppm in 2050 at world level. Five principal mega trends, or major sectoral shifts, have been identified:

1. Power generation – Emissions management moves upstream as electricity is increasingly the final energy carrier, displacing direct burning of fossil fuels in end use.
2. Industry and manufacturing – Industry, together with power generation, has been the first major sector to respond to the challenges posed by climate change and to be impacted by climate change legislation. Further challenges will arise in developing countries with increasing energy demands.
3. Mobility – As the desire for transport and travel increases, especially in developing countries, new technologies and behavioural changes are needed to achieve significant emissions reductions.
4. Buildings - Buildings give rise, directly and indirectly, to as much as 40% of CO₂ emissions. New energy-efficient building designs and materials, coupled with renewable heating and electricity, are increasingly attractive, while appliances have to meet ever more stringent efficiency standards.
5. Consumer choices – Society tends to think little of the CO₂ implications of simple everyday choices. Yet such choices are a key element in moving to a sustainable energy future.

To stabilize the Co₂ concentrations at 550-ppm at 2050 is a challenging objective, A 550-ppm emissions trajectory is in fact an ambitious undertaking in a rapidly developing world. It requires large scale deployment of a wide range of technologies with high investment and complex choices, completely transforming energy production and use. Issues around energy security and affordability will also play a key role in this

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transformation process. By 2050, the world must generate a dollar of GDP with only half the energy used in 2002, equivalent to an economic efficiency improvement of 1.5% per year, a rate of change 20% higher than that achieved in the last 30 years.

The impacts (potential positive pathways) for transport and mobility are the following:

The overall emissions from the mobility sector should fall by over 10% relative to 2002, with an even greater reduction achieved in road transport. These reductions are achieved by:

- **An increasing number of high-efficiency and hydrogen vehicles;**
- **Shifting towards rail transport and biomass fuels.**

Within the mobility mega trend lies the aviation sector, where capital stock turnover is slower than for road transport and no large-scale viable alternative to fossil-based fuels is being considered. **As a result and with demand soaring, aviation emissions treble over the period, even with the introduction of high efficiency airplanes.**

A further shift to mass transportation offers considerable efficiency benefits. Rail transport can be up to seven times more efficient than a light duty vehicle. Possible low-carbon **technology options** for the road transport include the development of biomass fuels, hydrogen (fuel cells), hybrids and diesel engines.

At 2050 for the EU 25 the pathway concerning the fuel shift in the vehicle sector to a mix of gasoline-diesel / biofuel / hydrogen should be as follows:

Road transport fuel (%) at 2050	
Hydrogen	32%
Bio fuel	21%
Fossil	47%

Road transport should stabilize at 3.48 trillions vehicle kilometre.

Consumer choices are also important. By 2050 a basic precondition to the fulfilment of sustainable pathways is that our society needs to have understood that all consumer choices influence the energy balance and affect the environment. The energy and environment impact of such choices will need to become completely transparent and available so that informed decisions on the goods and services we use and the lifestyle options we seek can be made. **This will in turn encourage the development of products that offer a true low energy, low carbon value.**

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Visions for 2050 (abstracts)

Issuing Institution(s), Project, Author(s)	Shell International BV 2008	
Title	Shell energy scenarios to 2050	
Main focus	Energy transition	X
	Climate change	X
	Technological change	X
	Economic change	<input type="checkbox"/>
	Social change	<input type="checkbox"/>
	Policy change	<input type="checkbox"/>

Summary

This vision concerns with the future of energy supply and demand, developing two scenarios that describe alternative ways it may develop. In the first scenario – called **Scramble** – policymakers pay little attention to more efficient energy use until supplies are tight. Likewise, greenhouse gas emissions are not seriously addressed until there are major climate shocks. In the second scenario – **Blueprints** – growing local actions begin to address the challenges of economic development, energy security and environmental pollution. A price is applied to a critical mass of emissions giving a huge stimulus to the development of clean energy technologies, such as carbon dioxide capture and storage, and energy efficiency measures. The result is far lower carbon dioxide emissions.

The scenarios are developed at world level, under the awareness of some deepest dilemma to overcome in the next future: the development dilemma – prosperity versus poverty; the trust dilemma – globalisation versus security; and the industrialisation dilemma – growth versus the environment.

World population growth is one the most important background driver. **World population has more than doubled since 1950 and is set to increase by 40% by 2050.** History has shown that as people become richer they use more energy. **Population and GDP will grow strongly in non-OECD countries and China and India are just starting their journey on the energy ladder.**

In the **Scramble scenario** political and market forces favour the development of **coal as a widely available, low-cost energy option.** Partly in response to public pressures for “energy independence,” and partly because coal provides a local source of employment, government policies in several of the largest economies encourage this indigenous resource. **Between 2000 and 2025, the global coal industry doubles in size, and by 2050 it is two and a half times at large. Biomass represents around 15% of primary energy by 2050.** Biofuels become a significant part of this, in particular helping to diversify the supply of transport fuel. But with accelerating demand, fossil fuels remain an important part of the energy mix.

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In the **Blueprints scenario**, one of the key revolutionary transitions is that **economic growth no longer mainly relies on an increase in the use of fossil fuels. By 2050, over 60% of electricity is generated by non-fossil sources.** It is increasingly a world of electrons rather than molecules. **Electric vehicles are becoming the norm in the transport sector because of their attractiveness to consumers and cost-effectiveness** once governments have supported the build-up to mass production. Power generation from renewable energy sources is growing rapidly, while utilities that still rely on coal and gas are required to implement strict carbon abatement technologies. **In the developed world, almost 90% of all coal-fired and gas-fired power stations in the OECD and 50% in the non-OECD world have been equipped with carbon dioxide capture and storage technologies by 2050.**

The following tables summarize the energy consumption by type of source in the two scenarios up to 2050. In the Blueprint scenario, by 2055, the U.S. and the EU are using an average of 33% less energy per capita than today.

 Scramble	2000	2010	2020	2030	2040	2050
	EJ per year					
Oil	147	176	186	179	160	141
Gas	88	110	133	134	124	108
Coal	97	144	199	210	246	263
Nuclear	28	31	34	36	38	43
Biomass	44	48	59	92	106	131
Solar	0	0	2	26	62	94
Wind	0	2	9	18	27	36
Other Renewables	13	19	28	38	51	65
Total primary energy	417	531	650	734	815	880

 Blueprints	2000	2010	2020	2030	2040	2050
	EJ per year					
Oil	147	177	191	192	187	157
Gas	88	109	139	143	135	122
Coal	97	137	172	186	202	208
Nuclear	28	30	30	34	41	50
Biomass	44	50	52	59	54	57
Solar	0	1	7	22	42	74
Wind	0	1	9	17	28	39
Other Renewables	13	18	29	40	50	62
Total primary energy	417	524	628	692	738	769

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The authors stresses that the two scenarios are both challenging outlooks. Neither are ideal worlds, yet both are feasible and though prices and technology will drive some of these transitions, political and social choices will be critical. An overview of trends and characteristics of the main drivers in the two scenarios is provided in the following table.

	Drivers	Scramble scenario	Blueprints scenario
Demand	Choice	Mandates	Market driven but with incentives
	Prices	Externalities not included	Externalities included
	Efficiency technology	Mandates	Economic incentives & standards
	Efficiency behaviour	Necessity	Designed in
Resources	Oil & Gas	Constrained growth	Long plateau
	Coal	Fligh into coal	Coal not wanted unless clean
	Nuclear	Modest uptake	Continued growth
	Electric renewables	Sequential-wind, solar	Incentivise early stage technologies
	Biomass	Strong growth	Complements alternative fuel mix
Technology	Innovation	Strongly guarded	Extensively shared
	Implementation	National docking points	International flipping points
	Mobility	Hybrids & downsizing	Hybrids & electrification
	Power	Efficiency	Carbon capture & storage
	IT	Supply optimization	Demand load management systems
Environment	Land Use	Energy vs food principle	Sustainable principle
	Pollution	Important locally	Important
	Climate/Biodiversity	Background global concern	Prominent local & global concern
	Water	Energy production & climate change impact	Factored into development frameworks

