Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

The Vision Scenario for the European Union

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Dr. Felix Chr. Matthes
Sabine Gores
Verena Graichen
Julia Repenning
Dr. Wiebke Zimmer

in cooperation with

Séverin Poutrel
(ICE – International Consulting on Energy)

Öko-Institut e.V.

Berlin Office
Novalisstraße 10
D-10115 Berlin
Tel.: +49-(0)30-280 486-80
Fax: +49-(0)30-280 486-88

Freiburg Headquaters
Merzhauser Straße 173
D-79100 Freiburg i.Br.
Tel.: +49-(0)761-45295-0
Fax: +49-(0)761-45295-88

Darmstadt Office
Rheinstraße 95
D-64295 Darmstadt
Tel.: +49-(0)6151-8191-0
Fax: +49-(0)6151-8191-33

www.oeko.de

International Consulting on Energy (ICE)
6 rue de Verdun
F-93 450 L'Ile-Saint-Denis
Tel.: +33-(0)1-49 22 00 64
Fax: +33-(0)1-49 22 00 66

Summary

Energy and climate policy in the 21st century is facing manifold and far-reaching challenges:

- The problem of global climate changes requires fast and significant reductions in greenhouse gas emissions to stabilise the concentrations of these gases at a level which is sufficient to limit the increase of the global mean temperature to a level not exceeding 2°C above the pre-industrial levels;
- Finite fossil and nuclear fuel resources and the foreseeable concentration of fuel production in some politically sensitive regions is increasingly highlighting the problem of energy security;
- The integrated world energy markets and liberalised energy markets are increasingly facing the problem of highly volatile energy prices, which leads to an increased vulnerability of economies.

Against the background of these challenges, a business-as-usual approach in energy policy is increasingly being seen as no longer acceptable. However, there is no silver bullet for solving the majority of the problems that energy and climate policy is facing today. Many options must be explored and it will be necessary to implement many options.

Risk minimisation is the key strategic approach to meeting the various challenges. The proven advantages for the options to be used must be greater than the risks and the uncertainties connected to these options.

There is a wide consensus about some options which can be seen as favorable for energy-related activities:

- There is huge potential for energy efficiency in the end-use sectors as well as in the energy sector which can be exhausted in all sectors to a much wider extent than it can be assumed in the business-as-usual case;
- Renewable energies must play a key role in the future energy system, in power production, heating and cooling as well as in the transport sector.

In addition to these options, there is another emerging technology which could play a role in the medium term:

- Carbon capture and storage could contribute significantly to future CO_2 emission reduction; however, many scientific, technological and economic problems must be solved, the regulatory framework for this technology is predominantly lacking, and public acceptance is crucial for this technology pathway.

Besides the matured and consensual, and the emerging and potentially consensual, options for the development of a future energy system, the debate is affected by a strong controversy:

- There is no foreseeable consensus on the acceptability of nuclear power against the background of the possibility of large nuclear accidents and the manifold

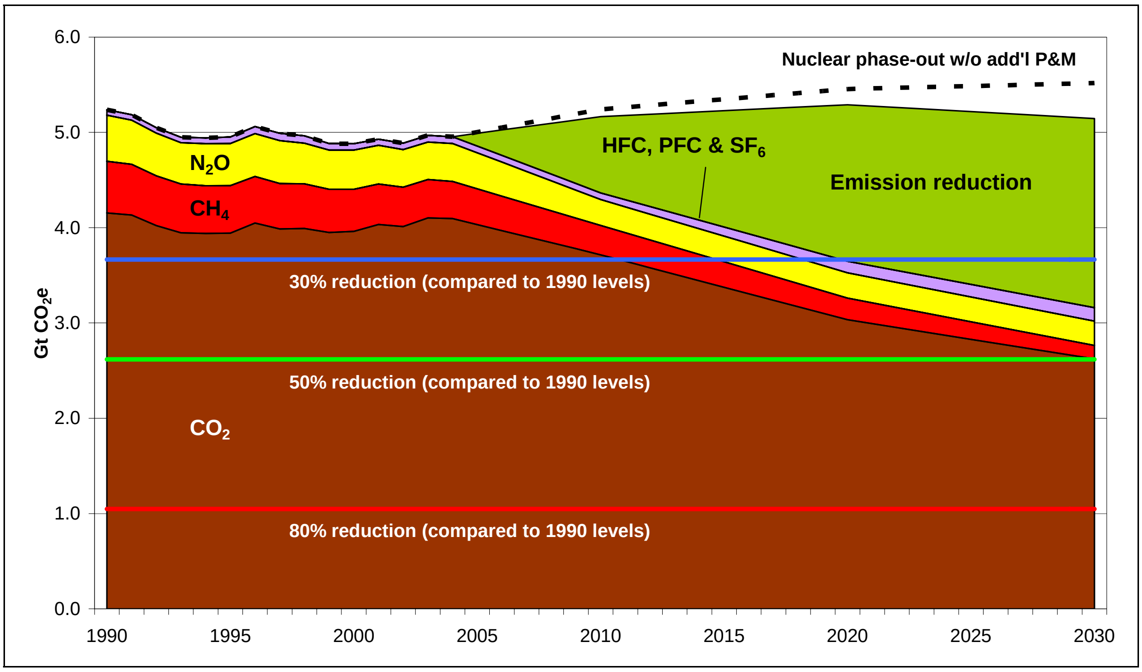
problems related to the handling of nuclear materials (from mining to processing of nuclear materials and the management of nuclear waste).

Scenario design and results

To illustrate the potentials of the non-controversial emission reduction options, a scenario analysis was carried out to analyse the implications and interactions of different options:

- The business-as-usual scenario (baseline scenario) indicates a development which could result if recent energy and climate policies are not strengthened;
- The vision scenario is a normative scenario based on two main assumptions:
  - All non-controversial greenhouse gas mitigation options should be used for the time horizon of 2030 so that an emission reduction of 30% can be reached by the year 2020 compared to 1990 levels and a significantly higher reduction after this date;
  - The use of nuclear power should be phased out based on the existing phase-out policies of different Member States of the EU or a technical lifetime of 40 years; in other words, no significant lifetime of existing nuclear power plants should be assumed and no new investments in nuclear power should be taken into account.

Figure 1 Greenhouse gas emissions in the business-as-usual case and emission reductions, 1990-2030

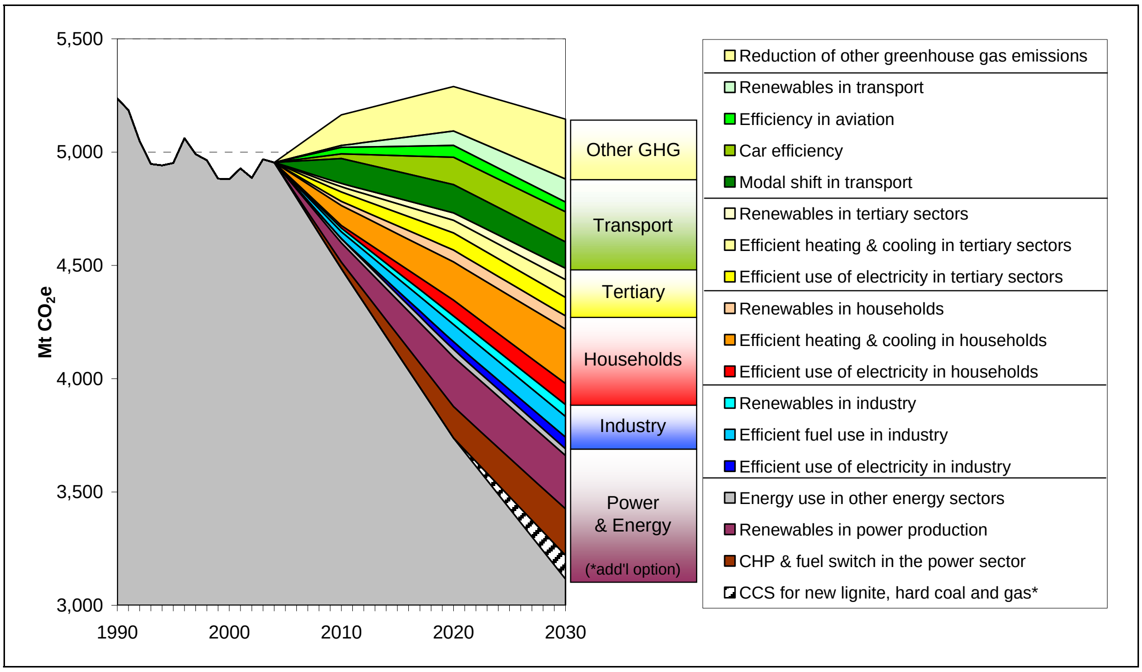


Sources: EEA, Member States inventory reports, Öko-Institut.

Figure 1 illustrates the past emission trends and the different emission pathways under the two scenarios. In the baseline scenario, total greenhouse gas emissions of the EU-25 will reach 1990 levels between 2010 and 2020 and will only moderately decrease again by the year 2030. If the level of nuclear power production is not maintained at a level of 85% of the 2000 level as is assumed in the baseline scenario and no further policies and measures are implemented, the total greenhouse gas emissions of the EU-25 could amount to 5% above the level of 1990 or 11% above the level of 2000.

In the vision scenario, total greenhouse gas emissions can be reduced by 31% by the year 2020 and 40% by the year 2030, compared to 1990 levels. Although measures for all greenhouse gases were considered, the main emission reductions stem from CO_2, which is still by far the main source of greenhouse gas emissions.

Figure 2 Greenhouse gas emission reductions in the vision scenario,1990-2030



Sources: EEA, Member States inventory reports, Öko-Institut.

Figure 2 shows the breakdown of the resulting emission reductions in the vision scenario by sectors and measures.

- The power sector is the main source of CO_2 emissions in the EU-25, mainly because of the high share of coal consumed in this sector, and represents the main potential for emission at the same time. The sector represents 36% of the emission reductions by 2030, two thirds of this by measures in the sector (CHP, fuel switch from coal to gas and power production from renewable energies) and one third as a result of a more efficient use of electricity in other sectors;
- owing to its strong growth dynamics, the transport sector (for which all greenhouse gas emissions from aviation were included in the scenario analysis) con-

stitutes the second most important contribution to emission reductions, making up about 20% by 2030;

- the residential sector, which is mainly characterised by energy consumption by buildings contributes a share of 15.5% to the total emission reductions by the year 2030;
- measures to reduce non-CO_2 greenhouse gases play an important role in the vision scenario and contribute 14% to the overall reduction by 2030;
- industry (8%), tertiary sectors (7%) and other energy industries (2%) also play a significant role in the total reduction of greenhouse gas emissions;
- if carbon capture and storage from large condensation power plants were commercially available as of 2020 for the plants to be built, the emission reduction by 2030 could increase by an additional 100 Mt CO_2, which equals 5% of the total emission reduction by all other measures listed above.

In total, the contribution of renewable energies amounts to 24%, the increasing use of CHP and fuel switch in the power sector to 11%, the reduced consumption of electricity to 12%, the more efficient heating and cooling in the end-use sectors to 21% and the effects of modal shift and a more efficient transport sector to 17% of the total emission reduction achieved by the year 2030.

Against this background, policies and measures with regard to the power sector, a more efficient use of electricity, the building sector and the full range of potentials in the transport sector should be seen as those with the highest priorities.

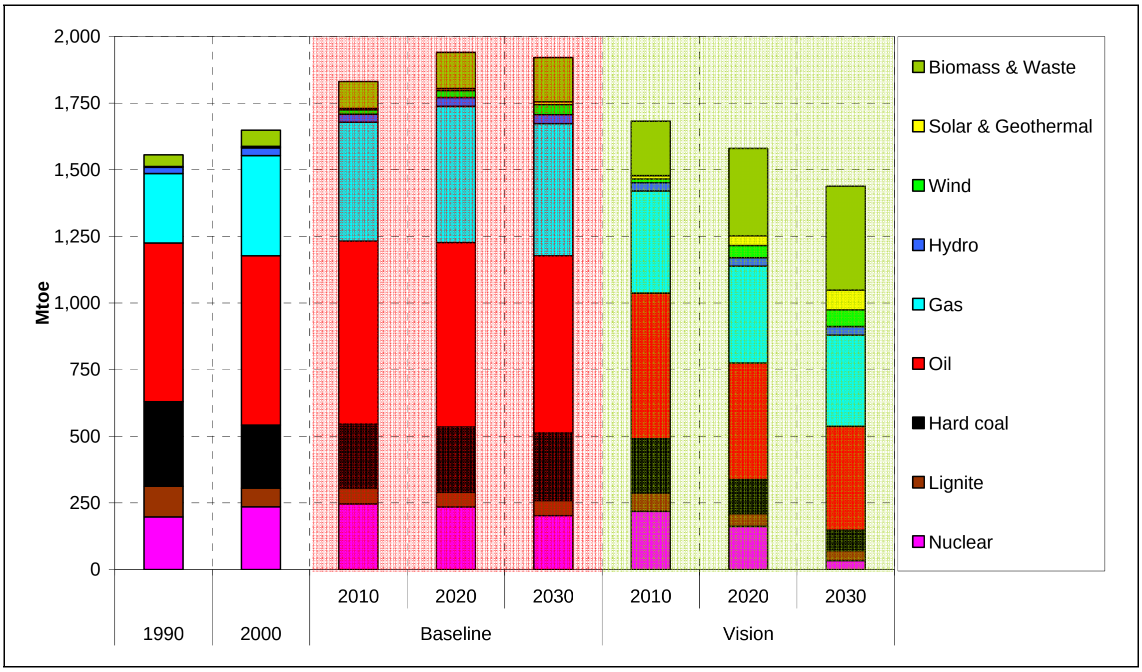
Key findings

The total primary energy supply increases by about 17% in the baseline scenario in the period from 2000 to 2030, whereas in the vision scenario the primary energy consumption is reduced by 13% in this period (Figure 3).

- The level of nuclear power production is maintained at a level of 15% below the 2000 levels in the baseline scenario and shrinks by 85% in the vision scenario.
- The consumption of gas in the EU-25 would be 32% higher in 2030 compared to 2000 in the baseline scenario and is decreased by 9% compared to the 2000 levels in the vision scenario, mostly as a result of the higher efficiency in buildings.
- The use of (fossil) oil in the baseline scenario expands by another 5% by 2030, whereas it can be reduced in the vision scenario by 39% in the same period.
- The total use of coal, which is almost stable in the baseline scenario, is reduced by 63% by 2030 in the vision scenario.
- Although the contribution of renewable energies increases by the factor of 2.6 in the period from 2000 to 2030, the share of total primary energy supply is still only 13% in 2030 in the baseline scenario. In the vision scenario, the contribu-

tion of renewable energies amounts to 39% of the total primary energy supply in 2030.

Figure 3 Total primary energy supply in the baseline and the vision scenario, 1990-2030



Sources: Eurostat, Öko-Institut.

