4.7 The testator should also be allowed, subject to certain limits, to choose which law should be applicable to his estate, for example that of his nationality (or one of his nationalities), or that of his usual place of residence.

4.8 Finally, the EESC believes that the Commission's excellent comparative work should be pursued and developed. It should be regularly updated on the Community website and translated into an adequate number of languages to ensure its general usefulness for members of the legal profession, public officials, administrators, and courts dealing with international successions. It should also be structured to include a chapter-by-chapter synthesis clarifying the general principles for European citizens wishing to draft a will with international scope or for their heirs.

4.9 The EESC awaits with interest the results of the consultations already carried out by the Commission or those still to come; it hopes that a general line of approach and more concrete legislative proposals can then be submitted to it for an opinion, and proposes then to examine them in detail, since it considers the issue of wills and successions to be one of major interest for the citizens of Europe; their hopes for a simplification of formalities, greater legal and fiscal certainty and a speedier settlement of international successions, which they expect from a Community initiative, must not be disappointed, whether the circumstances be those of private individuals, businesses, farms or other economic activities where the entrepreneurs or owners wish to ensure continuity after their demise.

Brussels, 26 October 2005.

The President
of the European Economic and Social Committee
Anne-Marie SIGMUND

Opinion of the European Economic and Social Committee on the Current situation and prospects for traditional energy sources — coal, oil and natural gas — in a future energy mix

(2006/C 28/02)

On 10 February 2005, the European Economic and Social Committee, acting under Rule 29(2) of its Rules of Procedure, decided to draw up an opinion on the *Current situation and prospects for traditional energy sources — coal, oil and natural gas — in a future energy mix*.

The Section for Transport, Energy, Infrastructure and the Information Society, which was responsible for preparing the Committee's work on the subject, adopted its opinion 1 September 2005. The rapporteur was Mr Wolf.

At its 421st plenary session, held on 26-27 October (meeting of 26 October 2005), the European Economic and Social Committee adopted the following opinion by 119 votes to 1, with 3 abstentions.

The EESC has recently adopted a number of opinions [1] on energy issues. Since by far the largest share of energy supply still comes from the fossil fuels: coal, oil and natural gas, and the question of resources and the release of greenhouse gases associated with their use has been the subject of political discussion, the present opinion evaluates these 'classic' fuels.

This should be followed by an opinion on 'The EU's Energy Supply: Strategy for an Optimum Energy mix' which builds on and summarises the findings of the series.

The strategic aim of this series of opinions, which an opinion on renewable energy sources and the present opinion bring to a conclusion, is to provide a solid basis for establishing realistic options for a future energy mix.

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[1] See Promoting renewable energy: Means of action and financing instruments (OJ C 108 of 30.4.2004); The issues involved in using nuclear power in electricity generation (OJ C 112 of 30.4.2004); Fusion energy (OJ C 302 of 7.12.2004) and The use of geothermal energy (OJ C 110 of 30.4.2004).

3. Resources, reserves, coverage

4. Energy reserves within the EU — dependence on imports

5. Trajectory of energy consumption in the EU

6. Coal, oil and natural gas in a sustainable energy mix

7. Environmental and climate protection

8. Technological development

9. CO_2 separation and storage

1. **Summary and recommendations**

1.1 Usable energy is the mainstay of our contemporary way of life and culture. It is only its ready availability that has made our present standard of living possible. If the Lisbon Strategy and the Gothenburg and Barcelona Council conclusions are to be implemented, a secure, cheap, environmentally-friendly and sustainable supply of usable energy is absolutely essential.

1.2 At present, the fossil fuels coal ([2]), oil and natural gas are the backbone of the European and global energy supply. Moreover, as they will continue to be important over the next few decades, they remain essential.

1.3 Their extraction and use, however, involves all kinds of harm to the environment, most notably the emission of greenhouse gases — especially CO_2 and methane. We are talking about the depletion of finite resources.

1.4 The use of these vital raw materials has led to Europe being heavily dependent on high-grade imports of them, and this is set to increase in future, particularly as regards oil and, increasingly, natural gas.

1.5 The expected lifetime of world-wide resources and reserves ([3]) of coal, oil and gas is dependent on several factors (economic growth, exploration and technological advances). It still extends over many decades (perhaps even centuries in the case of coal), although in the case of oil, in particular, there could be a drop in reserves and shortage of supply before the middle of the present century. The way the oil markets are going at the moment, there could be virtually unpredictable price hikes, even in the very short term, which could have a considerable impact on national economies ([4]).

1.6 The EU's energy policy must do everything to reduce this dependency over the long term, particularly by taking energy-saving measures, using all fuels more efficiently and making greater use of alternative energy systems, such as renewable and nuclear energies. Continued development of alternative energy systems is particularly important on this front.

1.7 On the other hand, the EU's energy policy must be fully geared to securing the supply and supply routes of fossil fuels, a particular problem here being the political stability of some of the main suppliers. Cooperation with the Russian Federation, the CIS states, countries in the Middle East and regions neighbouring the EU (such as Algeria and Libya) is particularly important in this regard.

1.8 Making greater use of Europe's considerable coal deposits could also help to mitigate this dependency.

1.9 If the European internal market is working as it should and appropriate climate-protection measures are in place, there would be applications for fossil fuels in accordance with their respective characteristics and price and cost levels. This automatically ensures they will be used in a way that is particularly energy-efficient and economical.

