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Climate Change and Nuclear Power

by

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WWF

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Foreword by WWF

One of WWF's leading priorities is to accelerate the implementation of solutions to global warming. It's a problem which is getting out of hand and constituting an increasingly urgent threat to nature around the world. The early warning signals of global warming are already evident on every continent and in most countries.

Surely, then, any means for reducing the carbon dioxide (CO_2) emissions that cause climate change is acceptable? Not necessarily. WWF's mission to stop the degradation of the planet's natural environment and to create a future in which humans can live in harmony with nature involves promoting reductions in pollution. Solutions to energy-related problems such as global warming can therefore only deliver long-term benefits if they reduce instead of merely displace humanity's burden on the environment.

As industrialized nations take on their first small commitments to limit CO_2 emissions under the Kyoto Protocol, some governments are pressing for nuclear power to be one of the central means for combating climate change. The government of Japan, for instance, favors building between 13 and 20 more nuclear power plants in its country over the coming decade in order to meet its Kyoto obligations.

As governments focus on framing international rules for "joint implementation" and the "Clean Development Mechanism" within the Kyoto Protocol, the nuclear industry sees a chance to inject new life into its stagnating business. Canada, France and Japan are among those keen to promote nuclear power to developing nations under the Protocol's "Clean Development Mechanism". The CDM is intended to allow industrialized countries to meet part of their Kyoto commitments by establishing projects in developing nations that reduce global warming gases while assisting with sustainable development.

Are there sound arguments for the industrialized world to again embrace nuclear power? Will developing nations have nuclear power foisted on them under the guise of "Clean Development"? WWF commissioned WISE-Paris, the World Information Service on Energy, to report on the status of nuclear power programs and to compare technological options for cutting back on CO_2.

WWF believes it is important to look forward, not back. It is incumbent on the international community to promote energy technologies which are sustainable and economic in preventing multiple environmental problems. WWF is therefore opposed to giving "carbon credits" to the construction, upgrading, retrofitting or maintenance of nuclear power plants. The Kyoto Protocol must be a vehicle for driving innovation and the market expansion of clean sources of energy. We share this view with other environmental organizations and with representatives of the rapidly-growing business community who believe that energy-efficient and renewable energy technologies offer the promise of a cleaner, safer world.

Jennifer Morgan
Director
WWF Climate Change Campaign

April 2000

Climate Change and Nuclear Power

1 Nuclear power and the climate change negotiations

The nuclear industry has increased its efforts to have nuclear power plants integrated into the post-Kyoto negotiating process of the UN Framework Convention on Climate Change. The Nuclear Energy Institute (NEI) states: “For many reasons, current and future nuclear energy projects are a superior method of generating emission credits that must be considered as the US expands the use of market-based mechanisms designed around emission credit creation and trading to achieve environmental goals.”[1]

The NEI considers that nuclear energy should be allowed to enter all stages of the Kyoto “flexibility mechanisms”: emissions trading, joint implementation and the Clean Development Mechanism. The industry sees the operation of nuclear reactors as emission “avoidance actions” and believes that increasing the generation of nuclear power above the 1990 baseline year either through extension and renewal of operating licenses or new nuclear plant should be accepted under the flexibility mechanisms in the same way as wind, solar and hydro power.

For the time being, there is no clear definition of the framework conditions for operating the flexibility mechanisms. However, eligible mechanisms must contribute to the ultimate objective of the Climate Convention of preventing “dangerous anthropogenic interference with the climate system”.

The information presented in the following sections of this report underlines that nuclear power is not a sustainable source of energy, for the following reasons:

- investments into nuclear power projects drain badly-needed funds from energy efficiency programs, most of which have a far lower specific greenhouse gas abatement cost than nuclear energy;
- nuclear power projects have a variety of negative systemic impacts including: the need for inefficient large grid systems; the need for highly-qualified staff; and blocking innovation in the supply and demand sectors, as well as in the development of efficient small-scale plant;
- countries with nuclear power are among the highest carbon dioxide (CO_2) emitters in the world because large-scale power plants tend to boost electricity consumption - and not only of nuclear origin - rather than improvements in efficiency;
- nuclear energy only produces electricity, but modern societies need a significant share of their energy in the form of heat (and cold). Under these circumstances, nuclear power loses its greenhouse gas emission advantage over natural gas-fired cogeneration plant and has significantly higher emissions than biogas cogeneration plants;
- nuclear power remains particularly dangerous and difficult to control as last year’s accident at Tokaimura, Japan, has once again illustrated. The radioactive waste problem remains unsolved and nuclear proliferation is one of the greatest threats to international peace.

In conclusion, an efficient greenhouse gas abatement strategy will be based on energy efficiency and not on the use of nuclear power.

[1] NEI Comments to the Department of State on Policies to Maintain the Contribution of Nuclear Energy to Carbon Abatement and Proposals for Possible Implementation of the Kyoto Mechanisms, February 1999

2 The decline of nuclear power

In September 1954, Lewis Strauss, then head of the US Atomic Energy Commission, launched the promise of the peaceful nuclear age. Electricity produced by nuclear power plants would be "too cheap to meter", in other words the investment into an electricity meter would outweigh the electricity generating costs. The rapid expansion of nuclear reactors in the world would allow abundant energy supply for all. Even 20 years after Strauss's declaration, the International Atomic Energy Agency (IAEA) forecasted the equivalent of up to 4,450 reactors of 1,000 MW installed in the world. Uranium would rapidly become scarce and plutonium-fuelled fast breeder reactors - generating more plutonium than they produce - would provide endless quantities of cheap electricity.

In 1977, André Giraud, then head of the French Atomic Energy Commission (CEA) saw an energy crisis arising "in any case before the end of the century" unless nuclear power programs were significantly accelerated. He added that while the energy content of France's uranium reserves would equal the North Sea oil fields, the use of fast breeder reactors would boost them to a level representing two to three times the oil reserves of Saudi Arabia. Consequently, Giraud forecast that 540 fast breeder reactors the size of the French Superphénix would be operating around the world at the end of the century.

But, today more than 45 years after Strauss's promise and 23 years after Giraud's outlook, the picture is radically different. At the end of 1999, 436 nuclear power reactors were listed as operating in 32 countries (that is 17% of the 185 countries represented at the UN), or less than 8% of the IAEA's projection of 1974. The current French government shut down Superphénix and not a single commercial-size fast breeder reactor is now operating anywhere in the world. Only five countries - the US, France, Japan, Germany and Russia - generate over 100 TWh (billion kWh) per year, representing 70% of the nuclear electricity generated worldwide.

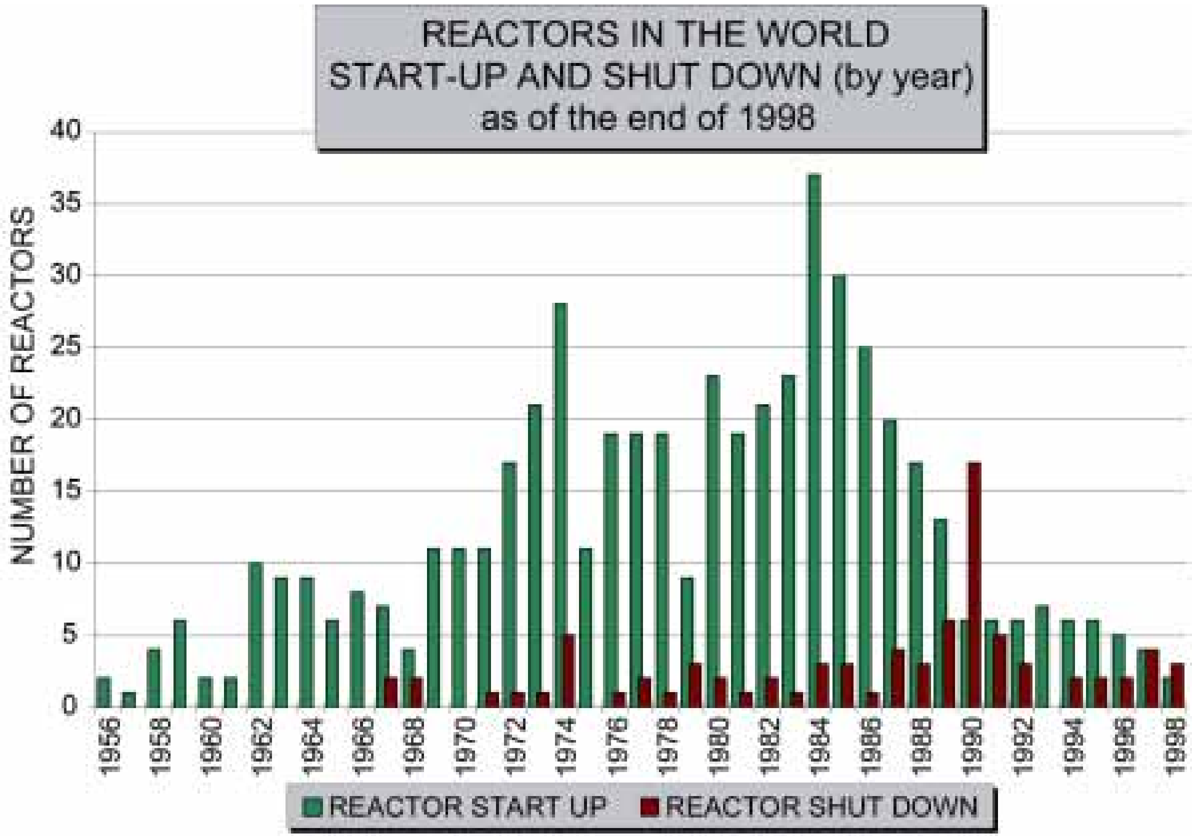
Nuclear power generated 7% of the world's commercial primary energy in 1998, far behind oil (40%), coal (26%), and natural gas (24%). Most of the renewable energy potential, like fuel wood, biogas, straw, cow dung, etc. is not commercialized and is therefore not included in these statistics. The world's commercial primary energy consumption decreased in 1998, for the first time since 1982.[2]

Despite remarkable technical improvements in the last decade, the conversion efficiency of new natural gas-fired electric power plants reaches at best 58% while conventional and older turbines reach only 35%. Cogenerated heat and power, however, has an energy use of up to 90% in modern power stations; even older cogeneration plants reach more than 70% conversion efficiency. Decentralised and efficient cogeneration is particularly useful for residential space and warm water heating. The relative amount of final energy made available by nuclear power plants in particular in the heat sector - a nuclear reactor heats water to operate a turbine to produce electricity which is transported to a home where water or space is heated - is not more than 30% of the primary energy. Globally, nuclear power contributes only about 2.5% of the final energy demand on the planet. On the other hand, nuclear plants provide 17% of the world's commercial electricity, with large differences from one country to the other, from less than 5% (Brazil, China, India, Kazakhstan, Netherlands, Pakistan) to over 50% (Belgium, France, Lithuania).