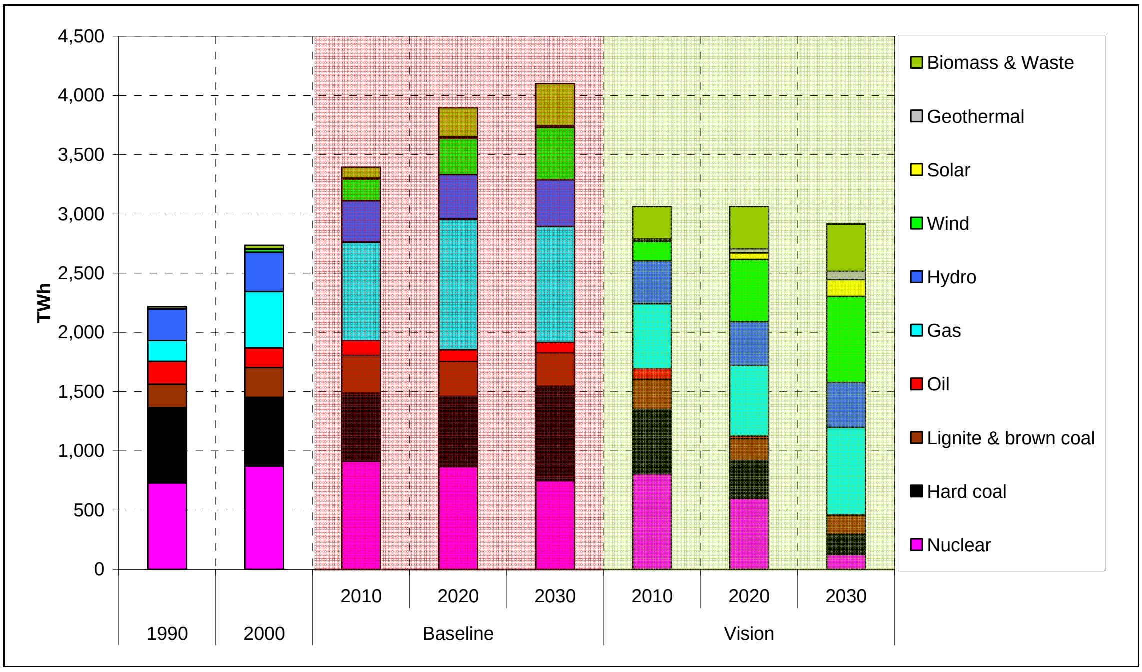
Energy security benefits from climate change policy

The major differences in the structure of primary energy supply lead to significant changes in the role of energy imports to the EU-25. In 2000, the share of imported energies amounted to about 60%. In the baseline scenario, this share rises to 74% in 2030. In the vision scenario, the share of imported energies decreases to 49% in the same period, assuming that all bioenergies are supplied from EU-25 sources. If a significant role is assumed for international trade with regard to biomass and biofuels, the total share of energy imports in the vision scenario is slightly higher (53% in the case of 15% bioenergy imports).

As a summary of the results on import dependence, the vision scenario delivers a major contribution to a decreased dependence on import by means of diversification towards other energies and energy savings. Thus, the economic vulnerability of the EU-25's economies to price spikes and volatilities on the global energy markets is significantly lower.

The generation of electricity and the production of district heat is the most significant sector in the EU-25's energy system with regard to both energy consumption and CO_2 emissions.

Figure 4 Net electricity generation in the baseline and the vision scenario, 1990-2030



Sources: Eurostat, Öko-Institut.

In the baseline scenario, the power production follows the steady growth of electricity consumption in the different sectors in the period from 2000 to 2030, which results in a power production that is 50% higher in 2030 compared to the 2000 levels (Figure 4). In the vision scenario power consumption (and production) can be stabilised at 7% above the levels in 2000 by the year 2030.

- The replacement of inefficient electric appliances and installations leads to a much lower demand for electricity production.
- The production of nuclear power plants decreases by 15% in the baseline scenario by 2030 and shrinks by 85% in the vision scenario.
- The electricity generation from hard coal increases by 38% and from lignite by 11% in the baseline scenario, whereas in the vision scenario power production from lignite decreases by 36% and from hard coal by 71% in the period from 2000 to 2030.
- The production of gas-fired power plants almost doubles in the baseline scenario by 2030 and increases by 55% in the vision scenario.
- The power production from renewables is extended by a factor of 3 and represents a share of 29% in 2030 in the baseline scenario, whereas it increases by a factor of 4.4 in the vision scenario, equalling a share of renewable energies of the total power production of 44% in 2020 and 59% in 2030.

It is also worth mentioning that the share of combined heat and power (based on both fossil fuels and biomass) represents 32% of the total power generation in the vision scenario by the year 2030.

In the vision scenario, the power sector is, against this background, facing a fundamental transition towards renewable energies and towards fossil power generation that is more efficient or less CO_2-emitting.

The implementation of an energy and climate policy framework which has a development outlined by the vision scenario as its goal requires some key activities. These are:

1. A strong focus on energy efficiency measures
   - for appliances and installations consuming electricity in all sectors (household equipment, motors, pumps, etc.);
   - for improvement of buildings (heating and cooling) for both new buildings and the renovation of the existing building stock so as to reach low energy or passive house standards in the period up to 2030;
   - for the substitution of electric appliances for low temperature heating purposes;
   - implementing ambitious performance standards for cars and car fleets.
2. A strong focus on changing the modal split targeting public and rail freight transport
   - with comprehensive efforts to avoid transport;
   - with a consequent liberalisation approach to the railway system and major system investments to strengthen the competitiveness and the infrastructure of rail transport and sustainable modes of transports in cities;
   - with measures to establish a level playing field between the different modes of transport, e.g. by removing the tax advantages for kerosene and jet fuels for aviation.
3. Ambitious efforts to increase the share of renewable energies in both the energy and the end-use sectors
   - to set a share of about 20% in the end-use sectors by 2030 as the target;
   - to reach a share of about 45% by 2020 and 60% by 2030 of the electricity production.
4. Securing the necessary investments in the energy infrastructure
   - to integrate a large share of power production from fluctuating, decentral and offshore sources;
   - to develop the necessary infrastructure for heat networks which constitute an essential element for many options of biomass use and CHP;

- to improve the networks and the storage facilities for the EU-25 wide supply of natural gas, mainly in Central and Eastern Europe;
- to secure the supply of biofuels in the range indicated above.

5. Implementation of effective political instruments
    - strengthening the EU ETS to develop it as an instrument of effective carbon pricing for new investments and the operation of existing plants and introducing ETS as an instrument for lowering the greenhouse gas emissions from aviation;
    - to support CHP as a key technology for using hydrocarbons as well as biomass with the highest efficiency possible;
    - to reach ambitious performance standards for energy consumption of electric appliances and installations and of buildings as well as cars in the framework of the internal market;
    - to establish sufficient support schemes or standards for the significant penetration of energy production from renewable energies for power production, heating and cooling as well as the transport sector;
    - strengthening the EU energy market liberalisation and enforcing competition for the electricity market and especially for the gas market so as to enable access for new and efficient technologies and new players on the market;
    - to define a coherent EU gas strategy;
    - to push forward the technology of CCS and other emerging technologies in the fields of renewable energies, energy efficiency and energy storage;
    - to address the full range of emission reductions achievable for non-CO_2 greenhouse gases in industry, agriculture, waste management and the energy sector.

The vision scenario indicates a very ambitious pathway towards a sustainable energy system. However, compared to the different dimensions of the baseline scenario in terms of greenhouse gas emission, consumption of fossil fuels and the different aspects of energy security, the vision scenario shows that a plethora of benefits can be created if such a pathway forms the framework for the design of future energy and climate policies.

Contents

List of Figures

List of Tables

1 Introduction

Energy and climate policy in the 21st century is facing manifold and far-reaching challenges:

- The problem of global climate changes requires fast and significant reductions in greenhouse gas emissions to stabilise the concentrations of these gases at a level which is sufficient to limit the increase of the global mean temperature to a level not exceeding 2°C above the pre-industrial levels;
- Finite fossil and nuclear fuel resources and the foreseeable concentration of fuel production in some politically sensitive regions is increasingly highlighting the problem of energy security;
- The integrated world energy markets and liberalised energy markets are increasingly facing the problem of highly volatile energy prices, which leads to an increased vulnerability of economies.

Against the background of these challenges, a business-as-usual approach in energy policy is increasingly being seen as no longer acceptable. However, there is no silver bullet for solving the majority of the problems that energy and climate policy is facing today. Many options must be explored and it will be necessary to implement many options.

Risk minimisation is the key strategic approach to meeting the various challenges. The proven advantages for the options to be used must be greater than the risks and the uncertainties connected to these options.

There is a wide consensus about some options which can be seen as favorable for energy-related activities:

- There is huge potential for energy efficiency in the end-use sectors as well as in the energy sector which can be exhausted in all sectors to a much wider extent than it can be assumed in the business-as-usual case;
- Renewable energies must play a key role in the future energy system, in power production, heating and cooling as well as in the transport sector.

In addition to these options, there is another emerging technology which could play a role in the medium term:

- Carbon capture and storage (CCS) could contribute significantly to future CO_2 emission reduction; however, many scientific, technological and economic problems must be solved, the regulatory framework for this technology is predominantly lacking, and public acceptance is crucial for this technology pathway.

Besides the matured and consensual, and the emerging and potentially consensual, options for the development of a future energy system, the debate is affected by a strong controversy:

- There is no foreseeable consensus on the acceptability of nuclear power against the background of the possibility of large nuclear accidents and the manifold problems related to the handling of nuclear materials (from mining to processing of nuclear materials and the management of nuclear waste).

Although is much consensus on the future role of energy efficiency, renewable energies ore potentially CCS in general many questions remain regarding the potential and the contribution of the different options to the necessary transformation of the energy system. A key challenge of the debate is to identify the potential of these options and to what extent the potential must be realised so that the overarching goals of climate protection and energy security can be met at acceptable costs.

The purpose of the analysis presented in this paper is to analyse potential combinations of the manifold options of energy efficiency and renewable energies as well as the shift to low carbon fossil fuels and the medium-term option of CCS over time, to identify key challenges and areas of action and to derive some technical and political conclusions. As a result of the analysis, a vision on the fundamental transformation of the energy system should evolve to assess the outcome of recent policies and measures and to contrast it with activities which go significantly beyond the business as usual. Special focus was placed on the analysis of the relations between different technical or political measures and their outcome in terms of greenhouse gas emissions as well as in terms of changes in the final and primary energy consumption.

Against this background, the analysis presented in this paper should be understood as a contribution to the necessary discussion on how and how quickly the energy system in the European Union could be restructured so as to meet the challenges of climate change, energy security and other dimensions of sustainable development.

Work on the study was conducted in a varied process of dialogue and fruitful discussions both within the project team and with the project sponsor, as well as with various colleagues from other institutions and organisations who delivered data and further information which was extremely valuable given the time and resource constraints for this study. For this extensive support the authors would like to express their thanks. Special thanks go to Vanessa Cook from Öko-Institut who worked on the English editing of the text. Responsibility for the contents of the study naturally resides with the authors.

2 Methodological approach

The analysis presented in this study is based on the scenario approach. The development of scenarios offers the possibility of assessing the implications and interactions and the total effects of certain energy and climate policy strategies in a transparent manner. The analysis is based on two scenarios:

- The business-as-usual scenario (baseline scenario) indicates a development that could result if recent energy and climate policies are not strengthened;
- The vision scenario is a normative scenario based on two main assumptions:
  - All non-controversial greenhouse gas mitigation options should be used for the time horizon of 2030 so that an emission reduction of 30% can be reached by the year 2020 compared to 1990 levels as well as a significantly higher reduction after this date;
  - The use of nuclear power should be phased out based on the existing phase-out policies of different Member States of the EU or a technical lifetime of 40 years; in other words, no significant lifetime of existing nuclear power plants should be assumed and no new investments in nuclear power should be taken into account.

The starting point for the development of the scenarios are the high efficiency and high renewables scenarios presented by DG TREN (2006) in combination with some other studies on EU projections (EEA 2005, WI 2005). In a first step, these scenarios were analysed and the baseline scenario was developed on the basis of the data and information given in the scenario report. In addition to the information which could derived directly from the documentation, additional expert judgements were carried out to fill the remaining data gaps.

All historic time series (for the years from 1990 to 2004) are based on data from Eurostat (energy data) and from the European Environment Agency (EEA) and the National Inventory Reports (NIR) from different Member States.

On the basis of the baseline scenario, a sectoral analysis was undertaken to analyse the implication of the baseline scenario and to identify and quantify additional potentials and options. The high efficiency and high renewable scenarios of DG TREN (2006) served as one of the guidelines for the extent to which additional measures could be assumed. In addition, the existing literature was explored and our own modelling exercises were undertaken.

The sectoral analysis was carried out in cooperation by Öko-Institut and ICE International Consulting in Energy:

- ICE analysed the sectors industry, private households and tertiary sectors (services, agriculture, etc.);

- Öko-Institut analysed the energy sectors, the transport sector, the non-energy and non-CO_2 greenhouse gases and developed the model in which the results from the sectoral analysis were integrated in a consistent manner.

Different models were used for the analysis. For the end-use sectors, ICE used their bottom-up model and modelling exercises. For the power sector Öko-Institut's ELIAS model[1] was used and for the transport sector a simple assessment model was developed within the framework of this study.

The integration of the sector analysis was implemented by a simple energy balance model which can also be used to calculate the related total primary energy supply (TPES) and the energy-related carbon dioxide (CO_2) emissions.

The development of the scenarios for the non-energy and non-CO_2 greenhouse gases was based on existing literature and additional expert judgments.

The analysis was carried out on an aggregate level for the European Union with 25 Member States (EU-25). However, for some sectors the analysis is based on a more detailed database which differentiates between the 15 'old' Member States (EU-15) and the 10 'new' Member States (NMS-10).

If not otherwise indicated, the metrics of all calculations are in tons of oil equivalent (toe) or in billion kilowatt hours (TWh). Greenhouse gas emissions are expressed in tons of carbon dioxide equivalent (t CO_2e) for the non-CO_2 greenhouse gases and the respective totals and in tons of carbon dioxide (t CO_2) for the energy-related emissions.

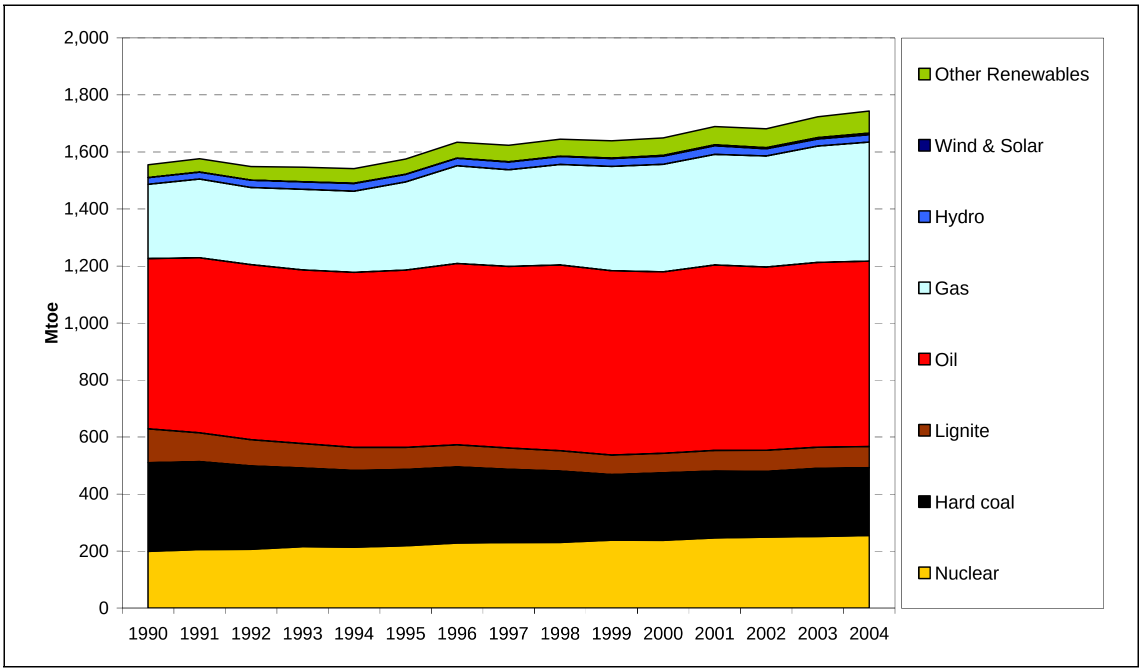
1 The Electricity Investment Analysis Model (ELIAS) was developed to analyse the impact of different political instruments (which are modelled in much detail) on the investment decisions in the power sector.