1.10 This has produced a situation in which coal predominates in the steel industry and in power plants, while oil and gas are used primarily in producing heat and in non-energy spheres. Oil-based products prevail in the transport sector.

1.11 Natural gas and oil are both more scarce and more versatile and so should be used in the energy mix predominantly for applications — such as fuel for transport and as raw material for the chemicals industry — where the use of coal would involve extra costs, energy consumption and CO_2 emissions.

1.12 Progress in technology must be used to achieve a sustained reduction in CO_2 emissions per product unit (e.g., kg CO_2/kWh, t CO_2/t steel and g CO_2/passenger-kilometre). This requires an improvement in energy efficiency in all areas of energy conversion and application.

1.13 Energy and economic policy needs, therefore, to provide a reliable framework for investment which will lead to improved technology in industry, trade and private consumption.

([2]) Lignite and hard coal.

([3]) See Chapter 3.

([4]) According to a study published in April 2005 by the Goldman Sachs investment bank, the price of oil could be in the early stages of a 'super spike' which could push prices as high as $105 a barrel. A price of $50 a barrel was anticipated for 2005 and $55 for 2006. However, at 29.8.2005 the price was already over $70.

1.14 In the coming decades, Europe will have to increase its power plant capacity by around 400 GW ([5]). If CO_2 emissions and fuel consumption are to be stabilised or reduced, these new plants must have the best available technology.

1.15 In the transport field, every effort has to be made to cut the specific use of fuel (consumption per passenger-kilometre) and to prevent total consumption continuing to rise. This requires technological progress in many areas of vehicle and fuel development, measures to avoid traffic congestion (building of roads and tunnels/routing systems) and a reduction in traffic ([6]). Increased use of electric-powered vehicles, such as electric trains, reduces reliance on oil by allowing diversification in the use of primary energies (coal, gas, renewable energies, nuclear power).

1.16 Improved efficiency in the energy sphere requires increased research and development, especially into power stations which use fossil fuels, which involves both industry and public support measures.

1.17 The Committee welcomes, therefore, the 'Energy' thematic area in the proposal for the 7th research and development framework programme. This should be adequately funded and cover all possible energy technologies. It should particularly include those measures which increase the efficiency of fossil fuel use, as the overall benefits to be had here are particularly great.

1.18 In the case of electricity from fossil fuels, there is also a chance of significantly reducing CO_2 emissions when converting energy, provided CO_2 sequestration and storage procedures (Clean Coal Technology) are used. Developing and testing procedures of this kind is therefore particularly important in the 7th research and development framework programme.

2. **The energy issue**

2.1 Usable energy ([7]) is the mainstay of our contemporary way of life and culture. Its ready availability opened the door to our present-day standard of living. The need for a guaranteed, economical, environmentally friendly and sustainable supply of usable energy is at the heart of the Council conclusions from Lisbon, Gothenburg and Barcelona.

2.2 The Committee has noted on several occasions that supplying and using energy puts a strain on the environment, involves risks and depends on unforeseeable and external political factors. None of the options and technologies which could contribute to future energy supply is technologically perfect, entirely free of adverse effects on the environment, suitable for all needs, and offers predictable pricing and availability over the long term. Added to this are the questions of diminishing reserves and resources with all that this entails. This difficult situation will be significantly exacerbated by the increase in the world's population, the increasing thirst for energy of the developing countries and, above all, the rapidly increasing energy needs of the big new industrial nations, such as China, India and Brazil.

2.3 A secure, long-term, environmentally sound and competitive energy supply must therefore remain a major goal of a forward-looking European energy policy. For the reasons given, this cannot rely on a few energy sources alone. Instead, the only way of countering energy shortages and other risks is through an energy mix that is diverse in type and origin and in which all available fuels and technologies are used and (further) developed so that eventually they can compete among themselves under accepted environmental conditions and in changing circumstances.

3. **Resources, reserves and coverage**

3.1 At the present time, around four-fifths of the world's energy supply — and that of the EU of 25 — is based on the use of the fossil fuels oil, natural gas and coal.

3.2 Forecasts of future development generally differ according to point of view and interests, given that they depend on assumptions about future demographic and economic developments, further advances in exploration and development techniques and the wider political circumstances in this or that country. This applies particularly to nuclear energy and to backing given to renewable energies.

([5]) Each block of a typical modern power station can produce up to 1 GW of electricity. One GW (gigawatt) equals 1 000 megawatts (MW), 1 million kilowatts (KW) or 1 billion watts (W). One watt second (Ws) equals 1 Joule (J), a kilowatt hour (kWh) therefore equals 3.6 million joules (or 3.6 megajoules (MJ)). One megajoule (M) is therefore around 0.28 kilowatt hour.

([6]) On the importance of reducing traffic and avoiding unnecessary transportation, see also CESE 93/2004.

([7]) Energy is not actually consumed, but merely converted and, in the process, used. This happens through conversion processes such as coal combustion, the conversion of wind energy into electricity, and nuclear fission (conservation of energy; $E = mc^2$). However, the terms 'energy supply', 'energy production' and 'energy consumption' are also used.

3.2.1 According to the reference prognoses ([8]) issued in 2004 by the International Energy Agency in Paris and the US Department of Energy's Information Administration (EIA), even 25 years from now, these fossil fuels will still account for over 80 % of the world's energy consumption.

