Energy Efficiency as a key element of the EU's Post-Kyoto Strategy – Results of an Integrated Scenario Analysis

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Abstract

Under the framework of the UN framework convention on climate change (UNFCCC) and its Kyoto Protocol the targets and strategies for the second and third commitment period ("post-2012") have to be discussed and set in the near future. Regarding the substantial emission reductions that have to be shouldered by the industrialized nations over the next two decades it is evident that all available potentials to mitigate greenhouse gas (GHG) emissions have to be harnessed and that energy efficiency has to play a key role.

To substantiate this we developed a comprehensive scenario analysis of the EU 25s energy system and other greenhouse gas emissions until 2020. Our analysis shows

- which key potentials to mitigate greenhouse gas emissions are available,
- by which policies and measures they are attainable
- and which will be benefits of greenhouse gas mitigation measures.

By this analysis we show the mayor role of energy efficiency in all sectors and all member states. We demonstrate that a reduction of EU 25 greenhouse gas emissions by more than 30 % by 2020 is feasible, reasonable and – to a large extent – cost effective. We also develop a comprehensive policy package necessary to achieve ambitious Post-Kyoto targets.

The scenario analysis results in a clear identification of the needed strategies, policies and measures and especially the relevance of energy efficiency to achieve the necessary ambitious greenhouse gas reduction targets. It also clearly shows the costs and the benefits of such a policy compared to a business as usual case.

Background of the Study

The impending changes in global climate request urgent action to reduce global greenhouse gas emissions. A first step has been made with the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) in which most industrialized nations have agreed to reduce their emissions of 6 greenhouse gases by about 5% on average vs. 1990 levels. The Kyoto Protocol, which has come into force on the 16th of February 2005, also requests the first conference of the Parties serving as meeting of the Parties to the protocol (COP/MOP 1) to start initiating the consideration of future commitments for industrialized countries. As at COP 10 in December 2004 in Buenos Aires no significant steps to elaboration of post-2012 targets and regime have been achieved this task will be on the agenda at COP 11 / MOP 1 in November 2005 (Brouns et al. 2004).

The EU has committed itself to limiting global warming to 2°C above pre-industrial level (Hare/Meinshausen 2004). This target requires, due to the most recent research of IPCC and others that global greenhouse gas emissions have to be cut by half until 2050. This consequently means that industrial economies have to reduce their greenhouse gas emissions by around 60-80% in order to leave some potential for higher emissions in developing countries (European Commission 2004a).

To achieve this challenging goal, action has to be taken rapidly. The second and third commitment period of the Kyoto Protocol with a time horizon of 2018 to 2022 or its successor will have to impose substantial reduction targets to its signatory states. And the debate on these targets has already started. Germany, for example, has announced it will adopt a minus 40% target for itself, if the EU as a whole adopts a minus 30% target until 2020 (Trittin 2004).

In January 2005, the European Parliament published a resolution on the outcome of the Buenos Aires Conference on climate change. It emphasised "the necessity of significantly enhanced reduction efforts by all developed countries in the medium term to be able to meet the long-term emission reduction challenge" which it quantified for industrial countries "of the order of 30% by 2020" and "of 60-80% by 2050". It also called "on the EU to adopt reduction targets at the 2005 Spring European Council which are in line" with these objectives (European Parliament, 2005).

Scenario analysis of EU 25 greenhouse gas emissions until 2020

In order to analyse whether and how this target of a reduction of greenhouse gas emissions by 30% or more until 2020 below 1990 levels can be reached, we conducted an integrated scenario analysis of the EU 25. The results presented here focus on the energy related greenhouse gas emissions. Our analysis consists of two scenarios. The Business as Usual (BAU) scenario assumes continuing policies and measures with no specific emphasis on climate and energy policies neither with regard to the Kyoto Protocol nor to rising energy prices and increasing concern about limitation of resources. The BAU scenario is mainly based on the data and assumptions made in the most recent energy projections for Europe (Mantzos et al. 2003). The main purpose of this scenario is to serve as reference to the Policies and Measures (P&M) scenario.

In the P&M scenario existing cost effective potentials to increase energy efficiency are exploited by targeted policies and measures and ambitious targets for market penetration of renewables are achieved. In addition a fuel switch to less carbon intensive fossil fuels and policies and measures to mitigate the exploding demand in the transport sector are assumed to be effective in the P&M scenario. In spite of a moratorium for new nuclear power plants the P&M scenario shows that ambitious greenhouse gas emission reductions are feasible by an integrated strategy and deliver further benefits in terms of risk minimization for the EU economy and the world.

In the following we first provide an overview over the BAU and the P&M scenario. Then we analyse by sector on which potentials the high efficiency strategy – which is key to achieve the emission reductions in the P&M scenario – has to draw upon and how it can be implemented.

BUSINESS AS USUAL MISSES THE TARGET

To a large extend the baseline projection published in "European energy and transport trends to 2030" by the European Commission (Mantzos et al. 2003) are used as the BAU scenario. Especially the economic assumptions and the demand baseline from the European energy and transport trends are used as input data. Key results of the BAU scenario are shown in the following Table 1.

Although it contains considerable energy efficiency improvements in all sectors, increasing renewable energy shares and a decoupling of gross energy consumption growth (+ 0.7% pa) from gross domestic product (GDP) growth (+ 2.4% pa), under BAU conditions no reduction of greenhouse gas emissions from energy use can be achieved by 2010. On the contrary, CO_2-emissions from energy use are expected to increase until 2010 almost to their 1990 level. By 2020 they are projected to increase by 7%. These results, which are in line with the official EU energy projections (see above), highlight that with existing EU climate policies and measures the Kyoto targets for the first commitment period (which covers the years from 2008 to 2012) of a reduction of the six gases by 8% vs. 1990 for the EU 15 and slightly lower

Table 1. Comparison of BAU and P&M Scenario.

