Parliamentary **Assembly**
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COUNCIL OF EUROPE CONSEIL DE L'EUROPE

Doc. 10486
30 March 2005

Energy systems and the environment

Report
Committee on the Environment, Agriculture and Local and Regional Affairs
Rapporteur: Mr Bill Etherington, United Kingdom, Socialist Group

Summary

Energy issues have been widely discussed by the Parliamentary Assembly in the past and the effects on the environment of conventional energies (fossil fuels and nuclear) are well known. Fossil fuels (oil, coal and gas) generate air pollution which contributes to global warming and climate change as well as fine particle pollution. In addition to the issue of the security of supplies, such energy sources are depleted rapidly without any possibility for a quick and natural replenishment.

Nuclear energy produced in modern nuclear power plants and envisaged as a possible medium-term solution to avoid increasing air pollution (greenhouse gases and fine particle pollution) has the drawback of the unsolved issue of processing and storing the spent fuel and other radioactive nuclear waste.

Renewable sources of energy (e.g. biomass, geothermal, hydropower, solar, wind, tidal and wave energy, etc.) can solve the sustainability issue and may offer a possible alternative to the conventional energy production systems.

The Parliamentary Assembly invites parliaments and governments to take all legislative and fiscal measures needed to develop new sustainable renewable energy policies and to reduce dependence on fossil fuels.

I. Draft resolution

1. As worldwide concerns on air pollution and climate change increase, the Parliamentary Assembly recognises that the environmental impacts of energy production, transport and use should be given increased attention.

2. Fossil fuels (oil, coal and gas) have serious environmental consequences. They generate greenhouse gases, which contribute to global warming and fine particle pollution. In addition to the issue of the security of supplies, such energy sources are depleting rapidly without any possibility of natural replenishment.

3. Modern nuclear power plants, envisaged by certain European states as a possible medium-term solution, avoid increasing air pollution (greenhouse gases and fine particles) but still bring with them the hitherto unresolved problem of the processing and storage of radioactive nuclear waste. Therefore, an urgent assessment needs to be undertaken by European states on the long-term safekeeping of spent fuels and other nuclear wastes produced in the Greater European Area.

4. Furthermore, accidents, whether natural, technological or caused by acts of terrorism, may have disastrous consequences for population safety. The risk of radioactive contamination may also be detrimental to the image of quality farm and food products from areas where nuclear power plants are sited.

5. Renewable sources of energy (e.g. biomass, geothermal, hydropower, solar, wind, tidal and wave energy, etc.) appear to solve the sustainability issue and may offer, in the long run, a viable alternative to conventional energy production systems. Targets for increasing the share of renewable energies have been set up in the European Union, although recent information indicates that they will not be achieved by the set deadline of 2010.

6. The Parliamentary Assembly considers that the environmental beneficial impacts of renewable energies should be assessed separately.

7. In order to mitigate climate change, a strong reduction of greenhouse gas emissions, which are mainly caused by the transport sector, is needed. Bearing in mind the increase of energy production, the targets of the Kyoto Protocol (United Nations Framework Convention on Climate Change) will be even more difficult to achieve without tackling the environmental impact of current energy sources.

8. In addition to climate change, the other main hazard linked to energy production is fine particles caused by combustion power plants and combustion engines (in particular diesel). When reducing greenhouse gas emissions, reducing the emission of fine particles should also be considered.

9. Environmental risk concerns are increasingly taken into account when planning energy policies as far as production, transport and use are concerned and are bound to become determinant when addressing environmental issues. In order to make correct decisions regarding energy issues, decision-makers need accurate information on the environmental hazards and risks of the different energy systems. Therefore, there is a strong need for a standardised method for assessing environmental hazards and risks.

10. The Parliamentary Assembly therefore invites member states to take urgent action to decrease the environmental impact of energy production, transport and use, in particular by:

i. technological measures:

a. gradually reducing dependence on fossil fuels and ensuring a secure and sustainable energy supply, through options such as further developing renewable energies, and including the setting of coherent targets at pan-European scale, taking into account those of the European Union;

b. working towards achieving the emission reduction targets for greenhouse gases set in the Kyoto Protocol with special attention to the energy, industry and transport sectors;

c. gradually implementing modern technologies in producing energy from fossil fuels (e.g. "clean coal technology" (CCT), co-generation (recovery of the heat generated during electricity production)) without jeopardising policies on waste reduction, sorting and recycling to which priority must continue to be given;

d. encouraging research and development in the field of nuclear waste management to minimise its environmental impact;

e. encouraging any action to secure nuclear power plants against the risks of radioactive emissions as a result of natural or technological accidents or acts of terrorism or of war;

f. supporting research and development in the field of nuclear fusion to gradually replace current fission-based nuclear power plants;

g. promoting and implementing in all possible areas (industry, transport, household, etc.) environmentally friendly technologies with increased energy efficiency and further encouraging research and development, particularly in the fields of energy use in the transport and building sectors;

ii. fiscal measures:

a. integrating environmental costs into energy pricing;

b. integrating the environmental costs of the transport sector into fuel pricing;

c. allocating a share of the revenue from energy taxes to research and development on clean technologies and renewable energies;

d. developing a system of tax credits, grants and other fiscal incentives in order to encourage environmentally friendly energy investments;

iii. educational and public information measures:

a. providing clear information on the environmental cost of using household electrical appliances in order to allow consumers to take informed and environmentally responsible decisions;

b. developing education and awareness-raising programmes and initiatives on environmentally friendly energy options and energy efficiency (schools, media, etc.);

c. providing information on energy options specially targeted at decision-makers.

11. The Assembly invites member states to strengthen co-operation between the authorities responsible for energy policies and those responsible for the environment with a view to facilitating the implementation of the above-listed measures.

12. The Assembly invites member states which use nuclear energy to respect the decision of other states which, in accordance with the precautionary principle, have decided against it in order to increase the level of public safety by avoiding siting nuclear power plants close to their borders so as not to overexpose the public in neighbouring states in the event of an accident.

13. It invites in particular Central and East European countries further to enhance their energy efficiency, safety and industrial restructuring, to diversify and decentralise their energy sources and to reduce their energy consumption.

14. The Assembly invites the European Environment Agency, in co-operation with the International Energy Agency, to consider elaborating a standardised method to assess the environmental impacts of the different energy systems.

15. It also invites the International Energy Agency to continue its work on climate friendly technologies and stresses the importance of focusing it on topics such as renewable energies, energy efficiency and new carbon capture and storage technologies.

16. The Assembly fully supports the European Union's commitment to promote environmentally friendly energy choices, as illustrated by its "Intelligent Energy – Europe" programme on energy efficiency and renewable energy sources (including the SAVE, ALTENER, STEER and COOPENER programmes) and invites all Council of Europe member states to develop similar initiatives at the national level in order to achieve a coherent pan-European approach.

17. The Assembly notes with interest current debates to set up an Energy Community of South East Europe (ECSEE), led by the European Commission and supported by a number of donor agencies including the World Bank, EBRD and EIB, and encourages its members to pay full attention to environmental aspects.

II. Explanatory memorandum by Mr Bill Etherington

Contents

1. Introduction[1]

1. One of the basic laws in physics states that "energy can neither be created nor destroyed: it can be converted from one form to another". It is ultimately these conversion forms of energy, which are of paramount importance for mankind.

2. There are many different forms of energy: solar energy - radiant energy resulting from thermonuclear reactions taking place in the sun; mechanical energy, known as the kinetic energy of motion or energy of moving objects; potential energy that is the energy of objects located above the ground – such as the water in a reservoir; chemical energy, resulting from the various ways atoms are bound together in molecules and may be released by chemical reactions - burning of fuels in air, electrical energy, generated by electrically charged atoms, nuclear energy - resulting from splitting the atoms, known as fission or combining the atoms, known as fusion, at nuclei level; and thermal energy - the energy from heated things.

3. Thermal energy is particularly important because in any occurring conversion the efficiency is less than 1, in other words one may never convert entirely one energy form into another as there are energetic losses in the form of lost heat, either directly or indirectly through various friction processes. The smaller those losses, the higher the conversion efficiency.

4. Surprisingly, trying to get rid of heat, e.g. in a hot summer day, we actually generate more heat: by using an air conditioning system to cool down a room, we release through the radiator, outside of the building, the losses of the conversion process as heat. So, on the whole, instead of decreasing the temperature, we are actually contributing to an increase in the global temperature of the environment.

