



# Backcasting approach for sustainable mobility

Edited by Apollonia Miola



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## *Summary*

Several approaches for strategy analysis and future analysis methods exist: scenario technique, forecasting, backcasting, Delphi studies. In this context, forecasting methods are dominant, but the complementary development of backcasting planning methodology is particularly useful when problems at hand are complex and when present time is part of the problem such as sustainability issues.

This report summarises the results of an exploratory research on “Backcasting approach for sustainability planning in the transport sector”.

Aim of this research is the identification of main elements of a methodology to develop backcasting scenarios for policy of sustainable mobility.

The report consists of two sections.

The first part analyses the most common future methods. It examines the applications of backcasting approach in a sustainability context and identifies main steps of a backcasting exercise to achieve a sustainable transport system.

In the second section, a backcasting exercise to define an EU sustainable transport system is developed to give a practical example of this method and to define some policy packages to achieve an EU sustainable mobility.

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**SECTION I: FUTURE STUDIES AND BACKCASTING  
APPROACH APPLIED WITHIN PROJECTS FOR  
SUSTAINABLE TRANSPORT**

## **1 Introduction**

Boulanger and Breger (2002) argue that policy making for sustainability constitutes a very special kind of decision making. This peculiarity is essentially connected to three reasons. Firstly, definition of the goals and objectives are part of the decision making problem itself. Secondly, there is a plurality of decision makers with their own preferences, objectives, and expectations. Thirdly, the assessment of costs and benefits is very difficult for sustainability issues because of the presence of externalities, uncertainty, and interplay of human beings and nature (*ibid*). To move society in the direction of sustainability, policy actions should be fostered through a set of principles like, inter and intra generations equity, precautionary principle, as well as the likely economic, environmental and social impacts have to be anticipated and assessed.

During the last decade, the number of tools and approaches to develop sustainability is growing rapidly (Robert *et al*, 2002). The complexity of planning for sustainability, because current trends and actions are part of the problem, has highlighted the importance of applying backcasting method to have an informed vision of one's goal in order to strategically deal with potential trade-off from different decisions (*ibid*).

This is valid also for planning a sustainable transport system.

In the past, transport has mainly been seen as having a serving function for the economy and leisure activities. Where sustainable mobility is a major policy objective, transport cannot fulfil these demands in an unlimited way.

During the last years the debate on transport policy has involved the challenge of sustainable development. There has always been a realization that transport has significant environmental costs, but in the past these have mainly related to local environmental issues, such as noise, severance, visual intrusion and some pollutants. The new debate is much broader and it includes the global pollutants, acid rain, the use of non-renewable resources, and the health effects of transport (Banister, 2005).

From the point of view of transport planning, the imperative to predict the growth in demand and the overriding importance of economic factors are becoming less dominant. Methods need to be developed to measure quality of life, social impacts,

and the environmental/ecological costs of transport (*ibid*) in the framework of sustainability of transport.

## **2 Future studies: typologies and techniques**

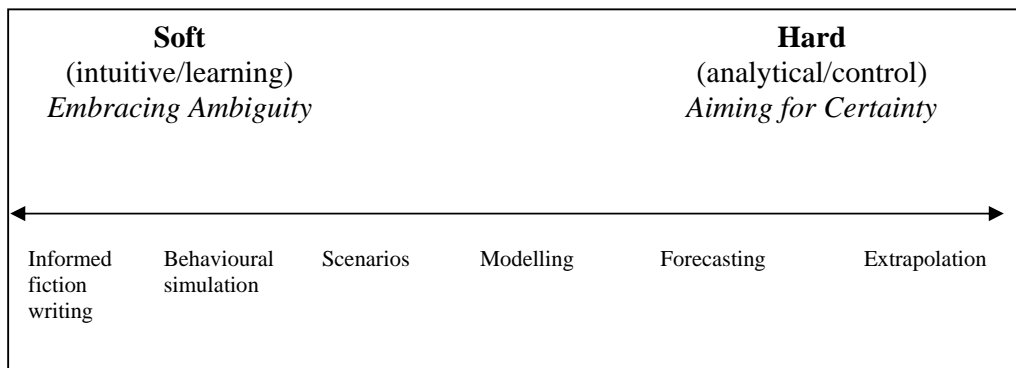
Future studies are basically used to provide analytical frameworks for policy decisions in the identification of dangers and opportunities and in assessing alternative actions under different conditions. Their role has become more and more central for current policy-making process that is characterised by increasing complexity at macro-or aggregate level as well as by decreasing degree of conditionality at the micro-level due to elevated autonomy of individual actors.

This means that social institutions are less powerful in affecting change through simple and straightforward policy response (Ling, 2002).

Substantive and long lasting transformation can only come about through the accumulation of several smaller-scale actions operating at the interface of policy domains rather than within a single perspective. In this context strategy and future analysis methods can help to identify such interface. They are often used to illustrate what might happen to society in order to permit the individual, or society itself, to adapt to perceived future trends.

The most effective futures studies are used to define a broader conceptual framework for discussing the future and to contribute to policy formulation and the emergence of unforeseen new options. Nevertheless, their aim is not to predict the future, but to assist decision-making under uncertainty which is to be defined as indeterminacy (Dreborg, 1996) especially for the long term.

According to Chatterjee and Gordon (2006), future studies can be categorized on the basis of the context that is being studied (fig1). If the context is simple, predictable and largely controllable then planning methodologies such as forecasting and extrapolation may be appropriate. However, in more complex and unpredictable circumstances, an alternative approach, such as scenario planning, is more appropriate (*ibid*).



**Figure 1: Practices used in the study or prediction of the future. Source: Chatterjee and Gordon, 2006.**

Moreover, Banister and Stead (2004) argue that future studies can be classified considering the three basically modes of thinking about the future:

- **Probable** futures: *what is most likely to happen?* This category includes forecasting studies which are characterized by a predictive nature and which are mainly focused on trend monitoring and historical data analysis;
- **Possible** futures: *what might happen?* Scenario studies are included in this group and can be categorised as descriptions of possible future states and their developments (Borjeson *et al*, 2006).
- **Preferable** futures: *what we would prefer to happen?* Studies focusing on normative or desirable futures, such as backcasting and normative forecasting, try to answer the question which characterises this group.

In general terms, there is no consensus on a single classification or a guide to apply the most suitable future study approaches. Beyond any kind of classifications or definitions, the user's worldview, perceptions and aims for the study are the most important thing when a future study is going to be developed.

However, the scenario approach is the most frequently used method.



## 2.1 Scenario typology

Scenarios can be defined as a representation of visions/images of the future and courses of development organised in a systematic and consistent way.

Since around the 60s, the first applications of scenario techniques were used by many companies (Multinational companies like the RAND Corporation and later Royal Dutch Shell were the first users). The first and widely cited definition was provided by Kahn and Wiener in 1967 (EEA, 2000): “*Scenario are hypothetical sequences of events constructed for the purpose of focussing attention on causal process and decisions points*”.

Rotmans and van Asselt (1998) define scenario as archetypal images of the future, created by mental map or models that reflect different perspective on past, present and future developments. Banister (2004) highlights the distinction between scenarios and visions or images of the future. Visions or images of the future are often static ‘snapshots’ in time, whereas scenarios are dynamic, logical sequences of events.

A scenario is a description of society’s current situation (or part of it) of possible and desirable future societal situations and series of events between current and future situations” (Becker *et al.* (1982)).

The starting point for many scenarios is to identify ‘predetermined’ and ‘underdetermined’ elements. The predetermined elements are the same in each scenario; the underdetermined elements are elaborated in several ways, depending on possible future developments, and thus result in future images (Van der Heijden, 1996).

There are different types of scenarios depending on the objectives and perspective of the scenario setters and their use. Summarising the relevant literature Ling (2002) draws a useful distinction between the ‘precautionary model’, the ‘visionary model’ and the ‘learning model’ of scenario writing.

Scenario developed under the precautionary model approach has as a goal to envisage a negative future state resulting from a certain course of events in order to demonstrate or make explicit the negative consequences of present actions and to elaborate ways to counteract these. Under the ‘visionary model’, a preferred future is designed and then strategies for reaching this future are outlined using the so called backcasting approach (Banister and Stead, 2004).

Both the precautionary and visionary models of scenario writing are normative oriented. In a consultation exercise further insights can be gained by comparing different normative scenarios arrived at by different stakeholders or institutions.

Additionally, following Rotmans's categorization (2000), scenarios can be classified distinguishing between:

- **Forecasting and backcasting scenarios.** Forecasting means to make statements regarding the future based on explicit or implicit assumptions from the present situation and observed trends. On the other hand, backcasting is a strategic problem-solving framework, searching the answer of how to reach specified outcomes in the future. In other terms, it is possible to distinguish projective and prospective scenarios. A projective scenario's starting point is the current situation; extrapolation of current trends results in likely future images. A prospective scenario's starting point is a desirable future situation, usually described by a set of goals or targets established by assumed events between the current and future situations.
- **Quantitative and qualitative scenarios.** Scenario may be expressed in two basic forms: qualitative and quantitative. Qualitative scenario is narrative and describes the future in the form of words or visual symbols. They are used in cases where data is missing or weak. Quantitative scenarios provide numerical information and often are based on models which contain many implicit assumptions about the future.
- **Descriptive and normative.** Description scenarios list a set of possible events without taking into account their desirability. Normative scenarios, reasoning from specific targets which have to be achieved, take values and interests into account.
- **Participatory and expert.** Participatory scenarios involve stakeholders to co-design scenarios with experts. Expert scenarios are developed by small group of experts who are responsible for their design and development.

Scenario can furthermore be classified taking into account their geographical scales (i.e. global, international regions, national and sub-national regions), time horizon (which can be short, less than 20 years, one generation, and long term, two generations and beyond), and the level of integration: vertical integration (cause and effect chains within one issue) and horizontal integration (between different sectors

and issues). Concluding, there is no general consensus on scenario typologies. However, key aspects of scenario types can be summarized (table 1) taking into account Banister and Stead 's classification of future studies and taking into account the specific needed technique for building each type of scenarios.

**Table 1. Scenario categories and main techniques. Borjeson et al.(2006).**

Scenario category	Quantitative/ Qualitative	Time frame	Main techniques
<i>PREDECTIVE – What will happen</i>			
Forecasts	Typically quantitative, sometimes qualitative	Often short	Surveys; Workshops, Original Delphi method, Time series analysis; explanatory modelling.
What if	Typically quantitative, sometimes qualitative	Often short	Surveys; Workshops, Delphi method, Time series analysis; explanatory modelling.
<i>EXPLORATIVE – what can happen?</i>			
External	Typically qualitative, quantitatively possible	Often long	Surveys; Workshops, Delphi method modified; explanatory modelling.
Strategic	Qualitative and quantitative	Often long	Surveys; Workshops, Delphi methods; explanatory modelling
<i>NORMATIVE – How can a certain target be reached?</i>			
Preserving	Typically quantitative	Often long	Surveys; workshops.
Transforming	Typically qualitative with quantitative elements	Often very long	Surveys; workshops, Backcasting Delphi.

## **2.2 Techniques to build scenarios**

The aim of a scenario defines also the most suitable technique to reach the user's objective. Some of these techniques are: trend monitoring, Delphi methods. All these techniques can be integrating in modeling that Borjeson (2006) defines as "a number of different techniques for integrating parts into wholes".

### **2.2.1 Trend Monitoring**

The first step in thinking about the future involves exploring trends that are already underway. A trend can be described as a pattern of change over time in things of importance to the observer. Quantitative trend analyses are probably the most common method of forecasting. They are often applied to areas where there are solid and preferably long historical data collections, such as demographics, economics and technology. The degree of uncertainty about the future is much smaller in some areas than in others.

They are mainly based on the analysis of historical sequence data by various fairly mechanical methods. A number of these methods are rather primitive; others are based on complex statistical analyses or on complex mathematical structures (Chatterjee and Gordon, 2006). Some of the most important methods and tools based on are: time series forecasts; trend extrapolations; cycle analyses; long waves analyses. These studies are often criticised for their lack of creativity and consideration of future developments. In effect, the tendency is to project from the past to the future in a straight line and not to consider less predictable possibilities.

Main advantage of mechanical projection is the impersonality and objectivity of this process (Banister and Stead, 2004). This means that it is possible to test whether the method has been used correctly. It is also possibly to evaluate statistically its validity in an applied setting. Quantitative analyses perform an important function by showing what will not be the future. If, for example, an extrapolation of a defined trend shows a logical inconsistency in the world picture, this could force a structural change.

A projection which shows the results of inaction can in itself promote a change of policies. Indeed, this maybe the very reason for making this projection.

The principal problem with quantitative analyses is a tendency for people to accept them unquestioningly as a kind of truth about the future rather than simply a starting point for discussion (*ibid*).

Quantitative trend analyses tend to work best for projecting forward in a relatively stable system. But an increasing number of dynamic and unpredictable forces may influence the field and therefore affect the forecast. They project historical trends out into the future. They are actually extrapolations of the past. Making decisions based solely on quantitative analysis, therefore, depends on a starting point in the past.

### **2.2.2 Foresight technique and Delphi Survey**

Foresight can be defined as a “systematic, participatory, future -intelligence-gathering and medium to long term vision building process” (FOREN, 2001). This technique is used to anticipate socio-economic, political, institutional, environmental changes and, accordingly, to define suitable policy strategies.

Foresight exercises have been used for several purposes:

- To forecast developments and changes in the areas of society, environment, economy, technology and science, and to create policy strategies to meet challenges;
- To define key areas of science and technology that are vital for economic development and hence that should be prioritised for funding;
- To elaborate pathways of technology application, to create wealth and to improve the quality of life whilst respecting environmental concerns.

