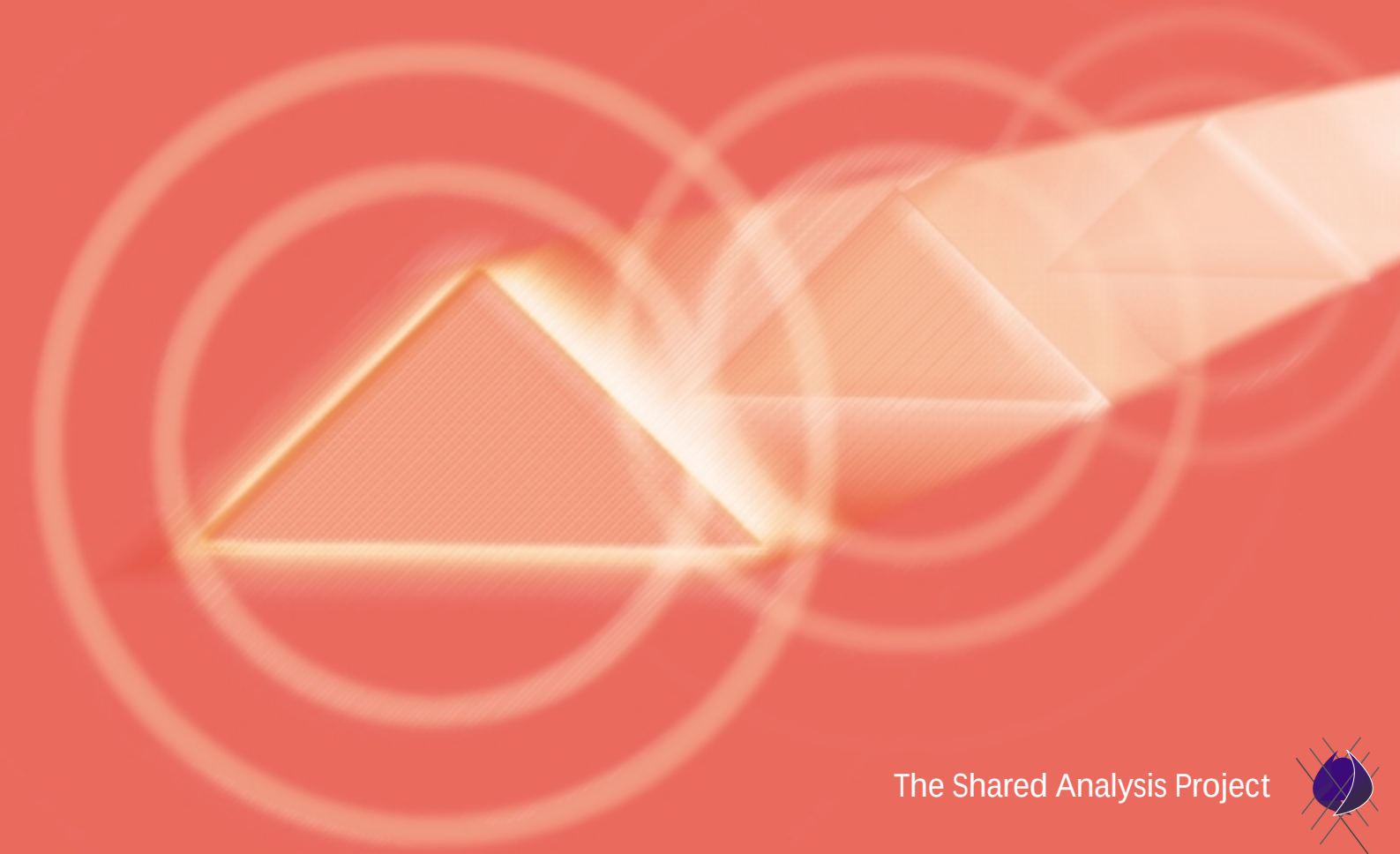
DIRECTORATE - GENERAL FOR ENERGY

ENERGY IN EUROPE

ECONOMIC FOUNDATIONS FOR ENERGY POLICY

SPECIAL ISSUE - DECEMBER 1999



The Shared Analysis Project

EUROPEAN COMMISSION

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/a	per annum, per year
bcm	Billion cubic metres (10^9 cubic metres)
boe	Barrel of oil equivalent
C	Carbon
CEEC	Central and Eastern European Countries
CH_4	Methane
CHP	Combined heat and power generation
CO_2	Carbon dioxide
COP	Conference of the Parties to the UNFCCC
EC	European Commission
EU	European Union (EU-15 : EU with current 15 Member States)
FSU	Former Soviet Union
GDP	Gross Domestic Product
GW	GigaWatt, or 10^9 Watt
HFCs	Hydro-fluorocarbons
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquid Natural Gas
M€	Million Euro
kWh	Kilowatt-hour
Mt	Million metric tonnes
Mtoe	Million toe
N_2O	Nitrous oxide
NO_X	Sum of NO (nitric oxide) and NO_2 (nitrogen oxide)
OECD	Organisation for Economic Co-operation and Development (excluding Hungary, Czech Republic and Poland)
OPEC	Organisation of Oil producing and Exporting Countries
PFCs	Per-fluorocarbons
ppp	Purchasing Power Parities
SF6	sulphur hexa-fluoride
SO_2	Sulphur dioxide
t	Metric tonne, or 1000 kilograms
toe	Tonne of oil equivalent (41.86 GJ)
TWh	Terawatt-hours (10^{12} Watt-hours)
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

ENERGY POLICY OBJECTIVES

(1) The Amsterdam Treaty of 1997 established the requirement for Community policy to *contribute to sustainable development*. Achieving sustainable development in its different dimensions – economic, environmental, social and geopolitical – is a complex and long-term process. Energy policy contributes to it by adapting its three core objectives to reflect the requirements of sustainable development:

- *security of supply* - which aims to minimise risks and impacts of possible supply disruption on the EU economy and society;
- *competitive energy systems* - to ensure low cost energy for producers and consumers to contribute to industrial competitiveness and wider social policy objectives;
- *environmental protection* - which is integrated in both energy production and energy use to maintain ecological and geophysical balances in nature.

(2) To assist in designing a policy which is supportive of sustainable development in the Community and also meets the challenges of the future, the European Commission is utilising its own and other *analytical and modelling capabilities* to provide rigorous evaluation of major EU and global trends and their policy implications. With this objective in mind, the European Commission funded the Shared Analysis Project. This commenced in January 1998 and was intended to provide a common framework of energy analysis involving experts from all Member States, as well as from academic institutes, industry and Non Governmental Organisations (NGOs). The Shared Analysis Project analysed *generic EU-wide issues* at the heart of energy policy for the Community and its Member States with the aim of assisting both Commission services and various other stakeholders.