				BAU scenario			P&M scenario			
	1990	2000	% pa '90-'00	2020	% pa '00-'20	% delta to 1990	2020	% pa '00-'20	% delta to BAU 2020	% delta to 1990
GDP (in 10^9 Euro'00)	7.32	8.94	2.0%	14.5	2.4%	+97.7%	14.5	2.4%	0.0%	97.7%
Final Energy Demand (Gtoe)[1]	1.00	1.06	0.5%	1.32	1.1%	+31.5%	1.03	- 0.1%	- 22.3%	+ 2.2%
Gross Inl. Consumption (Gtoe)[2]	1.51	1.6	0.6%	1.83	0.7%	+21.7%	1.53	- 0.2%	- 16.5%	+ 1.6%
Renewable Energies (Gtoe)	0.06	0.075	2.7%	0.12	2.1%	+97.9%	0.29	6.9%	+150%	+400%
CO_2 Emissions (Gt CO_2)	3.76	3.67	-0.2%	4.02	0.5%	+7.02%	2.38	- 1.8%	- 36.1%	- 31.7%
Import Dependency	51.7%	55.9%	0.8%	69.8%	1.1%	+35.1%	56.1%	+0.03%	- 19.7%	+ 5.5%
Energy Intensity Indicators (1990 = 100)										
Industry (Energy / Value added)	100	83	-1.9%	60	-1.6%	-39.6%	48	- 2.7%	- 20.0%	- 51.7%
Residential (Ener./priv. income)	100	88	-1.3%	66	-1.4%	-33.9%	52	- 2.6%	- 21.4%	- 48.0%
Tertiary (Energy / Value added)	100	84	-1.7%	63	-1.4%	-37.0	48	- 2.7%	- 23.3%	- 51.6%
Transport (Energy / GDP)	100	98	-0.2%	82	-0.9%	-17.5	62	- 2.1%	- 24.3%	- 37.6%

Source: own calculations, for BAU: based on Mantzos et al. (2003)

[1] 1 Gtoe is equivalent to 41.869 PJ.

[2] Gross inland consumption equals primary energy demand.

reductions for the new member states will not be met even if further greenhouse gas emission reductions in other sectors and gases are taken into account[1]. Tougher long term targets for the next periods up to 2020 which are indicative to mitigate climate change seem to be even more out of reach with BAU policies.

The EU member states share this overall result as shown by the "Greenhouse gas emissions trends and projections in Europe 2004" compiled by the European Environment Agency (EEA 2004a). They show for EU 15 that with current EU and member states climate and energy policy the Kyoto targets will be missed. Only with the implementation of additional measures can the targets be reached. This highlights again the need for substantial additional greenhouse gas emission reduction measures in all sectors.

Table 2. Final Energy Demand by Sector for BAU and P&M Scenario.

	1990 (Mtoe)	2000 (Mtoe)	2010 (Mtoe)	2020 (Mtoe)	% pa '00-'20
BAU					
Industry	325	307	336	365	+ 0.86%
Tertiary	145	154	174	194	+ 1.15%
Household	270	275	300	313	+ 0.64%
Transport	262	313	370	418	+ 1.46%
P&M					
Industry	325	307	298	292	-0.26%
Tertiary	145	154	166	148	-0.18%
Household	270	279	267	260	-0.34%
Transport	262	307	330	323	+0.30%

Source: own calculations, for BAU: based on Mantzos et al. (2003)

POLICIES AND MEASURES TO CHANGE THE COURSE

To explore how the alarming course of the BAU development can be changed into a more sustainable direction a high efficiency scenario was developed for the EU 25. The P&M scenario includes additional or improved policies and measures to enhance emissions reductions. Supplementary to the high efficiency strategy a renewable strategy is outlined which is based on the EC renewable energy mid term potentials (European Commission 2004b) and produces substantial additional emissions reductions. As an effect of the combined strategies, the share of renewable energies will be increased to 21% of total primary energy supply and about 37 % of electricity production in the EU 25 until 2020 (BAU: 7.15% / 7.32%). As additional benefit of the P&M import dependency of the EU 25 can be held at almost current levels around 56% while in the BAU scenario dependency increases to almost 70%.

THE P&M SCENARIO – SECTOR BASED DESCRIPTION

The development of the final energy demand in the BAU scenario shows a demand growth between 0.64% and 1.46% per year from 2000 to 2020 in the different sectors (see Table 2). Whereas the final energy demand decreases in all sector for more than minus 1% per year in the P&M scenario compared to BAU.

End use energy efficiency and demand reduction are the most important strategies in the P&M scenario. The policies and measures for each sector to realise this change in final demand development are discussed in the following paragraphs.

Households

The residential sector was responsible for 27% of total final energy demand in 2000 in the EU 25. Although this share is expected to decrease to 25% in 2020 in the BAU scenario, absolute figures are still growing. The reasons for this development are an increasing number of households and increasing living standards, connected to a certain catch-up demand for household appliances in the new member states. However there are huge and cost-effective saving potentials, both for electric appliances and lighting as well as for residential heating. Energy Savings of 24% as against the BAU level are possible in 2020 if corresponding measures are implemented. This equals a reduction in demand of more than 10% as against 1990.

Appliances and lighting

The P&M scenario for electric appliances assumes that today's best available technology of domestic appliances will be the average fleet value in 2020. Furthermore it is assumed that three quarters of all electric light bulbs are substituted by compact fluorescent lamps. These two factors would lead to a demand reduction of more than 36% as against BAU.

