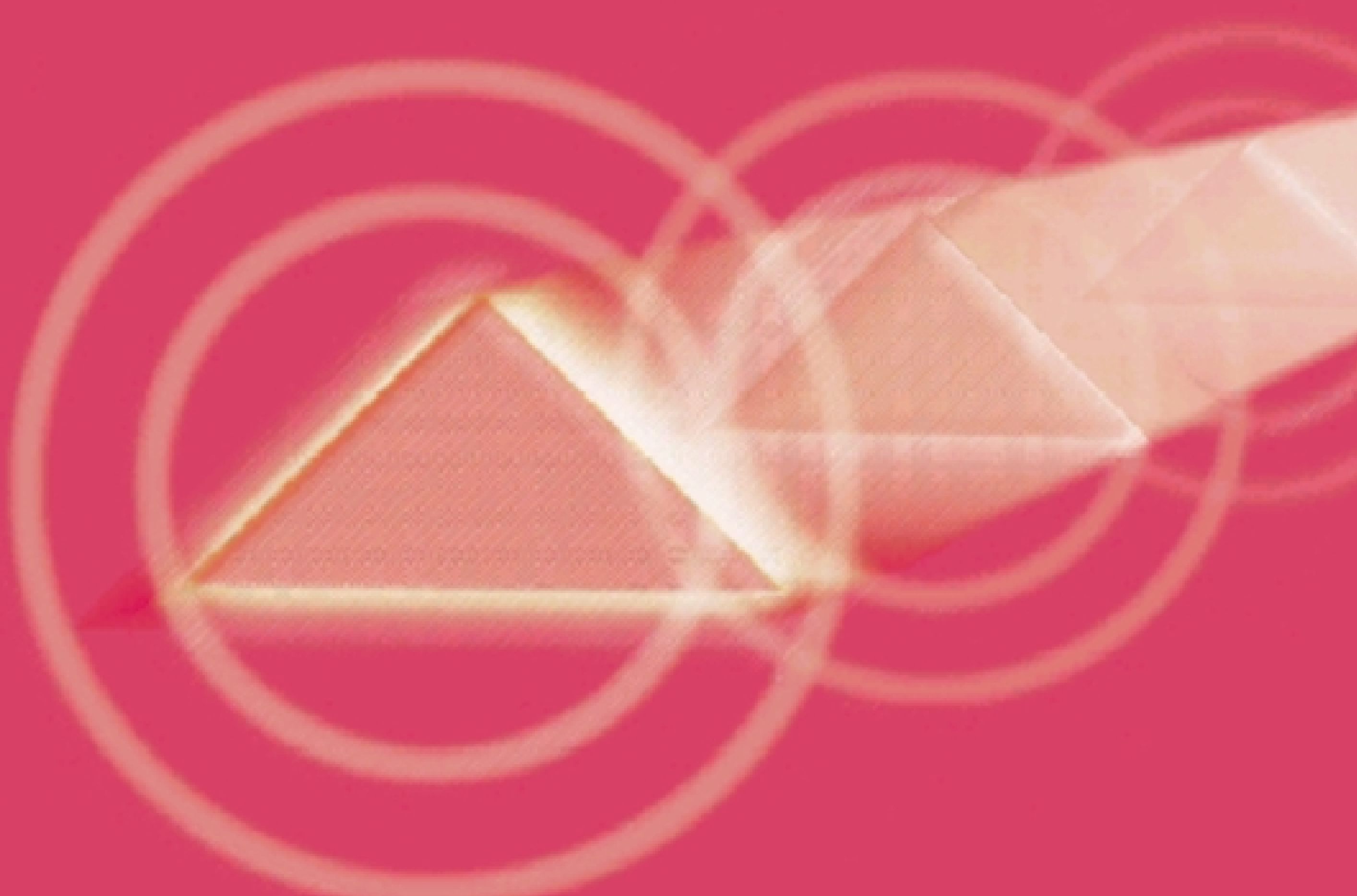
EXECUTIVE SUMMARY



EXECUTIVE SUMMARY

The purpose of this study is to present a consistent EU energy and energy related emissions outlook for the period to 2020. The derivation of the results and conclusions, which are presented here in the context of the "Shared Analysis Project", has been based on quantitative analysis and on a process of communication with and feedback from a number of energy experts and organisations.