Foresight is always concerned with the long term look into the future, typically with a time frame of five to thirty years. It has to be considered a process, rather than a set of techniques, which contains the interaction of many societal groups like the scientific community, policy makers, government, and different sectors of the economy.

It could be said that foresight is an overall attempt to prepare for future challenges and changes by trying to assess the challenges entailed in the long-term future.

Generated strategies should not only prepare for future challenges but they also should try to influence and alter the changing process due to own perceptions and goals.

There are several techniques that can be used in foresighting.

Central to a foresight exercise are expert consultations, which, in turn, can use brainstorming, scenario-writing analysis and Delphi method.

Namely, the Delphi method has been developed in the 1950's and 1960's by the RAND Corporation to make forecasts on future developments. It has been used since then in various national foresight processes to design roadmaps of future technological developments. A Delphi analysis involves the survey of experts' opinion – 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 a series of questionnaires sent out to the same group of experts several times, each time adding the results of the previous rounds. One feature common to most Delphi surveys is that the "questions" are formulated as statements or hypothesis. Whereas the experts are then asked to state the time when they believe the hypothesis will be fulfilled. From this, roadmaps or timetables of future developments can then be drawn. In addition to the core variable time, in many Delphi exercise the possible impacts of the hypothesis become true and measures to foster an earlier occurrence are assessed.

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 anonymity of the participants.

### **2.3 Conclusion**

In general terms, there is no consensus on a single classification or a guide to apply the most suitable future study approaches. Beyond any kind of classifications or definitions, the user's worldview, perceptions and aims for the study are the most important thing when a future study is going to be developed. Scenario typologies and techniques are essential to answer user's questions on future.

Aim of this report is to analyze backcasting approach and technique to support policy makers to reach sustainability in a specific sector such as transport.

### 3 Backcasting

Backcasting stands out as an alternative to traditional forecast (Robinson 1990). It is a method in which the future desired conditions are envisioned and steps are defined to attain those conditions, rather than take steps that are merely a continuum of present methods extrapolated into the future. A definition of Backcasting is given by the World Health Organization (WHO) glossary: “*Moving step-wise back in time from a future scenario to the present in order to identify the decisions and actions that must be taken at critical points if the scenario is to be achieved*” ([http://who.int/terminology/ter/Health\\_futures.html](http://who.int/terminology/ter/Health_futures.html) ).

Backcasting approach was originally developed in 1970s as an alternative to traditional energy forecasting and planning technique for electricity demand and supply.

Energy studies using backcasting were especially concerned with so-called soft energy policy paths, characterized by a low-energy demand society and the development of renewable energy technologies (Quist, Vergragt, 2006). In general terms, at that time, energy studies were a response to regular energy forecasting, which were mainly based on trend extrapolation, projections of rapidly increasing energy consumption and which were focused strongly on large scale fossil fuel and nuclear technologies to deal with estimated growth.

By developing an energy backcasting approach the focus became analysis and deriving policy goals. The *backcasts* of different alternative energy futures were also meant to reveal the relative implications of different policy goals (Robinson, 1982) and to determine the possibilities and opportunities for policy making.

From the 1990s, backcasting has been focused on the identification of sustainability solutions regarding a wide range of different topics like river basins, transportation and mobility, transforming companies into sustainable ones, sustainable technologies and sustainable system innovation. Shifting the emphasis on sustainability, a development towards participatory backcasting has taken place utilizing inputs from broad range of stakeholders. It has been argued that the distinctive features of backcasting make it appropriate for sustainability applications. This mainly has to do with the idea of taking desirable (sustainable) futures or range of sustainable futures

as a starting point for analyzing their potential, their feasibility and possible ways of achieving them.

### **3.1 Backcasting method**

The term backcasting was coined by Robinson (1982) in the description of a method of policy analysis. Robinson defines the backcasting like a normative and designed-oriented method which works “backwards from a particular desired end point to the present in order to determine the feasibility of that future and what policy measures would be required to reach that point” (Robinson, 1990 p.823) .

A backcasting process moves from a definition of future goals and objectives. Then those are used to develop a future scenario. End points are usually chosen for a time far into the future, around 25-50 years. Though several varieties of backcasting can be distinguished, it is possible to put them into a methodological framework for participatory backcasting consisting of several stages which can be schematized in the following steps (Quist, J., *et al*, 2006):

- Step 1 Strategic problem orientation;
- Step 2 Specification of external variables;
- Step 3: Construction of future visions or scenarios;
- Step 4 Backcasting: backwards-looking analyses;
- Step 5 Elaboration and defining follow-up and an action agenda.

The strategic problem orientation of step 1 includes definition of normative assumptions and setting goals. The backcasting process starts determining objectives with a description of purpose of analysis; temporal, spatial and substantive scope of analysis and number and type of scenario. Then, the objectives are translated in specific goals, constraints and targets for scenario analysis and exogenous variables.

In the step 2 the exogenous variables are specified to describe the system not incorporated within the backcasting itself, but significant to describe the context within which the analysis take place. This description is useful to define external components that could act as direct inputs to the scenario analysis (i.e. changes in precipitation levels and patterns).



The construction of future visions or scenarios of the third step is the core stage of the backcasting process. It consists of the analysis of the future context at the end and mid points, development of future visions or scenarios, analysis of internal consistency of the scenario.

The elaboration in step 4 includes both design and analysis. This step undertakes impact analysis by consolidating scenario results, analysing social, economic and environmental impacts, analysing the consistency between goals and results.

The process is useful if it is connected to the policy process by the last step which aims at determining the behaviour and institutional responses that are required for the implementation of the scenarios and the policy measures that are implied in those responses.

It is stressed that although the approach is depicted stepwise and seems to be linear, it is definitely not. Iteration cycles are likely, while there is also a mutual influence between steps following one another.

Finally, four groups of tools and methods can be distinguished within this framework. The first group consists of participatory tools and methods. This group concerns all tools and methods that are useful for involving stakeholders and for generating and guiding interactivity among stakeholders. The second group consists of design tools and methods. This includes tools and methods for scenario construction, but also for designing and elaborating systems or stakeholder interaction processes. The third group relates not only to different assessments of scenario and design like consumer acceptance studies, environmental assessments and economic analysis, but also includes methods for evaluation of (social) processes in the backcasting project and stakeholder analysis. The fourth group concerns overall management, co-ordination and communication tools and methods. (Quist, J., *et al*, 2006).

### **3.2 Backcasting approach**

Backcasting is explicitly intended to suggest the implications of different futures, chosen not on the basis of their likelihood but on the basis of other criteria defined externally to the analysis (e.g. criteria of social or environmental desirability).

Dreborg (1996) argues that backcasting is not a method in *strict sense*, but it is more useful to think of this as an approach which is particularly useful when:

- problem to be studied is complex and there is a need for major change;
- dominant trends are part of the problem;
- problem to a great extent is a matter of externalities;
- scope is wide enough, and
- time horizon is long enough to leave considerable room for deliberate choice.

In the backcasting process one envisions oneself acting in a desirable future, where the principles for success have been met, and then one plans what must be done now to move towards that point. In complex systems like the ecosphere, and with complicated projects, like sustainable development, this is an effective methodology to align various measures with each other, so that each activity can be the logical platform for the next. (Robert, K.H., 2000). Following Dreborg, backcasting is an approach to facilitate discovery, different from the more commonly applied strategy forecasting, i.e. starting the planning procedure from today's situation, and projecting today's problems and trends, and what are considered realistic solutions today in to the future.

Dreborg (1996) distinguishes differences between forecasting and backcasting studies at different levels and states that backcasting studies must reflect solutions to a specified social problem. The table 2 summarizes the differences between forecasting and backcasting studies.

A significant difference between forecasting and backcasting approaches is in the attitude taken to uncertainty (Dreborg, 1996). In forecasting approach the uncertainty is usually treated in terms of sensitivity of the model results to variations in external variables. The future studies of forecasting have as idea to figure the future out what will really happen in order to permit society or a customer to adapt to the more or less inevitable trends. In the forecasting approach it is impossible to predict our own future decisions to the extent that they are influenced by future knowledge. They often are total causal model. The backcasting approach takes into account the indeterminacy of the future and tries to define a broader conceptual framework for discussing the

future; the study is less vulnerable to unforeseen change. This kind of studies may give an impulse for new knowledge.

	<b>Forecasting</b>	<b>Backcasting</b>
<b>1.Philosophical view</b>	Causality; Determinism Context of justification	Causality & teleology; Partial indeterminacy; Context of discovery;
<b>2. Perspective</b>	Dominant Trends Likely futures Possible adjustments How to adopt trends	Societal problem in need of solution; Desirable futures; Scope of human choice; Strategic decisions; Retain freedom of action;
<b>3. Approach</b>	Extrapolate trends into the future; sensitivity analysis	Define interesting futures; Analyse consequences, and conditions for these futures to materialise;
<b>4. Method</b>	Various econometric models	Partial & conditional extrapolations Highlighting interesting polarities and technological limits
<b>5. Techniques</b>	Various mathematical algorithms	

**Table 2: Forecasting and backcasting five levels. Dreborg, 1996, p 819.**

### 3.3 Conclusion

Backcasting can be defined as first creating a desirable (sustainable) future vision or normative scenario, followed by looking back at how this desirable future could be achieved before defining and planning follow up activities and developing strategies leading towards desirable future. Hojer and Mattsson (2000) suggest that forecasting and backcasting are complementary. If the visions are unlikely to be reached according to the most reliable forecasts, model calculations and other estimates, the purpose of the backcasting study should be to generate images of the future or

scenarios that fulfil the targets. Furthermore, Hojer and Mattson (2000) emphasise the importance of scrutinising how to attain that future, identifying the necessary measures and actions for bringing about that future and using models and regular forecasting tools for quantifying the consequences of different measures.

While forecasting is a way of predicting a likely future state of affairs, backcasting is a way of constructing a desirable future. In forecasting, the present situation and present trends are important factors in the process, while a desirable future is the starting point when constructing the strategy in a backcasting process (Roth, 2002). In the next section, backcasting approach is analysed as a useful tool to achieve sustainability.

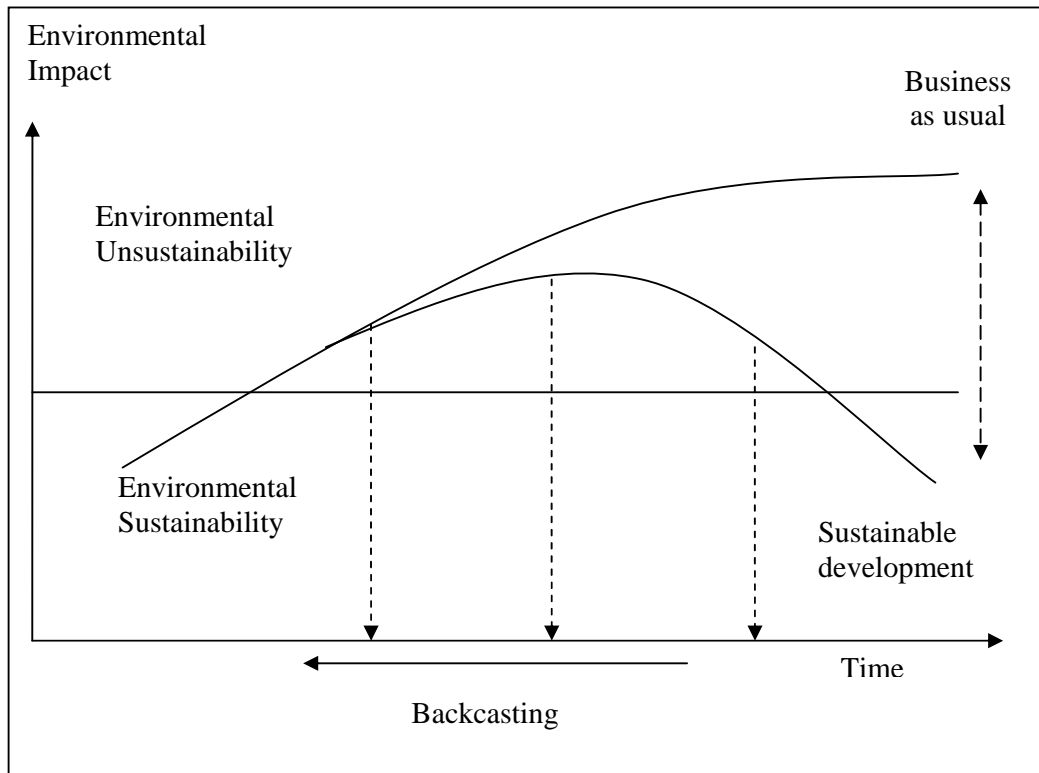
#### **4. Backcasting approach and sustainability**

To move society in the direction of sustainability, policy actions should be fostered through a set of principles like, inter and intra generations equity, precautionary principle, as well as the likely economic, environmental and social impacts have to be anticipated and assessed.

During the last decade, the number of tools and approaches to develop sustainability is growing rapidly (Robert *et al*, 2002). The complexity of planning for sustainability, because current trends, actions and planning are part of problem, has highlighted the importance of applying backcasting method to have an informed vision of one's goal in order to strategically deal with potential trade-off from different decisions (*ibid*). That strategic thinking is not always the case can be highlighted by many examples from the current debate. For instance, in the energy sector rather than discussing various options (nuclear power, renewable energies, etc.) from a sustainability perspective, the public debate often focuses on the short term consequences and problems from alternative energy sources, and then projects those full scales into future, without considerations of the goals or the full potential for the alternatives. A *sustainability perspective* should take into account that today's trend should only influence the initial scale of the transition, not its directions. That is the essence of backcasting, which should be followed and complemented by the more commonly

applied methodology of forecasting. If the forecasting is the sole planning strategy, there are substantial risks that ‘fixing the problems’ will retain the principle mechanisms from which the problem arose.