The policy measures to achieve this goal are first of all setting minimum standards for power consumption of electric appliances. These standards should apply to on-mode as well as to standby use. They should be combined with an extension of energy labelling to all appliances (especially consumer electronics and home office equipment), and with a revision of labelling every 3 years to guarantee that the most efficient appliances are A-rated.[2] Furthermore, the purchase of these appliances should be stimulated by rebate schemes to accelerate the market penetration of the most efficient appliances, meaning that buyers get a rebate if they decide to buy an energy efficient appliance. An according scheme was running very successful in the Netherlands until 2003, causing A-rated appliances to become dominant in the market and making the market share of the most efficient A+ and A++ appliances the highest in the EU (www.energiepremie.nl).

Heating

Heating, including space heating, water heating and cooking accounts for about 89% of total final energy demand in households (EU 15).

A huge potential for energy savings is obvious in residential space heating. Two main strategies should be embarked on: Firstly, strengthened efforts concerning the insulation of buildings, going beyond the current EU directive on the energy performance of buildings. Secondly an increase of effi-

1. For a the scenario results on all GHG see Lechtenböhmer et al 2005.
2. Today's labelling standards have been introduced up to 12 years ago, which may result in less efficient appliances still to be A-rated. The newly introduced A+ and A++ classes for cool appliances may confuse consumers.

ciency for the entire heating system, combined with a fuel switch to gas and biomass. Improving the efficiency of the space heating system, i.e. heat generator (boiler), heat emitter (e.g. radiator) and control of the system by 10% versus BAU from 2010 on would lead to a reduction in energy demand of more than 11% in 2020 in the EU 15. A further 20% reduction could be achieved if the EU Directive on the energy performance of buildings was extended to all buildings being newly built or undergoing considerable reconstruction (EU 15). The relative saving potential for the new member states is estimated to be even higher due to an older average building stock. Accompanying policies to achieve improvements are e.g. rebates for the installations of more efficient heating systems (e.g. upgraded boilers) and insulation measures (e.g. low-emissivity double glazing, wall insulation), the building certification that is already being introduced, and professional training of architects and installation contractors. Introducing a European standard for single building components (e.g. k-values for windows) will have the highest effectiveness. The introduction of financial support schemes for the construction of low energy and passive houses will also add to the desired energy savings.

Water heating is responsible for about 25% of total energy demand. For the P&M scenario a 10% higher efficiency as against BAU is feasible through more efficient heating systems. At the same time solar heating systems will take over a substantial share of water heating (up to 36%). Corresponding policies are higher minimum standards for hot water boilers and a mandatory installation of solar panels on all new and renovated buildings, like recently decided in Spain (ECEEE news 2004).

Table 3. Annual Change of Energy Intensity in the Commercial and Services Sector (2005 - 2020).

	EU 15	NMS[1]	EU25
Final energy			
BAU scenario	-1.3%	-2.7%	-1.4%
P&M scenario	-2.9%	-4.3%	-3.0%
Electricity			
BAU scenario	-0.3%	-1.3%	-0.3%
P&M Scenario	-1.7%	-2.7%	-1.7%

Source: own calculations, for BAU: based on Mantzos et al. (2003)
[1] 10 New Member States that acceeded to the EU in 2004.

Table 4. Annual Change of Industrial Energy Intensity (2005 - 2020).

	EU 15	NMS	EU25
Final energy			
BAU scenario	-1.4%	-3.8%	-1.7%
P&M scenario	-2.5%	-5.1%	-2.7%
Electricity			
BAU scenario	-0.9%	-0.9%	-0.8%
P&M scenario	-1.5%	-1.6%	-1.5%

Source: own calculations, for BAU: based on Mantzos et al. (2003)

Commercial and Services Sector

The commercial and services sector (which also includes agriculture) is the smallest demand sector in the EU. However, growth rates are projected to be second to the transport sector under BAU conditions. High increases are especially expected for electricity consumption due to higher demand for office and multi media equipment, air conditioning, cooling and lighting.

The galloping demand in the commercial and services sector is driven by increasing importance of this sector on the one hand and by the rapidly increasing number of equipment on the other. Two main policies are assumed to be useful to curb this development: First of all labelling and minimum standards for the increasing number of electric appliances are of crucial importance. Under the framework of the eco-design directive, tough and dynamically improved minimum standards for office equipment and installed appliances such as air conditioning should be implemented. Voluntary agreements with producers (e.g. on standby consumption) and public procurement actions in order to further improve the best available technology on the market are additional measures. The second policy field in the tertiary sector is the extension of the buildings directive. The directive should set stricter standards for energy consumption in commercial and residential buildings and be extended to smaller buildings and refurbishments of existing buildings should. Regulations in order to make refurbishments of existing buildings mandatory as well as the expansion of the regulation to the installed equipment (e.g. lighting, air conditioning, elevators etc.) are further necessary steps. With this framework sector specific energy and electricity consumptions e.g. per square meter should be made mandatory. As a first step towards this aim voluntary agreements with sectors on these targets could be reached.

With this package of policies it is assumed that in the commercial and services sector the cost efficient savings potentials[3] can be realized. The energy intensity reductions (see Table 3), which are expected to develop rather slowly with 1.4% per year in the BAU-scenario, can be accelerated by about 1.6 percentage points per year. In total the energy consumption of this sector can be stabilized by 2015 and then reduced to about 3% above 1990 levels in 2020.

