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World Information Service on Energy

World Nuclear Industry

Status Report

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Index

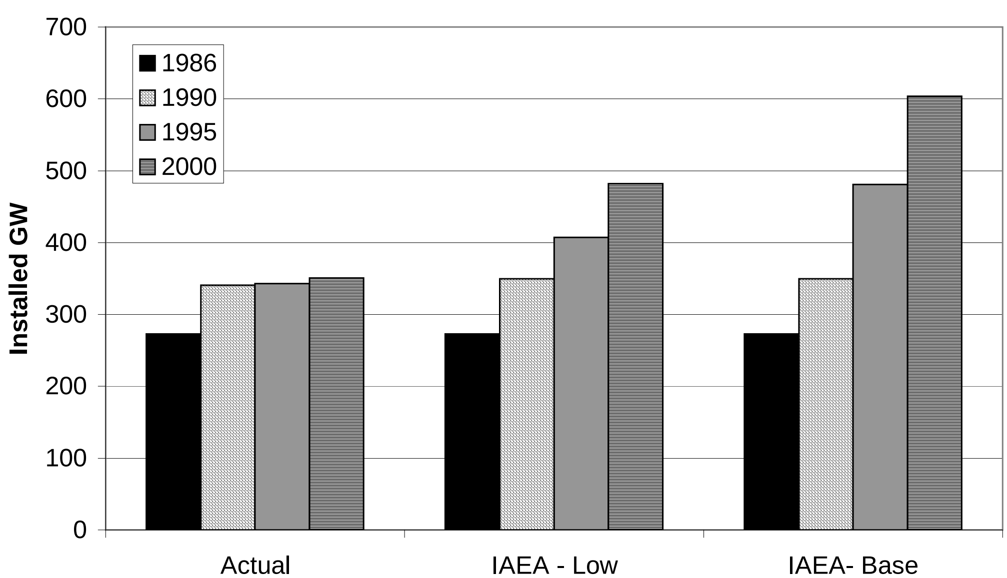
Executive Summary

Introduction

Nuclear power is a mature technology producing electricity in thirty-two countries. The commercialization of nuclear technology was born out of the dropping of atomic bombs on Japan. The first nuclear power plant began producing electricity nearly 50 years ago. This was followed by a rush of statements that nuclear power would be peaceful and could offer cheap and clean power that would change the world. These have proved to be hollow and predictions about the dominance of nuclear power have come to little.

One can understand the overly optimistic claims for nuclear power at its launch in the 1950s, as they were made in the euphoria of the birth of the new technology. It is harder to accept industry claims in the late 1980s, after the accidents of Chernobyl (1986) and Three Miles Island (1979). In its 30th Anniversary edition, the International Atomic Agency's (IAEA) publication The Bulletin continued to claim that nuclear power would go from strength to strength[1]. However, as the graph below shows, between 1986 (Chernobyl) and 1990 a number of reactors were completed, but since then there has been virtual stagnation of the global nuclear industry. Those overseeing the World's nuclear industry totally misunderstood the degree of opposition from the public and politicians that led both to orders being cancelled and - to a much greater extent - utilities moving away from nuclear power towards other non-nuclear generating capacity.
Source: IAEA

IAEA's Post Chernobyl Forecast for Global Nuclear Industry

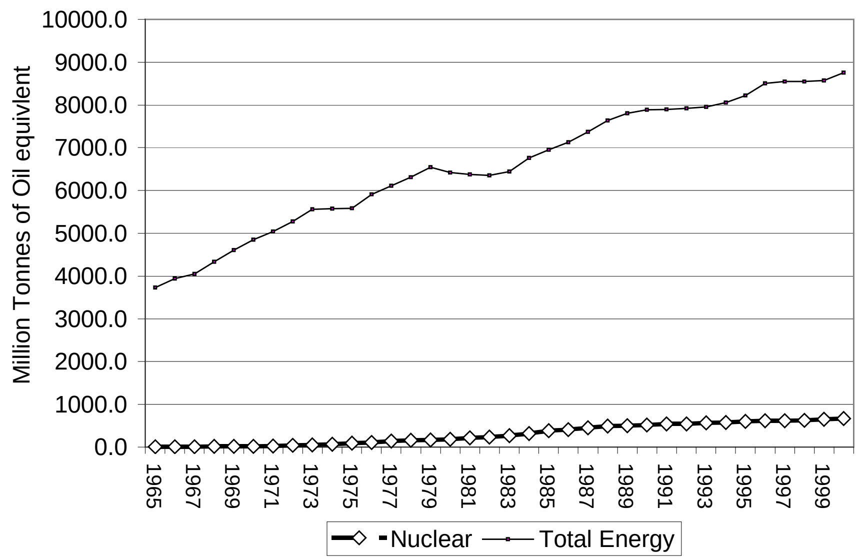


Since Chernobyl, the capacity of installed nuclear power plants has increased globally by approximately 25%. The IAEA forecast nuclear power to increase by between 1.7 and 2.2 times.