3 Trends in energy supply and greenhouse gas emissions in the EU-25

The development of the total primary energy supply (TPES) of the EU-25 in the period between 1990 and 2004 is characterised by two main trends (Figure 5):

- The first years after 1990 show that the economic crisis had a significant impact in the new Member States and the eastern part of Germany which led to a slight decrease in primary energy consumption. However, besides this special trend in the eastern economies in transition, the TPES rose steadily. The total increase in primary energy consumption amounted to 190 million tons of oil equivalent (Mtoe) which equals an increase of about 12%.
- Significant changes in the structure of primary energy can be observed. The share of coal dropped and the role of natural gas expanded significantly. In 1990 the share of hard coal in the TPES was 20% and the share of lignite amounted to 7.7%. By 2004, these shares decreased to 13.6% and 4.2%, respectively. The contribution of natural gas to the TPES increased from 16.7% to 23.9%. Only small changes can be observed for the contribution of oil and nuclear energy. The highest growth rates are indicated by the renewable energies which supplied 59% more primary energy in 2004 than in 1990. However, because of the low base level, the share of the TPES only increased from 4.4% in 1990 to 6.2% in 2004.

Figure 5 Total primary energy supply by fuel in the EU-25, 1990-2004



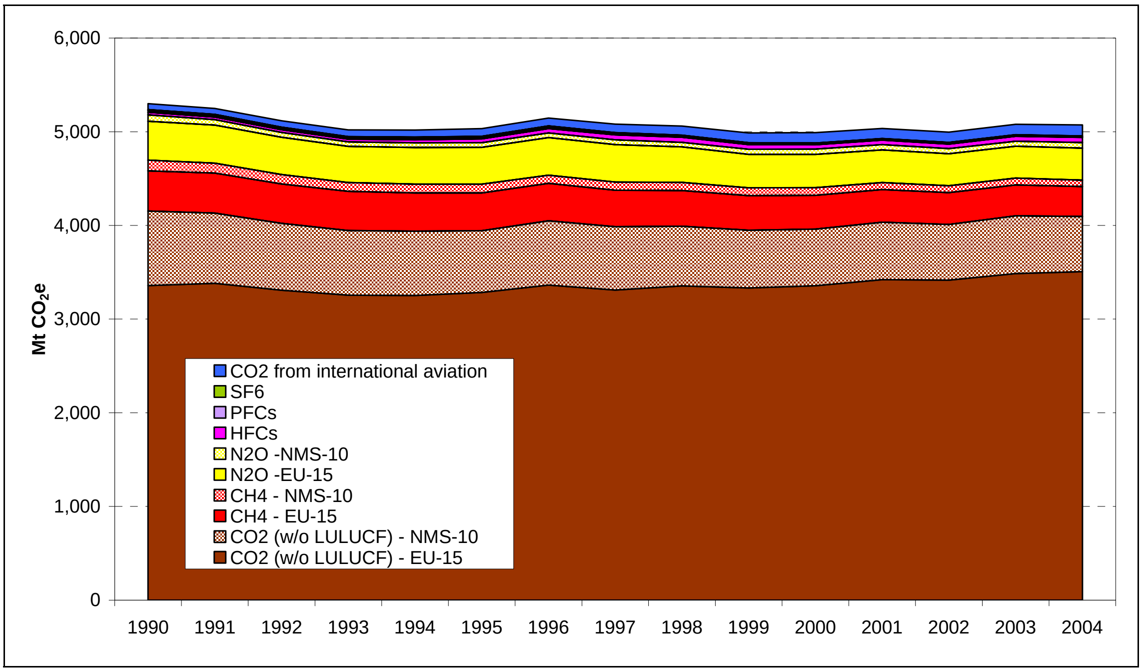
Sources: Eurostat, Öko-Institut.

In total, the increase in TPES was only partly compensated by the trend towards fuels with lower carbon emissions which results in a significant increase of carbon dioxide emissions from energy use.

The level of greenhouse gas emissions in the EU-25 is dominated by the emission trends in the EU-15 Member States (Figure 6). However, the emissions decrease of about 5.4% in the period from 1990 to 2004 mainly results from developments in the new Member States.[2] Whereas the level of total greenhouse gas emissions in the EU-15 Member States was 0.6% below the 1990 level in 2004, the emissions decreased in the new Member States by about 26.3%.

A more detailed analysis of the developments in the EU-15 shows that the total decrease of emissions in the period from 1990 to 2004 results from the significant decrease of the non-CO_2 emissions; CO_2 emissions rose by approximately 4.4% from 1990 to 2004. The only other greenhouse gas which also shows an increasing trend is the group of HFCs. The total emissions of HFS increased by about 87% in the period indicated above.

Figure 6 Greenhouse gas emissions in the EU-25, 1990-2004



Sources: Inventory reports of the EU and Member States, Öko-Institut.

2 It should be mentioned that in the framework of the first commitment period of the Kyoto Protocol some Member States chose a different base year for all or some of the gases covered by the Kyoto Protocol. Some of the new Member States chose a base year before 1990 and most of the EU-15 Member States chose 1995 as the base year for the emissions of HFCs, PFCs and SF_6. However, for the total EU-25 emissions, these different base years only have minor consequences for the total emission reductions achieved by the year 2004. Last but not least, CO_2 emissions from land use, land use change and forestry (LULUCF) were not taken into account although some Member States intend to do so for the first commitment period of the Kyoto Protocol.

Furthermore, it is important to mention that CO_2 emissions from international aviation are not included in the totals of greenhouse gas emissions reported under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Against the background of the exceptional growth of aviation in the course of the last decade,[3] this exclusion of emissions from international aviation results in different assessments on the progress made in emission reduction in the fourteen years between 1990 and 2004:

- If CO_2 emissions from international aviation are taken into account, the total greenhouse gas emissions of the EU-15 increased by about 0.6% from 1990 to 2004. If CO_2 emissions from international aviation are not considered in the emission totals, the total greenhouse gas emissions decreased by 0.6% in this period.
- The share of CO_2 emissions from international aviation for the new Member States is significantly lower. However, the total greenhouse gas emissions dropped by 26.3% if international aviation is not included and by 26.0% if these emissions are considered in the totals.
- For the EU-25 the total greenhouse gas emissions decreased by 5.4% from 1990 to 2004 if the emissions from international aviation are not considered. If the fast-increasing emission levels from international aviation are taken into account, the total emissions only decreased by 4.3%.

The trends for the total level primary energy supply as well as for the structure of TPES and the CO_2 emissions clearly indicate that major efforts will be needed to achieve major emission reductions for CO_2, the most important greenhouse gas, as well as to make renewable energies constitute a significant share.

Last but not least, the share of fuel imports increased significantly for some energies. In 1990 the share of imports in the total hard coal supply was 24% for the EU-25. By the year 2004, this share expanded to more than 50%. Whereas the share of imported oil remained stable at a 79% level, the contribution of imported natural gas to the total gas supply for the EU-25 increased from 46.5% in 1990 to 54% in 2004.

Consequently, the import dependency of EU-25's energy system grew significantly. The total share of imported fuels in the TPES rose from 56.4% in 1990 to 64% by the year 2004.[4]

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3 The total CO_2 emissions from kerosene and jet fuel increased in the EU-25 from about 90 to 145 Mt CO_2 in the period from 1990 to 2004.

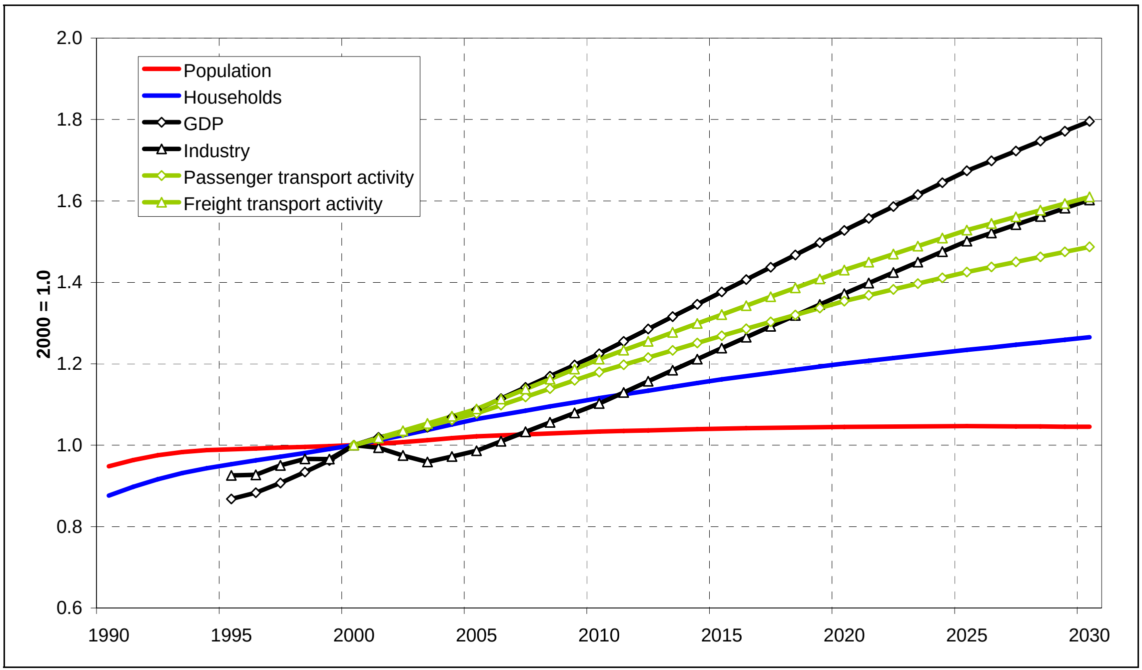
4 In most of the official statistics, the share of imported fuels is lower than the data indicated above. The main reason for this is the fact that nuclear fuels are not considered as imported fuels in this approach. In this study we consider nuclear fuel as that which it is, a fuel that is more or less completely imported to the European Union. If nuclear fuel is considered as domestic energy source for the EU-25, the total share of imported fuels would have been increased from 44% in 1990 to 50% in the year 2004.

4 Main driver economic and demographic drivers

Figure 7 indicates some of the key drivers for the economic and demographic development which were considered for the scenarios. These assumptions were taken from the recent projections of DG TREN (2006). The main assumptions regarding population, gross domestic product (GDP) and the value added from the industrial sectors remain unchanged for the different scenarios. Only for the transport sector different assumptions were considered in the baseline and the vision scenario which were derived from the assumptions on model shift, etc.

- For the development of the population only a small increase is projected, in the period beyond 2020 a stabilization of the population in the EU-25 is assumed.
- However, the number of households is projected to growth significantly, mainly because of the trend towards smaller families and single households in many Member States.
- The growth of GDP in the period 2000 to 2030 is significant, the level of GDP, in constant terms, will be 80% higher compared with the 2000 levels.
- The industrial production will increase significantly lower, which is based on the assumption that major dynamics in the economic development of the EU-25 will result from growth in the tertiary sectors.
- A significant growth is projected for the transport activities. In 2030 the level of passenger transport activities will exceed the year 2000 levels by 50% and the freight transport activities by 60%.

Figure 7 Economic and demographic drivers for the scenarios, 1990-2030



Sources: Eurostat, DG TREN, Öko-Institut.

5 Baseline and vision scenario

5.1 End-use sectors

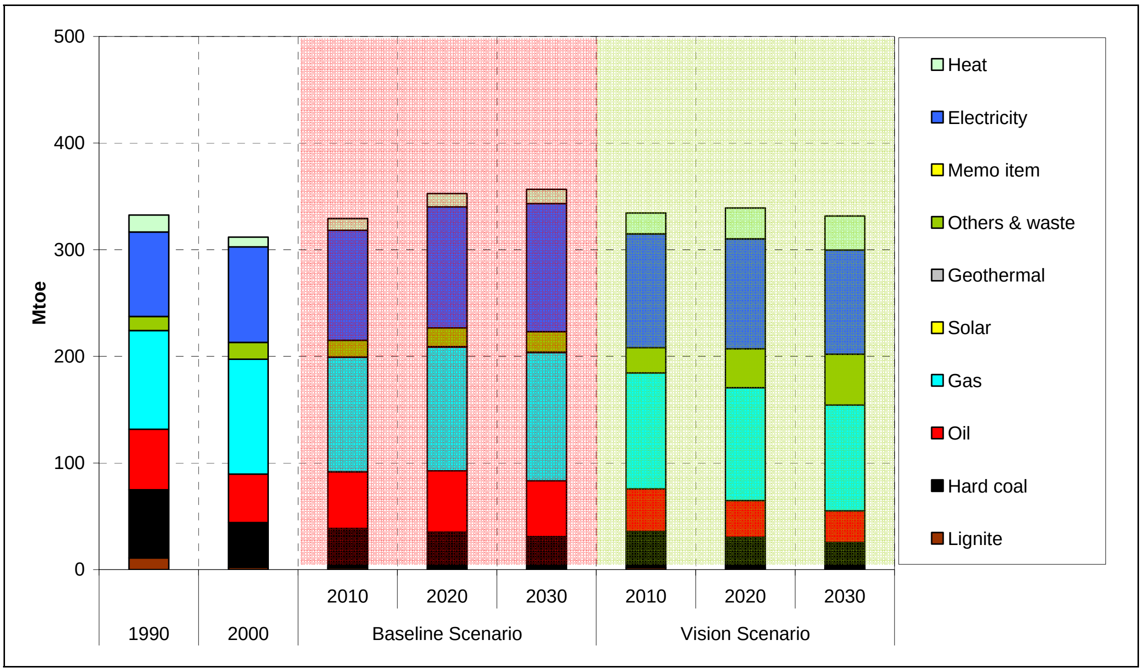
5.1.1 Industry

The final energy consumption of industry was the main energy consuming sector in 1990. With a share of 33% in total, final energy consumption industry was by far the most important sector compared to private households, tertiary sectors and transportation.

In the decade between 1990 and 2000, this pattern changed. The energy consumed in the transport sectors (including international aviation) was higher than in industry. This is mainly because the energy consumption in industry decreased from 333 Mtoe in 1990 to 312 Mtoe in 2000 and the energy consumption in all other sectors rose significantly.

However, industry is still the largest consumer of electricity among the final energy sectors. More than 40% of the total electricity consumed in the final energy sectors came from industrial consumers. Industry also makes up the majority of fuel consumption in terms of final energy for solid fuels and for natural gas.

Figure 8 Final energy consumption by fuel in the EU-25 industry, 1990-2030



Sources: Eurostat, DG TREN, ICE, Öko-Institut.

In the baseline scenario, the final energy demand is projected to rise (Figure 8). The total final energy consumption increases by 14% by the year 22030 compared to 2000 levels. Whereas the consumption of solid fuels is projected to decrease further, the consumption of oil and natural gas is projected to moderately increase, by 15 and 12% respectively, and it is considered that the electricity consumption will rise by 34% in the period from 2000 to 2030.

The role of renewable energies in industry remains slight and amounts to 5.5% of total final energy consumption in 2030.

The vision scenario for the industry is based on four assumptions for the industrial sectors:

- The structural change between energy-intensive industries and the other industrial sectors will significantly advance. In the baseline scenario, the share of energy-intensive industries in the total industrial value added is 21% in 2030; in the vision scenario, the contribution of energy intensive industries only amounts to 18%.
- The energy intensity will improve slightly. Considering the fact that an improvement of energy intensity in many industrial sectors is seen as being between 15% and 30% by 2030 in the baseline scenario, additional measures for improving the energy efficiency could provide additional efficiency gains of 1% to 8% in 2030.
- The use of renewable energies (mostly biomass) and waste will be tripled by 2030.
- The use of CHP in the industrial sectors will significantly increase by 2030.