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Time horizon: 2030

Topic	Issuing Institution
2.1 International and EU policy outlooks	
ESPON Programme	European Union
2.2 International and EU climate change and energy outlooks	
Global Climate Policy Scenarios for 2030 and beyond	JRC-IPTS
VIEWLS project “Clear Views on Clean Fuels”	ED DG TREN
EurEnDel - Technology and Social Visions for Europe’s Energy Future, European Energy Delphi	EC DG Research
Climate change and a European low-carbon energy system	European Energy Agency (EEA)
World Energy Outlook 2006	International Energy Agency (IEA)
Transport strategies under the scarcity of energy supply	EC DG Research
European Energy and Transport Trends to 2030 –Update 2007 -	DG TREN
2.3 Relevant foresight studies produced by business and other stakeholders	
Hydrogen Energy and Fuel Cells - A vision of our future	European Hydrogen & Fuel Cell Technology Platform (HFP)
The Vision 2030 Project – Final Report	UK Highways Agency
Mobility 2030: Meeting the challenges to sustainability The Sustainable Mobility Project – Overview 2004	World Business Council for Sustainable Development

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International and EU policy outlook

Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	EUROPEAN UNION Interreg III, Ministry of Interior and Spatial Development in Luxembourg May 2007												
Title	ESPON Project 3.2 Scenarios on the territorial future of Europe												
Main focus	<table> <tr> <td>Energy transition</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td>X</td> </tr> <tr> <td>Social change</td> <td>X</td> </tr> <tr> <td>Policy change</td> <td>X</td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input type="checkbox"/>	Economic change	X	Social change	X	Policy change	X
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Policy change	X												

Summary

This vision aims at providing a long-term scenario on the evolution of the European territorial system. The approach is the following:

- Firstly, it seemed essential to identify the most significant driving forces likely to shape the evolution of European territory in the decades to come; on such a base a Trend scenario at 2030 has been defined;
- Secondly, two integrated scenarios were elaborated looking at two possible socio-economic directions in the European arena: the competitiveness-oriented and the cohesion-oriented scenarios

The Trend scenario is based on the following hypothesis:

- As economic disparities at world scale remain significant, despite the rapid catching up of a number of emerging economies, **external migration pressure will continue to increase**. The primary sources of potential immigration are the countries of the southern and eastern parts of the Mediterranean basin and of Africa which have considerably higher population growth rates and much younger population structures than Europe. Migration flows to Europe increasingly come from countries originating from a broader spectrum of cultural, economic and social backgrounds.

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- In the context of progressing **globalisation**, it can be expected that **trade flows with Latin America and a number of emerging Asian countries will intensify**, while trade with Africa is not expected to grow significantly. Considering foreign trade specialisation, Europe has a strong position in the exports of technological and industrial products, but also of agricultural products and, increasingly also of services. In the context of the WTO, **numerous trade barriers for manufactured products were removed** and, in future, further trade liberalisation is expected in the sectors of services and agricultural commodities **The relocation of businesses** outside Europe is the most sensitive aspect of globalisation. In future, not only manufacturing activities but also service activities such as software production and programming, telephone marketing, law and tax consultancy, accounting, and financial information analysis etc., will be affected. In terms of territorial impacts, **only the mainly centrally located regions benefit from globalisation processes** if a number of conditions are fulfilled: economies strongly supported by R&D, medium-sized cities with strong cultural, scientific or tourist potential, good environmental conditions.
- Europe's external context will also continue to be characterised by **growing external energy dependency**, especially in the field of fossil energy sources (oil, gas, coal), but also in that of nuclear energy sources (uranium).
- A trend that is likely to continue into the coming decades is the **increasing proportion of people of pensionable age** in the general population.

It is interesting the evaluation of the **transport impacts** on the Trend scenario. Up to 2030, in fact, the transport situation in Europe has been conditioned by rather **modest average economic growth**, but traffic flows **have however continued to increase under the influence of continuing European integration**, of accelerating globalisation and of catching-up processes in Eastern Europe. The nature and geographical distribution of flows has also changed thanks to structural evolutions in the economy and to EU enlargements. **The levels of traffic congestion have generally increased. In Central and Eastern Europe, however, ambitious programmes of infrastructure development (mainly motorways) have alleviated the bottlenecks of the early 2000s.** More and more public-private partnerships have developed to provide the necessary financial resources. The privatisation of networks has progressed as has the liberalisation of the railway sector.

The two scenarios, the competitiveness-oriented and the cohesion-oriented ones, have the following characteristics:

- The **competitiveness-oriented scenario** is likely to generate stronger economic growth and higher competitiveness, with a more substantial emergence of new technologies. It will also produce **higher environmental and social costs** related to growing disparities at various scales, likely to result in the long range in economic and social drawbacks as well as in **territorial imbalances** with enhanced differences in living conditions and polarisation between areas.

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Economic activities and dynamic population development will be concentrated in central areas. On the macro, pan-European scale, this means the continued dominance of the area between the British Midlands and the north of Italy with some extension corridors. On a meso scale, capital cities will reinforce their polarisation.

- The **cohesion-oriented scenario** is likely to produce a significant amount of **added value in terms of territorial cohesion and balance**, of demographic revival, of socio-cultural integration, of lower damages related to natural hazards, of less negative impacts on rural regions, **but its economic and technological performance will probably be lower** than that of the two other scenarios. In addition, several new areas of economic integration with significant critical mass will emerge in the periphery. Some of their major metropolitan areas will rise in the European urban hierarchy. On the meso-scale, polarisation potentials are distributed among a greater number of urban areas with mid-sized cities playing an important role.

The following table summarises the hypothesis underlying the three scenarios. It can be seen that in terms of **transport impacts** the main difference between the competitive and cohesion alternative relies in the different priority given to the less-developed areas (accessibility): very low in the competitiveness option, higher in the cohesion alternative.

Baseline	Competitiveness-oriented	Cohesion-oriented
<i>Enlargement</i>		
- Combination of deepening and widening	- Priority given to enlargement	- Priority given to deepening
- Western Balkans in 2020	- Western Balkan and EFTA/EEA countries in 2015	- Break on further enlargement
- Turkey in 2030	- Turkey in 2020	
<i>Demography</i>		
- Stable total population	- Selective external in-migration; no constraints to internal migration	- Restrictive external in-migration
- Significant population ageing	- Increase in retirement age	- More flexible retirement ages
- Increasing but controlled external migration	- Encouragement of fertility rate through fiscal incentives	- Encouragement of fertility rates by more flexible arrangements for child care
- Unchanged constraints on internal migration		
<i>Economy</i>		
- Slowly increasing activity rate	- Strong reduction of EU budget	- Maintaining EU budget
- Decreasing public expenditure	- Further liberalisation and privatisation of public services	- Reinforcement of structural funds and concentration on weakest regions
- Growing R&D budget	- Strongly growing R&D budget	
<i>Energy</i>		
- Steady increase of energy prices	- Increasing energy consumption	- Realisation of TEN-E
- Stable energy consumption	- Realisation of TEN-E: investments in infrastructure according to market demand	- Promotion of decentralised energy production, particularly renewables
- Increasing use of renewables		
<i>Transport</i>		
- Continued traffic growth	- Realisation of TEN-T: investment in infrastructure according to market demand	- Development of TEN-T, priority given to peripheral regions
- Constant investments in infrastructure, but below demand	- Priority given to links between metropolitan areas	- Support to transport services in rural and less developed areas
- Partial application of Kyoto Agreement		

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International and EU climate change and energy outlooks**Visions for 2030 (abstracts)**

Issuing Institution(s), Project, Author(s)	JRC-IPTS Peter Russ, Tobias Wiesenthal, Denise van Regemorter, Juan Carlos Ciscar 2007												
Title	Global Climate Policy Scenarios for 2030 and beyond												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	<input type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

This scenarios have been provided by the Institute for Prospective Technological Studies (IPTS) of the JRC as a contribution to the European Commissions' Communication of January 2007 on "Limiting global climate change to 2 degrees Celsius". In particular, the JRC provided a number of model-based scenarios that were used as reference in preparing the EC Communication.

The scenarios have been developed using two model:

- The POLES energy model, providing insights into the response of the energy sector to the policies reducing the GHG emissions
- The GEM-E3 model, assessing the adjustments in the whole economy and the resulting impacts on GDP and household welfare.

Three main scenarios have been developed:

- A baseline scenario trend
- A Reference scenario, with the introduction of dedicated policies improving energy efficiency
- and a greenhouse gas (GHG) reduction scenario, taking into account the climate change policies aiming at reducing by 25% by 2050 the GHG (compared to 1990).

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It is important to consider that a **novel approach has been used in shaping the scenarios, i.e. not assuming a perfect emissions trading system in all sectors and across all the world regions**. Road transport, residential and tertiary sectors have not included in the international trading schemes and various clusters of countries are assumed to enter in the scheme at different points in time.