Nuclear power plants require very long "lead times" - the time taken from planning a reactor to its commercial operation. It is therefore quite easy to gain a good overview of the outlook for nuclear power if one considers when reactors have been ordered and when construction started. The last reactor order in the US, which has not later been canceled, dates from 1973. All of the currently operating reactors in the US have been ordered over the 10-year period between 1963 and 1973. No order has been placed by European utilities outside France since 1980. In France, the last construction site opened in 1993 and the reactor (Civaux-2) was connected to the grid on Christmas Eve 1999. (See Figure 1)

[2] BP Amoco Statistical Review of World Energy 1999

Figure 1: Reactors in the World - Start-Up and Shut-Down



Source: PRIS, CEA 1998, ATOMWIRTSCHAFT, Doc. WISE-Paris

As of the year 2000, there are no reactors under construction, ordered or even planned in any of the countries of Western Europe or North America. On the contrary, there has been a net decrease of the number of reactors operating in both these regions since 1989 when it reached its peak of 294 units, compared to 276[3] listed in 1998. (See Figure 2).

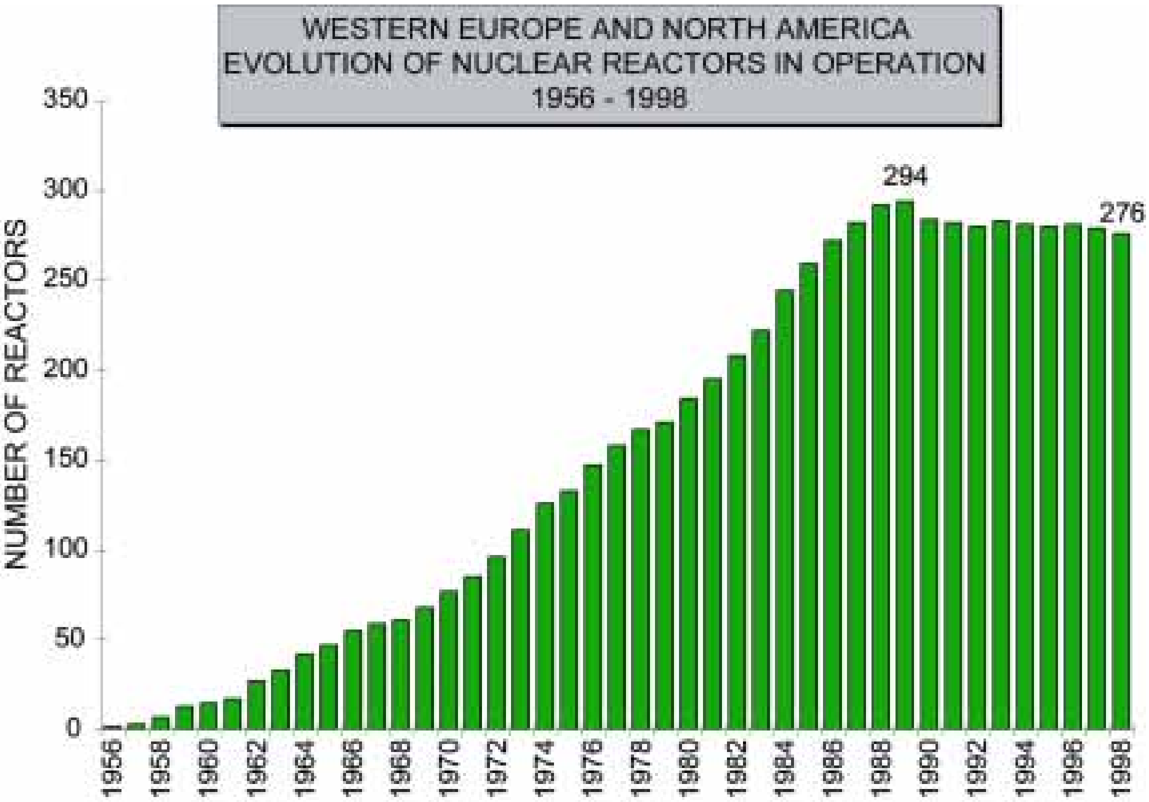
With a delay of ten years, the decline becomes visible on a worldwide level. In 1999, there were four fewer reactors listed as operating (436) than two years earlier. (440). (See Figure 3)

The future outlook for nuclear power is dim. At the end of 1999, the IAEA listed 38 units under construction in 14 countries. However, a closer analysis shows that many of those building sites have slim chances of being completed. 13 of these plants are located in former eastern block countries with significant economic problems. Most of them have been listed as "under construction" for more than 15 years. The same applies to long-lasting construction sites in Argentina, Brazil, India and Iran.

South East Asia will not make the difference. The region has 17 reactors under construction (7 in China, 4 in South Korea, 4 in Japan and 2 in Taiwan). One of the immediate effects of the Asian Economic crisis in 1998-99 was the overall economic slowdown, by an average of 1.5% in Asia, but with a drop of 6% or more in South Korea, Thailand and Indonesia. This led to a massive cancellation of orders for electricity generating capacity. Thailand is now even considering mothballing some of its existing generating capacity, let alone completing most of the new capacity that was originally

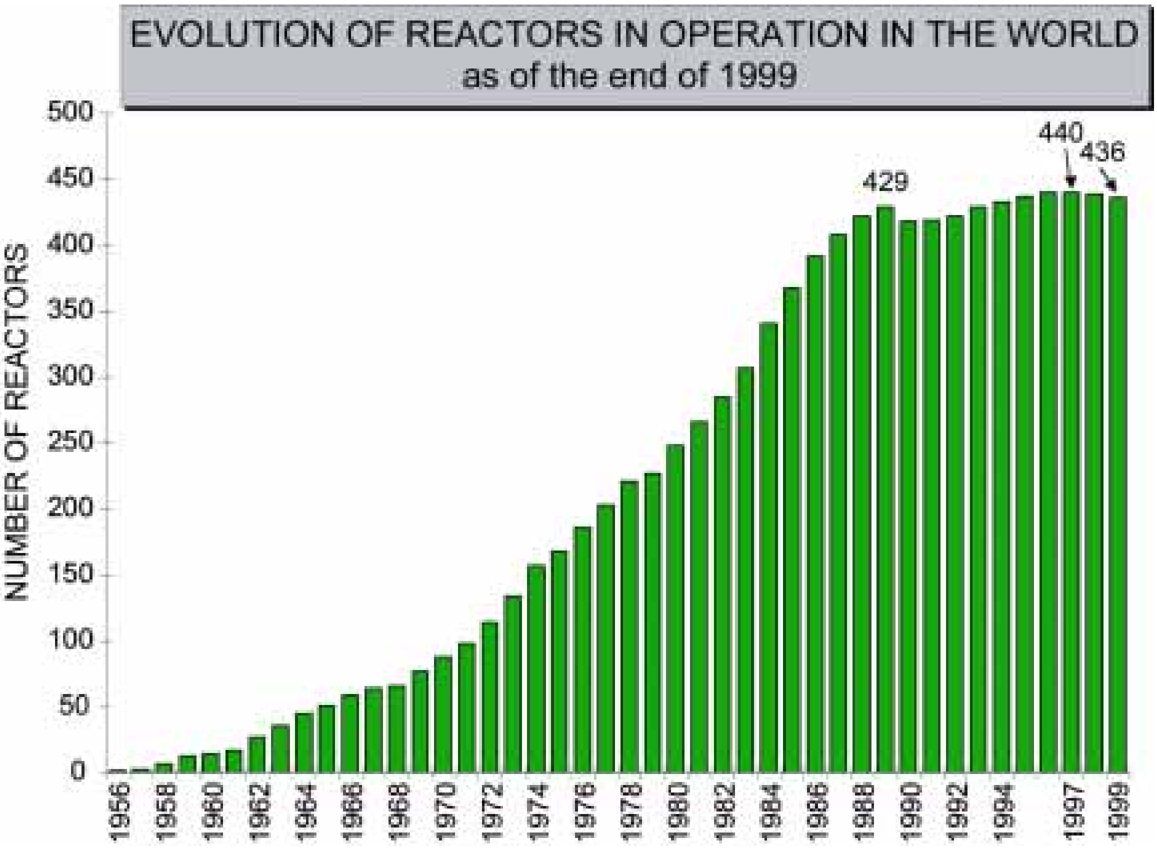
[3] It should be noted that this figure includes 7 reactors in Canada and 1 in Germany, currently shut down, which will almost certainly never be brought back on line.

