COUNCIL OF EUROPE
CONSEIL DE L'EUROPE

Parliamentary Assembly
Assemblée parlementaire

Strasbourg, 1 March 1991
AAS14.42

Restricted
AS/Science (42) 14

COMMITTEE ON SCIENCE AND TECHNOLOGY

DRAFT REPORT

on renewable energy sources and solar hydrogen

Rapporteur : **Mr Scheer**

I. PRELIMINARY DRAFT RESOLUTION

1. The Assembly notes with concern that world energy supply is heavily dependent on fossil fuels of which there are limited reserves unevenly distributed over the planet. The concentration of nearly 60 % of the world's oil reserves in the Middle East is a permanent threat to peace in that region.

2. Among human activities the burning of fossil fuels is the main responsible for the increase of carbon dioxide concentration in the atmosphere and therefore it is also one of the main contributors to the man induced greenhouse effect. Burning fossil fuels also releases pollutant gases such as SO_2 and NOx.

3. The Assembly considers that the use of nuclear energy will remain restricted for as long as waste disposal and security problems are not considered to be satisfactorily solved. On the other hand nuclear energy production requires highly advanced technology and administration and therefore it does not seem likely that it will play a significant role in the energy supply of countries with a less developed economic infrastructure.

4. In theory, the potential of renewable energies is more than enough to meet the needs of mankind. World energy consumption in one year is equivalent to the solar radiation that reaches the earth in only 45 minutes. This energy can be used either by converting direct solar radiation into heat or electricity or through atmospheric winds, ocean thermal energy, hydropower or biomass. Other renewable energy sources are the waves (ocean kinetic energy) and geologic heat (geothermal energy). It should be noted that renewable energies produce less impact on environment and human health than fossil or nuclear energy. No difficulties arise from waste or reactor accidents and there are no traces of gas which are harmful to the earth's atmosphere. Irreversible global damages do not arise

5. The Assembly believes that energy policy should be linked to environment policy and therefore energy conservation through the efficient use of energy and the gradual replacement of traditional energy sources with renewable energies should be among the goals of any sound energy policy.

6. It notes however that renewable energies have not been a priority in European research and development budgets in the field of energy. Indeed R & D in renewables have stagnated or decreased in many European countries since 1981 despite its contribution to the solution of many technical problems, the reduction of a number of uncertainties and the establishment of solid technical basis.

7. Therefore, in order to prepare for a sound long term energy policy that would secure energy supplies, protect and improve the quality of the environment and ensure a rational utilisation of natural resources, the Assembly calls on member states to :

i. pursue, in particular through the continuation of present efforts, research, development and demonstration programmes at national and international levels, and periodically assess them from the techno-economic point of views, in relation to market potential ;

ii. review priorities for further development of renewable energy and energy saving technologies, in coordination with European and international organisations and focus on those which seem most promising, considering each country's resources and constraints ;

iii. compile national inventories of renewable energy resources and disseminate these inventories as widely as possible at international, national, regional and local levels ;

iv. promote cooperation among industries producing equipment for the exploitation of renewable energy sources and promote the transfer of technology and cooperation between small and medium enterprises to facilitate their adjustment to potential demand ;

v. promote the transfer of technology between industrialised and Third World countries in particular through the establishment of an International Solar Energy Agency (ISEA) which would promote and coordinate international non-commercial technology transfer as recommended by the General Assembly of the United Nations in November 1990 ;

vi. guarantee tariffs for the supply to the distribution network of energy generated by private enterprises from renewable sources in the light of Italian and German legislation in force since 1 January 1991 ;

vii. consider the introduction of technologies for the use of renewable energies in private homes, small and medium sized enterprises, agricultural facilities, etc. through financial subsidies and tax benefits;

viii. ensure that in public investment the possibility of using renewable energy and energy saving measures is taken into account ;

ix. introduce, where appropriate and necessary, legislation and/or administrative procedures which would help to overcome, on a non-discriminatory basis, obstacles to the exploitation of renewable energy sources ;

x. increase taxes on the use of energy from conventional sources to take account of the effects of such energy on the environment and human health ; national policies in this respect should be coordinated at international level (e.g. agreements regarding CO_2 emissions) ;

xi. ensure that information on renewable energy and energy saving technologies is widely circulated among those who could best develop their utilisation either as producers or consumers of energy ;

xii. ensure that the teaching of renewable technologies is included in the cirrucula of the appropriate university or other post-secondary level studies (e.g. solar passive design in architecture).

8. The Assembly instructs its Committee on Science and Technology to consider energy policies and prospects in Europe and the world, to take account of the work of international organisations in the field of energy and to propose guidelines and measures for a comprehensive long-term energy policy.

II. EXPLANATORY MEMORANDUM

by **Mr Scheer**

Introduction

1. Theoretically, the potential of renewable energies is sufficient to meet the needs of mankind. In just 45 minutes, the sun radiates as much energy onto the earth as mankind consumes in an entire year. In addition to direct solar energy, the potential for energy is available through hydroelectricity, wind energy, biomasses, geothermal energy and sea energy. All of these energy sources are inexhaustible, i.e., they are available without limit. Conversion of primary energy into usable secondary energy sources produces no waste or emissions.

2. There is a wide variety of technologies available which enable the conversion of renewable energy sources. The spectrum reaches from the passive use of solar radiation in homes to the use of agricultural waste for electricity, heat, combustibles and fuel generation ; from direct conversion of sunlight into electricity (photovoltaic energy), the conversion of solar heat into the generation of warm water and turbines (solarthermal energy), as well as the use of wind, biomass, hydropower, and sea energy for the generation of electricity. The use of geothermal energy for electrical and heat generation also falls within the spectrum of possibilities for the conversion of renewable energies.

3. In the world energy supply, commercial energy conversion is differentiated from non-commercial energy conversion, especially in countries of the Third World. Among the commercial energy carriers (approximately 85% of world wide supply), fossil fuels account for about 88% of the world supply (oil 37%, coal 29%, gas 22%). Both nuclear energy and hydropower contribute 6% each to the world energy supply. Global environmental problems arise with the use of fossil fuels (e.g. the greenhouse effet as a result of CO_2 emissions, deforestation, impairment of health in densely populated areas). The use of nuclear energy presents additional serious global environmental and security problems (e.g. fallout from reactor accidents, problems of atomic waste disposal, dangers of proliferation of atomic weapons). Of renewable energy sources, only hydropower plays a statistically relevant role in the commercial world energy supply at present although only about 5% of its potential has been exploited thus far. The use of hydropower, however, often occurs in conjunction with serious consequences for the natural environment (e.g. power stations require large spaces for reservoirs).