KEY ASSUMPTIONS

World population is likely to increase by almost 2.5 billion people in the period to 2020 but its rate of growth is projected to slow down to just over 1% per annum (pa) in the latter part of the projection period. EU population is projected to increase by only 12 million people in the period 1995-2010 and to be effectively stable after that.

The world economy is expected to grow by slightly more than 3% pa throughout the projection period. All OECD regions are projected to slow down to a growth rate slightly below 2% pa in the longer term while most non-OECD regions continue to experience average annual growth rates of more than 3.5% after 2010.

Economic growth in the EU is expected to be just under 3% pa in the short run but it is assumed that, despite the generally favourable overall international context, the EU growth rate after 2000 will decelerate to levels that are consistent with long run historical trends. In the period 2000-10, the annual economic expansion is projected to be around 2.3% while, in the period after 2010, it is limited to less than 1.8%.

The long established trend of restructuring of EU economies away from the primary and secondary sectors and towards services and high value-added products (less material and energy-intensive products) is assumed to continue, although the pace of change is expected to decelerate in the long run.

The baseline scenario is based on the assumption that EU policies currently in place will be continued. These include the further integration and liberalisation of electricity and gas markets in the EU, further improvement of energy technologies in both the demand and supply sides, the continuation of support for renewables and co-generation, the extension of natural gas supply infrastructure, the extension of the lifetime of nuclear plants to 40 years, and stringent regulation of acid rain pollutants. The baseline scenario does not include any policies that specifically address the climate change issue.

WORLD ENERGY BASELINE PROJECTION

Total primary energy consumption is likely to increase by an average annual growth rate of 2% in the 1990-2020 period and the energy intensity of the world economy is expected to decline by 1.4% pa in the period to 2010 and by slightly less than 1% after that.

The global energy system will continue to be dominated by fossil fuels over the next 25 years. The dependence on fossil fuels is likely to be close to 90% by 2020.

Gas is expected to grow quite rapidly in the Asian region. European importers of gas from parts of Russia and Central Asia could face competitive pressures from Asian consuming regions.

Given the projections for growth in primary energy demand and the continued dominance of fossil fuels, global emissions are expected to grow quite rapidly. For the period 1990-2020, China and South Asia account for almost 50% of the increase in global CO_2 emissions.

The baseline projects that global energy markets will remain well supplied at relatively modest cost throughout the projection period. Crude oil prices (at the EU border) by 2020 are projected to be close to roughly 25 Euro'98/bbl, which is less than their level of 1990 (in real terms) but above their level in recent years. Gas prices in Europe are assumed to rise significantly faster, mostly in the medium to longer term. The price of hard coal imported in the EU is expected to remain relatively stable.

EU PRIMARY ENERGY SUPPLY AND DEMAND

Production of fossil primary energy within the EU is expected to continue to decline throughout the period to 2020, after peaking in the period 2000-2005. Renewable sources of energy are likely to receive a significant boost as a result of policy and technology progress. The decline of EU indigenous solids and oil is especially noticeable.

Despite the evidence of some saturation for some energy uses in the EU, energy demand is expected to continue to grow throughout the outlook period even though at rates significantly smaller than in history. The growth rate of primary energy consumption is expected to continue to be close to 1% pa over the period to 2010 and then to decelerate to just 0.4 % pa until 2020.

The implied energy intensity improvement is gradually expected to increase and to reach an annual rate of more than 1.5 % towards the end of the projection period. Structural change in the demand side mainly explains this change. The role of energy technology is also important.