The figure below summarizes the backcasting approach in comparison with the forecast approach in a sustainability framework.



**Figure 2 Backcasting and forecasting approaches in a sustainability framework. Banister, 2006.**

The backcasting approach, due to its normative and problem solving character, is well suited for long-term problems and long-term sustainability solutions (Dreborg, 1996). According to Mudler and Biesiot (1998), backcasting approaches extend the definition of sustainability, by emphasizing the equity in space and time and, it also deals with

the issue whether the intra-generational equity may or may not be reached by the actual timetable given.

Robinson (1990) mentioned that backcasting is not necessarily only about how desirable futures can be attained, but also possibly about analysing the degree to which undesirable futures can be avoided or responded to.

Dreborg emphasises that our perception of what is possible or reasonable may be a major obstacle to a real change.

#### **4.1 Conclusion**

Achievement of sustainability objectives requires combinations of technological, cultural, social, institutional and organizational changes, while affecting many stakeholders when diffusing into society and involving complex process of social change on the long term. Sustainability is very complex, due to the inherent uncertainty of the future and the inherent ambiguity of stakeholders having different value sets.

Planning for sustainable development requires different methods and paradigm from traditional planning (Rotmans, 2000) because of need for understanding of the possible linkage among socio-economic, environmental and institutional processes.

Backcasting for sustainable strategies means that the goal of the planning process is a future sustainable solution. Backcasting starts from defining the future sustainable situation. The future situation can be defined in several different ways and also by viewing different aspects of the future. A way of approaching the definition of the future is to create image of the future, which describe how the society developed to a sustainable condition. These external images describe the development of the political and market environment of the future, and do not necessary give any quantifiable information of the future sustainable situation.

#### **5. Backcasting for sustainable transport planning: some applications**

Several future studies were developed during the last years as additional policy analysis tools. In France a strong research tradition called *La Prospective* (Godet,

2000) has been developed to design scenarios of future states; in Germany *Leitbilder* tradition is to inspire visions or to guide images (Dreborg, 1996).

The backcasting study approach has been used widely in Scandinavian research over the last 20 years. In Sweden, where the future studies are particularly developed, backcasting has been elaborated as a methodology for strategic planning for sustainability (Holmberg, 1998), which has become known as the Natural Step methodology. This variety of backcasting has been applied quite successfully in corporations like IKEA.

The shift to participatory backcasting using broad stakeholder involvement started in the Netherlands, where it was applied at the governmental programme STD that ran from 1993-2001 (Vergragt, Jansen, 1993) and in its EU funded spin-off, the research project “*SunHouse*” that ran from 1998 to 2000 (Quist *et al*, 2001). Both initiatives are focused on achieving sustainability and need fulfilment in the far future, using a backcasting approach that includes broad stakeholder participation, future visions or normative scenarios, and the use of creativity for moving beyond present mind sets and paradigms.

More recent future studies have been carried out with similar approaches, in sustainable transport, recycling and waste management (Dreborg and Steen, 1994; Jungmar *et al*, 1995). The EU-POSSUM project (Banister *et al*, 2000) was the first project to assess European Transport policies as to their consistency and feasibility, using qualitative scenario based on backcasting approach.

Then, the OECD project on Environmentally Sustainable Transport (EST) (OECD, 2000; 2002a; 2002b) uses backcasting method to consider what the transport system would look like in Europe if current transport emissions were reduced by 80-90%.

More recently, in UK VIBAT project examines (Visioning and Backcasting for UK Transport Policy) the possibilities of reducing transport carbon dioxide emissions in the UK by 60% by 2030 using scenario building and backcasting approach.

The next paragraphs describes these projects to identify main elements of a backcasting approach for sustainable transport.

## 5.1 OECD project on Environmentally Sustainable Transport

In 1994, the Environmental Policy Committee's Task force on Transport of the Organization for Economic Co-operation and Development (OECD) initiated a project on Environmental Sustainable Transport which was completed in 2000. The project involved several team of experts from nine countries<sup>1</sup>, each with a separate geographical focus. Main purposes of project were: (i) 'to examine and refine the concept Environmentally Sustainable Transport (EST); (ii) to determine the kind of actions required to achieve EST and (iii) to develop guidelines for the attainment of EST that could be of use to Member countries in formulating policies and measures whose implementation would result in EST (OECD, 2000).

The analysis of policy approach to transport environmental impacts highlighted the predominance of forecasting methodology which usually involves an assessment of future conditions in terms of current trends and accommodation to the trends or modest adjustment of them.

This approach has been considered to be reasonable in short term, but not sufficiently effective to indicate solutions to environmental problems caused by the transport sector needing structural changes and long term horizons. In effect, in the long term, the potential for policies to influence development in desired directions is relatively large. Major obstacle to real change is perceptions of what is possible or reasonable (OECD,2002b).

These considerations are at the basis of the choice of putting backcasting methodology at the core of the EST project. Indeed, the scenarios of a backcasting exercise may broaden the scope of solutions finding by describing new options. Moreover, because such a method highlights differences between current trends and a desirable future, it may capable of generating the motivation needed to implement new policy directions.

The following table compares the conventional approach to decision making about transport and backcasting approach which has been followed within EST project.

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<sup>1</sup> Germany, Netherlands, Switzerland, Austria, France, Norway, Canada, Sweden and the Central and Eastern European countries.



<b>Conventional approach</b> <i>(key process is forecasting)</i>	<b>Management by EST objectives</b> <i>(key process is backcasting)</i>
1. Assess problems arising from current transport activity and expected from a continuation of current trends.	1. Define what is meant by EST both qualitatively and in terms of a long-term vision of the future (EST scenario)
2. Address problems almost always by improving infrastructure and by improving technology, and sometimes by displacing traffic from trouble spots to other routes.	2. Determine what must be done to secure the vision in relation to what would happen if no extraordinary steps were taken (Business As Usual scenario)
3. Repeat step 1 when problems return because growth in transport activity has offset the infrastructure expansions and technology improvements.	3. Identify and apply instruments capable of moving from the present to the EST scenario rather than BAU scenario, adjusting the implementation strategy according to results.
4. Repeat step 2 (and contribute the predict and provide spiral)	4. Do what is required to maintain conformity to the quantitative features of the EST scenario.

**Table 3: Approaches to decision making about transport. Source: OECD 2002b, p. 14.**

It is possible to identify three key differences between the EST approach and conventional approaches (OECD, 2002a): the consistency of EST goals with specific requirements of sustainable development; the EST attempts to address the totality of transport's environmental impacts (conventional approaches tend to focus on the reduction of the impacts per unit of transport activity); the selection measures and instruments including consideration of the need to restrain growth in the most environmentally damaging forms of transport activity.

### 5.1.1. EST project phase and methodology

The EST project had four phases:

1. A review of the OECD Member Country programmes and plans on transportation and the environment. Furthermore, this phase identifies the characterization criteria, including quantitative EST criteria;
2. Conducting of EST pilot studies for the countries involved in the project. The pilot studies consist of three scenarios containing measures to meet the EST criteria. The criteria and scenarios are defined as agreed in Phase 1 of the EST project;
3. Phase 3 comprises the identification of packages of policy instruments whose implementation would result in the attainment of EST, and description of a possible implementation time-path of these packages of policy instruments. Furthermore, this phase comprises a deeper consideration of the social and economic implications of implementation the EST scenario features;
4. Refinement and extension of the EST definition and establishment of guidelines for policies and measures consistent with the EST achievement.

The first step of the project has been to characterize Environmentally Sustainable Transport which has been defined as one where: *“Transport does not endanger public health or ecosystems and meets needs for access consistent with a) use of renewable resources below their rates of regeneration, and b) use of non renewable resources below the rates of development of renewable substitutes”* (OECD, 2000a).

Internationally agreed goals, guidelines, and standards have been used to make operational this definition and to set EST criteria and thus reduction targets.

Six criteria have been identified as being the minimum number required to address the wide range of health and environmental impacts from transport (Table 4).

<b>Environmental and health goals</b>	<b>Action targets</b>
<i>Noise</i> WHO Guidelines attained	<i>Noise sources:</i> -50% -70%
<i>Air quality</i> WHO Guidelines (NO <sub>2</sub> , PM) Critical levels for ozone attained	<i>Air emissions:</i> -50% NO <sub>x</sub> ; >-99% PM -80% NO <sub>x</sub> and VOC
<i>Acidification/Eutrophication</i> Critical loads attained	<i>SO<sub>x</sub>/NO<sub>x</sub> emissions:</i> -75% -80%
<i>Climate protection</i> Stabilisation of CO <sub>2</sub> conc.	<i>GHG/CO<sub>2</sub> emissions</i> OECD -80%, global -50%

**Table 4: Operationalising EST Criteria. Source: OECD 2002a, p. 18**

The achievement of these targets is planned to be the year 2030 which is a target date that enables to avoid the cumulative adverse effects of transport and to allow enough time for effective actions.

On the basis of these targets and definitions of Environmentally Sustainable transport a Business as Usual (BAU) scenario has been developed for the respective study areas. The BAU scenario is a reference scenario that reflects the continuation of present trends in transportation, moderated by likely changes in legislation and technology.

In developing a vision of such a system, two alternative scenarios have been explored: the first focused on reaching EST criteria solely through technological means; the second relied on restraining transport activity.

In the high-technological scenario, technological progress is assumed to satisfy the EST criteria. The high technology scenario (EST1) has two categories of change: (1) change in 'existing' vehicle categories and technology; the vehicle categories from BAU scenario are assumed to use the best technical means; (ii) introduction of new technologies, e.g. hybrid vehicles. The second EST scenario (EST2) may be defined a mobility management scenario, because EST criteria are satisfied by mobility changes of passenger and freight transport. This scenario has two main characteristics: (i) overall motorised mobility has to be reduced significantly; (ii) the remaining demand for mobility has to be met with vehicle categories having the lowest unit impact.

A further scenario (EST3) can be developed by the combination of the EST 1 and EST 2 scenario assumptions.

Having developed and characterised these scenarios the following step has been the identification of which policy instruments could be deployed in order to reach them.

The basic technique chosen has been the *structured brainstorming*.

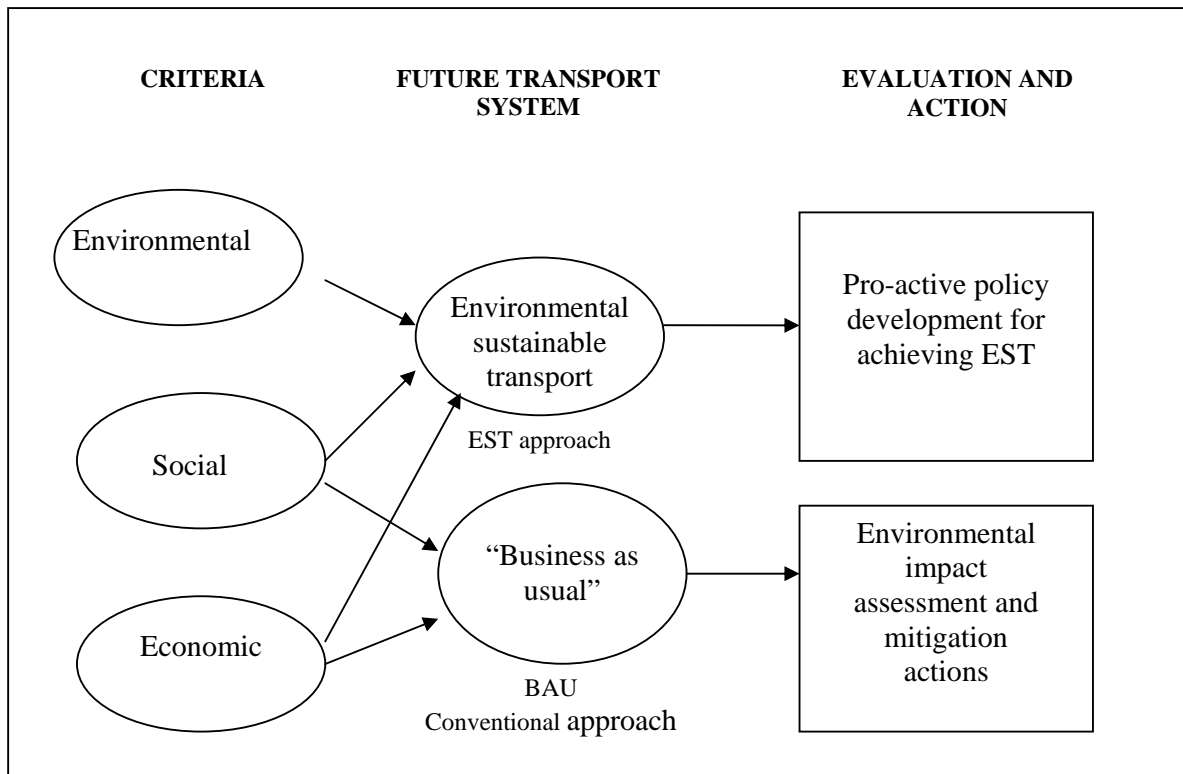
It has involved iterative identification and assessment of potential instruments and packages of instruments by groups of experts using a consistent methodology.