Background

4. The non-commercial energy supply (total share approx. 15%) contributes a large share to the energy supply in a few countries of the Third World. (According to the last report of the World Resources Institute (1987), the share in the Third World's large countries is as follows : 29% in China, 54% in India and 29% in Brazil, as well as 71% in Bangladesh, 88% in Niger, 95% in Ethiopia, 98% in Nepal, and 84% in Somalia). In the case of non-commercial energy sources, it is largely a matter of renewable energies lacking the implementation of technologies or it is a question of the use of forest resources resulting in uncontrolled forest destruction.

5. The environment-political tasks can no longer be separated from the energy-political tasks ; energy policy can no longer function without environmental policy. Environmental policy requires a new energy policy. Thus we are faced with the general goal of continuously reducing conventional energy sources through two measures :

- the conservation of energy,
- the replacement of traditional energy sources with renewable energies

The necessity of this results from an ecological challenge no longer solely due to limited resources of conventional energies, as the Club of Rome stated in 1971 in its report "The Limits of Growth".

6. Fossil fuels are finite. At the present rates of consumption, coal will last for more than 250 years but gas will last for 60 years only and oil will be exhausted in 30 years time. If we take into consideration the increase in world population and the increase in energy demand in developing countries, these lifetimes could be halved. It is urgent therefore to save oil for transport and chemical industries instead of burning it in power stations. Uranium deposits are also limited. Their potential can only be lengthened through fast-breeder reactors, a sensitive nuclear technology which exposes heightened security problems, generates additional public acceptance problems and moreover can be technologically operated in only a few developed countries. The use of fusion energy still needs decades of research and developmental work. It is doubtful that it will be available before the year 2050. Fusion energy does not present itself as an alternative for the next 50 years, which is why alternative strategies must focus on the use of renewable energy sources, for which the technology is currently available.

7. Fossil fuels are unevenly distributed over the planet. 57% of world's oil reserves and 26% of gas reserves are located in the Middle East. Western Europe has 9% of coal reserves, 6% of gas reserves and only 3% of oil reserves (The latter will be dry by the end of this decade). The present gulf crisis reminds us that this situation is a serious threat to peace. This threat will grow proportional to the depletion of resources. Nuclear energy, whose use requires highly advanced technology and administration, is also unevenly distributed. Add to this the fact that nuclear energy is produced in large plants which require an extensive network for electricity distribution. Such a network is, however, not available in a large part of the Third World, which is why nuclear energy is directed to decentrally installed energy conversion plants.

8. The burning of fossil fuels is responsible for 60% of man made CO_2 emissions and these emissions account for half of the likely greenhouse effects. In addition the combustion of fossil fuels releases SO_2 and NOx which are also greenhouse gases and at the same time atmosphere pollutants (inter alia responsible for acid rain). The only means of reducing CO_2 emissions without incurring significant economic and social costs are improved energy efficiency and substitution of fossil energy resources.

What are renewable energies ?

9. Renewable energy technologies, like the energy sources they are associated with, vary enormously. Therefore, renewable energy sources and technologies cannot be lumped together under one homogeneous and coherent heading or discussion. But there are a number of characteristics in common, stemming from the similar nature of renewable energy sources, such as the following :

- renewable energy sources are those which, in terms of the human life span, are perpetual and therefore virtually inexhaustible ; these include solar radiation, atmospheric winds, ocean thermal and ocean kinetic energy, geothermal energy, thermal and chemical energy from biomass, and mechanical energy from falling water ;

- renewable energy sources are widely dispersed and, in general, for either physical or economic reasons, they are developed and used at sites where the resource is available ;

- renewable energy sources generally have low power and energy density and, as a result, their technologies often have large space requirements. These requirements can nonetheless be reduced through careful and intelligent planning ;

- renewable energy technologies often have high initial costs, while operating costs are low and relatively insensitive to fluctuations in conventional energy prices ;

- renewable energy technologies are often modular and can be installed relatively quickly in response to varying demand.

10. Renewable energies already contribute today some 6 to 7 % of Europe's energy supply. This represents a sizeable amount but in Europe it is restricted to the utilisation of hydropower, fuelwood and some biomass. Most other renewable energy technologies which have emerged more recently are virtually unused at present. The case of electricity networks, where continuous supply is of utmost importance was investigated in detail in 1988/90 in a joint effort of renewable energy and utility experts from the European Community and the USA. The study confirmed that even the most intermittent sources, such as wind and photovoltaics, could be used in industrialised countries in very large amounts (up to 10 to 15 % of current power capacity) without particular implementation problems :

- need for large land areas for installation : all renewable energies require collecting areas for solar radiation or wind, which are not in excess of the land which is currently employed for the installation of conventional energy systems (mining, transport, fuel storage, conversion, distribution, disposal areas, etc.). An exception is biomass, where the best collection efficiencies of solar energy are only between 1 and 2 %. However, biomass must be seen as an agricultural commodity just like food production, for which efficiencies are also in this range. Unlike conventional energy systems, most solar energy collectors - for heating or in the form of photovoltaics - can be easily integrated into existing building structures and in particular the roofs, so that no land requirement is involved at all. Photovoltaics could also be integrated into other existing structures - along highways etc. - which can otherwise not be used. Dual use is also possible for wind energy. There exist many examples where the land on which wind turbines have been installed is further employed for agricultural use, cattle breeding, etc. ;

- high cost : most of the renewable energies have now entered the range of cost-competitiveness with conventional energy sources. This is the case for solar energy applications in buildings, for biomass, for hydropower, for tidal power and wind. Photovoltaics is so far cost-competitive for remote applications only. Compared to the conventional, renewable energy systems offer additional cost advantages for large-scale implementation. Renewable energies involve easier and faster implementation. Moreover they are installed close to the consumer. Hence they can be more easily adapted to the users' needs and their evolution in time. As a result, the planning of renewable energies becomes more realistic in comparison to conventional power systems. It is well known that energy projections in the 1970s and at the beginning of the 1980s were overestimating future consumption. Since construction times for conventional power plants are in the order of 10 years and more, it is difficult to readjust planning once construction has started. As a consequence, a lot of overcapacity of conventional power plants was built. The large cost involved could have been avoided with a type of short-term and realistic planning which is possible with renewable energies. Hence there can be a considerable cost advantage for renewable energies on a macro-economic scale because of this effect.

Renewables versus conventionals

11. Compared to fossil fuel and nuclear energy production and use, renewable energy sources can, in general, be considered to produce less impact on environment and human health. Fossil and nuclear energies incur considerable social costs. A quantitative assessment of these costs has been attempted through scientific criteria for quite some time (See for instance "Social Costs of Energy Consumption" by O. Hohmeyer, New York, 1988). Indeed there are also environmental burdens which arise from the implementation of renewable energy methods (agricultural alterations, agricultural consumption, changes in the local climate) which must be avoided as much as possible. The carelessly considered construction of a large hydropower station could cause problematic changes in natural regions. A strict condition for the use of renewable energy sources would be that these energies should only be used when the renewability of the natural environment from which these sources originate is not endangered. But the impact on the regional environment which results from the use of renewable energies does not compare to the irreversible global damages which result from the consumption of conventional energies. This is a qualitative fundamental difference between conventional energy carriers and renewable energy sources.

