COMMISSION EUROPÉENNE

GREEN PAPER – TOWARDS A EUROPEAN STRATEGY FOR THE SECURITY OF ENERGY SUPPLY

TECHNICAL DOCUMENT

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I INTRODUCTION

Europe's future depends on a secure, affordable and ecologically sustainable energy supply. It is no longer adequate to assure the simple physical availability of energy sources. Supply policy needs to consider the immediate and longer-term availability of energy products at a price which is affordable to all consumers (domestic and industrial), while respecting environmental requirements and the needs for sustainability. It also needs to take into account trends in demand. Under current patterns of energy production and energy use, the European Union is consuming limited reserves at rate which compromises the availability of energy to future generations and threatens the local and global environment. This document analyses the background to this assertion and anticipates the Commission's Green Paper on Energy Supply Security.

For the European Union (EU), energy supply has *an internal dimension and an external dimension*. Internally, Europe needs to balance supply and demand, while respecting environmental, consumer, safety, political and economic demands. Externally, adequate and suitable supplies must be available to fill the gap between domestic production and domestic needs. The objective of independence from external energy suppliers has been replaced by the objective of managing external dependence.

European energy supply faces different forms of risk. Physically, *short term* disruption and *longer term*, perhaps permanent, interruption to supplies of one source or another, or from single geographical area. Economically, Europe is susceptible to changes in energy prices – such as the recent rises in the oil price. Finally, environmental pressures are beginning to bear on energy production and use and, ultimately, on supply decisions.

Energy supply has been a political priority for the EU since its inception. The foundations of European integration were treaties based on energy considerations (the European Coal and Steel Community and the European Atomic Energy Community, or Euratom). The oil "shocks" of the 1970's illustrated the consequences to Europe's economy and society of disruptions to supplies and volatile energy prices and led to a transformation of energy markets aimed at reducing dependence on oil. The Commission's White Paper on Energy in 1995[1] confirmed the importance of a secure energy supply.

Today, the energy market has changed, but the main challenge to EU supply policy has not - *the growing dependence of the EU on imported fossil fuel sources*, with its implications for the economy, environment and international relations.

The EU is relatively poor in conventional energy reserves, as Table 1 shows. [*]
However, this fact has not affected the rise in energy demand over the previous decades and is not expected to act as a brake on consumption for the foreseeable future (see below). As a result, Europe is increasingly dependent on imports. Best available estimates show that under business-as-usual assumptions the Community's overall import dependency will rise from today's 50% to about 60 to 70% in 2020. Especially critical is the import share of oil and natural gas. Imported oil is likely to increase from 80% of total EU oil supply in 1997 to 87% in 2010. Gas imports are forecast to rise from 40% today to 66% in 2020. Growing imports are not in themselves a threat to security supply, but they highlight the importance of good trade links, communication and political relationships with external partners. A further consideration is the physical distance and existence of infrastructure between the EU and its suppliers.

[1] COM(95)682 of 20.12.1995 – An Energy Policy for the European Union
[*] in this table, as in others, figures are of the European Commission, unless otherwise stated

TABLE 1 - WORLD RESERVES* 1999

	World Reserves * Gtoe	World Production Gtoe	Reserves in years	Percentage of reserves in world regions									
				Europe	Former Soviet Union ****	Middle East	China	India	Australia	North America	Japan	Central South America	Africa
Oil	140,4	3,45	40,6	2,0%	6,3%	65,4%	2,3%	0,5%	0,3%	8,0%	0,0%	8,6%	7,2%
Natural Gas	134	2,1	66	3,5%	38,7%	33,8%	0,9%	0,4%	0,9%	5%	0,0%	4,3%	7,7%
Coal *****	984211#	2,1	156	12,4%	23,4%	0,0%	11,6%	7,6%	9,2%	26,1%	0,1%	2,2%	6,2%
Uranium**	40->2000	0,35	60->2500***	3%	29%	NA	NA	2%	20%	18%	< 1%	7%	17%

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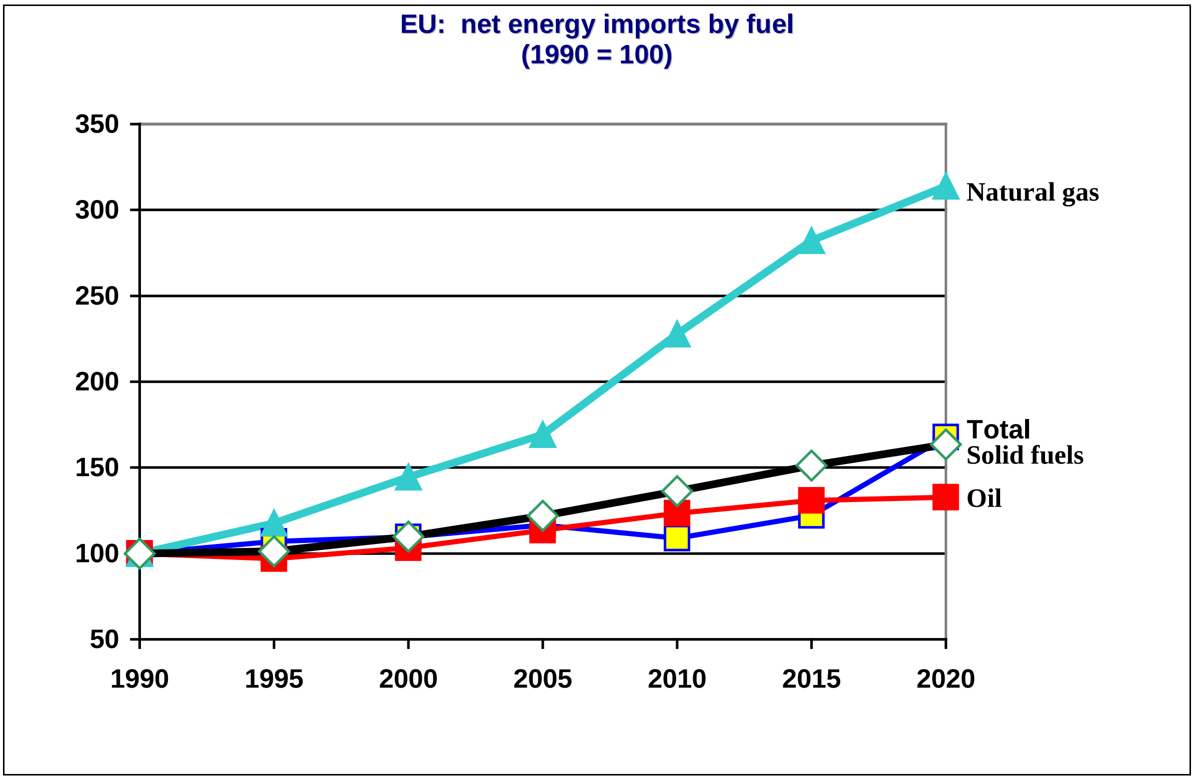
* economically recoverable
** depending on technology used; figures are for 1998
*** based on consumption of 0,65 Gtoe and not on production
**** Russia + other CIS countries
***** Including sub-bitumous and lignite.
\# million tonnes

Source : BP Amoco (excluding nuclear)

European Union: Relative development of import dependence – the direction is upwards – in all sectors



The supply security debate is coloured by the growing awareness of the *environmental impact of energy use*, both globally and locally. All forms of energy use have an impact on the environment or natural surroundings, or create additional risks in terms of transport, waste and by-products. Energy production and use, including transport, accounts for 80% of greenhouse gases. Unless current patterns of energy consumption are changed, emissions of greenhouse gases will rise. Although the immediate need for improved energy efficiency and more renewable energy to respond to climate change is generally acknowledged, (including Financial Times editorial, 21 August 2000) the dimension of effort has not yet been fully defined. This creates an uncertain framework for future energy scenarios. These concerns, together with the European *internal market for energy*, international *competition* and *globalisation* have transformed the forum for debate. *Enlargement* is another factor which could create new issues for the EU energy supply in terms of less up-to-date hardware and greater dependence on a single source (Russia).

A successful *economy* depends on a secure energy supply. The price of oil has long been a determinant of economic performance, with high oil prices associated with high inflation and high interest rates leading to higher unemployment. This situation has had drastic consequences in some third world countries, which find they are unable to pay their debt. It also undermines Europe's economic competitiveness – the oil price rises of the early 1970's took a long time to work their way out of the system, and the effect of the recent oil price rises is only starting to be felt. At the same time, economic growth always goes hand in hand with increased energy consumption. Increased energy consumption almost inevitably increases Europe's dependence on energy imports. One of the challenges for energy supply policy will be definitively to de-link economic growth and rises in energy consumption.

New technologies have changed the pattern of energy use and production since the 1970's. In particular they have drastically reduced the energy intensity of industrial and domestic activities. However, the increased demand for consumer goods has, in general, cancelled out any energy saving benefits of the new technology. For example, in transport, increasing the efficiency of cars has not reduced petrol needs because the growth in the number of cars and passenger miles has more than cancelled out any savings.

In the future, new technologies which favour renewable energy sources and energy efficiency could once again transform the supply debate. New technologies currently at the research stage, such as fuel cells and nuclear fusion, could radically change energy markets, while energy technologies based on, for example, wind, solar and biomass, could reverse the trend of growing dependence on imports.

The changing scene in the European Union is mirrored in part in the US, where recent presidential policy statements have confirmed the role of affordable and environmentally responsible energy in maintaining economic prosperity. These statements put emphasis on technical development, energy efficiency and alternative energy sources.

Europe's energy supply is not under any immediate threat of disruption. However, the physical supply of energy has increasingly to respond to sometimes conflicting economic, environmental and market pressures. Against this background, the following developments are taking place: a) energy demand is rising; b) demand for conventional energy sources is rising, c) demand for imported energy sources is also rising and d) at least in the short term, without targeted measures cleaner, more efficient and renewable energy technologies are unlikely to greatly influence these trends. The first challenge for energy supply policy is not to deny or over-dramatise this, but to manage this situation and prevent it developing into a crisis. The second challenge is to balance the needs of energy supply policy with political, environmental, social, technical and economic objectives. The third challenge is to develop instruments, such as renewable and non emitting energy technologies and energy efficient practices, which will reduce energy demand and dependence on imported fuels, remove the connection between economic growth and energy consumption, improve diversification of energy sources and thus improve energy security in the long term.

II CONTEXT

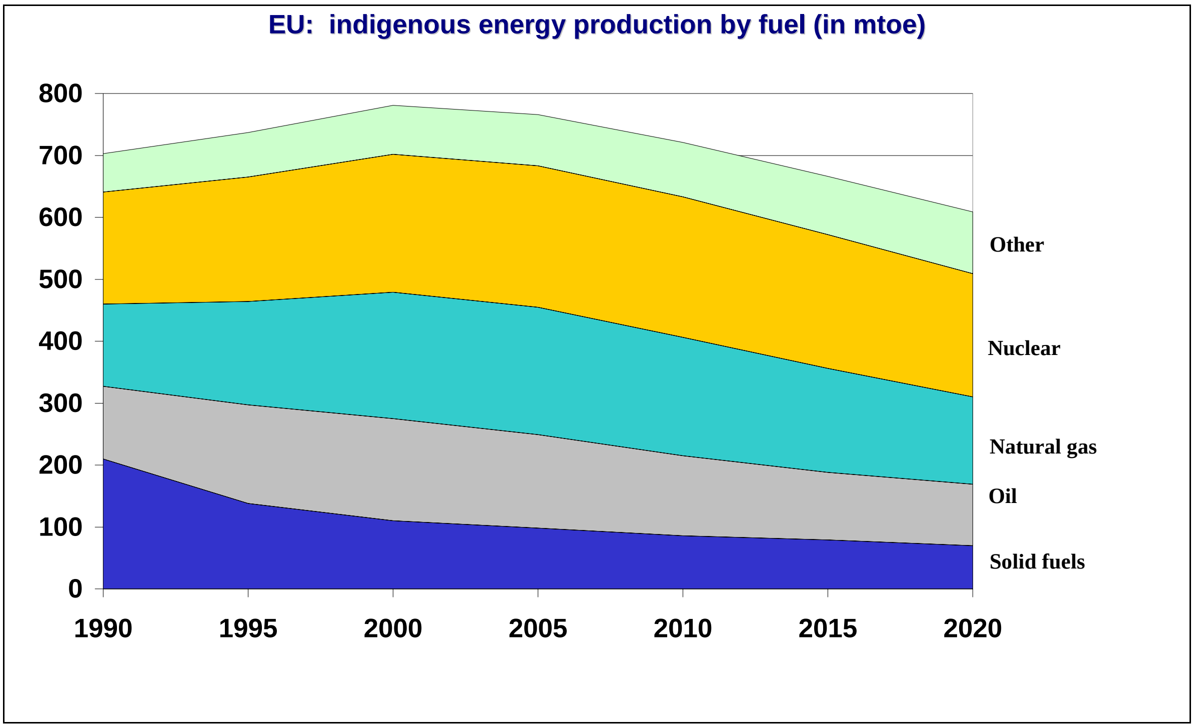
Security of supply cannot be considered in a vacuum. It is closely related to policy on sustainable development, economic factors, other energy market developments as well as socio-economic trends (e.g. transport, information technology etc) and the ultimate shape of the European Union. This section will consider each of these considerations in turn.

a) Enlargement

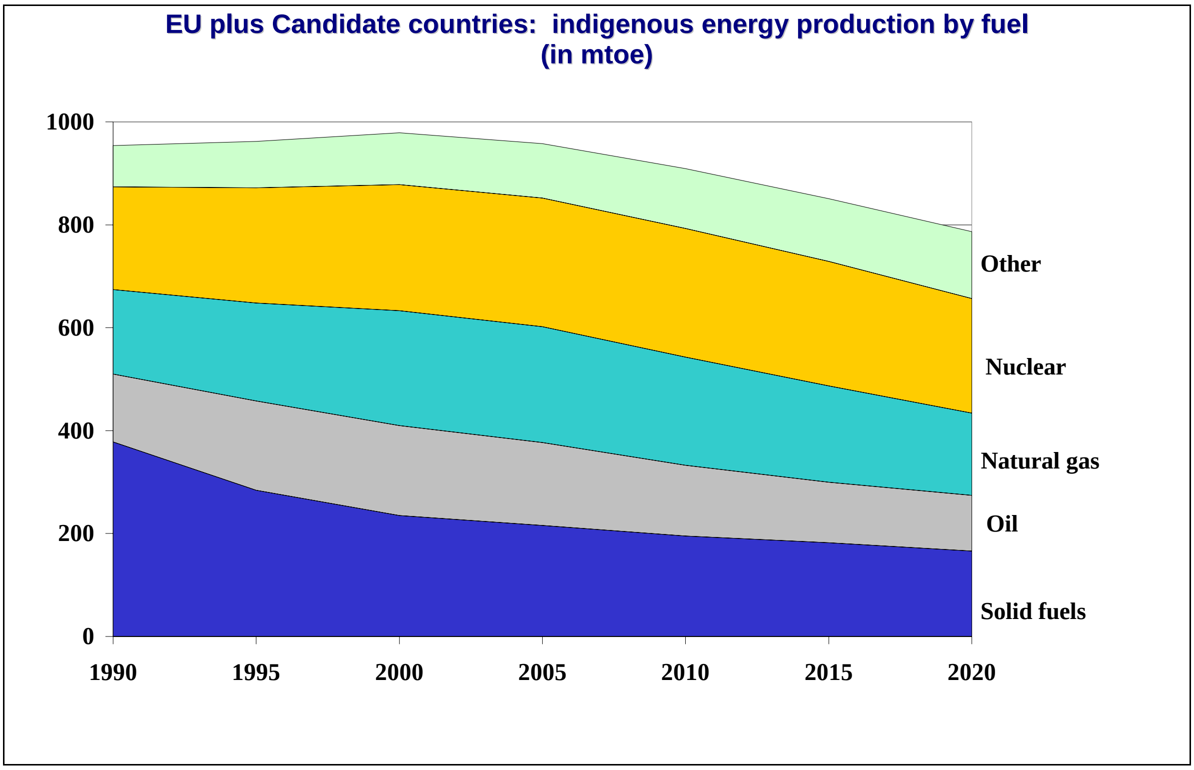
The accession of a number of Central and Eastern European states to the EU is likely to confirm the current trends in energy provision and use (see graphs below). In general, accession countries[2] have a similar balance of energy supply and demand. However, there are differences in the operating environment, such as the age and technical performance of infrastructure and plant, including nuclear. Enlargement will bring additional factors to play in the supply security debate. For example, import dependence on mostly one source – Russia; the dominance of solid fuels; different legal and regulatory frameworks; the predominance of state-owned, vertically-integrated monopolies; low energy efficiency; obsolete technologies and persistent technical difficulties. In particular, the threat of demand outstripping supply is increased. These considerations are impossible to quantify statistically, but they are crucial to energy supply security.

[2] This phrase is used throughout to refer to 10 Central and Eastern European Candidate Countries plus Cyprus, Malta and Turkey. Graphs refer to 10 CEE candidate countries only

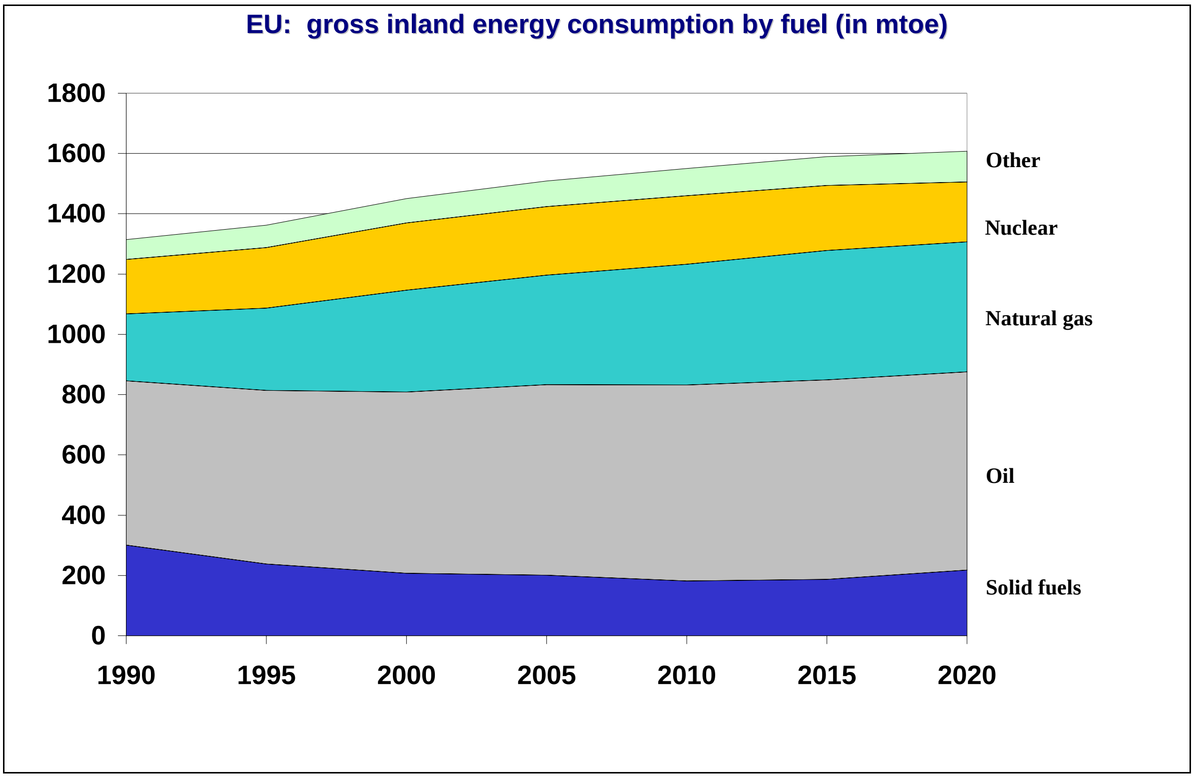
Indigenous energy production in the EU is beginning to decline…



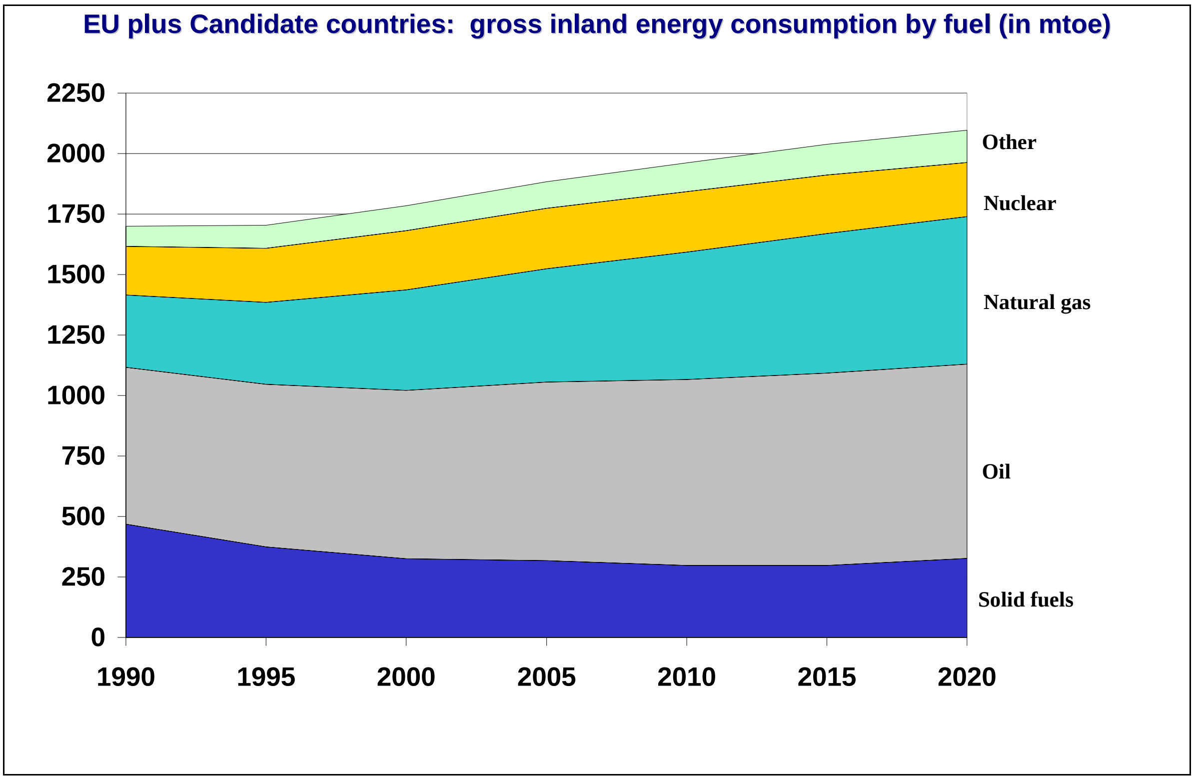
… Enlargement will not affect this trend



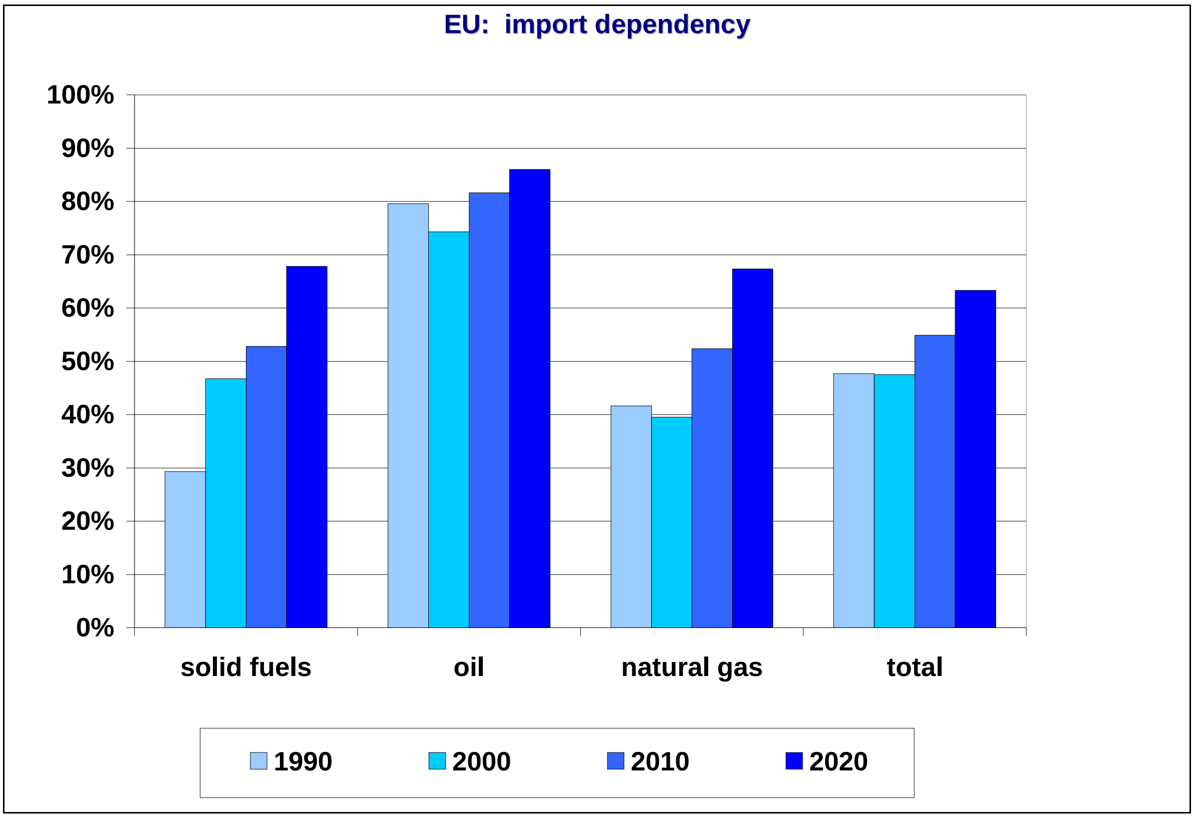
EU energy demand is rising and will continue to do so…



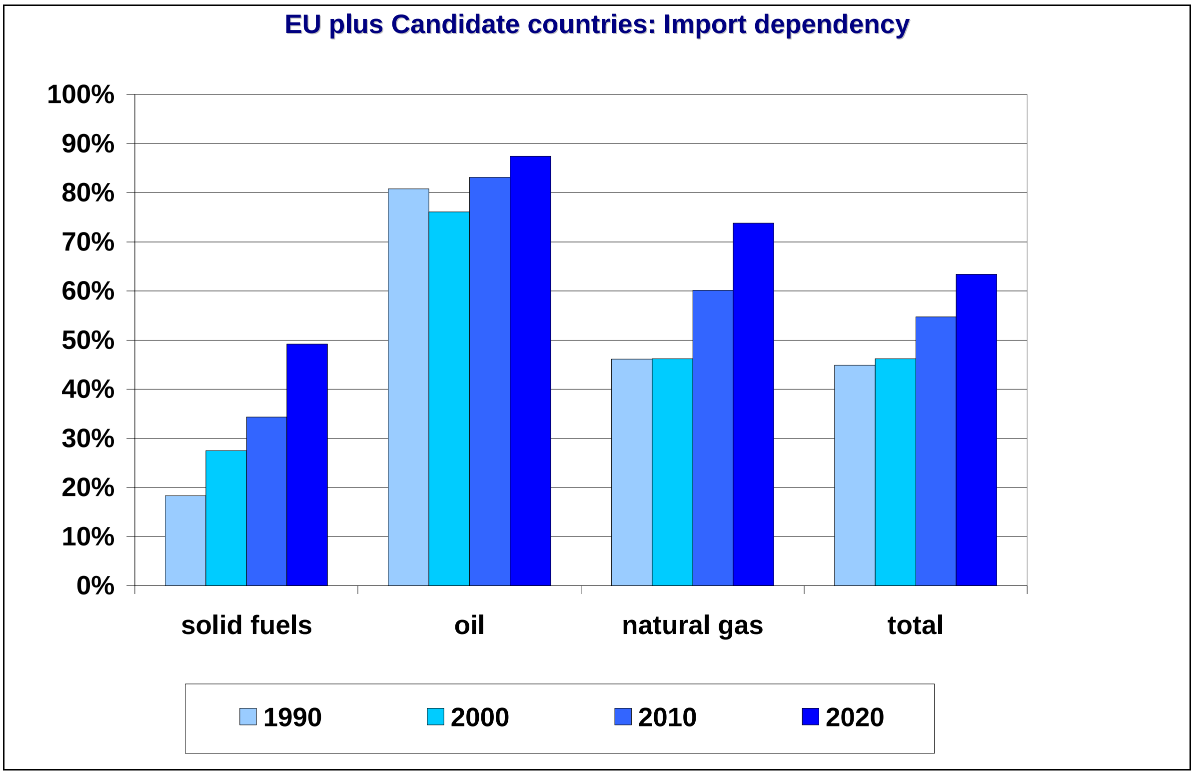
…While demand in candidate countries is forecast to rise even more quickly



The patterns for energy import dependence will be accentuated...