Industry

With a final energy consumption of 310 Mtoe in 2000 industry accounted for about 28% of final energy consumption of the EU in 2000. This share will remain almost constant in the future under BAU conditions. This means that final energy demand will increase by 19% until 2020 in spite of a decrease of energy intensity from 185 toe to 131 toe per Million Euro of value added.

The key policy to achieve the acceleration of energy efficiency by harnessing the cost-effective saving potentials is the further development of the EU emissions trading scheme. However, especially for the implementation of the huge electricity savings potentials and for the support of industrial CHP, additional instruments are necessary. These are among others minimum standards on energy consuming

3. The cost-efficecective savings potential is modelled by energy use and energy carrier based on the results of a wide range of potential and scenario studies.

products – in industry mainly for motors and drives. These standards should be developed and implemented by a continuous improvement of the eco design directive (COM 2003 453). The Integrated Pollution Prevention directive (IPPC; Council Directive 96/61/EC) as well could be used to improve the best available technology for various industry processes and to create higher pressure for the implementation of highly efficient technology in industry. Voluntary or mandatory energy audits and other "soft" policies and measures should support industry in their efforts to save energy and reduce CO_2 emissions.

By active implementation of the emissions trading scheme and other measures, the reduction of industrial energy intensity can be accelerated by 1 percentage point to 2.7% per year (see Table 4). This improvement is achieved by the implementation of the economic saving potential in all industrial subsectors with emphasis on cross cutting technologies such as efficient drives and motors, efficient lighting, process optimisation etc. The still substantially higher energy intensity in the EU 10+ compared to EU 15 will then be mainly due to structural differences and lower value added. By this active energy efficiency strategy energy consumption of industry can be further reduced to about 10% below 1990 (5% vs. 2000) levels in 2020.

Power sector – electricity and steam generation

In 2000, about one third of the total CO_2 emissions in the EU 25 arose from electricity and steam generation. Therefore, this sector is important for an active climate policy strategy. By an active use of the emissions trading scheme supported by strong policies to promote electricity savings, expansion of CHP and increased use of renewable energies CO_2 emissions of the sector can almost be cut by half compared to 1990 levels. The first important strategy is *electricity savings in all demand sectors*. Together a reduction of about 1.4% per annum versus BAU can be achieved. On this basis four key policies are assumed for the supply side:

- An *increased use of renewable energies* on the supply side reduces greenhouse gas emissions. In the P&M scenario 38% of the electricity is produced from renewable energies in 2020. Wind energy (11%) and biomass (12%) represent the major share of the total renewable electricity production.
- In the P&M scenario, the *share of electricity produced in co-generation plants almost doubles* from 12.5% in 2000 to 23.5% in 2020. This will be achieved primarily by higher electricity to steam ratio of new gas fired combined heat and power plants and an increased use of decentralized CHP. In the EU 15 45% of combined heat and power generation will then come from biomass, 50% from gas and 5% from coal-fired units. In the EU 10+ countries the share of coal is about 20%, gas and biomass contribute 40% each.
- *Fuel switch to low-carbon fuels* leads to a high penetration of gas turbine combined cycle power plants (GTCC) that are operating with natural gas and consequently the amount of hard coal and lignite fired power plants decreases.
- *Efficiency of thermal power plants will increase* in the P&M scenario from 37% in 2000 to about 49% in 2020. This efficiency improvement will be achieved by the fuel switch to gas-fired combined cycle power plants with high electric efficiency, a general preference of best available technology for new power plants and specific research & development.

In the P&M scenario, a high share of power plants will be reinvested. New plants, however, will be mainly realised as gas-fired combined cycle power plants and renewable capacity. Therefore an active strategy to retrofit old power plants is not adopted. Compared to the BAU projection the P&M scenario includes cutting new fossil power plant investment by 50% and no new nuclear capacity. Conversely, investment in combined heat and power plant capacity is doubled compared to BAU.

In the BAU scenario the need for re-investing of a huge share of the EU power plants is already a major challenge to the industry. It can be assumed that liberalized electricity markets can only deliver this with clear guidelines and directives and stable frameworks set up by national and EU policies. In the P&M scenario this investment has to be redirected towards higher shares of renewable and CHP generation capacity. This as well needs clear targets and a suitable framework to direct the market.

Transport Sector

Transport is the fastest-growing sector in terms of final energy demand and CO_2 emissions. The rapidly increasing final energy demand and the high dependence on oil products has raised concerns about the long-term security of oil supplies (the transport sector accounts for around 70% of the oil consumption of the EU 25 with a slightly increasing share). In addition, the transport sector causes increasing environmental damage by emissions of CO_2, congestion, noise and other pollution (INFRAS/IWW 2004).

In the BAU scenario a slight decoupling already exists between passenger transport activity growth (1.8% pa) and GDP growth (2.3% pa). The freight transport activity increases by 2.2% pa, which indicates a growth parallel to GDP and shows already reached improvements. Still this transport demand development underlines the imperative for ongoing organisational and technological efficiency increases in the transport sector to accomplish overall emission reduction targets. In the P&M scenario, the increase in transport energy demand will be stopped and turned into a decrease after 2010, while CO_2 emissions can be reduced below 2000 levels. Policies and measures to achieve this are first of all technical efficiency, followed by demand-side measures and increased use of biofuels.

Substantial vehicles efficiency improvements account for almost 50 % of all emission reduction in the P&M transport scenario. The average specific emission target for the passenger car fleet is reduced to 100g CO_2 per vehicle kilometre by 2020 (minus 106 Mt CO_2 _ see Table 5). The European Commission and car industry represented by the European, Japanese and Korean Automobile Manufacturers Association reached an agreement to achieve average CO_2 emissions of 140g/vkm by 2008/2009 for all new passenger cars. To accomplish the very ambitious targets of the P&M

Table 5. Share of CO_2 emissions reductions by measure.