The EST project considers a large number of policy instruments: regulations, hybrid regulatory and fiscal instruments. In general these instruments are: (i) directed at the movement of people rather than freight; (ii) regulatory rather than fiscal in nature; (iii) directed towards achieving mode shifts and favouring non-motorised alternatives rather than towards numerous other objectives.

The project showed that the implementation of the instrument packages implies a fundamentally different society in 2030 compared to the current and 'business as usual' society of 2030. It implies also many changes outside the transport sector (changes in the political, societal, economic and spatial context).

For each instrument packages was developed an implementation time-path using the backcasting method. It is assumed the instrument to have its full effect by 2030, and calculate backwards to establish the start of the implementation.

The following figure summarises the EST project approach highlighting also the differences with the conventional approach within the context of planning a transport system.



**Figure 3: Comparison of EST Approach and the conventional approach to transport policy making. Source: OECD (2002b), p. 12.**

The project concludes with the development of Guidelines for moving towards environmentally sustainable transport, designed to assist government at all levels in the development and implementation of appropriate strategies towards Environmentally Sustainable Transport which is considered attainable, although only with a broad based commitment.

## **5.2 POSSUM project.**

Policy Scenarios for Sustainable Mobility (POSSUM) is a research project which has been developed by a consortium of European Institutes of Research within the 4<sup>th</sup> Framework research programme with the aim of investigating policy scenario building at European level for the period 1995-2020. The methodology developed is

based on backcasting approach to establish targets for economic, development and environmental set out in the EU Common Transport Policy to achieve sustainable mobility.

An important element in any backcasting study is the definition of targets to be met by the scenarios. POSSUM has defined targets focusing the analysis on the goals of environmental protection, regional development and efficiency. The targets are defined as: 25% reduction of CO<sub>2</sub> emissions; 80% reduction of NO<sub>x</sub> emissions; no degradation of special protected areas; no or only minor net increase in infrastructure surface; improved relative accessibility of peripheral regions and full cost coverage of transport under market conditions.

These targets have been used as a framework for the construction of nine Images of Future. These Images combine contextual elements (outside the scenario building process) and strategic elements (included in the scenario building process) to present visions of the future (2020). The contextual elements cover the expansion of the EU, the key role that different decision makers play and levels of cohesiveness or competition within Europe.

The Images of future developed by POSSUM are based on two main categories of change that are needed to achieve the planned targets by the year 2020:

1. reduction of energy use per passenger –kilometer and tonn-kilometer of freight by means of technological improvements, new fuels, increased load factors and modal shifts. (called Technological improvement)
2. decrease in transport intensity of GDP – Decoupling.

The next step of the backcasting approach has been to develop paths between an image of the future and the present situation. To influence the development, so that an image is likely to be reached, different policy measures are available. Policy paths in the POSSUM project are combinations of policy packages that lead from the present to one of the Images of the Future. The policy measures have been divided into:

- Lifestyle-oriented policies;
- Market-oriented policies;
- Regulation oriented policies, and
- Public infrastructure/services.

The construction of the packages in the POSSUM project has been achieved through the combination of two different approaches:

- A more deductive, systematic one on the basis of the framework of the images, has helped to define the outline of the packages and paths; and
- A more intuitive, inductive approaches starting from a list of measures, has helped to allow for creative process of inventing new combinations of policies.

The policy packages have been developed from combining individual policy measures into mutually supporting groups. The process of packaging policies and the identification of policy paths are iterative and involve both the expertise of the consortium and external experts.

The path also describes the course of action over time, including the possible difficulties in implementation. The following table summarizes the ten different policy packages which have been described in the POSSUM project:

The main methodological contribution of the POSSUM project is the development of a tool to support a target oriented management process. The outcome of the POSSUM scenario building process are recommendations about what policy decisions need to be taken now in order to reach the assumed targets for sustainable mobility. It recognises that sustainability is not a definitive end goal, but it is a direction which policy can head for.

Finally, the POSSUM project has underlined that target oriented approach can help to identify more innovative policy options (for instance, tradable mobility credits), but requires a considerable mental, organizational and behavioural effort compared to conventional incremental policies. This is so partly because they often have a too short time perspective. In a longer time perspective, the gains of specific measures will be more clearly visible, and therefore changing the balance between benefits and efforts.

<b>Policy package</b>	<b>Construction logic</b>	<b>Main Measures</b>
Ecological tax reform	Externalities, resources use and environmental harmful activities are taxed too lightly, while labour is taxed too heavily	<ul style="list-style-type: none"> <li>• Lower taxes on labour;</li> <li>• Increased taxes on energy, materials and CO2 emissions;</li> <li>• Local road pricing</li> </ul>
Liveable Cities	to make cities more attractive by diminishing the dependence on car travel. Strategic measures are	<ul style="list-style-type: none"> <li>• increased accessibility by IT;</li> <li>• more space and higher priority for walking, cycling and public transport combined with decreased space for cars and parking</li> </ul>
Electric Cities Vehicles	Better matching of transport demand with type of vehicle used	<ul style="list-style-type: none"> <li>• Introduction of small low speed vehicles;</li> <li>• Support for car pooling and car rental;</li> <li>• Low speed zones in residential areas.</li> </ul>
Long distance Links-Substituting for Air Travel	Reduction of long distance passenger travel by substituting highly energy intensive modes with less energy intensive modes and other forms of communication.	<ul style="list-style-type: none"> <li>• Restrictive policy regarding building new airports, railways and roads;</li> <li>• Support to the use of Teleconference facilities;</li> <li>• Harmonization of railways.</li> </ul>
Fair and efficient distribution of mobility – Tradable mobility Credits	Introduction of distributional; mechanisms to ensure fair levels of accessibility	<ul style="list-style-type: none"> <li>• Tradable mobility credits;</li> <li>• Replacing taxes by differentiated road pricing.</li> </ul>
Promoting Subsidiary in Freight Flows	Reduction of travel distance of goods to decouple freight transport from economic growth.	<ul style="list-style-type: none"> <li>• Promotion of regional consumer markets, company networking and industrial district;</li> <li>• Labels with declaration of regional origin.</li> </ul>
Promoting dematerialization of the Economy	Reduction of necessity for transport	<ul style="list-style-type: none"> <li>• To give incentives for rental and sharing of goods and services.</li> </ul>
Minimizing specific emissions	Significant reduction of specific real world emissions from road and air transport	<ul style="list-style-type: none"> <li>• Frequent control of real emission levels;</li> <li>• Long term producer responsibility for emission levels;</li> <li>• Incentives for hybrid vehicles.</li> </ul>
Resource Efficient Freight Transport	To increase the resources efficiency of freight transport and reduction of haul distance.	<ul style="list-style-type: none"> <li>• Promotion of standards and technologies for automatic flexible freight handling and tracing;</li> <li>• Technical and organizational harmonization of railways.</li> </ul>
Customer Friendly Transport Services	To make public transport and intermodal travel more convenient	<ul style="list-style-type: none"> <li>• Promotion of Multipurpose Communicator for real time information on travel services and information services.</li> </ul>

**Table 5: POSSUM Policy packages.**



### 5.3 VIBAT project

The project named “Visioning and backcasting of UK transport policy” (VIBAT), was sponsored by the UK Department for Transport under its New Horizons programme<sup>2</sup> 2004/2005. The VIBAT project examines the potential for a 60% CO<sub>2</sub> reduction in the UK transport sector over the period 1990-2030, using the backcasting scenario methodology.

The year 2030 has been selected because it was sufficiently far into the future so it is not looking just necessarily at trends; it is looking at ways in which it is possible to look beyond trends and looking at what we call trend-breaking futures.

The 60% target is directly sourced from the UK Government’s Energy White paper which suggests a path towards a 60% reduction in emissions of Carbon Dioxide by 2050 in the UK.

The study method consists of three main stages:

- 1) Baseline and targets setting;
- 2) Image of the Future;
- 3) Policy packages and Policy Patrons.

The first stage defines a baseline and targets which will be the framework for the construction of the visions of the future and the nature and scale of change needed from the trend-based future (the business as usual scenario).

In the second stage, two *Images of Future* are built up to comply with policy targets. One image is based on a strong push on technological innovation, and the other with a strong behavioral perspective using pricing and land use policies.

The last stage policy measures are collected in policy packages to achieve the scale of change required in the scenarios, and the paths relate to the timing of the introduction of the alternatives are defined. As in the OECD EST project, VIBAT project concludes that the ambitious target of 60% reduction in CO<sub>2</sub> transport emissions by 2030 is attainable, but it requires radical and trend breaking measures. The project clearly underlines that a business as usual approach, or limited variations around this, will not deliver the sustainability of transport. The application of the backcasting methodology, the elaboration of policy pathways and milestones

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<sup>2</sup> The New Horizons programme is quite small-scale research projects which are intended to look further forward, looking at new ideas.

backwards from the future images to the present are tools to build a radical change towards this sustainability.

The study process is shown in the following figure.

### SCENARIO BUILDING PROCESS

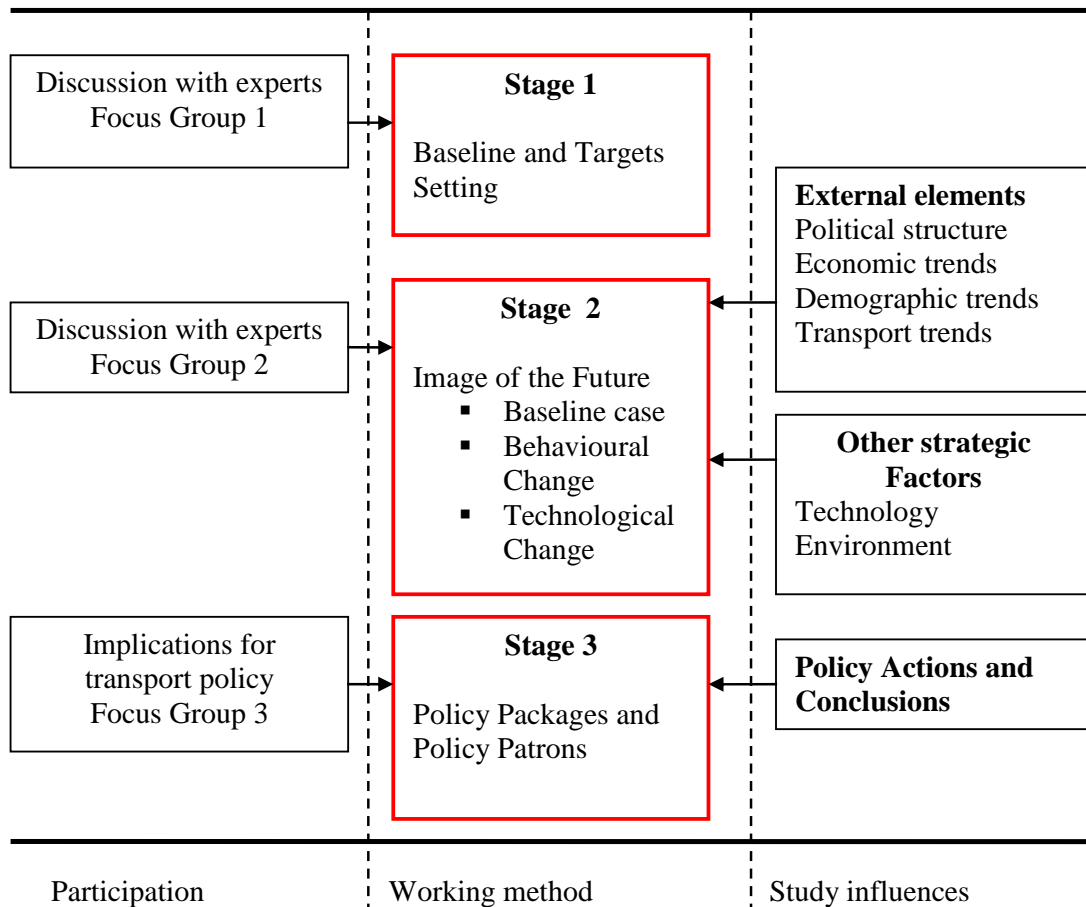


Figure 4 : VIBAT process, Banister, 2005. pg 12

## **6 Conclusion**

The complexity of planning for sustainability, because current trends, actions and planning are part of the problem, has highlighted the importance of applying backcasting method to have an informed vision of one's goal in order to strategically deal with potential trade-off from different decisions (Robert et al, 2002).

According with Quist (2006), backcasting may be defined as an innovative participatory foresighting approach for sustainability based on stakeholder involvement, construction of normative sustainable futures. Its essence consists of generating desirable sustainable future visions and turning these, through backcasting analysis, design activities and analysis, into follow-up agendas, planning for actions and realising follow-up activities (Robinson, 2003) .

Backcasting originates from 1970s and was originally developed as an alternative for traditional forecasting and planning. The original focus was on policy analysis for energy planning and later on exploring sustainable futures and solutions, while stakeholder participation and achieving implementation became important in the last decade.

Backcasting study is essentially constituted by four steps or tasks (Hojer, 2000). The first step is the setting of one or few long-term targets. The second step, each target is evaluated against the current situation, prevailing trends and expected developments. The third step is the generation of images of the future that fulfil the target. The fourth and final step is to analyse the images of the future in terms of, e.g. feasibility and paths towards the images (Akerman and Hojer, 2006).

The analysis of the more recent studies, which have applied the backcasting approach to design a plan for a sustainable transport, have underlined the efficacy of this approach in a sustainability context.

In the next section a backcasting exercise is developed applying the main elements and steps identifying in the previous literature review.