[1] Nuclear Power development: History and Outlook, Events Have Changed The Global Prospects For Nuclear Power, N.L.Char and B.J. Csik. International Atomic Energy Agency, Bulletin, 29/3, 1987

The graph below shows the global development of nuclear power and total energy consumption. Nuclear power has increased its actual and percentage contribution to global energy, but not significantly. Currently 7.6% of the world's energy is supplied by nuclear power (16% of electricity), up from 6.5% in 1990 and 2.8% in 1980. Nuclear power has not become a major provider of global energy.

Global Energy and Nuclear Consumption 1965-2000



Source: BP Statistical Review 2001[2]

However, some predict a change in the fortunes of nuclear power. Nuclear supporters are hoping that a combination of environmental and geopolitical factors will tip the balance in favour of nuclear power. Most importantly, they hope that concern about climate change will outweigh that about the environmental impact of nuclear power, i.e. uranium mining, waste production, nuclear proliferation or deliberate and accidental environmental discharge of radiation. They also hope that concern over dependency on energy reserves in non-OECD countries will overcome fears of the instability that comes with nuclear proliferation.

This paper will review these issues and address the equally important question: how will nuclear power fare in the global electricity market? Driven by political desires for smaller government sectors and the economic incentives of the private sector, the former electricity national monopolies are being broken up and privatized and electricity markets liberalized. This has resulted in increased transparency of costs and consequently less interest in the large capital costs associated with nuclear power, when power plants that are cheaper and quicker to build are readily available. The question facing the nuclear sector today is whether it will gain sufficient political support to overturn the ideologies of the de-regulated electricity system and justify political intervention in the market. Without this support and associated subsidies, nuclear power will gradually fade from the global energy system.

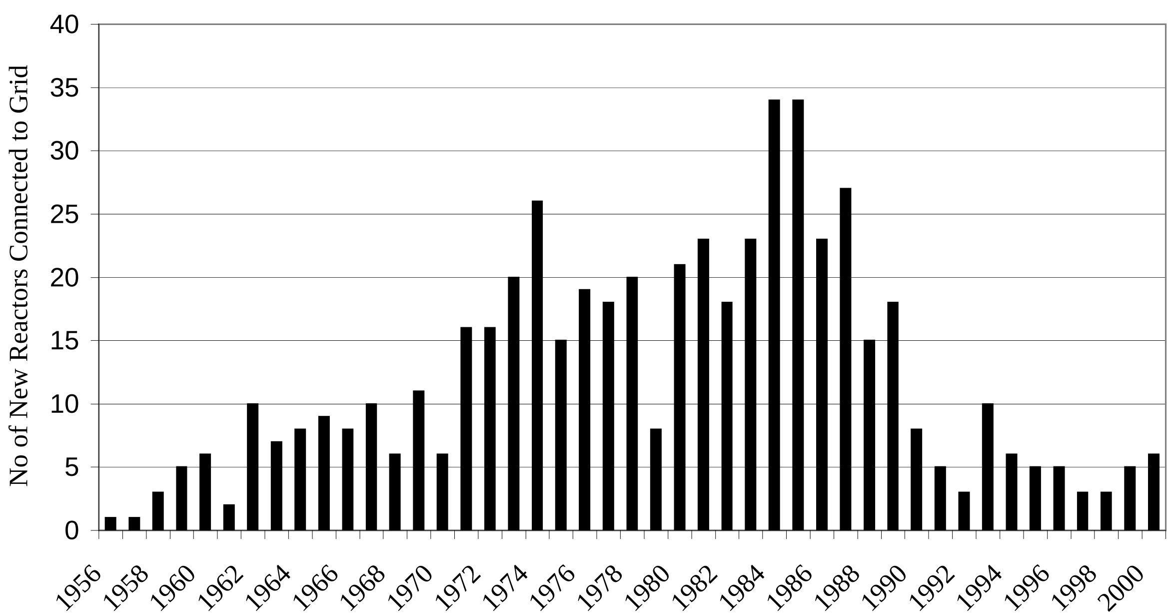
[2] http://www.bp.com

Global Development of Nuclear Power

The supporters of nuclear power claim that it is a technology that has not yet showed its true potential. To date nearly 550 reactors have been built around the world, of which nearly 440 reactors are currently in operation. The graph below shows how nuclear power has developed since the first reactor was connected to the grid in 1956. The peak of nuclear power occurred in the mid 1980s, when over 30 GW of nuclear power was connected to the global grid. Three Mile Island, the most significant accident in a reactor prior to Chernobyl, did not appear to have a long-term impact on the pace of global orders, but may have affected reactor starts in 1979 (which had the lowest number over the 1970s and 1980s). With regard to the construction of new reactors, 1975 was the global peak, with 38 GWs of new construction.