Figure 2: Evolution of Reactors Operating in Western Europe and North America



Source: PRIS, CEA 1998, ATOMWIRTSCHAFT, Doc. WISE-Paris

Figure 3: Evolution of Reactors Operating Around the World



Source: PRIS, CEA 1998, ATOMWIRTSCHAFT, Doc. WISE-Paris planned. China has made it clear that it will downgrade its investment into future generating capacity, and the role of nuclear power - with only 0.6% of total electricity production - will continue to be marginal. Energy demand in China, South Korea and Thailand fell by over 3% in 1998 while the decade-long decline in energy consumption in the countries of the former Soviet Union continued.[4]

3 The future of nuclear power: unrealistic assumptions

"And if nothing is being built, since many years and for many years to come, then one is on a phase-out track, whatever one might call it."

Werner Müller, German Minister of Economy, May 1999

Nuclear power programs around the world have reached their peak and are now in decline. The question remains how fast the decline will be and whether a revival is possible. The climate change issue is considered to be *the* essential issue to influence decision-makers over the destiny of existing or new nuclear programs. Besides the environmental component, economic and political considerations are frequently used both in favor of and against the use of nuclear power.

The OECD's Nuclear Energy Agency (NEA) established three scenarios in early 1999 for the potential future development of nuclear power.[5]

Table 1: Installed Nuclear Capacity in the World 2000 - 2050 *(in GWe), according to three scenarios developed by the OECD Nuclear Energy Agency*

Scenario	2000	2010	2020	2030	2040	2050
I – Phase-out	360	354	257	54	2	0
II – Continuous development	367	453	569	720	905	1,120
III – Decline followed by revival	355	259	54	163	466	1,120

The first scenario considers the phase out of existing nuclear power plants at the end of a projected 40-year lifetime without any replacement beyond units currently under construction. The installed capacity would decrease by 29% by 2020 and the last reactor would be off line by around 2045. The NEA authors recognize that this is "not the most pessimistic scenario", since many units are projected to be taken off the grid significantly earlier than projected in the NEA scenario. The Energy Information Administration of the US Department of Energy, in a recent world energy outlook, projected in its low scenario a 49% decrease in worldwide installed nuclear capacity by 2020.[6]

The NEA authors also note that among all OECD countries, only Japan and Korea have firm commitments to increase their installed nuclear capacity by 2015. On the other hand, 102 out of the 358 reactors (or 19% of the installed capacity) operated in OECD countries in 1998 would be taken off the grid by 2015. The NEA scenario tries to put across the message that CO_2 emissions will increase and, in the absence of short-term renewable energy solutions, natural gas might become "the only energy source" for a certain number of countries. However the scenario fails to ask what the potential energy mix could be for the same countries were they to rely on a demand-side energy service approach.

[4] BP Amoco Statistical Review of World Energy 1999
[5] NEA, Bulletin, Spring 1999
[6] see http://www.eia.doe.gov/oiaf/ieo99/nuclear.html

A second NEA scenario assumes the continued development of nuclear power programs. By 2020, installed capacity would increase by 55%, more than triple by 2050 and supply 12% of the world's commercial primary energy consumption and 35% of its electricity. The authors note that in order to achieve that result, a "rapid modification" of conditions unfavorable to the development of nuclear power would be needed. Furthermore, the questions of nuclear safety and the final storage of nuclear waste need to be "solved" in order to gain public confidence. Further "problems" with this scenario that are identified by the authors include the rate of construction of 35,000 MW - about 30 units - *every year* between 2010 and 2050, the extraordinary level of investment that would be called for, and the search for satisfactory sites.

The final NEA scenario models a rapid nuclear phase out - minus 85% in 2020 - and then a rapid revival to reach the same level as in the second scenario of 1,120 GWe in 2050. The reasons for decline are a combination of "unfavorable pricing schemes and public distrust". The main motivations given for a strong nuclear revival are increasing world electricity demand, the absence of a proven technology to replace nuclear power, the aim of protecting the environment, as well as energy security and diversity of supply. The reactor building industry would have to expand to unprecedented dimensions towards the end of the period considered: 55,000 MW to 75,000 MW - or 50 to 70 units - *per year* would have to be installed. This compares with the historical maximum of 38 units connected to the grid during 1984. Averaged over a period of several years, however, the rate never exceeded 20 units per year.

The NEA authors conclude that the phase out scenario could have "very severe effects on the environment" and in numerous countries on the security of supply and the diversity of fuel sources. The scenario NEA would reflect the interest of nuclear power to "limit the risks linked to climate change and to decrease the dependence on fossil fuels".

While the long-term future of nuclear energy seems more difficult to predict, the immediate situation and the short-term future is quite easy to understand. It is therefore all the more surprising to see the NEA authors - as many others - building scenarios along assumptions that are simply impossible to fulfill. The following sections attempt to shed some light on the reasons not only why the revival of nuclear power is unlikely but also why it is likely that nuclear energy might disappear much faster than many people consider.

4 Climate change offers no nuclear lifeline

The NEA study referred to above is only one of the latest of numerous attempts by the nuclear lobby over recent years to use the climate change issue for its own survival. In various countries the nuclear industry has developed full-scale public relations campaigns on the issue. The usual basic approach is the calculation of "avoided emissions" of greenhouse gases through the use of nuclear power as compared to coal-fired power plants. The figures for "avoided emissions" given by the nuclear industry are often misleading as the alternative is not necessarily coal. In Europe almost all new power stations are fired by natural gas (with the notable exception of significant increases in installed capacities of wind power in some EU countries). Per kilowatt-hour (kWh) of electricity generated, the carbon dioxide emissions from a natural gas-fired power station are approximately one-third to one-half of those from a coal-fired power plant. (See Figure 5). The US nuclear industry lobby group, the Nuclear Energy Institute (NEI), claims: "Around the world, nuclear energy is, and will continue to be, the primary large-scale source of electricity produced without emitting greenhouse gases."[7]

Further analysis shows that the NEI is led more by wishful thinking than by fact. Not a single new nuclear unit is in the pipeline either in North America or Western Europe and the Far Eastern potential has been largely overestimated.

[7] NEI, op.cit.

As to the Franco-German project EPR (European Pressurized Reactor), it is more of a phantom than an industrial reality. The German government has stopped all funding for the development of the reactor and the German utilities only pay lip service to the project. The German Minister of Economy, Werner Müller, revealed that as early as 1994 utility representatives disclosed during confidential talks with political leaders regarding the prospects of a large EPR "that they never want to build such a project".[8] Müller added: "I don't see yet that the EPR ever can be internationally competitive."

And if there is no reference plant, it is all the more difficult to sell even a single unit elsewhere. The US company Westinghouse, which pushed its "advanced" reactor design AP600 through the licensing process, had this experience. Westinghouse's CEO Charles Pryor explained: "When Westinghouse tried to sell the design in China, the Chinese asked why the US isn't building it if it's so great".[9]

Before touching further upon political or economic issues influencing the prospects of nuclear power, several technical and organizational points should be raised:

- the approach of avoided emissions must be enlarged to include other energy supply sources as well as energy efficiency;
- nuclear power has indirect greenhouse gas emissions that have to be taken into account in the comparison;
- the ultimate goal should not be the production of electricity but the provision of energy services (space heat, hot water, light, communication, etc.);
- the choice of nuclear energy determines the grid size and therefore the need for a large-scale power transport and distribution system;
- the choice of nuclear power has many other systemic consequences such as:
    - strong stimulation to increase electricity consumption rather than improve energy efficiency;
    - the need for a large number of highly-qualified staff in the reactor building industry and for operating the plants;
    - inhibiting innovation in the energy sector in general;
    - the need for the long-term smooth operation of infrastructures in order to guarantee job security and to organize highly-sophisticated management of nuclear material, radioactive waste, radiation control and monitoring systems throughout the entire nuclear fuel chain.

[8] speech at the Jahrestagung Kerntechnik, Karlsruhe, 18 May 1999
[9] Nucleonics Week, 10 June 1999

5 Nuclear power versus other energy supply options

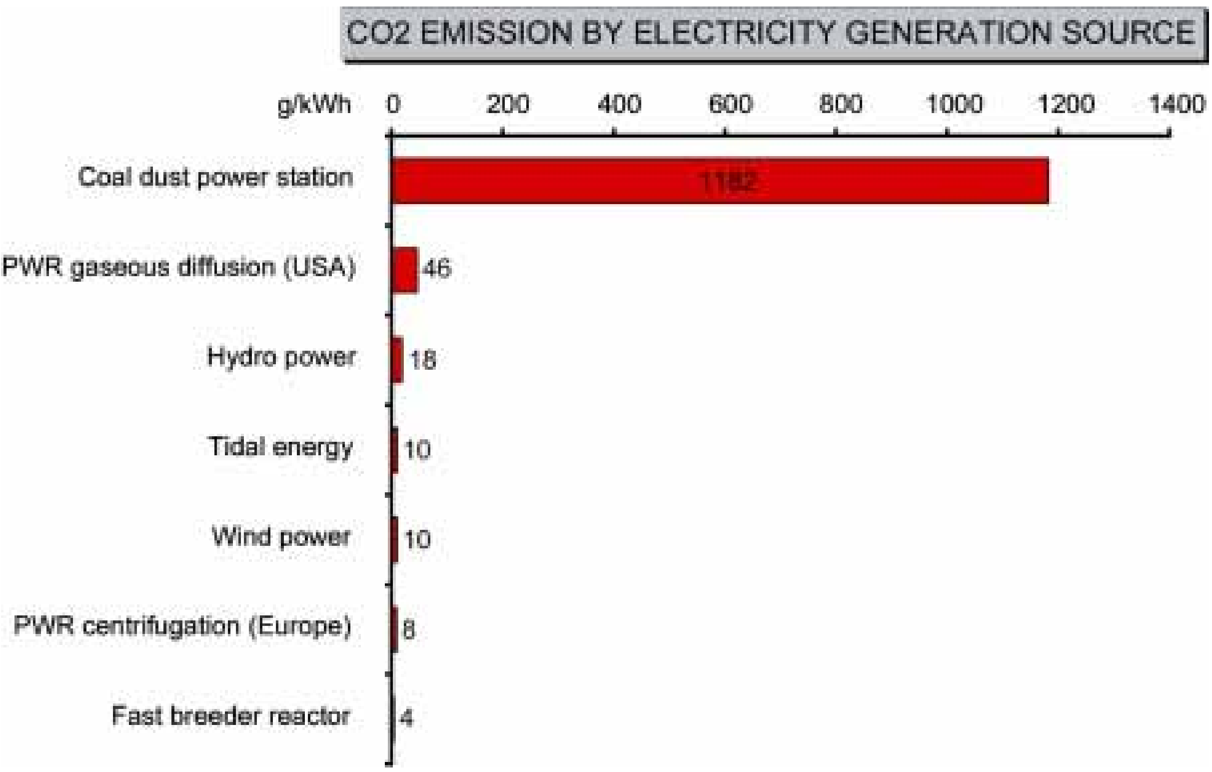
Comparative lifecycle analysis shows that nuclear power indirectly generates greenhouse gas emissions, just as any other energy supply option. The main origin of these emissions is the very large energy consumption of uranium enrichment facilities. Therefore the emissions of the nuclear fuel chain depend largely on the energy mix in the grid of a given country.