... Greater coal production will be outweighed by higher imports of oil and natural gas



In particular it is likely that dependence on gas among the new Member States will rise more quickly than among current Members, and that indigenous production of coal will be slashed. Both factors will aggravate import dependence, in particular from the former Soviet Union, the traditional supplier to Central and Eastern European countries. It will make the eastern part of the Union largely dependent on one supplier. Currently, apart perhaps from Russia, the systems do not exist to transport the quantities which will be required to satisfy growing demand. Links to key non-Russian suppliers are lacking. Also there is a need for missing links to be created to and within candidate countries.

TABLE 2 Missing links – gas sector

Poland – Lithuania	
Poland – Czech Republic	
Poland – Slovak Republic	
Hungary – Slovak Republic	
Hungary – Slovenia	in the framework of the VOLTA scheme, which has been put on cold storage for the time being
Hungary – Croatia – Slovenia – Italy	alternative route to the proposed VOLTA system
Romania – Bulgaria	new interconnection between the city of Tumu (Romania) and Polski Senovets (Bulgaria)
Hungary – Romania	interconnection between Salontu (Romania) to domestic grid in Hungary
Bulgaria – Macedonia	
Bulgaria – Serbia	
Romania – Serbia	
Romania – Moldova	
Slovenia – Bosnia-Herzegowina	
	Source : PHARE Study

Accession countries have a different tradition of energy pricing and taxation which results from their different history and culture. In the socialist system, energy received subsidies and the markets were based almost solely on Russian supply. Some south-east European countries are now having difficulty paying for energy supplies. In order to respect EU legislation these countries will need to take action in two areas: VAT and mineral oil taxation. Statistics from the International Energy Agency show that while private consumption is now being increasingly taxed and brought closer to the EU level, industry still seems to be widely exempted from taxation.

Enlargement will bring advantages in terms of energy supply by creating new opportunties for investment in new, energy efficient technologies, closer links with major suppliers and transit countries, economies of scale for new technologies and a larger market for renewable sources.

Finally, enlargement will change the shape of the European market. To a certain extent, the existence, since 1994 of the Energy Charter Treaty[3] has eased interplay between energy market actors in the countries concerned. Incorporation of new members into the larger European energy market will create additional interconnections and partnerships which will have implications for energy supply security. The difficulty for policy makers will be to provide, within a liberalised market, appropriate patterns of customer behaviour, corporate investment and infrastructure development in order to prevent growing consumption in the Eastern part creating new energy supply difficulties for the whole of the Union.

[3] The Energy Charter Treaty of 17 December 1994 OJ N° L 69 of 9 March 1998

Enlargement

Enlargement will broadly confirm current trends – rising consumption, growing demand for conventional fuels and increasing dependence on imports. In addition, it will bring additional factors into play as a result of industrial and fiscal restructuring, replacement of outdated plant and ageing infrastructure and new opportunities for investment in advanced technologies and alternative energies. It will also accentuate import dependence and create the need for new pipeline links and transit connections, including with the former Soviet Union.

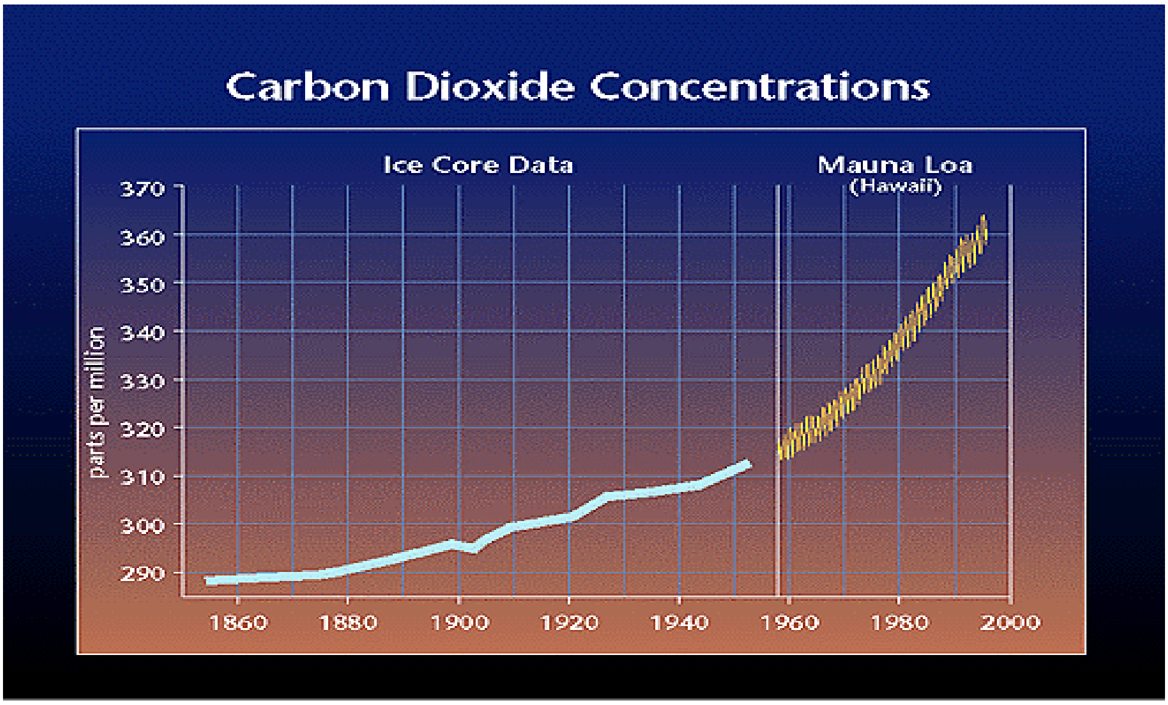
In the sections below, the issue of enlargement is brought out further when it has a particular relevance to the subject in question.

b) Environment, climate change and sustainable development

Even before climate change became an issue, the link between energy production and use and environmental damage had been proven. All energy production has some impact on the environment. Climate change concerns have made the environment and sustainable development key components of the supply security debate. In the long term a secure supply of energy depends on respecting the principle of sustainable development.

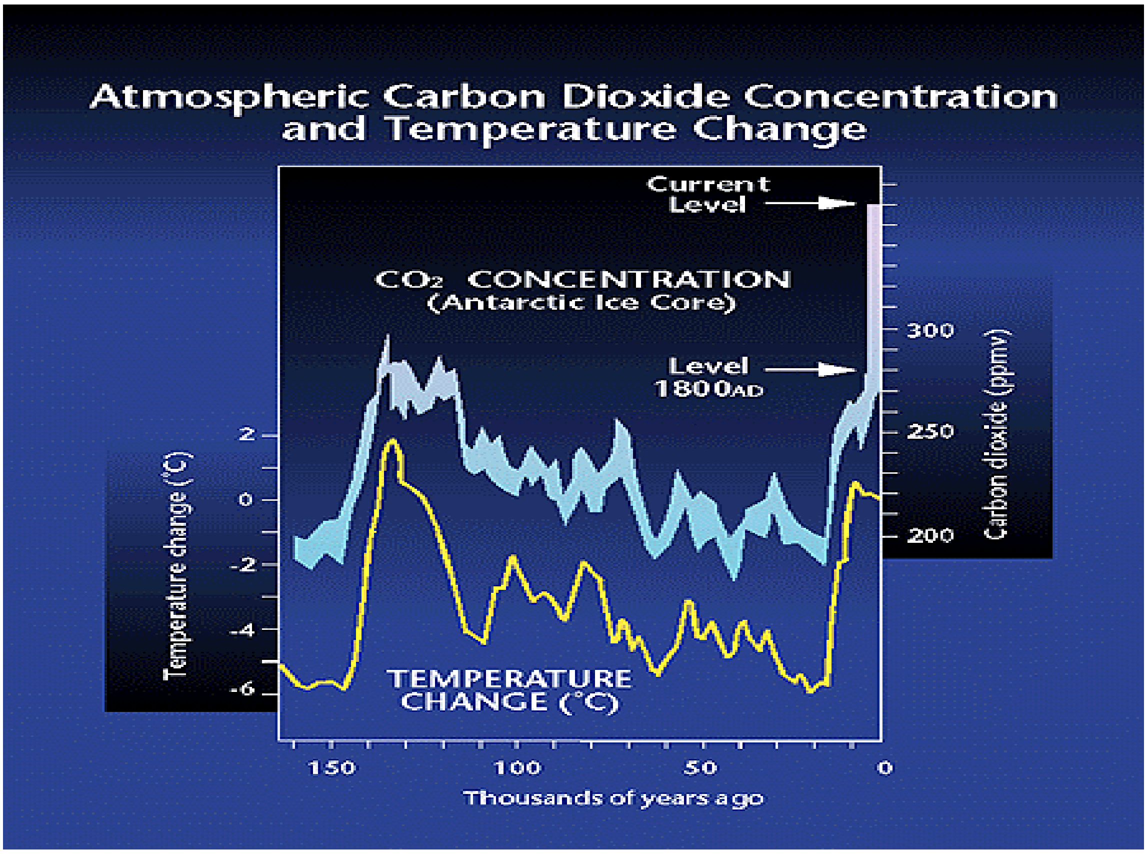
It is now clear that energy, primarily fossil fuel use, is a major cause of increasing CO2 emissions, the principle greenhouse gas, and thus probably a primary contributor to climate change. Industrialisation and population growth have greatly increased emissions of CO2 from human activity over the last 100 years and the trend is rising: burning oil, coal and natural gas releases about 6 billion tons of carbon into the atmosphere each year world-wide. The result is that the atmospheric level of CO2, the most important human-derived greenhouse gas, has increased by 30%, from 280 to 360 parts per million (ppm) since 1860. Indeed, if current emissions continue over the next century, concentrations will rise to levels not seen on the planet for 50 million years.

The rise in carbon dioxide concentrations is accelerating…



Source – Radiative Forcing of Climate change, WMO 94/694 Fig 2

… Higher carbon dioxide concentrations have accompanied higher global temperatures for hundreds of thousands of years.



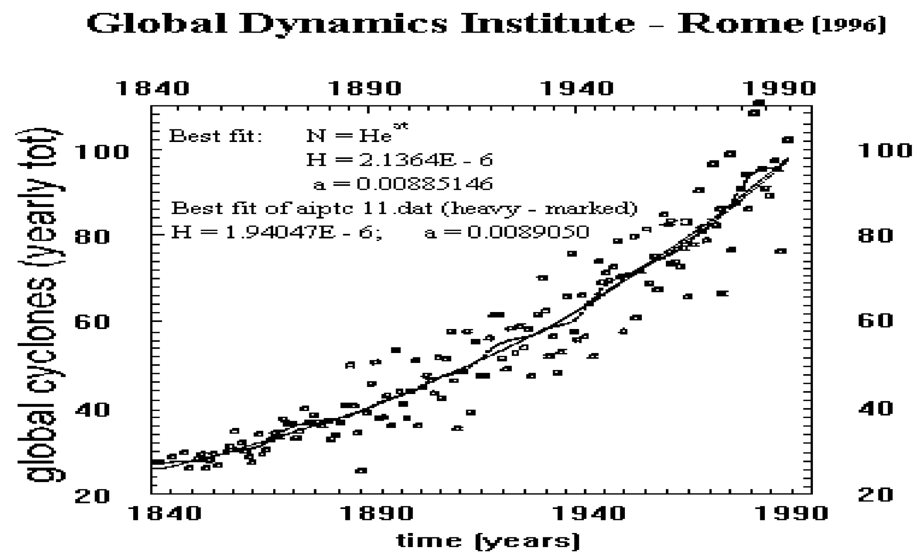
Source – EOS vol 80 No 39 (1999) p453 Fig 3, reproduced from Jouzel, J. et al, Nature 364 (1993) p 407

In 1995, 73 percent of the total CO_2 emissions from human activities came from the developed countries. The United States is the largest single source, accounting for 22 percent of the total, with carbon emissions per person now exceeding 5 tons per year. However, over the next few decades, 90 percent of the world's population growth will take place in the developing countries. Furthermore, per capita energy use in the developing countries, which is currently only 5-10% of the U.S. level, will increase.

Factors closely related to climate change will therefore probably be accentuated over the coming decades – economic growth in developed and, more significantly, developing economies, population growth, demand for energy intensive consumer goods. Unless swift action is taken, the result will be an acceleration of climate change. The European Union is committed to using all policies at its disposal to tackle climate change issues.

There is now a growing consensus that there is a relation between greenhouse gas emissions and climate change. Weather patterns are starting to be observed which appear to confirm the need to adapt policies. Although the correlation cannot be proven, there has for example been a growth in the number of cyclones recorded world-wide.

Number of cyclones in the world: an upward curve



Other examples are the melting of ice caps and glaciers, interruptions to normal weather patterns (floods, hurricanes, etc), gradually rising sea levels, a series of record global average high temperatures, unusual patterns in the Gulf Stream, on which North Western Europe relies for its temperate winter weather, and more acute manifestations of natural phenomena, such as el Niño. There is also speculation as to whether the frequent high winds and heavy rainfall in parts of Europe in recent years and droughts in other parts are related to climate change.

Energy use and production are by far the most important source of total greenhouse gas emissions, representing around 80% of 1990 EU emissions. The most important gas is CO_2 coming from fossil fuel production and use.

TABLE 3 - CO_2 emissions in the EU in 10^8 tonne of CO_2 (1990): Transport and electricity generation are greatest contributors

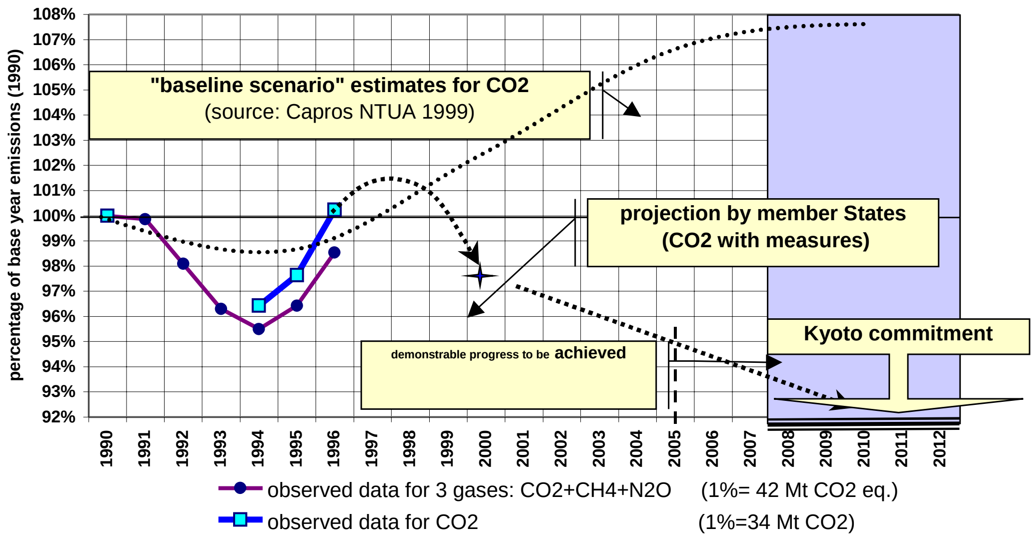
	Solid Fuels	Oil	Natural gas	Total
Thermal electricity production	6.3	1.2	1.5	9
Industry	1.9	1.4	1.8	5.1
Transport (road transport)	0	8.4 (7.0)	0	8.4
Households, Commerce	0.4	3	3	6.4
Others	0	1.4	0.3	1.7
TOTAL	8.6	15.4	6.6	30.6

Source: Eurostat

Around a third of total EU emissions of CO_2 originates from electricity and heat production. Transport accounts for over one quarter of total EU emissions in 1990 – a proportion which is growing. Analysis shows that in the absence of new policy measures it is the sector with the greatest potential for growth in CO_2 emissions up to 2010. Emissions of N_2O due to catalytic converters and HFC emissions from on-vehicle air conditioning are also expected to grow strongly over this period.

As far as enlargement is concerned, CO_2 emissions in the candidate countries are expected to increase again from current levels after the substantial decline in emissions since 1990 as a result of restructuring in Central and Eastern European candidate countries. Compared with 1990 levels, CO_2 emissions growth in an enlarged Union is expected to be lower than for the present EU, up to 2010, although not as low as required by the kyoto Protocol, (Moreover, such comparisons are not possible under kyoto). However, after this date, it is expected that this difference will be eliminated due to the fact that emissions growth in the candidate countries will be higher than in present Member States. Overall, the pattern of CO_2 emissions 2000-2020 is hardly affected by enlargement.

Greenhouse gases emissions for the EU 1990-2012 : without additional action, rises in greenhouse gases will go in precisely the opposite direction from what is required



Climate change is thus a new and crucial factor in the energy supply debate. Moreover, The European Community's commitments made in climate change agreements change the political context completely.

The Community and Member States have agreed in the Kyoto Protocol to reduce the emissions of a basket of CO2 and five other greenhouse gases by 8% by 2008-2012 compared with 1990 levels. However, the "Shared Analysis Project" expects that the CO2 emissions in 2010 will be around 7 % higher than in 1990, if no major new policies are introduced. Thus, the actual reduction which it is necessary to achieve is nearer 15%.

In numerical terms, the reduction targets fixed in Kyoto will oblige the European Union to reduce its annual emissions by 272 Mt of CO2 by 2010. If nothing is done , the present policies will allow the emissions to grow by around the same figure, which means that it is necessary to provide an effort of 544 Mt of reduction. If, as proposed by the Commission (see below) the share of renewable energy sources in primary energy could be increased from 6% to 12%, this would provide a reduction of 200 Mt. It would still be necessary to find an additional 350 Mt.

Various scenarios have been elaborated. For example, the replacement of coal and oil by natural gas in electricity generation, could theoretically lead to a 31% reduction in EU CO_2 emissions (coal and oil have a 2 and 1.5 higher CO_2 emission per unit of energy than natural gas). Maintaining the share of nuclear capacity by building 100 Gwe (some 70 reactors) of nuclear capacity could theoretically reduce CO_2 emissions by 22%. The sequestration and underground storage of CO_2 from electricity plants (see below), which could increase the cost of coal by 60% and that of natural gas by 30-40%, theoretically could reduce EU CO_2 emissions by 30% but risks of long term management of such storage have to be addressed. Reducing energy demand in the transport sector in particular would have a positive impact given that CO_2 emissions from transport are growing at the fastest rate. Finally, the increased use of renewable energy sources (RES) combined with energy efficiency could, theoretically, remove a large proportion of CO_2 emissions from energy production and use.

Unfortunately, however, CO_2 distributes itself around the globe within a few weeks. Therefore it is imperative that the EU encourages actions to reduce demand for fossil fuels and increase the viability of renewable energy in other parts of the world. Otherwise, the increase in global emissions elsewhere, especially in the developing world, would soon offset EU efforts. This presents….

The timetable for Kyoto means that only technologies which are currently beyond the research phase can serve the Kyoto targets. Hence the importance of demonstration and dissemination of energy technologies. It is likely that the urgency to tackle climate change will increase and that even stricter targets and policies will be agreed in the future, but in the meantime, the mix of policies and instruments used to tackle climate change will have a direct impact on energy supply. Indirect effects on energy markets are also inevitable. It is possible that investment and price-setting behaviour might change as companies gear themselves up for possible targeting by Member State legislation. For example, investors in the fossil fuel sector might reduce their investment budgets in anticipation of shrinking market volumes, which could have a negative impact on security of supply.

Environment

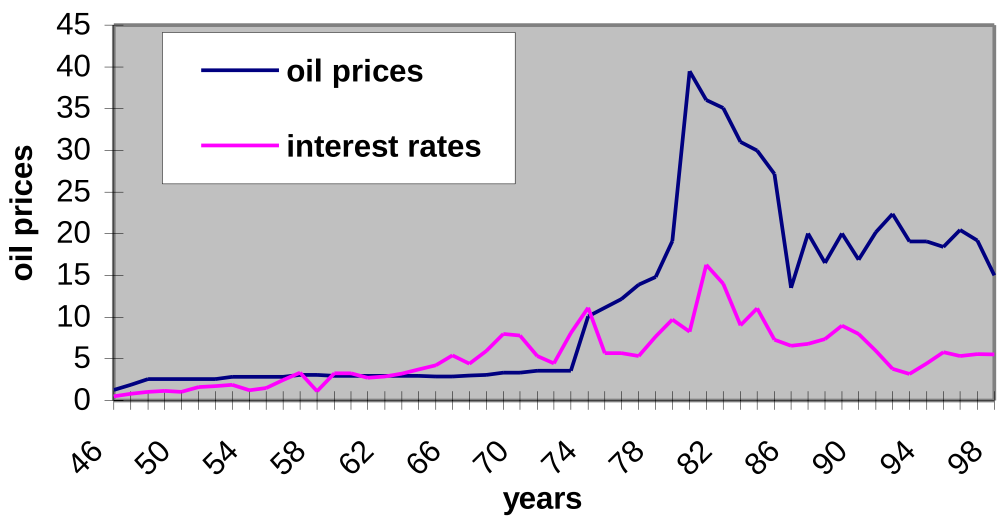
The evidence of climate change and the demands of sustainable development greatly restrict the possible options in the supply security debate. Yet secure energy supplies and sustainable development share similar aims: reducing energy intensity, improving energy efficiency and increasing clean, indigenous and renewable energy sources simultaneously serve environmental and energy supply objectives. Environmental considerations could have beneficial effects on energy supply by increasing awareness of the environmental impact of energy use and therefore encouraging voluntary energy efficiency and the use of cleaner technologies. Energy supply considerations need to respect the requirements of sustainable development, as incorporated into the Amsterdam Treaty, as well as the methods chosen by Member States to ratify the Kyoto Protocol.

c) Economy and fiscal framework

Energy prices have a direct and indirect effect on economic performance, and, based on previous trends, economic performance and energy consumption are often related. Any significant change to energy prices has wider economic implications since energy is a major component of industrial production costs in all sectors as well as domestic running costs.

The price of oil has come to be seen as a determinant of economic performance. Despite decreases in energy intensity and improved energy diversity in industry and heating, the price of oil remains, directly and indirectly, an important component of economic costs. This situation is, if anything, worse than 30 years ago because of the massive growth in the transport sector, which depends almost exclusively on oil. In the 1970's and 1980's the worst economic recessions after the second world war were caused by the oil shocks, and it was not until the second half of the 80's that the macroeconomic consequences - inflation, third world debt, unemployment – were brought under control. The rises in oil prices in 1999-2000 have directly fuelled inflation in Europe, pushing interest rates up, albeit to a controllable degree to date. The inevitable consequences for employment, investment and enterprise are likely to become apparent gradually.

Oil prices and interest rates – a close correlation



Studies in the USA[4] have confirmed the role of oil prices in the business cycle. In particular, a close correlation has been observed between oil prices and unemployment. Although unemployment is a lagging indicator, it generally rises as a result of higher inflation. The link between oil prices and unemployment becomes apparent when the higher inflation is triggered by higher oil prices – as was the case in the 1970's and as it starting to happen now. Low oil prices have benefited economic cycles, but there is new concern that recent oil price rises will, over time, slow down the world economy.

Increasing dependence on imports thus brings increasing exposure to price fluctuations, most of which are outside of Europe's control. This has implications for Europe's economy and employment market and is a key issue for energy supply policy. A reduction of external dependence on oil would be attractive for both economic and energy supply reasons, yet, given the limited indigenous reserves, this is unrealistic. This highlights the importance of improving diversity of supply and diverting demand away from oil.

[4] "Unemployment Equilibria and Input Prices: Theory and Evidence from the United States" Review of Economics and Statistics, November 1998

The Kyoto Protocol (see above) and environmental considerations are relatively new factors influencing economic and industrial decisions relating to energy. Currently, economic analysis of the full costs and benefits to society of economic activities (externalities) are not yet reflected in the market prices. Although there is no universally agreed definition of externalities and what they should include, it is clear that, if external environmental and societal costs gradually become incorporated into energy prices, there will be a direct impact on the economic attractiveness of different energy sources. In particular, some sectors related to renewable energy sources could compete more easily with conventional fuels (see graphs below).

Decisions relating to energy, in particular, tend not to take into account wider costs of the type of fuel used. For a range of reasons, producers and users often lack the economic incentives or technical information necessary for taking the full costs of environmental degradation into account. Job creation and trade balances are also usually perceived as a separate issue. Adapting the political and economic framework in order for prices to include externalities could change the balance of favour between energy sectors, transform the basis on which energy-related decisions are made (see Table 4) and ultimately create a more efficient way of pricing energy[5].