12. There are at least four different types of external costs which should be considered when comparing renewable energies with conventional sources and utilisation schemes. The first one concerns pollution effects due to SO_2, NOx, radioactive fall-out or other emissions. The second concerns the greenhouse effect. The third is related to the benefits of a national economy through industrial production of energy in the country which displaces imported fossil fuels. The fourth has to do with the costs involved in the military or other protection measures needed to secure the sources of supply.

i. As to chemical and radioactive pollution, most of the economic consequences have still to be evaluated. A start has been made for electricity production in Germany with the conclusion that the external costs of fossil energy utilisation are in the range of up to 4 cents/kWh and in the case of nuclear up to 8 cents/kWh of electricity produced. For renewable energies, the external costs would be negligible. For the US, a study from Pace University, in the State of New York, concluded that, for fossil sources, external costs could be up to 7 cents/kWh. These external costs depend in any case on local conditions and the detail of electricity networks. It is important to note that, so far, this type of external cost has not yet been internalised into market prices. This lack of action goes to the expense of renewable energies which is penalised in terms of macro-economic competitiveness with fossil and nuclear energy.

ii. The second environmental effect entailing external cost of energy production is global warming. 1990 was the warmest year of the globe on record since the time measurements have been taken. The threat of global warming is well realised on international level and is the subject of intense activities to take measures against the further increase of emissions of greenhouse gases. At the 2nd World Climate Conference held in Geneva in October 1990, all 137 participating countries welcomed the CO_2 emission stabilisation commitment which was undertaken by the European Community and nearly all the other major industrialised countries with the exception of the United States. It is estimated that the cost of fossil fuels will have to be increased by 50 to 150 % of present energy prices in order to attain a CO_2 emission reduction in the order of 20 % solely by relying on price regulations. Hence, the external costs involved in CO_2 emissions are extremely high and may dramatically change economic competitiveness in favour or renewable energies. The Commission has proposed, in a communication to the Council, a global price increase of conventional energy in the order of 10 US&/barrel mark-up. Three-quarters of such a new fiscal instrument would represent an energy tax reflecting the thermal equivalent content of fuels. The other quarter would represent a carbon charge modulated according to carbon content. Renewable energy sources would in principle be exempted from these energy taxes and charges. The Commission's paper also expresses the opinion that the development and increased use of renewable energy sources could make a significant contribution to the limitation of CO_2 emissions in the medium- and long-term perspective.

iii. The third factor having a macro-economic impact involves the national economy. Renewable energies are produced in the country, new industrial activity and new jobs arise contributing to the gross domestic product and creating tax income. They displace imported fuels which do not have these effects. Furthermore, the balance of payments is relieved accordingly. In quantitative terms it is estimated that both effects add virtually another US& 5 per barrel equivalent to the advantage of renewable energies.

iv. A fourth aspect involving external costs for conventional energies is the need for protection of conventional resources and their exploitation. This includes e.g. protection of nuclear installations. It would also include, in particular, military expenses for the protection of oil resources in the Gulf region and elsewhere. Unless military activities in the Gulf in 1991 are dramatically expanded, this additional cost of oil would not exceed an extra 10 US&/barrel equivalent.

Obviously, all these costs for the society have so far not been internalised for the benefit of renewable energies, but they should.

13. An overview of the different renewable energy technologies shows which are the most relevant for each of the four more important sectors of energy consumption in Europe :

- Heating (the sector represents about 1/4 of Europe's energy consumption at present)

  . passive solar energy
  . active solar energy
  . wood and biofuels

- Electricity (approximately 1/3 of present European energy consumption)

  . hydroelectricity from large and small plants
  . biofuels, energy from waste
  . wind energy
  . tidal energy
  . photovoltaics

  . (wave energy)

- Transport (approximately 1/4 of Europe's energy consumption)

  . biofuels
  . (electricity - see above)
  . (hydrogen produced from electricity - see above)

- Industry

  . biofuels
  . (high temperature solar collectors)
  . (hydrogen produced from electricity - see above)

Solar hydrogen

14. Contrary to conventional energy, most renewable energy technologies cannot be developed anywhere (wind, hydro, geothermal) and do not depend on continuous flows (direct solar radiation, tidal, wind). This poses the problems of storage and transport of energy. A new generation of electric batteries should be developed to store energy and hydrogen could be used to transport it from production sites to consumption areas. The second essential function of hydrogen stems from the fact that it is used as a fuel and is thus capable of substituting for oil, coal, and gas. Hydrogen thus serves beyond the generation of electricity as a universal energy carrier.

15. A project of a hydrogen-based energy system was conceived by the Joint Research Centre of the Commission of the European Communities in Ispra. This pilot project on the basis of a 100 MW hydropower plant aims at demonstrating the feasibility of producing electricity in Quebec where a large potential is readily available, then converting it into hydrogen via electrolysis and shipping the hydrogen to Europe where it will be stored and used in different ways

(electricity/heat generation, bus fleet operation, aircraft propulsion, etc.). The present study phase, which includes a techno-economic macro analysis and special study activities, is estimated to be completed in 1991. Blue-print production will last 1 to 2 years and hardware realisation another 3 to 4 years. It should be noted that 25 European companies and 8 Canadian companies are associated with the project, together with state organisations and research institutes.

Research, Development and Demonstration

16. R & D programmes in the field of renewable energies increased in importance (and in public funding) until 1980/81 when IEA member countries spent annually more than 1 500 million US dollars. Since 1981, R & D spending on renewables has decreased and in 1989 it amounted to less than 500 million US dollars. If we consider the European members of IEA (the Council of Europe member states with the exclusion of Czechoslovakia, France, Finland, Hungary, Cyprus, Malta, Iceland, Liechtenstein and San Marino), the amounts spent in R & D for renewables increased to 380 million US dollars in 1981, decreased to 200 million in 1986/87 and then increased to 256 million in 1989. As a consequence Europe, which represented only 17% of IEA Government R & D budgets for renewables in 1978, increased its participation to represent 52% in 1989 (see Appendix I). Decreasing research expenditures, which have been sinking since the beginning of the 1980s, are often justified by falling oil prices during this same time - a justification which does not wear well due to the fact that research expenses are not directly related to energy markets. There were no cuts in public programmes of fusion research, for example. The break in the 1980s is more likely explained by the lack of political foresight among political decision-makers.

17. Despite the neglect of political promotion in research policy, noteworthy successes in development have been achieved. The effort in research, development and demonstration for the last 15 years has led to the solution of many technical problems, the reduction of a number of uncertainties and to the establishment of a solid technical basis. Some technologies have become economic and no longer need intense government R & D funding ; others have been deemed to be of lower priority or less appropriate to national energy requirements.

18. Government incentives, information programmes, regulations, leadership activities and international co-operation have also allowed an array of renewable energy technology industries to emerge sooner than they would have done, without government involvement. Appendix II gives a brief overview of national policies in the field of renewable energies in some Council of Europe member states.