Since carbon emissions per kilowatt-hour of electricity are much higher in the US than they are on average in the EU, and because several EU states operate the less energy-intensive centrifuge enrichment process rather than gaseous diffusion plants, the greenhouse gas emissions associated with nuclear electricity in the US are also much higher than in European nuclear countries. The greenhouse gas emissions of French nuclear electricity have not been calculated, though they should be comparable to other European nuclear countries since the industry uses the more energy-intensive gaseous diffusion process, but has a higher percentage of nuclear and hydro power in their electricity mix.

That nuclear power generates greenhouse gas emissions is obvious, and generally recognised by the nuclear community, as illustrated by Figure 4. In that respect, the NEI position is rather surprising and its insistence on factually-incorrect statements has led several non-governmental organizations, in particular Ralph Nader's organization Public Citizen, to file complaints with the Federal Trade Commission (FTC) for “false and misleading” advertising.

Irrespective of the particular national or regional situation, the overall electricity consumption of activities in the nuclear fuel chain is significant. In France, for example, the power consumption of the nuclear sector is in the order of 25 TWh per year, equivalent to the average output of 4.5 nuclear reactors (900 MW) in the country.

Figure 4: Nuclear Industry Representation of CO_2 Emissions per kWh for Various Electricity Production Systems

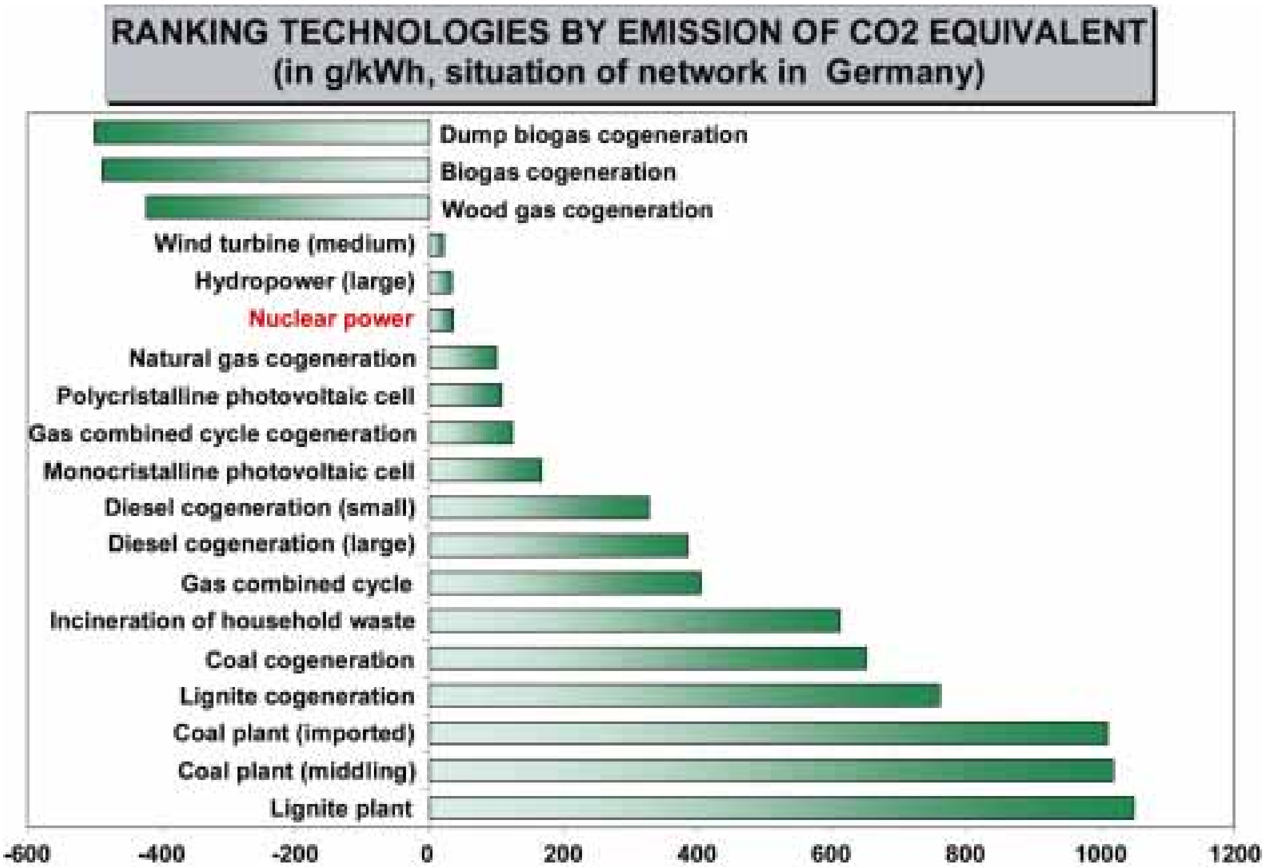


Source: Revue-Générale Nucléaire, May-June 1998

More detailed lifecycle analysis has been carried out by independent experts to compare the performance of a wide range of different energy supply systems under a variety of operating conditions. Figures for greenhouse gas emissions per kWh calculated by the German Öko-Institut were generally comparable to those calculated by various nuclear industry sources. The respective figures were: for nuclear power, 35 grams versus 8 g to 60 g; for wind power, 20 g versus 10 g; and for hydro power, 33 g versus 18 g. However, a number of combustion technologies fill the huge emissions gap identified by the nuclear industry between the light water reactor and coal-fired power plants. (See Figure 5). Plants fired by natural gas, and even coal-fired cogeneration plants have significantly lower emission rates - between 100 and 650 g/kWh - than conventional coal-fired power plants (about 1,000 g/kWh).

The best performance stems from cogeneration technologies based on biogas (wood, landfills or agricultural origin) and considerable further technical advances are expected in this area. According to the US National Renewable Energy Laboratory (NREL), the transformation of biomass into synthetic gas could nearly double the generating efficiency of most current biomass-fired power plants.[10] But even in the case of current technology, the emissions from electricity generation are lower than those which are displaced on the heat side. In other words, if the heat had to be produced by other means (oil combustion has been used in the present calculation), the emissions would have been much higher than those of the combined heat + power biogas system. Therefore biogas technologies get an "emission credit", which is why the figures appear as "negative emissions" in the following figure.

Figure 5: Greenhouse Gas Emissions per kWh per Supply System



Source: GEMIS 3.0, 2/1998

[10] Michael T. Burr, "Biogas Rising", Independent Energy, Vol. 29, Issue 6, July-August 1999

6 Supply efficiency: heat, power, gas and renewables

Every industrialized society consumes energy as heat and in the form of electricity. In the average French household, for example, two-thirds of the energy used is heat, the remainder as electricity. The conventional thermal power plant transforms about one-third of the primary energy into electricity, two-thirds being released as waste heat into the environment. A further 7% to 10% is then lost in the transmission system. Only about one-quarter of the primary energy is available as final energy at the consumer's location.

Combined heat and power (CHP) or cogeneration plants recover most of the waste heat, delivering either to industrial processes or urban heating systems. The efficiency reaches 75% to 90% as compared to the 35% to 58% of conventional plants.