[5] see also European Commission's White Paper Growth Competitiveness and Employment 1994

TABLE 4

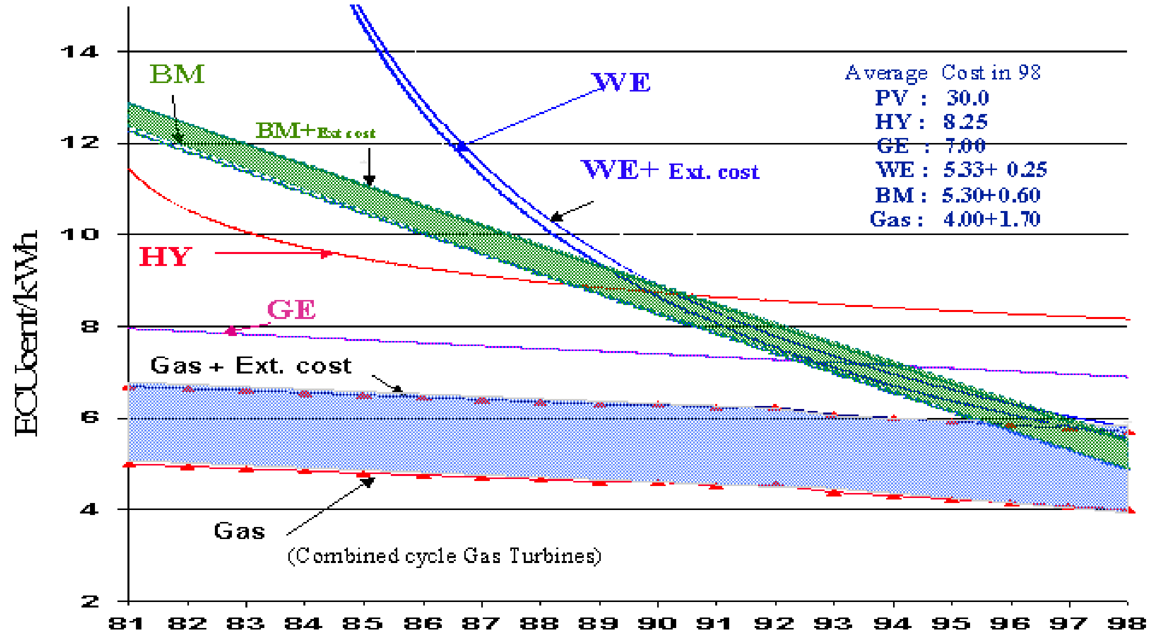
**EXTERNAL COSTS FOR ELECTRICITY PRODUCTION
WITH DIFFERENT FOSSIL FUELS, NUCLEAR FISSION AND RES
IN EUROCENT/kWh****

Country	Coal & lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind	Waste (EURO/t waste)
AUT				1-3		2-3	0.1			
BE	4-15			1-2	0.5					
DE	3-6		5-8	1-2	0.6	3		0.1-0.3	0.05	
DK	4-7			2-3		1			0.1	
ES	5-8			1-2		3-5*			0.2	15-24
FI	2-4	2-5				1				
FR	7-10		8-11	2-4	0.3	1	1			67-92
GR	5-8		3-5	1		0-0.8	1		0.25	
IE	6-8	3-4								
IT			3-6	2-3			0.3			46-77
NL	3-4			1-2	0.7	0.5				
NO				1-2		0.2	0.2		0-0.25	
PT	4-7			1-2		1-2	0.03			
SE	2-4					0.3	0-0.7			
UK	4-7		3-5	1-2	0.25	1			0.15	

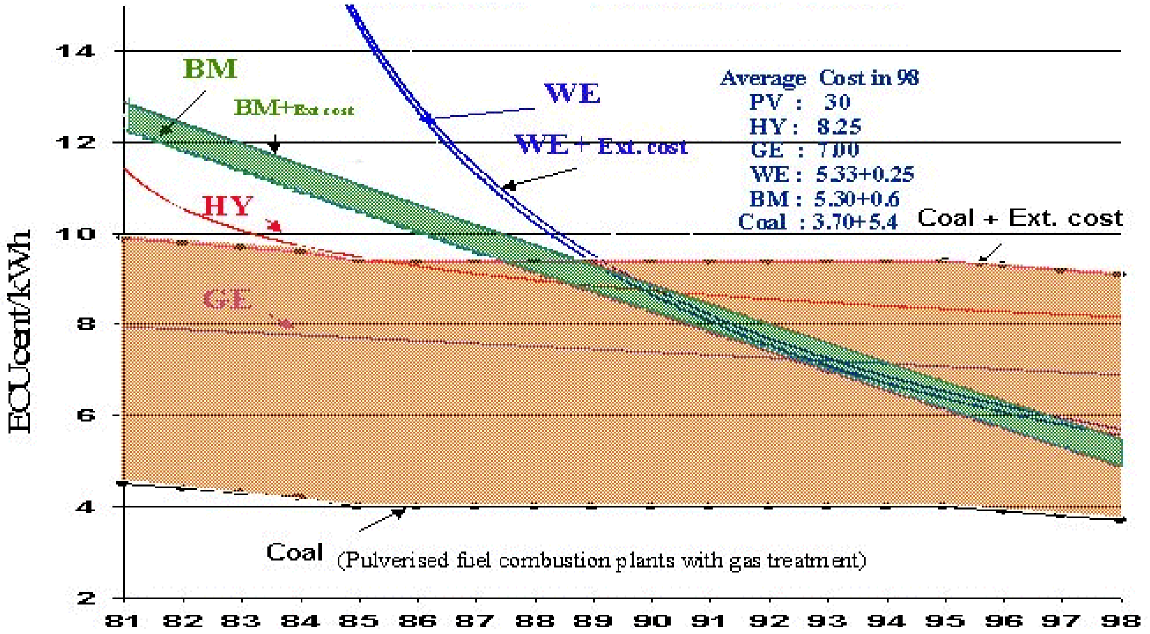
* : biomass co-fired with lignites

** : sub-total of quantifiable externalities (such as global warming, public health, occupational health, material damage)

**Gas and Renewable Power Plants Production cost
Including External cost: if externalities are included, most renewables can compete with gas…**



**Coal and Renewables Power Plants Production cost
Including External cost: if externalities are included, renewables can undercut coal**



HY = small hydropower; BM = Biomass; WE = wind, GE = Geothermal; PV = Photovoltaic
Source - EXTERNE

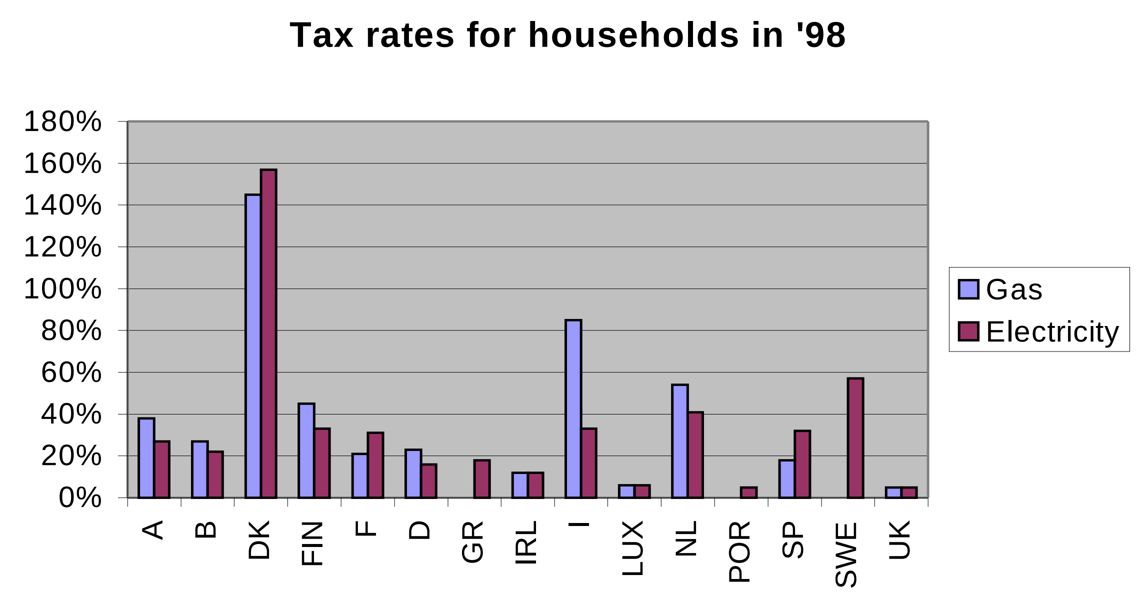
A balance needs to be struck between on the one hand incorporating externalities into energy costs as an incentive to reduce energy demand, particularly of fossil fuels, and to invest in more sustainable energy forms, and, on the other hand, the demands of competitiveness. In the long term, the inclusion of external costs in energy bills, within a stable economic framework, is likely to be an incentive for energy efficiency and investment in new and renewable energy technologies, both of which are favourable to energy supply security. However, more attractive prices will not be enough to convert customers en masse to renewable sources. Mass marketing by industry will be necessary. Regulation and fiscal policy are two instruments available to governments.

The fiscal framework for energy varies from Member State to Member State. It has in common that the level of taxation varies not only according to the product but also according to the final use. Only one part of the Community energy market - mineral oils – is currently taxed according to the common system. Besides the product/end-use differentiation, Member State use widely diverging methods for the definition of the tax rate and for allowing exemptions and tax refunds. Some Member States also provide subsidies, for example for coal production. Tax exemptions and refund arrangements complicate the situation further.

The Member States of the Union can be divided into two broad categories vis-à-vis their approach to taxation. Some Member States have a relatively wide base for taxation and their rates are also relatively high. Other Member States, often with below average per capita GDP, have decided not to increase energy taxation and they remain unconvinced about proposals on Community energy taxation. This results in a difficult impasse, given the decision-making procedure on taxation (unanimity in the Council).

A general observation across Member States is that domestic and transport use of energy is more heavily taxed than industrial use. Another general observation is that mineral oils for automotive use are more heavily taxed than energy for other use.

The following graph shows how electricity and gas for households are taxed in Member States. There are as many Member States that tax gas more than electricity as those who have decided to do the opposite.



Source IEA

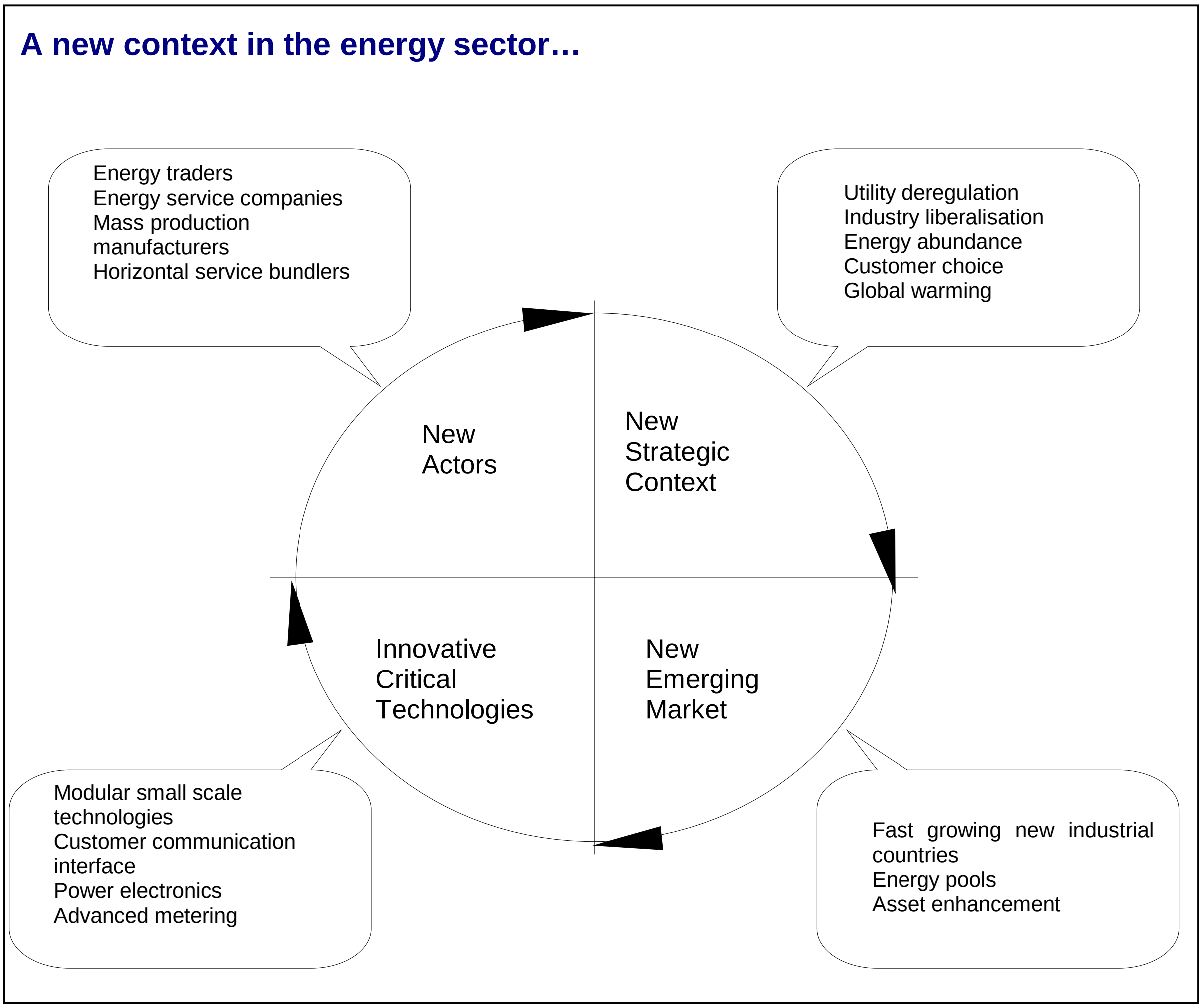
In terms of taxation of fuel input to industry, there are two common approaches. Some Member States have no taxation at all for other products than mineral oils (A, B, F, IRL, SP and UK), while others apply some tax on industrial energy use. In the latter case the rates are sometimes, but not always, based on CO2/energy considerations.

In response to environmental and employment pressures, some Member States have introduced taxation policies which change the balance between social and energy taxes – a model which has been developed in the Commission's White Paper on Growth, Competitiveness and Employment (see footnote 6). For example, in Denmark, a carbon tax is levied on industrial energy consumption and an SO2 tax has been introduced. In return, companies are offered subsidies for investments in energy saving technology and reductions in social security and pension contributions. Additional support for SME's is also available. The economic result for companies is broadly neutral.

Economy and fiscal framework

The link between energy and economic performance is evident at the micro-level and the macro-level. Oil prices have an impact on all measures of economic performance, and, until now, economic growth and growth in energy consumption have usually gone in parallel. Growing dependence on imports is making Europe more vulnerable to price fluctuations resulting to factors outside of their control. A revision to energy pricing mechanisms which incorporated external costs into market prices, supported by promotional measures and mass marketing, could rapidly make some indigenous and renewable energy sources economically more attractive. However, there are important political and economic implications to changing tax structures or actions which result in raising the price of energy. Member States also have differing approaches to energy taxation, and are reluctant to accept harmonisation in this area. As well as balancing economic and fiscal demands with the needs for supply diversity and socially and environmentally fair energy prices, energy supply policies also need to respond to wider demands, in particular the EU's stated goal of becoming "the most competitive and dynamic knowledge based economy in the world" (Lisbon Summit 2000).

d) Liberalisation, the Internal Market and Globalisation



Liberalisation, that is the trend towards privatisation and deregulation of utility companies, re-regulation via regulatory agencies, the European Internal Energy Market[6] (internal market) and globalisation are creating a new framework for energy markets. Liberalisation and the internal market are creating new trends towards desegregation on the one hand and mergers on the other. Industries and segments of industries in the energy sector are desegregating towards firms specialising in specific competitive activities ranging from energy production to consumer services. Privatised energy industries are forming partnerships, fusions and joint ventures in order to compete more successfully in a European and global market place.

The internal markets in electricity and gas are not yet fully established, but they are already influencing behaviour. For example, it is no longer possible for governments to address directives to state-owned companies. Also, a new factor is introduced in the form of competition regulations. Regulatory authorities are being established and a new relationship is developing between these and energy companies. The onus is on companies to respect rules of competition, environmental protection and consumer rights. The onus is on governments to monitor supply developments and to anticipate and manage risks for energy supply or society in general.

[6] 96/92/EC Directive of the European Parliament and of the Council concerning common rules for the internal market in electricity
98/30/EC Directive of the European Parliament and of the Council concerning common rules for the internal market in gas

In the internal market, the key policy instruments available to governments are regulation (limited to competition considerations), price signals, fiscal incentives for producers or consumers or incentives to invest in new technologies. In general terms, the market and free market prices will ensure that when capacity is nearly full, new capacity will be built. In a future supply crisis situation, the responsible behaviour of companies and partnership between policy makers and industry and an appropriate regulatory and fiscal framework will be decisive.

The internal market in electricity has brought benefits to consumers in terms of lower prices and greater choice of service provider. However, it has had two opposing effects related to security of supply. First, it has improved the overall efficiency of the energy system and created a market for more energy saving electrotechnologies. The objective is to obtain a larger energy service output for a smaller fuel input. Second, however, it has made investments which require large capital input or which have long pay back periods less attractive. Investment in research, particularly basic research, and development of new energy technologies may be put at risk. An additional issue is the impact of competition. If this brings prices down, as appears to be the case, demand could rise as a result. A further unknown factor is the effect of e-commerce on prices and consumer behaviour. This could encourage further competitive cost-cutting and indirectly lead to increased demand. This combination of factors could work to the disadvantage of supply security and consequently lead to price rises or even interruptions in supply, as has been seen in parts of the US market.

The internal market for gas could bring benefits for security of supply by diversifying the supply base by creating the conditions for competition between different suppliers. Alternatively, it could magnify the demand for the cheapest source or sources.

A fully functioning and secure internal market depends on transeuropean networks (TENs) which link Member States, not only internally, but also with external providers. These will enable companies to compete in a truly open market and will offer greater choice to consumers. The completion of TENs is a current EU priority. Such a network will also facilitate pragmatic solutions to energy supply, including for more remote regions. Table 5 below illustrates missing links in the gas pipeline network for the EU.

Globalisation is a parallel factor which is changing the shape of energy markets. Many of the effects are similar – mergers and restructuring (such as the recent wave of mergers in the oil industry), more intense competition for customers and greater pressure on costs. These moves are necessary for companies to compete in the global market place and they benefit consumers by lowering prices. However, they could make investment in research and development and other projects with a long pay back period less attractive. This would be to the detriment of supply security which will probably, in the long term, depend on the availability of innovative, renewable energy and energy efficient technologies.

This suggests that supply security could be enhanced by public support for new technologies and energy efficiency, for example programmes to promote best available technologies, to encourage investment in cleaner, more efficient and renewable technologies, to encourage energy efficient behaviour and to develop cleaner or renewable electricity generation. The needs of supply security, sustainable development and climate change could provide justification for such intervention.

TABLE 5 Missing links – gas sector

Member State	Missing links	Comment
Finland	Interconnection to Nordic countries Including Germany Interconnection to Baltic States	Identified TEN project of Common interest (h3) the North Transgas project providing a link from Russia via Finland offshore across the Baltic Sea to Germany and possibly Sweden
Sweden	further interconnection to Finland or	Identified TEN project of Common

	Germany	interest (h3) Possibly also the North Transgas project (see Finland above)
Greece	link to Italy link to Turkey increased links to Bulgaria to ensure Russian supplies	Identified project on the indicative list of projects of Common Interest (f13) Identified TEN project of Common Interest (h11)
Ireland	link between Ireland (or Northern Ireland) and the UK (second interconnector)	Identified TEN project of Common Interest (f1)
Portugal	Development of LNG facilities	Identified TEN project of Common interest (e5(a))
Spain	Increased links to France	Identified TEN project of Common Interest (f5)
Italy	link to Libya	
Austria	link to Czech Republic	Identified on the indicative list of TEN projects of Common interest (f14)
Austria	link to Slovenia and Croatia, strengthening of the gas transport capacity between the three countries	Identified on the indicative list of TEN projects of Common interest (f14)

Finally, the global context in which energy markets operate necessitate third country collaboration in the energy sector. Ultimately, actions which the EU undertakes which reduces energy demand in other parts of the world, such as technology transfer to developing countries, have a favourable impact on long term supply prospects in the EU. Additional benefits include lower global emissions and positive trade balances.

Liberalisation, the Internal Market and Globalisation

The cumulative effect of these changes on energy supply security is difficult to gauge. The Internal Markets for gas and electricity remove some powers from central authorities and create new obligations. Globalisation is changing company behaviour across Europe as industries prepare for competition in a global market. In the short term, the impact of these changes will depend on the power of authorities or regulators to intervene, the obligation of private companies to provide service and the rights of consumers. In the medium term, an important factor will be the economic justification for clean energy sources and clean energy use. In the longer term, energy supply interests will make it essential for public authorities to continue to have a role in a liberalised, global market, in particular in promoting new technologies. The incentive for companies to invest in research, development and marketing of new energy technologies and long-term supply projects will be crucial to the long-term security of supply in a liberalised market.

Context – Conclusions

The context for European energy supply policies has changed over the last 30 years as a result of political, environmental, economic and energy market developments. Policies for a secure energy supply must respect these new political needs and objectives. Recent developments in energy markets and related policies create new tensions and constraints for governments and administrations by, on the one hand, providing additional targets, as in the case of climate change, but removing traditional instruments, such as direct management of utilities.

These changes mean that it is necessary to look at the whole spectrum of energy supply and demand. A secure energy supply depends not only on the security of a single energy source, but on the balance of energy markets and the possibility of replacing one source with another source or other energy policy instrument (e.g. energy savings). Available options need to take into account not only energy supply objectives, but also the wider context outlined above.

At first sight, the aims of energy supply security are not always fully compatible with those of competitiveness, environment protection and liberalisation. Enlargement will bring its own challenges. The task for policy makers will be to reconcile wider objectives with energy supply and to seek instruments which can serve common objectives, for example, energy efficiency and new technology.

The following chapters analyse a range of aspects relevant to energy demand and energy supply in order to bring out their implications for energy supply in the European Community.

III ENERGY SOURCES

The following sections will consider the impact on energy supply of the following factors for each energy source:

- reserves in Europe and the world
- costs of production and transport
- forecasts of demand/supply
- import needs.

The analysis offered is selective and seeks to identify the major trends which are likely to affect the energy supply security debate within the EU. Fuller analyses of current and future supply and demand can be found in documents from, amongst others, the European Commission[7], International Energy Agency[8], World Energy Council (WEC)[9] and the International Institute for Applied Systems Analysis (IIASA)[10].

For the purposes of this analysis, considers, where relevant, short term (5-10 years), medium term (10-20 years) and long term trends (up to 50 years).

A Oil

Oil has a larger share of the energy market than any other fuel type, although this proportion is falling. In 1970, oil represented more than 60% of primary energy supply. This figure is now down to 44%. Demand for oil continues to grow, particularly in the transport sector. Transport is particularly important to oil markets because it is both almost completely dependent on oil as an energy source, and it is also one of the major customers for oil. For this reason, a crisis of supply in this sector would be more difficult to handle than an interruption in supply of another fuel in a different sector. (This has been recently demonstrated (Sept.2000) in parts of the EU where oil refineries were blockaded).

Against this background, Europe has benefited from the exploitation of indigenous reserves. However, these are economically less attractive and limited (including Norway, less than 2% of world reserves). The net result has been, in the short term, a reduction in dependence on imports. Nevertheless, dependence on imports continues to fluctuate around 60-70% and this rate is likely to increase in the near future due to growing demand and falling indigenous reserves. Enlargement is unlikely to affect these developments.

a) Reserves

The world's reported proven reserves continue to be dominated by the Middle East, which holds 64% of total global reserves. Other important oil reserves are located in the former Soviet Union and in the Americas, however these find ready customers and markets on their doorstep. The

[7] European Energy to 2020
[8] World Energy Outlook
[9] WEC Statement 2000 – Energy for Tomorrow's World
[10] Global Energy Perspectives, a joint study by the WEC and the IIASA

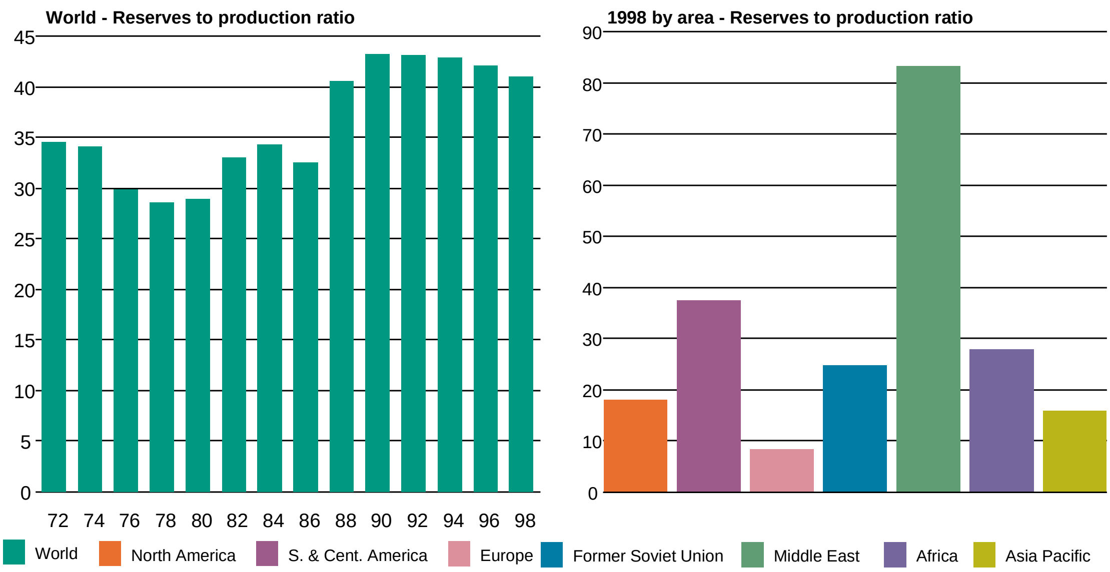
Middle East is therefore likely to remain Europe's most interesting source of oil for the foreseeable future.

Estimates of oil reserves have traditionally been conservative, particularly in the North Sea. On the one hand, new fields add to the available resources. On the other hand, new technologies, such as horizontal drilling, extend the possibilities for extracting oil from older or small wells or from more difficult sites, for example, deep sea drilling. Further, non-conventional oils offer another possibe source for oil, subject to technical progress. For these reasons, it is certain that the estimates of total oil reserves will rise.

However, the rate at which reserves are being exploited is high in all regions apart from the Middle East. Non-OPEC conventional supply is around its peak. It is worth noting that some forecasts (IEA "business as usual" scenarios) assume a doubling in Middle Eastern production from around 20 Mb/day to over 40 Mb/day by 2010. This may prove to be optimistic. Moreover, it is likely that other regions of the world who currently have adequate supplies on their doorstep might increase their demand for Middle East oil. Such a situation might not only reduce the availability of resources for the EU, but also push the price up.