5. There are various ways of converting energy. Although from the theoretical point of view energy conversion is bi-directional, where a form of energy A may be converted into another form of energy, B, and energy B may be reverted back to A (e.g. a mobile phone using a rechargeable battery, where the chemical energy stored in the battery is converted to electricity - battery discharge and then one uses electricity to remake the initial chemical compounds - battery recharge), from the practical point of view, energy conversion is looked upon as an uni-directional process: it is very difficult to reconvert to the original state the fossil fuels burnt for heating or for propelling cars.

6. Even in the case of so-called reversible processes (e.g. the above-mentioned conversion of chemical energy to electricity), it must be emphasised that we may never get the same amount of energy as at the initial point (the temperature of recharged battery is higher, meaning that some electricity was lost by direct conversion to heat), so that the common conception of "energy conservation" should be looked upon as higher energy conversion efficiency and lower energy loss (e.g. thermal energy).

7. A similar process takes place in a pendulum, where the potential energy is converted into kinetic energy (motion) and back into potential energy. In order for a clock to work, one must compensate for the friction (that is the conversion of mechanical energy to heat) by rewinding the mechanism or pulling the weights, otherwise it will come to a standstill.

8. Everyday we are surrounded by various forms of energy conversion and energy convertors: electrical energy is converted to heating using an electric heater, chemical energy stored in fossil fuels to heating or mechanical energy (gasoline or diesel powered cars), potential energy to electrical energy (hydropower), electrical energy to mechanical energy (electric motors), chemical energy to electricity (batteries, fuel cells), nuclear energy to electric energy (with intermediate stages).

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[1] The Rapporteur would like to thank Professor Danut-Ionel Vaireanu, Vice-Dean of the Faculty of Industrial Chemistry of the Polytechnical University of Bucharest, for his invaluable contribution in the preparation and drawing up of this report.

9. The problem is to get a useful form of energy using the shortest way possible. If an energy convertor has a low degree of efficiency, it will inevitably affect the environment by releasing various harmful gases resulting from incomplete transformations (carbon monoxide, nitrogen oxides) or residual heat. Nature provides us with countless energy convertors: plants are among the most efficient energy convertors - they convert solar energy to chemical energy, releasing into the atmosphere the oxygen needed for further energy convertors.

10. Improving the efficiency of an energy convertor does not necessarily solve the problem - it just transfers it to a larger scale. In the case of fossil fuels even the most efficient energy convertors will still affect the environment. By obliging car manufacturers to fit vehicles with different catalysts, the decrease in carbon monoxide and nitrogen oxides is substantial, but the release of carbon dioxide, a greenhouse gas, will still affect the environment on a larger scale – the greenhouse effect followed by global warming. This is why technical improvements in energy conversion and energy use (e.g. zero emission vehicles, electric vehicles, clean coal technologies) must be strongly backed up by political measures (implementation of the Kyoto Protocol for the reduction of carbon dioxide).

11. As time has passed, some classical energy production systems based on burning fossil fuels have been replaced by modern ones such as hydropower and nuclear energy. If hydropower may be looked on as a "green", renewable source of energy, nuclear power plants have a major disadvantage, namely that of the increased risk of potential radioactive contamination in the event of an operational accident or a natural catastrophe. The danger of radioactive contamination is by far greater in comparison with other risks due to the long-term persistence in nature of any spilled radioactive material and the difficulties associated with cleaning such materials.

12. Energy and the environment cannot be separated as they are inter-linked in a system where each one reciprocally affects the other; so there will always be an environmental risk associated with production and distribution of energy. As energy is one of the cornerstones of our welfare and development, everyone, from the end-users to the government, must take immediate action to minimise the environmental risks, to conserve energy and to finding means to convert energy efficiently, affecting the environment as little as possible.

2. A short history of energy

13. At the beginning of evolution, the only large-scale source of energy available for human beings, other than human or animal muscle, was the sun. It was the only provider of light and heat. The discovery of fire for cooking food and heating caves and the subsequent skills acquired in manufacturing tools and weapons were past from generation to generation, leading to the discovery of easier ways to get work done.

14. The invention of the wheel and the use of wind power for ship propulsion made it possible for humans to conquer and enslave new populations - used mainly as a cheap source of energy for various work, extend their territory, and ultimately the development of many civilisations.

15. Flowing water and wind-based rotary propulsion systems have been largely used, wherever it was possible, to pump water, process grains and raw materials for textile production, becoming - alongside wood and coal - major energy sources in ancient times and the middle ages.

16. The beginning of the 18^{th} century was marked by the revolutionary discovery of the steam engine, allowing virtually any type of heavy work, mechanical and repetitive, to be carried out, regardless of location (on land or sea) or climate. The first steam engines were very inefficient, using less than 2% of their fuel energy and losing more than 98% of it.

17. Another drawback of the steam engine compared to the wind or water systems is that it requires fuel for burning. The larger the engine, the more fuel it consumes, so the first empirical search for energy conservation, expressed in terms of higher efficiency, came into being.

18. The expansion of towns and cities demanded networks of railroads and has determined, alongside the use of coal for burning, increased coal consumption. Global coal production (estimated at about 10 million tons in 1800) shot up 100-fold by 1900 - less than 100 years.

19. The extraction of oil has increased with the invention of the internal combustion engine and improved the energy efficiency of fossil fuels. Natural gas, considered initially as a useless by-product of oil extraction, later became a valuable energy source for lighting and heating.

20. Although the behaviour of electrically charged particles was known since ancient times, the actual use of electricity for powering mechanical equipment and for domestic use emerged in the late 19th century, with the discovery of electric motors. This invention, corroborated with that of the rechargeable battery, has offered the user a total independence on location for various types of work.

21. The 20th century has seen dramatic changes in technology alongside an exponential growth in population size and energy consumption. The need for increased productivity at industrial and domestic level, the use of automobiles, ships and planes for transportation and two major world wars have put a strain on fossil fuel reserves.

22. Hydroelectric generation plants and electricity generation by nuclear fission became the answer to increased energy demand. Energy use has roughly doubled every 10 years while its cost was constantly declining.

23. The 1970s and 1980s have brought into discussion the popular conception of diminishing energy prices at the expense of environmental degradation. The Three Mile Island and Chernobyl nuclear power plants suffered major nuclear accidents and have invalidated the misconception that a nuclear accident could never happen.

24. Increased awareness of the depletion of fossil fuels resources, the damaging effect on the environment and human health of greenhouse gases and the threat of major climate change have determined a new quest for practical applications of renewable clean, environmental friendly energy sources which "*meet the needs of the present without compromising the ability of future generations to meet their own needs*".

3. Environmental risks associated with different energy systems

25. Environmental risk concerns are more and more taken into account when planning energy policy (e.g. fossil fuels extraction, processing and their use) and are bound to become the determinant points when addressing environmental issues.

26. In order to evaluate the potential consequences of the harmful effects of a particular process or operation, one has resorted to *risk assessment*. It involves a combined answer to the following questions: what can go wrong, how likely is to go wrong, and what are the adverse consequences?

27. The notion of *environmental risk* may be defined as the possibility of danger or harm to the environment. It contains at the same time the likelihood or probability of an occurrence combined with the likelihood of a consequence or loss with respect to the environment (see Appendix).

28. Assessing a particular risk involves the identification of all issues and potential hazards that represent the interaction between the environment and the considered process or operation and the examination of potential consequences derived from these interactions.

29. Environmental risks can be greatly reduced by limiting exposure or reducing the hazards associated with that particular process or operation. An anticipatory principle, backed up by historical evaluation of events, may be a good-sense approach to dealing with risk and uncertainty in preparing for the potential eventualities and consequences.

3.1. Fossil fuels

30. Fossil fuels are natural substances resulting from the fossilisation process of the living tissue of ancient plants or animals. After millions of years, high pressure, heat and the absence of oxygen have turned decomposing remains into fuels capable of supporting combustion processes (e.g. coal, oil and natural gas). A little more than half of the total power generated in 2002 in the EU came from fossil fuels (see fig.1).