**SECTION II: BACKCASTING EXERCISE APPLIED TO  
EU TRANSPORT TO ACHIEVE SUSTAINABLE  
MOBILITY**

## **1. Introduction**

In this report, the application of backcasting approach within the transport planning is finalized to achieve a sustainable mobility that, for the scope of our analysis, is defined by a relevant cutting of CO<sub>2</sub> emissions from EU transport sector by 2050.

Following the OECD EST guidelines (OECD, 2002a) the main steps of this exercise will consist of:

- a. Definition of a long term vision of a desirable transport future that is sustainable for the environment (in our analysis abatement of CO<sub>2</sub> emissions) and that provides benefits of access and mobility;
- b. Assessment of long term-trends considering all aspects of transport activity;
- c. Identification of packages of measures and instruments for reaching the targets.

This exercise is based on the analysis of literature. In details, the backcasting target is set taking into account the most relevant decisions that have been taken by the European Parliament and the European Commission in the field of sustainable transport.

Regarding the long term trends on main transport drivers, our estimations are based on the main results of a literature analysis of the sector.

Finally, the indications of packages of measures are illustrative rather than perspective. They indicate the type and magnitude of the responses that might be expected from the policies examined, rather than representing recommendations to undertake the simulated policy actions.

This section moves from the analysis of the role of transport planning and the main impacts of transport. Then, the main transport drivers are analysed to identify their main trends to 2050 and to define the space of efficient transport policy measures.

Finally, the backcasting scenarios to 2050 are developed and policy strategies are designed.

## **2. Transport planning for sustainable mobility**

The role of transport planning in the past has been associated with understanding traveller behaviour and modelling and predicting that behaviour (Lay, 2005). This has resulted in good incremental developments and increasingly wise policy decisions. The transport planning process, once the data are collected and the model predictions become available, is a search for possible solutions and a prioritizing of those solutions on the basis of community principles. During the last years high level principles have been articulated such as respect for the environment, sustainability and positive management measures (*ibid*).

Transportation planning is most effective when it establishes policy goals for the transportation system that are based on a long-term vision (Gur, 1999) which: (i) assesses existing conditions; (ii) identifies the future demand for travel; (iii) generates alternative strategies to support projected demand; (iv) evaluates those alternatives and recommended to decision makers a practical portfolio of policies, programs, and investments that would maintain and improve the mobility of people and the movement of goods, while supporting the area's goals and objectives. To be effective, a long term transportation plan must be based upon in the community's vision, reflect early and frequent public involvement, have a comprehensive system perspective, be developed with strong technical methods.

According with Banister (2005) the current transport planning process is still driven by the desire to reduce travel time and cost. But at the same time travel seems to be too cheap and the prices must be raised to account for other factors, such as externalities. To accept arguments for sustainability means a reduction in consumption and a much higher price for travel (Banister, 1993).

During the last years the debate on transport policy has involved the challenge of sustainable development. There has always been a realization that transport has significant environmental costs, but in the past these have mainly related to local environmental issues, such as noise, severance, visual intrusion and some pollutants. The new debate is much broader and it includes the global pollutants, acid rain, the use of non-renewable resources, and the health effects of transport (Banister, 2005).

In the past, the main concern has been over increasing the quantity of travel, the acquisition of a car and the notion of the freedom to use that car. As affluence increases, other factors related to quality and environmental responsibility become

important, and values change. The technological revolution now taking place allows such a transition.

From the point of view of transport planning, the imperative to predict the growth in demand and the overriding importance of economic factors become less dominant. While a sustainable transport system (namely, to provide tools to decision makers on how increase mobility and accessibility while minimizing the negative environmental, ethical and economic impacts of travel as well as involving a wide range of participants in the process) is extremely important. Methods need to be developed to measure quality of life, social impacts, and the environmental/ecological costs of transport (*ibid*) in the framework of sustainability of transport.

On the basis of the analysis of the previous section, a backcasting approach is capable of generating the needed new policy directions if transportation is to become sustainable.

### **3. Transport sector impacts.**

Although the sustainability is a broad concept, which requires economic development, environmental protection and social justice in terms of equity, the debate on sustainability of transport has been mainly addressed on the adverse environmental impacts of transport activities and the possible measures to tackle these adverse effects. The transportation systems are 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.

Emissions from transport represent a very high share of the overall emissions. The main components of transport emissions include: Carbon Dioxide (CO<sub>2</sub>), Particulate matters (PM), Nitrogen Oxides (NO<sub>x</sub>), Sulphur Dioxide (SO<sub>2</sub>) Carbon Monoxide (CO), lead (Pb), benzene and volatile components (C<sub>m</sub>H<sub>n</sub>).

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.

For the scope of our analysis, this report will be restricted CO<sub>2</sub> emissions.

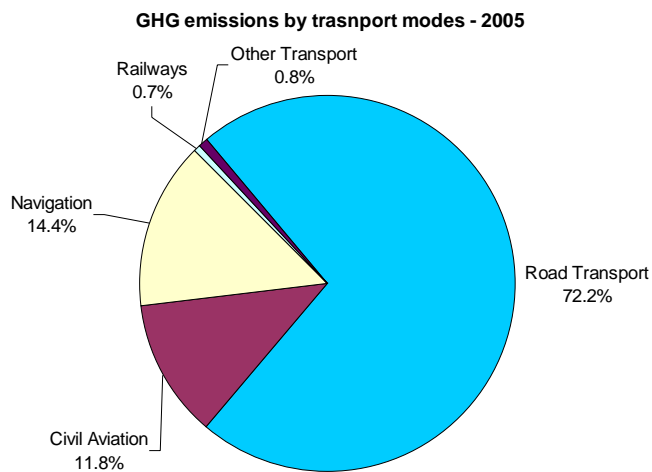
CO<sub>2</sub> emissions are the major component of the so-called greenhouse gases and cause global effects on the atmospheric composition with long term impacts on the Earth's climate. The evidence of climate change has been clearly highlighted by the Intergovernmental Panel on Climate Change (IPCC) 4AR, Working Group 1, which estimates in the 4<sup>th</sup> Assessment Report that global warming ranges from 1.8° to 4° C by 2100 compared to 1990 levels.

In this report the choice of CO<sub>2</sub> emissions as indicator of sustainable mobility is due to the evidence of the relevant contribution of transport sector to the greenhouse gas emissions. According with EEA analysis (2008), after the stationary energy sector, transport is the second largest growth sector in EU GHG emissions.

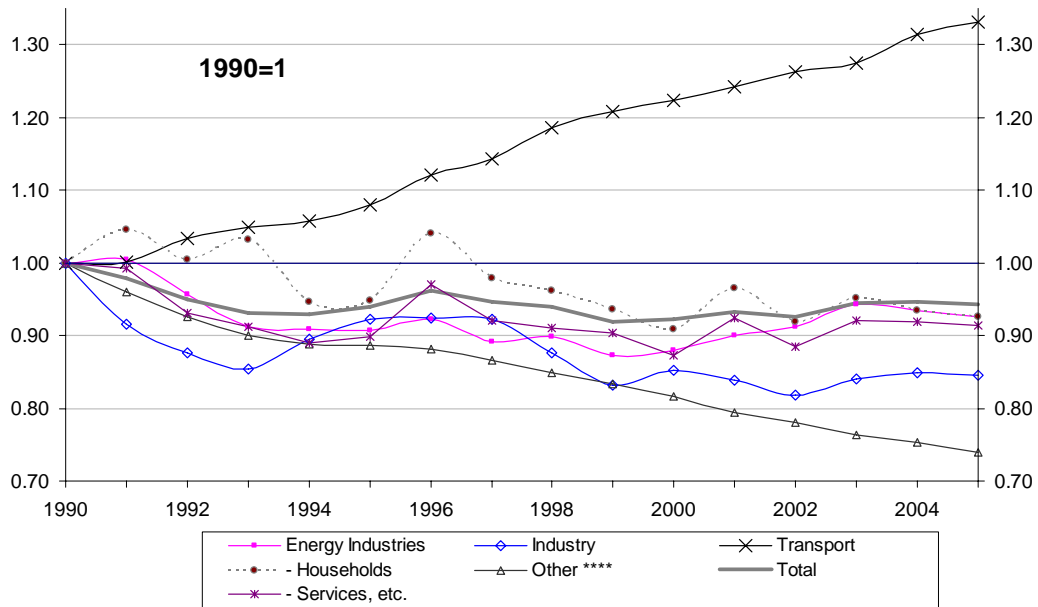


In 2005, it has accounted for 23.4% of EU-27 greenhouse gas emissions, with vast majority of these emissions produced by road transport sector, freight and passenger transport, and the increasing contribution of aviation (figure 1).

Additionally, between 1990 and 2004, CO<sub>2</sub> emissions from transport had the highest increase in percentage terms of all energy related sectors (figure 2) (EC, 2008).



**Figure 1: GHG emissions by transport modes – 2005. EC, 2008.**



**Figure 2: GHG emissions by sector EU-27 (%). Source: EC, 2008.**  
**3. Setting Backcasting targets.**

The transport sector is not included in Kyoto Protocol, but its increasing CO<sub>2</sub> emissions calls for specific policy action. For this reason, this Backcasting exercise poses its attention on the achievement of a global low carbon economy, which is central pillar of EU policy to tackle climate change.

Indeed, in the Communication "2020 by 2020 Europe's climate change opportunity" COM (2008)30 final, 23.1.2008, European Commission poses the objective of a very different Europe by 2050. The objectives included in this Communication, agree with the indications of the 2007 Spring Council which settled to reduce EU green house gases emissions by at least 20% by 2020 and, in case of a global and comprehensive agreement, by 30% by 2030 and called for a global reduction of up to 50% by 2050 compared to 1990 levels.

Following this European Commission Communication targets, this backcasting exercise poses as targets to cut EU-25 CO<sub>2</sub> emissions from transport by 50% by 2050. The choice of this target might seem very ambitious, but it is coherent with the requirement of the EU Parliament to achieve a low carbon economy and the main characteristic of the Backcasting approach that is to create a vision of future which is a desirable future instead of a possible or likely future as a forecasting approach provides (*see paragraph 2 of the first section.*).

Moreover, the measures that will be indicated in the following backcasting exercise are mitigation action. In general terms, global warming calls for a two main kinds of policy actions: mitigation and adaptation. Mitigation actions are to early prevent by early climate change impacts by cutting GHG emissions and a swift transition to a global low-carbon economy. On the other hand, adaptation actions aim at reducing the risk of damages produce by current and future harmful impacts using cost effectively measures or exploiting potential benefits (EC, 2007a).

#### **4. Analysis of main transport drivers**

There are fundamental uncertainties in projecting transport demand and simulating future transport systems. Uncertainties in demographic, economic, technological and institutional factors will affect the current level of future transport demand, the mix of energy supplies consumed, and the associated rates of CO<sub>2</sub> emissions.

Knowledge is limited of the complex interactions of technological, cultural and political forces that determine the development of transport schemes.

It is therefore not certain that today's relationships will persist for the next 30/50 years. Main drivers of transport demand are: Demographic trends; Economic trends (i.e. GDP and sectorial production trends; World oil prices); Technology progress, *et cetera*.

In this paragraph some of these factors are analysed in order to identify their main trends to 2050 and to define the space of efficient transport policy measures.

##### **4.1 Demographic dynamic**

One of the factors that influences transport demand is the 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 (Siu et al 1994). Particular attention is paid to the way trip rates for each person category that changes in relation with income. Related to that is the role of car ownership. Car ownership is an important determinant of household travel behavior and it is fundamentally interconnected with residential location and decision-making

regarding motorized trips (Scott and Axhausen, 2006). Car possession compels its use rather than alternative such as public transport<sup>3</sup>. In general terms, car ownership is not only connected with the basic principle of accessibility/mobility, but, particularly in western industrial society, the car is synonymous with individual freedom and free movement. Using individual vehicle is considered nearly as a basic human right. Additionally, high levels of automobile ownership are associated with urban sprawl, increasing levels of automobile travel. Thus, understanding how households choose the number of vehicles to own, conditional on their place of residence, is of vital importance to urban planners and decision makers.

The relevant importance for a sustainable transport system is the redistribution of the population over time in urban areas or lower density areas, which can have very different model mixes from higher density areas.

In this context, of relevant importance is the urbanization. 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. Increased average trip length and suburb to suburb trips also increase fuel consumption and related emissions of air pollutants and greenhouses gases.

## **4.2 Economic growth**

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

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<sup>3</sup> The broad relationship between income, car ownership and the demand for public transport are well documented. A study of UK National Travel Survey on increases in real income and car ownership levels in the UK and across Europe, highlights that during the last 25 years with respect to a GDP growth there has been an increase number of cars per households and a relevant decrease of public transport demand.

increase in economic growth leads to greater demand for transport services (Meersman, 2003).

However, the analysis of the relationship between transport and economic growth remains complex and difficult to specify because of the causal and feedback mechanisms that involves. Decoupling of economic and transport growth remains challenging subject of current and future analysis about how (and whether) economic growth could be compatible with ecological and social sustainability.

The increasing mobility intensive nature of the current consumption and production activities poses questions on whether economic growth or material growths are compatible with environmental and social sustainability. During the last years, the mobility intensive nature of production and consumption of goods and services have been stimulated by several factors such as (i) the new global dimension of modern production and consumption which has re-shaped European and world trade; (ii) use of *just-in-time* techniques which allow manufactures and wholesalers/retailers to dispense with warehouses (OECD, 2002); and (iii) integration of European market.