Ultimately, the future of world oil supplies will be driven by the rate of availability, as well as by the size of the total resource. The uncertainty factors include levels of investment in technology and infrastructure, physical availability and geopolitics. What is fairly certain is that rates of production will decline before reserves are fully exploited. Another factor which might affect exploitation of reserves is Climate Change. According to some industry calculations, burning currently known reserves would have a dangerous impact on the global atmosphere, raising CO_2 to over twice pre-industrial levels (550-600 parts per million).

Oil: Generally a low rate of reserves compared to production
(Middle East excluded)

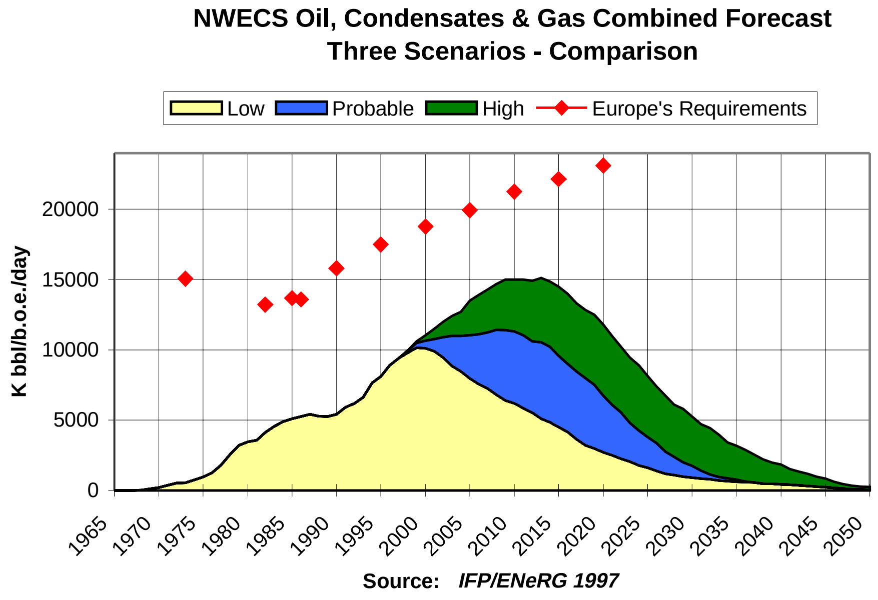


b) Production

Global crude oil production has continued to rise since an uneven spell in the 1970's and early 1980's. It is significant that, when Middle East oil production slowed down in the early 1980's, other regions made up most of the difference. This meant that the effect of regional disruptions on global production was less marked than in the early 1970's. The Middle East is now returning to the greatest producer of crude oil, a position that is likely to be confirmed by political developments, such as possible closer ties with Iran.

North Sea oil production is incapable of satisfying European needs. However, it could be an instrument in managing external dependence. If North Sea production continues at 6000-7000 kbbl per day, it could extend until 2025 – at which point European demand could be in excess of 25000 kbbl per day. If production were raised to 8,000-9,500 kbbl per day, no more than 10 years' production could be assured, against a demand growing to more than 20,000 kbbl per day. In both these scenarios, demand would continue to rise, while North Sea production would fall dramatically. Under both scenarios, new sources would be needed to fill the gap. In fact, North Sea oil production is already close to decline.

Europe requirements and North Sea: Medium term prospects are poor



The North Sea is one of the most expensive areas for oil production, not least because of the high cost of deep-sea exploration and extraction. New technologies might bring these costs down, but it is likely that exploration and production costs will continue to be up to up to three times higher in the North Sea ($8-10+bbl) than in the Middle East ($3-5). Depending on the market price for oil, this factor could continue to make the Middle East Europe's favoured source of oil.

c) Demand

Oil demand has continued to rise and is likely to continue this trend in the foreseeable future. Although the oil "shocks" of the 1970's led to diversification in many sectors, oil remains the dominant fuel of the transport sector, where it represents over 98% of market share. In an emergency, the possibilities for substituting oil in transport are currently extremely limited.
The price of oil has, with the exception of the 1970's, had relatively little effect on the trend of growing demand. Demand for oil continues to rise, although the price of oil over the last 30 years has been more volatile than over the previous 100 years. Users are relatively insensitive to price increases in the short term – they are unlikely suddenly to change their car or central heating system. However, over the longer term, the energy intensity of oil appliances has decreased by a factor of 50% since 1973, not least due to consumer demand. Over the same period, with the exception of transport, oil has been widely replaced by alternative fuels in the industry, heating and energy generating industries.

As oil demand rises, rises in oil production are necessary. This is already leading to increased costs as demand threatens to outstrip supply, as well as increased emissions of pollutants.

Without a technical breakthrough, transport is likely to maintain a growing appetite for oil and could account for up to 65% of oil demand by 2020. Although energy efficiency and environmental requirements have reduced the energy intensity of most forms of transport, the increase in usage has more than cancelled out any energy savings. Unless alternative technologies are developed, for example fuel cells for cars, then the anticipated rise in transport needs will further increase the demand for oil.

Although it is impossible to foresee when oil reserves will be depleted, for economic reasons it is in the EU's interests to divert demand away from oil well before any threat of oil depletion is indicated.

d) Imports

Europe currently imports around 80% of its oil. Norway is the biggest exporter to the EU (17%). In the EU as a whole, suppliers are varied, which means that a local disruption would have limited effects on the overall economy. However, the situation differs in individual Member States, where a small number of suppliers often provide a large proportion of market needs. Accession states are largely dependent on former Soviet Union countries. Although EU oil imports have fallen over recent years, it is expected that they will rise to nearly 90% by 2020.

OPEC states are a major source of imported oil. International oil prices are not subject to free market principles. OPEC exerts a strong influence on oil trading markets, and can put the EU, as buyer, in a weak position. Hence the creation of such initiatives as the Producer-Consumer Dialogue.

The issues for oil imports are multiple. First comes the strategic management of domestic resources, mainly North Sea reserves. Second, infrastructure links must be adequate, particularly with the Middle East, which is likely in the long term to become our major supplier. Pipeline links have added safety attractions over shipping. The issue of transit, i.e. the transport of imported fuel into the EU, is considered in chapter VIII below. Finally, the capacity and political will must exist in exporting countries to satisfy growing demand world-wide. This is perhaps the most uncertain aspect and could have a significant impact on price.

Oil – Conclusions

EU dependence on imported oil is starting to grow despite recent falls. The cost of producing oil in the Middle East is low and supplies in this area are relatively abundant. However, uncertainty surrounds future investment levels and physical availability of Middle East reserves. North Sea oil is expensive to exploit and reserves are limited – at best an estimated 25 years' supply at current production levels. Unless a breakthrough is reached which removes the almost complete dependence of the growing transport sector on oil, Europe's reliance on Middle East – and OPEC - oil is likely to be virtually complete in the long term, providing that supplies are technically and geopolitically available. In the past, reductions in energy intensity and the replacement of oil in heat and power applications transformed the market for oil. Nevertheless, demand continues to rise. Decisive elements for future oil requirements are the dependence of the expanding transport sector on oil, the risk of price fluctuations and the development of alternative transport fuels.

B Natural Gas

A full analysis of the situation regarding gas supply, as well as an analysis of gas markets, is contained in the Commission Communications "European Community Gas Supply and Prospects"[11] and "Security of EU Gas Supply"[12]. The Council Conclusions[13] are also relevant to future policy developments in the area of supply security.

[11] COM (95) 478 of 18.10.1995
[12] COM (99) 571 of 10.11 1999
[13] 2267.Council – ENERGY, Brussels, 30.05.2000, Press: 186 – No 8835/00

Gas is of particular significance to the supply security debate for three reasons. First, it is increasingly becoming the favoured fuel for electricity generation (including Combined Heat and Power) replacing oil and coal. Gas powered plants have a low investment cost which gives a quick return on investment and are more efficient. Second, due to its chemical composition, gas has lower greenhouse gas emissions than oil and coal for many types of energy services. Finally, it benefits from being easily available from reservoirs both within the EU and close to its borders (e.g. Algeria, Russia and Norway).

In the medium term, domestic EU gas production is expected to decline, and gas will have to be produced under more hostile circumstances and transported from more distant regions to EU markets. Against this background, gas production and transportation costs are likely to rise. To what extent increased costs will influence the competitivity of gas will depend on other factors, including developments in other sectors and the functioning of the internal market. In the case of gas for electricity generation, for example, two thirds of the total electricity cost is accounted for by gas prices, therefore rises in the price of gas could affect the competitivity of gas for electricity generation.

As regards an enlarged EU, applicant countries are, overall, experiencing an even faster growth in gas demand than the EU. An enlarged EU would face a growth in gas demand of 46% by 2010, compared with 34% for the present EU. The applicant countries have very few indigenous resources and for historical reasons, most of their gas comes from Russia. Although most of these countries are diversifying their supply base to some extent, their accession is likely to increase considerably the EU's dependence on Russian gas. Gas exports to Europe are important to Russia – almost one quarter of the Russian Federation's budget is paid for by the gas industry, which accounts for around 21% of total Russian export revenues and 4.6% of Russian GDP.

a) Reserves

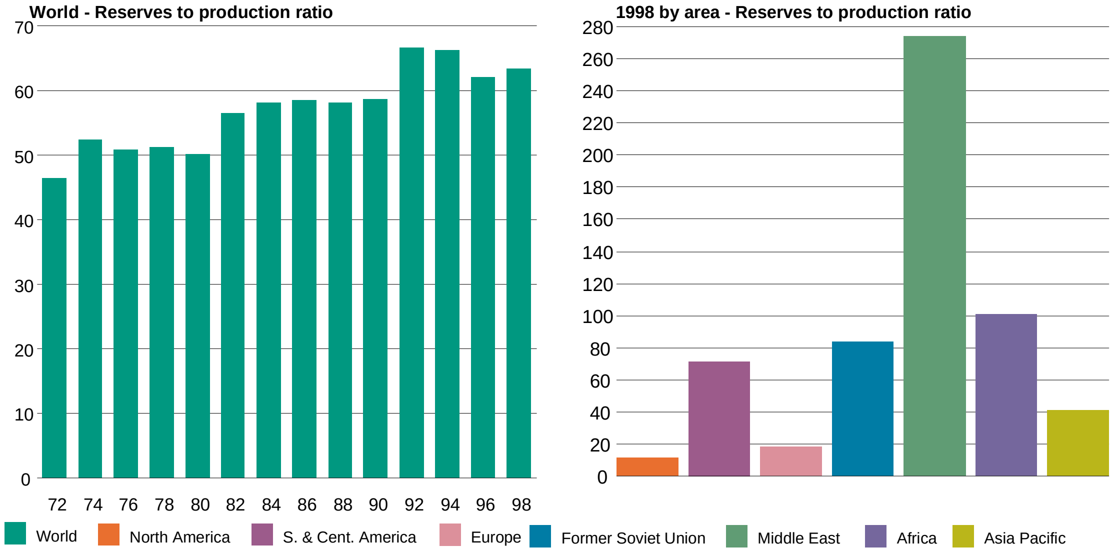
Gas reserves are, compared with oil, relatively well distributed around the globe. The former Soviet Union is the major source of gas reserves, with the Middle East a close second. Other major reserves are spread in Asia Pacific, the Americas, Africa and Europe.

Estimates of world gas reserves, like oil, continue to rise, by around 1% p.a.

As far as the EU is concerned, 80% of world reserves are within a recoverable distance from the EU. The fields of most interest to the EU are in the North Sea, North Africa, in the former Soviet Union and Middle East. These are logistically easier to exploit and provide adequate security. However, competing pressure for supplies will increase as demand grows in Eastern Asia in particular.

Worldwide, the prospects for gas supply are relatively good in the short term, with a ratio of reserves to production of over 60 years and the depletion decline point coming in perhaps 20 years or so. The former Soviet Union has particularly good prospects of 80 years, while in Europe the figure is almost 20 years (based on current production levels).

Natural gas: reserves are being exploited at a far lower rate than for oil



b) Production

Gas production has risen across the globe over the past 10 years to cope with growing demand. Within the EU, based on current prices, production is expected to decline within 5 to 10 years, leading to a greater dependence on imports.

Supply costs, usually consisting of production and transportation costs, may increase in the future due to rising distances, although lower wellhead costs might outweigh some of these increases. The extent to which this will affect the market position of gas will be dynamically determined by demand and supply in a competitive energy market. For the time being, gas prices are indexed to oil and do not mirror the supply costs involved. Due to inter-fuel competition and the possibility of substituting gas by oil in most market sectors, oil prices are likely to remain important also in relation to gas prices in the future.

Liquefied natural gas (LNG) production is growing, and will increasingly become an attractive alternative to conventional gas due to technological progress exerting downward pressure on the supply costs. LNG is also a means for bringing gas into Europe from more distant gas fields. Increasing the processing capacity of ports around the Union is a potential instrument of improving the security of gas supplies.

c) Demand

Gas demand has risen across the Community over the last 10 years, representing a growth in market share from 16% to 21%, albeit at uneven rates. Gas demand is likely to continue to rise rapidly in the near future due to its having lower greenhouse gas emission than coal and oil and due to the increased efficiency of combined cycles in electricity production. On average, the market share of gas is estimated to rise from 21% in 1998 to 27% in 2020. Two thirds of the increase in demand is accounted for by power generation, including CHP.
The anticipated growth in demand will make it necessary for the EU to find new suppliers. This is likely to mean looking farther afield – Iran, Irak, Qatar and Turkmenistan, countries from which imported gas can cost up to 2 times that from Algeria or Libya, due to transmission costs.

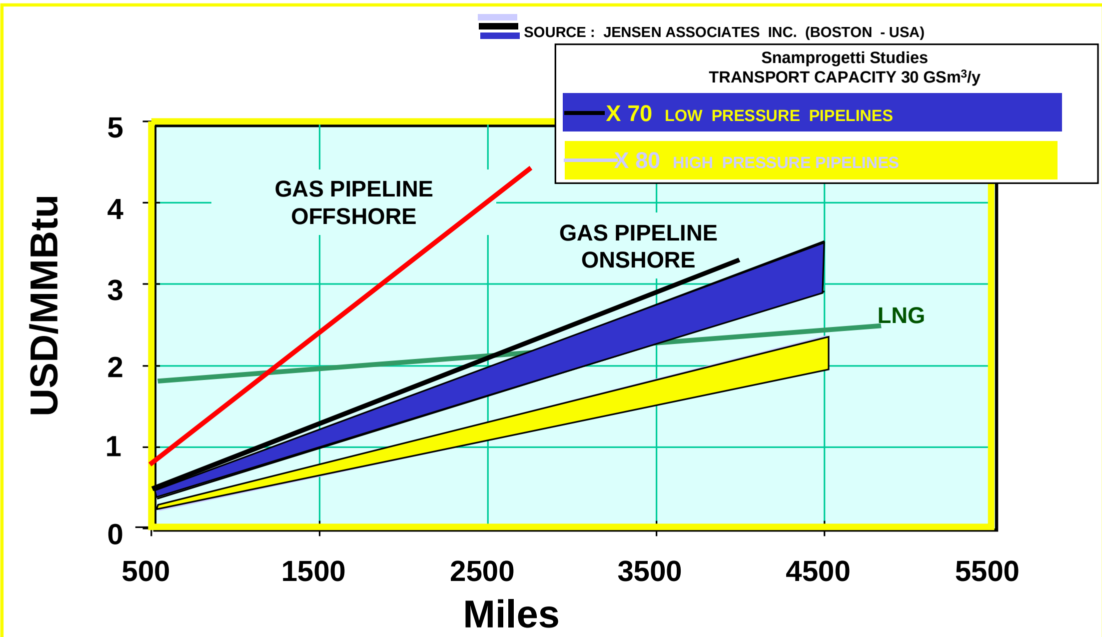
Natural gas export potential (bcm): the EU has a wide choice of suppliers, providing prices permit (estimates)

d) Imports

The current issue for gas imports is less that of reserves and more that of bringing gas supplies to the market at competitive prices, both within the EU and from external sources.
Currently, the EU's principal suppliers of imported gas are Russia (17% of total EU gas demand), Norway (11%) and Algeria (12%). On the basis of already contracted supplies, their shares will increase to 38%, 34% and 23% respectively by 2020, subject to new supply contracts. In terms of security of supply, Norway, as a member of the EEA does not constitute any risk. The dependence on Russia is likely to increase considerably as a result of enlargement. An economic risk arises from the cartelisation of Russian suppliers. In terms of physical risk, Russian gas exports occasionally have to deal with problems arising from important transit countries, such as Ukraine, so far without any serious consequences for European customers. Russia's dependence on gas transit across Ukraine is expected to decline significantly due to supply projects currently planned or being built (Yamal pipeline, Blue Stream pipeline and North Transgas project). As for Algeria, there might be a potential risk of terrorist disruption. Overall, mutual dependence between Europe and its external suppliers has created, and is likely to continue to create, a stable framework for future reliable gas supplies to the European market.

Although most Algerian gas and all Russian gas is shipped by pipeline, Europe will probably require greater import capacity to cope with the increased demand for imported gas. The Transit chapter below (part VIII) will consider this issue in more detail.

Long distance gas transmission systems - offshore pipelines quickly become uneconomic



The level of import dependence is forecast to rise significantly in the near future: from 40% today to 66% in 2020. Some Member States are already completely dependent on imports. Others will see their dependence rise close to 100%. Depending on the progress of the enlargement process, the average percentage may increase even more.

The current cost of importing gas is contained because of the geographical proximity of Europe's principal suppliers. However, the cost of transporting gas rises in proportion to the distance covered, and in the case of offshore gas pipeline, costs can rise significantly beyond a distance of

800-1000 km. Although no accurate estimates exist, the cost of importing gas to the EU from Siberia (4000 km away), for example, could have a serious impact on market prices in general, perhaps doubling gas prices. Costs are also likely to rise as gas may have to be produced under technically more challenging circumstances (deep water offshore, permafrost regions). These could at least in part be counteracted by technologies for more reliable exploration, higher depletion rates of existing fields and higher working pressure in pipelines. Over short distances, LNG is relatively expensive to transport, but it starts to become economically more attractive than pipeline gas at distances over 4,000-6,000km. Improved LNG technology are bringing costs down along the whole LNG chain. As a consequence, LNG supplies will become increasingly competitive.

New suppliers from North Africa, the Atlantic, Middle East and Central Asia are likely to tap the European market, thereby reducing overall dependence on a single region. However, there is currently uncertainty about the long term likely sources of gas to the rapidly growing markets of East Asia. In the event that Russia and the former Soviet republics are called upon to supply this region as well, EU countries could face significant competition and increased prices. The level of reserves in the Middle East and its relative proximity to the EU suggest that, in the future, dependence on Middle East gas is likely to increase. Pipeline connections to this region, which might accommodate gas and oil, could help to stabilise long term supply. Ultimately it will be for the market to decide. A stable political environment providing reliable investment conditions in the countries is key in this respect.

Gas - Conclusions

Europe's increasing demand for imported natural gas will confirm the need for strong political and physical links to North Africa and Russia, and increase the attraction of suitable pipeline links to the Middle East and Central Asia. Enlargement is likely to confirm market trends for gas, while increasing the EU's dependence on Russia's vast reserves.

The short term supply situation for gas is relatively comfortable in terms of reasonable reserves within an economic distance. In the medium to long term, however, it remains to be seen whether gas is able to defend or even increase its market share due to probable rises in exploration, exploitation and transportation costs. In the event that Russia and the former Soviet republics are called upon to supply the growing markets in East Asia, EU countries could face significant competition and increased prices. A set of measures aimed at promoting technological developments, supply diversification and gas-to-gas competition, integration of markets in a wider Europe as well as reinforced relations with external supply and transit countries would enhance supply security.

C Solid Fuels

Solid fuels include anthracite, bitumous coal and lignite. They are attractive in supply security terms because European reserves, particularly of hard coal, are plentiful. However, indigenous coal production is falling for a range of reasons, thus increasing EU dependence on imports, while the attraction of solid fuels for many operations has diminished due to the harmful emissions from its use. Technological advances (see below) could renew interest in coal.

Enlargement would accentuate this trend. In some applicant countries, coal is being phased out across some sectors for environmental reasons. At the same time, Poland, the major solid fuel producer among the applicant states, is scaling down its production to such a degree that Poland will soon no longer be self-sufficient in coal.

a) Reserves

Almost 80% of world coal reserves are now concentrated in North America, Asia Pacific and the former Soviet Union. Reserves in Europe, based on calorific value, are estimated at 72 billion tons of coal units (of which 70% is hard coal). Overall, coal represents 80% of fossil fuel reserves in the EU (96% in Eastern Europe). More limited reserves can be found in S. America and Africa.

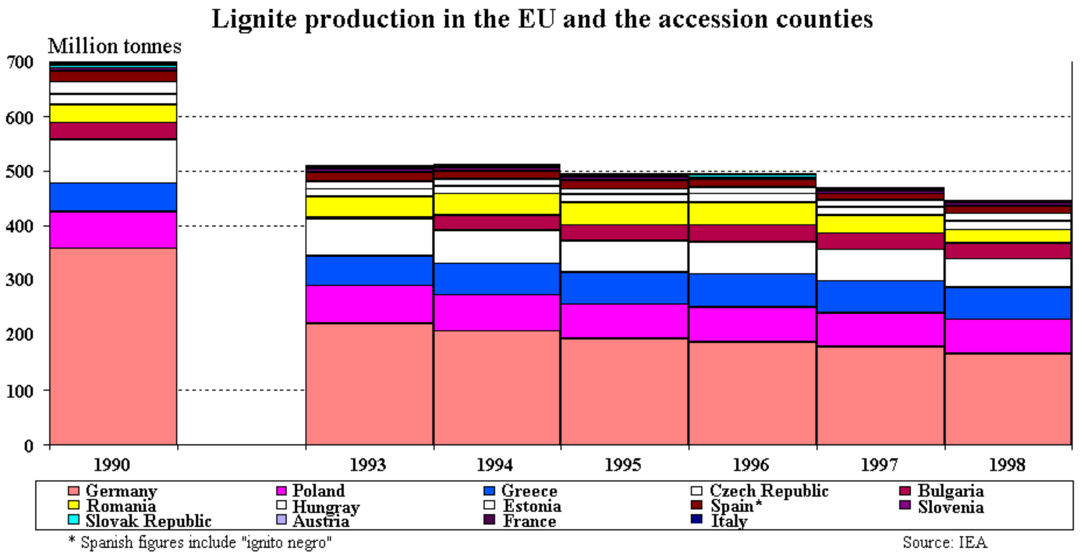
Coal reserves are being used at a far slowest rate than oil and gas, particularly within the EU and applicant countries.

b) Production

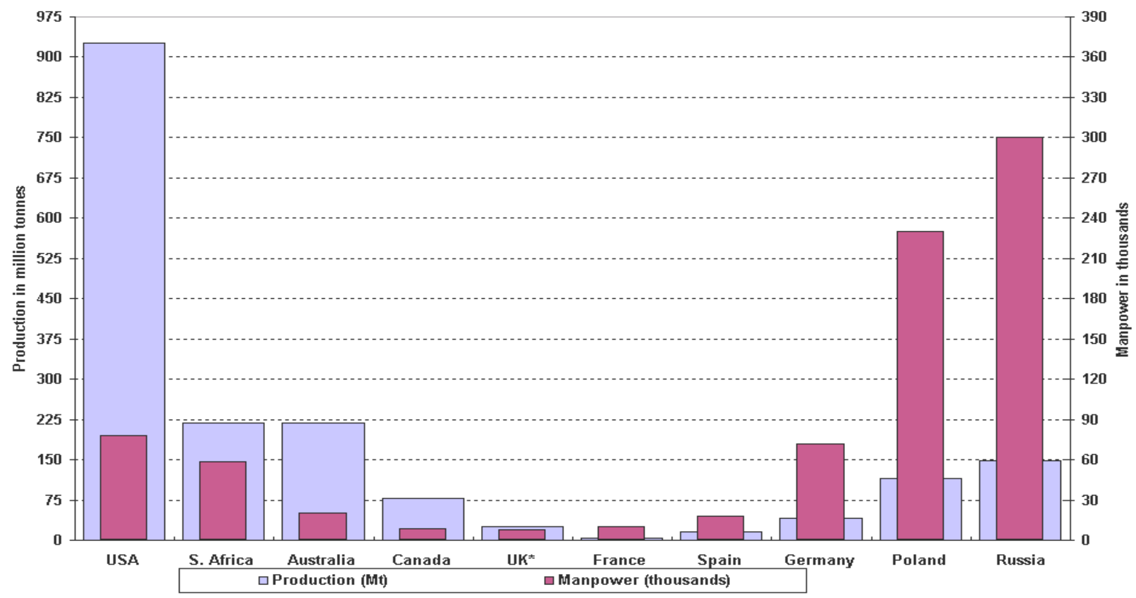
Hard coal production across the globe has grown over the last 25 years and is likely to go on expanding because of rising demand from developing countries. In 1999, coal production in the EU was 100 mtonnes, out of a total consumption of 247mtonnes, almost all of it dependent on subsidies. Production within Europe is falling and is likely to continue to do so as traditionally large producers continue to scale down production – as was seen in the UK in the 1990's. A similar trend is apparent in applicant countries, for example, Poland, where accession is likely to speed up the slimming down of their coal (mainly lignite) industry.

A key factor in coal production is cost. Despite its leading position as a developer of clean coal technology, the EU is at a disadvantage for structural and geological reasons. It has many deep mines which are expensive to operate. Drastic cost-reduction programmes have taken place in Germany and the UK which have reduced their cost and raised productivity – the UK now has the highest productivity among EU producers, but levels of production have been slashed. Similar developments are taking place in France and Spain. Compared to USA, Canada, Australia and S. Africa, productivity in the EU is relatively low. Poland's productivity is several times lower again.

Lignite: an important indigenous energy resource in Europe



Production and manpower in major hard coal exporting countries: In the EU, increased productivity has meant reduced production. Will this be repeated in Poland?