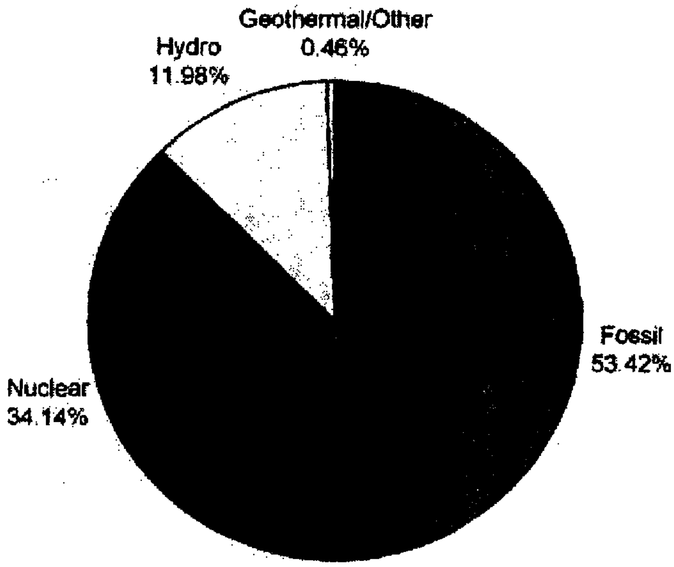


Fig. 1. EU Power Shares in 2002
Source: International Energy Agency

3.1.1. Coal

31. Coal is a form of carbon resulting from the fossilisation of trees that were submerged in swamps. There are different varieties of coal, depending on their development stages: peat, lignite (low-grade coal with respect to the amount of energy per unit of mass), bituminous coal and anthracite (high-grade coal).

32. Coal must either be extracted from underground mines or from open-pit mines (disturbing large areas of land, above and underground with major environmental impact on plants, animals, as well as people). Mining, drilling and transportation equipment may involve hazardous chemicals such as drilling "mud" and oily products, contaminating the land. Methane gas, associated with underground mining can cause underground explosions.

33. Burning coal contributes to the increase of the total amount of carbon dioxide in the atmosphere. Carbon dioxide is notorious for its greenhouse effect, acting like an insulating layer in the atmosphere and trapping solar heat. As a consequence, less and less heat is radiated back into space and this triggers a process of global warming, causing a change in climate (a possible melt down of polar caps, rising of ocean levels, drying and expansion of deserts).

34. Apart from climate change, burning coal also generates sulphur and nitrogen oxides which, when absorbed by atmospheric raindrops, create the phenomenon called acid rain, an environmental transboundary issue; these raindrops fall as acidic rain or fog, very often far away from the originating source. The effect on forests and lakes in the long term can be significant, inducing a higher acidity in soils, lakes and rivers, lowering their pH values, weakening trees and killing fish.

35. A combined environmental risk (radiation and radioactive contamination) of using coal for electricity generation comes from the fact that there are some naturally radioactive trace elements in coal such as uranium, thorium and their decay products, including radium and radon. Although these elements are in minute concentrations, questions have been raised concerning the possible risk from radiation and radioactive contamination for miners and the environment.

36. The radiation hazard from airborne emissions of coal-fired power plants have been evaluated in a series of studies conducted from 1975 to 1997 and there is no agreement as far as the findings are concerned. While some studies have presented results showing that the radioactive contamination around coal mines and power station is substantial, other studies concluded that the maximum radiation dose to an individual living within 1 km of a modern power plant is equivalent to a minor 1 to 5 percent increase above the radiation level from the natural environment.

37. Another risk factor is waste water resulting from the cooling processes taking place in coal power plants, known as thermal pollution. As this water flows into rivers it increases the water temperature, generating a decrease in dissolved oxygen, depleting aquatic plants and fish by depriving them of oxygen.

38. As a whole, the environmental risks associated with coal-burning technologies include significant damage to land by mining, air pollution, the greenhouse effect, global warming, acid rain, the issue of disposing of large quantities of resulting ash and even respiratory illnesses for animals and humans.

39. "Clean Coal Technology" (CCT) represents a possible solution for improving the environmental acceptability of coal as an energy source, increasing at the same time its economic efficiency. The generic term of CCT includes a new generation of processes for the production of electricity and fuels from coal, meant to increase energy efficiency while keeping the environmental impact of coal use to a minimum (reduced air emissions, waste products and other pollutants in comparison with the old coal-based power plants). This process is achieved mainly by using Advanced Combustion Technologies, Gasification Technologies and Controlled Emissions by Selective Catalytic Reduction.

40. CCT also provides a potential solution for the conversion of obsolete power plants based on low-grade coal-burning in central and eastern Europe, which are in need of conversion or phasing out. However, CCTs cannot be accepted without reservations. The plants require high-tech equipment, are very expensive to build, and there is still the unsolved issue of carbon dioxide emissions, with proven impact on the environment.

3.1.2. Oil

41. Oil is a mixture of hydrocarbons formed by the deposition of dead microscopic plants and marine micro-organisms in or near marine sedentary basins. The geologic processes that determined the production of oil stretched over millions of years. Crude oil is pumped out of the ground and is transformed by a distillation process into a whole range of liquid and gaseous fuels: diesel fuel, kerosene, gasoline, home heating oil, etc.

42. At the present rate of consumption, it is estimated that oil reserves will last for no more than 40 to 50 years. Even if conservation measures are implemented in time and the rate of oil consumption per capita is reduced, this will be counter-balanced by rapid population growth, resulting in an increased rate of oil depletion.

43. Oil, besides its use for energy production, is essential for public and industrial transport as well as the chemical industry. Once crude oil is pumped out it presents a number of environmental risks. Oil drilling and the transportation of oil and oil products (either by land or sea) pose the constant risk of accidental leaks and spills with subsequent damage to the environment. Oil rigs and oil tankers have spilled many tons of oil in the past, killing birds and endangering many other marine and terrestrial organisms.

44. There is also the irresponsible action of using sea water to wash out the residuals of oil in tankers, severely affecting the environment for long periods of time, as hydrocarbons take a long time to break down into less harmful substances. It is easy to trace shipping routes as they are marked by traces of oil; the impact of leaks and accidental spills is significant as they often run along coastlines, disturbing some of the most fragile ecosystems.

45. Burning oil and oil derived products (gasoline, diesel fuel) greatly contributed in the past to increases in heavy metal pollution (leaded gasoline) and still contributes to the generation of greenhouse gases (although fitting cars with catalytic convertors has reduced the amount of toxic gases such as carbon monoxide, nitrogen oxides and unburned hydrocarbons).

3.1.3. Gas

a. Natural gas

46. Natural gas, considered as the cleanest burning of the fossil fuels, is a mixture of mostly methane and traces of other higher chain gaseous hydrocarbons, coming in most cases from dry gas fields (90%), where no oil is found. Because it is a gas, it is more difficult to handle. This is done with a network of pressurised pipes connecting the gas fields directly to towns and cities, or in tanks as liquefied natural gas (LNG). After a preliminary cleaning process, it is used for heating and cooking as it has a high caloric value and results in a smaller quantity of greenhouse gases, compared to coal or oil burning.

b. Liquefied petroleum gas

47. Liquefied petroleum gas (LPG) is a by-product of oil fields, containing a mixture of propane with several other higher chain gases found dissolved in crude oil. After the separation from liquid oil and storage under pressure in metal tanks, it is transported to homes for use in heating and cooking. In the case of gases, apart from the associated problems with burning this particular type of fuel as presented above, one may also find here the risk of accidental release of gaseous emissions into the atmosphere and the risk of explosions.

48. Co-generation (waste heat recovery), applied to gas power plants (as well as to coal and oil power plants) is a new approach to decreasing fuel consumption per energy unit by producing two different forms of useful energy from the same fuel. It works by burning fuel to heat pressurised steam which turns the electricity turbines; the residual partially cooled down steam is sent to domestic heating systems. It also reduces the risks of thermal pollution.

3.2. Nuclear energy

49. Nuclear energy results from splitting certain particular types of chemical elements (e.g. uranium-235), a process called fission, in a controlled environment inside a nuclear reactor. The chain reaction, kept under strict control, releases a high quantity of energy, a number of neutrons and atom splits, which are in fact two entirely new elements.

50. Energy from the fission reaction heats deionised water converting it to pressurised steam, which drives the turbines that generate electricity. Comparing the fuels, weight per weight, nuclear energy generates up to 3 million times more electricity than burning the equivalent amount of coal. The percentage of nuclear energy with respect to the total amount generated in Europe may vary from 0% up to 80% depending on the country (see fig. 2).