(3) The Shared Analysis Project concentrated on several specific core issues:

- future world energy demand - focusing particularly on the emerging countries in Asia and Latin America; and energy supply, especially as regards longer-term oil and natural gas availabilities and prices;
- the progress and implications of liberalisation of electricity and gas supply on the EU energy system and the wider economy;
- strategic policy responses to the Kyoto Protocol, taking into consideration energy- and non-energy-related greenhouse gas emissions and the possibility of trade in emission certificates among industrialised countries (Annex B countries);
- the opportunities for technological innovation in the energy conversion and end-use sectors which is likely to occur; or which might be accelerated by policy initiatives over the next two decades; and
- the specific and value added role of the Community's energy policy in supporting Member States' own policies.

(4) The underpinning analysis in this project has based its conclusions on quantitative energy demand and supply projections at the global and EU level and on extensive policy analyses conducted by the member institutes of the research consortium. The analysis was enriched by two symposia which drew upon the analytical results provided by experts drawn from leading energy suppliers, technology producers and NGOs.

ENERGY MARKET TRENDS

(5) *The analysis of the 1990s* concludes that the energy system of the Community has developed positively as regards both the objectives of energy policy and the goal of more sustainable development. In particular:

- The EU's energy import dependence has remained slightly below 50 %, due to technological progress in oil and gas production; supply diversity has increased due to larger oil and gas imports from CIS countries and Norway, growing coal imports from other countries, and to increased use of nuclear and renewable energies in the Community over the past decade.
- Energy use per capita has stagnated at 3.8 toe/cap, despite declining real energy prices since the mid-1980s and economic growth of 25 % during this period. This 'decoupling' of energy use and economic development was primarily due to improved energy efficiency in all sectors and to structural changes towards services and less energy-intensive production in manufacturing.
- Finally, energy-related emissions of sulphur dioxide, hydro-carbons and nitrogen oxides have been substantially reduced; while energy-related CO_2 emissions have been kept almost constant at their 1990 level.