The EU Emissions Trading Scheme will play a major role in creating additional potential in energy efficiency. However, other focused policies and measures will uncover and implement additional technical and organisational options. Regarding electricity consumption, improved standards for electrical motors, pumps and pressured air installations are crucial measures. Furthermore, the development of CHP at industrial sites plays a crucial role. Whereas the use of heat from CHP plants only increases from 9 to 14 Mtoe between 2000 and 2030 in the baseline scenario, the consumption of heat from CHP plants rises to about 30 Mtoe by 2030 in the vision scenario.

The major differences between the baseline scenario and the vision scenario can be summarised as follows:

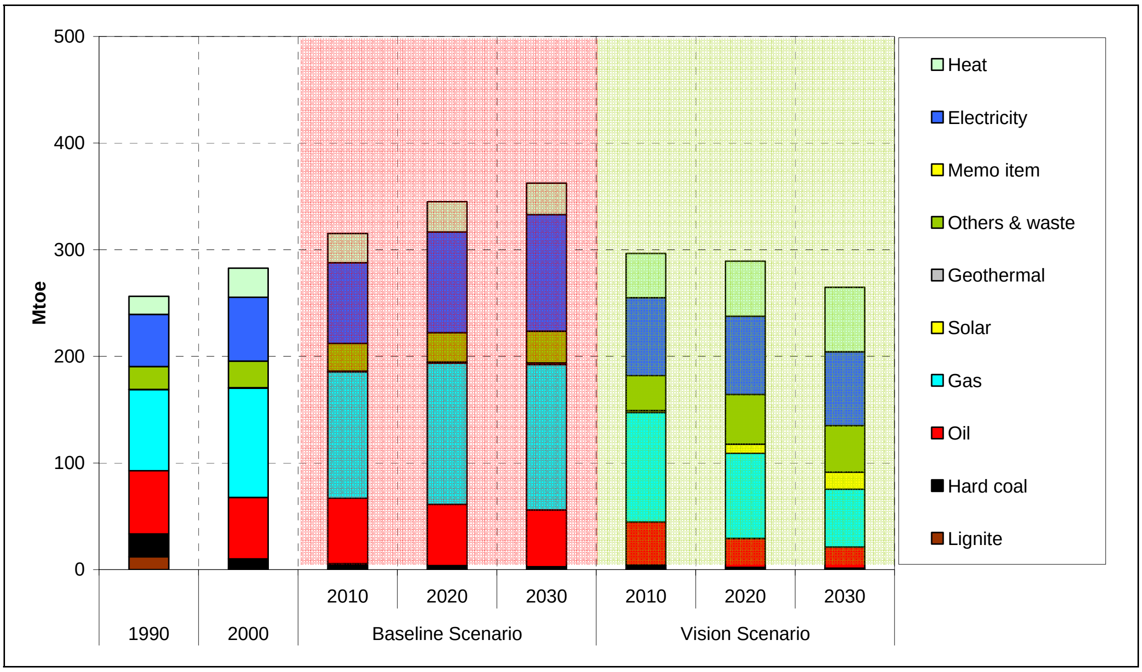
1. The trend of hard coal and lignite consumption in industry is not significantly different in the baseline and the vision scenario.
2. The consumption of oil is more than 40% less in the vision scenario in 2030 compared to the baseline scenario.
3. Compared to the levels of the baseline scenario, the consumption of gas is 17% lower in the vision scenario in 2030 and the demand for electricity is 18% less than in the baseline scenario.
4. The use of renewable energies (mostly biomass) and waste exceeds the levels projected for the baseline scenario by a factor of 2.4 in the vision scenario in the year 2030.

As key result of the vision scenario for the industry sector is, that the total level of final energy consumption is reduced by 8% in the vision scenario compared to the baseline scenario by the year 2030. The share of renewable energies (and waste) expands from 5.5% in the baseline scenario in 2030 to 14% in the vision scenario.

5.1.2 Households

In contradistinction to the projected trend in industry, the final energy consumption rises substantially in the baseline scenario. The total final energy consumption increases by about 28% in the period from 2000 to 2030. Among the traditional energy carriers, the consumption of electricity represents the most marked increase. It is projected that the electricity consumption in households will reach a level 83% above the 2000 levels. The consumption of natural gas is also projected to rise significantly in this period, by 33%. The additional gas partly substitutes oil consumption in private households, for which a slight decrease is assumed in the baseline scenario. Solid fuels will only play a minor role for the time horizon of 2030 (Figure 9).

Figure 9 Final energy consumption by fuel in EU-25 households, 1990-2030



Sources: Eurostat, DG TREN, ICE, Öko-Institut.

The consumption pattern of the residential sector in the EU-25 is dominated by heating, cooling and cooking applications, which represent about 85% of the total final energy consumption. Electric appliances and lighting only represent a share of less than 15% of total final energy consumption in private households. It is worth mentioning that about half of electricity consumption in the EU-25 is used for different heating purposes and cooling at present.

The following seven key assumptions characterise the alternative projection of the vision scenario:

- The energy efficiency standards for the construction of new buildings are between 25% and 30% stricter in 2030 in the vision scenario than in the baseline scenario.
- In the vision scenario, 2.5 times more existing buildings are retrofitted in terms of energy efficiency during renovations than in the baseline scenario.
- The share of electric space heating and electric hot water heating is significantly reduced.
- More efficient heating installations reduce the final energy demand for heating purposes.
- A significant increase in heat supply from CHP and district heating plants.
- More efficient electric appliances and installations and lighting systems lead to a more efficient use of electricity.
- The contribution of renewable energies reaches a significant market share, especially for heating and hot water (20% to 30%), and grows by 135% compared to 2000, amounting to double the level of the baseline scenario.

As a result, the total final energy consumption in the vision scenario is stabilised at a level that is 6% lower than the consumption in the year 2000, or 27% below the level in the baseline scenario. The use of oil and gas for the residential sector is decreased by 50% or more during the period from 2000 to 2030. The increase of electricity consumption is limited to 16% above the 2000 levels or 60% below the consumption projected for the baseline scenario in 2030.

The use of solar energy for hot water and heating increases by a factor of 16 and reaches a share of 6% of total residential final energy consumption. However, the use of biomass, which doubles compared to the baseline scenario, provides nearly three times the amount of renewable energy in 2030 (16.5% of the total final energy consumption) compared with energy from solar heat. The total contribution of renewable energies amounts to 22.5% of the total final energy consumption in the year 2030.

Last but not least, heat from CHP plants plays an increasingly significant role in the energy mix for the residential sector. In the baseline scenario, the contribution of heat is more or less stabilised at recent levels. By contrast, heat from CHP and district heating plants doubles by the year 2030 in the vision scenario and represents a share of 23% of the total residential final energy consumption.

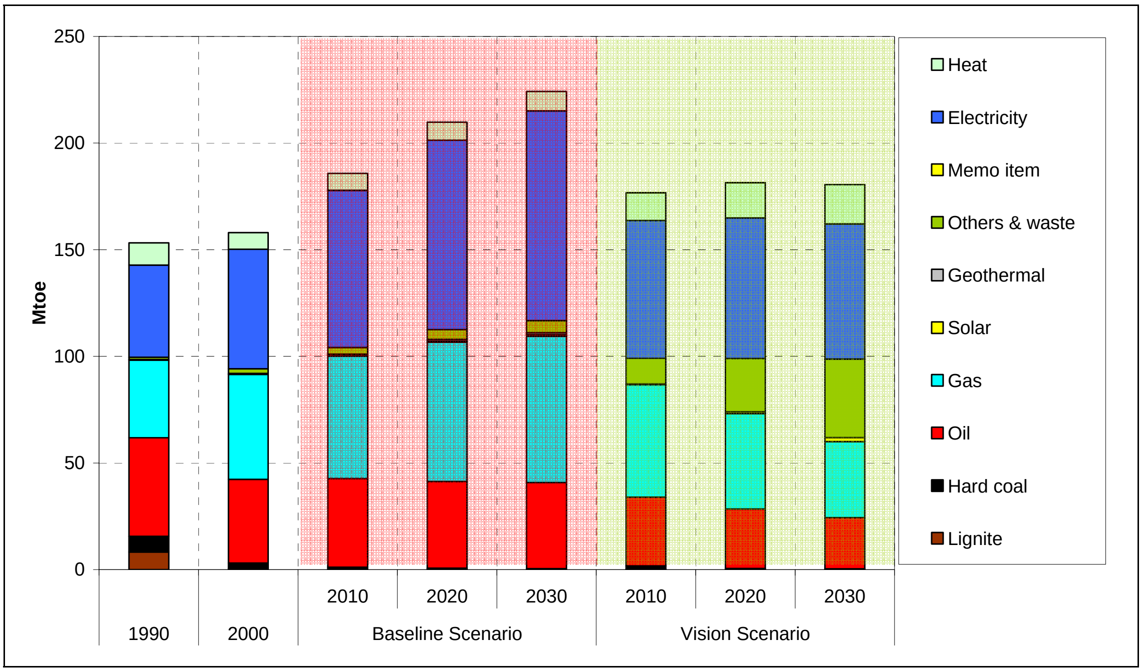
5.1.3 Tertiary sectors

The tertiary sectors represent the non-industrial sectors of the economy, i.e. the energy consumption from the service sector, the public sector, and from agriculture.

In accordance with the fast economic growth in the service sectors, the energy consumption of the tertiary sectors shows strong growth in the baseline scenario. Compared to the 2000 levels, the total final energy consumption increases by 42% in the period up to 2030. Again, the increase in natural gas and electricity consumption is the most significant trend among the conventional fuels.

The electricity consumption rises by 76% by the year 2030 compared to 2000 levels, and the gas consumption expands by nearly 40% in this period. The consumption of oil is more or less stabilised in the coming decades; solid fuels only represent a minor share of the total final energy consumption in 2030.

Figure 10 Final energy consumption by fuel in the EU-25 tertiary sectors, 1990-2030



Sources: Eurostat, DG TREN, ICE, Öko-Institut.

The share of energy consumption for heating and cooling is about 20 percentage points less than in the residential sector. The use of electricity and some other specific energy uses (e.g. agriculture) amounts to about 30% of the total final energy consumption.

Taking into account the same measures as with regard to the residential sector, the total final energy consumption of the tertiary sectors can be stabilised at a level of about 14% above the 2000 level in the vision scenario.

The potential for reducing electricity consumption is significant, but only constitutes one third of the total consumption level in the baseline scenario. As a result, the electricity consumption in the tertiary sectors is stabilised at a level 15% higher than in the year 2000. The use of renewable energy (mostly biomass) increases significantly, reaching a share of 21% of the total final energy consumption in 2030.

5.1.4 Transport

The transport sector is the fastest-growing sector in terms of energy use. In the baseline scenario both the passenger transport and the freight transport activity is projected to continue to rise. After 2020, the energy demand slowly decreases as a result of enhanced efficiency. In 2030, however, the energy use for transport is around 47% higher than in 1990. A strong increase is especially assumed in the use of kerosene and jet fuels, which is estimated at 34% above the level of consumption in the year 2000. Although the role of biofuels is increasing over time, their share in terms of the total final energy consumption of the transport sector is not higher than 7% in 2030 (Figure 11).

Additional measures are required so that the transport sector fulfils its contribution to achieving significant higher CO_2 emission reductions. In the vision scenario, three different packages of measures were considered with regard to the fuel efficiency of private cars, changes in modal shift and transport avoidance together with the introduction of an emissions trading scheme for emissions from aviation, which could potentially be linked to the existing EU Emissions Trading Scheme.

More than half of the energy use in road transport stems from the demand of private cars. It is therefore essential to realise the potential for energy efficiency gains of private cars. Due to the close link between fuel efficiency and the CO_2 emissions of vehicles, efficiency measures in the area of private cars has a significant influence on the CO_2 emission levels of the transport sector. To enhance the fuel efficiency of cars, different measures are taken into account:

- Legislation for a CO_2-emission target of new cars sold within the EU (80 g/km in 2020);
- Tax base of both registration taxes and annual circulation taxes directly related to the carbon dioxide emissions of passenger cars;
- Amendment of the Car Fuel Efficiency Labelling Directive (1999/94/EC) including a comparing Labelling Directive as already exists for household appliances;
- Incentives for the use of fuel efficient lubricant oils and tyres which allows for a further reduction in fuel consumption; tyre pressure monitoring systems in new vehicles should be implemented as well;
- The broad promotion of a fuel-efficient driving style combined with in-car devices which indicate the actual fuel consumption of the car to the driver.

To calculate the reduction potential in comparison to the baseline scenario, some assumptions have to be made. According to the analysis from the TREMOVE project, the share of light duty trucks driving with gasoline is assumed to be 8% in the EU-15 and 15% in the EU-10 (TML 2006). This results in diesel cars having a share of about 22% in the EU-25. The occupancy rate is projected at 1.6 persons per car.

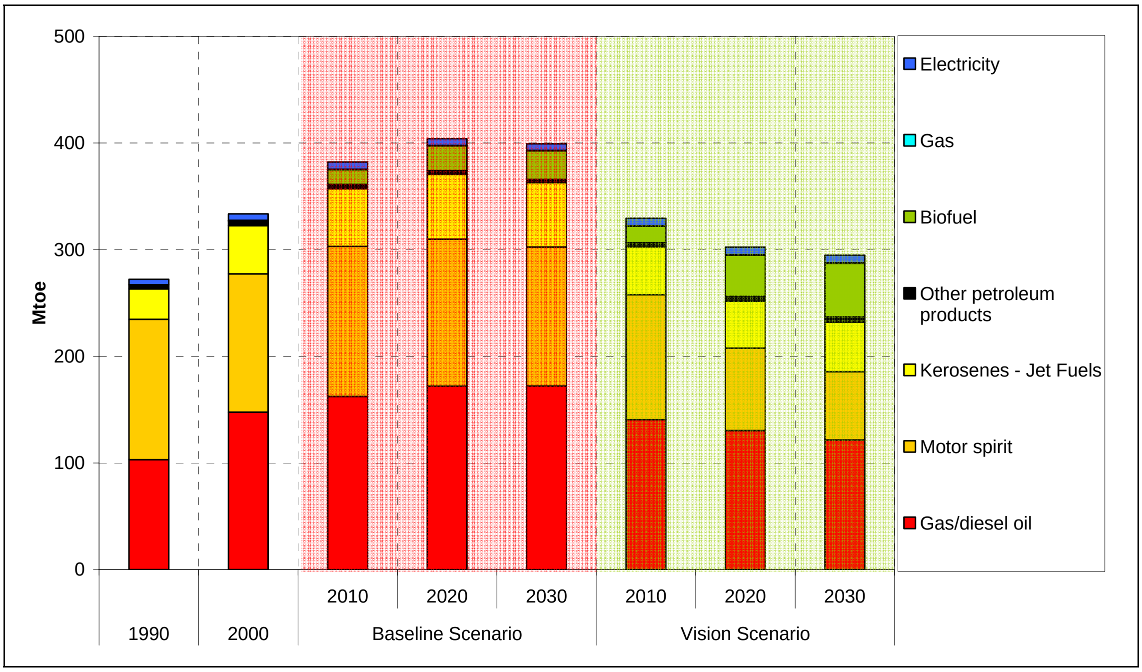
A broadened comparing Labelling Directive and a CO_2-related taxation of cars support a faster stock exchange. Additionally, under the assumption that new cars have a higher mileage than older ones, the specific CO_2-emissions of cars in the stock allows the emission target to be reached 10 years later, i.e. the specific CO_2-emissions in the car stock means that the 2020 target of 80 g/km is reached in 2030.