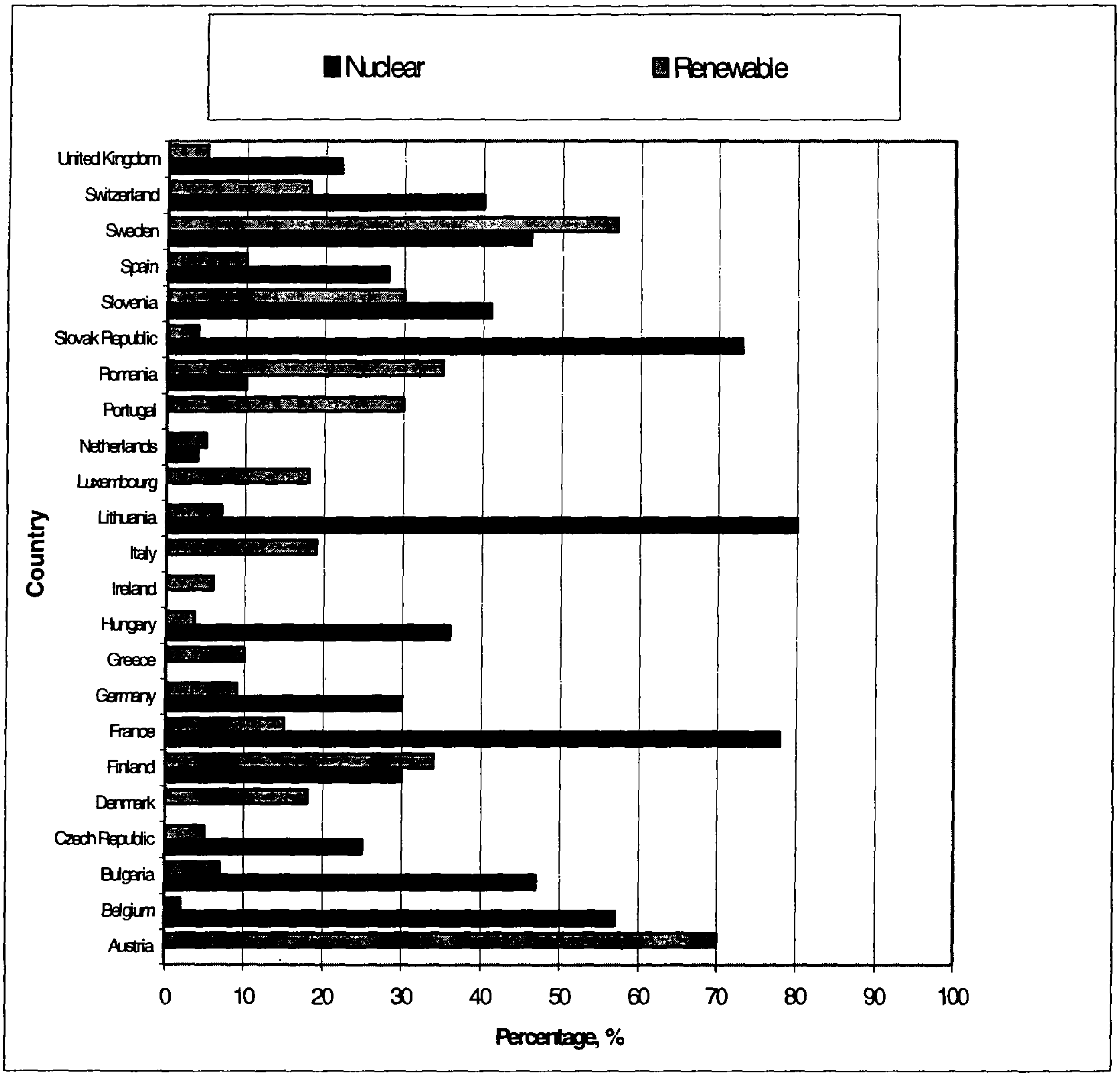


Figure 2. Comparison of percentage of electricity generated from renewable sources and nuclear power plants in various European countries.
[Source: Europa - Renewable Energy White Paper and International Atomic Energy Agency]

51. Uranium-235, used as nuclear fuel, is a rare isotope contained in uranium ore, its occurrence being of about 0.7% of all uranium deposits. Taking into account the present usage rates it will last less than one hundred years. This is why nuclear fuel can be considered as a non-renewable source of energy.

52. An attractive solution in the near future might be nuclear fusion, where two small atoms of hydrogen are combined together resulting a larger one, namely helium, alongside a huge quantity of energy.

53. Although the reaction has been proved possible from the practical point of view (military applications of H-bomb), no industrial power plants have been developed for this particular reaction for generating electricity due to the associated technological problems of maintaining the system at a controlled temperature. It will therefore not be commercialised before 2050, so current nuclear technology will still have to carry on its task of producing clean electricity for a long time.

54. It is considered that the generation of electricity using nuclear fuel presents the risks of radioactive contamination resulting from the processing of uranium ore (each tonne of fuel-grade uranium results in about 500 tons of low level radioactive waste); decommissioning of past-by-date nuclear plants; storage of spent fuel that may last for thousands of years as well as minor nuclear accidents (radioactive leaks) or significant power-plant accidents.

55. The future of nuclear power as a share of total energy will depend on the action taken by governments, who will have to identify levels of safety for nuclear plants and the means of eliminating waste acceptable to the general public.

3.3. Renewable energy systems

56. The use of biomass, geothermal, hydropower, solar, wind, and tidal energy depend on a flow of energy originating from nature, the heat of the earth's inner core, water flow, the sun, the constant motion of the moon. As these energy sources do not run out considering the evolutionary scale of time, they are known under the generic term of renewable energy sources.

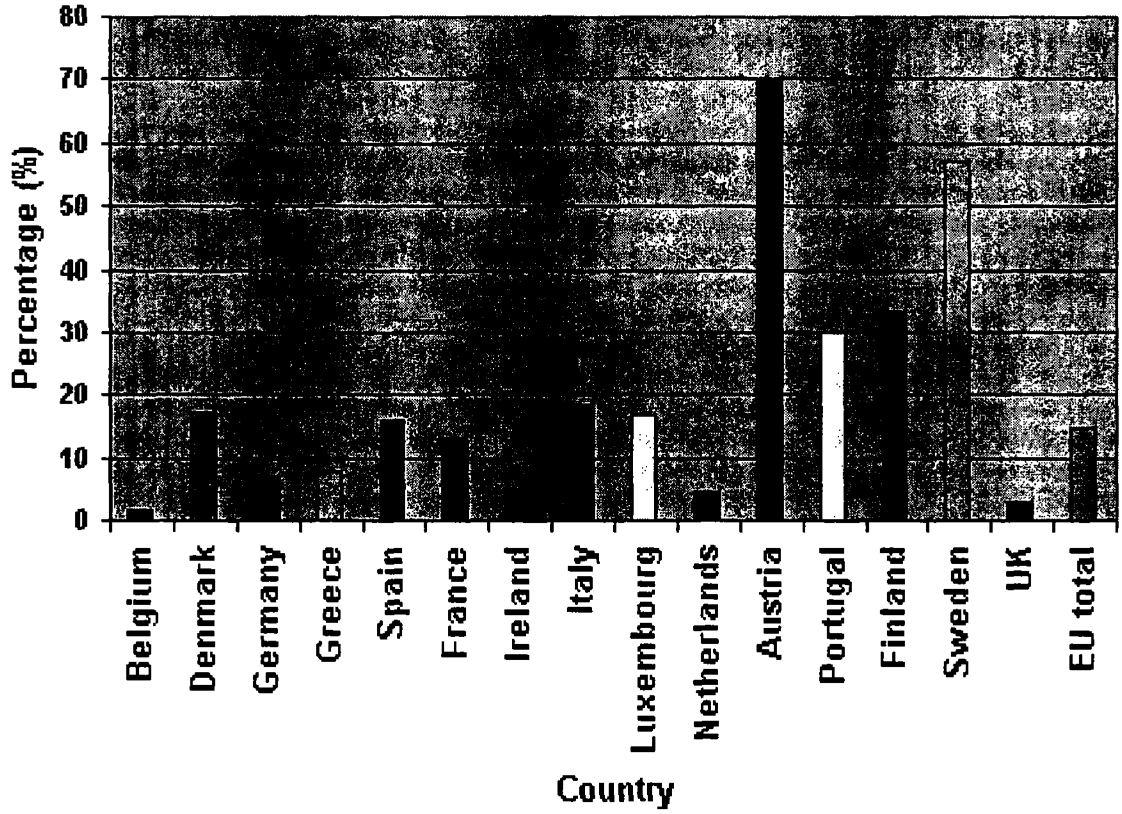


Fig.3. Percentage of electricity generated from renewable sources in various European countries. Source Europa - Renewable Energy White Paper

57. In economic terms, the cost of some renewable energy sources (see Appendix 2) appear to be more expensive due to production methods, low market demand and the high-tech equipment involved in comparison with the energy obtained from fossil and nuclear fuels.