Chernobyl (1986) had a huge and unparalleled impact on the nuclear industry. Construction began on only one reactor during this year. During the 1970s and 1980s an average of 23 reactors were connected to the grid each year, but by the 1990s this had dropped to around 5., Assuming an operating life of 40 years, at least ten new reactors need to be built each year in order to maintain the status quo in reactor numbers. Thus we can see that the decline in nuclear power effectively began a decade ago.

Global Development of Nuclear Power



Source: IAEA

Market Trends.

Liberalising Energy Markets

"Deregulation of the European markets could represent an even bigger threat to the future of nuclear power than anti-nuclear ideologues[3]

Since the late 1980s significant changes have occurred within the electricity industry. In Western Europe energy planners and free-marketeers have the ideological aim of creating a single electricity market across Europe, a trend which has been replicated across the world. As this occurs there are far reaching social, environmental and economic consequences. In the short term it will impact particularly on the type of power stations chosen by utilities, in respect both to current usage and future construction. This has had a dramatic impact on the nuclear power industry with fewer and fewer reactors being ordered.

Restructuring Privatization and Liberalization.

The restructuring of the UK electricity industry began before most other countries and has become a yardstick - although not a template - by which other countries can be measured. The partial privatization of the UK industry began in 1989, but the market was only fully liberalized in 1999 with small-scale consumers able to choose their electricity supply. The decade of restructuring breaks down into five stages[4].

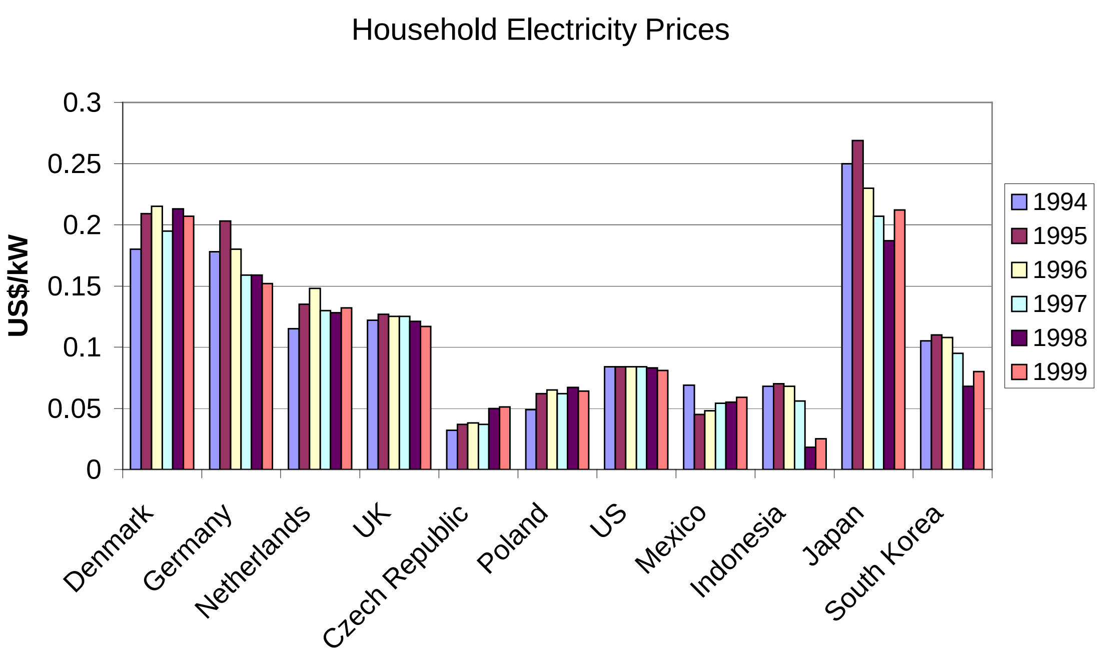
- **Privatisation.** In 1989, the industry was wholly owned by taxpayers via central government. Over the next six years (mostly in 1990 and 1991), it was progressively transferred to private shareholders;
- **Restructuring and de-integration.** The industry was divided into four separate parts: electricity *generation*, the high voltage *transmission* system, the local *distribution* system and *supply* to final consumers. The existing companies (one large generation and transmission company and 12 distribution companies) were restructured and in some cases broken up along these de-integrated lines;
- **Liberalisation and introduction of competition to generation.** All central planning of the generation sector was effectively abandoned and barriers to entry for new generation companies removed.
- **Liberalisation and introduction of competition to supply.** All final consumers were to be allowed to choose their electricity supplier, not only from the existing companies, but also from any other company that chose to enter the field; and
- **Re-regulation.** Prices for activities regarded as natural monopolies (transmission and distribution) were to be set by a new Regulator using a 'price cap' or 'incentive' formula. Prices for competitive activities were to be set by the market, but under the scrutiny of the Regulator who had a duty to promote competition wherever possible.