Thus, history may consider the past decade as the *"Golden 1990s" of the EU energy system* for two reasons: a successful outcome of energy policy, in particular with regard to the internal market and the liberalisation of electricity and gas supply; and the coincidence of other factors such as the closer co-operation with the countries in economic transition, and major technological advances in energy production, energy conversion and end-use efficiency.

CHALLENGES

However, the results of this Shared Analysis Project suggest a possible turnaround in many of these favourable trends leading to a new set of significant challenges:

ENERGY DEPENDENCE AND DIVERSITY OF SUPPLY

(6) World total primary energy consumption is likely to increase by around 2 % per year in the period of 2000-2010 and by slightly more thereafter (see Chapter 4.1). World *dependence on fossil fuels is expected to remain at high levels* - close to 90 % by 2020 with the following major trends foreseen for resource use and availability:

- Global crude oil production is likely to be re-concentrated upon the Middle East, rising from 32 % at present to over 42 % by 2010 and thereafter.
- In the North Sea, crude oil production is likely to decline progressively, leading to a higher dependence of around 85 % on oil imports in 2020.
- The rapid projected growth of natural gas demand in the EU (+ 28 % between 2000 and 2020) also increases import dependence, from some 40 % at present to more than two thirds by 2020.
- Although solid fuel use may fluctuate at around present levels over the next two decades, coal imports could well increase by some 50 Mtoe due to declining domestic hard coal production in a few Member States.
- The additional contribution of renewables to overall EU primary energy supply is likely to be small (around +30 Mtoe in 2020 compared to 1995).
- The nuclear contribution in 2020 is expected to be somewhat lower than today as result of progressive decommissioning of the older power plants.

COMPETITIVE ENERGY PRICES

(7) Global energy markets are likely to remain well supplied at relatively modest costs throughout the projection period and thus to convey the impression of a world of low energy prices. Crude oil prices (at the EU border) by 2020 are projected to be around 20 to 25 $\$_{90}$/barrel. Natural gas prices in Europe are estimated to rise somewhat faster. The price of hard coal imported into the EU is projected to remain relatively stable at around 45 $\$_{90}$/tonne. These projected, relatively low, prices of fossil fuels will strengthen their competitive position in global energy markets over the next 10-20 years and also that of the related fossil fuel conversion technologies.

Box 1: European Energy Outlook to 2020 – the Baseline Scenario

Key assumptions: EU population of the present 15 Member States increases by 12 million people until 2010 and stabilises thereafter. The world economy is expected to grow slightly above 3 % annually throughout the projection period to 2020, whereas EU economic growth is assumed to develop linearly over time by around 430 EURO per capita per year, i.e. 2.4 %/a until 2010 and 1.8 %/a thereafter.

The main *policy assumptions* of the Baseline Scenario are: for further integration and liberalisation of electricity and gas supply in the EU; further efficiency improvement in the end-use and conversion sectors; the continuation of support for renewables, co-generation, and natural gas supply infrastructure; the extension of the life time of nuclear power plants to 40 years; and stringent regulation of acid rain emissions. However, the Baseline Scenario does not include any new policies which specifically address the climate change issue.

EU primary energy demand is expected to continue to grow throughout the outlook period: close to 1 % per year over the period to 2010 and 0.4 % per year thereafter. The EU energy system remains dominated by fossil fuels over the next 20 years; their share rises marginally from their level of just under 80 % in 1995. The use of solid fuels is expected to continue falling to 2010. Natural gas is by far the fastest growing primary fuel. Its share in primary energy consumption increases to 26 % by 2010, but stabilises thereafter. The share of oil in primary consumption remains relatively stable at 41 %.

Economic implications: Due to efficiency and productivity gains throughout the energy system, the cost of energy to the consumer stabilises or even decreases. Facilitated by liberalisation, the average electricity price is projected to decrease in 2010-2020 by 15 % below the current level. The share of energy costs in total production costs (for companies) or in total income (for private and public households) continuously decreases.

Environmental trends: The rising share of fossil fuels is likely to increase CO_2 emissions by an average of 0.6 %/a in the period 1995-2020. The transport sector contributes nearly two thirds to the total increase until 2010 (+220 million t CO_2). Beyond 2010, electricity and steam generation are projected to contribute most to the increase in CO_2 emissions. The Baseline Scenario suggests that, in 2010, CO_2 emissions are expected to exceed the 1990 level by 7 %. But conventional emissions of sulphur dioxide, nitrogen oxides and hydrocarbons of the energy system, from power generation in particular, are expected to decline rapidly over the whole period.