A strong focus on measures in changing the modal split by targeting public and rail freight transport with comprehensive efforts to avoid transport with a consequent liberalisation approach of the railway system and major system investments to strengthen the competitiveness and the infrastructure of rail transport has to be implemented in strategies for measures in transport sector. Projections relating to these points were made according to the Primes case 'Promoting rail and enhanced load factors' 2004 (DG TREN 2004). It reflects a series of measures under the option C scenario of the Transport White Paper such as pricing, revitalising alternative modes of transport to road and targeted investment in the trans-European network. The energy consumption in 2030 would change as a result of the modal shift compared to the baseline scenario in the following fashion:

- The energy consumption of public road transport would increase by 11.5%.
- The consumption of private cars and motorcycle would decrease by 12%.
- The consumption of trucks would be reduced by 12.7%.
- The energy demand of rail transport systems would increase by about 20%.
- The role of inland navigation would increase, leading to an increased fuel consumption of 5.4%.

Air transport is the fastest-growing section in transport. Therefore, as an additional measure, the introduction of an emissions trading scheme for aviation was assumed according to the high efficiency and high renewables scenario of DG TREN (2006); this scenario is consistent with the existing analysis on the introduction of an emissions trading scheme for aviation (Wit et al 2005). This new scheme could be potentially linked to the existing EU ETS. The fuel consumption of national and international aviation would decrease by 23% in 2030 compared to the baseline scenario. The share of biofuels in transport sector in the baseline scenario is projected at about 4% in 2010, 7% in 2020 and 8% in 2030. It is realistic that renewable energies will be much more strongly supported in the transport sector. Supporting biofuels of the so-called second generation, such as the conversion of biomass to transport fuels by gasification and thermochemical routes and the conversion of cellulose to sugars, is important. The advantages of these kinds of biofuels are the unspecific feedstock and that their greenhouse gas emissions are clearly lower in the pre-chain than biodiesel from rapeseed or sunflowers and bioethanol from grain or sugar beet (i.e. by agriculture). It is envisaged that the second generation biofuels will assume a 75% share. International quality-standards for the production of biofuels, including standards for imported fuels, are essential to a means of introducing high shares of such fuels that is compatible with sustainability. The share of biofuels in the transport sector substituting gasoline and diesel in the vision scenario reaches 5.75% in 2010, 18% in 2020 and 25% in 2030.

Figure 11 Final energy consumption by fuel in the EU-25 transport sectors, 1990-2030



Sources: Eurostat, DG TREN, Öko-Institut.

Figure 11 also indicates the final energy demand in the transport sector for the vision scenario. The overall energy use in the vision scenario is reduced by about a quarter in 2030 compared to the baseline scenario and by around 11% compared to the year 2000.

The level of renewable energies consumed in the vision scenario rises significantly to a level which is double that of the level in the baseline scenario. The share of biofuels in the total final energy consumption of the transport sector in the vision scenario amounts to 17% in 2030.

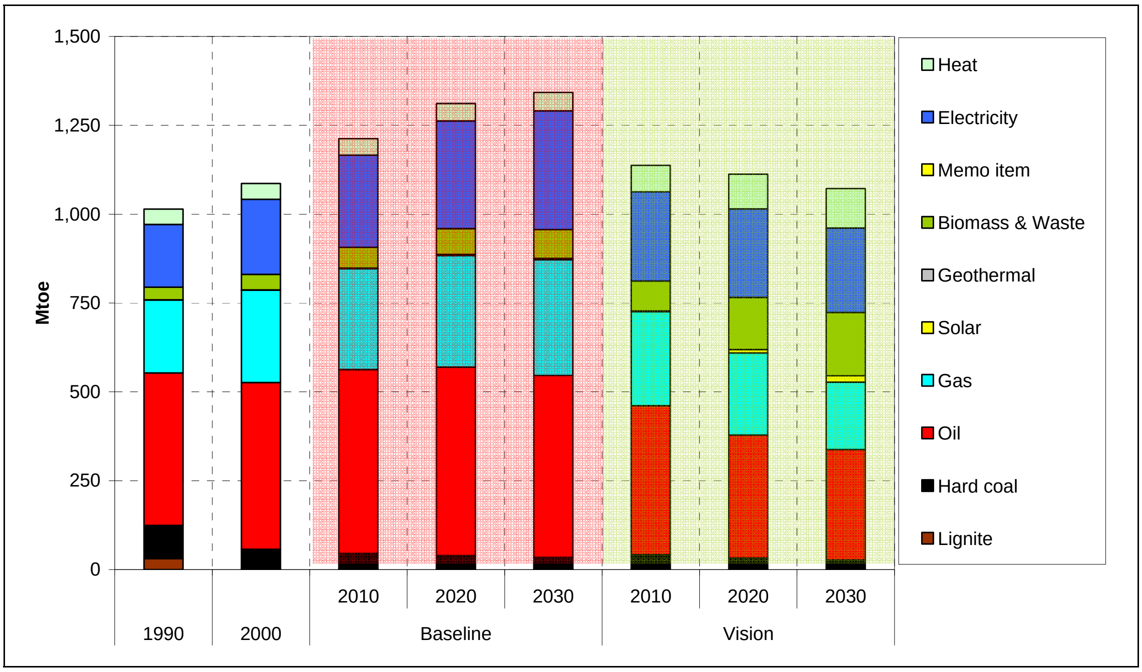
5.1.5 Total final energy consumption

As a summary of the sectoral scenario analysis presented in the previous chapters, the total final energy consumption results as follows (Figure 12):

- In the baseline scenario the total final energy consumption increases steadily and reaches a level of 24% above the level of 2000 in 2030. In the vision scenario the final energy consumption attains the level of 2000 again in the year 2030. In the years in between, the total final energy consumption is at a level between 2% and 5% higher than in the year 2000.

- The structure of final energy consumption differs significantly between the baseline and the vision scenario. Whereas the consumption of oil is stabilised at recent levels and natural gas and electricity consumption rises significantly in the baseline scenario, the consumption of oil and gas can be reduced significantly in the vision scenario and the electricity demand is limited to a level that is 12% higher than in 2000 by the year 2030. Both the contribution of renewable energies and of heat from CHP and district heating plants is more than doubled in the vision scenario in the year 2030 compared to the baseline scenario.

Figure 12 Total final energy consumption by fuel in the EU-25, 1990-2030



Sources: Eurostat, DG TREN, ICE, Öko-Institut.

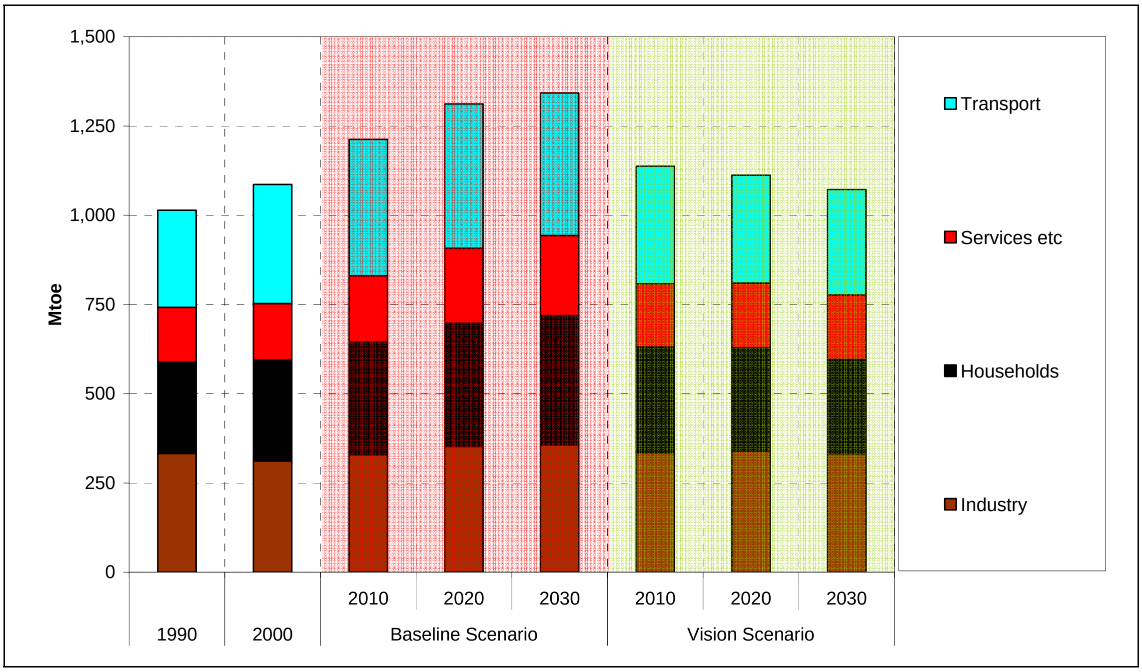
The most important contribution to the decreased final energy consumption in the vision scenario is delivered by the transport sector, which assumes a 39% share. The second most important sector is the residential sector, which contributes 36% of the total final energy savings. The industry and the tertiary sectors provide energy consumption reductions which are considerably smaller but are still significant (9% and 16%, respectively).

However, for different energy carriers, varying patterns result between the sectors for the changes in the vision scenario compared to the baseline scenario:

- The total electricity savings by 2030 arise as follows: 41% from the residential sector, 36% from the tertiary sectors and 23% from industry.
- The reduction in gas consumption is broken down as follows: 60% from measures in the residential sector, 24% from the tertiary sectors and 15% from industry.

- The most relevant sector for oil savings is the transport sector. 64% of the total decrease in oil consumption stems from this sector (including international aviation). Private households deliver 17%, industry 11% and tertiary sectors 8% of the total reduction in oil consumption.
- The increasing use of renewable energies is relatively evenly distributed among the sectors. 28% results from the tertiary sectors (which include agriculture), 26% from private households, 25% from industry (including waste) and 21% from the increased consumption of biofuels in the transport sector.
- The additional demand of heat from CHP and district heating plants arises as follows: 53% from households, 31% from industry and 16% from the tertiary sectors.

Figure 13 Total final energy consumption by sector in the EU-25, 1990-2030



Sources: Eurostat, DG TREN, ICE, Öko-Institut.

The significantly reduced electricity consumption and the extended heat consumption from CHP and district heating plants create significant effects in the energy sectors (see chapter 5.2).

5.2 Energy sectors

The energy sector is by far the largest consumer of primary energy in the EU-25. About 50% of total primary energy supply is delivered to the different sectors of energy industry. The most important of the energy sectors is power production. 38% of the TPES is consumed by power plants. Some primary energies (e.g. lignite, nuclear, as well as hydro and wind) are almost completely consumed by energy industries.

Other energy sectors like district heating, refineries, etc. represent a share of about 11% of TPES and are much less significant for the energy industries compared to the power sector.

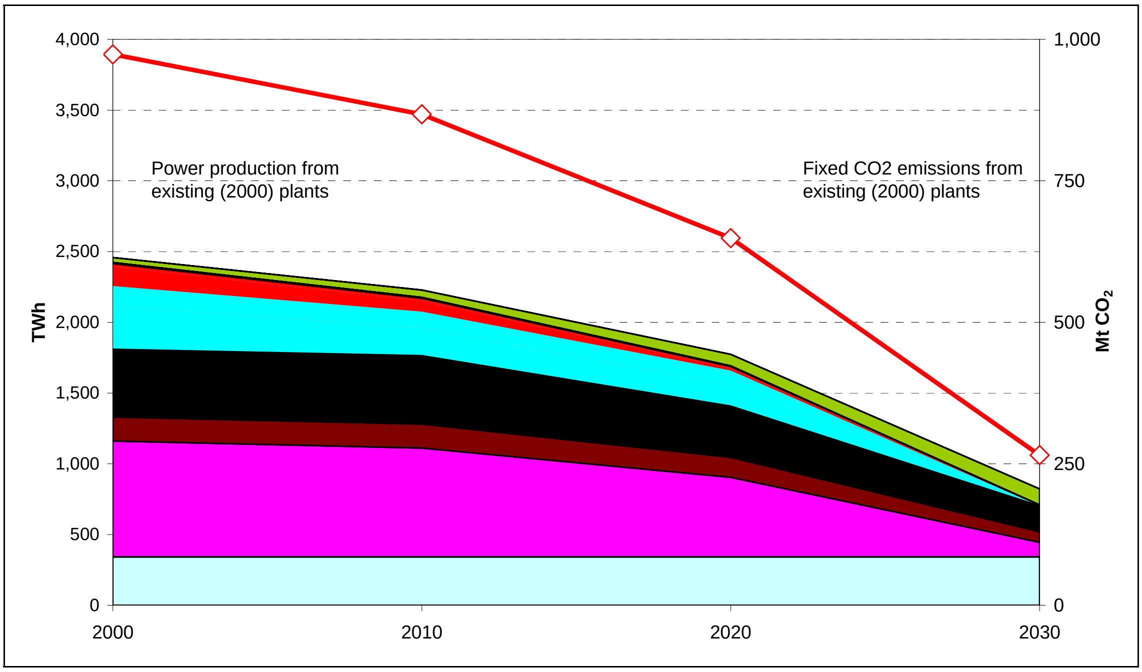
The net electricity production in the EU-25 rose by 34% in the years from 1990 to 2004. In the last four years of this period alone, power production in the EU-25 increased by 10 percentage points, which equals approximately one third of the total growth from 1990 to 2004.

In the baseline scenario the strong growth in power production continues steadily. In 2030, power production is exceeding the 2000 levels by 50%. However, the structure of power generation changes significantly in this period:

- The level of nuclear power generation decreases by about 14%, which is equivalent to major lifetime extensions of existing nuclear power plants and/or strong investments in new nuclear installations. Against the background of the increasing total power production, the share of nuclear power drops from 32% in 2000 to 18% in 2030.
- Power generation from hard coal is more or less constant by the year 2020 and increases substantially in the third decade. In total, the increase in electricity generation from hard coal amounts to 38% in the year 2030 compared to 2000 levels. The total share of hard coal-based power production decreases only slightly from 21% in 2000 to 19% in 2030.
- Electricity production from lignite is an important source of power production in some EU-25 Member States. However, it represented 9% of the total power generation in 2000. For the following three decades, the power production shows an increase of about 11% by 2030. The share of total power generation drops by 2 percentage points to about 7% in 2030.
- The power production from natural gas is assumed to double in the period from 2000 to 2030. The share of natural gas-based electricity generation expands from 17% in 2000 to 23% in 2030.
- Power production from renewable energies rises substantially. Compared to the 2000 levels, the total electricity generation from renewable energy sources increases by a factor of 2.5 by 2030. The share in terms of the total power generation increases by about 11 percentage points from 15% in 2000 to 26% in 2030. Whereas the production from hydropower plants increases only slightly, the main growth results from the dynamic development of wind power and biomass.

The power production from wind energy increases by more than 400 TWh from 2000 to 2030; the electricity generation from biomass rises by more than 300 TWh.

Figure 14 Development of the existing capital stock for power generation in the EU-25, 2000-2030



Source: *Öko-Institut.*

The power sector is characterised by a long-living capital stock. If technical and economic lifetimes of 40 years and more are assumed for the exchange of the capital stock, the modernisation of the power sector constitutes a medium-term issue. Figure 14 shows the development of electricity production from those power plants which already existed in 2000. About one third of the power plant capacities which were producing in 2000 will also be operated in the year 2030. This also has consequences for the CO_2 emissions from the power sector. 25% of the 2000 levels of CO_2 emissions from the power sector are more or less fixed for the time horizon of 2030 (Figure 14).