	% annual change '05-'20		P&M Scenario	
	BAU	P&M	Mt CO_2 reduction in 2020	Share of total emission reduction
Demand Measures				
Passenger Road Transport	+ 1.4 %	+ 1.25 %	17	4.9 %
Aviation	+ 5.3 %	+ 4.0 %	34	9.9 %
Optimisation of Logistics				
Trucks	+2.6 %	+ 1.7%	55	15.9 %
Efficiency Improvements				
Passenger Car	+ 1.1 %	+ 2.5 %	106	30.7 %
Aviation	+ 0.58 %	+ 1.55%	21	6.1 %
Trucks	+ 0.3 %	+ 1.0%	48	13.9 %
	Share in 2020			
Biofuels	3.6 %	8.0 %	64	18.6 %
Total			**345**	**100%**

Source: own calculations, for BAU: based on Mantzos et al. (2003)

scenario the existing technological options[4] have to be implemented without delay by the car manufacturers. Further emission reductions by 21 Mt CO_2 result from a additional 1% improvement per year of average specific fuel consumption of airplanes until 2020 compared to the BAU scenario (European Commission 2001 and Lee 2003). In road freight transport, only very slow energy efficiency improvements by 0.3% per year are reached in the BAU scenario compared to 1.0% in the P&M scenario resulting from technological improvements e.g. engine improvements, weight improvements, aerodynamic drag reduction and reduced rolling resistance (Bates, J. et al 2001).

In the BAU scenario air transport is the fastest growing transport mode (+ 5.3% pa) (Airbus Industries 2003), followed by freight road transport (+ 2.6% pa) and passenger road transport (+ 1.4% pa). Active policies and increasing energy prices cause a slightly lower demand growth in passenger road transport (+ 1.25% pa) and aviation activity (+ 4.0% pa) in the P&M scenario (Scenes 2001), summing up both results in emissions reductions of 51 Mt CO_2 in 2020 compared to BAU scenario. Based on optimising freight organisational measures, transport logistic, road telematics, driver training and an intermodal freight transport (shift from road freight transport to combined road-rail and road-shipping transport) the growth of freight transport activity is alleviated (Bates et al 2001) resulting in an emission decrease by 55 Mt CO_2.

New energy forms are assumed to remain insignificant in absolute terms despite their rapid growth rates. Only mixed biofuels in diesel and gasoline fuel contribute notably to emission reductions by reaching the EU 8% target in 2020. The market entry of biofuels is supported by tax exemptions. However, biomass is a finally limited source due to the land availability in the EU[5]. As it can be used as fuel, for other energetic purposes and as raw material there could arise a long-term competition between these uses under a sustainable energy and production strategy. Whether biomass is used in the transport sector in the most efficient way has still to be clarified (EEA 2004b).

Policy for high energy efficiency

Energy efficiency, notably energy end-use efficiency, takes a crucial position on the way to greenhouse gas emission minimisation. It refers to technical improvements on all stages of the energy cycle, i.e. on the supply as well as on the demand side. Sometimes it is not possible to clearly differentiate according to these categories, i.e. demand and supply side options often overlap or interact. For example, increased energy efficiency in households leads to less energy demand, which can help energy suppliers to easier achieve their commitments under the EU emissions trading scheme. Nevertheless, action is necessary in all fields of the energy sector; the most important issues and according policies and measures alternatives are described in the following.

Even under BAU conditions general technical progress leads to more efficient products and processes. However, it is not sufficient to offset growing energy consumption caused by higher living standards, a higher population and economic growth. In industry e.g., energy demand is projected to grow by 7.9% for the period 2010-2020, already taking into account a structural change to less energy-intensive manufacturing processes. For the household sector this figure accounts for 6.6%, incorporating changes in the fuel mix as well as technological improvements in buildings and equipment. The tertiary sector is expected to grow by 11.6% in the considered time period, while the demand for energy in transport increases by 10.3%.

These figures make it clear that – in spite of huge potentials to reduce emissions – the general technical improvements assumed in the BAU case can only mitigate the growth in demand, but not reduce growth or even demand significantly. Further policies and measures to accelerate technical improvements and to increase the market shares of best available technologies are necessary. On the EU level, the following policy initiatives should as soon as possible be adopted and/or implemented in a stringent way:

4. e.g. shift to diesel cars, direct injection gasoline cars, hybrid cars, lightweight structures etc. See Bates et al (2001), pp 10
5. if it is not going to be imported, e.g. Bioethanol from Brazil.

- the proposed Directive on energy end-use efficiency and energy services, which would set a target to the Member States for achieving additional energy savings of 1% per year, compared to the policies and measures that are already implemented;
- the proposed Directive on eco-design requirements for energy-using products;
- a new framework Directive on energy labelling;
- and the national implementation and further revisions of the Directive on the overall energy performance of buildings (see also Bowie & Jahn 2003).

Furthermore, cross cutting policies are important. Two highly effective measures are the introduction of energy saving funds in all member states following Danish and British examples (www.elsparefonden.dk and http://www.est.co.uk, see also Thomas/Irrek 2005) and the definition of individual savings targets for energy suppliers under the framework of the energy end use efficiency directive for electricity and gas suppliers or network companies as already introduced in the UK, Denmark, Italy, or Flanders (Belgium) (OFGEM, 2004), some of them also known as "white certificates".