[3] Is there Life After 40 for Western Europe's Nuclear Plants? Plant Life Extension – Nukem Market Report, August 1997.
[4] Has Privatisation Reduced the Price of Power in Britain? Steve Thomas SPRU, University of Sussex Monograph published by Unison November 1999

The annotated diagrams below highlight the changes that have occurred in the electricity market. In the "unrestructured" system, one company – often State owned - runs the generation, transmission and distribution. They also supply the consumers, who have no choice of electricity supplier and are a captive market. The regulator is charged with ensuring the monopoly does not abuse its position.

However, in the "restructured" system there are a variety of producers who sell their electricity either through an electricity exchange or direct to the transmission operators, who in turn sell the electricity to the distribution companies who supply the customers. This "unbundled" system should increase competition between the actors and thus lower the price to the final consumers.

Over the past few years in the EU and in general globally there has been a downward trend for electricity prices. According to the European Commission[5], average electricity prices within the European Union fell by around 6% between 1996-9. The graph below shows the global trends in electricity pricing. The price fall for EU electricity is significant and much larger than that in the United States. The much larger fall recorded in Asia is related more to the currency collapse in 1998 than energy restructuring. In Eastern Europe prices have increased as the energy sector strives to become financially viable and make prices reflect actual costs.

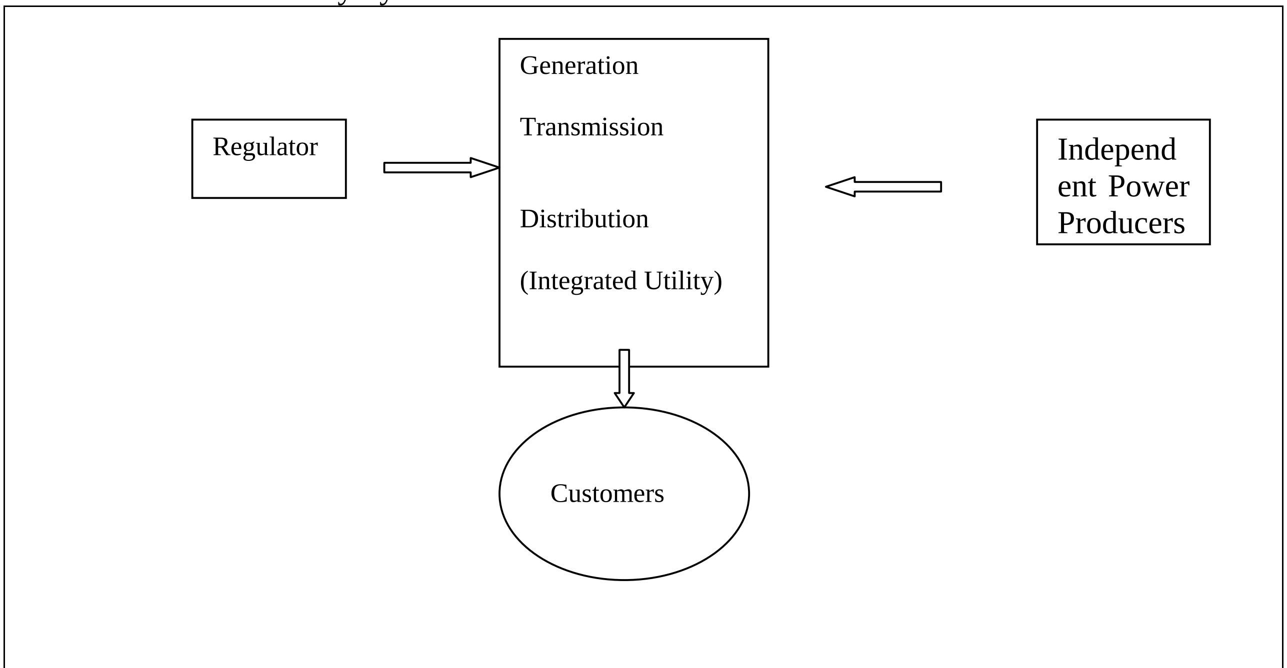


Source: US Department of Energy[6]