The following table summarises the assumptions:

	Baseline scenario	Reference scenario	GHG Reduction Scenario
Main characteristics	Business-As-Usual development of the energy system	Introduction of dedicated policies aiming at improving energy efficiency as a response to concerns about supply security	Introduction of dedicated GHG emission reduction policies. Differentiation of efforts between regions/countries and across sectors.
Global Population [million people]	8085 (8885)		
World GDP [million € PPP]	113644 (171646)		
GDP per capita [€ ₁₉₉₉]	14057 (19320)		
Oil price [€ ₁₉₉₉ /barrel]	55 (72)	51 (62)	48 (47)
Gross Inland Consumption per capita [GJ/cap]	85 (95)	78 (81)	74 (69)
Gross Inland Consumption per GDP [MJ/€ ₁₉₉₉]	6.1 (4.9)	5.5 (4.2)	5.3 (3.6)
GHG emissions per capita [t CO _{2,eq} /cap]	5.7 (5.7)	5.2 (4.9)	3.7 (2.3)
Global GHG emissions compared to 1990 levels	168% (186%)	153% (158%)	110% (75%)

Note: numbers in parenthesis are for 2050.

In the baseline scenario the future (at 2050) energy sector trends are projected on the basis of the current trends:

- Economic growth will offset the energy consumption per GDP decline, fossil fuel will dominate energy consumption, even if nuclear power and renewables will increase their share from 25% to 35%. GHGs will increase by 86% compared to 1990 level.

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- The Reference Scenario considers more sustainable policies as they are being introduced currently, e.g. the Chinese ambition to reduce the country's energy consumption. Energy efficiency, e.g. in the appliances sector and in the road consumption (emission standards), e.g. **car fleet reduction by 22% between 2005 and 2030**, will be substantial.
- The GHG scenario builds on the Reference, with the consideration of additional policies. Climate change policies are simulated through a carbon value. Differently by other scenarios a differentiated carbon market (by country and sector) is simulated, i.e. the carbon market is created for energy intensive sectors (including power) with industries joining later, Road transport, residential and tertiary sectors are not included. The carbon market actually existing in Europe (the EU ETS) is extended in all developed countries with a phased approach, e.g. in Russia carbon prices are assumed to align by 2020

The results of the scenarios can be summarised as follows:

In the baseline, **global GHG emissions are projected to increase by 86% (1990-2050)**, in particular due to the developing countries contribution. In the GHG reduction scenarios, after a peak in the 2020, there is a fall up to 2050 as consequence of the application of international emission trading schemes, **reducing the emissions from developed countries by 60% (+43% in developing countries)**. It is important to stress that without international participation (of the developing countries), the target can not be met. The following table summarises the trends

GHG emissions changes relative to 1990	2020			2030			2050		
	BASE	REF	RED	BASE	REF	RED	BASE	REF	RED
World	49%	41%	23%	68%	53%	10%	86%	58%	-25%
Developed Countries	10%	0%	-18%	16%	1%	-32%	19%	-7%	-60%
Developing Countries	130%	124%	106%	172%	159%	95%	222%	192%	43%
EU-25	-1%	-10%	-21%	-2%	-15%	-36%	-5%	-25%	-60%

Note: The table presents the domestic emissions compared to 1990; it does not illustrate emission reduction targets that include the use of flexible mechanisms. Emissions are from sectors included in the POLES model, thus excluding emissions from agriculture and land use and land use change.

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The carbon price should be 65 €/tCO₂ equivalent in 2030 (except in the low developing countries). **The power sector will be affected by the price of carbon-fuels, due to the availability of low carbon alternatives. Nuclear and renewables will increase their shares.**

The direct costs needed for restructuring the energy sector are 0.4% of GDP for the period 2013-2030. **The change on global GDP is -0.24% (year) to EU 27.**

Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	VIEWLS Project Eric van den Heuvel (Project Coordinator) and partners 2005												
Title	Shift Gear to Bio fuels. Results and recommendations from the VIEWLS project												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	<input type="checkbox"/>	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Economic change	<input type="checkbox"/>												
Social change	<input type="checkbox"/>												
Policy change	<input type="checkbox"/>												

Summary

The project provides in the short < 10 years and long term horizon (> 10 years) an estimate of:

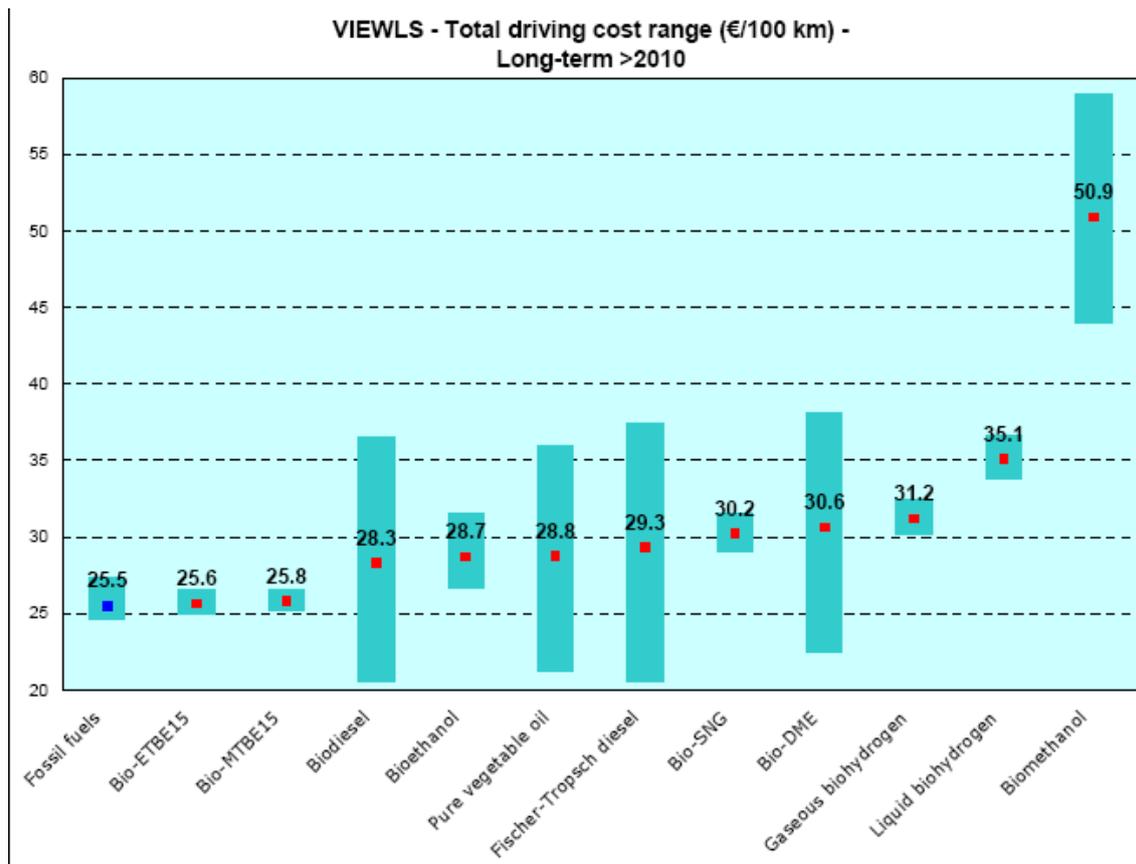
- The economic and environment - technical performances of the various transport bio fuels, both existing bio fuels and those still under development.
- The biomass production potential in the Central and Eastern European region, and the possible bio fuel trade chains that may develop from this within Europe.

Concerning the bio fuels **production costs**, they are higher than those for traditional petrol and diesel. This applies to the current bio fuels and is also expected to apply to the future bio fuels. The latter is primarily caused by the technological development stage that these fuels have currently reached. **A structural reduction in production costs for these fuels is in fact only expected in the long term.** At current oil prices the production costs are 2 - 3 times higher for the current bio fuels and will be 2 - 4 times higher for future bio fuels. Recent extreme oil prices have a positive effect on the difference between the production costs. Apart from the production costs, transport costs (expressed in euro per kilometre) are also an important parameter, and include all costs necessary to move a car one km; fuel costs are just one item on the list. The result

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is that the extra costs – per km driven – of bio fuels, compared to their fossil - based counterparts, are much smaller: between 3% and 29% for the current bio fuels, and 1 - 100% for future bio fuels.

The following graphs display the reference VIEWLS values and ranges for the various bio fuel costs and fossil-fuels based in a long term horizon (>2010).



The long - term horizon (>2010) shows that the passenger cars that could compete (under good production conditions) with a fossil fuel car are those fuelled with a mixture of up to 15% bio - ETBE and bio - MTBE, and those running on 100% bio diesel, vegetable oil, FT - diesel and bio - DME. This could also be the situation with bio ethanol, under very good production conditions .