3.2.2 The contribution of renewable energies will grow, but not at a rate above that of energy consumption, according to IEA and EIA estimates; their share will thus remain constant. If present trends continue, nuclear energy is also expected to take a slightly larger share in supply in absolute terms, but again, assuming the broad policy conditions do not radically change at EU level, the increase will be below the overall trend in consumption. As a result, the IEA and EIA are now even anticipating a decline in nuclear energy's share in covering the world's energy consumption.

3.2.3 The European Commission's baseline scenario ([9]) for the EU-25, published in September 2004 and at variance with the worldwide trend as seen by the IEA and EIA, envisages an increase in the share of renewable energies in the EU-25's total energy consumption from today's 6 % to 9 % in 2030. However, as this estimate also sees a reduction in the share of nuclear energy in the EU-25, the Commission's baseline scenario equally concludes that, in the EU-25 too, fossil fuels will still account for over 80 % of the total energy consumption in 2030.

3.3 Fossil fuels are non-renewable raw materials. The potential of fossil fuels needs to be examined in order to estimate how long oil, natural gas and coal can retain their key role.

3.4 This requires definition of terms and units of measurement. The terms used are reserves, resources and potentials. A variety of measurements ([10]) are usually used for energy sources, such as tons or barrels for oil, metric tons or tons of coal equivalent for coal and cubic metres or cubic feet for natural gas. They are compared in terms of their energy content, measured in joules or watt seconds.

3.5 The Estimated Ultimate Recovery (EUR) is the total recoverable amount of energy raw materials present in the earth's crust before exploitation by man. Not all experts necessarily agree on this estimate. The better we know the earth's crust, however, and the more sophisticated the investigative techniques, the more the prognoses converge.

3.6 Only the recoverable part of resources is included in the Estimated Ultimate Recovery. This depends, however, on the available technologies and their cost-effectiveness and could therefore increase as these continue to be developed. The remaining potential is obtained by subtracting from the EUR the amounts already recovered.

3.7 The remaining potential comprises reserves plus resources. By reserves are meant those amounts of energy raw materials which have been confirmed and can be economically recovered with currently available technology. By resources are meant both those amounts of an energy raw material which either have been confirmed but cannot yet be economically and/or technologically recovered and those which, although they have not been proven, are anticipated on the basis of geological indications.

3.8 It is reserves which are at the forefront of public debate, because it is from these that the coverage of energy sources is derived. By dividing reserves by current annual consumption, we get the 'static lifetime'. This gives us a static lifetime for resources worldwide of around forty years for oil, around sixty years for gas and around two hundred years for coal.

3.9 However, the reserves and their static lifetime are by no means fixed amounts. In reality, a decline in the static lifetime of reserves triggers more intense exploration, which results in resources being converted, not least thanks to technological progress, into reserves. (Thus, for example, in the 1970s the static lifetime of oil was put at thirty years.)

3.10 The statistically proven resources of oil are around twice the size of the reserves, of natural gas and coal as much as tenfold the reserves.

3.11 A further indicator of future availability of fossil fuels is the already recovered share of the EUR. If this exceeds 50 %, and thus the Depletion Mid Point is reached, it will be difficult to increase recovery or even to maintain it at the same level.

([8]) (IEA) World Energy Outlook 2004, p. 57: 'Fossil fuels will continue to dominate global energy use. Their share in total demand will increase slightly, from 80 % in 2002 to 82 % in 2030'.
(EIA) International Energy Outlook, April 2004, [http://www.eia.-doe.gov/oiaf/ieo/]: The *IEO2004* reference case projects increased consumption of all primary energy sources over the 24-year forecast horizon (Figure 14 and Appendix A, Table A2).

([9]) (EU-Commission), [http://europa.eu.int/comm/dgs/energy_transport/figures/scenarios/doc/chapter_1.pdf], EU-25 energy and transport reference case to 2030 (baseline): page 9, table 1-8.

([10]) 1 kg oil = 42.7 MJ; 1 kg TCE = 29.3 MJ; 1 m^2 gas Hu = 31,7 MJ (for joules (J) und megajoules (MJ) see footnote 3).

3.12 **Oil**: More than a third of 'conventional' oil's EUR of 380 billion tons oil equivalent has been recovered so far. At present recovery volumes, half of the conventional potential would be used up in around ten years. Any increase in recovery after that would mean turning increasingly to non-conventional deposits (heavy oil, oil sand, oil shale). This would put back the Depletion Mid Point. Otherwise, there could be a drop in reserves and a drastic fall in supply ([11]) even before the middle of the present century.

3.13 **Natural gas and coal**: the position is similar in the case of natural gas, where non-conventional deposits such as gas hydrates can also increase the remaining EUR. In the case of coal, the estimated EUR of 3 400 billion tons of oil units, only around 3 % has yet been recovered.

3.14 However, exploration for gas (methane) hydrates and the technology for recovering them are still at the research stage, so no reliable claims can be made about how much they can contribute to the energy supply. On the one hand, there are estimates that the potential supplies exceed all the known supplies of fossil fuels, while on the other, nothing is certain concerning their recovery (basically technology and costs). Moreover, their release — whether due to climate change or the actions of man — is seen to involve an element of uncertainty, or even risk, as this could produce an accumulation of the powerful greenhouse gas methane in the atmosphere, which would be extremely damaging to the climate.