19. Private industry is beginning to show its interest and has started putting money into renewable energy technology as it becomes technically and economically viable under certain conditions.

20. Nonetheless, technical development potential remains at an early stage. Therefore, commonly heard prognoses regarding the supposedly limited possibilities of the use of renewable energy sources are false. Despite the benefits of renewable energies for the environment and the central relevance of the energy issue, the funds given for research and development in this field have been less than those

given for the development of a new fighter jet, significantly less than those given for nuclear energy or space research and less than those given for fusion energy as well. The extent of scientific development potential exposes itself, for example, in the fact that, in nature, the organic membranes in plants generate energy at local temperatures when they are converted by solar energy. In comparison, the material of solar cells functions only under very high temperatures. In addition, natural membranes are about one thousand times thinner than our solar cells today. Since the same physical laws apply both to nature and to technology, there is an immeasurably large potential for the use of solar energy. The need to make this accessible is so great, that a change in research priorities for the use of solar energy is indispensable.

21. The extent to which renewable energy sources contribute to the energy supply cannot be determined. The contribution depends upon the size of state research expenditures, the outlook of investment advances, the level of investment, and the price development of traditional energies. In any case, it is necessary to increase the contribution of renewable energy sources as quickly as possible.

Promotion of renewable energies

22. There are substantial price differences between renewable energies. Whether the method of conversion, under the given circumstances, is competitive with conventional energy carriers is also dependent on geographic factors. For example, solarthermal electrical production plants in California are already competitive (electricity price : 6 cents per kWh). In Europe they are not. (Rapporteur's note : the next draft will contain current figures regarding the prices of renewable energy sources.)

23. Competitiveness increases according to the market which can, through political incentives, stimulate mass production. There are no such mass productions taking place at present, which reveals a vicious circle : small market, high prices : high prices due to small market.

24. Lack of information also plays an important role in preventing a wider use of renewable energy technology, for instance in the field of passive solar design. It should be the role of governments, in co-operation with international organisations, to make such information readily available while sweeping aside any legal or administrative barriers to their development.

25. Renewable energy, with the exception of fuel wood and large hydroelectricity, is virtually not yet utilised at all in Europe. Since these energies are socially desirable and will have to play an important role in Europe's future energy mix, it is important to stimulate acceleration of market uptake. Otherwise, our society will not be able to benefit from its environmental and social advantages : under normal conditions lead time for new energy sources is in the order of several decades.

26. In our free market economy, new products are accepted by the market only if they are cheaper and/or more convenient than conventional products. In recent times there was a fuel switch for heating of buildings from coal to oil and currently from oil to gas mostly for reasons of convenience. Oil is easier to bring into buildings than coal, and gas requires no storage in the building.

27. Conventional energy systems involve long development and construction times. The introduction of solar devices into the building market will also depend heavily on the construction rate of new buildings which, compared to the total building stock, is very low. Renewable energies therefore need a long-range planning process.

28. As a result, it will not be sufficient that, in the market place, renewable energy products are as good and as cheap as conventional products. This can only be achieved by a number of particular promotional measures. The following measures would all be necessary :

- on a national and international level, in particular on a European level, policy decisions have to be taken and market goals defined in order to set a general frame and express the willingness of the decision-makers to foster the development and market introduction of renewable energies ;

- a first prerequisite of market introduction is the development of well designed products already industrially and commercially available for easy utilisation and integration. For complete production systems, in particular if they involve a high degree of complexity, demonstration projects are needed to give the example ;

- regulations are necessary to make the existing energy networks accessible for this new type of decentralised and renewable energy sources. This is, in particular, the case for feeding renewable electricity into utility networks. It has to be recognised that much progress has been realised in the last few years in Europe to achieve co-operation with the utilities for the rising renewable electricity input to the grid and to reimburse the supplier at an appropriate rate. For renewable fuels, and in particular biofuels, the same requirements have to be fulfilled concerning integration into the conventional oil and gas networks, including refineries etc. ;

- financial support is most critical to improve market competitivity of renewable energies. Direct subsidies for development, manufacturing and utilisation of renewable energy products have to be considered. A second instrument for the same objectives is tax deductions and cost shifting in favour of renewable energies through charges for conventional energies. It is important to note that these measures are not to develop unfair competition at the expense of public budgets. On the contrary, these subsidies should reflect and be quantitatively in accordance with the macro-economic cost benefits of renewable energies for society, i.e. these subsidies are the result of the internalisation of external costs. They are in the financial interest of society and not at their expense.

- well-designed products which are user-friendly can be successfully developed only if norms and standards are agreed on to speed up widespread energy market uptake and stimulate competition between European manufacturers. It is particularly important in view of the single European market of 1993.

- upstream of the market research and development remains an essential instrument of promotion. Prenormative R & D and scientific and technological promotion are the basis to improve performance and reliability of products and systems and to further decrease their cost.

Prospects for the future

29. For Europe only, little information is available on the role of renewable energies in today's production and consumption systems and their projection into the future. For the United States, the official figure for renewable energies contribution today is 8 % of total consumption. This includes mostly hydroelectricity and some heat for households. It also includes 8 GW of bioelectricity, mostly from wood, and 1 GW from landfill gas. With a 6 to 7 % contribution, the European Community employs only a little less renewable energies than the United States. There is in particular less utilisation of large-scale bioelectricity production. As to the future potential of renewable energies in the United States, a remarkable report was issued about 1 year ago. This report looks at 3 different scenarios (business as usual, market incentives, RD & D intensification) and at various time horizons. RD & D turns out to be a very critical parameter of the obtainable market share. For the year 2010, the share of renewable energies in the US could more than double compared to the present level to 18 % in the case of RD & D intensification. In the case of business as usual, it would increase less than half to 11 %. It is interesting to note, in this scenario of 18 % in 2010 in the US, that biomass would take approximately twice the share of hydroelectricity and wind energy would increase as high as half of all hydroelectricity. Photovoltaics would remain small but acquire an encouraging 0,5 % of the market. After 2010, biomass and wind would continue to increase very rapidly compared to hydroelectricity and, by 2020, photovoltaics would achieve a market penetration of almost half of total hydro capacity.

30. In Europe, a more superficial analysis has been made earlier on the occasion of "Euroforum New Energies" of the European Community in 1988. It is possible to attain a total energy consumption of 1350 Mtoe in the year 2010. The Euroforum report estimates that renewable energies could represent 15 % of this figure in that year. This compares very well with the US estimate for the scenario involving market incentives but no RD & D intensification. In the European estimate, bioenergy would slightly exceed hydroelectricity in 2010, whereas passive and active solar heating in buildings would achieve about the same importance as hydroelectricity. The latter is confirmed by a more detailed study published in 1991. Photovoltaics would still remain below 0,1 % while wind energy would develop to one-half of the share of hydroelectricity. In another study of the European Wind Energy Association, performed for the Commission of the Community, possible wind penetration for 20 years later - 2030 - would be 10 % of European electricity production.