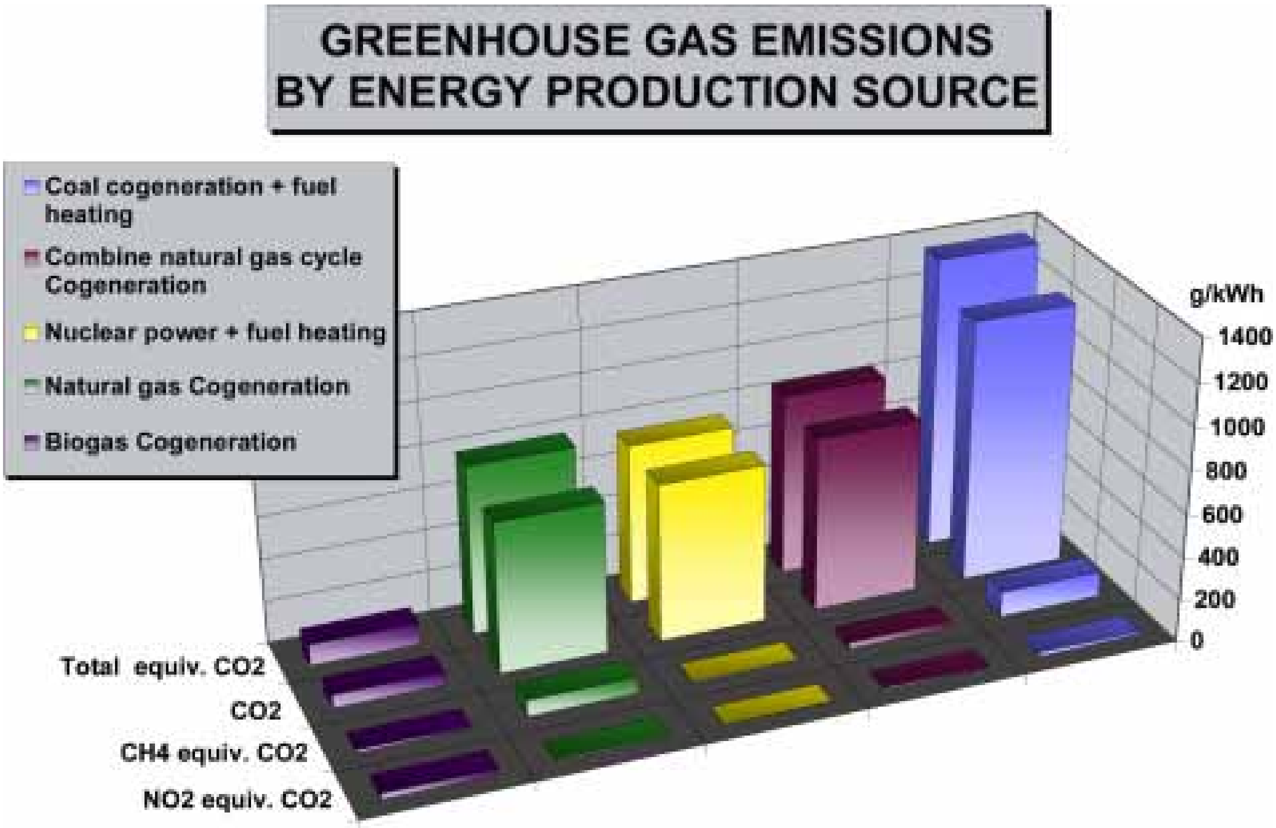
In contrast, the waste heat from nuclear power plants around the world (with the exception of some units in the former Soviet Union) is not recovered, and there are no plans to do so. Providing heat for nuclear-powered societies means using additional sources of energy. For illustration, one can add to the nuclear electricity the amount of heat provided by a central heating system which burns oil. This is a medium hypothesis if compared to either central heating using gas - which leads to lower greenhouse gas emissions - or to electricity, which is more polluting because as seasonal peak use it usually has a strong fossil fuel component based on coal or oil, particularly in nuclear-intensive countries. The results are shown in Figure 6.

In order to keep the calculation coherent, the Öko-Institut has compared the emissions induced by the generation of 1 kWh of electricity and 2 kWh of heat through various systems. While the biogas- and natural gas-fired plants generally produce one-third electricity and two-thirds of heat, the coal-fired, combined cycle gas or nuclear systems generate little or no useable heat. In the case of nuclear power, the emissions stemming from 2 kWh of heat generated by an oil-fired central heating system are added to the emissions induced by one nuclear kWh. The results are striking. The nuclear + oil case leads to emissions of the same order of magnitude as natural gas-based systems. The advantage over the coal-fired cogeneration + oil case shrinks to less than a factor of 2, compared to a factor of 300 if emissions resulting from nuclear electricity are simply compared to electricity generated by a large coal-fired power plant. The biogas-fired plant has the lowest greenhouse gas emissions - at least 7 times lower than other systems.

It is interesting to note that the highest percentage of electricity production by cogeneration occurs in non-nuclear or low-nuclear countries, for example in Western Europe: Denmark (greater than 50% in 1998, with a projection of 70% by 2010); the Netherlands (35% in 1998, with 50% projected by 2010); and Finland (33% in 1998). Over 4,500 MW of small-scale cogeneration facilities were added between 1991 and 1998 in Germany. In Finland, wood and peat - much of which goes into municipal cogeneration plants - provide almost as much primary energy (27%) as oil (28%), while nuclear power stagnates at 17%. On the other hand, nuclear-intensive European countries have hardly begun to develop their cogeneration potential: like France (3% in 1998, projecting 5% in 2010); Belgium (5% in 1998, rising to 11% in 2010); and Sweden (7% in 1998, reaching 11% in 2010).[11] The European Commission has set a target of doubling the installed cogeneration capacity within the European Union by 2010. Currently, on average, 13% of the electricity produced in the EU is from cogeneration. However, even in nuclear-intensive France, cogeneration development was unprecedented during 1998 with installed capacity increasing by almost a factor of 10 to reach some 5,300 MW.

[11] most of the data from Market Line, quoted by Peter Hennicke, Wuppertal Institut, at Brandenburg Technical University, 2 July 1999

Figure 6: Nuclear Power + Oil versus Cogeneration



Source: Öko-Institut

Japan, which officially has had a strongly pro-nuclear policy to date, has one of the lowest cogeneration shares of any industrialized country. In March 1999, cogeneration plants accounted for 4,627 MW, which was 1.8% of total generation capacity.

Spectacular increases in efficiency have been reached in gas turbine technology over the last 10 years. Today's combined cycle turbines achieve 60% efficiency, with further advances expected. The efficiency performance is of great significance because of the high sensitivity of the gas price to the overall cost per kilowatt-hour (relatively low investment, high fuel cost share).

While it is clear that renewable energy sources will lag behind supply-side and demand-side efficiency improvements in their significance for greenhouse gas abatement in the short term, some recent advances have been far beyond expectations.

Wind energy in particular has experienced a strong push since the beginning of the 1990s. Two prominent examples are the German and Indian wind power programs. Regulations in Germany required utilities to buy wind power from independent producers at 75% of the average sales price of the same utility. This boosted wind power programs in a way which transformed Germany into the world's largest wind power generator within the eight years from 1991 to 1999. Wind power capacity increased in 1999 alone by a stunning 1,569 MW - or by more than 50% - to reach 4,444 MW; equivalent to four nuclear reactors or half of the installed wind power capacity in the EU. The power output increased twice as fast as installed capacity to reach some 6 TWh in 1999. India increased its installed wind power capacity in only four years from 54 MW in 1993 to 900 MW in 1997. Meanwhile, the number of biogas plants in India also showed impressive growth, increasing from 1.8 million to 2.5 million units.

In China, renewables - essentially hydro power - are the second largest electricity contributor after coal, representing a 17% overall share in 1996.

7 End-use energy efficiency versus nuclear power

The World Energy Council, a high-level federation of energy producers, concluded at its conference in Houston, Texas, in September 1998: "Increased efficiency in the end use of energy offers the most immediate, largest and most cost-effective opportunity to reduce consumption and environmental degradation."

China has frequently been portrayed in the climate change debate not only as a major player - which is obvious given its 21.5% share of the world's population - but as the main potential threat to global climate. In reality, China has so far been just the opposite. The country provides a brilliant example of successful energy efficiency policy under strong economic growth conditions. Since 1980, China has cut its energy intensity (energy consumption per unit of GDP) in half while GDP per capita has grown fourfold. As a consequence, China's CO_2 emissions grew only "modestly" by 136% over the same period.[12]

China's energy consumption has increased by a factor of 2.5 since 1978 to reach 1,440 million tons of coal equivalent in 1997 and now accounts for approximately 63% of total energy consumption in East Asia (excluding Japan). In global terms, China accounted for 9.6% of world energy consumption in 1997. By 2020, however, projections indicate that this share could have risen to approximately 16%. In 1997, the United States had a per capita energy consumption more than five times higher than the world average and nearly 12 times that of China. Were China to have exhibited the same per capita energy consumption as the United States did in 1997, China would have consumed more energy than the entire world combined. Per capita carbon emissions have closely followed energy consumption, with the United States emitting 5.6 metric tons of carbon per capita, the world on average 1.1 metric tons, and China 0.7 metric tons of carbon per capita.[13]

Numerous studies have evaluated the potential for improving energy efficiency in industrialized countries. In Western European countries the potentials generally range from 30% to 50%. In the US, the utilities' Electric Power Research Institute (EPRI) estimated the technical energy savings potential at 30% of overall electricity consumption. Calculations by Amory Lovins's Rocky Mountain Institute, in Colorado, place the potential for saving energy much higher - at over 70% of current power consumption in the US.

The analysis of nuclear phase-out scenarios for Germany shows that while the short-term abandoning of nuclear power (within one to two years) would lead to a short-term increase in greenhouse gas emissions, about four years later the emissions would drop below the reference level.[14] In Germany, the over-capacity is such that the phase-out pattern is not determined by available generating capacity. According to the Öko-Institut, in 1998, the total installed capacity in Germany was 109 GW (109,000 MW) of which about 100 GW were technically available. The daily peak load during the year was 72.4 GW, thus an over-capacity of some 27 GW. This over-capacity is to be compared to the total installed capacity of nuclear power plants of about 21 GW. In other words, there is no technical capacity problem in phasing out nuclear plants even in the short term. However, extending the phase-out process could lower and shorten the medium-term rise in greenhouse gas emissions were some of the energy efficiency potential to be tapped and if there was low-emission replacement capacity. By 2020, the contribution from renewables could be increased from the current 6% level to some 35% with approximately 40% of electricity supply being provided by cogeneration plants.