Sources: European Commission and the International Energy Agency. *UK figures are RJB Mining only

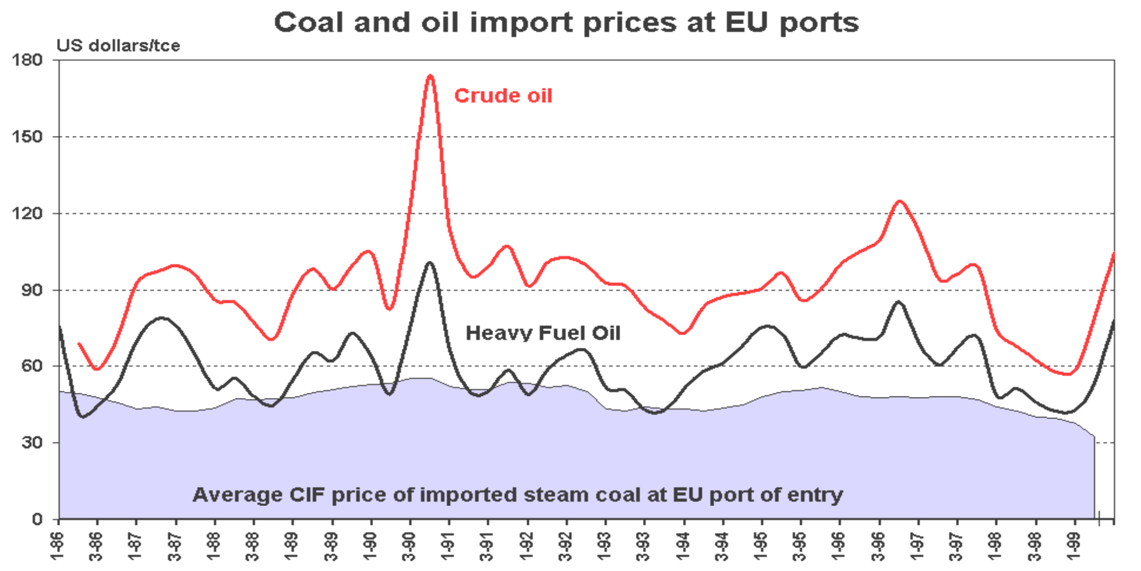
Despite the vast hard coal reserves of the EU and applicant countries, most EU hard coal production has no future without subsidies. Belgium has already ceased indigenous production. France plans to do so by 2005. In the UK, the price of coal delivered to generating companies delivered to generating companies lies above world levels. The UK coal industry is the only EU one to operate without state subsidies, but the number of operating mines and employment in the coal industry are a fraction of what they were 10 years ago. It is now proposed to reintroduce state aids for the coal industry. The question of state aids to the coal industry goes beyond the scope of this document but may be an issue in energy supply security policy.

Eastern European developments are dominated by trends in Poland. Overall, consumption is falling – from 166mtonnes in 1990 to 118mtonnes in 1998. The same period saw falls in production, mainly of lignite, from some 178 mtonnes to 135 mtonnes.

Coal has in the past been associated with pollution, and is still a large emitter of CO_2. The coal industry has introduced measures to reduce pollution and new technologies are being developed which could further cut harmful emissions from coal generation, including CO_2 (see below). These could make coal more attractive and benefit supply security.

Economically, coal offers the advantage over oil and gas of relatively stable prices, partly due to an excess of supply over demand. Over the last 15 years, average coal import prices have fluctuated by no more than 20$/tce, compared to over 120$tce for crude oil.

International coal prices: a reliable base



Heavy Fuel Oil - price in NW Europe. Crude oil - price in IEA Europe. Source: IEA

c) Demand

EU coal demand is following a determined downward trend, due to the wide-scale removal of coal from domestic households, the substitution of coal generation by gas and the restructuring of the steel industry. Domestic production is falling even more quickly, leading to a slight increase in imports. Imports are not rising as quickly as they would have if EU coal demand had remained constant.

Enlargement could benefit the EU's coal balance if Eastern European coal satisfied some of the demand in the existing EU. However, a more likely scenario is that restructuring in accession states leads to new falls in production without corresponding falls in demand. The net result is likely to be increased dependence on coal imports.

The medium term projection is that demand for coal would increase after 2010, especially for power generation, due to a projected price increase of gas and the decommissioning of ageing nuclear power plants.

d) Imports

Imported coal is far cheaper than domestically produced coal. At an average of 42€/tce, imported coal costs a fraction of, for example, German coal, at 143€/tce. Coal imports come from a wide range of countries, but mainly from Australia, Canada and USA. This factor reduces the risk element of dependence on imports. Providing that these reserves are available to European markets, there are more than sufficient alternative low-cost reserves accessible to markets in other parts of the world.

Coal - Conclusions

From an economic and energy supply viewpoint, coal is attractive. There are extensive world-wide reserves, including in Europe, and competitive, well supplied markets keep prices low and stable. However, coal has been phased out from homes (in earlier "clean air" legislation) and, more recently, electricity generation, where gas is the preferred choice. Restructuring of the steel industry has also removed an important customer.

In the long term, coal is likely to remain important as new technologies come on stream which reduce extraction costs, reduce emissions and dramatically increase its efficiency. After the expiry of the ECSC Treaty in 2002, mechanisms will remain to monitor prices and promote clean technologies. Thus, it is likely that coal will continue to be used for electricity generation in the long term, to the benefit of energy diversity and security of supply.

D Nuclear

From a small base in 1970, the EU now depends on nuclear energy for 35% of its electricity production. Conventional nuclear power depends on uranium, so any analysis of prospects for nuclear must focus on the availability of uranium. Any analysis of nuclear energy raises several related factors, namely the issues of plant safety, reprocessing of fuel, storage and disposal of highly active waste and non-proliferation. However, the commentary below will concentrate on the technical issues relevant to supply security.

Although several Member States have taken a political decision to phase out nuclear, replacement fuel is not easily and cheaply available in large quantities. Another difficulty is that alternative conventional fuels emit significantly more pollutant gases.

Enlargement is not going to accentuate the current situation. Some candidate countries are also highly dependent on nuclear generation, e.g. 40% of Bulgarian, 40% of Hungarian, 44% of Slovakian, 38% of Slovenian and 77% of Lithuanian electricity generation comes from nuclear. It has been estimated that the nuclear share of electricity generation in accession coutries plus Switzerland and Norway could fall from around 15% now to 8.5% in 2020 (source E3MLAB ICCS/NTUA, Athens).

A full analysis of uranium production and supply is contained in the Annual Report of the Euratom Supply Agency.[14]

a) Reserves

Globally, conventional uranium reserves cover between 60-260 years, depending on cost and probability of occurrence, using present reactor technology; with breeders the same reserves are sufficient to produce electricity well over 3000 years at today's level. In addition substantial unconventional uranium resources exist in phosphates (360 years) and sea water (66000 years). For certain reactor types thorium could be used as source for nuclear fuel. Uranium reserves are well distributed around the world including Australia, Canada, USA, as well as Kazakhstan, Uzbekistan, Africa, Brazil and Russia. Within the EU natural reserves are small, but supplies for the rest of the nuclear fuel cycle are not threatened.

There are considerable secondary sources of uranium – civil inventories of natural or enriched uranium, resulting from the blending down of highly enriched uranium no longer needed for defence purposes, irradiated uranium separated by reprocessing or contained in spent fuel and depleted uranium that can be further used. However, the availability of these sources is variable, depending on its form.

b) Production

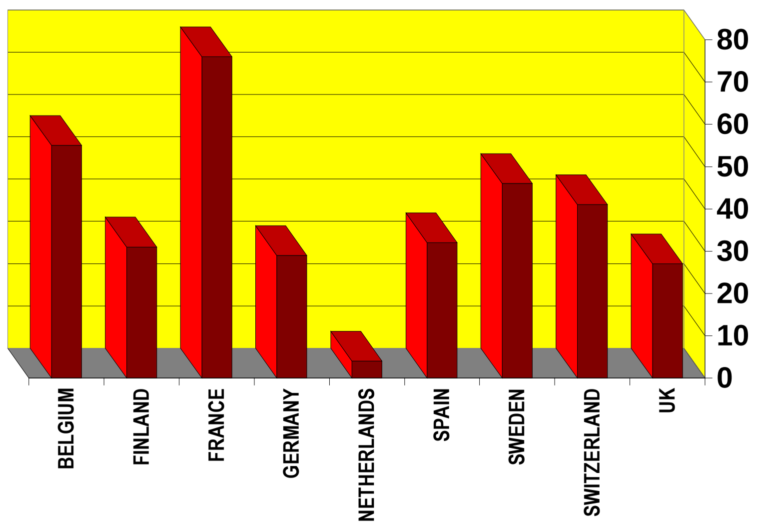
Since around 1984, substantial quantities of uranium, coming from inventories, USSR or CIS countries, or from uranium no longer needed for defence purposes, have been put on the market, resulting in an oversupply situation and a substantial and prolonged price decrease. This price decrease caused the closure of many uranium mines in the world. This situation could last several more years, but the availability of these secondary sources is by no means guaranteed.

[1] Euratom Supply Agency Annual Report 1999

Uranium production has been lower than requirements since 1990 due to mines closing or slowing production, the shortfall being made up from secondary sources and utilisation of MOX (Mixed Oxide fuel).

Current annual world uranium production is 31.000 tonnes, compared with needs of some 60.000 tonnes. Secondary supplies (stocks, military material, recycling) cover the gap. Within the EU, uranium production, which used to represent 3% of world total, is being phased out, such that EU could become exclusively dependent on imported uranium for its annual 20.000 tonnes needs.

Nuclear generation in the EU 1998 in % of total electricity generation: national pictures vary widely



Uranium prices are currently very low (7-10$/lb U308 or 18-26 $/kg U), due to the excess of supply over demand. The effect of secondary sources and possible early phasing out of reactors creates an uncertain market future. The US Department of Energy's Energy Information Agency forecasts an increase to 13$/lb by 2003-2007 while the International Atomic Energy Agency suggests that secondary sources will keep prices below 20$/lb until 2020.

Total fuel cycle costs including waste disposal, however, represent only about 20-25% of nuclear electricity production costs. Of these costs, uranium ore costs represent about 26-30%, i.e. about 6% of total electricity production costs. (source: Economic Aspects of the Nuclear Fuel Cycle – NEA/OECD-1994). As a result, nuclear electricity costs are much less sensitive to fuel costs than electricity from coal, gas or oil.

Uranium production is dominated by a relatively small number of operators: 3 uranium producers cover more than half of production. There is a large degree of consolidation among the fuel cycle industry – 2 major traders, 5 major converters, 4 major enrichers, 3 major fabricators, with 2-3 smaller ones, and 2 reprocessors. Despite the existence of an oligopolistic market, competition is intense.

The growth of the nuclear industry in the developed countries has been dramatic. Security of supply considerations were one of the main motives to opt for nuclear energy. From a small base in 1970, nuclear production now accounts for up to 75% of electricity generation (France). However, the picture varies across the EU. Nuclear installations are unevenly distributed in the EU, with widely differing capacities. Some countries have never produced nuclear, some (Italy) have phased it out, while the average among those EU countries which produce nuclear energy is around 42%.

Nuclear generation as a percentage of electricity is still growing, mainly as a result of more intensive use of installed capacity. Nuclear energy production in the EU grew by 3% between 1998 and 1999.

Nuclear power: a growing share of electricity generation						
Country	**N° of Units in Operation 01.01.00**	**Generating Capacity (MWe net)**	**Production in 1998**		**Production in 1999**	
			TWh	% of total	TWh	% of total
Belgium	7	5713	43.9	55.2	46.7	57.7
Finland	4	2656	21.0	31.3	22.1	33.1
France	58	61733	368.4	75.8	375.0	75.0
Germany (1)	20	22341	145.3	28.5	160.8	31.2
Netherlands	1	459	3.6	4.1	3.6	4.3
Spain	9	7470	56.7	31.7	56.5	29.9
Sweden	11	9460	70.0	45.7	70.2	46.7
UK	35	12926	91.1	27.1	87.7	26.0
EU-15	145	122757	800.0	34.1	822.6	34.6
(1) One unit not in operation in 1999						Source: Eurostat

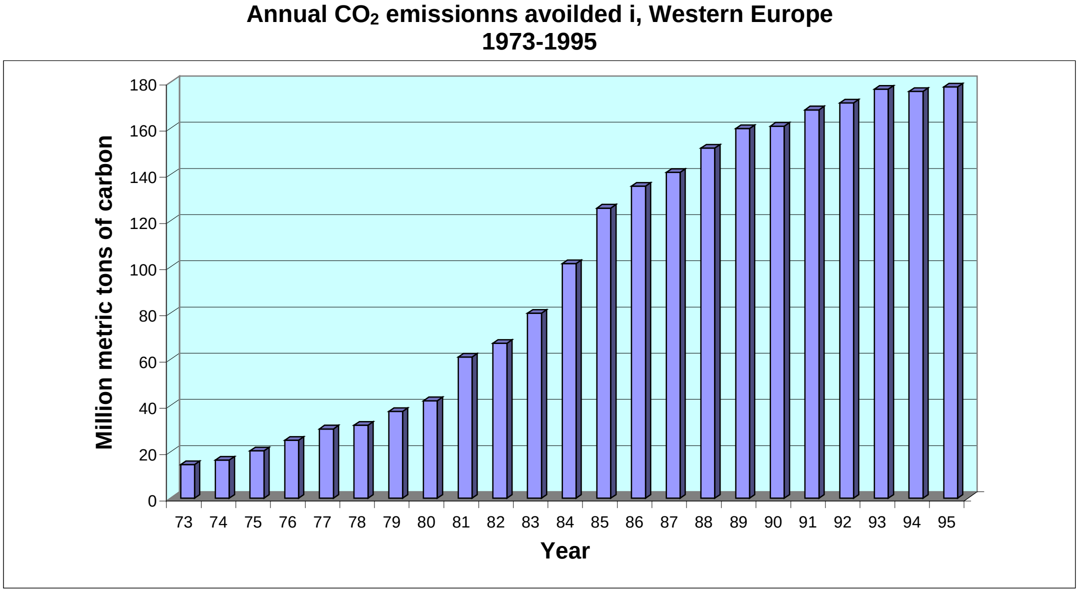
Nuclear is also an important source of power in Central and Eastern Europe, as the table below shows (figures are not directly comparable with statistics for EU). In some of these countries, closures of old Soviet-type reactors are scheduled between 2002 to 2009 and alternative sources of electricity will need to be found.

Nuclear installations in Central and Eastern Europe					
Country	Number of Units in operation	Generating capacities (MWe)	Production in 1999 (TWh)	Production in 1999 (% of total)	Notes
Lithuani a	2	2370	9.9	73	Agreement on closure of Unit 1 by 2004 and Unit 2 by 2009 (to be confirmed) No Rechanneling.
Czech Republic	4	1760	13.4	21	Temelin Power Plant to be completed by 2001-2002 : Additional Capacity 2000 MWe
Slovak Republic	5	2020	13.1	47	Agreement to close Bohunice V1 in 2006 (Unit 1) and 2008 (Unit 2) 1 more Units will be commissioned at Mochovce in 2000 : Additional Capacity 440 Mwe. Potential for 2 more units later (880 MWe).
Hungary	4	1840	14.1	38.3	
Slovenia	1	632	4.5	37.2	
Bulgaria	6	3538	14.5	47.1	Agreement on closure of Kozloduy Units 1-2 in 2002 and Units 3-4 in 2004 (to be confirmed) Modernisation of the Kozloduy Unit 5 and 6 – Euratom Loan.
Romania	1	655	4.8	10.7	

Unique among energy sectors, the nuclear industry is subject to supply policy rules under the Euratom Treaty. This gives the Euratom Supply Agency an exclusive right to conclude or, under some conditions, to refuse contracts (its right of option has never been used). In the interests of EU supply security, the Euratom Supply Agency recommends that EU users keep a sufficient inventory to cover at least one year and maintain a portfolio of diversified, long-term contracts at equitable terms with primary producers. With regard to supplies from the NIS, the Agency applies a policy of reasonable dependence, which has been endorsed by the Court.

Nuclear production has the advantage that it produces very few greenhouse gas emissions. All come from fossil energy used by the nuclear fuel cycle. More than 40 million kilowatt-hours of electricity are produced from one tonne of natural uranium. The production of this amount of electricity from fossil fuels would require the burning of over 16,000 tonnes of black coal or 80,000 barrels of oil.

Carbon avoided as a result of nuclear generation (1 ton C = 3,66 tons CO_2)



EU production has not yet reached its maximum capacity, but this capacity is likely to be reduced in the near future as a result of phasing out of nuclear plant. This includes both old plants being taken out of production and operational plants being closed as a result of political decisions, such as in Sweden and Germany. If the lifetime of EU reactors were to be extended, as in the US, this reduction in capacity would be delayed. The test for environmental and supply security policy will be how the energy from these plants is replaced – or saved; more specifically, whether adequate renewable generation can be provided to replace lost capacity, whether new nuclear supplies will come on stream or whether the use of fossil fuels and imported sources will increase. The first two face technical, social and market barriers (see below), while the third contradicts environmental commitments.

Maintaining nuclear fuel's present share in electricity generation would keep CO2 emissions in this sector to roughly their 1990 level and would require construction by 2025 of 100 GWe (some 70 reactors) of nuclear capacity to replace reactors reaching their end of life and meet increased demand. Keeping existing nuclear plants for a normal lifetime of 40 years without building new ones would entail exceeding the 1990 emissions level by 4%. Phasing out existing nuclear plants would make the Kyoto objectives extremely difficult to achieve, as CO2 emissions would exceed their 1990 level by 12% (Dilemma Study). In fact, in a situation where some, but not all, power stations will close over the coming 10 years, and no new ones will be built, the actual picture is likely to between these two.

c) Demand

EU demand for uranium has stabilised at about 20,000 tonnes per year, it is only partly fulfilled by fresh production, and the gap between production and requirements is likely to remain for some time, as secondary and non-commercial sources are being run down. Currently MOX contributes around 3,000 tonnes per year of uranium equivalent.

Future trends in demand are unclear given the uncertain future for nuclear power in several Member States. Demand for uranium in the EU will increase if nuclear generation increases. This will create greater dependence on external resources, e.g. Russia, Canada and Australia including uranium no longer needed for defence purposes. Recycling spent fuel and using fast breeder reactors could moderate this increase.

Demand for nuclear energy will be strongly affected by demand for electricity on the one hand and the capacity to generate electricity (cleanly) from renewables and coal.

d) Imports

In terms of import dependence, uranium is available in limited quantities within the EU, but in the long term dependence on imports is almost inevitable. Thus, in terms of security supply, the EU is increasingly dependent on imports of natural uranium, unless recycling or breeding is used. However, it is possible to stockpile several years of requirements and to diversify supply sources.

The EU's largest suppliers of uranium are Russia, followed by Niger, Australia and Canada. After rising steadily in the 1990's, the market share of Russia and other uranium exporting republics of the former Soviet Union is tending to stabilise. The rising trend is likely to resume following enlargement.

Nuclear – Conclusions

Nuclear energy in the EU has been faciliated by international treaties (eg Euratom), specific agencies and government financing. Although nuclear energy accounted for a very small part of energy supply in 1970, the EU is currently dependent on nuclear generation for a significant part of its electricity supply: approximately 23% of installed electricity generation capacity and 35% of electricity production. This proportion is likely to remain at least in the short term. However, medium term prospects are uncertain. On the one hand, nuclear power has the advantage that it produces very few greenhouse gases; on the other hand, several Member States have introduced nuclear moratoria.

Nuclear electricity in Europe depends, with today's technology, on an imported raw fuel, uranium. Sources of uranium, however, are more diversified, geographically and physically, than oil and gas. Stockpiling is also possible. Furthermore, when following recycling and/or breeding policies, the imported resource becomes a domestic resource.

Enlargement of the EU is likely to confirm this situation, because, in general, many of the applicant countries are in a similar situation to nuclear producers within the EU.

Technically, nuclear could provide a non-fossil fuel burning source of electricity that would be capable of filling a substantial part of the gap in electricity supply that would be created if fossil fuel electricity generation were to be drastically reduced as a response to Kyoto. This would require the construction of 100 GWE (70 reactors) of nuclear capacity or more. However, the construction time for a nuclear power plant is significantly longer than for fossil fuel plants and liberalisation in electricity markets, coupled with public and political opposition to nuclear power, complicate decisions regarding nuclear capacity. Lifetime extension of existing plants, as has been proposed in the US and Switzerland and more intensive exploitation of existing plant are further options.

Looking beyond 2010, the long lead-in time for energy technology means that it is essential to maintain long-term research, partly to find a solution to the problem of waste and partly to hand down nuclear expertise to future generations.

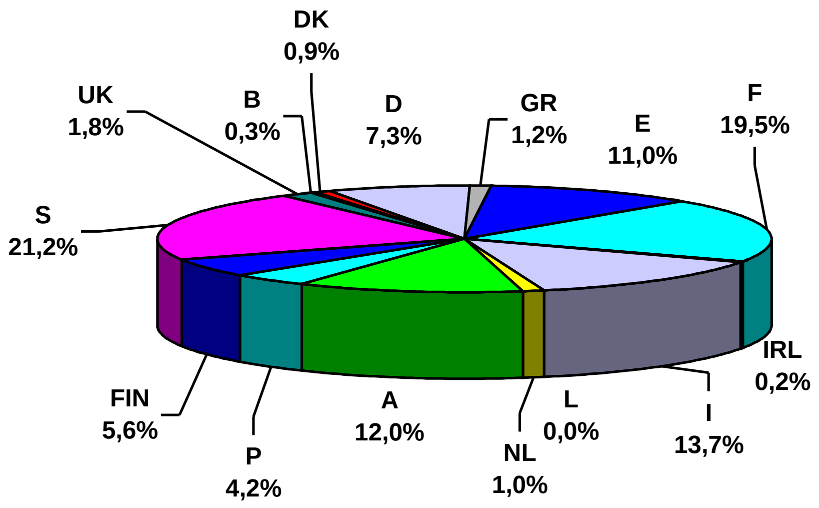
E Renewable Energy Sources (RES)

The major RES sectors are wind, photovoltaic (PV), solar thermal, (solar thermal power plants and solar energy in buildings) hydro (small and large scale), biomass (with and without waste) and geothermal. Their obvious attraction in terms of energy supply is that they are either naturally occurring or can be replaced quickly, do not need to be imported, and in general have less impact on the environment than conventional energy sources. In the long term, with appropriate development and promotional support, they could help significantly to combine secure energy supplies with a healthy environmental and economic performance.

Renewable energy sources are currently unevenly and insufficiently exploited in the European Union. Some countries, such as Austria and Sweden, France and Italy have a large renewables sector, some, such a Germany, have intensive programmes or legislation in favour of renewable and some have little exploitation of renewable sources. In one renewable sector, large hydropower, potential EU capacity has been almost fully developed, while in others, such as PV and solar thermal, very little potential has been tapped. The renewables industry has created many new jobs, around 15,000 in the Danish wind industry alone.

Although their potential is significant, renewable sources of energy make a disappointingly small contribution of around 6% to the Union's overall gross inland energy consumption, of which 4% is hydropower. The challenge for the renewables sector is to increase this proportion: the European Commission has set a target of 12% by 2010, i.e. a four-fold increase if large hydro is excluded. This is helpful to environmental targets, because, in general, renewable energy sources are CO2 neutral. Yet the Commission's targets are made more difficult by the fact that overall energy consumption is growing.

Member States' Contribution to EU-15 RES Electricity generation in 1997



In spite of its attraction for energy supply, the exploitation of renewable energy sources goes beyond energy supply policy. Technical, economic, social and physical obstacles require other instruments (fiscal, agricultural, land use planning, research etc). The example of nuclear energy shows the potential for governments to transform energy supply by a targetted programme of measures.

The problem of increasing the supply of renewable energy will be made even greater by enlargement, given the dependence of applicant countries on traditional energy sources. However, enlargement also gives the renewables sector a promising opportunity: the need to replace old plant coupled with the demand for environmentally friendly technologies make renewable energy sources particularly interesting. However, present market conditions do not favour the competitive position of renewables.

A fuller analysis of the challenges for the renewables sector, including an analysis of the renewables production in EU Member States is contained in the Commission's Green and White Papers on Renewables.[15] The task of realising the ambitious targets for renewables over the coming years should be facilitated by the recent draft directive on the promotion of electricity from renewable energy sources in the internal electricity market[16], providing that it is backed by national and regional initiatives.

a) Production

The contribution of renewables to energy production across the EU (EU15) has risen slightly since 1990 – from around 5% to around 6%. They represent around 14% of electricity generation – a figure that was fairly constant throughout the 1990's. This figure disguises significant real rises in RES production (over 30%) because energy demand also grew over the same period. It also does not reveal the growing interest in renewables among conventional energy sectors and financial institutions, shown for example by recent substantial investments made by several of the world's leading energy companies.

Renewables production in the EU varies widely among Member States. Sweden (hydro), Austria (biomass and hydro), France, Italy and Spain account for over 77% of all EU renewables production.

RES exploitation faces technical and socio-economic challenges. It is therefore essential to address both at once. Under present policies, the contribution of RES to primary energy consumption is unlikely to increase dramatically. Changing pricing mechanisms such that external (environmental, health, social) costs are included in energy prices would increase their attraction, as would the aggressive marketing of the most advanced technologies. Such measures could bring down the relative price of renewable energy and produce economies of scale and thus significantly boast the role of renewables.

Much RES technology is still at a relatively immature stage of development, compared with conventional energy technology, moreover, new entrants often have a difficult task in entering traditional markets, and energy is no exception. Against this background, without strong customer incentives and mass-marketing, government pressure and publicity, the full potential contribution of renewable energy to energy supply will probably only be fully realised in the medium to long term.

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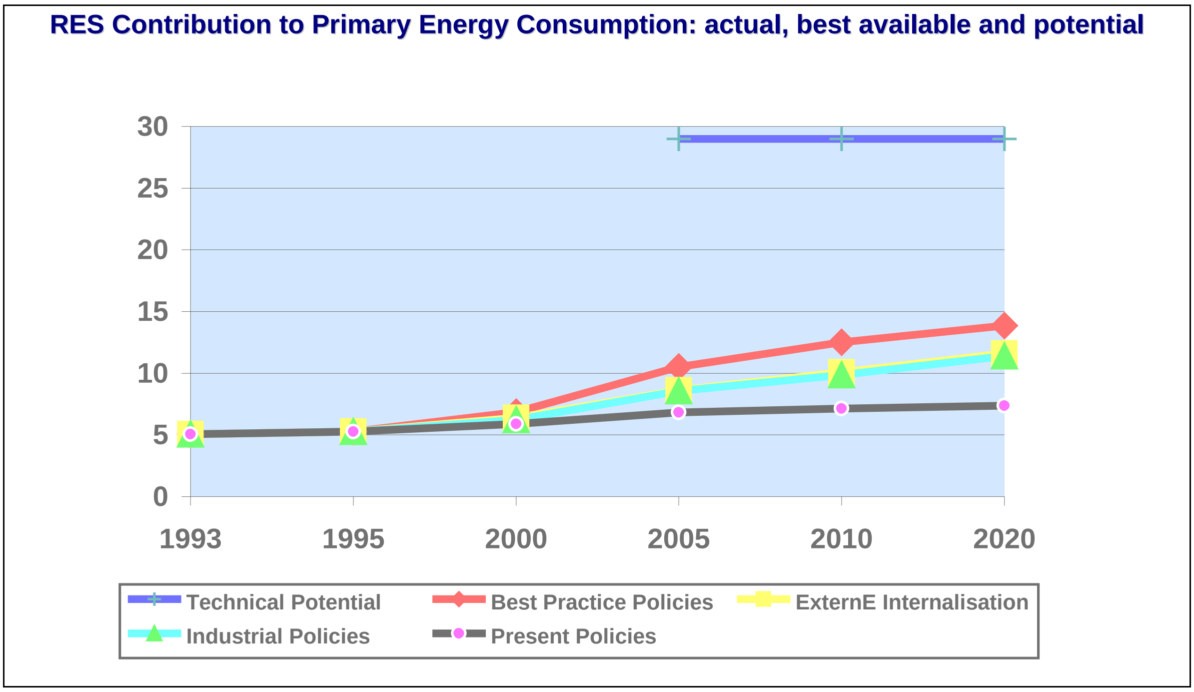
[15] Energy for the Future: Renewable Sources of Energy COM (96)576 of 20.11.96
Energy For the Future: Renewable Sources of Energy – White Paper for a Community Strategy and Action Plan COM(97)599 of 26.11.1997
[16] COM(2000) 279 of 10 May 2000



Large-scale hydropower is the largest renewables producer. The major growth sector in renewables is wind, which grew 1,275% between 1987 – 1997, from 46 ktoe to 631 ktoe. Solar thermal production more than doubled over the same period, from 146 Ktoe to 323 Ktoe. Biomass grew by almost a third, from 39.976ktoe to 51.676ktoe. Geothermal and hydro also increased, by 27% and 18% respectively. In 1997, EU RES production totalled over 80 Mtoe, an increase of 27% over 1987. This growth pattern has also coincided with more reliable and better smaller applications for renewable energy sources.