The current bio fuels are characterised by higher costs per ton of avoided CO₂ - equivalents. The review revealed that the costs are generally 300 - 700 euro per ton CO₂ - eq., although some studies indicated exceptions, both above and below these amounts. These high costs are caused by higher production costs, but primarily by the relatively limited CO₂ - eq. benefit. The study review showed that, in the long term

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(after 2010), **reduction costs could fall to levels between 40 and 200 euro per ton CO₂ - eq.** This is mainly due to (i) improved production methods for the current bio fuels, with lower costs and better CO₂ reduction, and (ii) the arrival of bio fuels produced from cellulose - based raw materials, which are characterised by significantly higher CO₂ - eq. reductions.

Concerning the production potentials, The new Member States on the eastern side of the European Union offer prospects for growing raw materials to produce bio fuels.

The following table summarises the conclusion of the project.

Environmental and economic performance	Potential and trade in CEEC region	Biofuel market introduction model
<p>Lower GHG emissions</p> <p>Further reduction with future biofuels</p>	<p>Potentially up to 6-12 EJ biomass reservoir at 35-44 Mio ha.</p> <p>In agro-intensive scenario</p>	<p>High share of biofuel possible (20% in 2030)</p> <p>Sufficient land for biofuels available</p>
<p>Higher driving costs</p> <p>But almost competitive with oil price increases</p>	<p>Low biomass production cost possible < 2 €/GJ</p> <p>Based on perennial lignocellulosic biomass</p>	<p>In short-term least-cost conventional biofuels</p> <p>Future Ligno-fuels become important</p>
<p>GHG mitigation costs can drop to 40 €/tCO₂-eq.</p> <p>Shift from oil crops to lignocellulose biomass</p>	<p>Export from CEEC to WEC with existing key transport corridors</p>	<p>Break-even points for biofuels at 40-80 \$/bbl crude oil</p>

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Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	EurEnDel Project Timon Wehnert (Project Coordinator) and partners 2004												
Title	Technology and Social Visions for Europe's Energy Future a Europe-wide Delphi Study												
Main focus	<table> <tr> <td>Energy transition</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input checked="" type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	<input checked="" type="checkbox"/>	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input checked="" type="checkbox"/>
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Policy change	<input checked="" type="checkbox"/>												

Summary

The aims of the visions at 2030 are the following:

- to explore future trends in energy technology development.
- to assess the potentials of emerging and existing technologies to contribute towards a sustainable development.
- to add the development of a common European knowledge base on energy technologies.
- to identify research needs in the energy field which help to promote a sustainable development.

The methodological approach for defining the visions is the DELPHI survey. More than 3,400 energy experts from 48 countries were originally invited to participate in this two-round, web-based Delphi exercise. The response rate was about 20%. The results with reference to energy and transport domains are the following:

- Energy Demand

On both statements on energy demand there is a great consensus by the survey participants. **Doubling the energy efficiency in industrial production** is considered to be likely before 2030 by 65% of the respondents. An even higher percentage, 75% of

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the respondents anticipate 50% of **all new buildings in Europe to be low energy** buildings before 2030. Only a marginal share (1 to 2%) consider these developments to be totally unlikely.

- Transport

A 20% market share of fuel cell driven cars is expected by the respondents in the late 2020s. Note that this is well before hydrogen is expected to play a significant role in Europe's energy system. **On the issue of a 25% share of bio fuels for transportation the expert's opinions are divided:** The majority expects this to happen before 2030. However quite a large share (15%) of respondents consider 25% a too larger number.

Furthermore, a comparison of the EurEnDel Delphi results with two energy scenarios, which were developed from quantitative models, has been carried out. These were "European Energy and Transport - Trends to 2030" published by the European Commission, DG TREN and the "With Climate Policies (WCLP) scenario which is used as one of the baseline scenarios in the EU-wide CAFE (Clean Air For Europe) process managed by the European Commission, DG Environment.

The next table summarises the results.

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No	Delphi Statement	Time of Occurrence *	Never **	Reference studies: Trends 2030 / WCLP	Comparison Result	Deviation ratio
Demand						
1	Industrial energy consumption in Europe is reduced by 50% per produced unit through novel production processes	2028 (2021 – 2034)	2%	No info on novel production processes; energy intensity reduction 2000 - 2030: 38% (<i>Trends 2030</i>); 39% (<i>WCLP</i>)	Delphi more optimistic than reference studies.	1.3
Transport						
3	Fuel cell driven cars reach a European market share of 20%	2027 (2020 – 2032)	1%	Fuel cell cars are not expected to gain significant market share until 2030 primarily due to costs but also lack of fuel supply infrastructure. (<i>Trends 2030</i>)	Delphi much more optimistic than reference study.	> 10
4	Bio-fuels will have a European market share of >25% in the road transport sector	2027 (2018 – 2030)	15%	5% in 2030 (<i>Trends 2030</i> and <i>WCLP</i>)	Delphi much more optimistic than reference studies.	5
5	Improved logistics based on information and communication technologies raise the railway's market share in Europe's freight transport to 15% [1990: 11%, today: 8%].	2019 (2012 – 2023)	10%	No info on ICT in railways the share of rail freight transport declines from 17.1% (2000) to 11.2% (2030) (excluding short sea shipping) (<i>Trends 2030</i> and <i>WCLP</i>)	Delphi much more optimistic than reference studies.	-
Storage and Distribution						
6a/ 6b	Hydrogen produced from diverse sources (H2 from RES: solely from renewables) and used as an energy carrier constitutes a significant part of the energy system (transport and stationary application)	2031 (2023 – 2040) (H2 from diverse sources) 2034 (2026 – 2042) (H2 from RES)	5% (6a) 19% (6b)	Share of new energies (hydrogen etc.) in final energy demand will rise to 1.4 Mtoe in 2030 (i.e. 0.1%) (<i>Trends 2030</i>)	Delphi much more optimistic than reference study.	> 20
Supply						
14	Renewable energy sources cover 25% of Europe's total energy supply [Today it is 6%]	2028 (2020 – 2033)	4%	"Relatively slow penetration of renewables"; the use of renewables will rise by 74% (<i>Trends 2030</i>) between 2000 and 2030 (<i>WCLP</i> : 106%); the share of renewables in gross inland consumption rises from 5.8% in 2000 to 8.6% (<i>Trends 2030</i>) in 2030 (<i>WCLP</i> : 10.5%)	Delphi much more optimistic than reference studies.	3 / 2.5
15	Photovoltaic cells contribute with >5% of European electricity generation [Today it is 0.15%]	2030 (2023 – 2040)	9%	"Solar photovoltaic energy starts emerging beyond 2020 (accounting for 1.3% of total installed capacity by 2030). (<i>Trends 2030</i>) No data on production shares	Delphi much more optimistic than reference study.	> 10

* (Mean value of the 2nd survey round considering only respondents who classified themselves as either "experts", "knowledgeable" or "familiar" for the respective topic. The given time range in brackets refers to the lower and the upper quartile. This means that 50% of the respondents expect an occurrence in the given timeframe, 25% expect an earlier, and 25% expect a later occurrence.)

** Share of respondents who consider this statement "never" to become reality

It can clearly be seen that the results of the EurEnDel Delphi are generally more optimistic in terms of technical developments and structural changes compared to the reference studies.

Visions for 2030 (abstracts)

Issuing Institution(s),	European Environment Agency (EEA)
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Project, Author(s)	Andreas Barkman, André Jol, Stephane Isoard, Aphrodite, Mourelatou and Tobias Wiesenthal (EEA) and others. 2005												
Title	Climate change and a European low-carbon energy system												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

This report presents an assessment of possible greenhouse gas emission reduction pathways made feasible by global action and a transition to a low-carbon energy system in Europe by 2030. It analyses trends and projections for emissions of greenhouse gases and the development of underlying trends in the energy sector. It also describes the actions that could bring about a transition to a low-carbon energy system in the most cost-effective way.

A baseline scenario and a climate action scenario have been defined:

The baseline scenario is a modestly optimistic economic growth scenario with a diverse development of the European energy system. The European population is projected to be **relatively stable** in the short to medium term and even to decline in the longer term, and thus increases in energy consumption are caused mainly by income growth. The baseline scenario **does not take into account climate policies** related to implementation of the Kyoto Protocol. At European level the 'long-range energy modelling' (LREM) results have been used. A similar baseline scenario is used up to 2020 for the Clean Air for Europe (CAFE) programme. For the purpose of this report, the European scenario was extended to include non-CO₂ GHGs using a model developed by AEA, and non-CO₂ energy emissions and carbon sinks using IMAGE, TIMER and FAIR models developed by RIVM. The POLES model, developed by IPTS (JRC), was used for additional global energy and CO₂ emission scenarios.