COMBINATION OF SPECIFIC POLICIES & MEASURES WITH THE EMISSIONS TRADING SCHEME

A most important policy strategy on the EU level is the combination of sector- and technology-specific policies and measures with the EU wide emissions trading scheme. Under the principles of the cap and trade regime established by the EU emissions trading scheme, the overall CO_2 emissions of all installations with a thermal power of more than 20 MW (i.e. most of energy consumption of industry and electricity generation) are regulated. Further sectors and greenhouse gases may be added. The member states of the EU allocate one state-wide emission ceiling for a certain trading period to these installations, distribute respective allowances to the owners who then can trade these allowances among each other in order to fulfil their obligations.

In 2000, the emissions falling under the regulation of the emissions trading scheme (most energy related CO_2-emissions of industry and power generation) amounted – according to modelling results – to about 2Gt of CO_2 or about 55% of energy related CO_2 emissions of the EU 25. In the BAU case, the emissions of the installations falling under the emissions trading scheme slightly decrease by about 5% until 2015 and rise again until 2020 to a level about 0.7% below 2000. The P&M scenario shows that in the power sector and in industry the biggest potentials for greenhouse gas emission reductions through higher energy efficiency and increased use of renewable energy are allocated. Emissions could decrease by almost 17% until 2010 and 870 Mt or 43% until 2020. This is equivalent to an overall annual discounting of allowances of 2.8% per year between 2000 and 2020. In the P&M scenario, about 60% of the overall emission reductions vs. BAU are thus connected to installations falling under the emissions trading scheme.

This development will, however, only be achieved if sector- and technology-specific policies and measures are combined with a consistent and stringent tightening of the national caps under the EU emissions trading scheme. Without the policies and measures, the emissions trading scheme will be "blind" regarding the emission reduction measures used. It is unlikely that the emissions trading scheme alone will harness the full potential of energy efficiency measures, which are cost-effective but dispersed as well as renewable energies with their higher initial investment. The policies and measures will reduce the transaction costs for energy efficiency and renewable energies and accelerate market introduction and technology learning. They will thus also reduce the price of a CO_2 allowance within each compliance period. On the other hand, if the caps under the EU emissions trading scheme are not adjusted according to the success of the policies and measures – particularly for those linked directly such as support for end use efficiency in industry or indirectly to the emissions trading scheme like electricity efficiency and policies to promote renewable electricity generation– EU companies might either sell excess allowance – indirectly generated by these policies – to other Annex I countries or be tempted to increase production for export or the EU market. Particularly the power producers might try to compensate measures for electricity efficiency by selling electricity for further end uses, for which it may not be the optimal solution. Thus the relevance to combine the emissions trading scheme with stringent energy efficiency and renewable energy policies, and the resulting necessity for the member states to follow a strictly decreasing pathway for their caps cannot be overestimated.

Supporting instruments in order to enable the actors of the emissions trading scheme to cope with a rapidly declining cap include in particular:

For industry:

- Supportive instruments to improve energy efficiency in industry by energy audits and targeted R&D.
- Especially a strong support of electricity savings measures is needed, as industrial installations do not get direct incentives to reduce electricity consumption from the emissions trading scheme.
- This includes the strengthened promotion of the most energy-efficient electric appliances such as electric motors and drives by minimum energy performance standards and the further development of energy labelling.

For the energy supply side:

- A clear strategy towards support of CHP, by adequate instruments such as fixed tariffs for electricity, quotas, or subsidy schemes.
- Clear support to increase market share of renewable energies, in particular in electricity and district heat generation. Here, feed-in tariffs following, e.g., the German example with technology-specific fixed and decreasing tariffs for renewable electricity generation combined with an active support to develop sites and exploit potentials are the instrument of choice.

POLICIES AND MEASURES FOR RESIDENTIAL, TERTIARY AND TRANSPORT SECTOR

Regarding the fuel use in other sectors – households, tertiary and services sector and transport – significant emissions reductions have to be achieved as well. Versus an increasing trend in the BAU case, more than 600 million tons of CO_2 in 2020 have to be reduced – not counting the indirect emission reductions from 1.4% per year through reduced electricity demand vs. BAU. Market barriers like lack of information, the investor-user dilemma or limited financial liquidity still retard a widespread penetration of energy and cost efficient appliances and services in these sectors. The most important policies here are:

- An improvement of the buildings Directive in order to achieve tougher mandatory standards for new and renovated houses.
- Targeted and well-appointed financial incentive programmes in order to accelerate renovation and energetic improvement of dwellings.
- And strong measures in the transport sector, which make 4 litre per 100 km cars mandatory as fleet average from 2012 on at the latest[6], introduce rapid improvements of air plane efficiency and reduce growth rates in transport by e.g. improved logistics. Demand management in the transportation sector?

The policies and measures sketched here have to be combined to create a comprehensive EU climate protection programme. In order to introduce and maintain the targeted developments of a more than 1% per year increase of energy efficiency vs. BAU and to stimulate a growth of renewable energies by 6% per year, this programme should include not only strong cross cutting and sector- and technology-specific policies and measures but also setting up a tough framework for the national emissions trading scheme caps in order to maintain the necessary decrease of the aggregated cap and in order to stimulate adopting the further policies and measures in time. It also should consist of targeted action programmes for energy efficiency, renewables, CHP, transport sector and electricity savings.

Risk minimisation by climate protection

As a result of the active climate policy in the P&M scenario – which basically consists of an active energy efficiency strategy both in the demand sectors as well as in the heat and power plants, an active promotion of CHP and the forced introduction of renewable energies into the market – also the development of the European energy market takes a different direction than expected under BAU conditions. This, in turn will reduce a number of other risks.