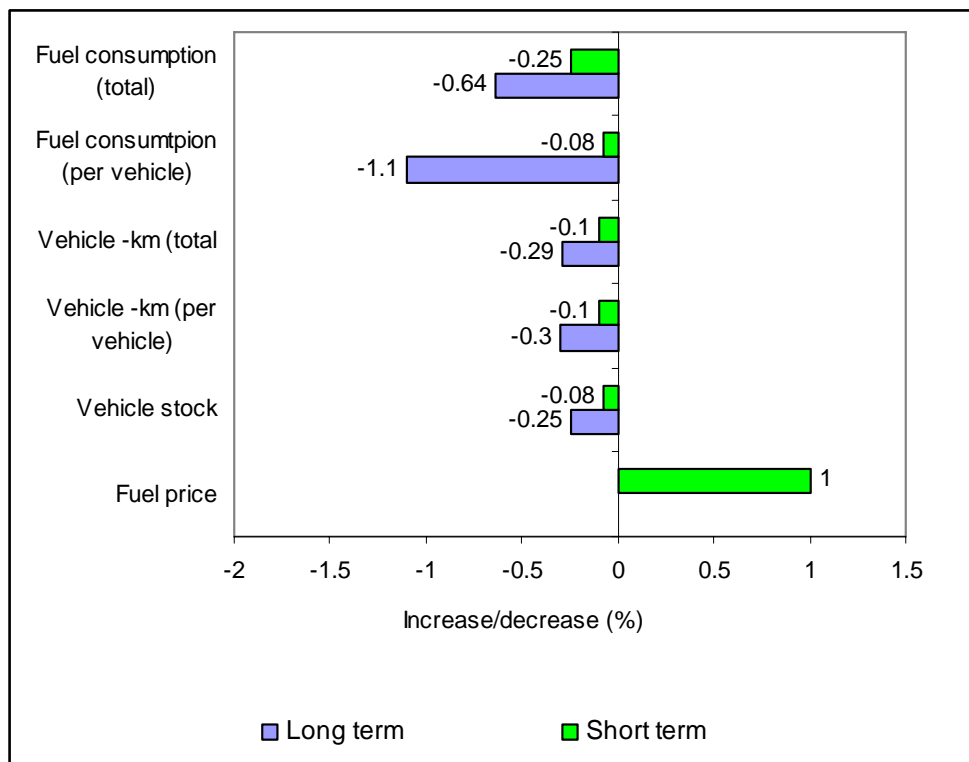
The growth in transport demand as a whole and in freight transport in particular, puts a considerable strain on society. The argument concerns the future relationship between evolutions in transport demand (passenger and freight transport) and economic growth, in the context of the debate on a necessary integration of transport issues into sustainable development policy.

### **4.3 Oil price and transport demand elasticity**

The prices for primary energy carriers traded on the global markets have in the last couple of years raised to a level that is considerable above the values used in energy scenarios and projections in the past (e.g. EIA, 2005; EWI/ Prognos, 2005; IEA, 2005). The high oil price affects all economic sectors and determines several macro-economic impacts. 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.

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 (2008c) the price elasticity of fuel demand is fairly low, meaning that prices have no big impact on demand.

In the figure below, the elasticity in transport demand estimated with respect to fuel price is illustrated. A 1% increase of fuel price leads to a 0.1% short term decrease in vehicle – km. In the long term the decrease is 0.3% per vehicle and 0.29% in total (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 (ibid).



**Figure 3: Elasticity of transport demand with respect to fuel price. EEA (2007), p. 46.**

#### **4.4 Tourism sector**

According to OECD (2008c) 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.

Tourism is estimated to account for about 75% of the demand for aviation, which is growing rapidly. Low cost carriers 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.

#### **4.6 Technological dynamic**

The technical considerations open 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 particular 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. It is clear that in the short run, technological changes could not have very significant market penetration. Consumer acceptance is one of the major obstacles for the introduction of both alternative power sources and fuels. The driver of today must be convinced that it is his duty to be *green*.

#### 4.7.1 Fuel options to 2050

As highlighted, transport is the one sector of the economy where substitution of oil with other fuels has been negligible. The research and development of new fuel options in transport sector respond to three main policy objectives Greenhouse gas saving; Security of Supply and Employment. In our analysis, the greenhouse gas saving is the only one objective that is taken into account. For this scope the approach followed to compare different fuel option is the Well to Wheels analysis (WTW). In general terms, this method examines the path of fuel production (Well to Tank analysis) and fuel consumption (Tank to Wheels analysis) and identifies the connected environmental impacts (in our analysis CO<sub>2</sub> emissions). The WTW approach enables to identify the more sustainable fuel options highlighting the full life cycle analysis of their environmental effects on both greenhouse gas emissions and indirect effect.

The fuel options that our analysis takes into account are:

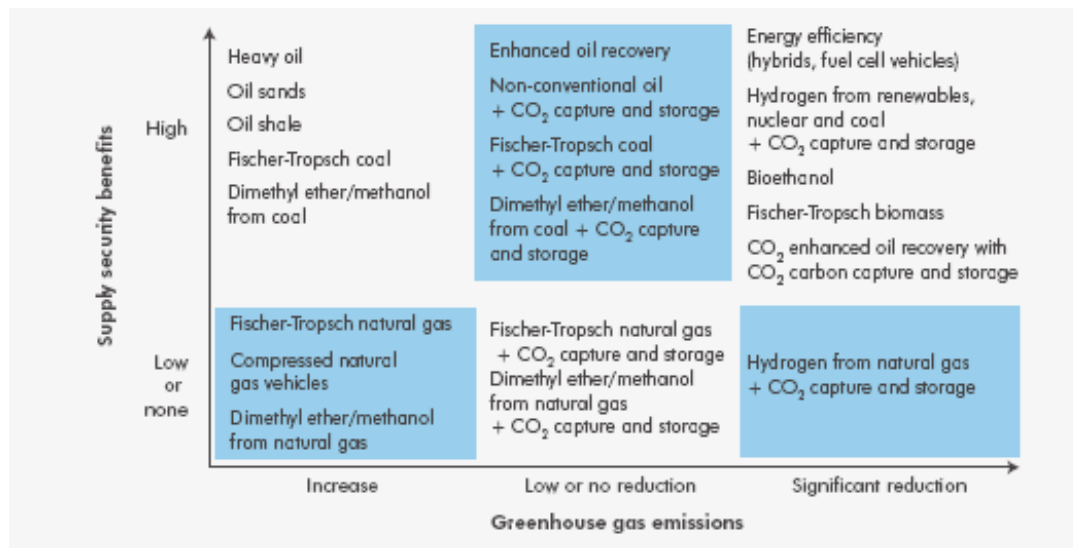
1. *Compressed Natural Gas (CGN), biogas, LPG.*
2. *Biofuel.* Biofuels are considered the key transport fuel option to substitute for oil. Biofuels is a common description for fuels made from biological material (namely, biodiesel from rape seed, soybeans and palm seeds; bioethanol from sugar cane, corn or wheat). A distinction has be done between 1<sup>st</sup> generation biofuels, that usually are from conventional crops, and second generation biofuels from agriculture or wood residues, waste and other lignocellulosic material (OECD, 2006). Both types of biofuels need public support for their production to be more competitive, but the Second generation biofuels are still at the pilot plant research stage (JRC, 2008). They emit less CO<sub>2</sub> than first generation biofuels, but are very expensive in relation with the investment costs needed for their production plants, and likely will not be competitive and commercial on large scale before 2020 (*ibid*). However biofuels are not equally effective in substituting for oil and in cutting green house gas emissions and promoting their production might have several adverse indirect impacts. According with EC-JRC (2007 and 2008), the potential saving of GHG emissions due to biofuels is high, but tanking into account also indirect effects (such as land use change, emissions due to fertilizer, impact on food prices, etc) the only major biofuels, which could save GHG emissions considering also indirect effects, are bioethanol from sugar cane from Brasil,



compressed biogas and second generation biofuels. Regarding the projections of biofuels production, the IPCC in the 4<sup>th</sup> Assessment Report on climate change policies has estimated a potential for biofuels from agricultural crops and wastes to replace 5% to 10% of road transport fuel by 2030 being competitive with oil (OECD, 2007a).

3. *Hydrogen.* Hydrogen technologies attract significant research and development funds, but they are not considered CO<sub>2</sub> abatement policy option for the short and medium term. The prospects of the development of hydrogen as a transport fuel are not very certain. Its development and market penetration depends on significant cost reductions, development of fuel cells vehicle market and hydrogen infrastructures. Currently, there are no commercially available vehicles using hydrogen as combustible fuel on the market and no extended distribution infrastructure exists for hydrogen as a transport fuel. These are due to the cost of hydrogen vehicle (namely, the cost of storage hydrogen on-board the vehicle and FC) and the extremely expensive hydrogen fuelling infrastructure.

In the figure below the alternative fuels are categorized on the basis of their contribution to supply security and CO<sub>2</sub> emissions reduction.



**Figure 4: Alternative fuel options and their contribution to supply security and CO<sub>2</sub> reduction. Source: OECD, 2006 pg 263**

#### 4.7.2 Vehicle technologies (engine and non –engine component)

In this category are included different types of technologies that improve vehicle fuel economy and related CO<sub>2</sub> emissions. First improvement in fuel efficiency have to be done in gasoline and diesel technologies even if conventional technology improvements are far from being more cost-effective than alternatives (in particular with regard to gasoline technology). The *hybrid and electric vehicles* that are particularly efficient in urban drive cycle have several technology potentials. 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 and their availability (much more models and sizes) to reach a full mass market deployment. Regarding fuel cells vehicles, which are propelled by electric motors with electricity produced within the vehicle, they 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. Further methods to improve fuel efficiency are:

- *Light weight material* that enable to consume less. This category includes a lighter engine and design research focused on material. In this case the main barrier consists of the needed large investments to modify the vehicle production process and the energy intensive costs of the most suitable material that is aluminium. 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 (around 60\$ percent point).
- *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.* In this category are included 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).

In the figure below the pathways towards cost competitiveness for transport technologies are showed. The picture highlights the stage of these technologies from R&D stage to the stage when the technology is cost competitive without specific CO2 reduction incentives.

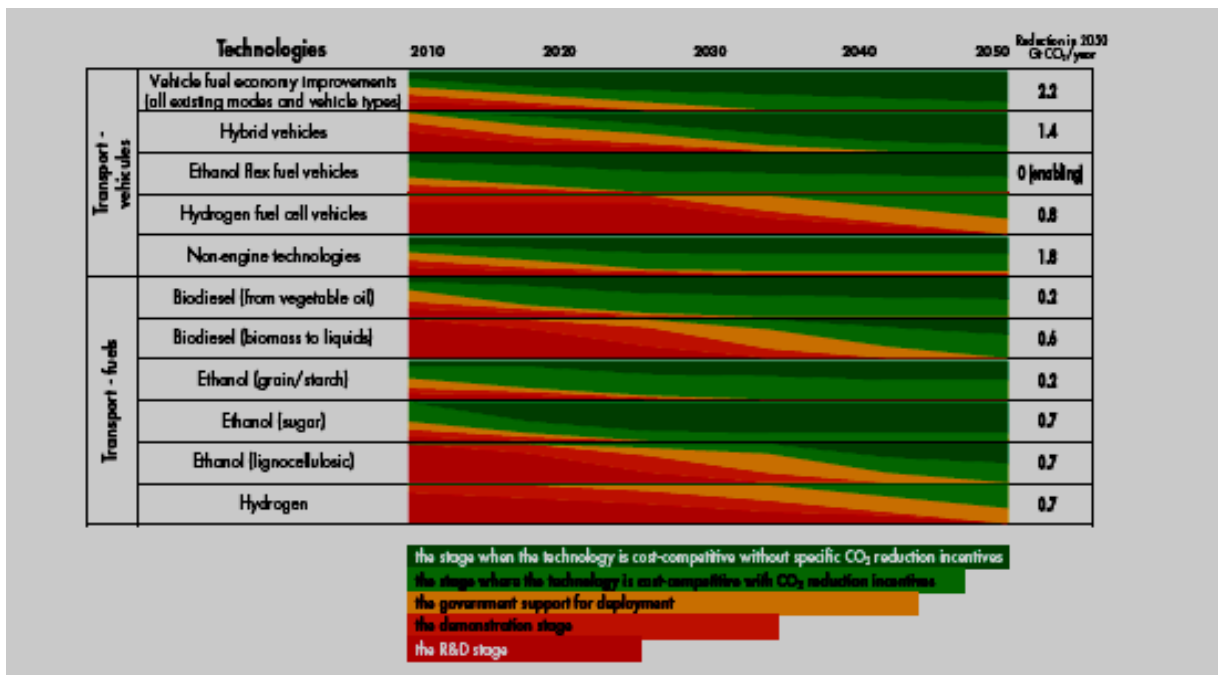


Figure 5: Pathways towards cost competitiveness for transport technologies. Source OECD, 2006 pg 137.