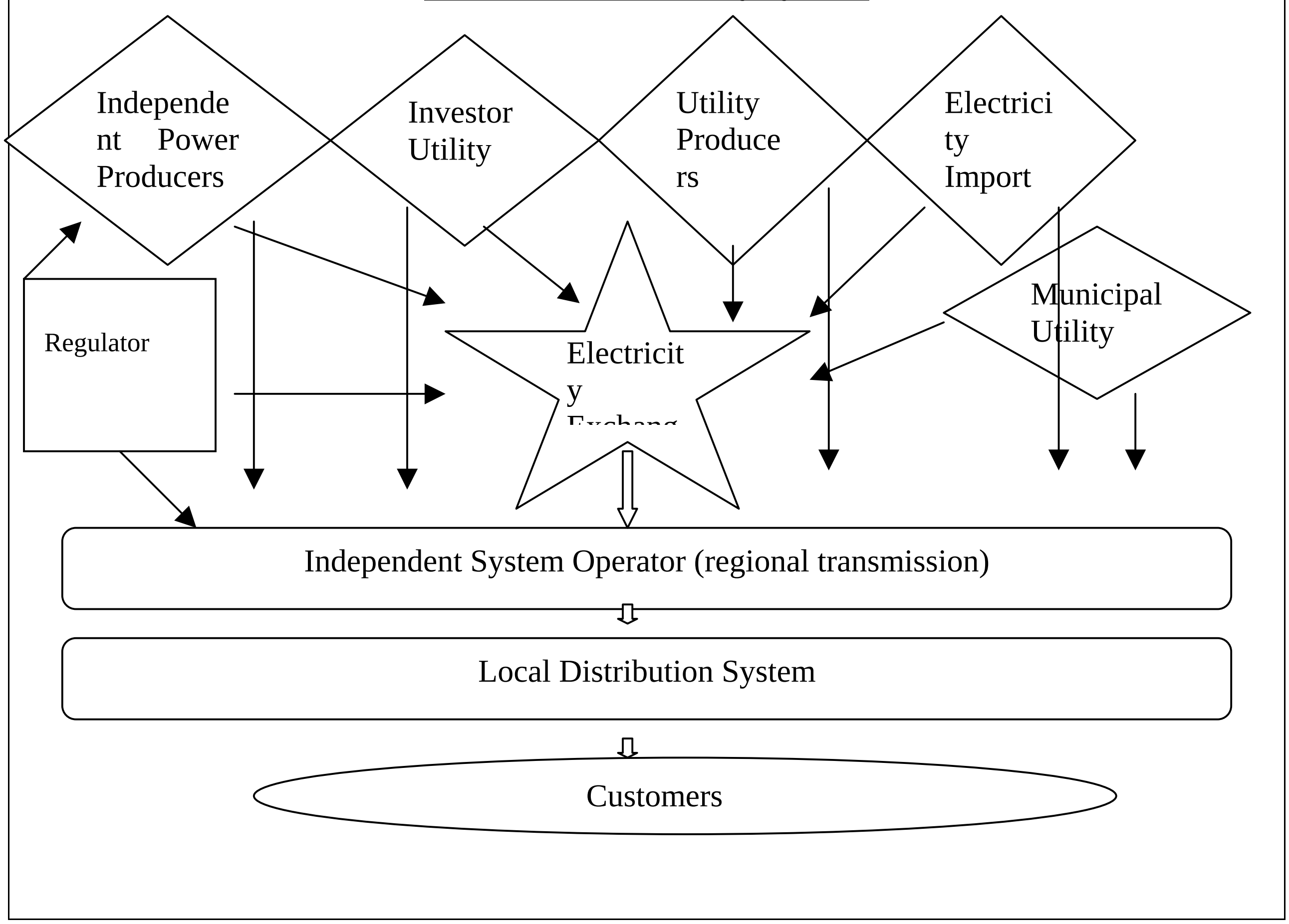
[5] Eurostat. *Statistics in Focus*. Environment and Energy. n° 6/2000 "Electricity prices for EU industry on 1 January 2000: downward trend" and Eurostat. *Statistics in Focus*. Environment and Energy. n° 5/2000 "Electricity prices for EU households on 1 January 2000: downward trend", http://europa.eu.int/comm/eurostat/Public

[6] http://www.eia.doe.gov/emeu/international/elecprih.html

Unrestructured Electricity System



Restructured Electricity System.



Between 1994-9, the countries in the graph experienced an average 6% decrease in electricity prices. In this situation, electricity generators must produce cheaper electricity and reduce costs - through reductions in workforce, lower fuel costs or increased efficiency - if they are to compete and still make a profit.

Over this period the global price of natural gas has fluctuated considerably, rising by 14% between 1994-96, rising by 14% and then falling by 10% by 1999[7] (since when it has risen considerably). As fuel is a major component of the cost of producing electricity from a gas fired power station, utilities using gas in these countries would have had difficulty maintaining profits between 1994-1996. However, the subsequent fall of gas prices would have enabled generators to increase profits. The operators of gas stations will produce electricity when the price allows, or else cease operation until prices increase.