The Commission's Green Paper on Renewables has resulted in a Strategy for Renewable Energy, as a result of which high levels of investment are anticipated in renewable energy – an anticipated increase of almost 30% between 1987 and 2010. If this is coupled with funding in research, technology development and demonstration for renewable energy technologies, the prospects for renewable production over the coming years are good. It is essential that Europe's position as a manufacturer, developer and user of RES technologies continues to improve. This will enable the EU both to maintain its leading role and to contribute to fast-growing markets in the EU and elsewhere.

Table 6 - Energy production from RES in EU-15, by sector

	1989	1996	1997	1998	Increase 89/98
Wind	46	417	631	1.037	**2154%**
Solar	146	294	318	347	**138%**
Hydro	21.859	24.814	25.452	26.262	**20%**
Geothermal	2.215	2.747	2.815	2.992	**35%**
Biomass	39.979	47.777	52.552	54.175	**36%**
Total RES primary Energy Production (ktoe):	**64.242**	**76.051**	**84.816**	**84.816**	**32%**
Total RES electricity generation (GWh)	**273.290**	**321.436**	**334.642**	**352.805**	**29%**

The following paragraphs summarise the principal renewable sectors. It should be noted that in all sectors technical progress is constantly changing the scene. Also, pictures differ from member state to member state, depending, primarily, on political and legislative measures.

Hydropower (hydro)

Of all renewable sectors, the large-scale hydro sector is the best exploited and perhaps most mature. Hydro represents about 90% of all EU RES production and supplies some 14% of electricity demand in the EU. Hydro production has continued to rise fairly evenly across the globe and is likely to continue to do so as undeveloped countries tap an almost unexploited potential. Hydropower is a particularly attractive option in mountainous regions. In Europe, however, most economically feasible sites have already been exploited. Although small hydro currently represents only 3% of all hydro production, the main growth in this area is likely to be in small-scale hydro (< 10 MW) for local, decentralised generation.

Small-scale hydro has high efficiency and potentially low installation costs (depending on the size of installation and location). A growth of some 2,500MW is anticipated by 2010. Decreases in head height, variable speed generators, reductions in the cost of equipment and environmental mitigation technologies will enhance the attractions of mini-hydropower.

Wind

Installed capacity for wind energy more than doubled in the 1990's and the potential is for a further dramatic growth. It is estimated that a quadrupling of market potential is possible by 2020 (world-wide the potential growth is even more dramatic). In the long term, and subject to tackling technical and local planning barriers, wind energy could have potential to contribute up to 30 % of the current electricity demand (15% of the overall primary energy in the EU). As new technologies for offshore installations, lighter structures and variable speed generators come on stream, the contribution of wind to the energy balance is likely to grow significantly, with greater capacity wind turbines and large dispersed wind farms. This makes wind energy a potentially powerful instrument in energy supply policy, subject to stability of production and electricity storage or back-up possibilities.

Photovoltaic (PV)

PV production is on a very small scale in the EU. Cost is a decisive factor – installation costs of 5,000 €/kW compared with 1,000€/kW for wind, and production costs – at 0.32€/kWh in Southern Europe - more than 5 times that of wind. Costs in Northern Europe are around twice this figure. PV is not highly dependent on local conditions, providing that there is direct light (not necessarily heat) from the sun.

Installed capacity has not grown as quickly in the EU as in the rest of the world. However, it is estimated that a significant market potential exists – perhaps as high as 2,000 MW in 2010, compared with 52 MW in 1995 and around 200 MW in 1999. Current market growth is around 20% per annum.

The future of PV production in the EU is likely to be decentralised – integration into buildings and multiple purpose installations, or the development of PV kits. PV is very attractive in urban situations where space is limited. Even today, PV is cost-effective in many off-grid applications.

Overall, unless the price can be brought down quickly, PV is unlikely to be a significant contributor to the energy balance in the short term, but will be an important factor in electricity supply in specific local situations. However, its theoretical potential is highly interesting for longer-term supply security, a fact reflected by the interest in PV among energy actors traditionally active outside the renewables field.

Solar Thermal

Solar thermal collectors, which produce low temperature heat for domestic applications face similar economic barriers to PV, although they are less dramatic – a production cost of 0.12 €/kWh and installation costs of 2,500 €/kW. Installed capacity world-wide has rocketed in the 1990's although the rate of growth in the EU has been relatively small. It is particularly attractive to integration into buildings as a replacement for gas or oil in heating or hot water installations. Solar energy has further uses in buildings, such as for lighting and cooling, which can significantly reduce energy demand. Even in northern parts of the EU, its potential for applications in new and existing buildings, including private homes, is enormous.

Biomass

Biomass as an energy source, with or without other fuels (solid fuels/wastes) is now commercial in unit sizes of 10-30MW. Small, decentralised Combined Heat and Power (CHP) applications are of increasing efficiency and importance. Production costs are comparable with wind energy, although installation costs are somewhat higher (1,500 EURO/kW – depending on the plant scale and technologies used). EU capacity did not increase substantially over the 1990's. However, predictions of market growth are positive, not least because of investment in technology development projects. It is estimated that market potential in the EU could rise from 3,862 MW in 1995 to 8,766 MW in 2010. In the long term, Biomass has a theoretical potential of up to 20 % of current primary energy (assuming 20 million ha of arable land for fuel crop with a yield of 6 toe of biomass per ha and the availability of 150 Mtoe of waste biomass).

Future trends are likely to be towards larger unit sizes of 50-100 MW and increases in efficiency of up to 50%. New technologies, including biomass-integrated gasification combined cycled plants, are increasing the efficiency of biomass generation for electricity. Efficiencies of up to 80% are possible in CHP operations. Multi-fuel operations are likely to be enhanced, in particular as the result of incorporating biomass use into CHP installations. A significant proportion of new sources will come from the agricultural sector, in particularly wood fuels and liquid biofuels.

There is a potentially large market for biomass applications in decentralised plants, especially CHP, and for substituting fossil fuel in electricity generation. Also, co-firing biomass in existing and new power plants is economically feasible and has great potential in the EU and beyond. Finally, small-scale applications, e.g. biomass and pellet stoves, could be widely applied in a short time-scale.

Geothermal and Heat Pumps

Geothermal energy depends on similar technology to the oil industry. *"Hot dry rock"* technology aims at "mining" heat of 200–250°C which is available in many places in the EU at a depth of 5,000 m. The installed capacity in the EU has risen gradually in the 1990's and is likely to continue to do so, but the market potential by 2010 is unlikely to exceed 2,700MW, unless costs can be brought down. In order to increase this potential, low enthalpy sources need to be exploited and exploitation of proven reserves must be intensified.

Heat pumps are devices which concentrate renewable energy from the air, ground or water to provide energy for space or water heating. The ratio of heat out to energy in (coefficient of performance) can be as high as 5. Of the 20 million residential dwellings in the EU heated by electricity, potential savings of 200 TWh/yr are possible, and in addition comparable savings could be possible by converting the 23 million dwellings that are oil heated to heat pump systems as well.

Renewable Energy Sources - Conclusions

RES energy is attractive to energy supply for environmental and geopolitical reasons. The raw fuel – sunlight, wind, waste etc - is free or cheap. Renewable energy has the potential to provide a safe, clean and affordable energy supply, without threat of external disruption or exhaustion of reserves. The Commission has set a target to double the share of renewables from 6% to 12% in 2010. However, in order to reach this target, specific and targeted action will be necessary. As well as technical and practical barriers, a major obstacle is the high cost of RES technologies compared to the cost of fossil fuels based technologies. This suggests the need for appropriate financial incentives to promote renewables. Another obstacle is the exclusion of external costs from the price of fossil fuels, coupled with an inheritance of subsidies on the part of conventional energies (including nuclear). This indicates that RES do not compete on an equal basis with conventional fuels. Helped by technology advances, costs in some sectors, e.g. wind, have fallen dramatically over the previous decade and continue to fall.With appropriate investment in the research, development, demonstration and promotion of renewable technologies, for short, medium and long term commercialisation, renewable energy has the potential to help resolve, in an environmentally and economically acceptable way, many issues facing Europe's long term energy supply. In particular, full development of renewable energy sources could play a large part in reducing greenhouse gas emissions from electricity production. However, this would require the early introduction of targeted measures, economic incentives and vigorous marketing.

IV SUPPLY DISRUPTION

Policies in favour of a secure energy supply aim to mitigate risks of short, medium and long term disruption to energy supply. European energy supply faces different forms of risk – physical, economic and environmental. Thus, there may be a *short term* physical disruption or a *longer term*, perhaps permanent, interruption to supplies. Economically, Europe is susceptible to changes in energy prices – as the recent rises in the oil price have shown. Finally, the link between environmental protection and on energy production and use is beginning to be felt in energy supply options.

Threats to energy supply might affect one sector or one geographical area or they may affect several. For example, political tensions in a key supplier might affect oil, gas and/or uranium supplies in the short to medium term by pushing prices up and reducing availability of the raw material. A major nuclear interruption, caused by an accident or technical difficulty, internally or externally, could have wide-ranging implications in the short term. Possible price increases or disruptions to supplies due to uncertain oil markets or the need to transport gas over longer distances are likely to change energy markets definitively. The effects of supply disruption on the economy, society and standards of living are dramatic and long-lived, as the oil crises of the 1970's demonstrated. The recent oil price rises are themselves beginning to create social, economic and political pressures.

For a number of reasons, intervention may be expedient in the event of instability in fuel markets. In the event of threatened or actual supply disruptions, a number of economic, operational and political instruments might be used in order to reduce the risks of disruption or price rises and to mitigate threats to supply. Economically, pricing mechanisms and taxation might be adjusted in order, for example, to move demand away from the source in question. Operationally, the gap in one energy source might be filled with another – for example, using oil pipelines for gas, or replacing networked gas and oil with locally produced renewable forms of energy. Politically, legislative instruments, consumer awareness campaigns (for example to encourage lower consumption) and reserve stocks may be used.

In terms of crisis mechanisms and legislation covering stocks, the experience of the 1970's has meant that the oil sector has been targeted. For EU Member States, these are at two levels of instruments, through the EU and International Energy Agency (IEA).

For the EU, Directive 73/238/EEC[17] compels Member States to be ready to act in the event of crisis, e.g. to put stocks on the market, to restrict consumption and to regulate prices. In addition, Council Decision 77/706/EEC[18] establishes a genuine Community crisis management mechanism: in particular, it enables the Commission to fix in the event of crisis a specified reduction in demand to be implemented by the Member States.

With regard to the IEA, two crisis mechanisms exist currently. The original mechanism IEP (Indicative Energy Programme) of 1974, which includes rules on the use of stocks, reducing demand and, if necessary, the sharing of oil, and the CERM mechanism (Co-ordinated Emergency Response Measures), developed in 1984. CERM requires each state to make an

[17] 73/238/EEC Council Directive establishing the legal Framework for Community response to an oil supply crisis

[18] 77/706/EEC Council Decision of 7 November 1977 on the setting of a Community target for a reduction in the consumption of primary sources of energy in the event of difficulties in the supply of crude oil and petroleum products

effort to restore market equilibrium (reduction in demand, reduction in stock levels, increase in domestic production or a combination of these elements).

These mechanisms recognise the importance of a secure supply of oil to Europe's economy and demonstrate the will of Member States to collaborate in the interests of a secure energy supply.

No Community legislation exists to influence gas markets in an emergency, and the conclusion of the recent debate[19] was that none is currently necessary. However, it is worth noting that, at the national level, some Member States have voluntary and legislative measures at local or national level. An EU committee has recently been established to monitor the situation at European level.

There is no legislation covering stock holding of EU coal, although reporting mechanisms exist. In practice, generating companies keep their own stocks for operational reasons, which together amount to 10-20% of annual production.

Likewise, there is no EU legislation governing uranium stocks. The potential for storing large stocks of uranium is attractive for supply security policy. The Euratom Supply Agency recommends that a sufficient level of stockpiles should be kept in order to face potential supply difficulties resulting from delivery disruptions or changes in market conditions. In practice, this means a minimum level of at least one year of total requirements for natural uranium. This is high compared to the USA, where "just in time" systems have become the norm. Japan on the other hand keeps 3 year inventories. The single market for electricity is likely to put pressure on utilities to reduce their stocks. It is however feasible to stock uranium corresponding to several years of requirements in order to address dependence concerns.

The risks for supply disruption can be minimised by the diversification of supplies by source and by geographical area for sources taken together. (In this respect, dependence on Russia is high for gas, uranium and, in candidate countries, for oil). Studies have shown (e.g. IEA) that, in cases of future shortages, Member States are prepared to buy from other Member States, for example electricity and coal. This suggests that supply security has taken on its own EU dimension.

Supply disruption – Conclusions

There are three types of potential threat to secure energy supplies, economic, physical and environmental. Disruptions to energy supply, whether actual or threatened, whether in one source or one geographical area or several, whether politically driven or caused by bad weather, can have dramatic effects on society and the economy. Thus, the disruptions to oil supply in the 1970's lead to international action to improve supply security, through the (newly created) IEA and the EU. The principles of subsidiarity and liberalisation have underlined the responsibilities of Member States and utilities for govern their own stocks, reserve planning and crisis mechanisms. New crisis management systems may be developed as a result of liberalisation, as the roles of companies and regulators become more clearly defined. Oil is the focus of recent legislation which improved the quality of the EU's strategic stocks. Efforts are currently underway to improve the EU's crisis management system. In gas, a committee has recently been established at EU level to monitor the import position. For uranium and coal, reporting mechanisms exist. In general, the influence of the single market and competition has been to put pressure on utilities to reduce their stockpiles.

[19] Council conclusions on Commission Communication Gas Supply and Prospects…

V ENERGY DEMAND

The previous sections considered supply security from the point of view of availability of raw fuel. The following sections look at the other side of the picture – the function of energy demand in supply security, with a particular focus on electricity, one of the prime customers for primary energy, and energy efficiency. A fuller analysis of energy efficiency potential in the EU is contained in the Commission's Communication from 1998[20].

A Energy Consumption

Energy supply is conditioned by demand for energy. Managing demand is a potentially powerful instrument in preserving finite reserves and mitigating threats to supply. It is worth noting that reduction of demand is a key instrument for coping in a supply emergency (see above). The following tables illustrate the growth in energy consumption since 1990 and the anticipated growth until 2020. The only fuel where demand has fallen over the last decade is coal. Only coal and, after 2010, nuclear are expected to have future falls in demand. The forecast increases in demand for gas and other fuels (mainly renewables) are dramatic.

TABLE 7 - EU: gross inland energy consumption in Mto

	1990	1995	2000	2005 Mtoe	2010	2015	2020
solid fuels	301	238	207	201	182	187	218
Oil	545	576	602	632	650	662	658
natural gas	222	273	338	363	401	429	431
Nuclear	181	201	223	228	227	216	199
Other	65	74	80	85	90	96	102
Total	1314	1363	1450	1509	1551	1590	1608

TABLE 8 - EU: gross inland energy consumption: 1990 = 100

	1990	1995	2000	2005 1990= 100	2010	2015	2020
solid fuels	100	79	69	67	60	62	73
Oil	100	106	110	116	119	121	121
Natural gas	100	123	152	163	181	193	194
Nuclear	100	111	123	126	125	119	109
Other	100	115	124	131	140	149	159
Total	100	104	110	115	118	121	122

[20] COM 98(246) of 29 April 1998 Energy Efficiency in the EU: towards a strategy for the rational use of energy

B Electricity

The electricity sector is one of the main users of primary fuels. It is effectively the only user of nuclear fuel and has become almost the only user of solid fuels. It is also the sector where renewable energy use is most promising. As observed above, the demand for gas in the electricity sector is growing dramatically. The demand for fuel in the electricity sector is particularly affected by three developments: consumer demand for and use of electrical goods, efficiency in electricity generation and efficiency in electrical goods. The cost of raw fuel can have an indirect impact on demand by pushing prices up or down.

a) Trends in demand

Electricity demand follows a growing trend across all sectors and is forecast to continue to do so in the foreseeable future.

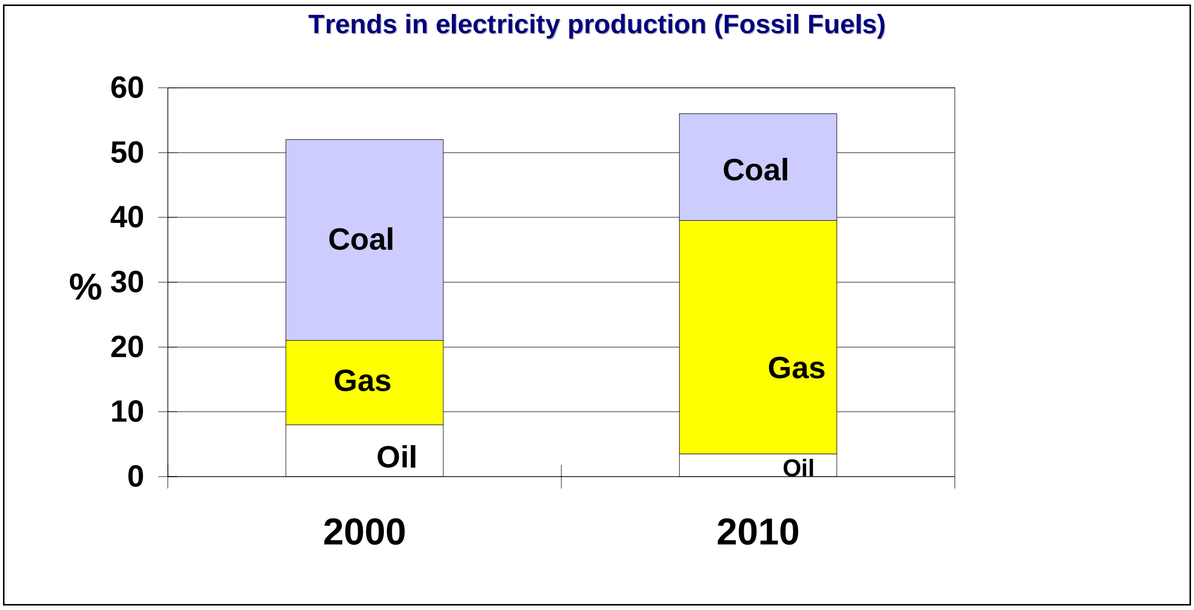
Overall, the EU has seen increases of 2.1% p.a. between 1985-1995 and 1.9% p.a. since 1995. Additional demand for electricity has been partly compensated by improved energy efficiency, for example energy saving light bulbs and better insulation in refrigerators. Improved energy efficiency has been more than offset by a growing demand for electrical goods.

In the present phase of the establishment of the internal markets for gas and electricity, there are signs of restructuring of electrical companies through, for example, mergers, de-mergers, take-overs and diversifying interests. Growing competition could also lead to increased pressure to reduce costs and prices. Overcapacity is likewise being reduced. It could be some years before the situation settles down.

b) Trends in generation

Electricity generation across the globe is rising quickly, including in the EU, in response to growing demand. This trend is likely to be confirmed by enlargement. Nevertheless, the OECD's share of world electricity generation is falling, as demand for electricity is growing more quickly in developing countries.

As far as fossil fuels are concerned, there is clear trend in electricity generation away from oil and coal and towards gas. This trend is likely to be confirmed in the coming years, and emphasised by enlargement. By 2010, it is likely that over 45% of electricity generation will be based on gas, from less than 20% in 2000.



With appropriate political and economic intervention, the contribution of renewables is electricity generation is bound to rise in the short to medium term. Renewables have a considerable potential to generate electricity cleanly, cheaply and locally, but without immediate wide-ranging measures to promote renewables, this potential will only be realised in the longer term.

Currently 8 Member States have nuclear generation. Over the whole EU, nuclear contributes some 35% of electricity production. The future contribution of nuclear to electricity generation will depend over the medium to long term on economical, political and technical developments.

There is great potential for energy efficiency in the electricity generation sector (see also below). In 1996 on average 9% of EU electricity was generated in combined heat and power units (CHP). These are a highly efficient method of producing energy and can combine renewable with conventional forms of energy. Denmark has the highest rate (46%), while in Finland it represents 32%, in the Netherlands 28% and in Austria 21%. This technology has considerable further potential, especially for applicant countries interested in updating their generating plant. An analysis of the potential for CHP and barriers to its development is contained in a Commission document issued in 1997[21].

c) Trends in prices

The electricity price for both domestic and industrial customers is on a downward trend, not least as a result of liberalisation. The trend is likely to continue in the single market due to competitive factors and consumer demand. This is a positive economic development, but presents a challenge to energy supply if demand increases and investment in economic energy efficiency and alternative energy falls as a result.

C Energy Efficiency

Energy efficiency in its wider sense, which here includes energy saving and management of demand, is an important factor in the energy supply debate. Given risks associated with all conventional energy sources, cutting demand and volumes consumed would be a cheap and speedy way of helping to ease pressures on energy supply. It is attractive because it can assure a similar level of economic activity with less fuel, or can absorb increased demand without putting pressure on supplies. It can be economically attractive as it can reduce the need for new plant and has a short pay-back period. It is also environmentally attractive because reduced consumption may mean fewer harmful emissions. It is estimated that 18% of energy consumed in the EU could be saved by simple energy saving efforts (eg switching off appliances when not in use, installing energy saving devices etc. More details of energy saving potential in the EU is contained in the Commission's recent "Action plan to improve Energy Efficiency in the European Community". [22] Shifting from one technology or source to another can enhance energy efficiency. However, it cannot be isolated from wider issues, such as personal mobility and the information society.

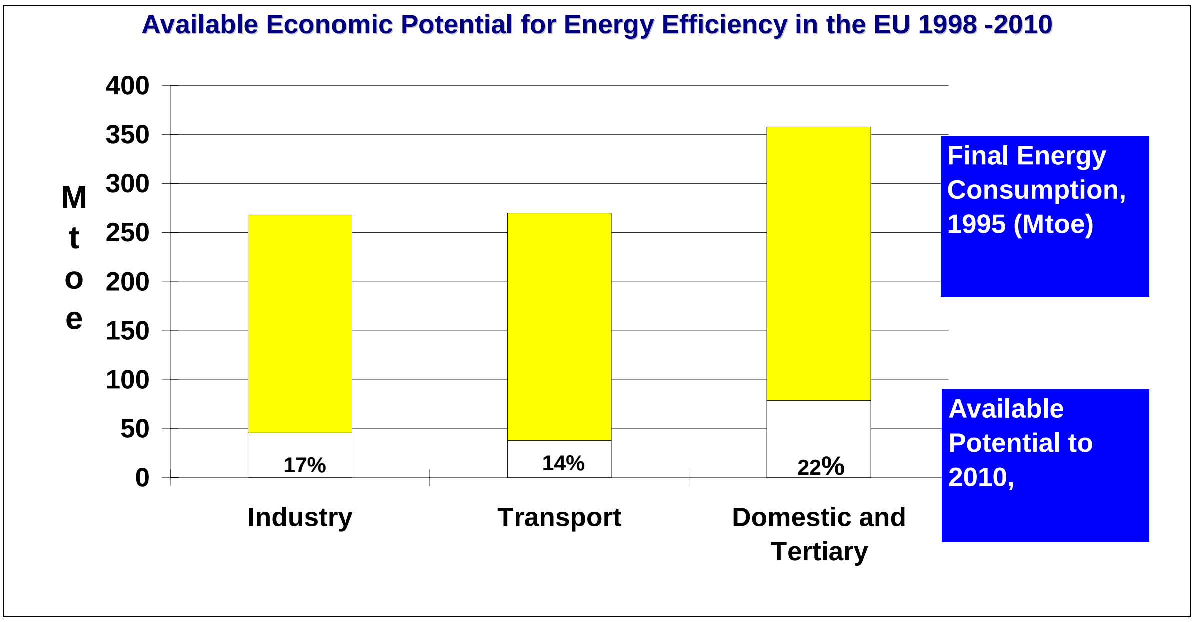
Forecasts of future energy use show that energy demand is on a persistently upward trend. Yet the potential for energy efficiency in energy generation and use is large. Energy efficiency in electricity production has improved and the trend is likely to continue. The EU aims at an improvement of 12% in energy efficiency between 1998 and 2010 (see footnote 21 above). Technologies are already available which might enhance this rate considerably, subject to their attractiveness to consumers. For example, energy saving lighting systems can save up to 50% of electricity bills. New technologies could further improve the picture. An appropriate mix of research and technological development programmes (including demonstration and dissemination), regulations, tax and other incentives and information could have an immediate impact on the efficiency of electricity production. The same applies to energy consumption, which could be reduced by the wider take-up of more efficient products. Enlargement could stimulate

[21] Communication from the Commission on a Community strategy to promote Combined Heat and Power and to dismantle barriers to its development COM(97)514 of 15.10.97

[22] COM (2000) 247 final of 26.04.00

interest in energy efficiency in applicant countries, where plant and machinery will need to meet EU norms.

The impact of energy demand management goes beyond energy supply security issues. For example, action to increase energy efficiency, especially in buildings, could have a positive economic impact in terms of cost savings and employment creation. Likewise, reducing demand in transport could have a positive impact on urban and rural areas.



In April 2000 the Commission presented an Action Plan to improve Energy Efficiency in the European Community (COM(2000)247). In this Action Plan it is pointed out that an estimated economic potential for energy efficiency improvement of more than 18% of present energy consumption still exists today in the EU. This is due to market barriers that prevent the satisfactory diffusion of energy-efficient technology and the efficient use of energy. This potential is equivalent to over 160 Mtoe, or 1,900 TWh, roughly the total final energy demand of Austria, Belgium, Denmark, Finland, Greece and the Netherlands combined.