[12] see the excellent analysis of Shong Xiang Zhang, "Is China taking actions to limit its greenhouse gas emissions? Past evidence and future prospects", in "Promoting development while limiting greenhouse gas emissions - Trends and baselines", UNDP-WRI, 1999
[13] US DOE-EIA, October 1999, http://www.eia.doe.gov/emeu/cabs/chinaenv.html
[14] "Einstieg in den Ausstieg", Energy Division, Öko-Institut, Darmstadt, July 1999

The analysis of the DETENTE nuclear phase-out scenarios for France suggests that the country's total consumption of fossil fuels in 2010 would remain on the same level in both the business-as-usual scenario and the phase-out scenario.[15] The over-capacity in the French power supply sector is even higher than in Germany. While the historical peak load was 70 GW in 1993, the total installed capacity is currently 114 GW of which 63 GW (55%) is nuclear. Technically, it would be no problem to shut down the 35 oldest of France's 59 operating nuclear power plants in the short-term, even while retaining a comfortable 19% reserve capacity.

The key issues for the stabilization of CO_2 emissions under a nuclear phase-out scenario in France would be the limitation of energy consumption in the transport sector and the conversion of a significant share of electric space heating systems, in particular by cogeneration-based urban heating.

8 Economic issues

You can spend a dollar only once. Therefore the key question remains, greenhouse gas abatement at what cost? This is not a new question. The first attempt to evaluate the comparative CO_2 abatement cost between energy efficiency and nuclear power was carried out by Bill Keepin and Gregory Kats, then with the Rocky Mountain Institute, in December 1988.[16] The authors defined their principal findings as follows:

- "Even a massive worldwide nuclear power program sustained over a period of several decades could not 'solve' the greenhouse problem. (...)
- The key to ameliorating future climatic warming caused by the combustion of fossil fuels is to improve the efficiency of energy usage.
- Improving electrical efficiency is nearly seven times more cost-effective than nuclear power for abating CO_2 emissions, in the USA."

Similar analysis showed overwhelming economic advantages for energy efficiency programs even in a nuclear-intensive country like France. A unique comparative empirical study[17] carried out by the Paris-based INESTENE (Institut d'évaluation des stratégies sur l'énergie et l'environnement en Europe) on the investments into the nuclear power plant of Fessenheim and energy efficiency measures in the same region, respectively, over a period of 10 and 15 years, concluded:

- it costs about half as much to invest in electricity savings in industry than it would to build a nuclear power plant of equivalent capacity;
- it costs about 1.4 times more to invest in energy savings in the commercial and residential sector but, globally, investment in energy efficiency measures pays back four times faster than investing in a nuclear power plant.

An estimate by the American utility industry-sponsored Electric Power Research Institute indicates that about 28% of US electricity consumption in 13 applications could be saved at costs of less than 4 US cents per kilowatt-hour. The Rocky Mountain Institute believes that the energy savings potential of around 70% is available at less than 5 US cents per kilowatt-hour saved.[18]

[15] for a short discription of the DETENTE scenarios, developed by INESTENE, see Pierre Radanne, "La sortie du nucléaire en France et la réduction des impacts sur l'effet de serre - l'offre de l'énergie", dans "Stratégies énergétiques entre les risques du nucléaire et de l'effet de serre", Proceedings of the conference held at the French Senate, 8-10 April 1994

[16] Energy Policy, Vo. 16, n° 6, December 1988

[17] Pierre Radanne et al.., "Analyse comparative des impacts économiques du site nucléaire de Fessenheim et des actions de maîtrise de l'énergie en Alsace", INESTENE, commissioned by Groupe Alsacien d'Information sur le Nucléaire (GAIN), March 1989

[18] quoted by Peter Hennicke, Wuppertal Institut, at Brandenburg Technical University, 2 July 1999

There is hardly any discussion about the cost-effective potential for energy efficiency. The lowest cost figures for nuclear power come from the French government. The latest so-called reference costs estimate nuclear electricity costs 2.7 - 3.4 US cents per kWh.[19] However, only under the condition of high gas prices and an unfavorable dollar exchange rate, is nuclear power competitive in base load (for use all year-round), never mind middle load. In France, as in other countries, gas turbines offer the cheapest option, particularly in cogeneration mode. But coal-fired steam turbines are also competitive, even in base load, assuming the steam can be utilized to its full economic potential.

Nuclear generating costs for any country are given in a broad range, depending on the origin of the figures. Five years ago, under an in-depth analysis commissioned by the Dutch Ministry of Environment, IPSEP (International Project on Sustainable Energy Paths), under the leadership of Florentin Krause, evaluated official cost data from various countries.[20] He estimated French nuclear generating costs at 4.8 - 7 US cents per kWh and German and British nuclear electricity costs significantly higher. In conclusion Krause wrote: "In view of the (above) economic and safety limitations, the resource contributions of nuclear power to greenhouse gas abatement are likely to be much smaller than previously anticipated. Its contribution in Europe may largely be limited to additional reactor projects already in the pipeline." For the time being, Krause is right.

The economic problems of the nuclear option when adding new capacity seem obvious. But what about the economic conditions of a nuclear phase-out? A recent thorough analysis by the consulting firm LBD in conjunction with the Öko-Institut on behalf of the Environment Agency of Hamburg evaluated the economic conditions of a rapid phase-out of four nuclear power plants operated with the shareholder participation of the municipal utility.[21] The stunning conclusion: "The short term phase-out of the use of nuclear energy and the investment into combined cycle gas turbines is linked to clear economic advantages for HEW [the Hamburg utility]. In the case of the power plants Brunsbüttel and Stade the short term shut down is urgently recommended." It should be noted that this exercise was limited to a pure substitution between nuclear power and gas-fired combined cycle plants. The analysis did not take into account any specific efforts in energy efficiency, which would almost certainly have increased the economic gap between nuclear and non-nuclear solutions.

What the HEW study did reveal is that prices per kilowatt-hour are largely subsidized by revenues from interest gained through back-end funds (for spent fuel, plutonium and waste management). Until recently, German utilities had the possibility of tax-free investments of huge funds - in total about DM 70 billion or US$ 37.5 billion. The revenues have been used to subsidize the real cost of nuclear power. Now a part of the funds have to be dissolved (DM 12 billion or US$ 6.4 billion in a first step) and significant taxes have to be paid on the revenues from investments. In fact, there are utilities in Germany where the invested money from back-end funds constitutes over 50% of the overall company capital. In other words, once the money is needed in cash, the company has to sell out. A high financial risk.

In comparison, the generating cost of gas combined cycle power plants in the US dropped by 44% between 1982 and 1999. A further cost reduction of 15% is anticipated by 2007.[22] And this is precisely what banks like. A dynamic technical context in a favorable economic environment. Low capital costs and short payback times. The World Bank's Environmental Assessment Source Book[23] sums up nuclear power's problems:

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[19] Ministère de l'Industrie, "Les coûts de référence de la production électrique", DGEMP-DIGEC, May 1997
[20] Florentin Krause et al., "Nuclear Power - The Cost and Potential of Conventional and Low-Carbon Electricity Options in Western Europe", IPSEP, commissioned by the Dutch Ministry of Environment, El Cerrito, California, 1994
[21] Dieter Viefhues, et al., "Gutachten über die Wirtschaftlichkeit der HEW-Kraftwerke", commissioned by the Environment Agency of the municipality of Hamburg, July 1999
[22] Boni Biagini, Dave King, "Nuclear Power: Too expensive to solve global warming", The Environment Trust, 1999
[23] World Bank, "Environmental Assessment Source Book" Vol. III "Guidelines for Environmental Assessment of Energy and Industry Projects", World Bank Technical Paper 154, 1992

"Even with low operating costs, the high capital costs of nuclear plants preclude their being selected as the least-cost alternative under any reasonable assumptions concerning prices of coal or oil.

Nuclear plants are thus uneconomic because at present and projected costs they are unlikely to be the least-cost alternative. There is also evidence that the cost figures usually cited by suppliers are substantially underestimated and often fail to take adequately into account waste disposal, decommissioning, and other environmental costs. Furthermore, the large size of many nuclear plants relative to developing country systems leads to risks of substantial excess capacity should demand fail to increase as predicted. (...)

Further complicating the issue is a perception of secrecy and lack of candor that characterizes the operation of nuclear power plants. In recent years, a number of accidents have raised doubts in the public mind as to the competence of the industry and the safety of the process. Many doubt the credibility of the industry."

The international banking system has never liked nuclear power. Neither the World Bank nor the Asian Development Bank has ever financed nuclear power plants. And the European Bank for Reconstruction and Development is struggling to decide on its first full-scale loan on a building project (K2/R4 in the Ukraine). Many inside the bank are opposed to the deal.

The climate change issue will not change the World Bank's attitude. In the Question & Answer section of its website, the World Bank writes:

"Q: Given its work on shadow prices of carbon, at what price does the Bank believe that nuclear energy is warranted in the fight against global warming?

"A: The issues surrounding nuclear power go beyond economic costs alone. Nuclear energy is not acceptable in many parts of the world because of concerns over reactor safety, disposition of nuclear wastes and proliferation of fissile materials. The trade-offs are thus complex and cannot be boiled down to a single carbon shadow value."

9 Deregulation effects

The general international trend towards liberalization of the energy sector has significant effects on current nuclear programs. Several trends have become clear. The competition has already reached a ferocious level in Europe. In one of the most advanced regions, electricity prices for residential customers under the Scandinavian trading pool Nordpool have been cut by half over the last few years. In Germany, very large quantities of power are already negotiated by trading companies, looking for the best offers on the market and packaging consumers' service needs. In certain areas of the US, it has become difficult to hold on to electricity customers so utilities are attempting to impose large disengagement penalties.