Nuclear power is particularly affected by price volatility in the market as it has large fixed costs. Construction represents around 75% of the total generation cost compared to 25% for gas fired power plants. Such large fixed costs and decreases in electricity price will diminish profits rapidly. This also makes it much more difficult for nuclear power plants to cut costs as all the savings must come from the remaining 25% of the electricity price – i.e. production costs – via dramatic efficiency increases, reductions in workforce levels etc. Equally importantly, nuclear power plants need to operate as much as possible as their fixed (i.e. construction) costs are upfront. Switching off a nuclear reactor because of low electricity prices has severe economic implications.

New Electricity Trading Arrangements

The restructuring of the UK electricity system is not complete: a new restructuring of the electricity market, the so-called New Electricity Trading Arrangement (NETA), is imminent. This one agreement is expected to have as great an impact on fuel choice as all the previous restructuring put together. The Government is disappointed with the lack of real competition that has emerged as a result of restructuring. As of July 2000 only 18% (5.5 million) of customers had changed their electricity supplier[8]. The majority of trade is done through the pool. Under the pool system all suppliers are paid the same price. This is the price charged by the final generator needed to cover all the needs of the national grid, i.e. the price paid to all generators is the maximum that any one generator can get for their electricity. Producers with relatively low production costs – such as nuclear power – do not therefore have to worry about price reductions in the pool market.

Under the NETA system (introduced in March 2001), the pool will be abandoned and generators will be forced to find real buyers for their electricity on a half hourly basis. The NETA system is similar to the electricity system in the European NordPool and some parts of North America (particularly California). The Government is hoping that NETA will help to drive down the price of electricity.

[7] US Department of Energy, based on gas prices in Czech Republic, Hungary, Ireland, Mexico, Spain, UK and US.
[8] http://www.ofgem.gov.uk/prices/switching.htm, June 2001

The impact of real competition between suppliers on nuclear power has already been seen in Sweden – which is part of the NordPool. In 1999 and 2000 it was reported that the spot market price routinely fell below the production costs of the Swedish nuclear fleet[9]. The effect of a prolonged period of below-production electricity prices on nuclear safety is discussed in later sections.

In the UK it is already anticipated that the nuclear industry may be significantly affected by the NETA system. The economics of the electricity market and poor availability of their aging reactors have already hit the nuclear companies hard. According to International Energy Agency (IEA) figures, the operating costs of the oldest reactors in the UK, the Magnox stations, are amongst the highest in the world at nearly 5 US cents/Kwh[10] (compared to less than half this for France, Hungary and the US). The more modern AGRs and PWRs operated by British Energy have operational costs of around 3.3 US cents/Kwh. However, gas and coal plants generate at costs around 2.0 US cents/Kwh. It will therefore be very difficult for the Magnox and AGR stations to compete, especially given their lack of economic room to maneuver due to their large fixed costs. British Energy preliminary profits for the financial year 00/01 have already fallen to £10 million, a drop from £241 million the previous year[11]. The reasons given were the low availability of power stations and falling sale price of electricity. In their 2000 annual report, British Nuclear Fuels reported a decrease of £50 million pounds in turnover from their Magnox stations, due to their lower output[12]. As many countries are following the UK model of restructuring it is quite possible that they too will adopt operating systems that remove the pool. Such moves would inevitably impact upon the economics of nuclear power.

Impact on New Construction

Only a few countries are currently building nuclear power plants: Argentina, China, Czech Republic, Iran, Japan, Republic of Korea, Romania, Russia, Slovak Republic, Taiwan and Ukraine. In all of these cases, except Japan, the nuclear industry is State owned. In Japan the Government gives huge subsidies to the industry through its research and development program. Furthermore, none of these countries has a fully liberalised electricity market although in most cases, there are plans to open up the market gradually.

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[9] Nordic Pool Prices Average Less than Swedish Unites Operating Costs, Nucleonics Week 14th January 1999, page 1 : Swedish Utility Cut Nuclear Output, Buy Cheaper Imports, Nucleonics Week 9th November 2000, page five

[10] Nuclear Power in the OECD, International Energy Agency, ISBN 92-64185798-8, 2001 page 126

[11] Preliminary Announcement 1st April'000- March 31'01, press release 16th May 2001