This Action Plan outlines policies and measures for the removal of these barriers and the realisation of this potential. If the proposed indicative target for improvement of energy intensity by an additional one percentage point per year above the estimated yearly baseline change is met, this could realise two-thirds of the available savings potential by the year 2010. This would result in avoided energy consumption of over 100 Mtoe, equivalent to avoided CO2 emissions of almost 200 Mt/year or around 40% of the EU Kyoto commitment[23]. Meeting the Community-wide target of doubling the use of cogeneration to 18% of EU electricity production by 2010 is expected to lead to additional avoided CO2 emissions of over 65 Mt CO2/year by 2010[24].

The following paragraphs consider energy efficiency in the key sectors of industry (industrial production), transport and buildings.

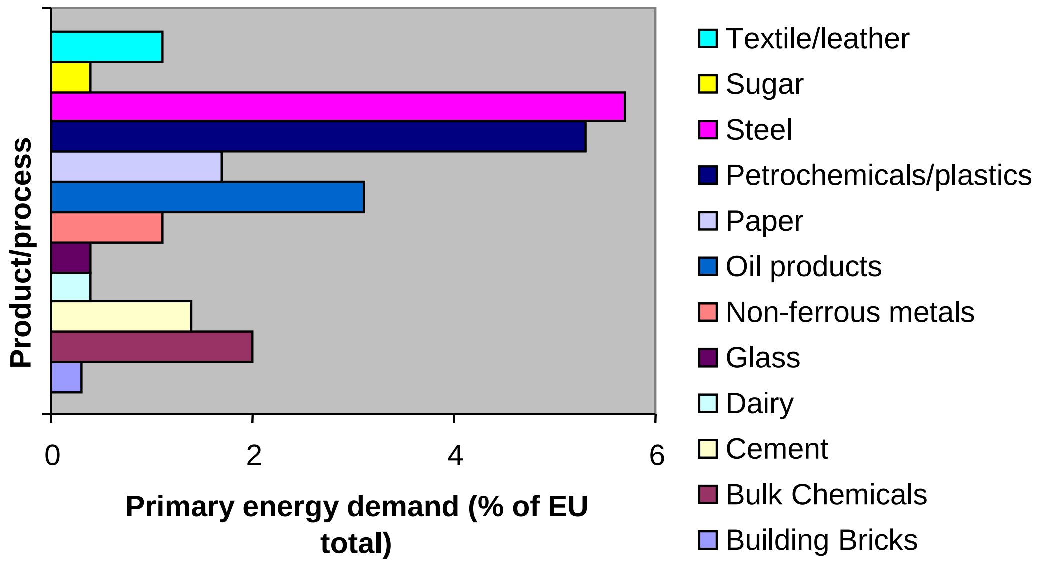
a) Industry

Energy use in the industrial sector in 1998 was 262 Mtoe or around 28% of the annual EU final energy use. It is forecast to rise to 290 Mtoe by 2020. Electricity and heat production represent 8% and 18.6% respectively; 1.6% of total industrial energy use is renewable energy. The two most energy intensive users are the iron and steel and chemical industries which consume 20% and 16.3% of industrial energy use respectively. Around 25% of electricity in industry is produced by industry itself.

23 See COM(2000)247, final of 26.04.00
24 *European Cogeneration Review*, July 1999.

Industry accounts for around 30% of the EU primary energy demand

Large Energy Consuming Industry in the EU



Many sectors have considerably improved energy efficiency over the past 20 years. Dominant market drivers are productivity, product quality and new markets. There is no EU energy efficiency legislation, although some does exist in Member States. The steps which industry has taken have largely been voluntary.

b) Transport

In 1998, energy consumption in the transport sector was 299 Mtoe or around 32% of the EU annual final energy. It is forecast to rise to 379 Mtoe by 2020. In the last 20 years, road share has increased from 30% to almost 50% whilst rail has decreased from 21% to 8%. Current forecasts are that demand will continue to grow, possibly at about the same rate as GDP, with a particular emphasis on road and air traffic. Unlike other sectors, the transport sector is almost completely dependent on a single fuel – oil. It is one of the biggest emitters of CO_2 and CO_2 emissions from transport are forecast to grow by 35% between 2000 –2010 (European Union Energy Outlook to 2020). Energy intensity in transport rose by around 10% between 1985 and 1998.

Transport accounts for around 30% of EU primary energy demand… and is rising

Transport sector energy consumption in OECD countries

	Mtoe 1993-1994	Increase since 1984 (%)
EU	*283*	*36*
CANADA	*47*	*21*
JAPAN	*84*	*47*
USA	*535*	*19*
OECD Total	*1036*	*27*

Energy efficiency in the transport sector has increased significantly since 1970. However, over the same period car passenger miles have more than doubled, and freight miles have almost tripled. By 2020 freight transport is forecast to be more than 50% higher than today. In air transport, which is exempt from the Kyoto protocol and certain energy taxes and legislation, traffic has doubled every eight years since 1960. Air passenger transport is forecast to be 147% higher than tady in 2020 (Shared Analysis). The transport sector consumes more energy (i.e. oil) than it did 30 years ago. Therefore, energy efficiency, although important, is not capable on its own of offsetting growth in demand. A major challenge in the transport sector will be to find ways of reducing energy demand without causing economic damage.

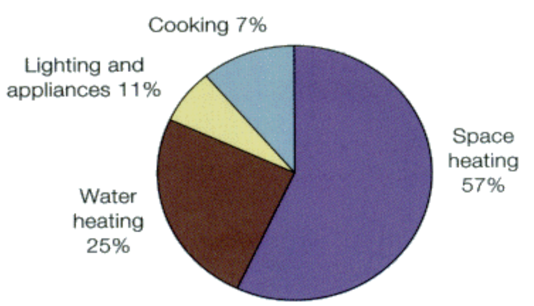
The rise in energy use in transport raises issues not only of supply security and the depletion of finite fossil fuels, but also of climate change, health and the quality of life in towns and the countryside. It has made the transport sector is a key area for technology development and demonstration projects. Road transport is the focus of new technologies. There is still considerable potential for technological based improvements, for example small and lighter cars, low and zero emission vehicles, hybrid cars. However, price and GDP elasticity are limited in this sector and the trend is towards larger cars used for shorter journeys. No significant penetration of other, non-oil-based fuels is expected in the short term. However, in the longer term, the cheaper availability fuel cells and hybrid cars could transform vehicle markets.

c) Buildings

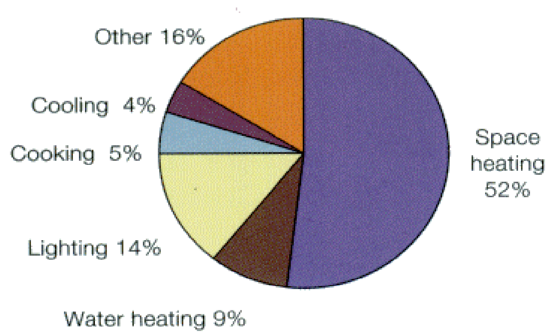
The energy use for 1998 in the building sector amounted to 384 Mtoe or around 40% of the annual EU final energy use. It is forecast to rise to 457 Mtoe by 2020. Electricity forms 10.5% and heat 27.5% (the remaining 2.75% is renewable energy which is predominantly used in households; this value could be increased dramatically with appropriate incentives). Residential use represents 70% of total energy consumption in the buildings sector. The energy use in households is 252 Mtoe and in commercial and public buildings 108 Mtoe, the ratio of electricity to heat is 25% and 68% respectively. Average consumption per square meter is increasing: by 1.3% per annum in the services sector.

Building sector accounts for 40% of total EU energy consumption

Breakdown of energy consumption by end use in EU residential and commercial buildings



Residential (70%)



Commercial (30%)

In the buildings sector, legislation has been very effective at improving energy efficiency in homes and in particular reducing energy intensity in new homes (e.g. improved insulation standards). Likewise, demonstration and dissemination programmes, e.g. programmes to promote solar panels, have increased the use of alternative energies in the home. Biomass district plants and efficient small-scale biomass CHP technologies have also been successfully implemented in some Member States. Great potential still exists for refurbishment of existing stock and domestic equipment and investment in energy efficient appliances, as well as education in energy efficient use. It is generally accepted that 20% of current usage could be eliminated through immediate measures, saving 430 million tonnes of CO_2 per year (Source : Caleb Management Consultants). Existing technologies have the potential to reduce consumption in households and offices by up to 60%.

There is a close link between energy efficiency and the use of renewable energy sources in buildings. In fact some advanced building projects have demonstrated that combining EE and RES best technologies, it is possible to have both commercial and residential buildings in cities not requiring any external conventional source of energy (e.g. electricity, gas or fuels).

Energy Demand – Conclusions

Managing energy demand is an important instrument in reducing consumption, preserving reserves, mitigating supply difficulties and facilitating sustainable growth. EU energy efficiency has gained 7% since 1990, but only 3% since 1993, although economic growth has resumed. In this area minor investments can lead to significant savings in energy and cost. Changes in consumer behaviour could change the energy demand forecasts for the EU completely. Energy efficiency improvements have failed to keep up with growing demand, such that energy consumption has continued to rise. Rising consumption, encouraged by rising purchasing power, increases pressure on energy supplies. In general, reducing demand is not a priority for suppliers of energy or electricity. The risk is that, without new instruments, incentives and promotion of energy efficient products, advances in energy efficiency will continue to slow down and demand for new, more efficient technologies will decline.

Unless energy efficiency improvements keep pace with increased demand, increased demand will lead to higher consumption and greater strain on energy supplies. In so far as they bring prices down, liberalisation and competition could also lead to higher consumption. The recent trend has been that rises in consumption have not been offset by investments in energy efficiency. For example, buildings are gradually better insulated, but other appliances and services, requiring increased energy use often offset efficiency gains. Likewise, road vehicles have improved their efficiency, but cars have become bigger, heavier and with more energy consuming devices. Despite significant increases in petrol prices recently, the number of cars and passenger kilometres is expected to rise. The challenge in this area is to reverse the trend of rises in consumption outstripping gains in energy efficiency.

The enormous potential for energy savings in the buildings and transport sectors indicates the progress which could be made in energy efficiency and reducing consumption if these sectors were to be targeted. However this would require a combination of factors, such as energy prices which reflected wider costs to society, regulations to eliminate inefficient products or practices and consumer education.

VI FUEL- BALANCE

The above analysis considered the main energy sectors in turn, but a key factor in the supply security debate is the balance of fuels in the energy market. This section will give an overview of how the trends observed in energy sectors fit into the overall pattern of energy supply and demand, with a particular emphasis on enlargement.

Of all raw fuel supplied, some is used directly, some is processed into another form of energy and some is simply lost. The flexibility and diversity between the first stage (raw material) and the last stage (useful heat and power) is a key factor in energy supply.

The primary energy form used is significant in economic and environmental terms. Oil, gas and coal create various forms of local and global pollution; the issue of nuclear waste has not yet been resolved; the oil trade balance drains the economy of currency reserves.

The primary energy consumption in the EU amounted to 1315 Mtoe in 1997. The distribution over the different fuels is given in Table 9 below.

TABLE 9 - Shares of primary energy consumption, EU, 1997

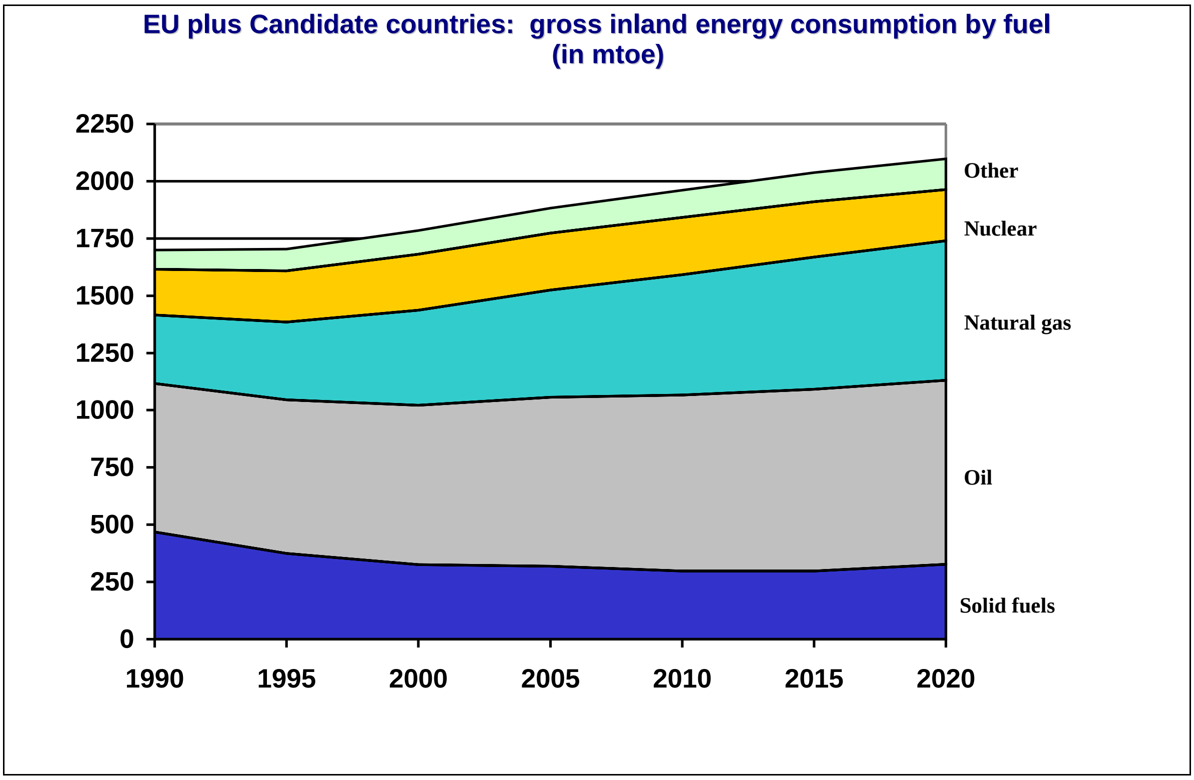
Oil	Nat. Gas	Coal	Nucl. Fission	Renewable
41.7%	21.4%	15.7%	15%	6%

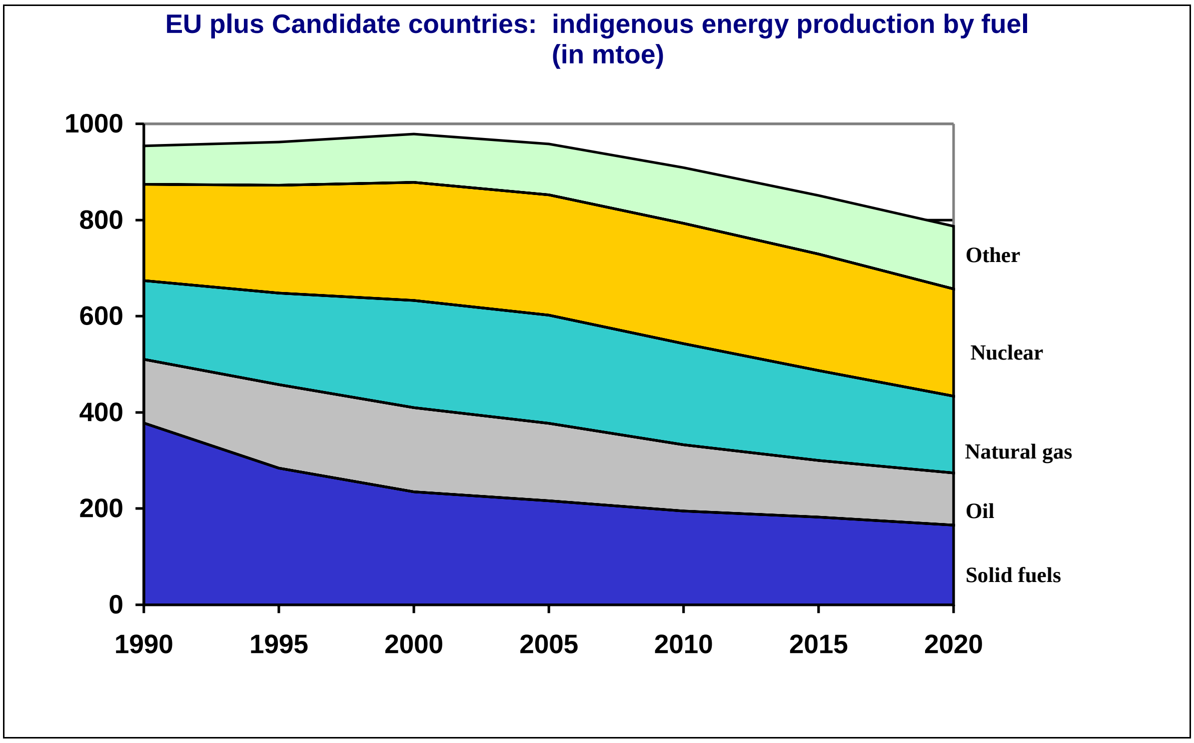
Source: Eurostat

It is unlikely that the EU will be so dependent on a single sector as it was on oil in the 1970's. It is also the case that new networks and decentralised generation have improved supply prospects throughout the EU. Dramatic fuel switches have taken place over the previous 30 years and the same may happen again, particularly if renewable energy achieves a commercial breakthrough. However, the exemption remains the transport sector, where reliance on oil is almost 100% and demand is rising faster than any other sector.

The sectoral analysis above has shown that the current and future growth in energy demand is likely to be spread among all sectors, inland production in all conventional fuel sources is in decline and that greater demands will be put on non-European suppliers for all forms of fuel. The exception to this is renewable energy, where production using indigenous sources is expected to increase. The rate of increase depends on favourable political, economic and social conditions. It is interesting to note that the nuclear sector has grown from nothing over the previous 50 years helped by government support, international treaties and a pro-active supply security policy. Looking towards the future, the measures taken to replace nuclear provision or remove demand will have a significant impact on supply security and the environment. One option, which is being explored by at least one Member State (Sweden), is to incorporate a mix of energy efficiency and renewable energy to replace electricity generated by nuclear. Further study would be needed to see how feasible this model is and how it could be applied in other countries (whether to replace nuclear generation or generation by fossil fuels).

As can be seen, the pattern of rising demand and declining domestic production is similar for an enlarged EU.





In terms of the overall energy balance, competition in energy markets, coupled with environmental pressures, could work in favour of diversification, both within sectors, such as oil, and across industries, e.g. the generating industry. However, one of the most beneficial tools would be energy saving and energy efficiency.

Fuel Balance - Conclusions

On the positive side, it is unlikely that the EU's global energy market will be so dependent on a single sector as it was in the 1970's, when oil accounted for over 60% of primary energy supply. This figure is now down to 44% (although the quantities involved are higher). However, it remains the case that the transport sector's almost complete dependence on oil, coupled with its stubbornly rising demand for oil and, consequently, dollars, is an Achilles' heel for Europe's economy. A further improvement in energy supply prospects is the creation in recent years of new European networks and decentralised generation. Further, the world energy market is now in many ways globally organised and interdependent, the result of which is that market changes affect economies similarly across the globe. Nevertheless, increases in demand are common to all energy sources, in particular imported sources, both across the EU and accession countries. This has serious implications for energy supply security. Therefore, a first step in improving overall energy supply would be to reduce demand. Although security of supply can no longer be seen in terms of independence from external supplies, the EU's control or influence on its energy supply will decrease as its dependence on imports from areas outside its traditional economic sphere grows. Given the common vulnerability of all key energy sectors, it is imperative that solutions should be found which increase diversity and viability of indigenous resources

VII ENERGY TECHNOLOGY

This section provides an overview of some recent technological developments which could have a particular impact on energy supply.

New technology for energy production and use could change the whole supply security debate. Most forecasts and estimates relate to scenarios based on current technologies. These scenarios are likely to be relatively little affected by technological changes in the short term because energy technology generally has a long lead in period. Technologies which today are at the demonstration phase may yet take 5 years to become commercially attractive, in terms of price and proven viability. In addition, the willingness of consumers to invest in new technologies is curtailed by the long lifetime of energy installations or machinery (10-30years). Our ability to anticipate likely technological trends over a longer period (30 years) is limited because energy technology which is currently at a basic stage could become commercial over such a period – or it might be abandoned. Nevertheless, there are technologies under development today which have the potential to completely transform our current appreciation of energy demand and production.

The most conspicuous applications of new technology are in the application of more efficient renewable energy generation and in more efficient products and processes (see sections on Renewable Energy Sources and Energy Efficiency above). This section considers a small selection of examples of technology which could have a dramatic effect on energy supply in the short term (in the case of some clean coal technologies), medium term or long term (over 50 years from now in the case of nuclear fusion). An overview of the priorities for EU energy technology development can be found in the Work Programme attached to the EU's ENERGIE programme[25].

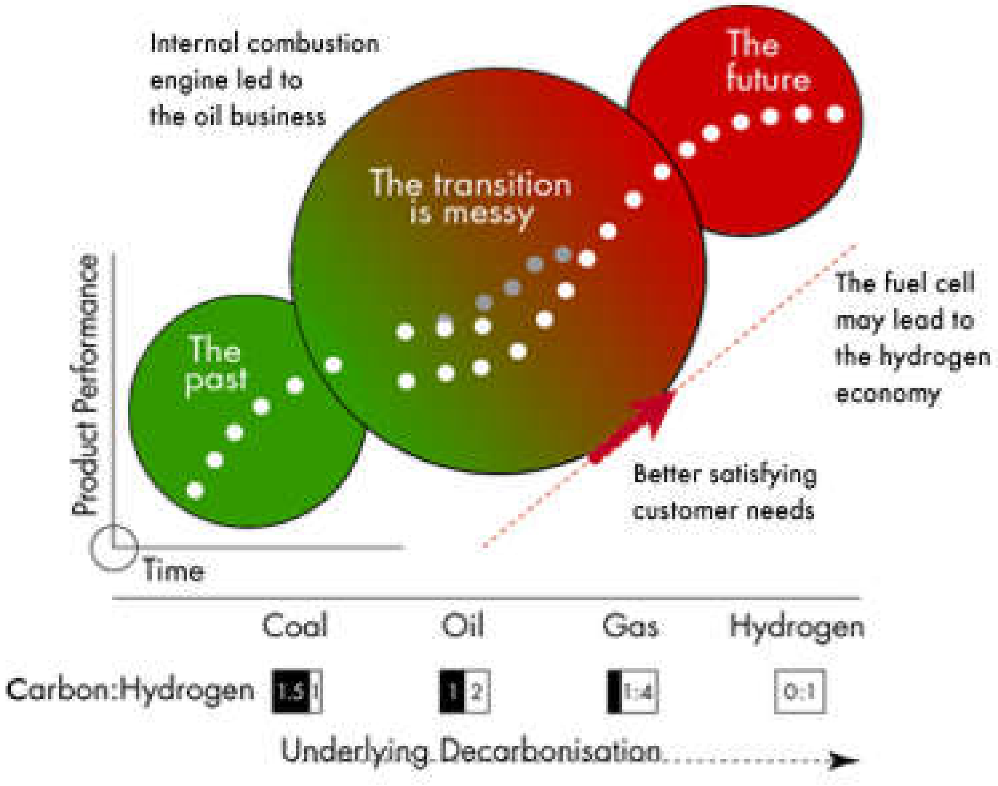
Enlargement could act as a stimulus to further energy technology development. Investment in new plant and services will create new markets for advanced European technologies. However, as with all technological advances, only the first barrier is technological. New procedures and processes also have to tackle economic, social and behavioural barriers. Therefore, the success of many new technologies may depend on other factors than their technical attraction. This is a crucial issue if new technologies will achieve their potential to improve energy supply security.

a) Transition to the hydrogen economy

[25] 99/170/EC – Council Decision of 25 January 1999 adopting a specific programme for research, technological development and demonstration on energy, environment and sustainable development (1998-2002). The part dedicated to energy is known as the ENERGIE programme (formerly Joule and Thermie programmes)

Steam and the internal combustion engine have driven the rapid advances of society and industry in the 20th century. However, these rely largely on fossil fuels which are limited and environmentally damaging. One area of research of interest to supply security and diversification of energy supply is hydrogen exploitation. Hydrogen can play a major role in bringing about clean energy conversion, in particular in combination with fuel cells where the only waste product is water. Further development is needed for smaller cost-effective systems which produce hydrogen from methanol and petrol. Storage and distribution problems present further barriers.

Transition to the hydrogen economy



Source: Shell

The planet is thought to have considerable reserves of gas hydrates, which, if exploitable, could fuel this revolution. However extraction is highly problematic and creates the risk of possible methane leakage. They could offer a very long-term option (in over 50 years).

Subject to technological progress, hydrogen could be to the 21st century what oil was to the 20th. In a fuel cell, hydrogen and oxygen combine to form water and the energy released produces an electric current. The reaction is electrochemical and the potential electrical conversion efficiency is up to three times higher than the useful energy produced by combustion. The conversion from hydrogen to electricity takes place with low emissions, and one application being developed is a replacement to the internal combustion engine. Although we are a long way from the hydrogen energy system, fuel cells could make a contribution by 2010.

In the EU, a major new alliance was formed to commercialise PEM fuel cell technology for transport applications. Two principle systems exist, a direct hydrogen system or reformed one. Each has trade-offs of cost, efficiency, and performance, and there is no consensus yet on which will predominate.

One of the significant challenges to the widespread use of fuel cells is fuel infrastructure. This obstacle can be overcome gradually in the case of captive fleet vehicles with a limited service area, by the use of a central fuel storage and transfer facility.

Progress is being made. It has been forecast (by the industry) that fuel cells for residential and commercial use can become the source of an alternative power supply. Homeowners could thus generate their own power with an appliance in their own house.

It is anticipated that first commercial units will have a 40% fuel efficiency, but the overall efficiency could exceed 70% if the excess heat generated is used for hot water and heating.

b) Decarbonisation

New technologies are being developed for the capture and sequestration of CO2. These could have a significant impact on our ability to continue to use fossil fuels safely and cleanly and may be a factor in achieving climate change commitments. Therefore, their importance to supply security could be significant.

Different systems are being developed, for example, the decarbonisation of fossil fuels, and storage possibilities are being explored, for example in empty oil fields or suitable geological sites.