3.15 The costs of recovering fossil fuels differ greatly. Depending on the deposit, those for **oil** currently stand at between 2 and 20 USD a barrel. Although ever smaller deposits have to be developed in increasingly difficult geological and geographical conditions, these cost increases can be offset, or even more than offset, by gains in productivity, mostly based on technological innovation. In the case of **natural gas**, too, there are corresponding differences in recovery costs. In the case of **coal**, costs very much depend on the depth of the deposit, seam thickness and also whether it can be recovered by opencast or only deep mining. The cost range is considerable, from a few USD/t (e.g., in Powder River Basin in the USA) to 200 USD/t in the case of mining in certain European coalfields.

3.16 The regional distribution of fossil reserves, particularly those of oil, is also very uneven. 65 % of **oil** reserves are in the Middle East. The distribution of **natural gas** is only slightly better, with two key regions, the Middle East (34 %) and the successor states of the USSR (39 %). **Coal** reserves, on the other hand, are more evenly distributed. The largest coal reserves are in North America and there are also large coal supplies in China, India, Australia, South Africa and Europe.

3.17 The concentration of strategically important fossil fuel sources — especially oil, though also natural gas — in geopolitically high-risk regions of the Middle East is particularly problematic for the security of the energy supply.

4. Energy reserves within the EU ([12]) — dependence on imports

4.1 Primary energy consumption in the EU of 25 in 2004 was around 2.5 billion tons of coal equivalent or around 75 exajoules (75 x 10^{18} joules). This corresponds to 16 % of the world's energy consumption of 15.3 billion tons of coal equivalent. At 5.5 tons of coal equivalent, the per capita consumption of energy in the EU of 25 is more than double the world average, albeit only half that in North America. In terms of the economic performance it produces, energy consumption in Europe is only around half the average in all non-European regions, as energy is used here substantially more efficiently than in many other parts of the world.

4.2 The most important energy sources in the EU of 25 in 2004 — measured in total primary energy consumption — were mineral oil at 39 %, natural gas at 24 % and coal at 17 %. Other important staples of the EU energy supply are nuclear energy at 14 % and renewable and other energy sources at 6 %. The shares of the various fossil energy sources differ widely among the 25 Member States. They range in the case of natural gas from 1 % in Sweden to almost 50 % in the Netherlands, in the case of mineral oil from less than 30 % in Hungary to two-thirds in Portugal, and in the case of coal from 5 % in France to 60 % in Poland. The main reason for these differences is the different size of fossil energy reserves in the individual Member States.

4.3 The total energy reserves of the EU of 25 are comparatively tiny at around 38 billion tons of coal equivalent. This is 3 % of worldwide reserves, if non-conventional hydrocarbons are included. Coal supplies (lignite and hard coal), at 31 billion tons of coal equivalent, account for the bulk of this and are roughly equally divided between lignite and hard coal. Natural gas reserves stand at 4 billion tons of coal equivalent and oil reserves at 2 billion tons of coal equivalent. For the foreseeable future, the EU will remain the world's largest net energy importer. According to European Commission estimates, this dependency will increase to more than two-thirds by 2030.

([11]) Indeed, the current crisis in oil prices, which continues to deteriorate, suggests matters could come to a head much earlier.

([12]) World Energy Council, Energie für Deutschland, Fakten, Perspektiven und Positionen im globalen Kontext 2004 Schwerpunktthema, 'Zur Dynamik der Öl- und Erdgasmärkte'.

4.4 The distribution of fossil energy reserves among the EU of 25 is very uneven. Oil supplies are concentrated particularly in the British and then the Danish North Sea. They are substantially depleted, so recovery will fall. Gas reserves are mostly concentrated in the Netherlands and Great Britain, while those of coal are distributed above all among Germany, Poland, the Czech Republic, Hungary, Greece and Great Britain. Norwegian oil and gas reserves also play an important role because, although not a member of the EU, Norway is a member of the European Economic Area.

4.5 Given the low reserves of fossil fuels generally, the EU of 25 already has to import half of its energy needs. According to the European Commission's Green Paper, this will increase to 70 % by 2030. Dependence on imports is particularly high in the case of crude oil, with more than three-quarters of needs covered by imports from non-EU countries. Imports of natural gas stand at 55 %, and of coal at one-third.

4.6 This has led to Europe being heavily dependent on imports of the vital raw material 'energy' (especially oil and, increasingly, gas) and it is set to be even more dependent in the future. The EU is, in fact, the world's largest net energy importer.

4.7 This means that the EU's energy policy must be fully geared to securing the supply and supply routes of fossil fuels, a particular problem here being the political stability of some of the main suppliers. Cooperation with the Russian Federation, the CIS states, countries in the Middle East and regions neighbouring the EU (such as Algeria and Libya) is particularly important in this regard.

4.8 But, equally, the EU's energy policy must also do everything to reduce this dependency over the long term, particularly by using all fuels more efficiently and making greater use of alternative energy systems, such as renewable energy (including development and brining to market) and nuclear energies. Continued development of alternative energy systems is particularly important on this front.

4.9 Against this background, making greater use of Europe's considerable coal deposits could also help to mitigate this dependency, particularly as far stricter environmental standards already apply to coal mining here than in other parts of the world.

5. **Trajectory of energy consumption in the EU**

5.1 The trajectory of energy consumption in the EU of 25 is set to follow the baseline scenario set out in the Commission's 'European Energy and Transport Scenarios on Key Drivers' [13] which assumes the continuation of current trends and policies. Its prognosis follows.

5.2 Primary energy consumption will rise by 2040 to 2.9 billion tons of coal equivalent — a mere 0.6 % p.a. However, GDP is expected to rise by 2.4 % p.a. up to 2030. The reduction in energy intensity (ratio of energy consumption to GDP) of more than 1.7 % p.a. (!) that this requires should be achieved through structural changes, improved energy efficiency and the introduction of advanced technologies.