31. The World Watch Institute in the US has estimated for the year 2030 a share of 50 % for all renewables worldwide. For this figure, it has to be borne in mind that, already today, renewable energies contribute approximately 16 % of the average worldwide energy consumption and the potential for renewables in some developing countries is even greater than that in the Northern hemisphere.

32. Compared to other energy technologies, the technical risk of R & D in renewable energies is low because the wide variety of options allows to spread the risk and improves the probability of further success. Furthermore, systems are comparatively small, and can be developed on a small scale. A "small step approach" is inherent for R & D in this field. It provides an opportunity for continuous control

of success and permanent readjustment of strategies if necessary. These factors and the relatively small uncertainties concerning techno-economical viability will make the implementation of renewable energies easier than that of other "monocultural" energy systems which can only be developed in very large single units such as nuclear breeder reactors or nuclear fusion plants.

33. There is tremendous hope of further R & D to improve the technical quality of products and to decrease their cost. This situation results from the fact that R & D efforts on renewable energies are only very recent and include very modest budgets compared to other energy sources for large-scale utilisation. Hence many technological routes have so far remained unexplored. The performance of most products and systems can be improved. Some R & D goals should be achievable by the year 2000 :

- for photovoltaics, the target is to achieve competitiveness with conventional grid power. To this end, a production cost of photovoltaic modules of 1000 ECU/kW has to be demonstrated by the year 2000.

- for wind energy, the challenge is to develop commercial machines in the MW power size ; only smaller ones are available today. The target is to achieve a cost of 1000 ECU/kW per installed operational 1 MW machine for sites with more than 5,5 m/s average wind speed.

- biofuels derived from agricultural biomass plantations have to become cost competitive with conventional fuels and in particular coal and oil. C4-plants (sweet sorghum is a good example) are promising to achieve sufficiently high yields in Northern and Southern Europe alike for producing bio-oil at a cost competitive with heavy fuel oil, whilst providing the farmer with an attractive yearly income. Crude bio-oil could then be produced at 125 ECU/toe. The absence of sulphur and external cost benefits are not yet included in this cost.

- in the building sector, it is difficult to put forward cost figures for solar energy products. In this field, the problem to be solved is a combination of technical criteria, on the one hand, and the aesthetical and design aspect, on the other. Cost aspects are less critical than in other energy markets. Active and passive solar collectors have the potential to replace conventional building elements and therefore their integration does not necessarily lead to any extra cost. Moreover, additional comfort benefits have to be included in the potential assessment of solar energy in buildings.

Conclusions

34. Implementation of renewable energies requires a well thought-out organisation. The political and the many macroeconomic and R & D facets must be integrated in view of the support of a decentralised utilisation scheme. On top comes the political message from governments and parliaments. From there, regulations, planning elements, information and incentives have to be interwoven in a co-ordinating structure of several levels, feeding a basis of implementation : the market and the users who actually decide on projects and investments.

a) Policies and financial measures

35. To speed up implementation of renewables in Europe, there is a need for national and European governments, parliaments and other decision-making bodies to declare their intention to promote renewable energies, to define strategies and policies, define overall goals for development and implementation and to decide, without any further delay, on the necessary laws and regulations. Policies should in particular focus on a sizeable increase of R & D funding, the encouragement of European industry, the setting up of regulations favouring penetration of renewable energies in utilities, municipal systems, the building sector etc., the encouragement to include biofuel in non-food agricultural production schemes.

36. Financial measures must be taken to include macro-economic effects in market prices of all forms of energies. It can be estimated that internalisation of all external costs together would result at least in a doubling of current prices of conventional energies through additional taxes and charges. Consequently, renewable energies would improve their market competitiveness by the same factor.

37. Furthermore, renewable energies should benefit from loan guarantees and low interest allowances. A major cost factor in current pricing of renewable energies is the discount rate. Due to their very nature, renewable energy systems are comparatively small and are financed through private budgets. Their cost will decrease considerably if the lower discount rates which are normally employed for public investments are employed (there are countries where this may be a 5 % discount rate instead of the normal 14 % bank rate). There could be, everywhere in Europe, special investment credits for installing photovoltaic systems at 70 % of cost until 1995. After that time, it could become 50 %. For wind, biofuels and hydroelectricity, this investment credit could be 20 %.

38. The electricity buy-back rate should be 100 % of the average selling price to the customer for electricity fed into networks from wind or photovoltaic systems. For hydroelectricity and electricity from biofuels, it should be 70 % of that price.

b) Regulations

39. The feeding into electricity utility networks must be regulated, not only from a financial but also from a technical point of view, to avoid disturbance of the networks and provide and guarantee security of the systems.

40. For oil and gas companies, the acceptance of bio-oil and biogas in the refinery and distribution systems also needs regulation. These regulations include financial aspects and product quality standards and their control.

c) Product development, demonstration and market introduction

41. There is still a lack of well-designed renewable products and systems. So far, development effort has focused on technical improvement and cost reduction. Additional effort has to be devoted in the future to industrial design and standardisation of products, their user-friendliness and their integration into existing energy systems, building structures, agricultural schemes, etc. Other incentives are needed for industrial investments, in particular in small and medium-size industries and for competition on the market.

42. Market introduction and promotion should include sales campaigns of new and well-conceived renewable products of established quality and reliability through conventional commercial channels. On the system level, pilot and demonstration projects are necessary. They must be full scale and well adapted to regional, climatic and social conditions.

d) On-site operators

43. Large-scale implementation of renewable energies will not be possible without the firm commitment of local authorities. Their sometimes negative attitudes based on the interpretation of existing regulations must be changed into positive promotional commitments. Those concerned include regional authorities and in particular the municipalities and their services for local electric and gas utilities, building permits, etc. Also concerned, in view of biomass utilisation are the local services established to give guidance to farmers for crop cultivation and marketing. These existing bodies should be given the responsibility of planning guidelines for renewable energy projects and on-site promotion. As the implementation of renewable energies involves the occupancy of new areas for installing solar collecting devices or agricultural plantations, it would make a tremendous change if the bodies in charge of planning and acceptance of the utilisation of land and building structures in this way turned from passive control structures into active promoters.

44. These bodies should be in charge of fixing short- and medium-term goals for the introduction of renewable energies schemes in their field of responsibility. They should be responsible for the achievement of these goals.

e) European centres for information, testing and training

45. A widespread network of small European centres for information, testing and training should be set up. Each centre would in particular provide the necessary support to the on-site operators and planners described above. To start with, it would organise workshops for the operators to introduce them to the new subject.

46. It has been noticed that in the past, regional centres played a major role in the promotion of products and systems, namely in the field of biogas, wind and others. A concrete example is the Risø Centre in Denmark which was one of the keys for the success of wind turbine development and worldwide Danish leadership for wind energy. These centres should have the task of performing acceptance tests for new products and qualify them for the market. They should also be in charge of the acceptance of new types of renewable energy systems and of training manpower and organising seminars on a regular basis.