58. However, if one takes into account the total cost, considering here as well the damage inflicted on the environment by fossil and nuclear fuels, and the benefits, such as reduced negative environmental impact of the renewable energy sources, one may say that the trend towards the development and application of renewable energy sources is a clear gain for a sustainable economic development.

59. Environmentally positive energy sources and practices have to be promoted and efforts to curb pollutant emissions generated by energy production have to be intensified. Although some renewable energy sources such as hydropower have been in place for a long time, it is of paramount importance that other renewable energy sources should be brought to the attention of developers, consumers, planners and investors so that the present percentage of electricity generated from renewable sources (see figure 2) needs to increase in the near future.

60. Governments should take measures in such areas as taxation, subsidies and regulation, which will not only help them meet their energy security and environmental goals, but also contribute to faster technological progress and economic development.

3.3.1. Biomass

61. Biomass covers a wide variety of energy-generation routes, with many types of resources, a number of conversion technologies and three final energy products: heat, electricity and liquid fuels for transportation. It includes: oil crops (rape, sunflower), sugar and starch plants (sugar beet, cereals, sweet sorghum), solid biomass (wood, straw, peat), wet biomass (organic waste, manure). Unlike other energy resources, the use of biomass material has a dual beneficial effect: energy production and the disposal of biomass waste materials - a potential environmental risk.

a. Heat production

62. Combustion of wood for heat production is the main route for bioenergy. Several systems can be considered depending on size. Small-scale heating systems for households will typically use wood logs or pellets. Medium-scale use will typically involve burning woodchips in grate boilers. Large-scale boilers will be able to burn a large variety of fuels, including wood waste and refuse-derived fuel.

b. Electricity and cogeneration of heat and power

63. Combustion is the main option in this area at present, but new technologies are emerging: gaseification (thermal treatment of biomass resulting in mixtures of gases which can be used for energy generation), pyrolysis (thermal degradation of wood resulting in a liquid, or bio-oil), anaerobic digestion (a biological process that converts biomass into biogas, mainly methane and CO_2). Cogeneration, similar to that applied in the case of fossil fuels to increase overall energy efficiency. While electric generation is roughly 30-40% efficient, thermal production can result in overall efficiencies of 80-90%.

64. The use of urban wastes in generating electricity and heat in urban and peri-urban agriculture is gaining increasing acceptance as an important way to reduce the costs on rubbish disposal and nevertheless an attractive strategy for a sustainable urban development. This can be achieved by transforming the domestic waste to biogas in large methanisation factories (e.g. Seine-Saint-Denis, France) in order to reduce as much possible the waste or to use pre-sorted parts of domestic waste with high caloric power in combination with conventional fuels for heat and electricity cogeneration.

65. However, one must mention that there are as well risks and disadvantages of using urban waste for electricity and heat generation, which render this method unappealing. Composting urban waste presents various hazards and negative socio-cultural aspects like the potential for transmission of diseases and pathogens agents; an increased cost of transportation of raw material and end products; the labour costs for the collection; and sorting the waste and the loss of amenities near the processing location.

c. Liquid biofuels

66. Vegetable oils, methyl esters or biodiesel can be used for car engines, either in pure form or blended with fossil diesel. Ethanol (a liquid biofuel produced by fermentation of sugar-based raw materials, followed by distillation) can also be used in gasoline engines. Liquid biofuels can also be produced from upgraded biogas (methane) and their production from wood-based materials is under development.

67. If the biomass is managed sustainably, burning these fuels does not have the same effects as burning fossil fuels: additional plants harvested as a future source of biomass, consume carbon dioxide through photosynthesis, so as a whole, the balance of carbon dioxide emissions during the burning stage is less compared to burning fossil fuels.

68. The advantages of biomass as an energy source consist in their widespread availability, the security of supply (they can be stored in large amounts), their contribution to the creation of stable jobs, especially in rural areas, as well as presenting good opportunities to export developing technologies and know-how, and they contribute to CO_2 mitigation and other emission reduction (ex: SOx).

69. However, the extremely low efficiency of plants in converting solar energy into biomass determines the need for huge areas of cultivated land to obtain the same energy output. Energy resources estimate that around 600 ha of harvested biomass are necessary to fuel a 1 MW installed capacity power plant.

70. In order to make use of the benefits of biomass on a large scale, better solutions must be found for avoiding the competition for land with agricultural food production (e.g. the use of biogas and liquid biofuels) and to maintaining natural landscapes intact. Moreover, such intensely managed systems would require additional fossil fuel to power mechanical equipment, obtain fertilisers, pesticides, diminishing the net energy balance.

3.3.2. Geothermal energy and geothermal heat pumps (GHPS)

71. Geothermal energy is literally the heat contained within the Earth – more precisely the part that could be recovered and exploited. So far its utilisation has been limited to areas in which geological conditions permit a carrier (water in the liquid phase or steam) to transfer the heat from deep hot zones up to or near the surface.

72. Hot geothermal water is passed through a heat exchanger, and then used for domestic and industrial heating or for saving an important amount of energy heating greenhouses. Geothermal heat may also be used indirectly for electricity generation. The steam is produced in a similar way to the above described method and then used for running turbines in electric power plants.

73. Geothermal energy is largely available in Europe. Italy, Greece, France (Guadeloupe, reunion), Portugal (the Azores) and Austria are generating electricity. Hot dry rock (HDR) resources, which are currently under research, are expected to open new areas in the production of electricity within a few years.

74. High-temperature resources (over 200°C) and medium-temperature resources (100 – 220°C) are used for power generation in geothermal power plants, while lower-temperature resources (less than 150°C) allow geothermal heat to be used directly. Geothermal heating is widely used in Iceland, and other countries like Germany, France and Italy are operating a number of geothermal district heating systems.

75. Geothermal heat pumps (GHPs) are a new growth area that allows reduced electricity consumption, as it can produce heat, cooling or both. Here a fluid is flown through an underground loop of pipe, where it is warmed to the deep ground temperature. When it returns into the house, through a heat exchanger, the warmth from the ground is transferred to the living space. In the summer time, this process can be reversed in order to cool the house. The expansion of this sector is presently more important in Northern and Central Europe.

3.3.3. Hydropower

76. Water has been used for centuries to power up mechanical systems and is widely used today to produce electrical energy. Hydropower is the leading renewable energy source in the European Union, and it is estimated that about 84% of the electricity generation from renewable sources and 13% of the total electricity production come from hydropower.

77. A hydroelectric plant takes advantage of falling water; the higher the drop (the potential energy), the greater the flow, the more power can be produced. A large hydroelectric plant consists of a dam backing up a reservoir, which regulates how much water is passed through the turbines. The main advantage of such systems is the control and topping up of electricity production, especially during peak demand periods.

78. Reservoirs constructed for hydroelectric plants have the potential to cause some environmental problems: rivers dry up below hydropower dams causing losses of productive agricultural land, the dams destroy wildlife habitats, change the existing species of plants and animals in the ecosystem and block fish migration.

Small hydropower

79. Large hydropower plants are today technically mature and already well exploited. Attention should be focused today on small hydropower plants (SHPs), which are plants with an installed capacity of less than 10 MW. They generate electricity or mechanical power by converting the energy available in the flowing water of rivers, canals and streams. Small hydropower has a huge, as yet largely untapped, potential, which should enable it to make a significant contribution to future energy needs.

80. The environmental impact of a small hydropower plant is insignificant in comparison to a large hydropower plant - it does not require the construction of a reservoir as a part of the river's flow is diverted directly through the turbine. The remaining part of the river flows in the stream bed, allowing the normal river processes to continue.

3.3.4. Solar photovoltaics

81. Solar energy, considered on a planetary scale, is the most important source of light and energy; the entire life of the planet depends on it. It is clean and renewable. Apart from direct light and heat, no solar convertors were used in the past until the 20th century.

82. Photovoltaic (PV) technology involves the direct generation of electricity from light and is better known in applications to power solar calculators, watches and radios. The process of converting solar energy into electricity is carried out by the use of semiconductor materials, which can be adapted to release charged particles, forming the basis of electricity.

83. When light shines on the semiconductor, the electric field across the junction between two layers of semiconductor (one positively charged and one negatively charged) generates a direct current. The greater the intensity of light, the greater the flow of electricity.