The EU energy system remains dominated by fossil fuels over the next 25 years and their share rises marginally from its level of just under 80% in 1995. Nearly two thirds of overall energy requirements in the EU will be imported by 2020, compared to less than half in 1995. Import dependency will gradually increase for all fossil fuels and is likely to reach very high values in the longer run.

The use of solid fuels is expected to continue to decline until 2010 both in absolute terms and as a proportion of total energy demand. Beyond 2015, however, due to the power generation problems that will ensue from the decommissioning of a number of nuclear plants, and the partial loss of competitiveness of gas based generation, due to higher natural gas import prices, the demand for solid fuels is projected to increase modestly.

Spurred by its very rapid penetration in new power generation plant and co-generation, gas is by far the fastest growing primary fuel. Its share in primary energy consumption is projected to increase from 20% in 1995 to 26% in 2010. The baseline projection shows, however, only a modest further increase beyond 2010.

The share of oil in primary consumption is projected to be relatively stable over the period to 2020 and its annual growth rate is projected to decelerate from 1% in the period to 2010 to 0.1% during 2010-20.

Under baseline technology assumptions, novel energy forms, such as hydrogen and methanol, do not make significant inroads, primarily due to cost considerations.

FINAL ENERGY DEMAND IN THE EU

Final energy demand is expected to grow marginally faster than primary energy (because of improved rates of conversion efficiency in power generation), rising annually by 1.2% and 0.5% in the 1995-2010 and 2010-20 periods respectively. There are few changes in fuel shares over the next 25 years. The only notable change are the increase by nearly 5 percent points in the share of electricity and the continued decline in solid fuels, which nearly disappear as a final demand fuel by 2020. However, even by 2020, electricity continues to account for less than a quarter of final energy consumption. Energy demand in the tertiary sector is the fastest growing segment of final demand reflecting the expected restructuring of the economy towards services. The modest growth in residential energy demand reflects the lack of growth in EU population and the small increase in the number of households. By 2020, transportation accounts for almost a third of EU final energy consumption, followed by industry and the residential sector, which account for about 26% of consumption each.

Oil becomes almost exclusively a fuel for transportation and petrochemicals. The increase in transportation energy demand is actually greater than the increase in the demand for liquid fuels over the 1995-2020, implying a decline in the overall oil consumption in other sectors.

POWER GENERATION IN THE EU

Under baseline assumptions, the technology of electricity and steam generation improves leading to higher thermal efficiency, lower capital costs and greater market availability of new generation technologies. The assumed improvement, however, is not spectacular and no technological breakthrough occurs during the projection period in the baseline scenario.

The use of electricity is expected to expand by 1.7% pa over the projection period and its growth is expected to be especially rapid in the tertiary and in the transportation sector. Steam demand is projected to grow by 1.2% pa in the period to 2020. The industrial sector is projected to remain the dominant user of steam.

Total power capacity requirements for the EU increase by some 300 GW in the 1995-2020 period and a similar amount of new capacity will be required for the replacement of decommissioned plants. Thus the EU is projected to build 594 GW of new plants over the 1995-2020 period in order to cover its growing needs and replace the decommissioned plants.

The use of traditional coal and oil plants declines very rapidly. Due to the decommissioning of older plants, there is a modest decline in the capacity of nuclear plants while nearly half of the thermal plant currently utilised by independent producers is also expected to be scrapped. These declines in capacity are more than made up from the dramatic increase in gas turbine combine cycle plants and small gas turbines. These increase by nearly 10 times over the projection period to exceed 380 GW or almost 45% of the total installed capacity by 2020.

Growth in hydroelectricity and other renewable forms of generation is projected to be modest but at more than 50 GW of new capacity, the increase in these capacities will make a significant contribution. The additions mostly concern wind power. Significant growth in generation by clean coal plants and biomass generation is also expected to occur over the next 20 years, in particular towards the end of the projection period.