5.3 The share of fossil fuels in covering primary energy consumption will even increase by 2 percentage points, to 82 %, by 2030.

5.4 **Coal**: After an initial downturn, coal consumption is expected to rise again around 2015 as the result of its improved competitiveness in electricity production. Rising gas prices and the anticipated availability of advanced coal-to-electricity conversion technologies are the main reasons for this development. On this assessment, coal consumption in 2030 will match that for 2000. Coal's share in primary energy consumption in the EU-25 will then be around 15 %, as it was in 2005. As a downturn of 40 % in coal extraction in the EU is expected in the period 2005 to 2030, together with an increase in coal imports of around 125 %, the share of imports in covering the EU-25's coal consumption will rise from 1/3 in 2005 to almost 2/3 in 2030.

5.5 **Oil**: As growth rates are then expected to be sluggish — at 0.2 % p.a. -, oil's share in primary energy consumption is expected to fall in 2030 to 34 % — 5 percentage points lower than today.

5.6 **Gas**: At 2.7 % p.a., growth in gas consumption will initially be buoyant up to 2015. This trend will then slacken, for reasons which include reduced competitiveness in electricity production compared with coal. However, gas is expected to experience the strongest increase in consumption of all fossil fuels for the entire period to 2030. The share of natural gas in the EU-25's primary energy consumption will increase from 26 % in 2005 to 32 % in 2030. Liquefied natural gas (LNG) enables diversification of gas sources, as it can be transported by sea. At the present time, LNG accounts for around 25 % of world trade in oil. Indonesia is the largest LNG exporter, followed by Algeria, Malaysia and Qatar.

[13] European Commission, Directorate-General for Energy and Transport, September 2004.

5.7 Recovery of fossil fuels in the EU of 25 will fall by around 2 % p.a. up to 2030. This will increase reliance on imports of all fossil fuels by that year to more than two-thirds. As already mentioned, in 2030 import levels for coal will be at almost two-thirds, for gas more than 80 % and for oil almost 90 %. Particularly critical is the growing dependence on gas imports from a restricted number of suppliers.

5.8 Electricity consumption will grow to 2030 by an average of 1.4 % p.a. This will increase the demand on power station capacity from today's c. 700 GW (maximum electrical capacity) to c. 1 100 GW in 2030. Old power stations will also need to be replaced with new plants. The Commission's estimate in its baseline scenario is that the expected increase in capacity will come from an increase of around 300 GW in fossil energies and around 130 GW in wind, hydro and solar energies, while nuclear plant capacity is expected to decrease by 30 GW between 2005 and 2030, failing any lasting change in overall policy.

5.9 There will thus be great challenges and much work to be done in supplying the EU's energy over the next 25 years, though these could also bring economic opportunities. They include ensuring supply (including reducing import dependency), meeting growing environmental demands, guaranteeing the competitive price of energy and making the needed investments.

6. **Coal, oil and natural gas in a sustainable energy mix**

6.1 Coal, oil and natural gas are natural hydrocarbons produced over millions of years through a transformation from biological substances — deposited biomass; in effect, then, it is deposited solar energy. Different geological conditions in their formation (e.g., pressure, temperature and age) have resulted in different products. An important distinguishing feature is the fuel's hydrogen content. Natural gas has the highest ratio of hydrogen to carbon at 4: 1, while that of oil is 1.8: 1, and of coal 0.7: 1. This in large part determines the various applications to which these fossil fuels are put.

6.2 As yet there is no alternative to the use of coal, oil and natural gas as fuels, as the raw material for making many products (from medicines to common synthetics) and as a carbonaceous reducing agent for iron and steel production. However, their specific physical and chemical properties (state, hydrogen content, carbon content, ash content, etc.) make them particularly good for many applications and less so for others. Economic, technological and environmental criteria determine the choice of the hydrocarbon to be used.

6.3 Around 7 % of fossil fuels consumed in the EU are used for 'non-energy' consumption, i.e., mainly the production of chemical products. At the beginning of the last century reusable materials — initially ones derived from coal — were the basis for the newly emerging branch of manufacturing. Since then, hydrocarbon reusable materials have been almost completely edged out by natural gas and oil products. Oil and natural gas will continue to dominate in this segment of the market in future for as long as supplies remain. The lifetime of oil and gas reserves would be significantly longer if these fuels could be used less for producing energy and heat.

6.4 The established process for the production of basic oxygen steel is the carbon-based blast furnace/converter route. The blast furnace process requires the use of coke as a reducing agent for the production of pig iron, where it also serves as an insulator and for the gas supply system. At 475 kg per ton, the average consumption of reducing agent in modern European plants is close to the minimum that is technologically possible.

6.5 The transport sector is still experiencing high growth rates. This sector accounts for around 25 % of energy consumption and road transport is almost entirely dependent on oil products. Liquid fuels have a high energy content per unit of volume or mass. This is the prerequisite for economical and efficient application in the transport sector, which is why liquid fuels and their infrastructure have established themselves in road transport. Increased use of electric-powered vehicles, such as trains, reduces reliance on oil by allowing a range of primary energies to be used (coal, gas, renewable energies, nuclear power).

6.6 Competing with oil-based liquid fuels are natural gas and liquefied natural gas (LNG) used directly as a fuel. It remains to be seen whether these product lines will be able to secure greater market share ([14]).