The climate action scenarios explore ways in which Europe can move towards long term sustainable objectives, in particular the EU long-term target for global temperature increase. The scenarios include policies and measures to reduce emissions of all six Kyoto gases for all the relevant main emitting sectors. **A global emissions pathway to achieve a GHG concentration of 550 ppm CO₂-equivalent** has been developed in order to provide the global context. Since a large part of the emissions are from the energy sector, specific scenarios have been developed for this sector. The low carbon energy pathway (LCEP) scenarios form part of the climate action scenarios and are designed to illustrate the development of the energy sector in which carbon prices alone determine the development of the energy system. They explicitly analyse actions

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beyond those formally agreed to date. **They assumed a CO₂ price increase from EUR 20/tCO₂ in 2020 to EUR 65/tCO₂ in 2030.** In the ‘core’ LCEP scenario, CO₂ emission reductions are more or less evenly distributed over various technological options, in a least-cost approach. The choice between supply and demand options to reduce the emissions of GHGs is made on the basis of cost effectiveness of measures only.

The key conclusions can be summarised as follows:

- The climate action scenario shows that by domestic actions alone, based on a **carbon permit price of EUR 65/t CO₂**, the EU could reduce its greenhouse gas emissions to **16–25 % below the 1990 level by 2030**. Thus a substantial share of the reductions needed to achieve the assumed target of 40 % by 2030 could be achieved by actions inside the EU, with international emissions trading providing the remaining reductions.
- In the climate action scenario, substantial changes in the EU energy system are projected, leading to energy related emissions of CO₂ (the most important greenhouse gas) **in 2030 that are 11 % below the 1990 level**, compared with 14 % above in the baseline scenario.
- Reductions in the energy intensity of the economy are expected to account for almost half of the emission reduction in 2010. Towards 2030, their contribution will decrease, requiring a shift of effort to **further long-term changes** in fuel mix, mostly in the power generation sector.
- Towards 2030 **more than 70 % of the CO₂ emission reductions (in the climate action scenario compared with the baseline) are expected to be realised in the power generation sector**, mostly as a result of a shift to low or non-carbon fuels
- The use of solid fuels is projected **to decline substantially and of natural gas to increase rapidly**. Renewable energy (mainly wind power and biomass use) shows the largest increase of all primary energy sources (42 % higher than in the baseline)
- CO₂ emissions from transport are projected **to continue to grow in all climate action scenario variants (to 25–58 % above the 1990 level by 2030)**, because of the steady increase in passenger and freight demand.
- The additional **annual costs of the climate action scenario compared with the baseline scenario are projected to be about EUR 100 billion by 2030**. This would represent about 0.6 % of EU GDP, which is projected to double between 2000 and 2030.

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Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	European Environment Agency (EEA) Economic Analysis Division of the IEA in cooperation with and other divisions of the IEA 2006												
Title	World Energy Outlook												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

This scenario moves from the twin energy-related threats: that of not having adequate and secure supplies of energy at affordable prices and that of environmental harm caused by consuming too much. In such a context, the IEA report aims at advising alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future.

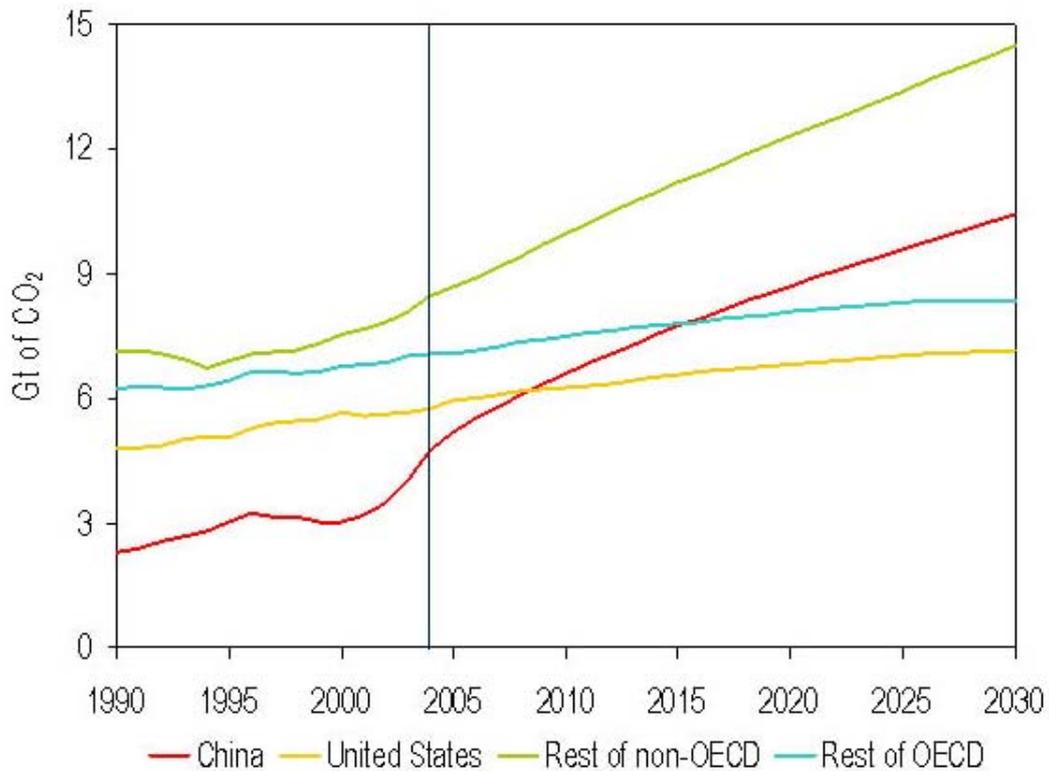
The Reference Scenario **presents projections for supply and demand of oil, gas, coal, renewables, nuclear and electricity to 2030**. It also assesses energy-related carbon dioxide emissions. The projections incorporate the latest energy-market and price developments as well as macroeconomic conditions. It covers 21 separate regions and the world as a whole. For the first time, separate projections for the United States and Canada are provided. This change reflects both the different energy context of the two countries and their positions as net importer and net exporter.

In the WEO 2006, the profile and significance of the **World Alternative Policy Scenario** is elevated and presented in the format that can be used as a 'policy tool' for governments to change the unsustainable trends of the Reference Scenario. **The Alternative Policy Scenario is built on policy measures such as energy efficiency and increased use of renewables and nuclear.**

The WEO 2006 also includes a study of **the impact of higher energy prices on demand and the economy**. The objective is to analyse quantitatively the consequences of higher energy prices on energy markets and the wider economy, both historically and in the future. In particular, it attempts to answer questions such as: Why have both energy demand and economic growth apparently responded so little to higher prices in recent years? To what extent do price subsidies dampen the impact of higher international energy prices on demand and accentuate the macroeconomic pain? What does recent experience tell us about prospects for energy demand and economic growth in the future? Which regions, sectors and social groups are most vulnerable to persistent higher prices? The work has global scope but will focus on developing regions, notably in developing Asia and Africa. The chapter also provides a global subsidy database. The work has been carried out in close collaboration with the IMF, the World Bank, the Asian Development Bank, the African Development Bank and the OECD.

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The CO₂ emissions in the baseline scenario show that at 2030 the contribution of China and developing world will be significant.



Carbon-dioxide emissions grow slightly faster than primary energy use as the fuel mix becomes more carbon-intensive. **Coal remains the leading contributor to global emissions. China accounts for 39% of the increase between 2004 and 2030, overtaking the United States as the world's biggest emitter before 2010.**

Coal is in fact the most abundant fossil fuel. Proven reserves at the end of 2005 amounted to around 909 billion tonnes, equivalent to 164 years of production at current rates. Around half of these reserves are located in just three countries – the United States, Russia and China.