TABLE 1: PRIMARY ENERGY DEMAND, ENERGY DEPENDENCE AND CO_2 EMISSIONS OF EU-15, BASELINE SCENARIO 1995 TO 2020

	Mtoe				Annual growth rates (%)			Shares (%)		
	1990	1995	2010	2020	1995/ 2010	2010/ 2020	1995/ 2020	1995	2010	2020
Total	**1,318**	**1,368**	**1,556**	**1,612**	**0.9**	**0.4**	**0.7**	**100.0**	**100.0**	**100.0**
Solid fuels	302	238	182	218	-1.8	1.8	-0.3	17.4	11.7	13.5
Liquid fuels	545	578	655	663	0.8	0.1	0.5	42.2	42.1	41.1
Natural gas	222	274	401	431	2.6	0.7	1.8	20.0	25.8	26.7
Nuclear	181	205	227	199	0.7	-1.3	-0.1	15.0	14.6	12.3
Electricity	2	1	2	3	2.7	1.2	2.1	0.1	0.1	0.2
Renewable energy sources	64	72	88	100	1.4	1.2	1.3	5.3	5.7	6.2
Energy import dependence (%)	47.7	46.5	55.0	63.4						
CO_2 emissions (Mt)	3,079	3,037	3,298	3,508	0.6	0.6	0.6			

(8) The *impacts of liberalisation* of electricity supply are now becoming clearer and some issues may need further attention:

- Increasing productivity of the electricity generation and distribution system has been observed, in particular in all early or fast liberalising Member Countries.
- As a consequence of initial liberalisation, electricity prices have been declining, increasing the competitiveness of the energy-intensive firms and reducing energy bills of households. Observed price reductions indicate, however, that (large) industry and companies in the tertiary sector are more likely to be able to reap the advantages of liberalisation.
- Reduced electricity price differentials among Member Countries can be observed.
- Specific environmental emissions from electricity generation are likely to decrease faster due to improved fuel conversion efficiencies in new and refurbished power stations; this is particularly supported by the huge observed, and expected, investments in combined cycle gas turbines (CCGT).
- Lower electricity prices may, however, reduce the economic incentives for greater end-use electricity efficiency, particularly by large users. But efficiency increases at the plant level through energy service contracting by utilities (as part of their efforts to hold on to important customers) or by other players may offset some of the efficiency losses caused by lower electricity prices in industry.
- The larger use of gas in power generation, whether within combined cycle systems or not, substituting for coal, has a positive effect for climate change policy.

(9) Similar impacts can be expected from the *liberalisation of the gas market* in the Community, although these will differ between Member Countries. This is because the extent of the natural gas provision varies across the EU-15 (accounting 49 % of primary energy use in the Netherlands, but still close to zero in Portugal; with an EU average of 22 %). During the implementation period of the EU Gas Directive over the next few years, it is very likely that most large gas consumers will benefit from the liberalised EU gas markets and the fierce upstream competition between large gas producers/suppliers.

(10) *Traditional trade of gas* via the transmission pipeline networks may decline and be substituted by swap deals and other "paper trade", thereby reducing the transmission costs for consumers, as these and other auxiliary costs (storage, quality) become relatively more important in a fully competitive market.

(11) For consumer services in electricity and gas market, facing more competition at the distribution level, one can expect increasing 'product differentiation'. Recent mergers of utilities indicate a trend towards multi-utilities and *energy service companies* offering service packages consisting of heating, cooling, compressed air, steam heat, water and cable services to consumers. Different electricity and gas tariffs, (or even district heat tariffs) will be offered, depending on energy inputs for electricity or heat generation (e.g. 'green tariffs'), the quality of electricity or gas delivered (e.g. contract provisions for supply interruption), the time of use and other aspects.

ENVIRONMENTAL TRENDS

(12) Conventional emissions of sulphur dioxide (SO_2), nitrogen oxides and hydro-carbons from EU energy use (and from power generation in particular) are expected to decline quite rapidly until 2020, due to the continuing impacts of environmental legislation in road transport, power generation and other stationary sources; but also due to improved energy efficiency in all end-use and conversion sectors.