As with many new technologies, cost is important, and the economic attraction of decarbonisation depends on low oil and gas prices. Other issues, such as environmental and safety implications, require further study.

c) Clean coal technologies

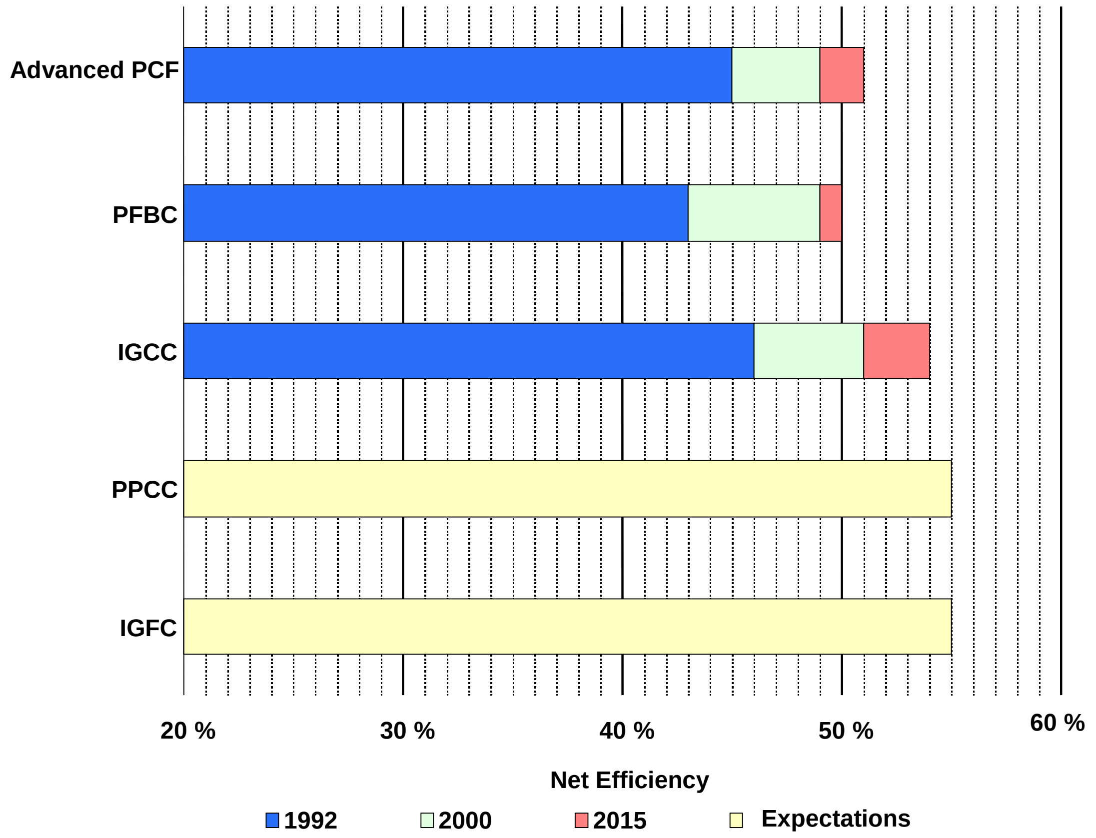
Fossil fuel use can be made cleaner and more efficient by improving the processes for electricity generation from coal. Various different techniques are currently under development, many with support from the EU. As well as coal, biomass generation could benefit from some of these developments.

These technologies, each of which is at a different stage of development, include the following:

- Advanced pulverised coal-fired boilers (PCF)
- Atmospheric fluidised-bed combustion (AFBC)
- Pressurised fluidised-bed combustion (PFBC)
- Integrated gasification combined-cycle systems (IGCC)
- Pressurised pulverised coal combustion (PPCC)
- Integrated gasification fuel cell systems (IGFC)
- Magneto-hydrodynamic electricity generation (MHD).

The attractions of these are the increased efficiency with which they can generate electricity (by up to 50%), the reduction of harmful emissions from generating processes and the combination, in some instances, of fossil and non-fossil fuels for generating purposes. All of these advantages make coal more attractive as a fuel for electricity generation, and thus are of relevance to the security supply debate. Furthermore, these technologies could open up new markets for European industry in other parts of the world.

Net Efficiency of Solid Fuel-Based Power and Heat Generation Technologies



Source – sectoral industry report to the European Commission

d) Gas to Liquids

One of the problems facing long term gas supply identified above was the evelated cost of transport from distant fields. Gas to liquids technology has the potential to reduce costs of transport over long distances by converting natural gas into synthetic crude (a middle distillate fuel).

The technology is based on the Fischer Tropsch process, which has for a long time enabled synthetic oil to be produced from coal. The new process adds oxygen to natural gas, thus producing synthetic gas. The resulting crude can be transported via existing oil pipeline and is particularly attractive for diesel applications. It has the advantage over conventional diesel of far lower emissions. Several major oil companies are currently involved in developing the technology.

e) Nuclear fission developments

Current technological developments relating to reactors concentrate on the simplification of systems and introduction of passive measures, under acceptable conditions of economic viability. Efforts to increase the reliability and safety of generators and to reduce the production cost concentrate primarily on water reactors.

These concepts use advances in well tested conventional technologies with the objective of reducing the probability of a major accident. Several designs accept MOX fuel (EPR, system80+). Passive features are incorporated to varying degrees in many evolutionary and innovative systems. Passive systems do not need active controls or operator intervention in emergency situations; for example thermal convection and gravity are used for several major safety systems such as residual heat removal and containment cooling.

Fast Neutron Reactors (FNR)

Fast breeder reactors make it possible to extract 50 to 60 times more of energy from uranium than with thermal reactors. Under these conditions, current uranium reserves could last for several thousand years.

Although development of sodium cooled reactors reached an advanced stage in the EU, the use of this type of reactor has been stopped, in Europe and the USA, except for Phoenix in France, which is running an RTD programme on transmutation of nuclear waste. Other choices of materials and design could make it possible to reconsider sodium cooling. Other cooling media deserve to be reconsidered, for example other molten metals, such as lead, molten salts or gas.

In particular there is a renewed interest in gas cooled fast reactors (CO2 or helium) as the emphasis moves from liquid-metal cooled systems towards in-service inspection, improved core safety and elimination of liquid-metal coolant chemical hazards.

In addition fast breeder reactors could make it possible to use the thorium cycle of which resources are 10 times more abundant than those of uranium.

High Temperature Reactors

The development of helium turbines better adapted to the HTGR (high-temperature gas reactors) revived interest in high temperature reactors. They can reach a higher efficiency and are appropriate for uses in industrial processes requiring high temperatures.

The designs for this concept are characterised by an increase in the efficiency of the system (about 50%) due to the higher operating temperature and improved fission products retention in the ceramic fuel. Other features include inherent safety, lower quantity of high-level wastes, an easier operation and the potential for the contribution to absorbing Plutonium stocks.

Accelerator Driven Systems (ADS)

Currently ADS is primarily interesting for its potential application for the transformation of waste. At a later date its use for electricity production could be envisaged. There is a wide range of parameters and designs depending on the neutron energy spectrum, type of fuel (solid or liquid), coolant/moderator type and objectives (energy production, transmutation of actinides).

Finally, the *Thorium cycle*, which produces no plutonium and less radiotoxic waste that conventional cycles, is considered as a long term option to simply long-term waste management.

f) Thermonuclear fusion

Subject to technical breakthroughs, nuclear fusion could, in the very long term (over 50 years from now), become an inexhaustible source of energy and reduce considerably the problem of nuclear waste. These long-term prospects have prompted research and development efforts on a European and world scale. They are particularly interesting in the context of stabilising and reducing the production of CO_2 from energy production.

Research on fusion is still to a large extent basic research. Important progress has been achieved during recent years. Numerous scientific questions as well as technological problems will have to be solved before commercial practice could be envisaged. Developments in this field are long and expensive (especially the developments of materials) and require world collaboration between the most industrialised countries. An intermediate stage could consist in the development of a hybrid fusion-fission generator. Such a prototype could be constructed in the shorter term. This approach would also make it possible to develop gradually the technologies necessary for pure fusion. It is also important to stress that the availability of fusion as an energy resource could be limited (while awaiting the use of more fusion reactions than the D-T reaction) by the Lithium and Beryllium resources for the generation of Tritium.

Technology - Conclusions

Technology will be critical in meeting the needs of current and future generations and de-linking economic growth from environmental degradation, both in the present EU and in an enlarged Europe. In the energy field, technological change is not cheap - research is expensive and requires a long development and lead-in period and the pay back is often uncertain. Successful marketing and consumer education are also key factor in their success.

Governments have for many years recognised the need for intervention to provide the right incentives and price signals to firms and influence consumers' awareness and behaviour. Thus, public funding, including from the European Community[26], often has a pivotal role in financing basic research underlying innovation in clean technologies and the support for the development of markets for the substantial stock of more energy-efficient technologies that are close to being competitive.

Energy technology is a useful instrument of energy supply security as it offers the potential to improve energy efficiency, reduce energy intensity and vastly increase the share of clean, durable and renewable energy use. It also has global potential to influence patterns of energy use and production, as advanced European technologies can provide developing countries with more sustainable and less damaging means towards economic growth.

[26] Decision No 182/1999/EC of the European Parliament and of the Council of 22 December 1998 concerning the fifth framework programme of the European Community for research, technological development and demonstration activities (1998-2002)

99/170/EC – Council Decision of 25 January 1999 adopting a specific programme for research, technological development and demonstration on energy, environment and sustainable development (1998-2002)

VIII TRANSPORT OF FUEL IN THE EU (TRANSIT)

Given the increasing dependence of the EU on external sources of energy, the question of transit will become a crucial element of the question of security of supply. In this section, the main challenges for energy transit are considered, and an overview of factors relevant to the EU's major suppliers and routes is presented.

The growing demand of the EU for external supplies of energy will place additional pressure on existing supply routes and necessitate the development of new routes. The prospect of enlargement is likely to place an additional demand on imports from Northern Europe, NIS and Southern Europe (the Mediterranean Region). Currently the systems do not exist to transport the quantities that will be necessary to satisfy this increased demand. Most of the world's energy reserves are at some distance from Europe. The Middle East holds 64% of the world's oil reserves (1998 figures), whereas natural gas is primarily to be found in the NIS (56.7 tcm) and Middle East (49.5 tcm).

The issues of electricity transmission are different to those of oil and gas. They are dependent on local/regional patterns as well as the development of the internal market. In general there is less need for the transit of electricity than for oil and gas. Electricity is not a primary energy source and is less bound by geography in terms of generation, which is usually located closer to the demand source.

a) Challenges for Energy Transit

Political

Political issues are of major importance for many transit routes. As illustrated by the political sensitivity surrounding the Caspian Sea, the conflicting political positions of countries involved in the transit of energy create difficulties and uncertainties which affect transit. In the Middle East, for example, until the end of 1995 every one of 8 petroleum pipelines in the region was shut down at least once since the first was built in 1931. In many cases this was due to political reasons. Another study recorded 27 natural gas "transit events" in the Former Soviet Union between 1.1.92 and 31.12.94. 10 of these were related to negotiations or renegotiations of agreements, 6 threats to supply, 3 irregularities in supplies and 8 actual cuts or reductions in supplies[27].

Iran is acknowledged as a potentially important country for the transit of oil and gas from Central Asian countries to world markets and Libya could be an important source of oil and gas for European markets. Current US foreign policy is against co-operation with these countries.

Financial

One major difficulty facing the development of new transit routes is the capacity to invest in the construction of new routes infrastructure from increasingly remote areas to the EU market, or even maintain and or upgrade existing routes.

Many governments in Eastern Europe have limited means to invest in new gas and electricity capacity. Lack of investment leads to deterioration of existing pipeline systems, which inevitably leads to problems in transmission.

The investment climate for energy transit projects needs to be enhanced, either via new or existing systems. Investors need more confidence in the legal framework in the region concerned. This will reduce the perception of political and economic risk associated with transit projects. Transit contracts are commercial deals, backed up by agreement or treaties between the states involved, and have a major role to play in ensuring safe and reliable transit routes. As well as bilateral agreements between countries or companies, the effect of international agreements, such as GATT or the Energy Charter Treaty, in helping to create a secure investment climate, should not be underestimated.

[27] Observatoire Méditerranéen de l'Energie/Energy Charter Secretariat

International banks are reluctant to increase their lending to emerging markets. Very little financing generally is available to countries such as Russia, and future loans will require government assurances of non-intervention and fulfilment of all past obligations.

Technical

Indications are that changes in the geographical positioning of gas supply and demand will move demand westwards as the EU increases its consumption whereas the supply of gas moves eastwards, as indigenous resources in continental Europe are gradually depleted and replaced by imports, mainly from Russia. The result of this would be that the routes needed to supply the market get longer and longer. The most accessible fields have been developed and are producing. Domestic reserves in the EU will be on the decrease, which combined with rising demand for gas will necessitate increasing imports from outside the EU. For this reason, there will be a need to turn to more distant areas and produce under more hostile circumstances. As a result, production and transportation costs are likely to increase.

However, this supply/demand reasoning has been used for the past two decades and has proved only partly correct. The resource base in Norway, Netherlands and the UK has proved much more resilient than anybody foresaw even 10 years ago. In addition even if the routes needed to supply the market do not get longer (gas will not come further to Europe than it does from Russia today), it is certainly true that the proportion of gas which comes from further away may increase, which will affect its cost.

Social

Social considerations must be taken into account. More aware consumers and the power of public opinion will affect decisions taken on existing and future energy transit routes. In particular, environmental considerations will be key regarding the necessity for increased transit. In the case of electricity, any electricity imported to the EU must be produced respecting adequate safety levels, and especially nuclear safety, and produced in plants respecting generally accepted environmental emission standards.

b) Suppliers and routes

Tables 10 and 11 below provide an overview of the main sources and suppliers of imported oil and gas to the EU. Table 10 covers 99% of EU oil imports.

Table 10 – Oil Transit

Country	Known Resources	Share of EU imports (%)	Main Routes	Comments
Norway	10.8 billion barrels	20		
Russia	49-55 billion barrels (estimates vary)	14	Friendship (Druzhba)	The majority of Russian oil is exported via terminals in the Baltic and Black Sea, however a lack of export routes is a major problem. Black Sea exports must pass through the increasingly crowded Bosphorus Straits. Russian oil is also exported to Europe via the 1.2 million bbl/d capacity Druzhba pipeline.
Saudi Arabia	263.5 billion barrels	12	Two major oil pipelines, the East-West Crude Oil Pipeline, (exports to refineries in the Western Province and to Red Sea terminals for direct export to European markets), and the Abquaig-Yanbu natural gas liquids pipeline.	Saudi Arabia currently has two existing pipelines out of operation: the Trans-Arabian Pipeline, which is mothballed and the Iraqi-Saudi Pipeline, which was closed indefinitely following the Iraqi invasion of Kuwait in 1990. The East-West pipeline system is currently running at only half capacity.
Libya	29.5 billion barrels	9	Amal-Ras Lanuf, Defa-nasser, Hammada el Hamra-Az Zawiya, Intisar-Zueitina, Intisar-Hatiba, Messla-Ras Lanuf, Nasser-Hatiba, Nasser (Zelten)-Marsa el Brega, Sarir-Marsa el Hariga, Waha-Es Sider	Libya's oil fields are connected to the Mediterranean terminals by an extensive network of pipelines. The National Oil Company plans for an expansion of the oil terminal at Az Zawiya. Libya's major expansion plan is the development of the el-Bouri offshore oil field, the largest producing oil field in the Mediterranean, together with Agip-ENI.
Iran	89.7 billion barrels	8		As a transit country, Iran would be a natural transit route for oil exports from Central Asia to world markets. However this possibility is complicated by political considerations and by discussions on the best way of transporting oil and gas to these markets.
Iraq	112 billion barrels	7	The 600-mile Kirkul-Ceyhan (Turkey) pipeline is Iraq's longest operable exports pipeline and has a capacity of around 1 mbd.	Much of Iraq's export capability was lost during the Iran-Iraq War. For example in 1982 Syria closed the 500 mile 650,000 bbl/d capacity Barias pipeline, which was a vital access route to the Mediterranean Sea and European oil markets. In August 1998 Iraq and Syria agreed to reopen the Barias pipeline, however any export via Syria will need UN permission.
Nigeria	22.5 billion barrels	4		Political uncertainty, combined with ethnic violence and unrest, has hampered oil exploitation in the country,

				with frequent production disruptions, although a number of Western countries persevere.
Algeria	9.2 billion barrels	3		Algerian oil is considered under-explored. Proven oil estimates expected to be revised upwards following recent oil discoveries and plans to increase production capacity. Approximately 75 % of Algeria's crude oil exports go to Western Europe: Italy is the main market followed by Germany and France, with the Netherlands, Spain and UK other important European markets.
Syria	2.5 billion barrels	3	250,000 bbl/d export line from SPC's north-eastern fields to the Tartous terminal, with a connection to a refinery at Homs; a 500,000 tons/years refined products pipeline systems linking Homs to Damascus, Aleppo and Latakia; a 100,000 bbl/d spur line from al-Thayyem and other fields to the T-2 pumping station on the old Iraqi Petroleum Company pipeline, and a spur line from the al-Ashara and al-Ward fields to the T-2 pumping station.	Oil output and production is declining continuously due to technological problems, depletion of oil reserves and low oil prices. Without significant new discoveries in the next few years, some believe that Syria could become a net oil importer in the next 10 years. In July 1998 Syria and Iraq reached an agreement on reopening the IPC pipeline, linking the Kirkuk oil fields in northern Iraq with Syria's port of Banias on the Mediterranean. In early March 2000 both the Iraqi and Syrian sections of the pipeline were ready for operation and Syria was using parts to transport its own crude oil to Mediterranean terminals.
Mexico	28.4 billion barrels	2		Pemex, Mexico's state oil company, is the sixth largest oil company in the world. Pemex has a monopoly over all aspects of oil exploitation and distribution. Foreign participation is limited. The US is the main recipient of Mexican oil (of exports of 1.4 million bbl/d, 1.2 went to the US)
Kuwait	96.5 billion barrels	2	Mina Al-Ahmadi (main export port), Mina Abdullah, Shuaiba, Mina Saud	Kuwait exports the majority of its oil to Asian countries, especially Japan. Other oil exports go to Europe and the EU. Foreign companies currently have limited participation in oil production, but Kuwait has hinted that it would like to relax these limitations.
Venezuela	72.6 billion barrels	2		

Table 11 – Gas Transit

Country	Known Resources	Share of EU Imports (%)	Main Routes	Comments
Russia	48.11 tcm	17	Brotherhood (Bratrstvo), Progress, and Union (Soyuz) (28.3 bcm each), Northern Lights (22.64 bcm), Volga/Urals-Vybord (to Finland) (2.83 bcm), Yamal (22.64 bcm), Blue Stream (under construction).	New northern pipelines include plans for infrastructure supporting the new gas producing regions of Yamal and Shtokman. Options for the Nordic area include the Nordic Gas Grid based mainly on onshore pipelines (1997) and the North Transgas, based mainly on direct offshore connection from Russia to the EU via the Baltic Sea (1999). A Finnish-Russian joint venture announced in June 1999 plans to build a pipeline to carry Russian gas via Finland to Western Europe.
Algeria	3.77 tcm	12	Algeria's natural gas pipeline export capacity of 39.05 bcm per year (2000 figures) includes 27.97 Bcm/y TransMed (Hassi R'Mel-Tunisia-Sicily-Italy (Minerbo)), and 10.98 Bcm/y via the Maghreb-Europe Gas (MEG) (Hassi R'Mel-Morocco-Spain (Cordoba)-Portugal (Leiria)	Of Algeria's two main gas export routes, the Transmed and the MEG pipelines, there are plans to add two compressor stations in Algeria and two in Tunisia by the end of 2000 to the Transmed pipeline, which would increase capacity to 28.3 bcm/y (to Italy and Slovenia) and efforts are underway to expand MEG to France and Germany, increasing its capacity to nearly 28.3 bcm/y. In addition, Algeria is developing the In Salah region as part of its plans to increase its gas exports.
Norway	3.96 tcm	11	Europipe I (capacity: 17bcm/yr) Europipe II (21 bcm/yr, commissioned in 1999) Norpipe (19 bcm/yr) Zeepipe (13 bcm/yr) NorFra (16 bcm/yr, commissioned in 1998) Frigg (7bcm/yr)	Europipe I and II and Norpipe land at Emden and supply above all the German market, some gas is also transported to the Netherlands, Luxembourg, Austria (swap with Russian gas) and Czech Republic. Zeepipe brings gas to Zeebrugge in Belgium, France and Spain, while NorFra supplies France and to Italy in the future. The Frigg system is exclusively for gas deliveries to the UK. Norway´s whole gas export capacity is estimated at more than 90 bcm/yr exceeding by far present Norwegian gas exports to Europe (1998: 41.8 bcm).
Iraq	3.113 bcm (plus approx. 4.245 bcm in probable reserves)			In 1996 Iraq produced only slightly more than 3.62 bcm, down severely from peak output levels of 19.81 bcm in 1979. Within two years of the lifting of UN sanctions, Iraq hopes to produce 15.56 bcm of gas and within a decade be producing about 118.86 bcm of gas annually.
Iran	22.98 tcm		Northern Option: Iran-Azerbaijan and/or Armenia-Russia-Ukraine-	Iran has also 15 % of the world's gas reserves, second only to Russia, but the bulk of these reserves are as

			Slovak Republic-EU. Southern option: Iran-Turkey-Greece (with link to Italy) or Bulgaria-Hungary-Austria	yet undeveloped. Suggested solutions to transport gas to external markets include a 25 bcm/y LNG terminal in the Arabian Gulf; a northern option to Azerbaijan and/or Armenia, joining the NIS system towards Bratislava to the EU; southern option routes are to Turkey and under the Bosphorus to the European Continent, through Greece and under the Adriatic to Italy; or through Bulgaria to Hungary and Austria; a combined solution includes a pipeline to the Mediterranean coast of Turkey or the Red Sea coast of Saudi Arabia, with an LNG plant for onward transportation to the EU.
Libya	1313 bcm		Libya - Italy	Potential exists for a large increase in Libyan gas exports to Europe, although currently Spain's Enagas is the only customer. However, plans exist to export large volumes of natural gas to Italy under the West Libyan Development Project. Less well-developed plans include a pipeline linking Egypt and Libya with Italy, and a proposal for a 900-mile pipeline from North Africa to southern Europe.
Qatar	10.9 tcm		Qatar-Kuwait-Iraq-Turkey-Europe (proposed) and Qatar-Saudi Arabia-Jordan-Lebanon-Syria-Turkey-Europe	Qatar has the third largest natural gas reserves in the world (after Russia and Iran). A gas pipeline to Lebanon exists, but a new pipeline is needed from Lebanon to Turkey via Syria.

The availability of gas pipelines will be crucial to the future security of gas supply in the EU. The following table presents a series of new (or partly existing but not operating) gas supply routes to the EU.

TABLE 12 - New gas routes into EU

Route	Comment	State of Play
Turkmenistan-Azerbaijan-Georgia-Turkey-Balkan States	Transcaspian pipeline linking Turkmen and Azeri resources to Turkey and Central Europe	private consortium (Bechtel/ General Electric and Shell) about to carry out feasibility study
Turkmenistan-Iran-Turkey-Balkan States	Upgraded pipeline linking Turkmen resources to Turkey and Central Europe	feasibility study carried out by Shell on behalf of Turkmen government
Iranian LNG terminal – Europe	LNG terminal in the Arabian Gulf	
Iran-Azerbaijan and/or Armenia-Russia-Ukraine-Slovak Republic-EU	Northern option for Iranian gas; existing, but needs rehabilitation and possibly upgrading	
Iran-Turkey-Greece (with a link to Italy) or Bulgaria-Hungary-Austria	Southern option for Iranian gas; new pipeline in Turkey, probable rehabilitation and possibly upgrading of the system in Iran	
Egypt-Libya-Italy or Algeria	Link between Egyptian resources to Europe either directly or via Algeria	proposed by ENI
Egypt-Israel-Lebanon-Syria-Turkey-Europe	Circum-Mediterranean pipeline	proposed by ENI
Egyptian LNG terminal – Europe		proposed by BP-Amoco
Libya-Italy	Link between Libyan resources and Italy	ready to start (ENI project)
Qatar-Kuwait-Iraq-Turkey-Europe	Link between Qatar resources and Europe (in addition to the existing LNG terminal)	proposed by Qatar
Qatar-Saudi Arabia-Jordan-Lebanon-Syria-Turkey-Europe	Link between Qatar resources and Europe (pipeline to Lebanon exists, new pipeline from Lebanon to Turkey via Syria to be constructed)	
Barents Sea (Russian part)–Finland–Sweden–Denmark–Germany, alternatively: LNG terminal	Link between Russian resources in the Barents Sea to the Russian transmission system providing new resources to Russia and the Baltic States	PSA approved by the Russian Duma in October 1999; joint venture with Gazprom, Rosshelf, Conoco, Neste, Norsk Hydro and Total
Barents Sea (Norwegian part, either pipeline or LNG)-Norwegian system-Europe	Link between Norwegian resources in the Barents Sea to the existing Norwegian pipeline system	
Angola LNG terminal		

Transport of fuel into the EU (Transit*)* - Conclusions

The growing demand for external energy supplies will place additional pressure on existing supply routes and necessitate the development of new routes. This has implications for the availability and price of supplies. Secure energy supplies depend not only on the availability of reserves, but also on such factors as the capacity of countries to provide adequate quantities, the willingness of third countries to permit transit, the technical and financial resources to create and maintain transit routes and an international framework which creates stable trading conditions. Therefore, the need to transport energy into the EU gives added emphasis to issues of international co-operation, both between the EU and its suppliers and among suppliers and their neighbours, foreign policy, finance, trade agreements and technical collaboration.

IX CONCLUSIONS AND NEXT STEPS

One of the key aims of EU energy policy is a diverse, secure, environmentally friendly and cost effective EU energy supply. Part of the objective of this document is to set out the background to a European strategy for a secure energy supply.

In general, the EU is increasing its energy consumption. This is perhaps the first issue to be addressed in the interests of supply security. Indigenous production, although growing in some sectors, e.g. renewables, is not keeping pace. The availability of conventional indigenous resources is decreasing for a range of reasons - industrial (coal) or natural (oil, gas and uranium). Therefore, dependence on imports is rising at a growing rate. The exploitation of renewable resources is hindered above all by cost considerations.

Energy supply considerations are coloured by environmental, economic and political developments. Currently, some aspects of policy tend to favour certain forms of energy, e.g. climate change policies might give preference to gas, renewables or nuclear compared to coal and oil; market liberalisation has made gas more popular for reasons of cost; technological developments could tilt the energy balance in favour of renewable energy sources, advanced nuclear energy technologies, fuel cells or “clean” coal. National, local and individual decisions, such the Swedish and German Government’s decision to phase out nuclear power, affect Europe’s ability to maintain a diversified and secure energy supply. The way in which appliances, vehicles and machines are used affect energy demand and thus energy supply. Enlargement will bring additional factors to the supply security debate but is unlikely to influence the overall trends for the short to medium term - increased consumption, growing imports and rising import dependency. In the long term, subject to favourable conditions, renewable energy technologies, new technology combined with energy demand measures could reduce demand and help to provide a cleaner, more diverse and sustainable supply of indigenous energy.

The above technical analysis and discussion provide the basis for the Commission’s Green Paper on energy supply security.