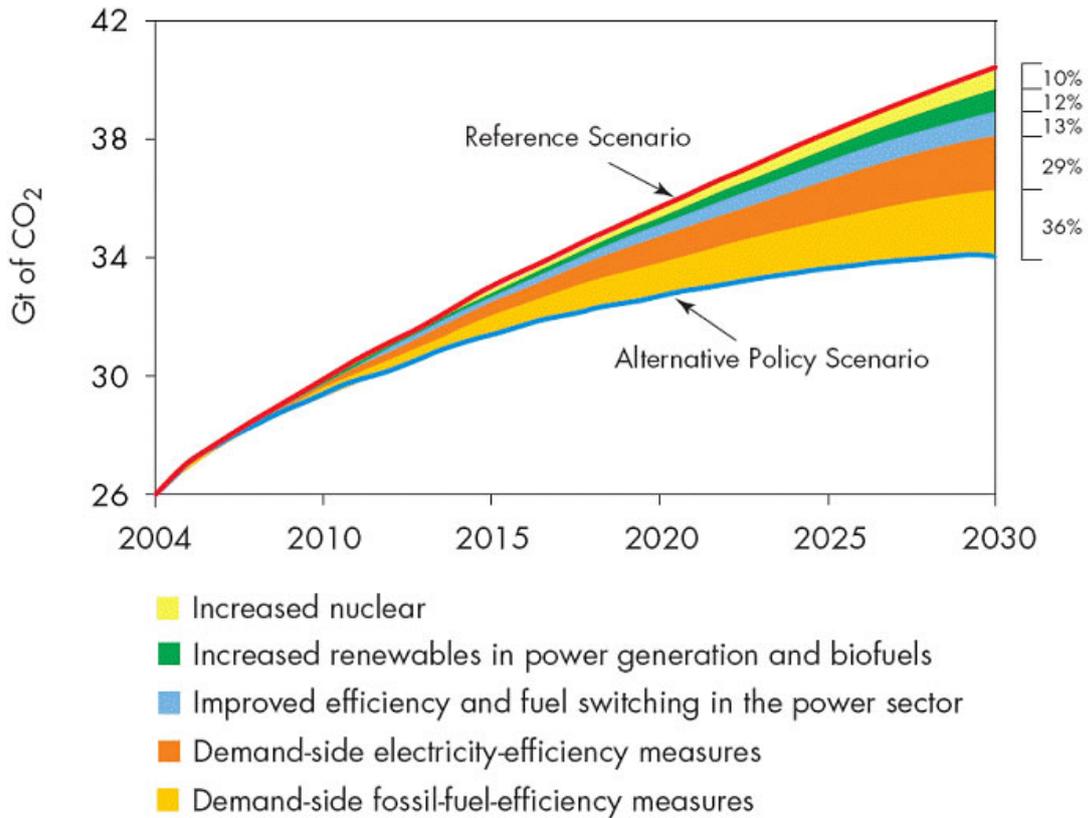
- Power generation accounts for 81% of the increase in coal use to 2030. Demand will remain sensitive to developments in clean coal technology and government policies, as well as to relative fuel prices.
- Coal needs continue to be met mainly by indigenous production. China –the world's leading coal producer – and India account for over three-quarters of the 3.3 billion-tonne increase in coal production in 2030 over 2004.

The Alternative Policy Scenario analyses how the global energy market could evolve if countries were to adopt all of the energy security and CO₂ emissions policies they are currently considering.

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World primary energy demand in 2030 is about 10% lower in the Alternative Policy Scenario than in the Reference Scenario – roughly equivalent to China’s entire energy consumption today. The impact of new policies is felt throughout the period: in 2015, the difference between the two scenarios will already be 4%, or 534 Mtoe.

The graph below shows the contribution to the overall gain in CO2 emissions from the single package of measures



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Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	European Union Project Buck Consulting (co-ordinator) and partners 2006												
Title	Transport Strategies under the scarcity of energy supply – STEPS Project												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

The scenarios at 2030 evaluates the impacts of two policy strategies against the BAU scenario. The scenarios have been defined both at national and local level.

The Business As Usual scenario is based on existing European policy concerning the transport and energy system. It assumes that actual measures and projects will be carried out and implemented and that the strategy based on this policy will remain the same up to 2030. This includes among others the planned TEN investments, at the assumption that these can be delayed due to shortage of funding.

The results include several aspects: transport demand, energy consumption, greenhouse and polluting emissions, economic development, local accessibility, etc. The analysis has been articulated in the following three main parts:

1. Analysis of the forecasted future trends is reported in the no-policy scenario under the low oil price growth assumption (scenario A-1) and in the business-as-usual scenario still under the low oil price growth assumption (scenario A0);
2. The effects of higher oil/fuel price, i.e. the results of the no-policy scenario under the high oil price growth assumption (scenario B-1) and in the business-as-usual scenario still under the high oil price growth assumption (scenario B0);
3. The impacts of the policy measures, i.e. the results of the scenarios A1, A2, B1 and B2

In the A0 scenario, car and road freight clearly continue to be the main modes even though their shares are slightly reduced. The growth of the overall mobility does not trigger a proportional increment of the energy consumption in the transport sector. Total fuel consumption in the A0 scenario is substantially unchanged over the simulation period. This effect is due to the evolution of the vehicle fleet: in fact it is assumed that innovative vehicles (electric, fuel cells, etc.) will amount to about 10% of the fleet at 2030 in the A0 scenario. A greater efficiency of the vehicles explains why more or less

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the same amount of fuel is used even if demand is increasing. Additionally, renewable energy sources assume a greater importance even if only the energy consumed in the transport sectors is considered. The measures simulated in the A0 scenario do not add much to the base trend of the A-1 scenario, even if direct greenhouse emissions are reduced in the final years of the simulation period. It seems this is not the case when well-to-wheel emissions are considered, as is forecast in the Edinburgh model.

On the economic side, the impact of the Business-as-usual policy measures (especially pricing and taxing of road modes) is to slightly reduce the growth of GDP and employment, but the base trend of the no-policy scenario is not significantly changed.

Of special interest is the impact of the higher assumptions concerning the **evolution of energy price**, that is results from scenarios B-1 and B0, where such an assumption is added to the no-policy or Business as Usual case respectively. The assumption about oil price is a 7% growth rate p.a., and the demand/supply mechanism in the fossil fuel market simulated within the POLES model leads to a slower growth of gasoline and diesel prices, which is on average about 4% p.a. **In fact, the main consequence of a faster growth of oil price seems to be a strong pressure for improving efficiency and using alternative sources of energy.** On the transport demand side, the impact is also visible (although not so dramatic) and consists partially of a reduction of total mobility and partially of a shift to non-road modes. Passenger demand seems more elastic than freight demand and the faster growth of fuel price significantly affects car ownership as well.

Two diverse policy strategies have been simulated, one pivoted around technology investments (scenarios 1) and the other aimed at transport demand regulation (scenarios 2). The expected impact of both strategies is especially to help save energy and reduce harmful transport emissions, but a full assessment of their effects has to take into account other dimensions also such as the effect on the economy and on accessibility.

The following tables summarise the impacts of the policy scenarios compared to the A-1 scenario, using some variables that can provide a broad idea about the environment, the energy system, the economy and the mobility: emissions, energy consumptions, the average travel time per trip, accessibility and economic cohesion.

Model	CO ₂ emissions	NO _x emissions	Energy consumption	% innovative vehicles	GDP	Accessi-bility	Relative Cohesion (GDP)
ASTRA	□	□	□	□	□	n.a	n.a.
SASI	n.a	n.a.	n.a.	n.a.	□	□	□

Increment change with respect to A-1
 Not significant change with respect to A-1
 Decrement with respect to A-1

Increment with respect to 2005
 Decrement with respect to 2005
 Near constant with respect to 2005

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Apparently, in comparison to the low oil price growth assumption, positive and neutral effects are dominant: pollution diminishes (even if CO2 is increasing with respect to year 2005) as well as energy consumption. Average time per trip is stable as well as GDP (even though a slight decrement is forecast) and relative cohesion. However, negative effects can be found on accessibility.

In brief, according to the modelling simulations, a faster growth of fuel price on its own would not be a too bad perspective, assuming that the modelled reactions in terms of improved efficiency are actually put into practice.

From the table below it can be seen that the technology investments scenario under the low oil price growth assumption is able to realise improvements for almost all the variables considered with some local exception. Progress is generally made also with respect to year 2005, although CO2 emissions are generally increasing and accessibility levels are diminishing.