The first victims of deregulation are the nuclear plants. In the US, at least six reactors have been shut down already (Big Rock Point, Millstone-1, Connecticut Yankee, Maine Yankee, Zion-1 and -2) following the opening of the energy market to competition. Various experts consider that up to 40% of reactors in the US might be shut down prematurely because they are not economically competitive. Other reactors are being sold for ridiculous prices. In 1998, two reactors were sold for US$ 20 million each, respectively 3% and 4% of their book value. In June 1999, the two Nine Mile Point units were sold together for US$ 226.7 million while the second unit had only been put into operation in 1988 for an investment cost of US$ 6.3 billion. In September 1999, the three Millstone units were put up for sale for the highest bid. The conclusion of the Union of Concerned Scientists was: Nuclear power is now "too cheap to matter".

Competition in a deregulated market with decentralized cogeneration plants scares nuclear operators. France's State utility EDF notes in an internal analysis: "The competition, which already exists on the demand side, will increase tomorrow at the front end, meaning on the production side, with an increased pressure effect on the prices and therefore on the costs. In this situation the competitiveness of the kWh more than ever will be crucial, because the price will make the difference. The production costs added to the transport costs will have to be sufficiently low to keep a price advantage over decentralized production."[24]

Supply reliability will be an additional matter, as Walt Paterson, analyst with the Energy and Environmental Program at the Royal Institute of International Affairs, in London, points out: "One of the driving forces behind the surge of interest in small-scale local generation is increasing concern about the reliability of traditional central-station electricity in the age of liberalisation."[25] In reality, deregulation might well lead to further decrease in average power plant size.

10 Systemic issues: size matters...

Starting in the 1960s, thermal power plants became increasingly large. In 1980, Ontario Hydro considered the ideal size (in $/MW installed) to be 1,000 MWe. Only 10 years later, however, the Canadian utility put the "optimal plant size" label on a 50 MW plant. No wonder that Ontario Hydro announced in early October 1999 its intention to put up for sale all of its 19 nuclear power plants. The question is who will buy at what price?

The tendency towards smaller units is still accelerating. Under the headline "small scale, big potential", the industry magazine "Modern Power Systems" indicated that, according to a consultancy report[26] on the future of small-scale power plants (1 kW to 5 MW), their market will grow by 32% over the next four years to exceed US$ 16 billion by 2003.

Soon the entire concept of large grid systems might be obsolete. Micro-scale island autoproduction with no grid connection or small-scale regional supply could take over within 20 years in industrialized countries. The advantages are obvious. Low specific capital and maintenance costs in the grid system, high investment flexibility and low grid losses all combined makes such an orientation very attractive.

Also the problem of power theft would be easier to avoid in small distribution systems. Today, especially in developing countries, significant quantities of electricity is either never paid for or disappears in illegal hook-ups. As the specialized magazine "Power Economics" recently wrote: "In Latin America where around a third of all people have no access to mains electricity, distribution companies are estimated to be losing around 40% of electricity due to theft, poor maintenance and inefficiency. In all, massive losses are also to be found in the distribution networks of Africa, South East Asia, the former Soviet Union and large swathes of Eastern Europe."[27]

In addition, high costs for maintenance and upgrading of distribution systems spurs small-scale autoproduction. A recent example is the Central Park Police in New York City that for US$ 1 million installed a fuel cell in its headquarters rather than spend US$ 1.2 million to upgrade the distribution system. On 1 May 1999, the police disconnected from the grid. As one police officer was quoted: "It's great to be self-sufficient".[28] Developing and transition countries could skip the large-scale grid phase and immediately go to smaller autonomous systems.

[24] EDF, La Lettre d'Information du Parc Nucléaire, n°33, January 1999
[25] Modern Power Systems, August 1999
[26] see James Varley, "Small scale, big potential", Modern Power Systems, June 1999
[27] David Appleyard, "Power theft: an insidious menace", Power Economics, July 1999
[28] Modern Power Systems, August 1999

In such a context nuclear power does not have any chance. The situation is further complicated by the need to maintain or build up a high level of expertise and a large number of highly skilled staff in the reactor building and operating industries. The trends are opposite. Nuclear engineering and technology is no longer an attractive issue, even within most nuclear countries. Student numbers are falling and the average age of employees is increasing. In the US, the number of university reactors has fallen from 70 to less than 30 since 1980. An estimated 25% of the US nuclear workforce will near retirement age in the next 10 years. In Germany, nuclear utilities are trying desperately to recruit students directly at the university gates.

The construction industry began to adapt a long time ago. In Germany, Siemens is the only significant nuclear constructor and even in this company nuclear only accounts for about 3% of their business; mainly maintenance and upgrading. In France, the State-controlled Framatome has pushed its non-nuclear share target above 50% for year 2000. Under these circumstances it is simply impossible for the building industry to embark in the short term on a massive nuclear expansion program as suggested in two of the NEA's scenarios discussed above.

11 Political issues: the risk factor

Last but not least, politics determine the dynamics of the energy sector. Beyond the adverse effects on nuclear power of deregulation and other systemic and technical developments, several nuclear countries have defined or even initiated active phase-out policies. Of the 18 OECD countries in Western Europe:

- 7 never embarked on nuclear power (Denmark, Greece, Iceland, Ireland, Luxembourg, Norway, and Portugal);
- 1 phased out nuclear power (Italy);
- 1 did not start up an already-built plant after a referendum (Austria);
- 9 currently operate nuclear power reactors, of which:
  - none currently plans any new investment;
  - 3 have defined a firm active phase-out policy (Belgium, Germany, and Sweden);
  - 1 has set a final shut down date (Netherlands).

The key reason for the political phase-out initiatives is socio-political pressure. Citizens consider that nuclear power is dangerous and unnecessary from an energy policy point of view. The failure of nuclear power to convince on the economic level has made it easier for politicians to act. Public support has further eroded since the beginning of the 1990s. It should be noted that while the Western nuclear industry has sought to characterize the Chernobyl accident as something which “could not happen here”, serious accidents have occurred recently even in advanced industrialized countries.

In particular the lack of “safety culture” in a nuclear-intensive country like Japan has shocked many people inside and outside the country. At least three serious accidents have happened in Japanese installations over the last five years:

- In December 1995 a sodium leak at the Monju fast breeder reactor led to a situation that could have threatened the integrity of the reactor core. Subsequent attempts by the operators to cover up the extent of the accident, led to the dissolution of the operator company PNC. The reactor is still down.
- In March 1997 a fire and subsequent explosion at the Tokaimura waste bitumenizing facility, part of the Tokai reprocessing plant, led to the release of radioactivity beyond the site borders.
- In September 1999 an operator failure in a uranium conversion facility at the Tokai site led to the world’s worst nuclear accident since Chernobyl. An uncontrolled chain reaction occurred and continued for 18 hours in a simple precipitation tank, effectively leading to a situation where a small nuclear reactor was operating in an ordinary room. One operator has subsequently died. The population in the immediate vicinity was exposed to a neutron "shower" for 18 hours. Over 400 people were exposed; one nearby resident receiving over 20 times the annual dose limit for radiation.

September's accident made the political climate for promoting nuclear power in Japan extremely difficult and it undoubtedly played a part in the decision to cancel the planned Ashihama nuclear plant which had been on the table for 37 years. Outside Japan the outcry was also significant. If such an accident can happen in *the* high-tech country par excellence, the message seems to be that "it *can* happen here".

12 Nuclear power <u>and</u> climate change?

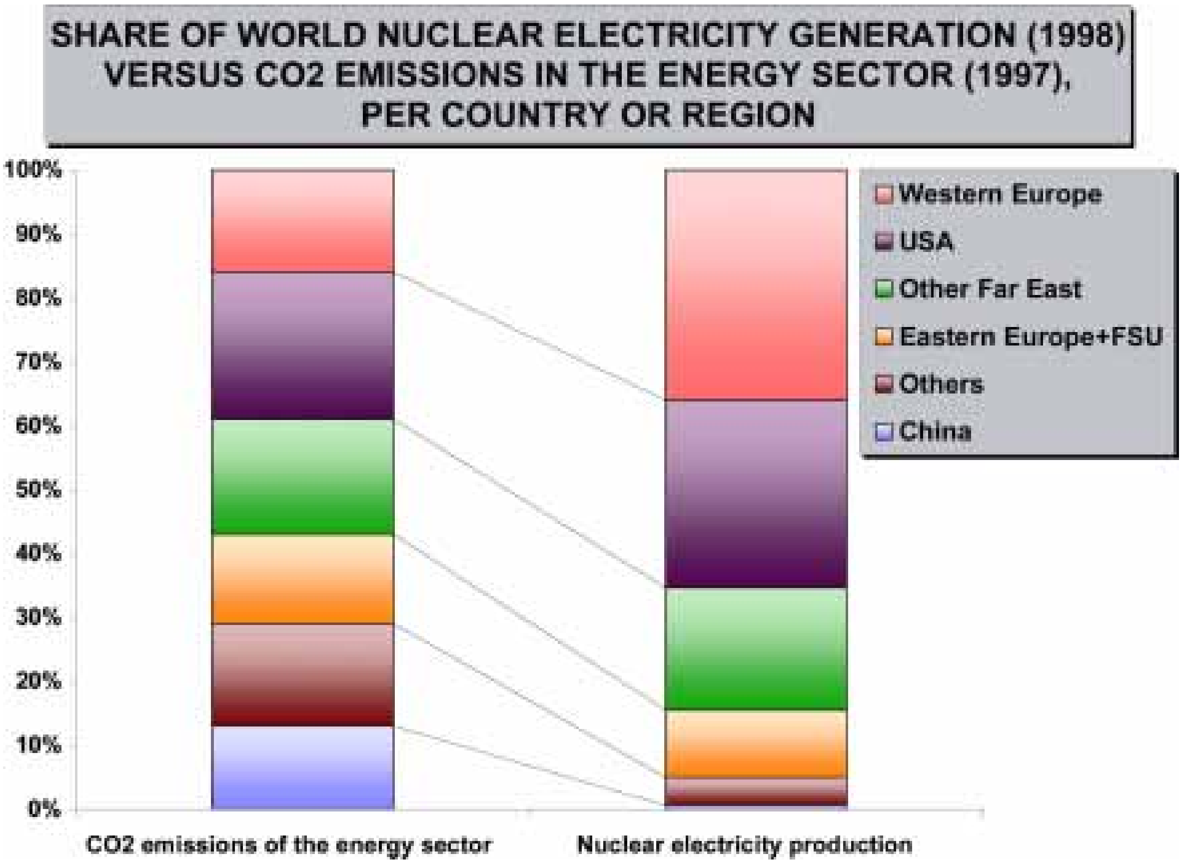
Given the large number of indirect systemic effects, it is interesting to evaluate the overall CO_2 emissions of the energy sector in countries with nuclear capacity. (See Figure 7). The largest generators of nuclear power also have energy sectors with the highest CO_2 emissions. Western Europe and the United States produce about two-thirds of the nuclear electricity in the world their energy sectors also produce 39% of the world's energy-related CO_2 emissions.