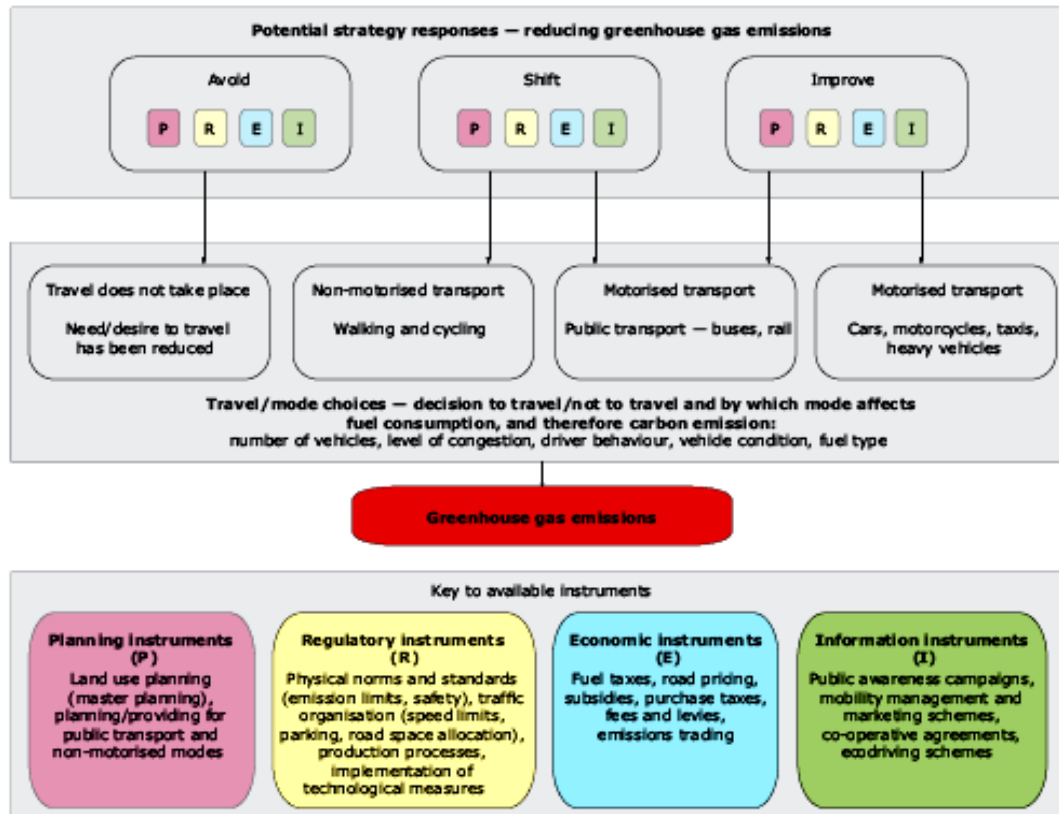
## 5 Policy measures

According with EEA (2008a), EU transport policy has mainly focused on the supply side and little has been done on the demand side to tackle the growing demand for transport. Furthermore, a number of actions designed to reduce greenhouse gas emissions within the transport sector have also led to mere efficient and cheaper transport; a rebound effect that has contributed to growing demand within the sector.

The Mid Term Review in 2006, *Keep Europe moving – Sustainable mobility for our continent* of the 2001 transport policy White Paper recognized that measures proposed in the White paper were insufficient and pointed to the need for a broader, more flexible transport policy toolbox.

For the scope of our analysis, namely to perform backcasting scenarios to cut CO<sub>2</sub> emissions from EU transport activity by 50% by 2050, energy use in transport sector is the focus. While the considered areas of interventions are (i) transport activity (demand for passenger mobility and transport of goods); (ii) modal mix (that is affected by consumer choices, availability of various modes, prices of competing fuels and vehicles, legislative and fiscal policies); (iii) fuel mix ; (iv) energy intensity (expressed as final energy per unit of transportation activity).

A broad range of policy instruments exist to reach a sustainable transport: application of carbon and fuel taxes; reformation of vehicle taxation and regulating vehicle standard; implementation road pricing and investments in public transport infrastructure and spatial planning policies. In the figure below these policy instruments are summarized and categorised in order to highlight their impact in cutting GHG emissions of transport. The categorisation is based on three main potential strategy responses: to avoid travel or travel motorised by non motorised modes; to shift to more environmentally friendly modes; to improve energy efficiency and technology of vehicles (EEA, 2008b). An efficient policy strategy to reach sustainable transport consists of combination of these responses and policy instruments.



**Figure 6: Sustainable transport instruments and their impact on greenhouse gas emissions. Source: EEA (2008b), pg 11**

### 5.1 Economic instruments

Transport prices rarely reflect their full social and environmental costs, resulting in over use and sub-optimal choices about type of transport to use. Transport prices should fully reflect the costs of environmental damages and health impacts.

Getting prices right is often a very efficient way of keeping the costs of environmental policies low and greening the economy<sup>4</sup>.

Efficient pricing requires not only that prices reflect all the environmental costs associated with transport, but also that these prices provide incentives to conserve existing transport capacity and to develop future environmentally-sustainable

<sup>4</sup> In practice it is difficult to accurately estimate the full costs of environmental, health and productivity damages caused by economic activities.

transport options. Fear of impacts on industrial competitiveness of environmental policies is a key obstacle to decisive policy actions.

A *pigouvian* carbon tax to internalise the social costs of CO<sub>2</sub> emissions, applicable at the same rate to all sectors of the economy and applied in a large number of countries, would be the most efficient policy response to the threat of climate change. Setting the rate for such a tax is a political exercise because of the very real uncertainties in estimating the costs of climate change through its physical impacts on sea level, weather and their consequent effects on crop production, river flows, ecosystems, health and frequency and intensity of natural disasters related to the weather. A tax on carbon would have a very similar effect to fuel excise duty in transport markets. The main difference is that a carbon tax would apply equally to all sectors of the economy whereas current taxes on oil products differ enormously between sectors.

As OECD argues (2008), taxes on transport fuels can perform three functions:

- The *pigouvian* objective of internalising costs;
- The Ramsey objective of providing public revenues in the least distorting manner.

Finally, in the economic instruments category *subsidies* are included. They have been traditionally used for economic or social reason and their use for environmental purpose is a more recent policy. In this context, subsidies and support schemes are designed to stimulate development of new technologies, to help creation of new market for environmental goods and services, to encourage changes in consumer behaviour, to temporally support achieving higher levels of environmental protection by companies (EEA, 2007a). Focusing on the transport sector, subsidies can be environmental beneficial by supporting the most environmentally friendly modes (e.g. modal shift from road transport to rail) and fuels; influencing the environmental performance of the means of transport (e.g. supporting the development of more environmental friendly vehicles) (EEA, 2007a).

## **5.2 Vehicle efficiency regulations.**

Intervention to promote fuel efficiency is frequently argued for on the basis that consumers undervalue fuel savings when they purchase cars because they employ higher discount rates than socially optimal. Consumer makes decisions on how much fuel economy to buy in a context of combined uncertainty and risk aversion. This leads to lower fuel economy compared to a risk-neutral environment but is not in itself a market failure. Compared to a pure carbon tax, regulations have the drawback that they are sector specific and tend to favour one technology over another according to the level at which they are set and the way in which they are measured.

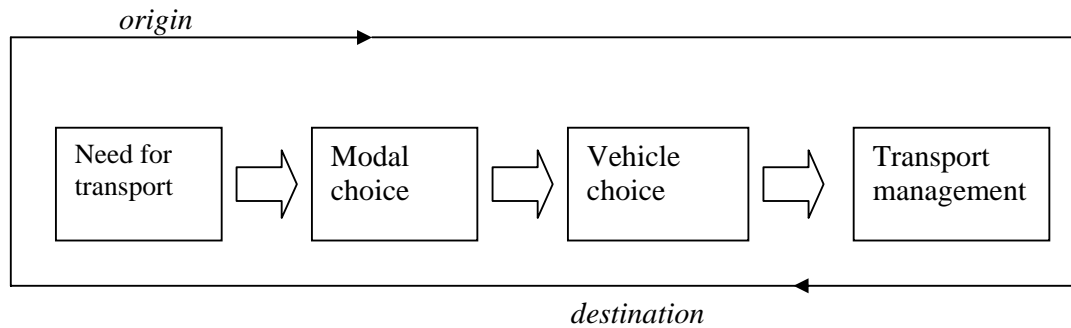
Regulations have to be designed carefully to avoid perverse effects.

Differentiation according to vehicle “footprint” is somewhat less distorting approach because there are larger costs for manufactures associated with changing wheelbase. Allowing weight to increase can cut costs. Other constraints also make it difficult to increase vehicle footprint, for example the size of typical parking spaces.

Regulations also entail monitoring and enforcement costs that are avoided with simple taxes. Regulations do, however, have some advantages that are avoided if simple taxation is applied. Regulations do have some advantages compared to taxes, not least in terms of politically acceptability.

## **5.3 Soft measures**

In this group, the policies that are categorised as soft measures have as objectives: change user behaviour and acceptance; reducing need for transport; enhancing modal shift; developing clean transport system; management of passenger and freight transport (figure 7).



**Figure 7: Orientation of policies at transport activity stages. Wolfram (2005), p. 21.**

Within the category that has the purpose of *reducing the need for motorized transport*, land use policies have a relevant role as part of policy combinations. Actually, the increasing urban sprawl due to people and enterprise moving to peripheral areas of the cities is the central component of the problem. The level of public transport services tends to be poor in peripheral areas and distances to other services and workplaces are long. This increases the need for car travel resulting in a variety of environmental problems. Land use patterns may have influence by reducing the per capita vehicle travel and /or average travel distance that residents must travel for some services.

The category “*enhancing modal shift*” includes policies making people to use alternative transport modes instead of a private car. In this category two groups of measures may be individuated: the so-called “push measures”, that aim at making less attractive driving car, and “pull measures” that aim at offering alternative mobility options.

The first group includes measures to internalize external costs of private cars, namely pricing measures such as: congestion charges; city centre pricing in Limited Traffic Zones; parking pricing. The second group of policies influences modal choice attracting people towards alternative modes through measures such as promotion of public transport, car sharing, walking and cycling.

The category of policies named “*vehicle choice-developing cleaned transport system*” consists of measures that regulate those motorized transport activities that cannot be avoided or shifted to alternative modes, but can be realized by low emissions vehicles. Some of these measures are: access restrictions based on emissions standards (Low emissions zones, environmental zones for heavy traffic); incentive and/or regulation schemes to support: alternative fuels vehicles, retrofitting for captive fleets, scrappage schemes for most polluting vehicles.



The policies categorized in the group “*transport management*” aim at optimizing efficient transport operations taking into account traffic flows, speeds and volumes.

This category includes: (i) transport passenger measures that regard mainly the regulation of road speed; (ii) freight transport management and logistic measures such as public transport for goods, shifting freight movements to night time; (iii) Intelligent Transport System such as traffic signalling for optimized flow, advanced driver assistance systems.

*Finally, fuel-efficient driving and logistics initiatives* are developed to promote fuel efficient driving, particularly through training programmes for both car and truck drivers offer significant cost effective savings. In the freight sector these initiatives imply a coupling with voluntary programme to improve both logistic organization and driver behaviour, such as electronic km-charges for road use by trucks.

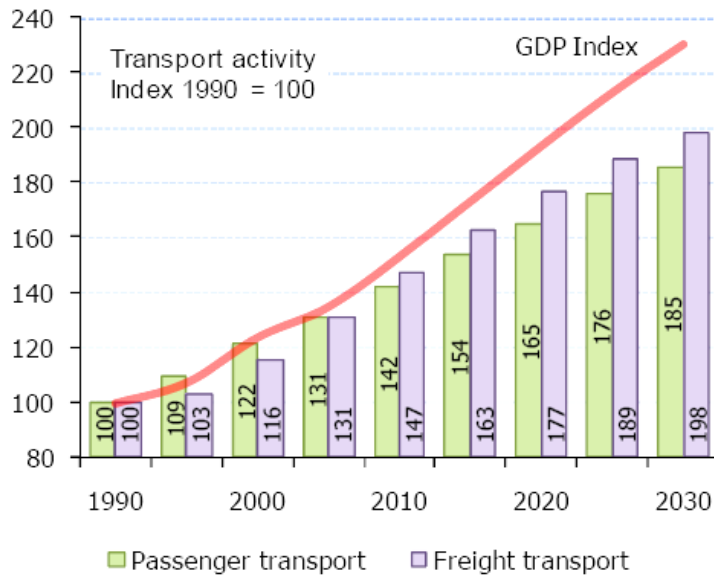
## **6 The Baseline Scenarios to 2050**

In our analysis, the Baseline Reference Scenario is based on the Baseline Scenario performed by European Commission to estimate Energy and transport trends to 2030 (EC,2008). 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)<sup>5</sup>. In 2030, it has been estimated 4267.7 Mt of CO<sub>2</sub> emissions in EU-27 with a contribution of 30% from transport sector and the higher annual percentage change.

The volume of transportation of passengers (figure 8) 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.

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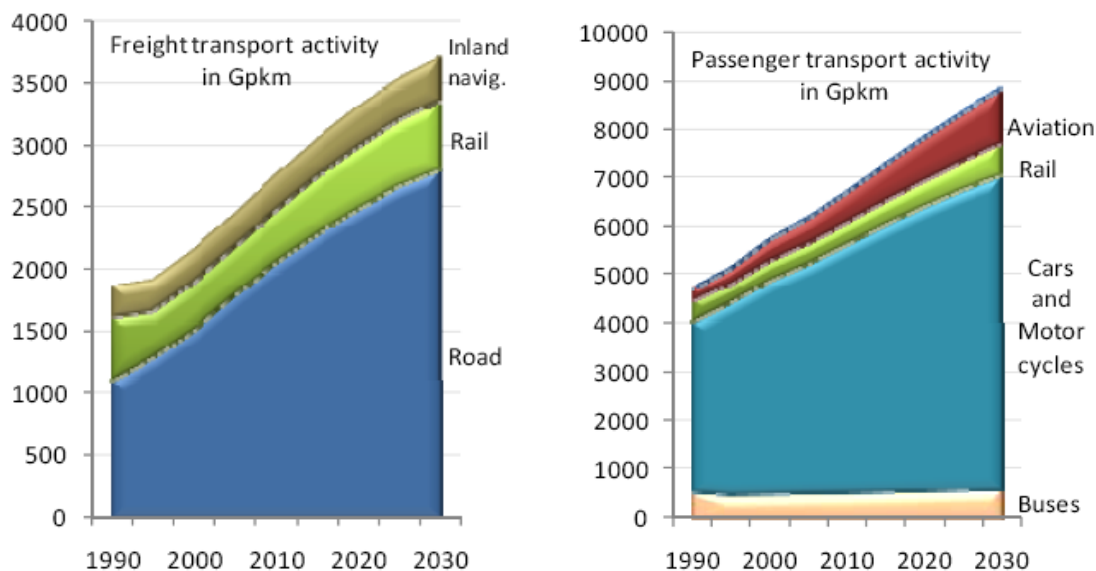
<sup>5</sup> More information can be found on EC (2008) - *European Energy and Transport – Trends to 2030 – Update 2007*. European Commission, Bruxelles, 2008



**Figure 8: Transport activity growth, 1990-2030. EC, 2008c pg 32**

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) (EC, 2008c).