6.7 Households and small consumers require around 30 % of energy. The choice of energy source is based on economic criteria and is increasingly dictated by convenience and the environment. In this sector heating oil, natural gas, electricity — and in populated areas district heating from combined heat and power plants — are in competition with one another.

([14]) The same is true for liquid fuel from biomass, which so far has only been marketable thanks to high subsidies.

6.8 40 % of the EU's energy consumption is converted in power stations to electricity and heat. Technologically speaking, coal, oil and natural gas — as well as nuclear energy — are all equally suited for conversion into electricity. In technologically highly efficient power stations, natural gas can provide an efficiency (in converting primary energy into electrical energy) of almost 60 %. For hard coal the figure in modern plants is between 45 % and 50 %, and for lignite 43 %.

6.9 Around 40 % of the world's electricity needs and around 30 % in the EU are derived from coal. Around 63 % of the world's coal production is used to provide electricity: coal is more economical than oil or natural gas in providing electricity and is reliably available all over the world from widely diversified areas of production.

6.10 The aim is to concentrate the use of coal on steel and electricity production and so get a fossil fuel energy mix which combines economic benefits, environmental protection, security of supply and protection of resources. Worldwide supplies of coal are substantially greater than those of oil and natural gas.

6.11 The broad policy conditions should therefore provide incentives to use natural gas and oil, which are both relatively scarce and relatively versatile, predominantly for applications — such as fuel for transport and as raw material for the chemicals industry — where the use of coal (as well as of nuclear power and, to some extent, renewable energy sources) would involve extra costs, technology and energy consumption — and hence more CO_2 production! The depletion of these reserves could thus be postponed to the benefit of future generations.

6.12 This would also mean incentives for the use of coal (and renewable and nuclear energies) in power stations for generating electricity, so that oil and natural gas would not be needed (see also point 8.12). Europe has available, in central and eastern Europe, considerable supplies of hard coal and lignite. These reserves can be used to prevent the EU's dependence on energy imports increasing further.

7. **Environment and climate protection**

7.1 Environmental analyses and comparisons of fossil fuels must cover the entire production and application chain: extraction and recovery of raw materials, transport, energy conversion and end use. All of these steps involve more or less major effects on the environment, as well as energy losses. In the case of imported fuels, those environmental effects which arise beyond the EU's borders also need to be taken into account.

7.2 Different environmental effects need to be taken into account in the recovery/production of coal, oil and natural gas. In the case of coal mining, depletion of the landscape needs to be limited, as do dust emissions. In the case of drilling and recovery of oil the leakage of oil and natural gas, as well as by-products, needs to be prevented; the same is true for recovering natural gas and for the related pipeline or tanker transportation of oil and natural gas. Special precautions are needed in the case of offshore production. The methane produced in oil recovery should not be burned off, but put to industrial use. Something similar applies in the case of coal mining to the fire damp produced, which can contain large amounts of methane.

7.3 The European Large Combustion Plant Directive sets strict environmental standards for the building and running of power stations with a performance of ≥ 50 MWth. Concentrations of pollutants in discharge gas from gas, oil and coal-fired power stations must be limited to the state of technology as determined in this Directive. Older plants are to be modernised. This should ensure that the emissions of dust (and fine dust, see 7.6), sulphur dioxide, nitrogen oxides and, above all, harmful heavy metals and toxic or carcinogenic organic substances are reduced to a tolerable level for nature and people. Noise levels must also be pre-emptively reduced to a level at which harm is avoided as much as possible.

7.4 Coal contains non-combustible substances which are separated (in electric or fabric filters) as ash following the combustion process in a power station. The ash content of hard coal is normally up to 10 % (and occasionally as much as 15 %). Depending on the composition, ash is used as an extender in the cement industry and road building or used for mine and land filling.

7.5 Oil also has a proportion — albeit small — of ash. When oil is processed in the refineries, the ash (which includes parts of vanadium and nickel) remains in a solid state known as petroleum coke. It is then used for its residue energy in power stations and combustion plants which have the necessary purification equipment for separating all the pollutants.

7.6 For a number of years now there has been intensified discussion of fine dust emissions ([15]). These are respirable suspended dust particles which are smaller than 10 µm and could be a trigger for respiratory diseases. Such particles are also emitted by oil and coal combustion, as the filters are not

([15]) Council Directive 96/62/EC of 27 September 1996 on ambient air quality.

able to completely separate finer ash particles. The most important source of fine dust emissions, however, are vehicles running on diesel which are not fitted with particle filters. In coal and oil power stations dust emission is restricted by the European Large Combustion Plant Directive's ceiling of 20 mg/m. In large power stations fine dust emissions are further reduced by wet flue gas desulphurisation. To reduce fine dust emissions further and to maintain emission ceilings throughout Europe, stricter conditions for diesel vehicles have been enacted by the EU which make particle filters obligatory in cars from 2008.

7.7 The desulphurisation of flue gases from large power stations and industrial combustion plants was made compulsory in some EU Member States as early as the 1980s. This put an end to the acidification of land and lakes that was already visible. The latest version of the European Large Combustion Plant Regulation prescribes an SO2 flue gas ceiling of 200 mg/m^3 for plants >300 MW. The current state of technology allows separation of sulphur parts to a level of more than 90 %. New markets have been found for the products of sulphur separation, notably plaster, and the consumption of natural resources thereby reduced.