Technological advances and changes in market structure will reduce the dominance of utilities in electricity generation. This trend is clearly related to the widespread use of gas turbines since with this form of generation economies of scale are very limited above a rather modest size of a turbine. The use of gas turbines in combined cycle mode will also greatly encourage the more widespread use of steam, especially by independent producers. Small-scale producers are projected to get close to a fifth of the electricity market by 2020.

A significant improvement is expected to occur in the efficiency of power generation. The efficiency of the overall power and steam generation system is expected to increase by around 12 percentage points and to reach 66% by 2020. This is the combined effect of adopting more efficient technologies (like GTCC) and co-generation of heat and power. The efficiency of generation of electricity excluding steam improves from 34 to 45% between 1995 and 2020.

The use of coal and lignite declines quite dramatically between 1995 and 2010 but after 2015 it recovers to reach, and marginally exceed (after 2020), its 1990 level. This is due to the increased decommissioning after 2015 of nuclear plants and the progressive rise of relative price of natural gas.

ECONOMIC IMPLICATIONS

The above energy trends have significant implications for the financial requirements of the EU energy system. At the primary supply level, the significant growth in the demand for gas in EU will make necessary the importation of gas from a number of distant fields in Russia and other countries. This will require the financing of a number of new expensive gas pipeline projects.

The further lightening of the consumed barrel of oil products, together with the required “cleaning” of a number of oil products, may require significant investments for the upgrading of the refining system of the EU or increased heavy product trading with the US.

The power generation sector will continue to be one of the most important investment outlets in the EU economies. However, due to the relative slow growth in electricity demand, the sector’s financial requirements will decline significantly as a share in gross fixed capital investment.

The structure of the financial requirements of the power and steam generation sector will change as the relative importance of capital requirements decline quite significantly while that of fuel spending increases. This is almost exclusively due to the penetration of GTCC and small gas units whose capital cost is significantly lower than that of conventional technologies.

Because of technological progress, throughout the energy system the cost of energy for the consumer stabilises and in some case decreases, despite the continuous rises of imported oil and gas prices. Also, facilitated by liberalisation, the average electricity tariff is projected to decrease in 2010-2020 in average by 15% below the current level. The share of energy costs in total production costs (for firms) or in total income (for households) continuously decreases.

ENVIRONMENTAL IMPLICATIONS

The rising share of fossil fuels will lead to an increase in the carbon intensity of the EU energy system. Together with the modest increase in energy demand, this will lead to an increase in CO_2, which are projected to increase annually by 0.6% pa in the 1995-2020 period. In view of the relative size of the increase in emissions from developing countries it is clear that any action to reduce emissions from the EU alone will only have a limited impact on long-run CO_2 concentrations.

In absolute terms, the increase in emissions originated from combustion of natural gas more than make up for the sharp decline in emissions that results from the decline in the use of solid fuels. Energy intensity improvements act in favour of moderating the rise of CO_2 emissions. The carbon intensity does not improve.

In the period to 2010, the sectors with the fastest increase in emissions are those where energy demand is expected to grow fastest, namely the tertiary and transportation sectors. However, in terms of their absolute contribution to the increase in emissions, it is the transportation sector, which accounts for nearly two thirds of the overall increase in emissions between 1995 and 2010. Beyond 2010, it is the electricity and steam generation that is almost solely responsible for the increase in CO_2 emissions.

Emissions of SO_2 and NO_X from the whole energy system and especially from the power generation system are expected to decline quite rapidly over the outlook period as a result of stringent standards for abating acid rain pollution and the fuel switching from solid fuels to natural gas.

LONGER RUN TRENDS

While the analysis carried out formally covers only the period to 2020, a number of trends and issues that are important for policy analysis become apparent for the period beyond 2020. The significance of discussing these emerging longer-term trends lies in that, often, energy policy must adopt a very long horizon in order for its effectiveness and economic efficiency to be optimised.