84. The performance of a PV cell is measured in terms of its efficiency at turning sunlight into electricity. Usually, for a given material, only sunlight of certain energies will work efficiently to create electricity, and much of it is reflected or absorbed by the materials that make up the cell, so that the overall efficiency of a PV cell is about 15%.

85. PV systems can be stand-alone, grid-connected or hybrid. The grid-connected systems are the most popular in developed countries. A module of PV cells contains about 40 cells; about 10 of these modules are mounted in PV arrays that can measure up to several meters across.

86. PV arrays can be fitted at a fixed angle facing south or on a tracking device that follows the sun, allowing them to capture the maximum of sunlight over the course of a day. About 10 to 20 PV arrays can provide enough power for a household. Placing PV cells on roofs can reduce the need for using additional land, as well as that of energy transmission.

87. Connecting the arrays to the local electricity network allows any excess power to be sold to the utility provider. Electricity is then imported from the network outside daylight hours. In isolated locations where grid-connected systems cannot be employed, a storage system based on rechargeable batteries may be used. In this case, the PV arrays need to be oversized in order to supply enough power during sunny periods to power household appliances and also to store a certain amount in rechargeable batteries. As the sun sets, the system is switched to batteries.

88. A similar system uses fuel cells instead of rechargeable batteries. Hydrogen and oxygen are produced by the electrolysis of water using PV technologies and can be reconverted into electricity using a fuel cell, with an energy ratio of (1:1.3). Hydrogen has also the potential to serve as a renewable gaseous and liquid fuel for transportation vehicles.

89. Hybrid systems consist of a solar system combined with another source of power (a biomass generator, a wind turbine or a diesel generator) to ensure a consistent supply of energy; hybrid systems can be either grid-connected or stand-alone.

90. Germany is the European leader in solar photovoltaic energy (80% of the grid-connected systems in Europe), with a total installed capacity of 278 MW in 2002, of which 92% was grid-connected. Germany is followed by the Netherlands, Italy, Spain, France and Austria.

91. PV technology has an important environmental advantage in producing electricity compared to fossil fuel technologies, as the operational emissions of carbon dioxide and other pollutants are null. However, the lifespan of PV cells (15 to 20 years maximum) and their limited conversion efficiency need to be improved and current production costs reduced by about fivefold in order to make them economically feasible.

92. The major environmental problem associated with photovoltaic systems is the use during the manufacture process of toxic compounds such as cadmium sulphide and gallium arsenate. As these chemicals are non-biodegradable, highly toxic compounds and persist in the environment for centuries, disposal of inoperative cells could become a major environmental hazard. This drawback could be overcome by silicon-based photovoltaic cells. Their low cost, simplicity to manufacture allowing for mass production, and relatively high efficiency make the cells less expensive and environmentally safer in comparison with the heavy metal cells.

3.3.5. Solar thermal

93. Solar thermal technologies transform solar radiation into useful heat or cooling. The solar yield replaces conventional sources of heat, mainly fossil fuels or electricity. The enormous growth potential of solar thermal is therefore the key to moving the heating or cooling sector towards sustainability, reducing environmental impact as well as energy imports.

a. Concentrating solar power

94. The system is based on concentrating the solar energy with the help of parabolic mirror systems tilted toward the sun that focuses sunlight on a pipe that runs down the centre of the mirror. Depending on the system, one may use a heating agent in the primary circuit that releases the heat to a secondary cooling agent used for heating or to a steam generator that powers a steam turbine to produce electricity or mechanical power.

b. Solar hot water

95. The shallow water of a lake is usually warmer than the deep water because the sunlight can heat the lake bottom in the shallow areas, which in turn, heats the water. The same principle may be used to obtain hot water for buildings and swimming pools.

96. Solar water heating systems have two parts: a solar collector and a storage tank. The first one is fitted on a roof and contains a thin rectangular box with a transparent cover that faces the sun. A network of small pipes run through the box and carry the thermal agent (water, salty solutions or antifreeze solutions).

97. The tubes are fitted to highly absorbent plates, painted in black. As heat builds up in the collector, it heats the fluid passing through the tubes towards the storage tank where the hot liquid is stored. If the system does not use the water as a thermal agent, a coil of tubing must be added in the storage tank to allow for heat transfer.

98. Solar water heating systems can be either active or passive. Active systems use pumps to move the liquid between the collector and the storage tank, while passive systems rely on gravity and the natural convection of water based on temperature differences. In the case of the swimming pool, the filter pump is used to pump the water through a solar plastic or rubber collector. The pool acts now as an open warm water storage tank.

c. Passive solar heating and daylighting

99. Solar energy can be used directly to produce heat in homes and other buildings. A growing number of homes are designed nowadays to take advantage of this natural resource. Passive solar heating systems make use of a special building design (passive solar heating systems have large, south-facing windows) to absorb solar energy and convert it into the heat needed inside the building.

100. Walls and floors made out of dense material such as concrete or brick absorb light and heat, warming the rooms. The design is based on materials with a high thermal mass (heat-storing capacity) which will stay warm longer at night.

101. The position and shape of doors and windows used in passive solar heating is of paramount importance to energy efficiency. They can be flat, arched, pyramidal, and any other combination such as flat on the low side and concave in section on the high side offering various degrees of flexibility in placement. If they are raised in comparison with classical ones, the light will enter from more extreme angles than flat or warped plane units allowing more positioning options.

102. A positioning that faces north provides a quite constant but cool illumination. The best option is to position a high proportion of windows towards the East, providing maximum light and solar heat gain in the morning, or towards West to provide afternoon sunlight and heat gain. If the main objective is to provide the greatest potential winter passive solar heat gain, than South-facing is the best choice. However, the latter will also cause a certain degree of overheating in the summer, a disadvantage that can be overcome by installing solar control barriers based on traditional curtains or more high-tech variable transparency films.

103. The most important technical restrictions as far as large-scale development of solar thermal technologies is concerned are:

- the mismatch between the solar input (highest during summer) and thermal energy demand (highest in winter) – an exception being solar cooling, for which solar radiation and peak demand coincide;
- the limited transportation possibilities;
- the low energy density (900 kWh/m^2 in the North – 1600 kWh/m^2 in the South).

104. There are also some environmental hazards associated with solar ponds such as possible soil and groundwater contamination with salts and other chemicals used to increase the heat-storing capacity of cooling agents.

3.3.6 Wind

105. Wind power has been used for many years to drive mills and water pumps and to supply the necessary energy for sailing ships. However, the commercial application of wind energy is electricity generation by wind turbines. These may be used as individual units or set up in clusters, known as wind farms, and the electricity generated is fed into the grid.

106. Wind turbines range in size from a few Watts (for charging batteries) to 5 MW (prototypes). The largest installed capacities are today found in Germany, Spain, Denmark and the US. In Germany, the average size of new turbines rose to almost 1,4 MW in 2002 and tower heights and rotor diameters in some cases exceed 100 m.

107. According to certain projections, the average size is expected to grow further. The development of wind energy will be pushed even more powerfully by the emerging offshore wind energy sector, and wind turbines of up to 5 MW are currently being developed for that market.

108. As mentioned, in Europe Germany, Spain and Denmark accounted for almost 90% of the capacity installed in 2002. At the end of 2002, Germany had an installed capacity of 12001 MW (meeting 4.7% of its national electricity needs), Spain had 4830 MW and Denmark 2880 MW (enough to supply 20% of its electricity needs). The Netherlands and Italy also reached 3-digit figures for installations in 2002.

109. The public acceptance of wind power is strong, but concerns remain in some areas, because of noise, visual intrusion into landscapes, bird impacts (birds fly into the supporting structures and the rotating blades) and interference with electromagnetic transmission.

110. Proximity to built-up areas has a substantial impact on public acceptance. Under certain conditions, shadow flicker may cause irritation, disorientation, and seizures in humans. Mitigation of these effects is possible by a careful site selection away from homes and offices. These problem slightly limit the areas suitable for wind farms.

111. Another factor worth taking into consideration is the reaction of local communities to prevent wind turbines from being installed in residential areas. This is caused by the opinion that wind farms diminish the aesthetics of the area, decreasing property value and limiting the use of land designated for recreational purposes.

3.3.7. Tidal and wave energy

112. The tidal energy resource which could realistically be developed is confined to a few select regions of the world which have exceptional tidal ranges. Within the EU, France and the UK have sufficiently high tidal ranges to make significant use of tidal energy.