7.8 At high temperatures in the process of burning fossil fuels, nitrogen oxides are produced from the nitrogen in the fuel itself or in the combustion air. At increased concentrations these nitrogen oxides can cause respiratory diseases and are also a precursor of environmentally damaging ozone. The European Large Combustion Plant Regulation demands that nitrogen oxide emissions from power stations >300 MW not exceed 200 mg/m^3.

7.9 Science goes on the basis of a causal relationship between the emission of man-made CO_2 and other so-called greenhouse gases and an increase in temperature of the earth's surface (the greenhouse effect). The extent of the effect is still uncertain. Every year 20 billion tons of CO_2 emissions are produced in the process of coal, oil and natural gas combustion; this is the prime source of man-made CO_2 emission. Alongside increasing efficiency and energy-saving measures, CO_2 separation technologies (see below) have the most potential for producing a considerable alleviation in the long term and therefore need to be developed.

7.10 Increasing efficiency in energy conversion and use is vital for comprehensive success in climate protection. The measures needed for this should be seized upon. Fuel substitution strategies are, by contrast, less effective, as they only have a one-sided effect on the consumption of certain forms of fuel (e.g., gas) and would thereby put in doubt economic efficiency and the EU's supply security. Moreover, gas is too important a raw material for the chemicals industry and the transport sector to be used for producing electricity.

7.11 Per energy unit, the combustion of natural gas produces only 50 % to 60 % of environmentally harmful CO_2 compared with the burning of coal, because not only the carbon in the gas is used (burned), but also the hydrogen. However, methane itself — a main component of natural gas — is a greenhouse gas far more harmful to the climate (c. factor 30) than CO_2. For this reason, everything must be done in the production and use of fossil fuels to prevent methane emissions. Methane released in the recovery of oil and coal must be captured and put to some use. It is also vital to avoid leakages of methane in transporting natural gas, as even the slightest losses in transit by pipeline are enough to offset the advantage natural gas has in this respect over coal.

7.12 Past experience shows that the best way to achieve rapid success in protecting the climate and the environment while using coal, oil and gas is to replace ageing plants and power stations with ones that have more modern technology and greater efficiency. For this reason, broad policy conditions which promote investment in new technology are particularly suited to achieving ambitious environmental protection objectives.

7.13 In the last twenty years, European environmental legislation has brought about harmonisation of environmental standards in the countries of the European Community. The European Large Combustion Plant Directive and the European Air Quality Directive have made important contributions to this, as have policies and measures to increase energy efficiency and reduce greenhouse gas emissions.

8. **Technological development** [16]

8.1 In the EU of 25, coal, oil and gas power stations account for more than 60 % of the total installed capacity of power stations and thus form the backbone of electricity supply in Europe. The need to replace decommissioned power stations and to satisfy increasing demands made on power station capacity (see point 5.8) means that a considerable number of new power stations will have to be built within the next twenty-five years. Even with more intense use of renewable energy and an expansion of nuclear energy, coal and gas power stations will have to meet a substantial part of this shortfall. The greater the efficiency and pollutant capture rate of these power stations, the easier it will be to meet environmental and climate protection requirements.

[16] See the Committee's Opinion: Research needs for a safe and sustainable energy supply.

8.2 For this reason, improved R&D efforts are also required in the field of power station development. In the 1990s these efforts were neglected and public funding for research fell drastically in almost all the Member States.

8.3 The Committee welcomes the fact that its repeated recommendation to create a special 'Energy' thematic area in the 7th R&D framework programme has been taken up. However, the relevant research programmes of the Member States should be modified accordingly. This could usher in an important change in the trend. This also concerns the further development of power station technology for using fossil fuels, which would also benefit the competitiveness of the European plant construction industry in a globally expanding power station market.

8.4 Modern coal-fired power stations achieve an efficiency of more than 45 % using hard coal and more than 43 % using lignite. The steps needed to achieve an efficiency level of 50 % in coal power stations by 2020 are known. The long-term goal is to raise pressure and temperature in the steam cycle of the power stations to 700° C/350 bar, which will require the necessary materials to be developed. Pre-treatment plants for drying lignite coal should be tested for a new generation of lignite power stations. Such ambitious development aims require the kind of international cooperation that exists in the EU projects AD 700 and Comtes 700 for the development of a 700° C power station. The demonstration of a new power station concept requires investments of up to EUR 1 bn. As individual companies are hardly in a position to bear the costs and risks alone, cooperation between European companies should be sought.

8.5 In recent decades the development of high-performance gas turbines in gas-fired power stations has produced considerable improvements in efficiency. The efficiency of newer natural gas power stations has reached almost 60 %. However, there is uncertainty about the long-term competitiveness of natural gas power stations, and hence the construction of new gas-power plants, due to a drastic price hike on the gas market.

8.6 If the production of electricity from coal is to benefit from progress in gas turbine technology, coal first needs to be converted into gas. In the 1980s and 1990s the EU made an enormous contribution, through research funds, to the development of gasification technology and supported the building of two demonstration power stations with integrated coal gasification. These lines of development should be pursued not only in view of the increase in efficiency for coal-fired power stations, but should also be the technological basis for further development of a so-called zero-CO_2 coal-fired power station.

8.7 Efficiency improvement and reduction of CO_2 need not be limited to industry and electricity production. At the present time, the potential for savings related to household and commercial end-use is particularly large, because so far the cost incentive (savings in consumption/costs for new building or conversion) has often not been given.