Energy import dependency problems will become very acute in the period beyond 2020 in the absence of breakthroughs in supply technologies or of new and unexpected large discoveries of oil and gas. The latter is not considered very likely.

Imports of gas will have to take place from increasingly distant places in Russia and the Middle East with potentially negative cost implications. Following the decommissioning of a large number of nuclear plants in the period around 2020, there is much uncertainty on the means through which these plants will be replaced.

The potential of new technological breakthroughs becomes very large both for alleviating the import dependency of the EU and for tackling emissions problems. This is particularly challenging for the power generation sector, which, beyond 2020, will face major strategic technology and fuel choice dilemmas, affecting the overall energy policy and European geopolitics.

A key uncertainty for the period beyond 2020 is the means by which the large number of decommissioned nuclear plants will be replaced. More than 110 GW of nuclear capacity will be retired between 2015 and 2030. Whether this capacity is replaced by nuclear plants or by plants using fossil fuels will make a significant difference to both the emissions and energy outlook of the EU.

EMISSION REDUCTION SCENARIOS

DEFINITION

Three CO_2 emission reduction scenarios have been ran with the PRIMES model in order to estimate the likely degree of difficulty and possible energy system impacts of imposing restrictions on the amount of CO_2 emissions that the EU energy system will be allowed to emit in 2010 and beyond.
The scenarios represent increasingly severe carbon constraints, starting from stabilisation of emissions in 2010 at their level in 1990, which implies a reduction of baseline emissions in 2010 by 222 Mt of CO_2 (Scenario S0). Under the assumptions of the most severe scenario examined, labelled S6, CO_2 emissions by 2010 amount to 2883 Mt, representing a reduction of 6% from the level of emissions in 1990 and a reduction of 406 Mt, when compared to the baseline emissions in 2010. The other scenario, labelled S3, involves a reduction of CO_2 emissions by 3% from their level in 1990, or 312 Mt from their baseline level in 2010.

The selection of the range of emissions in the above scenarios spans the likely requirement set out in the Kyoto protocol for cost effective reduction measures of energy-related CO_2 emissions, taking into account cost-effective reductions of other greenhouse gases included in the Kyoto protocol. The use of flexibility mechanisms according to the articles of the Kyoto protocol and the contribution of sinks would also alter the actual domestic reduction requirement to be accomplished within the EU energy system. The CO_2 stabilisation case (S0) is further motivated by the commitment of the EU to stabilise CO_2 emissions by the year 2000, and beyond, at their 1990 level.

The analysis assumes full flexibility adjustment within the European Union member-states. The carbon constraints have been applied as global constraints treating the EU energy system as one economic system without any a priori allocation of emissions reductions to any sector, fuel or country.

Carbon constraints were imposed globally on the EU energy system without any limits on the amount of emissions reduction that would originate from one country or one sector. The only criterion used was that of economic efficiency.

The imposition of the above carbon constraints for 2010 resulted in an annual marginal abatement cost that varied from 50 (stabilisation case) to 102 (S6 case) Euro of 1990 per ton of carbon avoided. In order to restrict carbon emissions beyond 2010 to their level in 2010 within the corresponding scenario, the carbon constraint induces an annual marginal abatement cost ranging from 59 Eur’90 per ton of carbon avoided (stabilisation case) to 115 Euro’90 (S6 case) in 2020.

ENERGY SYSTEM IMPACTS

The economic system can respond to the imposition of the carbon constraint by reducing its energy intensity and/or by changing the fuel-mix to reduce the carbon intensity of its energy system. For the period to 2010, in all three scenarios under consideration nearly half of the overall reduction in emissions is achieved through a reduction in energy consumption, i.e., in energy intensity, but this effect declines somewhat in 2020. This effectively means that as we move further into the future the economic system finds substitution among fuels (i.e. reducing the carbon intensity) more cost effective than reducing overall energy use (i.e. reducing the energy intensity).