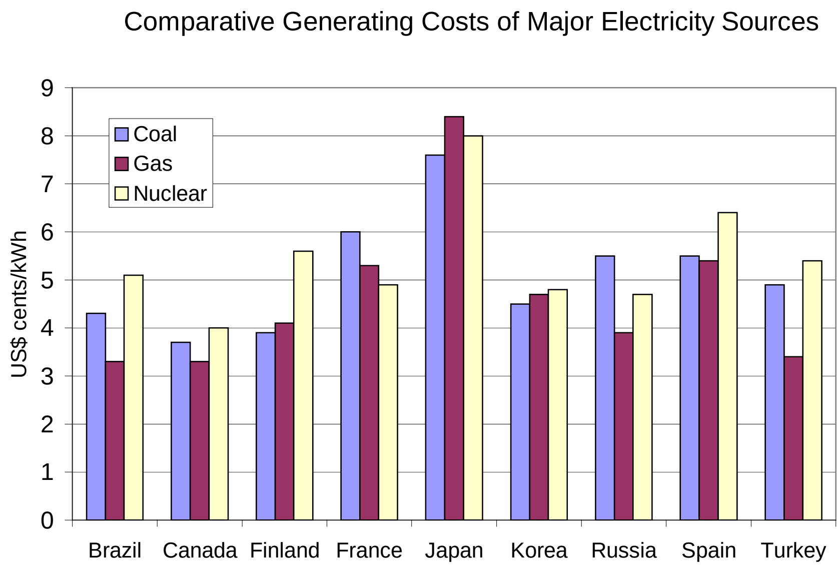
[12] 2000 Annual Report and Accounts, published 14th September, 2000

Economic Claims

Nuclear Power, which early advocates thought would be "too cheap to meter", is more likely to be remembered as too costly to matter[13].

In 1954 the then head of the US Atomic Energy Commission Lewis Strauss said that nuclear electricity would become "too cheap to meter" [14]. This shows not only the optimism and self-belief that the nuclear industry had at its outset, but also its naiveté. The "too cheap to meter" quote is now thrown back at the industry at regular intervals, especially given the subsequent economic failure of the industry, which resulted in Forbes business magazine describing the industry as "the largest managerial disaster in business history, a disaster on a monumental scale"[15].

Despite the economic problems that dogged the construction programs in the US, many in the 1980s continued to claim that nuclear power was cheaper than its competitors. By the 1990s few still argued this. Analysis released by the IEA in 1998 shows that in virtually all OCED countries, electricity from nuclear power is more expensive than conventional thermal power plants such as gas and oil. In only three countries (France, Japan and Russia) was nuclear power cheaper than coal or gas fired power stations – and only when using a 10% discount rate (the interest rate applied during construction and a key factor in the economics of nuclear power).[16] Taking a global average, nuclear power is 15% more expensive than gas and 6% more expensive than coal generated electricity. The graph below shows the results.



[13] A new Dawn for Nuclear Power?, Leader, The Economist, 19th May 2001

[14] Statement by Lewis Strauss, Chair of the US Atomic Energy Commission at a National Association of Science Writer's Founders Day Dinner in New York, 16th September 1954.

[15] J. Cook, "Nuclear follies', Forbes Magazine, 11th February 1985.

[16] Projected Costs of Generating Electricity – Update 1998, October 1998, ISBN 92 64 161 62-1, Table 9b.

New Build

The truth is it's currently uneconomic for anyone to start serious planning for a new station, let alone build one[17].

Until the industry can make new plants absolutely competitive, the capital cost of building a new nuclear power plant competitive with the capital cost of building combine gas turbine plants, the issue of building new plants isn't going to come up[18].

There are no nuclear reactors under construction or even on order in North America or Western Europe. These two regions account for 61% of the world's nuclear reactors. According to the International Atomic Energy Agency (IAEA)[19] as of 1st January 2001 there were 31 reactors under construction. The completion of four of these reactors is unlikely: Mochovce 3 and 4 in Slovakia are not part of their Government's energy planning and Khmelnitsky 3 and 4 in Ukraine are not being actively built at present. For political reasons the IAEA does not mention the Taiwanese program (with two reactors under construction) or that of North Korea (also with two reactors under construction). The other countries with reactors under construction are Argentina, China, Czech Republic, Iran, Japan, Republic of Korea, Romania and Russia. However, only China, Japan and the Republic of Korea have what might be called an active construction program; the others have non-active construction programs, or perhaps more aptly named finish-up programs. The table below highlights this for these latter countries: it shows the years elapsed since reactors were ordered. With an average time of nearly 18 years since order and long lapses in construction in all cases, it is unlikely that many of these projects will be completed.

Country	Reactor	Years since Order
Argentina	Atucha 2	21
Czech Republic	Temelin 2	18
Iran	Bushehr 1 and 2	14
Romania	Cernavoda 2	21
Russia	Kalinin 3 Kursk 5 Rostov 1	15 15 22
Ukraine	Khmelnitsky 2 Rovno 4	21 17

Source: Nuclear Engineering International Handbook

[17] Hollins, P, Chief Executive of British Energy plc (1999), *Science in Parliament*, Vol 56 No 3, p 6
[18] Jennifer Weeks, director of a research project at Harvard University's Kennedy School of Government, quoted in, General Electric's Nuclear-Powered Returns Tara Murphy, Forbes.com, 18th May 2001
[19] IAEA is a UN affiliated body established to promote and regulate nuclear power.