(13) *Global emissions of CO_2*, however, are projected to grow quite rapidly (on average by 2.1 %/a). For the period 1995 to 2020, China and India - with high economic growth and populations over 1 billion - each account for almost 40 % of the increase in CO_2 emissions. The commitments made by the EU and its Member Countries in the Kyoto Protocol, to reduce total greenhouse gas emissions by 8 % in 2008 to 2012 relative to the year 1990, is a specific challenge for energy policy as some 80 % of the EU's total greenhouse gas emissions originate from energy use.

(14) Much of the increase in the Community's energy-related greenhouse gas emissions is expected to arise from *road and air transportation*. Thus improving the efficiency of the European transport system is a major challenge given the growing demand for mobility, decreasing car occupancy levels and consumer preferences for more powerful cars. To avoid increasing CO_2 emissions from power generation, *more efficient production and use of electricity* will also be a major challenge, given decreasing electricity prices due to the liberalisation of electricity supply. The imposition of carbon constraints could lead to further penetration of most of the renewables, but at a rather slow rate.

(15) As regards the commitments of the *Kyoto Protocol*, the analysis of the current initiatives and policy actions of Member States concludes that the emissions of the two major non-energy related greenhouse gases, methane and N_2O, could be reduced by about 18 % by 2010. This expected decline would decrease the necessary reduction target for *energy-related CO_2 emissions* from the –8 % of the greenhouse gas basket to *approximately* –5 % (i. e. 180 Mio t) relative to their 1990 level. As energy-related CO_2 emissions almost stagnated during the 1990s, the Community may have a good chance to meet the present Kyoto targets by realising the potentials for methane and N_2O reductions, and by intensified energy policies at the EU and national level. Purchases of emission permits would have a supplementary role.

Box 2: Projected emission reduction variants of the Baseline Scenario

The Baseline Scenario highlights that, without specific climate change policies, it would be unlikely that the EU will meet its Kyoto commitments. Under the assumptions made, the analysis expects a 7 % increase of energy-related CO_2 emissions for 2010 relative to their 1990 level. Given the greenhouse gas reduction potentials outside the energy sector a scenario was calculated representing a CO_2 emission reduction of 6 % of the 1990 level or around 400 million tonnes compared to the unrestricted Baseline emissions in 2010.

Nearly half of the 6 % reduction is achieved through improved efficiency; the other half is due to the intensified use of less carbon-intensive fuels and renewables. The power and steam generation system appears to be the sector that can adjust in the most cost-effective way to the required CO_2 emission reductions, as it contributes almost 60 % of the required decline in 2010.

The direct total costs of achieving the 6 % CO_2 reduction from the energy system depend on many factors and their dynamics in the next decade. The direct total costs have been investigated in the Report and are discussed extensively in Chapter 5. Additional indirect costs have not been analysed, neither have the ancillary benefits from avoided environmental and social costs, or from reduced energy dependence and employment effects.

(16) These challenges of the next 10 years are also very likely to prevail over the period between 2010 and 2020, when major strategic decisions have to be made particularly *in power generation and transportation* to support further sustainable development in the Community. A high degree of flexibility of the EU energy system and the Community's energy policy may be essential to meet these identified and future challenges.

THE ENERGY POLICY AGENDA

(17) Due to the expected substantial changes in both world energy markets and within the Community, and the related challenges within the next decade (see also Figure 1), energy policy in the EU and its Member States is likely to have to undergo a further period of learning and searching to be able to react adequately to the possible new challenges. The uncertainties remain great; and thus maintaining flexibility to respond to them is judged essential.

- As regards *short term measures*, within the next 2-3 years, energy policy has to bear in mind the long-term re-investment cycles, slowly changing consumer behaviour and the time necessary for policy debate and decisions which inevitably limit the speed of change of the EU energy system.
- As regards *medium- and long-term measures* for the next decade and beyond, the next few years are needed for further research, discussions with stakeholders and preparation of any further policy changes judged necessary.