The climate strategy will work from two sides to stabilise import dependency at more or less current levels: On the one hand, due to increased energy efficiency on the demand side, final energy demand stabilises until 2010 at current level and then slightly decreases (see Figure 1). In the transformation sector an almost similar trend will be established. In total, gross domestic energy demand will remain at current levels in contrary to the BAU trend. On the other hand the climate protection strategy achieves a stable EU energy production at about current levels. The increased production of renewable energy will almost offset reductions in conventional fuel production. As a result, imports of coal will be re-

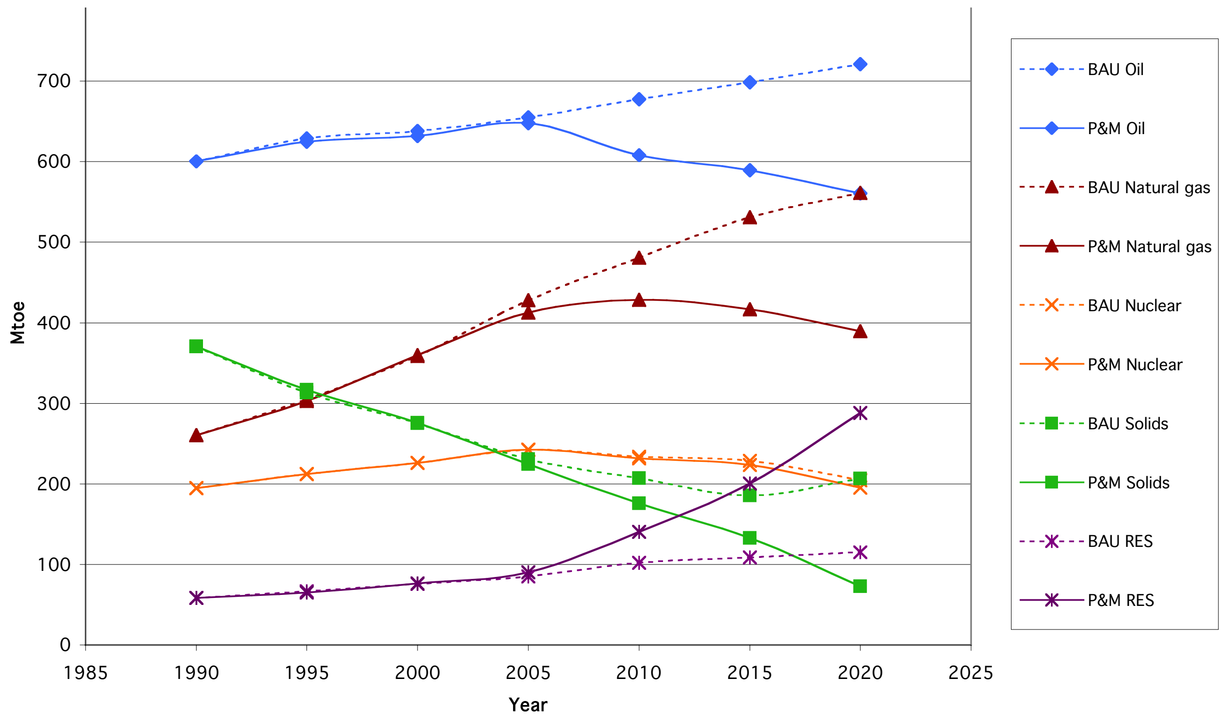

Figure 1. Gross Inland Consumption.
Source: own calculations, for BAU: based on Mantzos et al. (2003)

6. Equivalent to about 100g CO2 per vehicle km.

duced almost totally and oil imports decrease at nearly 1% per year. Gas imports – due to the fuel switch strategy toward gas – will continue to grow but with significantly decreased rates compared to the past and to the BAU projections.

By these two effects – stabilising of energy consumption through energy efficiency at all levels and maintaining of domestic production by increased production of renewable energies – not only climate mitigation is possible but at the same time the trend of increasing import dependency can be stopped. Domestic energy production will be able to deliver about half of the European energy consumption.

This reduces a wide range of risks and problems due to the current unsustainable trend of import dependency:

- Costs of imported energy for European economy can be curbed by between 60 and 120 x 10^9 Euro in 2020 (about 0.3 to 0.6% of GDP) compared to the BAU scenario, depending on price scenario and Euro/$ exchange rate.
- Price risks and risks of supply shortages are reduced.
- The pace of resource exploitation of important energy resources is slowed down globally, thus reducing again international conflicts and mitigation the danger of exploding energy prices
- Furthermore, the EU establishes itself as a leader towards a more sustainable world energy system. By stabilising its own oil demand on the world markets, risks for supply shortages and subsequent price shocks (see the discussion about peaking of oil production which is expected by most experts to occur before 2020) are reduced. And – if others follow – the balancing of oil production capacity and the demand for oil will be much easier than under BAU development.

Besides this economic risk minimization an ecological risk minimization can be achieved. Risks and potential costs of climate change will be reduced as far as possible, and other environmental damages – expressed as external costs of energy supply – will be substantially reduced as well in the P&M scenario compared to BAU.

Conclusions

We can conclude that an integrated and active climate protection strategy for the EU is not only a necessity in order to mitigate impending changes of global climate but also feasible, as it combines high challenges for the EU economy to accelerate its speed of improving energy efficiency and adapting power systems to renewable energy supply. Furthermore it is minimising risks, not only of global warming but also of disruptions in energy supply and of increasing energy prices.