For the vision scenario, a couple of changes to some key policies and measures are assumed:

- The allocation for new entrants in the EU Emissions Trading Scheme (EU ETS) is shifted from free allocation to new entrants based on fuel-specific benchmarks to an allocation approach leading to full internalisation of CO_2 costs in the investment appraisal (which is not the case in most of the EU-25 Member States National Allocation Plans at the moment). This could be either an approach where no free allocation is provided to new entrants or a free allocation based on uniform benchmarks for power production (Matthes et al 2005).[5]

- For the development of CHP, an active support policy is assumed which leads to a steady increase in power production from CHP. The policies and measures are focused on the increase of production from CHP plants for hard coal, natural gas and biomass. The overarching target is to double the recent levels of CHP production by the year 2030 against the background of considerably less growth in the total power production.
- Electricity generation from renewable energies increases substantially, by another 50% compared to the level reached in the baseline scenario by 2030.

The final consumption of electricity and heat determines the total net power and heat generation. The following factors are considered in the transformation of final energy consumption to the net production of electricity and heat in the vision scenario:

- The electricity consumption of the energy sectors remains at a level of about 100 TWh in the EU-25.
- The grid losses in the EU-25 network[6] decrease from about 7% in 2000 to about 5% in 2030, equalling total losses of about 140 TWh in 2030.
- The electricity imports remain constant at the level considered in the baseline scenario, which amounts to about 25 TWh in the scenario period.
- For heat from district heating network, losses of about 6% are considered in the scenario period.

The first significant difference between the baseline and the vision scenario is the significantly lower production level in the vision scenario, which results directly from the energy efficiency gains in the end-use sectors. The total power production is stabilised at a level of about 11% above the 2000 levels for 2010 and 2020 and a subsequent decrease to a level of 7% above the 2000 levels.

Besides this difference in terms of production levels, major structural changes in power generation characterise the vision scenario (Figure 15):

- Nuclear power generation is phased out according to the technical lifetime of the plants if no other policies (e.g. in Germany, Belgium) expedite this process. In 2030, the remaining power production from nuclear power plants amounts to about 120 TWh, which equals a share of the total power generation of 4%.
- Although some new investments in coal-fired power generation are considered, the level of electricity generation from coal decreases significantly. Compared to

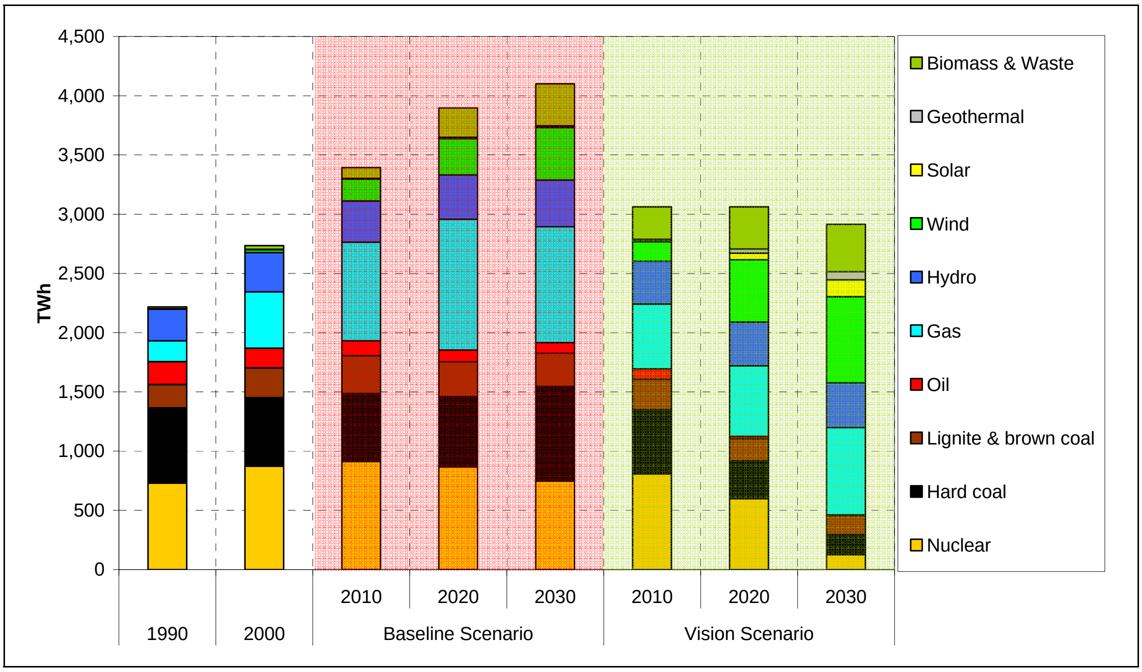
[5] For modelling of the impact of the EU ETS on the development of the power sector an allowance price was assumed which increases from 25 € per EU Allowance (EUA) in 2005 to 27 €/EUA in 2030.

[6] The relative grid losses are expressed as the share of grid losses in the total of net power production and the net electricity imports.

the year 2000 levels the hard coal-based power generation decreases by about 70% and the production from lignite power plants drops by about 36%.

- Compared with the 2000 levels, the power generation from gas rises by about 55%, which is 50 percentage points less than in the baseline scenario.
- Power production from renewables is extended to 1,300 TWh in 2020 and 1,700 TWh in 2030, which represents a share of 44% in 2020 and 59% in 2030. Compared to the baseline scenario, this equals a further expansion of power production from renewable energies by 500 TWh in 2030. The main contribution to the growth of renewable energies in power production comes from wind energy, which expands to about 730 TWh in 2030 (440 TWh in the baseline scenario). In 2030, about 52% of total wind power generation results from offshore installations. Electricity generation from biomass reaches a level of 400 TWh in 2030 (compared to 350 TWh in the baseline scenario). 57% of biomass-based power generation is produced from wood and wood waste, 26% from biogas and 17% from waste. CHP plays an important role in power production from biomass. Biomass-fired CHP plants represent 18% of the total CHP production in 2030. Solar and geothermal power delivers only a small share of the total electricity production from renewable energies. In 2030, the share of solar and geothermal energy amounts to 140 TWh and 70 TWh, respectively.
- Total power generation from CHP plants rises from 420 TWh in 2000 to 930 TWh in 2030 and represents a share of 32% in 2030. In terms of absolute production levels, this is 10% less than in the baseline scenario, but 5 percentage points more in terms of the share of total electricity generation.

Figure 15 Net electricity generation in the EU-25, 1990-2030



Sources: Eurostat, DG TREN, Öko-Institut.

The fuel input to district heating plants doubles in the vision scenario, from about 20 Mtoe in 2000 to 40 Mtoe in 2030 in accordance with the increasing demand for heat from CHP plants and district heating plants. The fuel input for district heating plants is dominated by natural gas with an increasing share of biomass over the scenario period.

The energy consumption by the other energy sectors is based on the High Efficiency and High Renewables Scenario of DG TREN (2006). The consumption of these sectors is about 10 Mtoe for hard coal and natural gas and about 80 Mtoe for oil in 2030 which is (in total) 30% lower than the levels in the year 2000.

However, compared to the changes in the power sector, changes as regards the consumption level and fuel structure in the district heating and other energy sectors are of much less importance.

The introduction of carbon dioxide capture and storage (CCS) was considered as an supplementary option. If CCS would be available on a broad commercial basis, all new condensation power plants commissioned from 2020 to 2030 could rely on CCS technology. These plants represent a power production of about 230 TWh and the total CO_2 emissions avoided by CCS amount to 105 Mt CO_2 by the year 2030.

5.3 Primary energy supply and CO_2 emissions

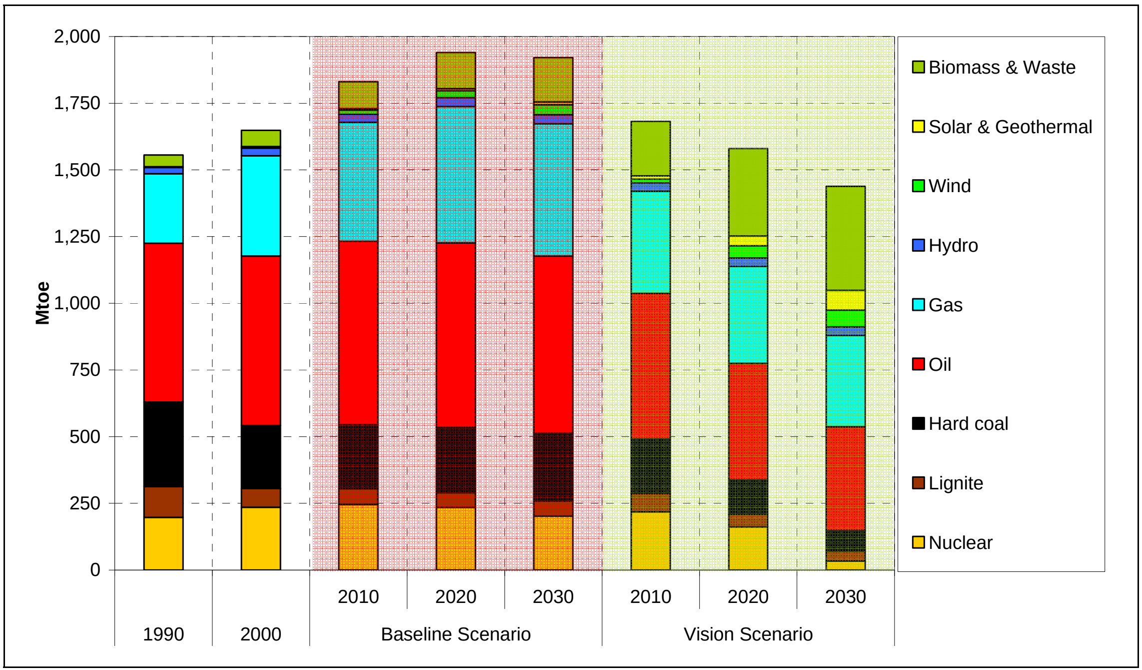
The total primary energy supply is calculated from the final energy consumption and the energy use in the energy sectors. The non-energy use of primary energies is excluded from the totals and the analysis below.

Following the general trends in the final energy consumption and the energy sectors, the primary energy supply in the baseline scenario increases steadily by the year 2020 and is more or less constant after 2020. In 2030, the TPES is 17% higher than in 2000. The trends regarding the structure of TPES can be divided into two main groups:

- The contribution of nuclear, coal and oil is only subject to small changes in terms of their level of supply. The supply of nuclear energy drops by 14% in the scenario period, the contribution of lignite decreases by 18%, the supply of hard coal increases by 7% and the total oil consumption expands by 5%.
- The primary energy supply from gas and renewable energies shows much stronger dynamics, but is limited by the low base level in 2000. The consumption of natural gas rises by 32% and the contribution of renewable energies increases by 160% in the period 2000 to 2030.

As a result, the structure of TPES changed significantly because of the increased supply levels and different trends in the structure of primary energy. The contribution of coal and oil decreases slightly, by 2 and 4 percentage points respectively. The share of nuclear shrinks to 11% in 2030 and the contribution of gas increases from 23% in 2000 to 26% in 2030. The contribution of renewable energies is extended from 6% in 2000 to 13% in 2030.

Figure 16 Total primary energy supply in the EU-25, 1990-2030



Sources: Eurostat, DG TREN, Öko-Institut.

In the vision scenario, the TPES can be stabilised at the 2000 levels between 2010 and 2020 and is decreased to 13% below the 2000 levels by 2030.[7] When the structure of primary energy in the vision scenario is considered, the following trends shall be highlighted:

- The contribution of nuclear energy decreases by about 86% in absolute terms and by 12 percentage points in terms of the structure of total primary energy supply.
- The role of coal is significantly decreasing in terms of both the overall level of supply and the share of the TPES. In 2030 the level of coal consumption is 63% lower than in 2000. The decrease of hard coal consumption is more significant than the drop in lignite use. In 2030, the share of coal in the TPES is 8%, which is 11 percentage points below the share in 2000.
- The use of oil is about 40% less than in the year 2000. The share of the TPES shrinks from 39% in 2000 to 27% in 2030.
- Even for the total consumption of gas, the level of consumption decreases compared with the 2000 levels. In 2030, the consumption of gas is 9% less than in 2000. However, the share of gas in the TPES rises from 23% in 2000 to 24% in 2030.
- The most significant change in terms of consumption levels as well as shares in TPES must be considered for renewable energies. From 2000 to 2030 the total use of renewable energies increases by 485% and reaches a share of 39% in the TPES. The most important contribution in terms of renewable energies results from the massive increase of biomass by the year 2030.

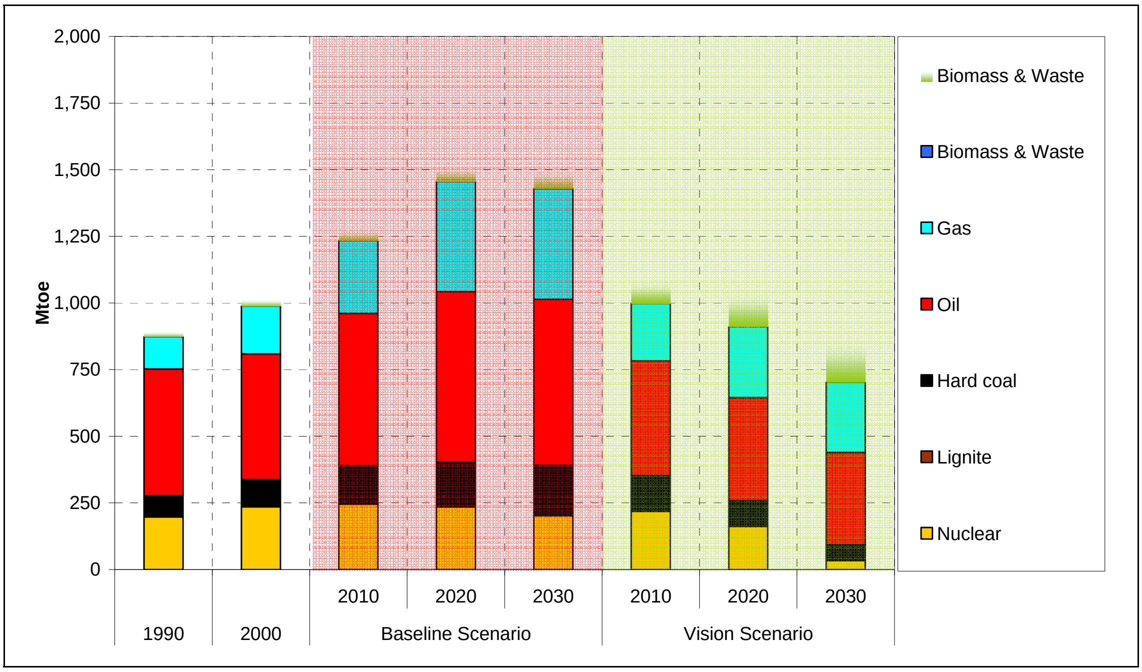
The major differences in the structure of primary energy supply lead to significant changes in the role of energy imports to the EU-25. In 2000, the share of imported energies amounted to about 60%. In the baseline scenario, this share is growing to 74% in 2030. In the vision scenario, the share of imported energies decreases to 49% in the same period, assuming that all bioenergies are supplied from EU-25 sources. If a significant role of international trade is assumed with regard to biomass and biofuels, the total share of energy imports in the vision scenario is slightly higher (57% in the case of 30% bioenergy imports and 53% in the case of a 15% import share, respectively).