By far the most significant effect in terms of primary energy fuels is the decline of solid fuel consumption, which falls not only because of the overall decrease in energy consumption but also because their use is replaced by less carbon intensive fuels. The reverse effect operates on gas and renewables, both of which increase in 2010 and 2020, compared to their consumption level under baseline assumptions.

Substitution at the primary level is rather easier to achieve than at the level of final energy demand. As the carbon constraint increases, final demand accounts for an increasing share in the reduction of emissions from their baseline levels. Structural changes and behavioural effects in the demand side contribute by 20% to total emission reduction.

In industry most of emission reduction comes from restructuring of industrial processes (e.g. more electric arc processing, more recycling of materials, etc.). Improved electrical technologies and heat pumps seem to be attractive and cost-effective options for reducing emissions. In general, the degree of flexibility available to industry for reducing emissions is limited.

The tertiary and household sectors seem to have large possibilities for emission reduction both through adopting more efficient electric appliances and through reducing their thermal needs by improving buildings.

The most noticeable changes in the transport sector concern trains and aircraft. In both cases the average efficiency progresses, but trains gain market share while air transports lose. The effects in the road sector mainly concern behavioural changes in car purchasing and use rather than in car technology itself. High emission reduction constraints are necessary to enable significant technology change in the transport sector.

In general, the rate of adoption of best available technologies is low, in the emission reduction scenarios examined. Sensitivity analysis, on the other hand, shows much potential from greater adoption of best available technologies. Consequently, there may be large scope for policy to promote best available technologies.

The bulk of the change in carbon intensity of the EU energy system is due to the electricity and steam generation system. For the period to 2010, nearly 60% of the overall required reduction in emissions is achieved through adjustments in the power and steam generation sector. By 2020 this proportion rises to more than 70%.

Thus, the power and steam generation system of the EU appears to be the sector that can adjust in the most cost-effective way to emission reductions. It is partly because the power and steam generation system is more flexible in the reduction of emissions that its output does not decline as sharply as that of other forms of final energy. On average, for every one per cent reduction in generation output there is a multiple decline in CO_2 emissions.

One of the reasons for the growing scope of relatively cost effective substitution in the power and steam sector after 2010 is that, under baseline assumptions, a large come back of solids was projected to take place. This was due to the rising prices of gas and to the gap in capacity that would be left from the decommissioning of nuclear plants. Under the carbon constraint scenarios, the impact of the increased relative price of gas is negated by the implicit cost of carbon, which results in a significant increase of the relative price of solids. Consequently, the power and steam generations system continues along its path to 2010, which involved that the bulk of new generation capacity would use gas as a fuel.

Renewable energies and nuclear also expand as a result of the imposition of the carbon constraints. The use of nuclear expands substantially while the effect of renewables is more limited. Similarly, the improvement in efficiency of generation in the three scenarios only accounts for a modest part of the reduction in emissions while the share of co-generated electricity from thermal plants increases modestly.

While the role of the electricity and steam sector remains dominant in meeting the carbon constraint, there are indications that the relative difficulties increase, as the constraint becomes tighter. Effectively, at low levels of the carbon constraint the flexibility of the generation system and the available fuel switch options make it a convenient and cost effective means to achieve emission reductions. As the constraint gets tighter, in any given time period, the options within the generation system become relatively more difficult and final demand is required to make a more substantial contribution.

ECONOMIC IMPLICATIONS

The imposition of emission reduction targets results in an increase of energy system costs. The additional costs implied by a CO_2 emission reduction target is conveyed to the energy system through the carbon value, which represents the marginal abatement cost incurred by the system in avoiding the last ton of CO_2 that is necessary in order to meet the reduction target.

Partial estimates (with an energy system model such as PRIMES) indicate that the total welfare loss of reaching the emission targets under the three scenarios for the EU in 2010 is between 0.02 and 0.07 of one percentage point of GDP. The net additional welfare losses for the rest of the economy have not been evaluated in this study. They are expected to be higher according to general equilibrium evaluations with the model GEM-E3, which has shown that the emission reduction constraints do lead to a net loss of economic welfare and GDP. However, there are economic policies that may partly alleviate the losses.