Aviation activity for passengers, that is currently the fastest growing mode, is project to grow reaching 12.2% in 2030. Finally, Rail transport inland waterway and passenger public transport are projected to have a marginal role.



**Figure 9: Freight and passenger transport activity by mode, 1990-2030 EC, 2008c**

On the basis of the above scenario to 2030, the Baseline Reference Scenario to 2050 has been estimated. The table below shows the estimated CO<sub>2</sub> 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 CO<sub>2</sub> 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. The importance of the dynamics in the developments of these modes has been masked to some extent by the general exclusion of international bunkers from many reports on energy consumptions and CO<sub>2</sub> emissions.

<b>End user Category</b>	<b>1990</b>	<b>2000</b>	<b>2010</b>	<b>2020</b>	<b>2030</b>	<b>2050</b>
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
<b>Total</b>	<b>810</b>	<b>988</b>	<b>1110</b>	<b>1213</b>	<b>1260</b>	<b>1299</b>

**Table1:CO<sub>2</sub> Emissions projection by end users in the EU-27. Our elaboration based on EC data. Units: Million tonnes of Carbon (MtC).**

## 7 Images of Future

In this paragraph 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 images regard only road transport sector whose contribution to CO2 emissions is around 80%. These visions are based on linear progression into the future of main current trends without shock or sharp transformation, and although are opposite visions both are feasible. These imagines are alternative and related to two different visions of future one based on behavioral change and one on technological change.

A common assumption of both visions is the elimination of the unsustainable subsidies that are pervasive in transport sector<sup>6</sup> and that might have a distortive role in reaching a sustainable mobility.

The investment costs of each vision have not been estimated, but a qualitative analysis of kind of possible needed investments is done.

In the table 2 the main external elements for each image are showed.

	<b>Technological vision</b>	<b>Behavioral vision</b>
<b>Population change</b>	<b>9%</b>	<b>9%</b>
<b>Economic growth (GDP)</b>	<b>3.5%</b>	<b>2%</b>
<b>World oil Price</b>	<b>160\$ a barrel</b>	<b>200\$ a barrel</b>

**Table 2: External elements of images of future. Our elaboration.**

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<sup>6</sup> A study of EEA (2007) has estimated that in Europe, the total annual transport subsidies are around EURO 270 – 290 billion per year, and are more concentrated in the road mode, namely road infrastructure subsidies. That means that, even if the objective of transport policy of improving mobility of people and good is achieved by cheaper transport due to subsidies, subsidies can influence volume of transport and the balance between modes, determining unwanted external effects in long run..

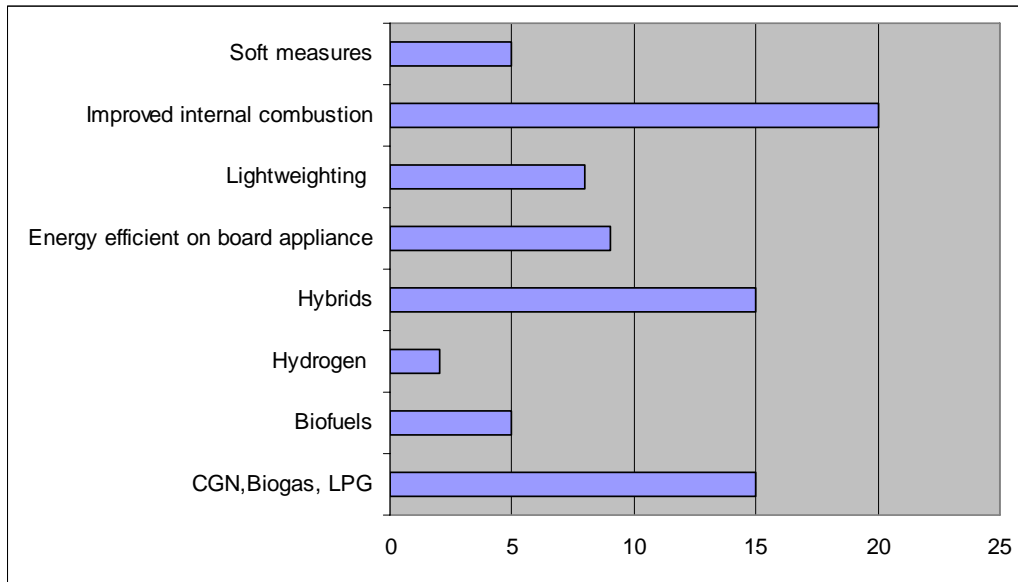
## 7.1 Technological vision.

This vision has a high expectation on new technology to deliver the solution to meet long-term CO<sub>2</sub> targets. In short term, although technology could theoretically provide the required reduction in CO<sub>2</sub>, this would be a difficult and expensive. This vision can be feasible because has to be realized in long term. 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 CO<sub>2</sub> 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 behavior (car ownership, shift to public transport, *et cetera*) have been done. According with Small and Denver's results (2008), in this vision the fuel consumption by passenger vehicle has considered become more price-inelastic over time and that it is increasingly dominated by changes in fuel efficiency rather than in amount of driving (*ibid*).

Policy interventions are to support technology. Key policy instruments are the fuel economy standards, which stimulate the use of technology to improve fuel economy, and regulation of fuel mix. Additionally, a central role have policy support to research and development and using taxation to enable the switch to fuels with low carbon content.

In the figure below (figure 10) the combination of technological solutions to reach the target by 2050 and their contribution in percentage are summarized. The relative contribution of each vehicle energy efficiency measures and fuel options is the likely maximum development potential by 2050 and is in line with the results reported by OECD (2006).

Marginal roles to soft measures are indicated. These are: ecological driving practises; tax incentives and awareness campaign to support change in purchasing behaviour to smaller and lower emissions cars.



**Figure 10: Technological policy package. Contribution to carbon reduction to 2050 (%).**

## 7.2 Behavioral image

Behavioral image is based on the assumption that a reduction in greenhouse gas emissions is considered equivalent to wealth generation and compensates the loss of wealth related to a travel behavior change. This new vision, which corresponds to increasing importance of values such as community and social welfare and environmental quality (Hickman, Banister, 2007), 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. Namely, according with Goodwin (2008), the response to increasing fuel prices is to decrease fuel consumption (i.e. via vehicle size choice) rather than decrease car travel. This is due to the fact that elasticity fuel consumption is at least twice as high as the elasticity of travel volume. On the other side, long-term elasticity of fuel consumption and of travel volume enables many behavioral responses such as vehicle purchase, housing, etc...

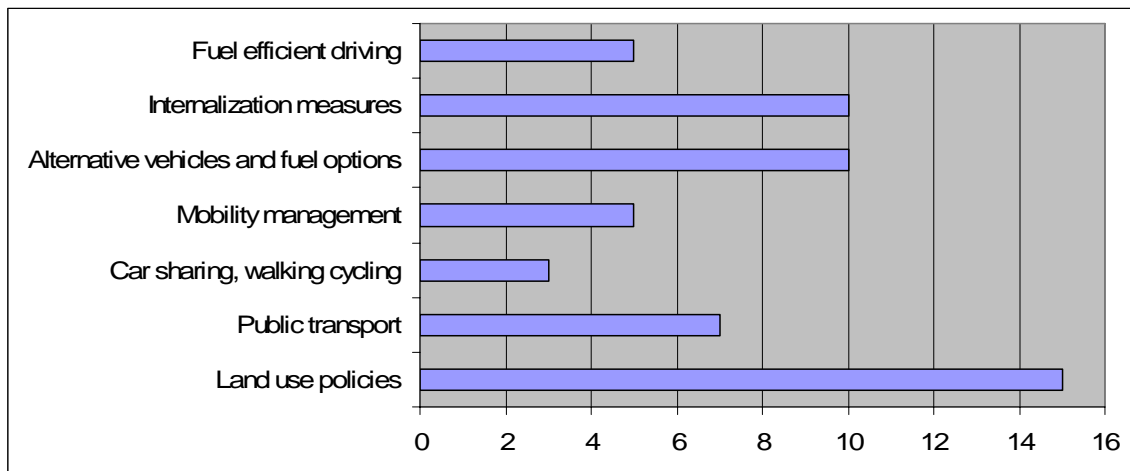
To reach the target of cutting CO2 by 50 % by 2050, the policy strategies coherent with this vision pay particular attention to the complexity of travel behavior which involves, at the same time, the location of activities and housing, several social practices and relations and transport network and supply.

In this scenario the behavior change is supported by demand side policies (by economic tools and soft measures such as information program) and integrated sustainable land use and transport plans.

The technology change gives a marginal contribution to meet the target with vehicle categories and fuel options having the lowest unit impact. This is supported by a taxation policy and pricing incentives to use cleaner technologies. Taxation and pricing scheme are also preferable tools to influence land use plans to locations that generate multi modal solutions.

The modal shift provides the main answer together with the so called smart measures which encourage voluntary behavior change.

In the figure below, the relative contribution of each policy measure to reach the target of cutting CO2 emissions by 50% by 2050 is illustrated.



**Figure 11: Behavioral policy package. Contribution to carbon reduction to 2050 (%).**

## 8 Conclusion

In transport forecasting scenario studies are very common. Problems are assessed due to current and future transport activity, based on the continuation of current socio economic trends. During the last years, backcasting has been applied in the transport planning highlighting its efficiency in indicating policy pathway for the complex transport market and to achieve a sustainable transport system.

The choice of this approach to design scenarios of sustainable mobility to 2050 is supported by its suitability when the policy targets do not seem to be reached by adjustments to a business-as-usual development. Indeed, scenarios based on backcasting may be capable of generating new policy directions needed if transportation is to become environmentally sustainable (OECD, 2002a).

For the scope of our analysis, two different images of future have been developed to reach the target of EU sustainable mobility that consists of cutting EU CO<sub>2</sub> emissions from the transport sector by 50% by 2050. The analysis taking into account the fundamental uncertainties in projecting transport demand and simulating future transport systems. Indeed, uncertainties in demographic, economic, technological and institutional factors affect the current level of future transport demand, the mix of energy supplies consumed, and the associated rates of CO<sub>2</sub> emissions.

Additionally, knowledge is limited of the complex interactions of technological, cultural and political forces that determine the development of transport schemes.

It is therefore not certain that today's relationships will persist for the next 30/50 years. In our analysis, the two images of future are based on two different feasible visions, based on technological and behavioural changes, which indicate policy packages to attain them.

These packages assume the need of a combination of policy measures that take into account the complexity of the objective of cutting CO<sub>2</sub> emissions of transport sector, that is oil dependent and environmentally unsustainable, but at the same time that has the central role of satisfying the basic need of mobility/accessibility.

The considered areas of interventions are (i) transport activity (demand for passenger mobility and transport of goods); (ii) modal mix (that is affected by consumer choices, availability of various modes, prices of competing fuels and vehicles, legislative and fiscal policies); (iii) fuel mix ; (iv) energy intensity (expressed as final energy per unit of transportation activity).



The scenarios and policy packages developed are illustrative rather than perspective. They indicate the type and magnitude of the responses that might be expected from the examined policies, rather than representing recommendations to undertake the simulated policy actions. Moreover, this exercise is based on the analysis of literature while backcasting is a participatory approach that has to involve several stakeholders. Finally, the application of a backcasting approach assumes a vision of policy process as evolutionary process rather than a revolutionary with a time frame of a generation (30-40 years) that are basic principles to enable the policy path towards sustainability. But the choice of including sustainability issues and backcasting visions in transport planning is more a political challenge than a scientific one. The most important challenges lie in the acceptability of the sustainability targets, visions and their component instruments.

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**Abstract**

*In transport policies planning forecasting scenario studies are very common. Problems are assessed due to current and future transport activities, based on the continuation of current socio economic trends. During the last years, backcasting approach has been applied in the transport planning highlighting its efficiency in indicating policy pathway for the complex transport market and to achieve a sustainable transport system.*

*The choice of this approach to design scenarios of sustainable mobility is supported by its appropriateness when the policy targets do not seem to be reached by adjustments to a business-as-usual development. Indeed, scenarios based on backcasting may be capable of generating new policy directions needed if transportation is to become environmentally sustainable (OECD, 2002a).*

*As example of the suitability of backcasting approach to design a sustainable mobility policy path, this report develops two scenarios based on two different images of future to reduce EU CO2 emissions by 50% by 2050 and to indicate policy packages to achieve this target. The indications are illustrative rather than perspective. They indicate the type and magnitude of the responses that might be expected from the examined polices, rather than representing recommendations to undertake the simulated policy actions. The choice of including sustainability issues and backcasting visions in transport planning is more a political challenge than a scientific one.*



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