Model	CO ₂ emissions	NO _x emissions	Energy consumption	% innovative vehicles	GDP	Accessi-bility	Relative Cohesion (GDP)
ASTRA	□	□	□	□	□	n.a.	n.a.
SASI	n.a.	n.a.	n.a.	n.a.	□	□	□

□	Increment change with respect to A-1	□	Increment with respect to 2005
□	Not significant change with respect to A-1	□	Decrement with respect to 2005
□	Decrement with respect to A-1	○	Near constant with respect to 2005

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Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	European Commission Directorate-General for Energy and Transport Prof. P. Capros, Dr. L. Mantzos, V. Papandreou, N. Tasios 2008												
Title	European Energy and Transport Scenarios Trends to 2030 – Update 2007												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

The 2007 report provides an update of the “Trends to 2030” published in 2003 (and updated in 2005). The scenarios and projections to 2030 encompass energy demand, transformation, imports and production by fuel and sector. The report also gives, in the annex, a breakdown of the main energy and transport variables as well as energy related CO2 emissions for all 27 Member States

The Baseline scenario was finalised in November 2007 and gives an update of the previous trend scenarios, such as the “Trends to 2030” published in 2003 and its 2005 update. This new Baseline scenario takes into account the high energy import price environment of recent years, sustained economic growth and new policies and measures implemented in the Member-States. The results were derived with the PRIMES model by a consortium led by the National Technical University of Athens (E3MLab), supported by some more specialised models. The Baseline scenario for the EU and each of its 27 Member- States simulates current trends and policies as implemented in the Member-States by the end of 2006.

Concerning the policy scenario, they have been constructed with reference to the Baseline scenario examining – among other things – **the achievement of energy policy targets on e.g. renewables or CO2 up to the end of 2006.**

The overall results can be summarised as follows:

- Total EU-27 energy requirements continue to increase up to 2030. **In 2030 primary energy consumption is 11% higher than in 2005.** The energy growth rates become smaller over time with consumption almost stabilising post 2020

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reflecting lower economic growth and stagnating population in the last decade of the projection period.

- **The 11% increase in the primary energy consumption by 2030 is much lower than the GDP growth over the same period (71%).** Thus, energy intensity (i.e. ratio between primary energy consumption and GDP) improves by 1.7 % per year up to 2030
- Renewables increase most, growing by over 90% from today to 2030. As a result of political decisions on nuclear phase-out in certain old Member-States and the closure of plants with safety concerns in some new Member-States, nuclear energy is 20% smaller in 2030 than it was in 2005
- The **share of fossil fuels** in total energy consumption falls only marginally by 2030, reaching 78% (compared with 79% in 2005).
- **Final energy consumption for transport and stationary purposes (e.g. in industry and households) increases by 20.5% from 2005 to 2030.** This is 10 percentage points more than the growth of primary energy demand
- **Transport energy demand in 2030 is projected to be 28% higher than in 2005.** After having seen very high growth rates in the 1990s, **the increase of energy use for transportation decelerates. In the projection period, transport energy demand growth rates decline over time. This reflects the decreasing growth rates over time of both passenger and freight transport activity.** In addition, there are fuel efficiency improvements in particular in passenger transport (e.g. private cars). Therefore, energy demand in transport grows less than transport activity (in passenger- and tonnekm).
- Contrary to the past, the projection period displays some significant fuel switching in the transport sector as a result of the implementation of the bio fuels Directive. **Under baseline conditions the bio fuels share in 2010 rises strongly to almost 4%** - however, falling somewhat short of the indicative target of 5.75%. Nevertheless, this target would be met in 2015 and the share continues increasing up to 2030 to reach 9.5%.
- The **structure of power generation changes significantly in favour of renewables, natural gas and solid fuels, whereas nuclear and oil lose market shares**
- The **CO2 results for EU-15 (which has a Kyoto target of minus 8% for greenhouse gases) are much more alarming.** EU-15 CO2 in 2010 (mid-year of the first Kyoto budget period) are projected to be 5.6% higher than they were in 1990 and these emission in EU-15 are expected to increase further by 2030 to 11% above the 1990 level

Relevant foresight studies produced by EU Member States

Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	European Commission DG TREN High Level Group for Hydrogen and Fuel Cells technologies 2003												
Title	Hydrogen Energy and Fuel Cells A vision of our future												
Main focus	<table> <tr> <td>Energy transition</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td>X</td> </tr> <tr> <td>Social change</td> <td>X</td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	<input type="checkbox"/>	Climate change	<input type="checkbox"/>	Technological change	X	Economic change	X	Social change	X	Policy change	<input type="checkbox"/>
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Summary

In 1999 the “Vision 2030” Project was commissioned to enable the Highways Agency (HA) to look further ahead than the usual 5-10 year planning cycle. The aim of Vision 2030 was “**to develop visions for mobility needs of people and goods in thirty years’ time**”. Clearly a spectrum of possible futures exist and it is not possible nor sensible to set out one single vision. So the approach has been to try and identify the key factors that are likely to influence transport over the next 30 years or so and document the main trends and possibilities.

The process of developing the three Vision 2030 scenarios and twelve transport visions of the future of inter-urban transport has drawn heavily on the information gathering phase of the project. Each of the visions reflects an imaginable picture of transport of the future which in turn has important implications for the HA. The relevant transport visions are summarised as follows:

- People. Demographic factors are important in shaping the UK’s travel patterns. **Population growth, the increase in the number of households and their location affect the number of journeys made.** Generally, as the population grows, **travel tends to rise proportionately due to factors such as increasing car ownership. By 2030 there will be more women drivers and more older drivers on the roads.** Infrastructure development will have to take into account large numbers of elderly people. **Because activities have become more dispersed, personal mobility, although clearly a basic right, is sometimes an obligation.** This problem, which relates to land-use planning, will become increasingly important as the population ages. **If distances to facilities and services increase, people will find it harder to give up their cars.** Providing the elderly with home services in isolation is not likely to be sustainable as the elderly will still want to have a social life, including visits to friends, and this will involve travel
- Lifestyle. **People will spend more time on leisure associated with a larger proportion of people in retirement,** flexible working patterns and increased opportunities for being economically active beyond the present retirement age.

Tourism continues to grow with faster long distance travel, and travel in non-peak hours may increase at a greater rate relative to commuting travel, as the retired have more leisure time.

- **Travel. Road:** With **increasing prosperity, more people with driving licences and several million new households likely** over the next three decades, there is potential for a **dramatic increase in traffic. Car ownership is continuing to increase as a result of increasing GDP**, falling vehicle purchase costs and changing living arrangements. **Air.** Demand for air travel has been growing rapidly, both globally and in the UK. In the UK, air traffic forecasts produced by DTLR10 show that unconstrained demand for passenger **air travel may more than double by 2015**. Air traffic at UK airports is expected to grow at an annual average of 4.5% between 1995 and 2020 under the mid-point forecasts (with no capacity constraints). **Rail.** By 2010, in order to meet the growing demand for transport, and to reduce its environmental impact, the Government hopes that **large-scale investment in upgrading and expanding the rail network will allow 50% more passengers to travel by train.**
- **Freight.** Growth in freight transport has resulted from increases in the **physical quantities** of goods produced and consumed; increases in the number of links in the supply chain; and increases in the lengths of these links. **New patterns of freight transport have emerged**, such as long hauls serving the whole of Britain, and “just-in-time” (JIT) logistics which involve precise planning of deliveries to match production or sales needs
- **Safety.** Most advances in safety have come from **improvements in road and motor vehicle design**, increased seat-belt use and decreased drunk driving. Public awareness campaigns have also helped to improve safety. Additional improvements in safety are expected to come from advances in motor vehicle road designs, in-vehicle technologies, technology enhanced traffic-law enforcement, and improvements in pedestrian/cyclist safety.
- **Environment.** By 2030 **air quality is likely to be better than it is today**. The improvements will be driven by the continuing public pressure for a healthier environment. New technologies and fuels will be the mechanisms by which air quality gains are made. Electric hybrid vehicles, fuel cell engines, and new fuels – from reformulated petroleum products and new sources like biomass – will be commonplace through widespread commercialisation and “green marketing”. **Despite progress in reducing noise from individual vehicles, as traffic volumes increase, noise pollution, particularly from road and air transport, is expected to rise and become an issue of growing concern.**
- **Energy.** Truly commercially competitive fuel cell products **are not yet available** and widespread uptake is unlikely before 2010. For the transport sector, capital cost projections for volume manufacture of fuel cell systems compare favourably with internal combustion engines.