The total energy system cost increases from baseline levels as a result of the imposition of the carbon constraints by between 25 and 55 billion Euro per year, including all extra costs induced by the carbon constraints. This increase in energy system costs reflects the increase in the sector's investment requirements, increased tariffs etc. It is by no means a pure economic cost since most of the additional funds will be recycled within the overall economy.

The energy system cost of CO_2 emission reduction differs substantially across the EU member-states. This is because there are large differences among member-states in the structure of power and steam generation, in the process of industrial restructuring, in the fuel mix and technology choices, as well as in base year emissions. Sensitivity analysis has shown that for the same reasons the marginal abatement costs also differ across the EU member-states. At this point, it should be recalled that the definition of the emission reduction scenarios (equality of carbon values) presupposes reaching emission targets at least cost. These assumptions significantly moderate the cost for the European Union economy for reaching the Kyoto targets. The costs could be higher in reality as a result of implementing carbon abatement measures in a non-optimal way.

The various economic sectors are affected differently by the imposition of the carbon constraint in 2010. The costs differ among sectors depending on their energy intensity.
In energy-intensive industrial sectors the increase in the average cost of sectoral output (industrial product) ranges from 3% (stabilisation) to 7% (-6% case) in 2010, compared to baseline.[1] The same increase in the output cost of non-energy intensive sectors ranges from 0.1% to 1%. In particular, the increase in the cost of energy for industry is higher, ranging from 14% to 30% in energy intensive sectors, and from 9% to 21% in non energy intensive ones.

The energy cost for the service sectors increases from 3.5% (stabilisation) to 9% (-6% case), however implying a small increase in total cost of the sector. Spending by households on energy fuel purchases and energy-using equipment increases by roughly 3% (stabilisation) to 10% (-6% case). The energy costs in the transports sector also rise, ranging from 5% (stabilisation) to 10% (-6% case). However, the cost of transportation increases less, ranging from 0.5% to 2% for passengers and from 1% to 4% for freight.

The costs incurred by the power and steam generation sector relate to higher capital expenditures (more expensive plant technology), the costs induced from stranded capital, and the high fuel costs needed for fuel switching. The average power and steam generation cost increases from 9% (stabilisation) to 18% (-6% case). The investment expenditures for power and steam generation also rise to maximum of 8%. Electricity tariffs increase from 6 to 22 %.

All the above costs are slightly higher in 2020 reflecting the higher carbon values needed in 2020 compared with 2010.

UNCERTAINTIES

The outlook for nuclear power is one of the key uncertainties of this outlook. Nuclear can play a very significant role in reducing emissions beyond 2010. Its impact will depend on whether the massive amount of nuclear plants that are due to be decommissioned between 2015 and 2030 will be replaced by nuclear plants or by fossil fuel plants. Despite the restrictions imposed on the expansion of nuclear power, it was shown, under the high oil and gas price sensitivity, that the role of nuclear power could be significant.

In the nuclear sensitivity it was shown that under an emissions constraint and without any restrictions on the scope of nuclear power within the countries that use this form of energy, nuclear capacity is projected to increase to 181 GW by 2020 and to 212 GW by 2030. This is quite a dramatic expansion of nuclear power and is only comparable with the nuclear capacity expansion that took place between 1960 and 1990. In terms of new capacity under the assumptions of the high nuclear sensitivity almost 200 GW of new nuclear capacity will have to be built between 2015 and 2030 to

[1] In terms of total sectoral output the cost increases are rather low because important cost components (e.g. wages) do not change.

expand the nuclear capacity and replace the units to be decommissioned. The impact of this sensitivity on the EU energy and emissions is substantial.