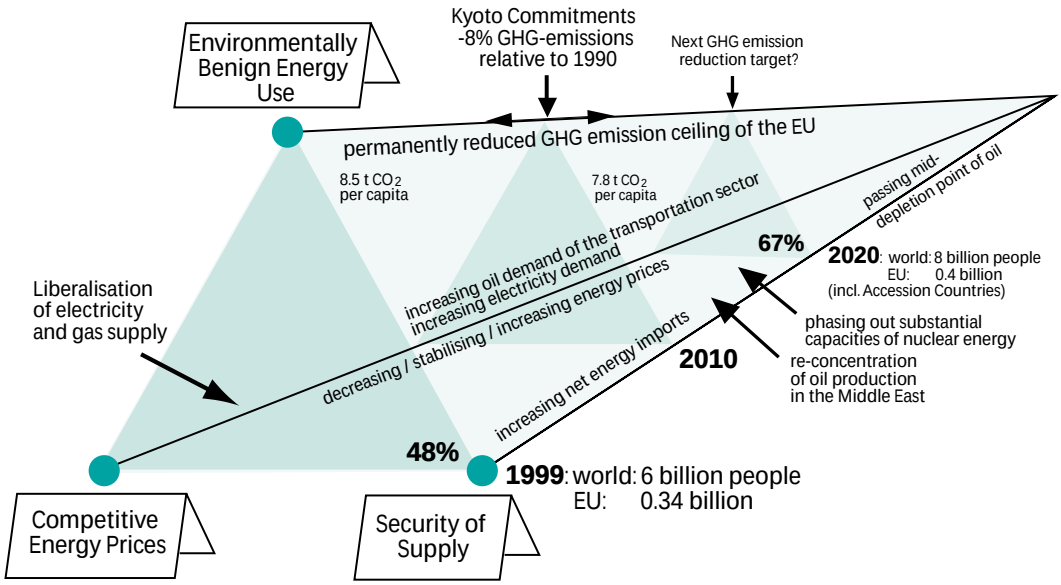

FIGURE 1: THE THREE OBJECTIVES AND NEW CHALLENGES OF ENERGY POLICY IN THE NEXT TWO DECADES

Given the challenges and related policy issues, the following key conclusions for the future policy agenda can be drawn from the results of the Shared Analysis Project:

EXTERNAL DIMENSION

(18) The analysis suggests that the EU may have to fulfil an important role in international diplomacy in the energy field with regard to:

- *energy exporters* - to secure crude oil and natural gas supplies for the EU by economic and political co-operation; reducing the potential for political instabilities; negotiations under the auspices of the Energy Charter may continue to conclude a multilateral Transit Framework to reduce the risks of physical disruptions to pipeline supplies;
- *the integration of the Accession States* - this may call for specific efforts to harmonise regulations and taxation, support for faster technological development through joint ventures, and other means of technology and know how transfer;
- *global environmental negotiations* - in particular, further negotiations will be needed to ensure that emerging Member States' experience with emission trading is compatible both with wider EU and global emissions trading regimes.

INTEGRATION

(19) The results of the analysis suggest that least-cost solutions to policy conflicts and trade-offs are unlikely to be found in the energy sector alone, but rather in the wider energy system including energy end-uses, related energy services and the underlying driving factors in final demand sectors. This means that the energy policy of the Community should perhaps pursue a *broader political approach in the next decade* than in the past by:

- ensuring that the transport sector is placed much more fully at the heart of EU energy policy, as road and air transport are likely to be the major single contributors (35 % to 55 %) to incremental growth in overall EU final energy demand (particularly dependent on oil supply) and in CO_2 emissions until 2020;
- *co-ordinating and harmonising national approaches to utility regulation* to ensure the success of liberalised energy markets by securing non-discriminatory access to the entire network and its auxiliary functions, and the protection of consumers;
- ensuring that energy policy making in future gives *due weight to energy efficiency*, by harmonising energy efficiency regulation (e. g. technical standards, labelling and voluntary agreements for mass-produced and traded appliances, such as vehicles, boilers, burners and electric motors);
- harmonising national energy taxes to ensure level playing fields; and the longer-term objectives of greater contributions to energy supply by renewables;
- broadening and *intensifying the dialogue* and co-operation among Member States, institutions, stakeholders, and the media.

CLIMATE CHANGE POLICY

(20) There are good reasons for concluding that climate change may require a *more* vigorous policy stance:

- Policy should seek to identify, and seek to implement, the *least-cost reduction potentials of other greenhouse gases*, e.g. methane in coal mining and landfills, or for N_2O from adipic acid production in the Community.