Relevant foresight studies produced by business and other stakeholders

Visions for 2030 (abstracts)

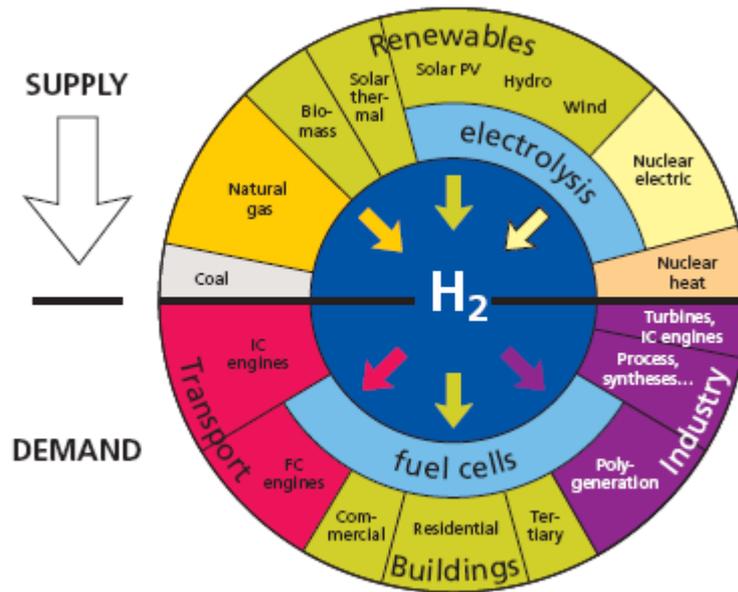
Issuing Institution(s), Project, Author(s)	European Commission DG TREN High Level Group for Hydrogen and Fuel Cells technologies 2003												
Title	Hydrogen Energy and Fuel Cells A vision of our future												
Main focus	<table> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Social change</td> <td><input type="checkbox"/></td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	<input type="checkbox"/>	Technological change	X	Economic change	<input type="checkbox"/>	Social change	<input type="checkbox"/>	Policy change	<input type="checkbox"/>
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Summary

The preparation of this vision requires the outlining of the research, deployment and non-technical actions that would be necessary to move from today's fossil-based energy economy to a future sustainable hydrogen-oriented economy with fuel cell energy converters.

The background of the report is the forecasted demand for energy that is growing at an alarming rate. The European "World Energy Technology and Climate Policy Outlook" (WETO) predicts an average growth rate of 1.8% per annum for the period 2000-2030 for primary energy worldwide. The increased demand is being met largely by reserves of **fossil fuel** that emit both greenhouse gasses and other pollutants. Those reserves are diminishing and they will become increasingly expensive. **Currently, the level of CO2 emissions per capita for developing nations is 20% of that for the major industrial nations.** As developing nations industrialise, this will increase substantially. **By 2030, CO2 emissions from developing nations could account for more than half the world CO2 emissions.**

The production of hydrogen from existing energy systems, its use through fuel cells and the wide range of their application is shown in the following picture.



The potential CO₂ emissions that could be avoided through the 35% of new cars fuelled by hydrogen-fuel cells in 2040 is shown in the table below.

YEAR	% of new cars ⁽¹⁾ fuelled by zero-carbon hydrogen	% of fleet fuelled by zero-carbon hydrogen	Average CO ₂ reduction (all cars) ⁽²⁾	CO ₂ avoided per year (MtCO ₂)
2020	5	2	2.8 g/km	15
2030	25	15	21.0 g/km	112
2040	35	32	44.8 g/km	240

(1) Figures based on an assumed European fleet of 175m vehicles. The fleet size will increase significantly by 2040, with correspondingly larger benefits.
 (2) Calculation is independent of total number of cars.

It is important to mention that the numbers for H₂-fuelled cars are an assumption based on a survey of experts for conventional and alternative automotive drive trains, but not a prediction of future production or sales.

On the policy side, the following steps are required:

- A political framework that enables new technologies to gain market entry within the broader context of future transport and energy strategies and policies.
- A Strategic Research Agenda, at European level, guiding community and national programmes in a concerted way.
- A deployment strategy to move technology from the prototype stage through demonstration to commercialisation, by means of prestigious ‘lighthouse’ projects which would integrate stationary power and transport systems and form the backbone of a trans-European hydrogen infrastructure, enabling hydrogen vehicles to travel and refuel between Edinburgh and Athens, Lisbon and Helsinki.

- A European roadmap for hydrogen and fuel cells which guides the transition to a hydrogen future, considering options, and setting targets and decision points for research, demonstration, investment and commercialisation.

On the technical side, the following barriers need to be overcome:

- Solving the technology challenges of hydrogen production, distribution, storage, infrastructure and safety, and reducing the costs of all of these, as well as the improvement in the materials, components and system design;
- Solving the technology challenges of fuel cell stack performance, durability and costs, as well as of all the peripheral components (reformer, gas cleaning, control valves, sensors, and air and water management systems).

Visions for 2030 (abstracts)

Issuing Institution(s), Project, Author(s)	World Business Council for Sustainable Development WBCSD 2004												
Title	Mobility 2030: meeting the challenges to sustainability												
Main focus	<table border="0"> <tr> <td>Energy transition</td> <td>X</td> </tr> <tr> <td>Climate change</td> <td>X</td> </tr> <tr> <td>Technological change</td> <td>X</td> </tr> <tr> <td>Economic change</td> <td>X</td> </tr> <tr> <td>Social change</td> <td>X</td> </tr> <tr> <td>Policy change</td> <td><input type="checkbox"/></td> </tr> </table>	Energy transition	X	Climate change	X	Technological change	X	Economic change	X	Social change	X	Policy change	<input type="checkbox"/>
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Summary

The project was launched in April 2000 to help the understanding of how the needs of society to move freely, gain access, communicate, trade and establish relationships might be improved without sacrificing other essential human or ecological requirements now or in the future.

In order to judge the present and possible future state of sustainability of mobility and how effective various approaches might be in facilitating its improvement, the authors identify a set of indicators that reflect sustainable mobility's various elements. The result was a set of 12 indicators that constitutes the most important dimensions of sustainable mobility.

They are: 1) **accessibility**, to be understood as “fundamentally concerned with the opportunity that an individual at a given location possesses to participate in a particular activity or set of activities”; 2) **the financial outlay required** to obtain desired personal and goods transport services. It does not reflect the external costs of transport. But it does reflect the affordability of these services from the viewpoint of those paying the bill including private costs generated by the existence of external costs (to the extent that these costs are reflected in the financial outlay required to obtain transportation services); 3) **travel time**, the time required for a trip; 4) **reliability**, it covers the degree of certainty in travel times on transportation systems; 5) **safety**, to the individual, the thing that matters is the likelihood that he or she will be involved in an incident that might result in death or serious injury. The analogous situation in goods transport is the shipper's perception of the risk that his or her shipment will be damaged or destroyed due to a crash or mishandling during a transfer. To society as a whole, what matters is the burden that traffic accidents impose – measured in terms of the total number of traffic-related deaths and serious injuries; 6) **security**, ranging from personal and related to the transport system, 7) GHGs emissions, 8) **environmental impact**, measuring a major aspect of society's concern about mobility – its impact on the environment and on public well being; 9) **resource use**, this “umbrella” indicator reflects another area of social concern. It covers three sub-factors: transport-related energy use and energy security, transport-related land use, and transport related materials use; 10) **equity**, addressing economic and social opportunity; 11) **impacts on public revenues**, addressing the impact on public revenues and expenditures, and the rate of return to suppliers of mobility inputs and services; 12) **rate of return to private business**, allowing the providers to earn an adequate rate of return.

Having defined the indicators, the next task has been to project over the next several decades if present trends continue.

The findings are the following:

- **Personal and goods transport activity will grow rapidly**, driven primarily by rapid growth in real per capita income. Transport activity growth will be especially rapid in countries of the developing world
- **Improvements in goods mobility** will enable consumers to obtain greater quantity and variety of goods at lower cost thereby helping to support economic growth and development
- **Transport-related GHG emissions will grow significantly** especially in developing countries. The energy efficiency of transport vehicles will improve but these improvements will be more than offset by a combination of increases in the number of vehicles and in average vehicle utilization
- **Transport will continue to depend overwhelmingly on petroleum-based fuels.**
- Transport-related conventional emissions (emissions of NO_x, VOCs, CO, and particulates) **will decline sharply in developed countries** over the next two decades reflecting more stringent emissions standards, improved technology, and relatively slow increases in total vehicle numbers. In urbanized areas of many developing countries, emissions are likely to grow in the next few decades before declining, reflecting rapidly increasing numbers of vehicles.
- **Road vehicle-related deaths and serious injuries will fall in the OECD countries** and in some “upper-middle income” developing countries.
- **Congestion may worsen in many urbanized areas** in both the developed and developing worlds
- **Transport-related security will remain a serious concern.**
- **Transport-related noise probably will not decrease.**
- Transport’s resource “footprint” will grow as transport-related materials use, land use, and energy use all increase.
- **Personal mobility spending as a share of households’ total spending should remain roughly constant or decline** for an average household in the developed world. In the developing world the household spending trend is difficult to project.
- In contrast, the trend in the **share of the average household’s income spent on goods mobility should continue to decline** nearly everywhere