However, although the share of the total imported energy differs significantly between the baseline and the vision scenario, the import share for the fossil fuels does not greatly differ. The nuclear fuel must be imported completely and the share of imports for hard coal is 75% in the baseline scenario in 2030 and 77% in the vision scenario. The share

[7] It should be highlighted that the reduction in total primary energy supply is partly a result of the statistical treatment of renewable energies and the decreasing role of nuclear energy. Whereas the relation between power production and fuel input is assumed to be 0.33 for nuclear power (modern fossil power plants reach 50% or more), the electricity from hydro, wind and solar is translated into primary energy using the factor 1.0. The reduction of primary energy resulting from this statistical definition is only a statistical artefact.

of imported oil is decreased to 89% in the vision scenario by 2030 compared to 93% in the baseline scenario. For natural gas, the amount of imports is 84% of the total consumption in the EU-25 in the baseline scenario and 77% in the vision scenario in the year 2030. The lower the level of domestic production in the EU-25, the less the impact of changes in consumption levels shifts the import rates for a certain fuel.

Figure 17 Primary energy imports to the EU-25, 1990-2030



Sources: Eurostat, DG TEN, Öko-Institut.

To summarise the effects on import dependence, the vision scenario delivers a major contribution to a decreased import dependence by diversification towards other energies and energy savings. Thus, the economic vulnerability of the EU-25's economies to price spikes and volatilities on the global energy markets is significantly lower. However, for the crucial fossil fuels of mineral oil and natural gas, the share of imported fuels does not greatly differ between the two scenarios under analysis.

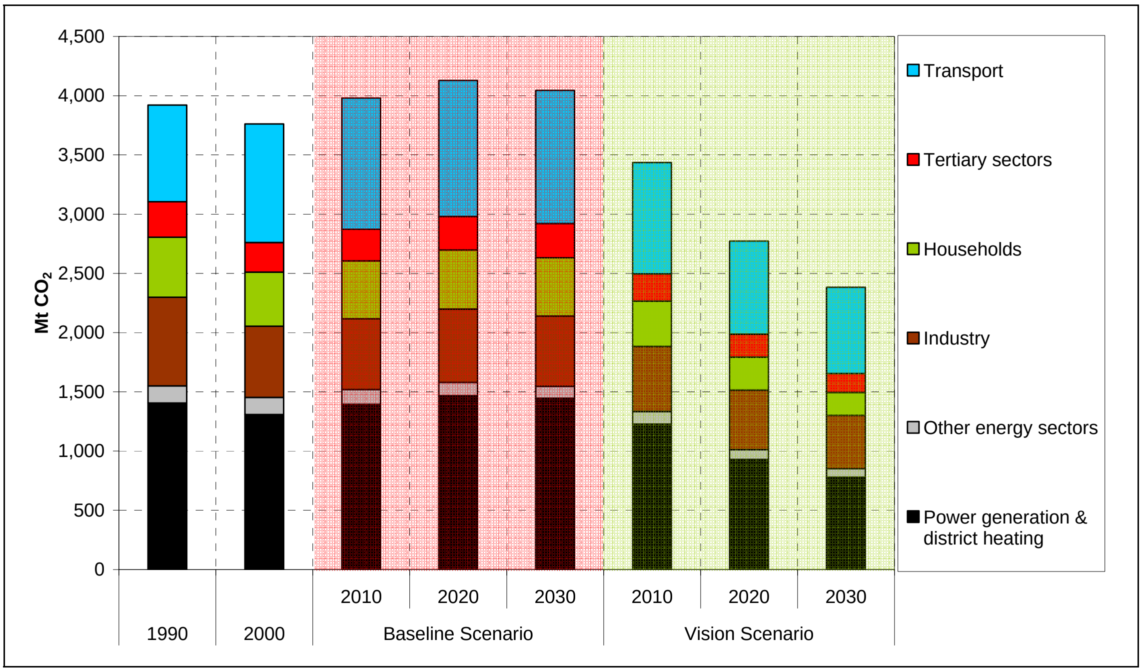
The calculations of energy-related CO_2 emissions were based on the total balance for final energy consumption, the energy use in the energy sectors and the total primary energy supply.

Figure 18 indicates the general trend and sectoral breakdown of energy-related CO_2 emissions in the baseline and the vision scenarios.

In the baseline scenario, the CO_2 emissions increase by the year 2020 and decrease slightly in the third decade of the scenario period. In 2020, the total energy-related CO_2 emissions amount to about 4,100 Mt, which is 5% above the 1990 levels. In 2030, the emissions are still 3% higher than the base level of 1990, which is far off any ambitious emission reduction targets.

CO_2 emissions from power production and district heating also constitute - at 36% - the major share of total emissions in 2030.[8] However, the strongest emission increase is to be found in the transport sector, for which the share of the total CO_2 emissions increases from 21% in 1990 to 28% in 2030. CO_2 emissions from transport rise by 12% from 2000 to 2030. Much higher dynamics result from aviation. The total emissions from kerosene and jet fuel use increase by about 34% in the period from 2000 to 2030. In 2030, CO_2 emissions from aviation constitute a share of the total energy-related CO_2 emissions of 4.6%.

Figure 18 *CO_2 emissions from energy in the EU-25, 1990-2030*



Sources: *Eurostat, DG TEN, Öko-Institut.*

In the vision scenario, the energy-related CO_2 emissions decrease significantly, reaching a level of about 29% under the 1990 emissions in 2020 and about 39% under the 1990 levels.

Not only the emissions level changes drastically in the vision scenario, but also the structure of emissions. In 2030, the share of emissions from transport is - at 31% - very similar to the share of the power and district heating sector (33%). The most significant emission reduction results from power and the residential sector. Compared to the levels of 2000, the emissions from private households decrease by about 58% by 2030, equalling an emission reduction volume of 265 Mt CO_2. In the same period, the emissions from power and district heating production drop by 40%, which equals about 530 Mt CO_2.

8 All data referred to in this chapter indicate direct emissions. Emission reduction by increased efficiency in electricity or heat consumption are accounted for in the power and the district heating sector. For a differentiation of emission reductions by sector of origin, see chapter 5.5.

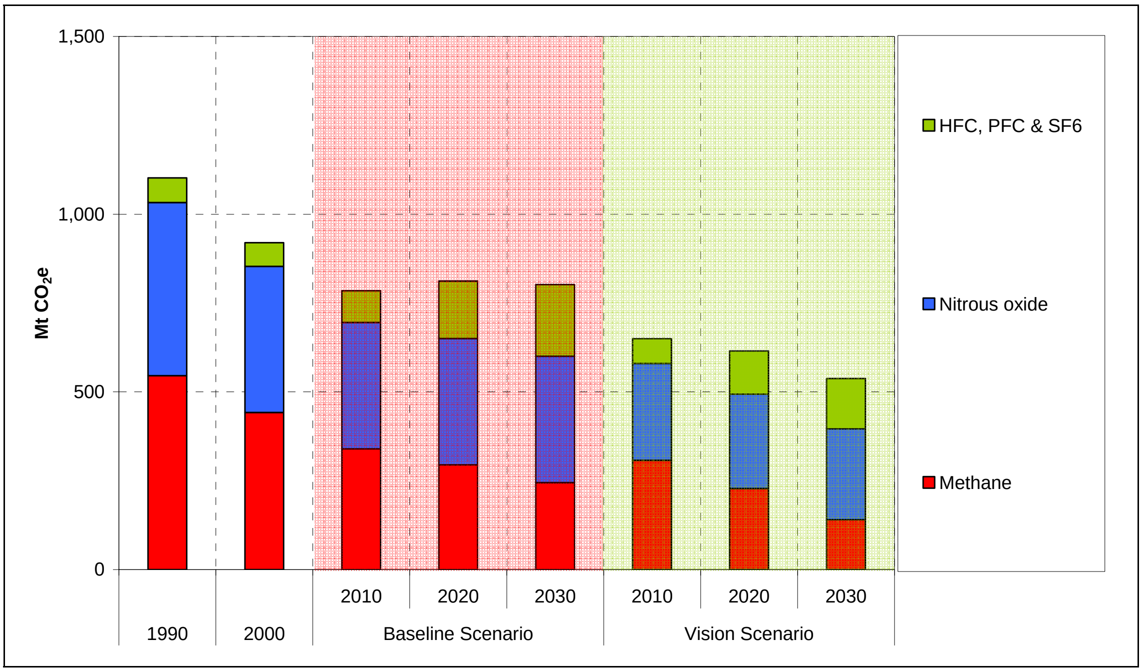
5.4 Total greenhouse gas emissions

For other greenhouse gases than CO_2, the emission trends refer to data given by the relevant literature (EEA 2006) or other surveys (WI 2005). The most comprehensive database on the range of future emission projections can be derived from the GAINS project of IIASA (2005a+b+c).

In the baseline scenario, the non-CO_2 emissions decrease significantly by the year 2010 and are more or less stabilised after this date. A small increase in the total non-CO_2 emissions results from HFC, PFC and SF_6 in the period from 2010 to 2030.

The most significant contribution results from the strong decrease in methane emissions, which amounts to 200 Mt CO_2-equivalent (CO_2-e) from 2000 to 2030. However, in the same period the emissions of HFC, PFC and SF6 rise by at least 135 Mt CO_2-e.

Figure 19 Non-CO_2 emissions in the EU-25, 1990-2030



Sources: EEA, IIASA, Öko-Institut.

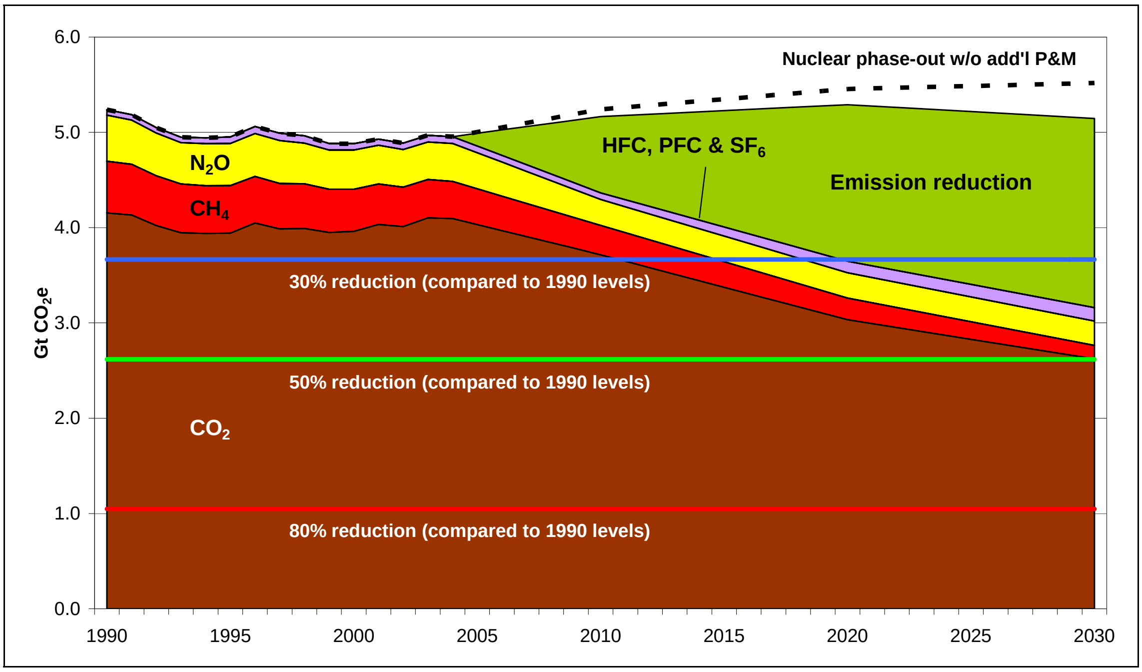
In the vision scenario, a rather rough estimate constitutes the basis of the scenario. It is assumed that 80% of the reduction potentials provided by IIASA (2005a+b+c) will be implemented over time.[9] As a result, the total non-CO_2-emissions is reduced by about

9 With regard to methane, the following groups are taken into account: increases in agricultural productivity, increased feed intake, changes to more non-SC in diet, replacement of roughage for concentrate, etc (IIASA 2005a). In respect of nitrous oxide sectors, the following options are included: selective catalytic reduction in industrial plants, process modification in fluidised bed combustion, optimisation of sewage treatment, replacing use of N_2O as anaesthetics, and optimised application of fertilizer (IIASA 2005b). Regarding HFC, PFC and SF_6 emissions, the following reduction measures were taken into account: thermal oxidation, good practice measures, and process modifications for HFC, measures in the primary aluminium production and the semiconductor production for re-

380 Mt CO_2-e. Again, the reduction of methane emissions emerges as having the strongest potential amongst measures regarding non-CO_2 greenhouse gases. 80% of the total emission reductions arise from measures to reduce methane emissions.

The total emission trends for the scenario period were derived from the baseline and the vision scenario for CO_2 and non-CO_2 greenhouse gases (Figure 20).[10]

Figure 20 EU-25 greenhouse gas emission trends and reductions, 1990-2030



Sources: EEA, Öko-Institut.

In the baseline scenario, the total greenhouse gas emissions (including CO_2 from international aviation) are, in a range of ±2%, more or less stabilised at the 1990 levels. If a nuclear phase-out were assumed in the baseline scenario, which is similar to the phase-out pathway in the vision scenario and without additional measures, an even higher emission level would result (5% higher compared to 1990).

In the vision scenario the emission reduction pathway meets the -30% target (compared to 1990 levels) and results in a reduction of – 40% in 2030. However, it should be mentioned that some additional emission reductions could result from the introduction of CCS in 2020 (see chapters 5.2 and 5.5).

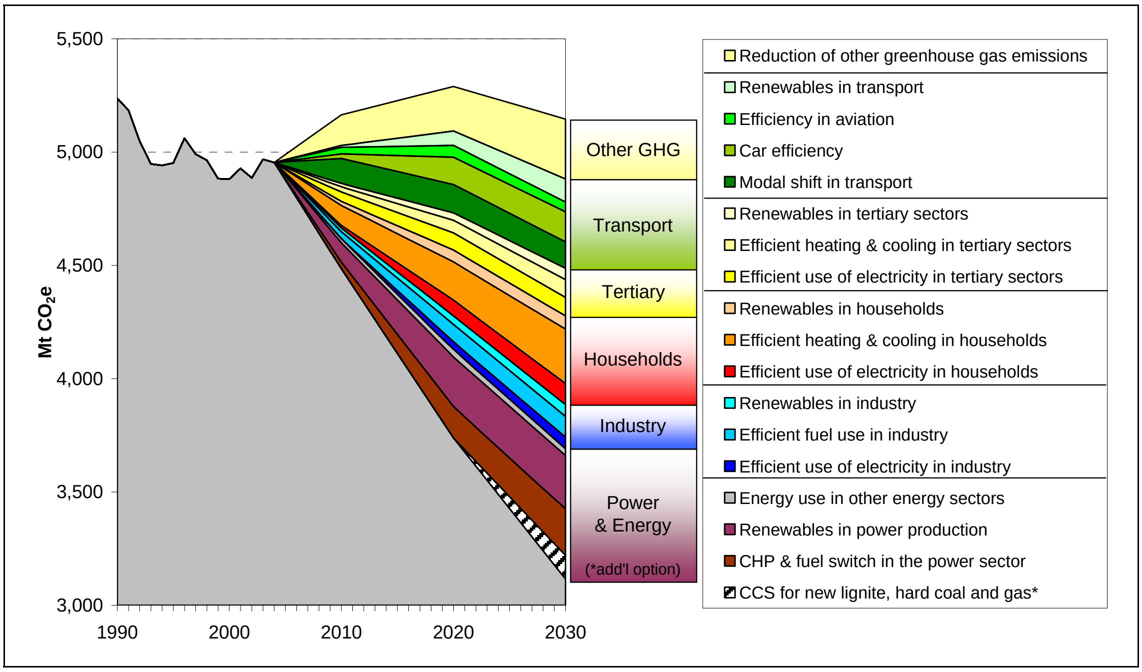
duction of PFC emissions, and good practice measures for SF6 emission reductions, use of SO_2 as an alternative protection gas, and bans on SF6 for windows and other applications (IIASA 2005c).