- There may also be a need for new initiatives, as the analysis suggests that the cost of CO_2 emissions reduction according to the Burden Sharing agreement differs substantially across EU Member States.
- To achieve the objectives of the Climate Convention, meaningful developing country participation will be necessary. This should start rather sooner than later, especially with high income OECD countries not yet included amongst the group of Annex B countries..

The *dynamics of climate change policy* deserve major attention. Long-term re-investment cycles of buildings, infrastructure like railways, power plants and transmission lines or district heat networks and of some basic industrial processes suggest the need for careful policy analysis and intensive dialogue with all stakeholders to avoid stranded costs, inflexibility of climate change policy or the need for purchasing emission certificates. *Power and steam generation* seem to be technological areas that can adjust in the most cost-effective way to meet initial emission constraints given their fuel switching options, increased cogeneration and further efficiency improvements. As the emission constraints are expected to tighten beyond 2010, much improved energy efficiency in all end-use sectors is also required.

CO-ORDINATION OF ENERGY POLICIES AT THE EU AND MEMBER STATE LEVEL

(21) The *principle of subsidiarity* remains of great importance in many EU Member States. However, its application to energy policy issues may now give rise to different perspectives in view of the requirements of the Single Market, liberalisation of EU electricity and gas markets, the growing cross border ownership and merging of energy companies, and the agreed EU response to global climate change.

- Much nationally-funded R&D loses its rationale in the context of the Single Market and of global players in appliance and equipment markets. Super-national R&D funding becomes increasingly important regarding energy production and conversion technologies, but also for energy efficiency of mass-produced and traded appliances, products and equipment where technical standards and labelling at EU level increasingly play a major role;
- Growing import dependence reinforces the need to re-assess the steps importing countries might consider to strengthen security of supply.

Box 3: The role of energy technologies, R&D and innovation policies

High economic potentials for improved energy efficiency are available in power generation (around 10 percentage points up to 2020) and in almost all end-use sectors (mostly 20 to 30 % in relation to today's average specific energy use). Technological analyses show that *additional efficiency potentials* can be economically realised if research and development is sufficiently directed to new promising technologies in end-use sectors (e.g. low energy buildings, more efficient cars, wide application of inexpensive sensors and control techniques including remote control, nanotechnology and biotechnology, membrane and absorption technology).

More efficient technologies in energy conversion and the end-use sectors not only strengthen the *competitiveness of energy-intensive industries*, but also represent growing world-wide markets for exports by European technology producers and, hence, contribute to additional employment in the EU.

The option of *"clean" fossil fuels* by converting them into hydrogen and CO_2 is potentially a very promising technological option in the longer term. The CO_2 produced could be sequestered in aquifers, depleted gas fields or used for tertiary recovery methods in oil production. All elements of this technological option, the gasification, hydrogen storage, its transport and use, as well as the sequestration of CO_2 in exploited gas fields are well-known elements of such a system which has huge potential for technical improvements and cost reductions.

The long-term scope for increasing conversion efficiencies of *renewables* and – more importantly – of reducing their production costs by learning effects and economies of scale is underestimated by some stakeholders at present. However, the necessary R&D and energy policy instruments need much more specific assessment of the different types of renewables, their different applications and possible niche markets.

ENERGY TECHNOLOGY

(22) Falling electricity and gas prices in the next decade due to liberalisation and technical progress and related implications may lead to a conflict of objectives, i.e. natural gas dependence may further increase and CO_2 emission reduction targets may have to be achieved with more and costly efforts. Therefore, technical progress in the energy system with regard to efficient energy use, renewables and other cleaner technical options are of major importance to minimise such conflicting objectives (see Box 3).

MONITORING AND ANALYSIS

(23) *Policy analysis and sharing of analyses* of economic, market, political, social and technological trends should be continued to develop consistent energy policies. Priorities include analysis which seeks to overcome possible inconsistencies and conflicts in different policy thrusts (e. g. liberalisation and competitive energy prices versus environmental protection and climate change policy; competitive energy prices versus diversity of supply, including nuclear energy, cogeneration and renewables). This analytical process should continue to involve, and to draw upon work undertaken by, technical specialists of the Member States and a wide range of stakeholders.

CONCLUDING REMARKS

(24) Given the long-term trends of increasing energy import dependence, the dynamics of the internal market and of liberalisation of the energy markets, the enlargement of the EU, concern about climate change, and the globalisation of major industries, the analysis suggests that the responsibility *of the Community in energy policy matters will gain importance*.