Under the assumptions of the high oil and gas sensitivity, it was shown that an increase in the (relative to other fuels) cost of gas in the longer term is sufficient to increase the use of solids significantly. This leads to an increase in CO_2 emissions despite the decline in energy demand that is caused by the increase in oil and gas prices.

The role of transportation is critical for the future increase in oil import dependency and significant for the future growth in emissions. Under a sensitivity which included the implementation of a recent voluntary agreement between the EU and the auto manufacturers association (ACEA), it was shown that 2010 oil demand is reduced by 28 Mtoe (or more than half a million barrels per day) in the EU, which is equivalent to more than 4% of EU oil demand. The 2020 impact on oil demand is about double that of 2010 and 2020 CO_2 emissions in the EU decline by 4.6% when compared to the baseline.

There is a great deal of uncertainty surrounding the future long-term structural changes that are likely to take place in the EU. Sensitivity analysis for Germany and France suggests that alternative economic structures than those assumed in the baseline could have significant impacts on future energy demand and emissions.

POLICY IMPLICATIONS

It was shown that under reasonable assumption for the period to 2010 (the baseline scenario), it is unlikely that the EU will meet its Kyoto undertakings, at least through energy related CO_2 emissions. Instead of the 8% reduction in emissions a 7% increase is projected for 2010 when compared to the level of CO_2 emissions in 1990. Depending on the outlook and policy measures for non-CO_2 greenhouse gases, a number of additional policy initiatives may have to be undertaken for the abatement of energy related emissions.

Using as sole criterion that of economic efficiency, the impacts that were discussed under scenarios S0, S3 and S6 were based on what would be cost effective irrespectively of any national or industrial political considerations. Under the three scenarios CO_2 emissions would decline by between 222 and 406 Mt of CO_2 from their baseline level in 2010. Whether these reductions are sufficient for the EU to meet its target will clearly depend on what measures are taken for emissions reductions from non-energy sectors.

The sensitivity analysis that was carried out earlier showed that a number of measures, other than the imposition of a global restriction on CO_2 emissions, can also be effective. However, many of these affect mostly the period beyond 2010. The one significant effect examined that is relevant for the Kyoto period is the potential contribution to emissions reduction from improvements in the efficiency of transportation. It was seen that the implementation of the 1998 voluntary agreement between the EU and the auto manufacturers association could result in more than 80 Mt of CO_2 reduction by 2010, a very significant contribution.

The decrease of demand for energy, the fuel mix shifts towards gas and the changes in power and steam generation in favour of non-fossil fuels, contribute to considerable reductions of the emission of acid rain pollutants, under the three additional scenarios examined.

One of the major conclusions to emerge from this volume is the crucial role that the electricity and steam generation may be called to play in reducing emissions. It is important to recall that the reduction in emissions from the sector are not only due to market forces, such as the relative price of gas and coal, but also to a number of other factors many of which are influenced by policy. These include any non-fossil fuel obligations, subsidies for renewables (or other measures in support of renewables), difficulties of insurance for nuclear plants, fair tariffs for co-generation, R&D support for promising generation technologies etc. Thus, the task of the regulator becomes even more important in monitoring and ensuring the implementation of a number of potential policy initiatives related to the sector. Orchestrating this role may prove quite difficult in the circumstances of liberalised, mostly privately owned and competitive markets.

EU long-term security of supply improves for the EU under the carbon constraint scenarios, as well as under the nuclear and high price sensitivities, but it remains a potential concern.

The imposition of carbon constraints does indeed lead to a further penetration of renewables. This is due to their relative price becoming more attractive once fossil fuels have to carry the cost implied by the carbon value. However, their share in total primary energy remains below 8.4% even under the S6 scenario for 2020. In general, the current EU target for renewables seems very difficult to reach. The cost gap between renewables and fossil fuels remains large even by the end of the projection period. The reductions in the costs of renewables needs to be much more substantial than those suggested by the alternative scenarios examined here. Alternatively, technological progress must be much more rapid than assumed here.