47. Furthermore, these centres should be given a new role in view of the stimulation of competition within the broad European single market, to become effective in 1993. The centres should actually have a complete record of products and systems produced in all European countries and their market price. These records should be frequently updated and published in the local language and widely made available to all possible customers. By this means, users will have the opportunity to choose the most convenient product at the best price.

f) International Solar Energy Agency

48. The establishment of an International Solar Energy Agency within the framework of the United Nations is necessary. The United Nations General Assembly recommended such an institution in November 1990. The argument in favour of this agency draws partly on the fact of the existence of the IAEA for nuclear energy, which, in addition to its tasks of promoting nuclear safety and supervising the fuel cycle, serves the purpose of helping to overcome the technological barriers to the introduction of nuclear energy.

49. The International Solar Energy Agency is to help each country, mainly in the Third World, to eliminate existing disparities between states and national economies and build up an independent infrastructure for the use of renewable energies - from training and research to the production of technical components and the construction and operation of installations.

APPENDIX I

Governments R & D Budgets for renewables

Extract from Energy Policies and Programmes of IEA Countries (1989 Review)

IEA Government R&D Budgets for Renewables in 1989 United States' Dollars
(Millions)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Canada	43.4	48.3	50.1	77.8	65.0	71.3	55.9	33.0	19.2	16.4	15.0	14.9
United States	675.6	915.2	1 000.0	898.4	431.4	324.9	265.7	243.5	179.6	163.2	128.5	118.3
Japan	52.3	67.4	164.0	161.2	167.6	152.1	140.8	126.6	122.9	109.5	121.0	99.7
Australia	n.a	11.8	16.5	20.2	n.a	16.0	n.a	10.2	n.a	1.0	n.a	n.a
New Zealand	4.5	4.0	5.5	5.5	4.1	4.7	4.3	3.1	1.4	0.5	n.a	n.a
Austria	6.8	7.8	9.5	7.2	6.9	7.7	3.9	3.8	2.9	2.8	4.5	2.2
Belgium	2.4	6.2	10.5	16.4	8.1	11.7	13.4	13.0	5.1	3.9	1.8	0.4
Denmark	8.0	15.1	7.2	4.6	4.7	4.4	4.3	3.8	5.0	4.5	n.a	9.4
Germany	39.3	85.8	90.0	94.7	143.6	69.1	84.2	75.1	47.0	66.0	70.3	93.2
Greece	0.8	2.6	10.1	12.4	3.3	3.1	4.5	6.8	10.5	5.1	5.6	17.1
Ireland	0.9	1.7	1.9	6.1	5.1	2.7	1.1	0.8	0.7	1.2	n.a	n.a
Italy	14.3	13.9	26.5	50.3	24.7	43.2	86.6	22.7	36.9	33.4	47.2	36.5
Luxembourg	n.a	n.a	1.3	2.0	n.a	n.a	n.a	n.a	n.a	n.a	0	n.a
Netherlands	17.3	20.0	22.4	26.8	25.9	30.1	24.4	44.9	21.7	19.7	16.2	18.7
Norway	3.0	6.4	5.8	4.8	3.7	3.9	3.2	2.8	3.0	2.6	7.9	7.9
Portugal	n.a	n.a	1.1	1.1	1.4	2.0	2.8	2.8	2.4	1.8	1.6	2.2
Spain	6.2	14.7	36.8	27.0	27.0	57.5	57.8	18.9	16.3	10.9	11.7	6.9
Sweden	34.4	68.2	58.0	73.7	70.7	51.9	48.9	33.3	23.1	17.0	19.1	19.3
Switzerland	8.2	12.5	12.5	13.2	11.1	12.7	11.8	10.1	10.0	11.1	14.7	18.3
Turkey	n.a	n.a	0.5	0.4	0.4	0.7	0.7	0.6	0.6	0.6	1.0	0.7
United Kingdom	18.5	32.4	28.8	41.6	31.2	24.5	27.4	23.7	19.0	22.8	23.2	23.7
IEA Europe	160.3	187.3	322.9	382.4	367.8	325.1	374.9	263.2	204.2	203.6	224.8	265.5
IEA Total	936.1	1 334.0	1 559.0	1 545.3	1 035.9	894.1	841.6	679.6	527.3	494.2	489.3	489.4

Source: Country Submissions.

Total R&D for Individual Areas of Renewables in 1989 United States' Dollars
(Millions)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Solar Heating	258.9	316.9	209.5	224.5	123.0	90.0	91.6	74.1	55.0	38.6	39.3	29.4
Solar Photo	115.0	215.1	309.1	311.3	244.2	182.8	265.0	197.9	159.0	150.3	157.6	163.0
Solar Thermal	159.9	189.0	329.5	229.6	135.4	98.6	70.1	57.2	37.6	51.1	45.6	42.9
Wind	82.7	132.7	150.0	196.8	126.4	99.6	104.0	114.5	72.1	65.5	59.2	85.3
Ocean	66.6	91.6	97.2	74.2	48.8	30.2	13.8	10.3	9.6	11.2	9.5	9.3
Biomass	56.6	102.0	123.8	160.0	141.4	172.1	161.4	126.0	97.3	96.0	101.4	76.1
Geothermal	196.5	286.7	339.8	346.3	206.1	179.1	129.7	99.2	96.3	80.4	83.0	82.0
Total Group	936.1	1 334.0	1 559.0	1 545.3	1 035.9	894.1	841.6	679.6	527.3	494.2	489.3	489.4

Sources: Country Submissions; OECD Economic Outlook.

APPENDIX II

National policies in the field of renewable energies in some Council of Europe Member States

Extract from Energy Policies and Programmes of IEA Countries (1989 Review)

AUSTRIA

Increased use of renewable energies is one of the main targets of the Austrian energy policy. Besides energy conservation, renewable energies play an important role in the Government's aim to reduce import dependency. The share of renewable energies (other than hydropower) in TPER[1] increased from 5.4% in 1983 to 7.4% in 1988 (including firewood). Combustible waste accounted for 3.2% of TFC[2] mostly in the pulp and paper industry.

In 1988, the number of heat pumps increased by 10 470 to a total of about 80 945 systems. This was mainly due to a high growth rate of heat pumps for hot tap water use. Application of solar energy systems expanded by 52 290 m^2 in 1988 to a total collector area installed of 330 830 m^2 — mainly for heating of swimming pools.

There is a tax incentive for private households for renewable energy projects.