- Our analyses show that there are huge and cost-effective potentials for improved energy efficiency in all sectors to stabilise EU energy consumption at or below current levels[7] and that a share of more than 20% of renewable energy supply can be achieved under an active strategy. Overall, a reduction of CO_2 emissions from fuel consumption by 31.7% until 2020 vs. 1990 is possible even with a phase out of nuclear energy. Regarding potential further greenhouse gas emission reductions in the agricultural sector (e.g. by increased use of biogas) and the waste sector, these results show that a 30% target for 2020 as envisaged by the European Parliament on the 13th of January 2005 (European Parliament 2005) is achievable with an active use of the strategies available.
- This makes it clear that the necessary reductions of greenhouse gas emissions can be achieved by exploiting the potentials for cost efficient energy savings and the expanded use of renewable energy sources.
- Another important result is that an active climate protection strategy yields further benefits in form of massively reduced risks of energy shortages and energy price peaks. It releases the European economy from high energy costs and also reduces other environmental burdens.

In order to change the course from BAU trends that lead to increased energy demand increased dependency on foreign resources and accumulating risks towards a sustainable energy strategy, *a comprehensive policy package is needed*. Combining the EU emission trading system with a comprehensive set of sector- and technology-specific policies and measures for energy end-use and supply efficiency, CHP, and electricity generation from renewable energies has to play a leading role as the emissions trading scheme covers sectors, in which about 60% of the total emission reductions are expected in our P&M scenario. Consequently an overall 2.8% per year decrease of emissions has to be implemented by the national caps. Policies and measures for transport, for energy efficiency, support for thermal uses of renewable energies and active support for CHP heating and renovation of households are needed as well.

Our results show that the strategy described by the P&M scenario is superior to a "muddling through" business as usual development with regard to quite a number of important economic and ecological variables. EU policy makers are well advised to further intensify and accelerate their efforts to speed up energy efficiency improvements in all sectors, to support further expansion CHP and prioritise renewable energy sources within the necessary re-investment of a large proportion of the European power plant stock.

7. This result is supported by the recently released "European energy and transport scenarios on key drivers " (Mantzos et al. 2005). This report refers to the Baseline developed by Mantzos et al. (2003) and in one of its scenarios, the extended policy option case, follows a more or less comparable philosophy with the P&M scenario developed here. However, the extended policy options case assumes strong policies and measures to be implemented mainly until and including 2010. After that time in key fields such as renewable energy no new policies and measures are assumed which leads to a somehow unrealistic break in the development of energy efficiency and renewable energies in this case.

References

Airbus Industries (2003): Global Market Forecast 2003. December 2003, available at: www.airbus.com

Bates, J. et al (2001): Economic Evaluation of Emissions Reductions in the Transport Sector of the EU – Bottom Up Analysis, Final Report March 2001, p.30 ff.

Bowie, R., Jahn, A. (2003) European Union – The new Directive on the energy performance of buildings – Moving closer to Kyoto, REVUE E TIJDSCHRIFT" (Société Royale Belge des Electriciens) April 2003

Brouns, B., Ott, H.E., Sterk, W., Wittneben, B. (2004): "It takes Two to Tango", US Stalls as EU Awaits a Change of Heart at the Climate Conference in Buenos Aires, Wuppertal, Buenos Aires

EEA (2004a): Greenhouse gas emissions trends and projections in Europe 2004. European Environment Agency, Technical Report No 5/2004

EEA (2004b): Transport biofuels: exploring links with the energy and agriculture sectors. European Environment Agency, Briefing No 4/2004

European Commission (2001): European Aeronautics – A Vision for 2020. January 2001

European Commission (2004a): Action on Climate Change Post 2012: A Stakeholder Consultation on the EU's Contribution to Shaping the Future Global Climate Change Regime, available at: http://europa.eu.int/comm/environment/climat/future_action.htm.

European Commission (2004b): The share of renewable energy in the EU – Country Profiles of Renewable Energy Sources in the enlarged European Union. Brussels, 26.05.2004, SEC (2004) 547

ECEEE News (2004): Spain launches big push for solar housing, 16.11.04, available at: http://www.eceee.org/latest_news/2004/news20041116b.lasso.

European Parliament (2005): European Parliament resolution on the outcome of the Buenos Aires Conference on Climate Change, P6_TA-PROV(2005)005, 13 January 2005.

Hare, B., Meinshausen, M. (2004): How much warming are we committed to and how much can be avoided? submitted to EU's stakeholder consultation on Action on Climate Change Post 2012, 28 October 2004.

INFRAS/IWW (2004): External Costs of Transport – Update study, Final Report, Zurich/Karlsruhe, October 2004

Lechtenböhmer, S., Grimm, V., Mitze, D., Wissner, M. Thomas, S. (2005): The WWF / WI EU 25 Post 2012 GHG-Mitigation Scenario. Final Report to WWF, Wuppertal

Lee, J. (2003): The potential offered by aircraft and engine technologies. In Upham et al. (2003): Towards Sustainable Aviation. Earthscan 2003

Mantzos, L. et al. (2005): European energy and transport scenarios on key drivers, published by DG TREN, Brussels

Mantzos, L. et al. (2003): European energy and transport trends to 2030, published by DG TREN, Brussels

OFGEM (2004): Energy Efficiency Commitment 2005-2008, Administration procedures, December 2004.

Scenes (2001): SCENES Transport Forecasting Model: Calibration and Forecast Scenario Result. Deliverable 7, September 2001, available at: http://www.iww.uni-karlsruhe.de/SCENES/Download/SCENES_D7.pdf

Thomas, S.; Irrek, W. (2005): Will there be an Energy Efficiency Fund in Germany? Paper 1,224 in these proceedings.

Trittin, J. (German Minister of the Environment) (2004): Announcement at the Climate Conference in Buenos Aires, available at: http://www.bundesregierung.de

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