113. Denmark has initiated a special programme, "The Danish Wave Energy Programme" in order to develop economic and reliable ways of converting wave energy.

114. The environmental effects of tidal energy have always been recognised as a significant factor. The environmental risks are due to changes of water levels, which modify currents, sediment transportation and sediment deposits, affecting the ecosystem biodiversity.

115. So far, these energies seem not to be sufficiently mature in terms of technology and market opportunities.

4. Environmental risks associated with transportation and transportation operations

116. Transportation, as a generic term within the content of this report, may be divided into two main categories, namely transportation of energy fuels and electricity from the extraction points, processing units and power plants to the end user, and transportation regarded as the mean of

conveying passengers and goods, other than energy and energy-related goods. The distinction line between the two categories is very fuzzy as the risks and impacts found in the first one may also be found in the second.

4.1 Transportation of energy fuels and electricity from the extraction points, processing units and power plants to the end user

117. With the exception of a few cases where the energy is generated locally, fuel processing plants and the power plants supply fuel and energy to variable distances and they must resort to various means of transportation.

118. Each time fuel is moved or processed some waste is generated. Oil, coal and uranium all go through several steps of refining and processing using a certain amount of energy and generating waste. As the extraction or processing stages are finished, the fuel is transported to the intended destination.

119. The risks of oil spills and leaks during the transport stage have increased lately due to intensification of the world's shipping routes. Although it is preferable to use pipeline networks for oil, this is not always feasible and the transport by sea is here to stay for the foreseeable future. Reducing oil consumption is one way of reducing risk factors and adverse impacts on the environment.

120. Although there are very well defined Clean Air Act regulations setting standards for emissions of certain pollutants resulting from the use of energy, air pollution from combustion of fossil fuels is still one of the major impacts of energy production.

121. Burning coal, hydrocarbons and gas will pollute the atmosphere with particulate material, carbon dioxide, nitrogen oxides and, in some cases, with sulphur oxides. Apart from the greenhouse effect, global warming, acid rain and other effects already mentioned, it should be underlined that there is also an increased risk of broad-spectrum, acute and chronic health effects.

122. Particulate air pollution (i.e. particles small enough to be inhaled into the lungs) is consistently and independently related to the most serious effects, including lung cancer and other cardiopulmonary diseases.

4.2 Transportation, regarded as the means of conveying passengers and goods, other than energy and energy related goods

123. Traffic and transportation form another component of environmental risks in society. Traffic-related burden includes not only injury, but also the consequences of heavy metals pollution, particularly lead, and the effects on urban air quality.

124. Urban air pollution is a direct result of the combustion of fossil fuels for heating, transport, power generation and other human activities. Diesel and gasoline combustion engines produce a complex mixture of pollutants such as diesel soot particles, lead derivates, products of secondary atmospheric reactions such as ozone, and sulphate particles formed from burning the sulphur-containing fuel.

125. Lead contamination of the environment has increased with industrial development and particularly the use of leaded gasoline. Currently about 60 countries have phased out leaded petrol and approximately 85% of gasoline sold world-wide is lead-free.

126. Lead and ozone have serious health effects. The analyses based on particulate matter estimate that ambient air pollution causes about 5% of trachea, bronchus and lung cancer, 2% of cardio-respiratory mortality, and about 1% of respiratory infection mortality globally.

127. Electrically driven vehicles (known as *zero emission vehicles,* ZEV), using either rechargeable batteries or fuel cells, in a hybrid or entirely electric configuration, have become popular lately. They are becoming more interesting for several reasons: instability of oil prices; stricter legislation in the EU and the USA on vehicle emissions; improvements in battery conditioning; new types of lighter high-tech materials and vehicle aerodynamics. A significant amount of research and development funds have been redirected towards electric vehicles.

128. The design and performance of electric vehicles are improving at a high speed in order to provide the benefit of a zero emission vehicle while preserving the comfort and mobility drivers are used to and which are not prepared to trade by switching from a personal car to public transport.

129. ZEV have the advantage that they do not have evaporative emission problems since they do not carry gasoline or diesel fuel. There is however a drawback in the use of electric vehicles concerned with the environmental impact of heavy metals, such as the lead and cadmium used in some types of rechargeable batteries. As the use of newly discovered types of batteries intensifies and the recycling of the old type of rechargeable batteries increases, this problem should decrease.

130. Another environmental impact of ZEV is the transfer of emissions. Strictly speaking ZEV are not quite zero emission vehicles unless the electricity used for recharging the batteries or producing the hydrogen by electrolysis comes directly from a clean renewable electricity source. If it is produced by a conventional power plant, then the emission issue is transferred to that power station.

131. It is expected that newer generations of rechargeable batteries and fuel cells combined with improved electronic control devices will shift the balance more and more in favour of electrically powered vehicles as their mobility, life cycle and rechargeability improves. The convenient features of electric vehicles, such as lack of noise, reduction of environmental risks and simplified automotive systems are also strong arguments in their favour.

5. Energy conservation

132. As population growth increases yearly and the search for new energy sources does not keep in step with energy demand, it is obvious that other measures must be put in place to ensure sustainable development. There are no reliable and accurate models to estimate the energy wasted (and this is different from the concept of inevitable energy loss) during the production, transport and consumption stages.

133. In a typical electric power plant, only about 35% of the chemical energy of coal is converted into electricity, because the chemical energy is first converted to heat and then the heat is converted into mechanical energy and ultimately into electricity. In a nuclear power plant, the conversion of nuclear energy to electricity is constrained by thermodynamic laws. In an internal combustion engine, only about 25% of the chemical energy of gasoline is converted into the mechanical energy of rotating wheels and the total amount available for conversion is also limited theoretically by thermodynamic laws.

134. It is obviously better to free up energy generated by current power plants than to build new plants. One possible way of reducing energy waste, besides improvements in technology and production efficiency, is energy conservation. It includes permanent activities in the field of energy regulations, technological improvements, environmental protection education programmes on energy saving methods, and subsidies and incentives for measures targeted specifically on energy saving and consumption reduction.

135. If one compares the consumption of an average house to that of an energy efficient house, it is possible to reduce the annual energy consumption by up to 35-40 per cent. One should consider developing an energy conservation plan reducing domestic energy requirements by using the following measures, all of them being both environmentally friendly and economically sound:

- insulation of walls, ceilings, water heaters and all accessible hot water pipes;
- the use of "green" low energy appliances instead of the old types;

- reduction of the temperature setting of water heaters from very hot or hot to warm;
- sealing leaks in accessible ducts and around doors and windows;
- the use of thermostated systems with controlled settings;
- replacing regular windows with double glazing as at least one third of total heat is lost through windows and doors;
- the use of alternative methods to air conditioning, such as whole house fans, evaporative cooling, window curtains and natural shading barriers (tree planting);
- the use of automatic lights and compact fluorescent lights instead of incandescent bulbs in areas where lights stay on for long periods;
- the use of heat-reflecting filters that can be mixed into paint, then painted on walls, keeping warmth in during winter and warmth out during summer;
- educating children in the spirit of environmental awareness.

136. Regarded in the past as a response to price increases, energy conservation has today a new meaning, namely that of reducing the environmental impact of energy usage. If we can get the services we need (warm showers, cold drinks, clean clothes) with less fuel, we also save on the costs of repairing the damage already done to the environment.

137. A reduction in energy consumption reduces vulnerability to rising energy prices and increases the reliability of supply. According to the EU Green Paper on security of energy supply, energy savings are the most efficient and cheapest way to reduce dependence on imported energy.

138. Energy conservation is an important means of reducing the environmental risks and impact from the energy sector, as savings in energy means in fact a way of complying with international agreements on reducing CO_2 emissions, especially the Kyoto Protocol.

6. Conclusions

139. There are limited supplies of fossil fuels (oil, coal and gas) which are being depleted rapidly without any possibility for a quick, natural replenishment; these are fuels that contribute greatly to atmospheric pollution and to climate change by global warming.

140. Nuclear energy produced in modern nuclear power plants may be a possible medium-term solution to avoid increasing air pollution (greenhouse gases and fine particle pollution) but has the limitation of the unsolved issue of processing and storing the spent fuel and other radioactive nuclear waste.

141. Renewable sources of energy (e.g. biomass, geothermal, hydropower, solar, wind, tidal and wave energy, etc.) appear to solve the sustainability issue and may offer a possible alternative to the conventional energy production systems.

142. Transport systems should evolve towards cleaner zero emission vehicles in order to reduce the associated impact of greenhouse gases on human health.