10 In addition to the energy-related CO_2 emissions, additional emissions and emission reductions for CO_2 emissions from non-energy sources were taken into account. These emissions result from cement, lime, glass and other productions.

5.5 The EU-25 wedges

Based on the scenario analysis presented in the previous chapters, an analysis was carried out in order to identify the policies and measures which lead to a certain emission reduction in the period from 2000 to 2030. Figure 21 indicates the collection of emissions reduction wedges which could lead to an overall emission reduction of about 30% in 2020 and 40% in 2030, compared to 1990 levels.

Figure 21 EU-25 greenhouse gas reduction wedges, 1990-2030



Source: Öko-Institut.

The major share of emission reductions in the vision scenario compared to the baseline scenario originates from the energy sectors:

- The change of investments in the power sector, the full carbon pricing in the framework of the EU ETS and the increase of the CHP share of the total power production represents a share of 24% of the total emission reduction in 2030 compared to the baseline scenario.
- A further share of 12% of the emission reduction results from a more efficient use of electricity which is induced in the final sectors (industry, households, tertiary sectors and transport), but is accredited to the power sector.
- Other measures in the energy sectors deliver 1.5% of the emission reduction.
- Furthermore, the introduction of Carbon Dioxide Capture and Storage (CCS) in 2020 as a commercial technology could lead to an additional emission reduction of 5% in 2030. This equals an additional emission reduction of 105 Mt CO_2 in 2030, which is not included in the totals provided above due to strong uncertainties related to the availability of this emerging technology.

Although the cost pressure from energy prices generates a comparatively high autonomous improvement of energy efficiency in the industrial sectors, significant additional emissions reductions can be brought about in these sectors:

- A more efficient use of electricity delivers 3% of the total emission reduction.
- A more efficient use of fuels could contribute a further 5%.
- The increased use of renewable energies (including waste) could expand its share of the total emission reduction, which amounts to 3%.

Private households represent the third largest contribution to the overall emission reduction:

- A 12.5% share of total emissions reductions originates from more efficient heating and cooling in buildings.
- The increasing use of renewable energies for heating (and cooling) delivers a share of 3% of the total emissions reductions.
- The effects of a more efficient use of electricity create a contribution of 5%.

Although the tertiary sectors represent the sectors with the lowest energy consumption among the end-use sectors, some significant emission reductions could be achieved:

- The more efficient heating and cooling of buildings or for processes in the service sector contributes 4% to the total emission reduction.
- An emissions reduction of a further 3% results from the increasing use of renewable energies in the tertiary sectors.
- As an indirect emission reduction effect, the more efficient use of electricity could contribute an additional 4%.

Besides the energy sectors, the transport sector (including aviation) is another key sector:

- A contribution of 6% to the total emission reduction results from the significant changes in the modal split towards more public and rail freight transport.
- The strengthening of fuel consumption standards represents a share of about 7% in the total emission reductions.
- The introduction of measures regarding greenhouse gas emission reductions in aviation creates a contribution of about 2% of the total emissions decrease.

Last but not least, the measures connected to the non-CO_2 greenhouse gases create a contribution of 14% to the overall emission reduction.

In summary, a plethora of options exists to reduce greenhouse emissions to a level which is consistent with ambitious climate targets. However, although there are some wedges which could deliver significantly more emission reductions than others, none of the wedges can be ignored if emission reductions of 30% in 2020 and even more in 2030 shall be achieved.

6 Conclusions and policy recommendations

The scenario analysis presented in the previous chapters indicate that it is possible to draft a strategy which combines ambitious greenhouse gas reductions, a phase-out of nuclear energy, less energy imports and the increasing use of renewable energies.

However, all sectors - especially the power and the transport sector - are facing a fundamental transition in the framework of such a strategy.

The implementation of an energy and climate policy framework which has the development outlined by the vision scenario as its goal requires some key activities. These are:

1. A strong focus on energy efficiency measures
   - for appliances and installations consuming electricity in all sectors (household equipment, motors, pumps, etc.);
   - for improvement of buildings (heating and cooling) for both new buildings and the renovation of the existing building stock so as to reach low energy or passive house standards in the period up to 2030;
   - for the substitution of electric appliances for low temperature heating purposes;
   - implementing ambitious performance standards for cars and car fleets.
2. A strong focus on changing the modal split targeting public and rail freight transport
   - with comprehensive efforts to avoid transport;
   - with a consequent liberalisation approach to the railway system and major system investments to strengthen the competitiveness and the infrastructure of rail transport and sustainable modes of transports in cities;
   - with measures to establish a level playing field between the different modes of transport, e.g. by removing the tax advantages for kerosene and jet fuels for aviation.
3. Ambitious efforts to increase the share of renewable energies in both, the energy and the end use sectors
   - to set a share of about 20% in the end-use sectors by 2030 as the target;
   - to reach a share of about 45% by 2020 and 60% by 2030 of the electricity production.
4. Strong efforts to increase the efficiency of power generation and to increase the share of low carbon fossil fuels in the electricity sector
   - to strengthen the use of combined heat and power production

- to limit the use of coal and increase the share of natural gas in power generation especially for the next two decades before emerging technologies like renewable energies or carbon dioxide capture and sequestration will be available on a broad commercial basis.

Although the structure of energy consumption between the different sectors changes significantly in the vision scenario, the effects on the necessary energy imports are notable:

- Although the gas consumption in the power sector will increase, the additional increase in gas consumption can be compensated by increased efficiency in other sectors in such a way that the consumption levels of 2000 are not significantly exceeded by 2010 and will be significantly less than the 2000 levels in 2030. In contrast, the gas consumption rises in the baseline scenario, being 32% higher in 2030 compared to 2000, although no nuclear phase-out is assumed in this scenario.
- The diversification in the transport sectors is improved significantly. For this most vulnerable sector, the dependency on oil can be reduced from about 98% to about 80% by the year 2030. The massive phase-in of biofuels will play a key role in this context.
- The availability of biofuels is one of the major challenges within the issue of energy imports. If it is assumed that international markets for biofuels will develop rapidly, the certification of biofuels will be crucial to ensure the sustainability of the biofuel strategy.
- The total dependency on energy imports decreases significantly in the vision scenario. Even if it is stated that the rate of energy imports is not the most appropriate indicator for addressing the issue of the security of supply, it should not be ignored that a high share of domestic energy production ensures added domestic value and jobs.

The transition of the energy system described in the vision scenario has strong implications for the development of infrastructures:

- The development drafted for the power sector requires the integration of large quantities of power generation from fluctuating, decentral and offshore sources. The network infrastructure and the necessary system services must be strengthened and extended in this framework.
- For the extension of power and heat production from CHP as well as from biomass and the increasing use of renewable energies and CHP for cooling, the rollout of heat networks will play a crucial role. The bigger the role of efficient heat networks is, the more efficient the use of CHP and biomass will be in many cases.
- The use of natural gas will change significantly. If natural gas shall play a more significant role in power generation and CHP, the strengthening of the gas net-

works, storage facilities and other infrastructure will prove to be a main priority in the EU-25, which is crucial especially for Central and Eastern Europe.

- If biofuels shall play a significant role, the investment in production facilities with biomass-to-liquids technologies will be of key importance.
- In the case that carbon dioxide capture and sequestration is widely used, the preparation of infrastructure for CO_2 transport and storage sites must start in the near future.

For all these measures in the field of infrastructure, significant investments will be necessary. However, the adjustment or the development of the necessary regulatory framework constitute a crucial basis for many of the new measures related to infrastructures.

The establishment of sufficient political instruments to create incentives and the framework for the necessary transition of the energy system is the most crucial issue. On the one hand, clear priorities must be set up as regards the necessary comprehensive policy mix. On the other hand, many experiences on how different political instruments interact and what clusters of instruments fit best still have to be gathered. A clear structure and the necessary flexibility to adjust the policy mix is probably the biggest challenge for future energy, transport and climate policy:

- The EU ETS is the central element of the policy mix. If carbon pricing is the necessary (but not necessarily sufficient) precondition for the transformation at the lowest costs, the EU ETS must be adjusted in a way that in all investments and for all operational decisions the full price of carbon is reflected. With the introduction of an emissions trading scheme for aviation, another crucial sector could be subject to market-based carbon pricing.
- CHP faces a few structural barriers and burdens. Clear targets for the development of CHP and a strong support of CHP (e.g. in the framework of the EU ETS but also eventually by separate instruments) would enable the most efficient use of hydrocarbons and biomass for power and heat production.
- In the framework of the EU internal market, ambitious performance standards for the energy consumption of electric appliances and installations and of buildings as well as cars should be established and updated on a regular and transparent basis.
- The early and strong penetration of the markets as regards electricity, heating and cooling and motor fuels requires a combination of internalisation and innovation approaches. Clear and differentiated targets should also be strengthened for renewable energies. Against the background of the necessary learning investments for many renewable energies, the establishment of special instruments which focus on certain renewable energy forms will be appropriate, at least for the next decade.
- The strengthening of the EU energy market liberalisation and enforcing competition for the electricity market and, especially, the gas market will play a crucial role in the transformation of the energy system. The fair access to grids is being

increasingly seen as a key measure and some progress will be made on this if a more strict ownership unbundling approach can be implemented. However, the extension of network services and the necessary regulatory framework as well as the reduction of market dominance especially in the power generation sector represent major challenges for the future.

- In the framework of energy market liberalisation and the different dimensions of energy security the development of a coherent EU gas strategy seems to crucial.
- Liberalisation will also play a crucial role in the transport sector. More attractive offers for public transport and a modal shift towards rail transportation could be induced by a carefully designed and strict increase in competition between transport services.
- The manifold options for reducing greenhouse gas emissions in the non-energy sectors were only cursorily addressed in the analysis presented in this study. It is necessary that a series of polices with regard to agriculture, waste management and a variety of industrial processes be developed and strengthened in this framework.
- Innovation plays a key role in extending the portfolio for the transformation of the energy system. Key issues to be addressed in the framework of an innovation program are the emerging technologies in the field of efficient use of energy in industry, in buildings and in the transport sector, the full range of renewable energies including biomass-to-liquid technologies, energy storage and carbon dioxide capture and sequestration.

The fundamental transformation of the energy sector drafted in the vision scenario indicates a very ambitious pathway towards a sustainable energy system. However, compared to the different dimensions of the baseline scenario in terms of greenhouse gas emissions, consumption of fossil fuels and the different aspects of energy security the vision scenario shows that a multitude of benefits can be raised if such pathway forms the framework for the design of future energy and climate policies.

Last but not least, the development of comprehensive, consistent, flexible and learning policies and measures within the framework of the European Union, which is characterised by many distributed responsibilities, requires a lot of transparency with regard to the interactions and gaps between the different policies and instruments on the one hand and the gaps with regard to the compliance with targets on the other. A suitable approach to dealing with this challenge is policy-oriented modeling. Significantly increased efforts should be undertaken in order to develop a transparent bottom-up modeling framework for the EU which enables the assessment and the development of policies and measures on a consistent and transparent basis.

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Annex

Table 1 Scenario results – final energy consumption, 1990-2030

Final energy consumption	1990	2000	Baseline Scenario			Vision Scenario		
			2010	2020	2030	2010	2020	2030
	Mtoe							
Industry	**333**	**312**	**329**	**353**	**357**	**334**	**339**	**332**
Lignite	11	2	2	1	1	2	1	1
Hard coal	64	42	37	34	30	34	29	24
Oil	57	46	53	58	52	40	34	30
Gas	93	108	107	116	120	109	106	99
Solar	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	1	0	0	0
Others & waste	13	16	16	18	19	24	36	47
Electricity	79	90	103	113	120	107	103	98
Heat	16	9	11	13	14	20	29	32
Households	**256**	**283**	**315**	**345**	**362**	**297**	**289**	**265**
Lignite	12	1	1	1	0	1	0	0
Hard coal	21	9	5	3	3	4	2	1
Oil	59	58	61	58	53	40	27	20
Gas	76	103	119	132	136	103	80	54
Solar	0	0	1	1	1	2	9	16
Geothermal	0	0	0	0	1	0	0	0
Others & waste	21	25	26	28	30	33	47	44
Electricity	49	60	76	94	109	73	73	69
Heat	17	27	27	28	29	42	52	61
Tertiary sectors	**153**	**158**	**186**	**210**	**224**	**177**	**181**	**181**
Lignite	8	0	0	0	0	0	0	0
Hard coal	7	3	1	0	0	1	0	0
Oil	46	39	42	41	40	32	28	24
Gas	36	49	57	65	69	53	45	36
Solar	0	0	0	1	1	0	1	2
Geothermal	0	0	1	1	1	0	0	0
Others & waste	1	2	3	5	6	12	25	37
Electricity	43	56	74	89	98	65	66	63
Heat	10	8	8	9	9	13	17	18
Transport	**272**	**334**	**382**	**404**	**399**	**330**	**302**	**295**
Oil	267	327	361	374	366	307	256	237
Gas	0	0	0	1	1	0	0	0
Biofuel	0	1	14	23	27	15	39	50
Electricity	5	6	7	6	6	7	7	7
Heat	0	0	0	0	0	0	0	0

Source Eurostat, DG TREN, Öko-Institut.

Table 2 *Scenario results – power production, total primary energy supply and greenhouse gas emissions, 1990-2030*

	1990	2000	Baseline Scenario			Vision Scenario		
			2010	2020	2030	2010	2020	2030
Net power production	TWh							
	2,217	**2,736**	**3,393**	**3,897**	**4,099**	**3,061**	**3,061**	**2,915**
Nuclear	730	872	913	867	748	807	600	124
Hard coal	634	579	574	592	797	542	319	171
Lignite & brown coal	198	252	318	295	280	257	187	162
Oil	194	167	126	98	89	89	20	5
Gas	175	475	833	1,106	980	547	595	737
Hydro	268	333	347	374	394	360	370	378
Wind	1	22	184	305	441	164	526	727
Solar	0	0	2	4	9	7	55	142
Geothermal	3	4	6	7	8	15	37	69
Biomass & Waste	14	31	91	248	353	273	355	401
CHP	**-**	**420**	**618**	**870**	**1,057**	**449**	**771**	**931**
Total Primary energy supply	**1,556**	**1,649**	**1,831**	**1,940**	**1,921**	**1,682**	**1,580**	**1,438**
Nuclear	197	235	246	234	202	218	162	34
Lignite	116	70	58	55	57	70	48	38
Hard coal	316	237	240	245	253	203	128	77
Oil	596	635	687	692	665	546	437	389
Gas	261	376	446	512	495	383	363	342
Hydro	23	29	30	32	34	31	32	33
Wind	0	2	16	26	38	14	45	63
Solar & Geothermal	3	4	6	8	10	13	37	74
Biomass & Waste	44	61	101	136	167	204	328	389
Energy-related CO_2 emissions	Mt CO_2							
	3,920	**3,762**	**3,980**	**4,128**	**4,044**	**3,435**	**2,773**	**2,383**
Power generation & district heat	1,406	1,308	1,395	1,466	1,447	1,227	929	781
Other energy sectors	145	145	124	114	100	106	81	70
Industry	748	600	598	619	595	551	504	451
Households	507	458	488	500	492	381	279	193
Tertiary sectors	299	250	268	282	288	230	193	159
Transport	816	1,001	1,107	1,148	1,123	939	787	729
Other greenhouse gas emissions	Mt CO_2e							
	1,391	**1,203**	**1,185**	**1,162**	**1,102**	**929**	**875**	**778**
Methane	545	442	340	295	245	308	228	141
Nitrous oxide	487	411	355	355	355	272	265	255
HFC, PFC & SF6	69	67	90	162	202	70	122	142
Other CO_2	289	283	400	350	300	280	260	240

Source *Eurostat, EEA, DG TREN, Öko-Institut.*