DENMARK

Denmark has a range of programmes and policies designed to accelerate the introduction of renewable resources such as straw, wood chips, other combustible solid waste, wind and solar energy as well as biogas. The Government has subsidised the development of renewable energy sources both directly and indirectly. For example, renewables are exempt from taxes, and grants have been given to promote the use of renewable energy in individual houses as well as the use of straw in DH plants. The financial aid given has been an investment subsidy of up to 30% of the costs. In 1989, the direct governmental subsidy has been stopped for both straw and wind energy. Indirectly, privately owned wind turbines are supported by a 35% reduction of the connection cost to the utility grid and by totally or partly refunding electricity taxes. Total subsidies for renewable energies in 1989 amounted to slightly over Dkr 600 million.

By the end of 1988, about 40 straw-fired plants, 19 wood-chip plants and 50 refuse-burning plants were in operation, supplying heat to DH systems, which corresponds to approximately 11% of the Danish gross energy heating demand. During the last ten years more than 2 500 privately-owned wind turbines have been installed with a capacity of approximately 250 MW. The wind turbines produce today about 1.7% of the electricity demand in Denmark. While still more expensive than conventional coal-fired power plants, costs of electricity produced by wind turbines continue to decline and may soon approach competitive levels.

A committee established by the Minister of Energy in 1986 has been responsible for a programme to clarify economic and practical possibilities for further development of biogas taking into account possible ways of reducing environmental problems within agriculture. The programme will collect, analyse and distribute information concerning biogas demonstration plants. In 1989, four demonstration plants were in operation and three are under construction. The programme will be finalised by the end of 1990.

While the potential for solar heating is regarded as being high, the present technology cannot compete with conventional oil and gas heating systems. The Government continues to support research and investment by giving grants to installation of both passive and active solar heating systems. Research in other renewable energies is also supported to encourage their further development.

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(1) Total Primary Energy Requirements
(2) Total Final Consumption

DENMARK (contnd.)

The act on governmental subsidies for renewable energy sources is being revised. The main purpose of the revision is to establish new regulations on approval and certification of wind turbines in order to initiate further qualitative development of wind turbines.

GERMANY

During 1988, about 2.5% of Germany's TPER was provided by renewable energy resources. Hydropower represented about two-thirds of this total, with wood and other biomass accounting for almost all of the remaining. Active solar heating, photovoltaics and wind energy still made only very minor contributions. The German Government and utilities have increased their support of renewable energy technologies during the past several years, including expanded R&D, commitments to substantially expand wind energy capacity and the support of a forum ("Forum für Zukunftsenergien") to give further impetus to the development and commercialisation of renewable energy. According to the recent PROGNOS forecasts, renewable energy production is expected to almost double by 2010, when it will account for 4-5% of TPER.

GREECE

The Greek government is strongly committed to minimising oil use in electricity generation by increasing use of domestic energy sources, mainly lignite but also hydro and renewables [...] The island systems are almost entirely thermal with the exception of some hydropower and some renewables [...] Legislation passed in July 1985 was intended to encourage the auto-production of electricity and to increase the use of renewable energy (solar, wind, small hydro) and co-generation by industry. This legislation has been partially successful, particularly in the field of wind energy [...] In November 1988 a Special Committee for the Development of Renewables and Energy Conservation was set up in the Ministry of Industry, Energy and Technology. Its tasks were to assess with objectivity the existing situation with regard to energy conservation and renewable energy and subsequently propose measures, such as the creation of new infrastructures and the adoption of new legislation, to streamline and co-ordinate all activities related to energy conservation and renewable energy.

ITALY

In 1988 about 12.3 Mtoe[1] of renewable energy was produced in Italy, roughly 8% of TPER. About 75% of this energy came from hydropower, and almost all of the remainder from geothermal, wood and other forms of biomass. By the year 2000, it is expected that the contribution of renewables will increase by about 50%, mainly from these same sources. Government support for the development of renewable energy is concentrated in those areas likely to make the greatest near-term contribution, but there has been an increase in support for wind, photovoltaics and other sources which may be able to make larger contributions beyond the year 2000.

(1) Million tons of oil equivalent

LUXEMBOURG

The Government has studied the feasibility of introducing renewable energy technology in Luxembourg. Research has been carried out into the potential for exploiting wind energy and flat-plate solar collectors in the country, but wind and solar power are not currently considered to be economically viable. Heat pumps seem to hold greater promise, although capital costs are a major barrier.

Energy from waste disposal is used in several projects such as biogas production at a number of sewage treatment plants and electricity production at a municipal waste incinerator plant.

The Energy Ministry can give subsidies to provide financial support for pilot renewables projects. One project for a privately run co-generating plant was approved in 1987.

NETHERLANDS

The Government's programmes to promote development of renewable energy sources advance several energy and environmental objectives: to increase the share of power from dispersed, small-scale facilities; to increase energy diversity; to reduce air pollution; and to stimulate technological development. For the near future, the scope of economically viable options is limited. Some R&D is being directed at geothermal, biomass and solar energy technologies, particularly solar heating and photovoltaic power, and investors in solar energy equipment are eligible for grants covering up to 40% of each project's cost — in 1988 such grants helped pay for 4 000 square metres of solar collectors installed on residential and commercial buildings. But by far the largest programme is for wind energy.

The Government's "stimulation scheme for wind energy" (IPW) made Gld 70 million available for the period 1986-90 to subsidise wind turbine investments, in addition to general conservation subsidies. Manufacturers can qualify for reimbursement on up to 70% of the cost of developing turbines with rotor blades longer than twelve metres. Grants offered to buyers were highest in 1986 and will decline through 1990. In 1989 a buyer in the Netherlands could qualify for an investment grant equal to 37% of the cost of each wind turbine, plus a somewhat smaller "environmental premium" (Gld 100 per kilowatt). Additional subsidies were available for turbines installed in certain regions. The primary aim of these grants is to encourage cheaper production methods and turbine designs at an early stage in the industry's development. The assumption is that such assistance will help reduce unit costs to such a level that, after 1990, further growth will be possible without continued subsidies.

The target levels of installed wind-generated capacity are 100 to 150 MW by 1992, and 1 000 MW by 2000. (These figures relate to peak capacity ratings at maximum wind load; average, dependable capacity would be about 20% of these values.) By end-1989, approximately 25 MW of wind turbine power was already operative. A large wind-energy park, half-financed by the Government, will be constructed in 1990 near Lelystad and will add another 10.5 MW of installed capacity. Grants have also been approved for other projects, totalling 90 MW.

NORWAY

In the renewable area, there is research on solar, wind, bio and wave energy. Funding for solar energy is to concentrate on the heating of buildings, particularly through passive solar technologies. Despite the moderate solar incidence in Norway, there are considerable periods during which solar rays coincide with heating requirements. Moreover, a focus on passive solar technology can build on Norway's considerable expertise in building and construction industries, as well as competence in materials technology. Wind energy programmes are focused on the dissemination of knowledge and experience through demonstration projects; roughly 10 to 15 windmills are to be installed between 1989 and 1992. The bio energy programme includes both long-term R&D and support of demonstration to increase the use of biomass in new energy technologies. R&D on ocean wave power is focused on installations of two concepts, the oscillating column and the tapered channel, with an aim towards substantial cost reduction.