8.8 The energy needs of the transport sector continue to rise, due in part to increasing mobility following EU enlargement. The increase in emissions of pollutants and greenhouse gases harmful to health must first be limited and then reduced to a minimum through the development of more efficient and less polluting motors and vehicles. Exhaust gas purification technologies must be continually developed. It seems that this goal can only be achieved through a successful development and blanket introduction of a bundle of progressive technologies. These include improvements to internal combustion engines, diesel technology, hybrid propulsion, fuel and the efficiency of vehicle fuels, the development of fuel cells and, possibly, hydrogen technology.

8.9 Fuel cells are ideally suited to boosting the efficiency of combined production of electricity and heat by perhaps around 20 % for both vehicles and stationary use in the household, commerce and industry. This also requires a gaseous fuel — natural gas, synthetic gas or pure hydrogen — which can be extracted, for example, from methanol via a reformer upstream of the fuel cell. However, although known about for 150 years, the fuel cell has not yet achieved an economic/technological breakthrough as a (competitive) vehicle fuel or decentralised combined power and heating plant. Nevertheless, research and development should be advanced, including with public support, to locate and — if possible — tap its potential.

8.10 No energy option has captured as much attention in recent years as the 'hydrogen' option and there is often even talk of the future hydrogen society. At the same time, there is often a misunderstanding among the public that hydrogen is, like oil or coal, a primary energy fuel. This is not the case: hydrogen must be recovered either from fossil hydrocarbons or water, in the latter case using electrical energy; just as CO_2 is combusted carbon, so water (H^2O) is combusted hydrogen.

8.11 Furthermore, the transport of hydrogen has a cost disadvantage compared with that of electricity or liquid hydrocarbons. This means that hydrogen should only be used where it would not be reasonable or possible to use electricity. An impartial analysis of this concept is needed to focus research on realistic goals.

8.12 Given the crucial importance to the transport sector of easily transportable hydrocarbons (fuels), reserves and resources should be safeguarded as far as possible, which means that oil should not be used where coal, nuclear or renewable energy sources would seem promising.

9. CO_2 separation and storage

9.1 The target the EU has set itself — and which goes far beyond 'Kyoto' — of a worldwide reduction in greenhouse gas emissions by the middle of the century can only be achieved if, within a few decades, power stations and other large industrial plants can be, to a large extent, conceived, built and operated as zero-CO_2 or reduced CO_2 forms of production. Even if nuclear energy and renewable energy sources are radically expanded, they will not be in a position to take on this role alone and replace fossil fuels in a few decades.

9.2 Several procedures have been proposed for running coal-fired power station on a zero-CO_2 basis. With modifications, these can also be used for oil and gas combustion. In principle, three methods are employed: (i) CO_2 separation from the combustion gas of conventional power stations, (ii) development of oxygen combustion and (iii) the gasification combined power station with CO_2 separation from the combustion gas; this last concept is the one furthest developed.

9.3 CO_2 separation from the combustion gas of coal gasification produces pure hydrogen, which can be used in hydrogen turbines to produce electricity. Harmless steam remains as the discharge gas. If this technology proves successful, a synergy with hydrogen technology in other fields is on the horizon.

9.4 For more than twenty years the concept of power stations with IGCC (Integrated Gasification Combined Cycle) has been intensively researched and developed. The gas purification procedures are in principle known, but need to be adapted to coal technology. But the costs of producing electricity on the basis of this concept of the power station could be almost double those of conventional power stations without CO_2 separation, and the consumption of resources will increase by around a third. However, in most places this technology will be more economical than other zero-CO_2 power producing technologies, such as wind or solar energy or electricity from biomass.

9.5 In the 1980s, various IGCC concepts — at that time, of course, without CO_2 separation — were developed in Europe, in part supported by the EU. 300 MW demonstration plans for hard coal were built and operated in Spain and the Netherlands. A lignite demonstration plant was developed, built and operated — again with EU support — to produce synthetic gas for subsequent methanol synthesis. Europe is thus excellently equipped technologically for developing zero-CO_2 coal-fired power stations and for testing in demonstration plants.

9.6 Not only power stations, but other industrial process which produce large quantities of CO_2 emissions — such as H_2 production, various chemical processes and mineral oil processing, as well as the production of cement and steel -, should be examined with a view to their potential for CO_2 separation. In many of these processes CO_2 separation could be carried out more economically and technologically more simply than in the case of power stations.

9.7 There is a great need for research into safe, environmentally acceptable and economical CO_2 storage. The possibilities are being explored of depositing CO_2 in depleted oil and gas deposits, geological aquifer layers and coal deposits, as well as in the ocean. While storage in depleted oil and gas deposits, where available, would be the cheapest alternative, depositing in geological aquifer layers is favoured for large quantities, not least because such geological conditions are readily available worldwide. The key question here is to provide reliable proof that CO_2 can be stored safely in such places for a long time and without adverse effects on the environment. A series of research experiments to achieve this is being supported by the EU. The results available so far are encouraging, though concerns remain that a rise in sea temperature might trigger a release of CO_2 deposited in the ocean (see also point 3.14).

9.8 A comprehensive introduction of CO_2 separation technology and storage will only be available after 2020 and even then on the assumption that the necessary R&D studies are on schedule and prove successful. Studies estimate costs of between EUR 30 and EUR 60 for every ton of CO_2 disposed of (CO_2 separation, transport and storage), which is more advantageous than most methods of renewable electricity production.

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The President
of the European Economic and Social Committee
Anne-Marie SIGMUND