The same analysis applies to overall CO_2 emissions per country or region. There is an interesting correlation between nuclear generation and CO_2 emissions. (See Figure 8). The United States alone, less than 5% of the world's population, accounts for 25% of the world's total CO_2 emissions and generates 29.4% of the world's nuclear electricity. Western Europe, with only 6.5% of the world's population accounts for about 15% of global CO_2 emissions and 34% of the nuclear power production. China is the counter example. With 21.5% of the world's population, the country emits 13.5% of global CO_2 and generates 0.6% of the world's nuclear power.

The example of China illustrates well the potential role of energy efficiency in greenhouse gas abatement. Analysis of developments between 1980 and 1997 shows that while the country reduced its CO_2 emissions through penetration of "carbon-free fuel" by hardly more than 10 million tonnes of carbon, the reduction due to energy efficiency measures delivered savings of more than 430 million tonnes of carbon over the same period.[29]

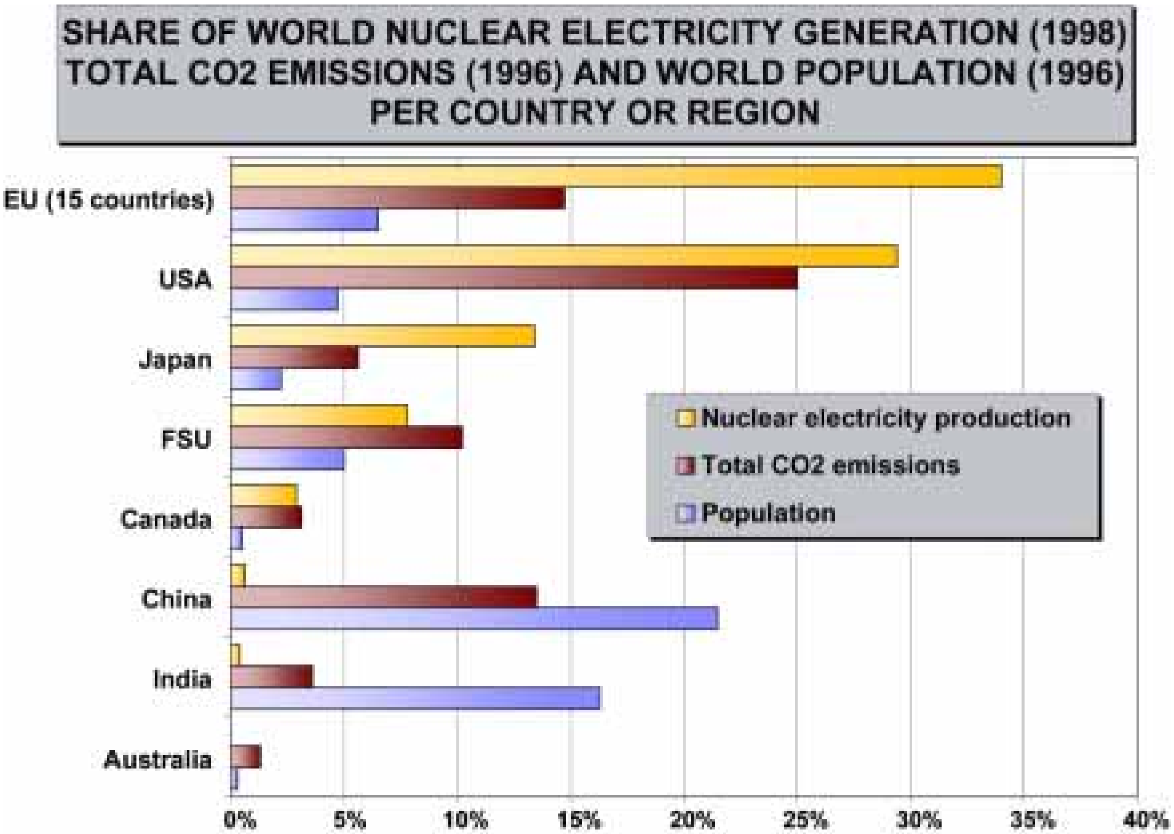
[29] Shong Xiang Zhang, op. cit.

Figure 7: Nuclear Electricity and CO_2 Emissions of the World's Energy Sector



Source: UNDP 1999; IAEA 1999

Figure 8: Nuclear Electricity, Total CO_2 Emissions and Population



Source: UNDP 1999; IAEA 1999

Projections for Germany, produced by Prognos, suggest that while nuclear power output is expected to decrease by 40% by 2020, CO_2 emissions per kilowatt-hour are expected to decrease significantly (probably by around 20% or more). This is not only because of a lower coal content in the fuel mix, but also especially because of an expected 22% decrease in the energy intensity of the German economy.[30]

It seems obvious that there is no forced correlation between a high level of nuclear generation and low CO_2 emissions of a given country. So far France is the exception. France is also the most nuclear-intensive country in the world, apart from Lithuania. France operates 59 nuclear reactors that produce 75% of its electricity while nuclear plants represent about 55% of the installed capacity. At the same time, France has a relatively low level of greenhouse gas emissions. The question is therefore justified whether a combined policy of nuclear power and energy efficiency is a possible alternative over the long run and whether it is cost efficient.

A recent major study carried out by the French national planning commission (Commissariat général au plan) which looked into three different scenarios ("market oriented", "industrial", "environmental") came up with some interesting results:

- even in the "environmental" scenario, France's final energy consumption would increase by 9% by 2020 (compared to a reduction of at least 5% projected by Prognos for Germany);
- the scenario with the lowest greenhouse gas emissions is not the most nuclear and "there is no evident correlation, even in France, between emissions and nuclear power", according to Benjamin Dessus, Chairman of the Long Term Working Group undertaking the study;
- nuclear power plants would have almost disappeared by 2020 under the "market oriented" scenario if their lifetime cannot be pushed from 30 to 40 years.

Certainly, for the time being, the French system has displayed a remarkably low level of CO_2 emissions. Besides the fact that the country faces the highest radioactive emissions in the Western world, piles up enormous amounts of radioactive waste (including from the exported electricity production) and is exposed to the daily risk of a nuclear disaster, the question is how long it will last? The system is extremely fragile. When in 1998 a number of reactors failed to operate as projected, France had to increase steeply (+36%) its fossil fuel use for electricity production. The country's CO_2 emissions increased accordingly by about 4%.

France has demonstrated resistance to the deregulation of the European energy market. It has attempted to push back the date for opening its market as far as possible, while aggressively acquiring stakes in the utilities of neighboring countries. In fact, the State utility EDF has no experience of competition. It has rested on its monopoly since its creation in 1946. According to a key internal strategy paper, the French utility intends to camp on its position: the two major advantages remain the huge production capacity and a large domestic heat sector. The energetically absurd and expensive electric space heating generates income of about FFr 28 billion (some US$ 4.3 billion) and the hot water sector another FFr 10 billion (US$ 1.6 billion). While many utilities around the world launch ambitious end-use energy efficiency programs, EDF regards the electricity consumption of household appliances (FFr 21 billion or US$ 3.4 billion turnover) as being "threatened by the efficiency increase of the appliances". In order to stimulate the EDF staff to promote a product which has lost all credibility - even inside EDF - the company's directorate proposes "internal education" for their employees "to believe again in electric space heating".

Large over-capacities on the supply side in countries with nuclear power will prevent energy companies from striving for energy efficiency. The main goal has been to sell kilowatt-hours. This is all the more true for Eastern European countries - in particular Russia, the Ukraine and Lithuania - which have experienced a devastating economic crisis and falling electricity consumption for 10 years.

[30] Konrad Eckerle, et al.., "Die längerfristige Entwicklung der Energiemärkte im Zeichen von Wettbewerb und Umwelt", commissioned by the Ministry for Economic Affairs, Prognos AG, Basel, October 1998

Today, over-capacities outweigh by far the total installed nuclear capacity in these countries. There is a formidable incentive to try and dump "cheap" nuclear electricity into a deregulated European energy market where every utility is looking for possibilities to save costs.

Another problem is that a nuclear utility by definition has acquired significant knowledge and expertise in large-scale supply-oriented energy distribution systems, with only a limited knowledge of decentralized energy systems or end-use efficiency. It is only from the moment when concrete steps are taken to phase out nuclear power (and other large-scale production facilities) that major changes and new initiatives can flourish.

WWF Climate Change Campaign

Global warming and climate change pose a serious threat to the survival of many species of plants and animals and to the well-being of people around the world. By 2001, WWF aims to ensure that industrialised nations set in motion a permanent downward trend in their domestic emissions of carbon dioxide - the leading global warming gas - as the first step towards substantial reductions by 2010.

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- promoting the reduction of pollution and wasteful consumption.