143. Measures for decreasing energy consumption and increasing energy conservation would reduce vulnerability to rising energy prices and the dependence on imported energy, increasing the reliability of existing EU energy sources.

Appendix 1

Likelihood and consequence definitions for environmental risk

Likelihood (How likely is the event to occur)			**Consequence** (Significance of associated environmental impact)		
Rating		**Definition**	**Rating**		**Definition**
A	Almost certain	The event is expected to occur in most circumstances	5	Catastrophic	Disaster with potential to lead to collapse
B	Likely	The event will probably occur in most circumstances (e.g. weekly to monthly)	4	Major	Critical event, which with proper management , will be endured
C	Moderate	The event should occur at some time (e.g. once in a while)	3	Severe	Significant Event, which can be managed under normal procedures
D	Unlikely	The event could occur at some time	2	Minor	Consequences can be readily absorbed but management effort is still required to minimise impacts
E	Rarely	The event may occur only in exceptional circumstances	1	Negligible	Not worth worrying about:

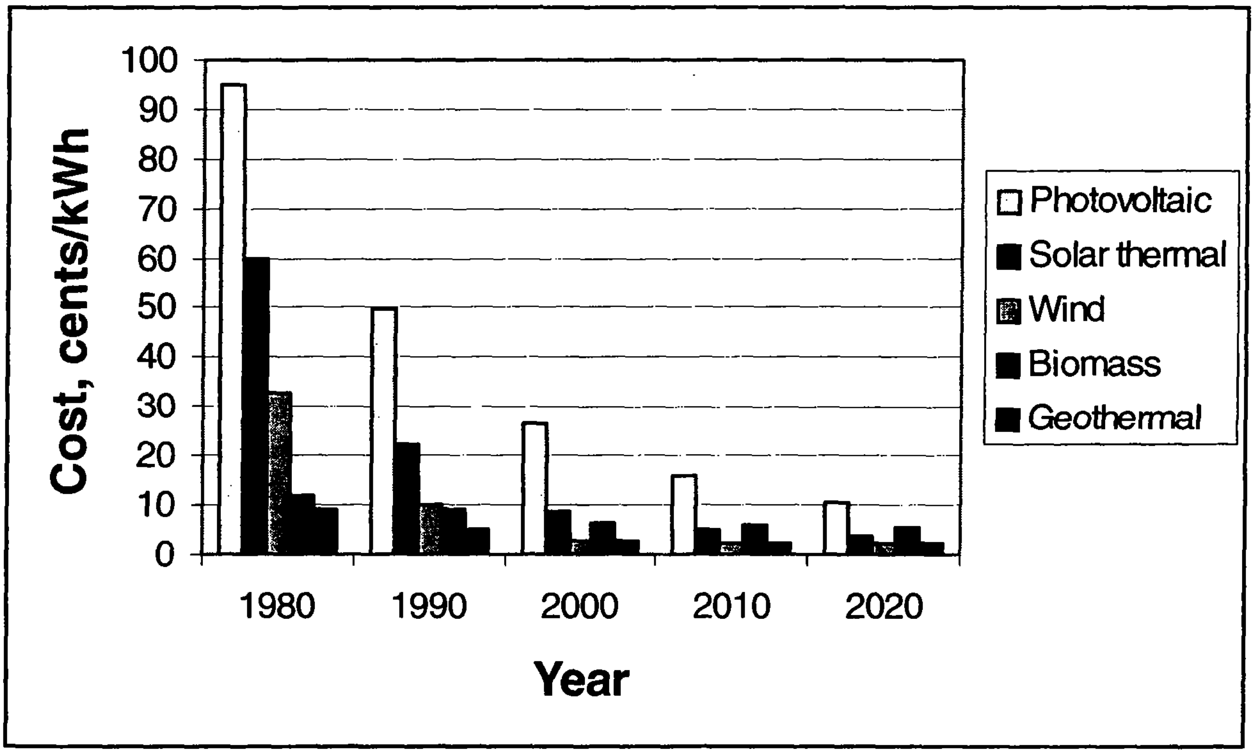
Source: Su Wild River, Environmental Risk Assessment and Waste Snapshot Report, 2001, Australian National University, Centre for Resource and Environmental Studies

Appendix 2

Cost trends for renewable energy (cents/kW-h)

	Year				
Renewable energy source	1980	1990	2000	2010	2020
Wind	32.9	10.1	2.9	2.5	2.1
Photovoltaic	95	50	26.7	16.1	10.7
Geothermal	9.3	5.1	2.7	2.3	2.1
Solar thermal	60	22.5	8.7	5.1	3.7
Biomass	12	9.3	6.2	5.9	5.6

Sources: NREL Energy Analysis Office (2002) and John A. Turner, Mark C. Williams, and Krishnan Rajeshwar, Hydrogen Economy based on Renewable Energy Sources, The Electrochemical Society Interface • Fall 2004



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Reporting committee: Committee on the Environment, Agriculture and Local and Regional Affairs

Reference to committee: Doc. 9717, reference no. 2817 of 31 March 2003

Draft resolution adopted by the Committee on 17 March 2005

Members of the Committee: Mr Walter **Schmied** (Chairman), Mr Alan **Meale** (1st Vice-Chairman), Mr Antonio Nazaré Pereira (2nd Vice-Chairman), Mr Renzo **Gubert** (3rd Vice-Chairman), Mr Ruhi **Açikgöz**, Mr Olav Akselsen, Mr Gerolf Annemans, Mrs Sirkka-Liisa **Anttila**, Mr Ivo Banac, Mr Jean-Marie **Bockel**, Mr Malcolm Bruce (*alternate: Mr Edward **O'Hara***), Sir Sydney **Chapman**, Mrs Pikria Chikhradze, Mrs Grażyna Ciemniak, Mr Viorel Coifan, Mr Valeriu Cosarciuc, Mr Osman **Coşkunoğlu**, Mr Alain Cousin, Mr Miklós Csapody, Mr Taulant Dedja, Mr Hubert **Deittert**, Mr Adri Duivesteijn (*alternate: Mr Leo **Platvoet***), Mr Mehdi Eker, Mr Bill **Etherington**, Mrs Catherine Fautrier, Mr Adolfo **Fernàndez Aguilar**, Mrs Siv Fridleifsdóttir, Mr György Frunda (*alternate: Mr Atilla Bela **Kelemen***), Mr Fausto **Giovanelli**, Mrs Maja Gojković, Mr Peter Götz, Mr Vladimir **Grachev**, Mrs Gultakin Hajiyeva, Mr Mykhailo Hladiy, Mr Anders G. Högmark, Mr Jean Huss, Mr Ilie **Ilaşcu**, Mr Jaroslav Jaduš, Mrs Renate Jäger, Mr Gediminas **Jakavonis**, Mr Ivan Kalezić, Mrs Liana Kanelli, Mr Karen Karapetyan, Mr Orest Klympush, Mr Victor **Kolesnikov**, Mr Zoran Krstevski, Mr Miloš **Kužvart**, Mr Ewald Lindinger, Mr Jaroslav **Lobkowicz**, Mr François Loncle (*alternate: Mr Guy **Lengagne***), Mr Theo Maissen (*alternate: Mr John **Dupraz***), Mr Andrzej Mańka, Mr Tomasz **Markowski**, Mr Giovanni Mauro (*alternate: Mr Pasquale **Nessa***), Mrs Luísa Mesquita, Mr Gilbert Meyer, Mr Goran Milojević, Mr Vladimir Mokry (*alternate: Mrs Svetlana **Smirnova***), Mrs Carina Ohlsson, Mr Gerardo Oliverio (*alternate: Mr Giovanni **Crema***), Mr Pieter Omtzigt, Mr Mart Opmann, Mrs Elsa **Papadimitriou**, Mr Jakob **Presečnik**, Mr Lluís Maria de Puig (*alternate: Mr Gabino **Puche***), Mr Jeffrey Pullicino Orlando, Mr Maurizio Rattini, Mr Marinos Sizopoulos, Mr Rainder Steenblock, Mrs Inger Støjberg, Mrs Maria **Stoyanova**, Mr Gàbor **Szalay**, Mr Nikolay Tulaev (*alternate: Mr Yuri **Kovalev***), Mr Iñaki **Txueka**, Mr Vagif Vakilov, Mr Borislav Velikov, Mr Geert Versnick, Mr Klaus Wittauer, Mr G.V. Wright, Mr Kostyantyn Zhevago

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N.B. The names of those members present at the meeting are printed in **bold**.