Nearly one-sixth of all Norwegian public funded energy research is focused on hydroelectric power. This research is directed at improving the efficiency with which hydro resources are used for power generation, transmission and distribution. Increased efficiency can ease the trade-offs between the desire to utilise economic hydropower which produces no air pollutants and the desire to preserve environmentally sensitive landscape.

The scale and composition of Norwegian R&D on renewables and energy efficiency appears well-suited to both Norwegian problems and opportunities. The management of the various programmes is, however, widely dispersed among a number of research agencies, which places a heavy responsibility on the Ministry of Petroleum and Energy to ensure co-ordination and a rational allocation of resources. The government's recent report on energy efficiency and energy research draws attention to this problem.

PORTUGAL

The promotion of electric production by independent power producers through the regulations published in 1988 and the influence of the EC Valoren programme have led to more than 700 applications for construction of mini-hydro projects. Currently under review, 400 of these applications are equivalent to a potential investment of over 200 billion Escudos[1].

During 1988, two sets of wind energy conversion systems (8 x 30 kW) were installed on the Açores and Madeira islands. Recognising the importance of biomass (wood residues and forest waste) as an indigenous energy resource, the Government has created a Technical Centre for Biomass.

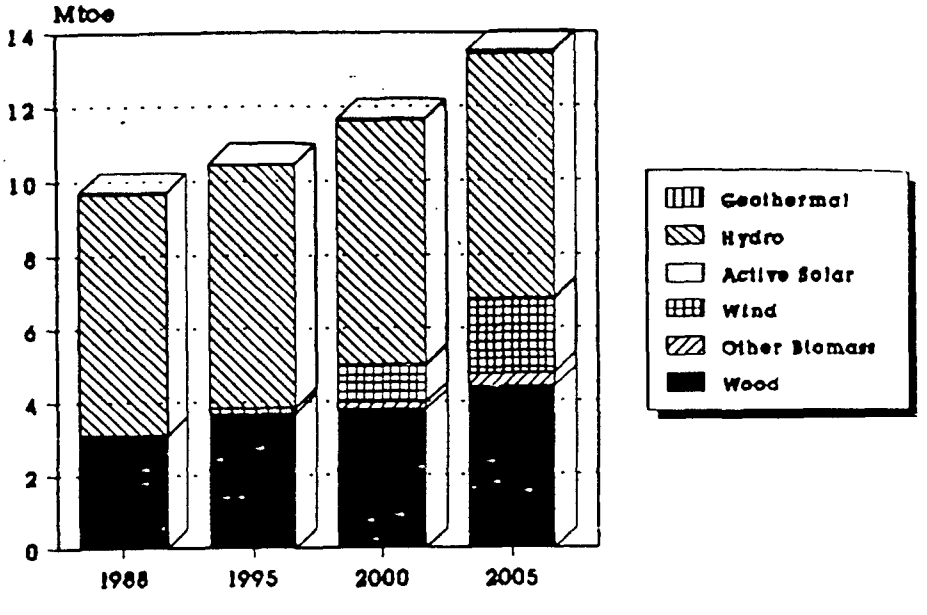
SPAIN

A National Plan for Renewable Energies (PER 89), developed by the Ministry of Industry and Energy, aims at increasing the use of renewables (solar, biomass etc.). The share of renewables in TPER, which was estimated to be 3% in 1988, is expected to reach 4% in 1992, according to the PER. The PER was based on the NEP 1983, which assumed that prices would remain stable in real terms at 1983 levels. Falling oil prices in 1986 and to a lesser extent in 1987 and 1988 have led the Government to consider adapting the PER to these new conditions. In the new NEP, which is now being developed, the renewables will be accounted in TPER which was not the case in NEP 1983.

SWEDEN

The anticipated make-up and contribution of renewable energy to energy supply to the year 2005 is illustrated below. Indigenous fuels such as peat and wood are not taxed in order to promote their production. The market for biomass and peat fuels is suffering from strong competition from imported fuels due to price evolution. In several municipalities which currently use these fuels for local heat and electricity production plans are in hand to switch to natural gas use. Manufacturers of upgraded wood fuels such as pellets and briquettes have experienced strong competition from oil products, and in some areas from natural gas. The forest industries sector is showing increased interest in wood fuel. The short-rotation forestry programme continues, with a plan to use the output in some district heating and co-generation facilities. No new peat production capacity has been installed in 1988. The installation of ten medium size wind energy converters in 1988, without government subsidies, is considered to be indicative of the near commercialisation of this technology in Sweden. The State Power Board (Vattenfall) is considering a new generation of 3 MWe large wind energy convertors and is investigating the possibility of installing a group of five wind energy converters, of which one may be offshore, by the mid-1990s.

Current and Forecast Contribution of Renewable Energy (in Electricity Generation and Direct Use) in Sweden



Source: Country Submission 1989.

SWITZERLAND

In 1988, wood and small hydro plants accounted for 2.9% of TPER. The contribution of other renewables was quantitatively insignificant. The Union of Swiss Power Stations is trying to promote the development of photovoltaic installations. The Federal Government and the cantons sponsor information activities and advisory services through the Association of Solar Experts. Some growth was noted in passive solar utilisation and photovoltaics in 1988. In 1989 a utility began construction of a photovoltaic installation with a capacity of 500 kW and an expected output of 800 MWh. This solar power station will come on line in 1991. Also in 1989, 44 smaller photovoltaic installations were connected to the grid which produce approximately 200 MWh annually. Furthermore, Switzerland has installed 100 kW of photovoltaic modules on noise-protection walls along motorways.

TURKEY

While wood and hydropower covered about (25%) of total primary energy requirements in 1988, the share of other renewable energy sources is still negligible. There are a few geothermal applications (including a power plant of 18 MW and thermal utilisation — greenhouses and space heating — representing 15 000 toe/year), and in 1987 350 000 m^2 of solar collectors were produced by about 200 private firms. Quality tests have been introduced in 1984 for collectors and complete water heating systems. Mandatory quality standards are under consideration. Between 1978 and 1985, 1263 km^2 of energy forests have been planted to reduce uncontrolled wood cutting in rural areas. This development is continuing between 1985 and 1990 with 450-650 km^2 per year and 100-200 km^2 renovations. Other applications of renewables (e.g. wind, photovoltaics) are still in the R&D stage.

UNITED KINGDOM

Historically, limited commercial use has been made of renewable energy in the United Kingdom, apart from the approximately 2% of electricity that is generated by hydropower. Following the first phase of an R&D programme during the late 1970s and early 1980s, the potential contribution from renewable energy sources by the year 2025 has been estimated at up to 70 TWh (9 million metric tons of coal equivalent (Mtce) or 6.02 Mtoe) per year from those energy sources that produce electricity directly, and up to a further 20 Mtce (13.38 Mtoe) per year from those producing heat.