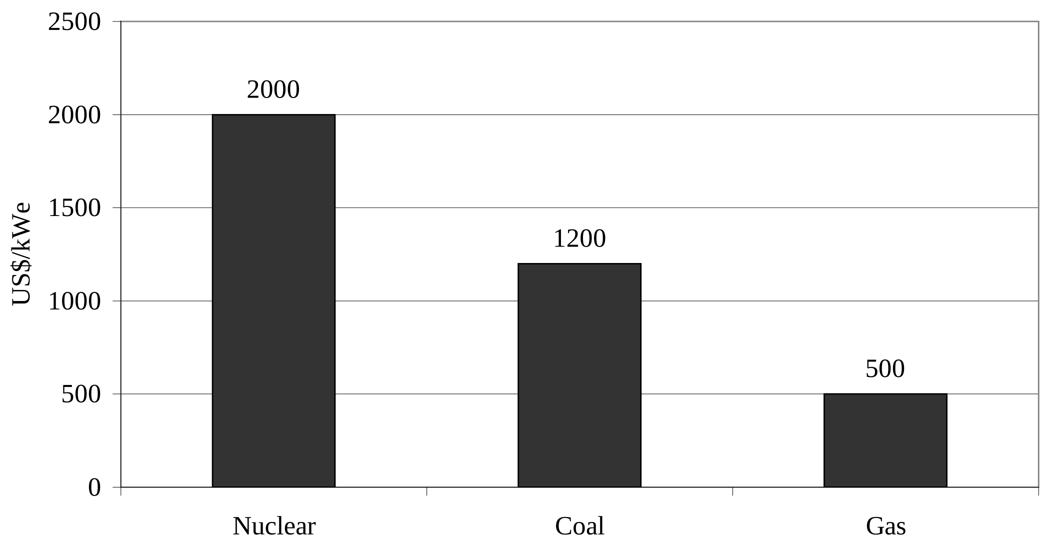
Reasons for Collapse in Orders

In recent years it is clear that the global trend of more liberalised electricity markets has reduced orders for and construction of new nuclear power plants. Liberalisation has forced some utilities to take a more market-orientated approach, which has tipped the balance against nuclear power in a number of key areas.

Capital Costs

The figure below shows that construction costs for gas fired power plants are now roughly 25% of those for a nuclear power plant, while those of coal power stations are approximately 50%[20].

Generic Construction Costs for Conventional Power Stations



Source: IEA

The capital cost of nuclear power is clearly a vital issue, particularly now in the United States, where nuclear power was once again in the media following President George Bush's release of the National Energy Plan in May 2001 (see US section for more details). Industry officials are already claiming that the next generation of reactors will cost significantly less to build than current reactors. On May 3, Corbin MacNeil, the chairman of the US utility Exelon's testified in front of a SU senate committee that its Pebble Bed Modular Reactors (PBMR) would cost $1,100 per kilowatt to construct[21]. US industry has subsequently claimed that it needs to reduce the construction cost to below $1000 per installed kW. This would mean halving current construction costs - be a remarkable and somewhat unlikely achievement. It is all the more unlikely given that the new generation of reactors are much smaller than current reactors which will from the outset cost more per kW. Concerns are being raised over the safety implications of such cost savings. Experience over the last decades, in particular lessons learned from

[20] Nuclear Power in the OECD, International Energy Agency, 2001, page 130
[21] General Electric's Nuclear-Powered Returns, Management & Trends, Forbers.com, 18th May 2001.

accidents, have required operational and design changes to reactors. These additional safety measures must not be reduced in an effort to save costs.

Construction Times

Nuclear power plants take considerably longer to plan and build than conventional power plants due to their technical complexity, their actual and potential environmental impact and the political nature of nuclear technology. On average nuclear power plants now take around eight years to build, a significant rise from the 1960s when the average was five years or less.[22] This is around thirty times longer than for a wind turbine[23].

Nuclear	Coal	Gas	Wind Power
5-10 years	4-5 years	3 year	3-6 months

Source: UNESA[24]

In 1971 the estimated cost of building a 1,000 MW nuclear plant in the US was US$ 345 million, but by 1980 this had risen to US$3,200 million. One of the reasons for this cost increase was an increase in construction times that rose from an average of 78 months in 1978 to 150 months in 1983[25].

The length of construction is particularly important in a liberalised market. Investors want a rapid return on their investment. From a purely financial perspective investing in a gas power station is preferable to a nuclear power station if you want a more rapid and assured return.

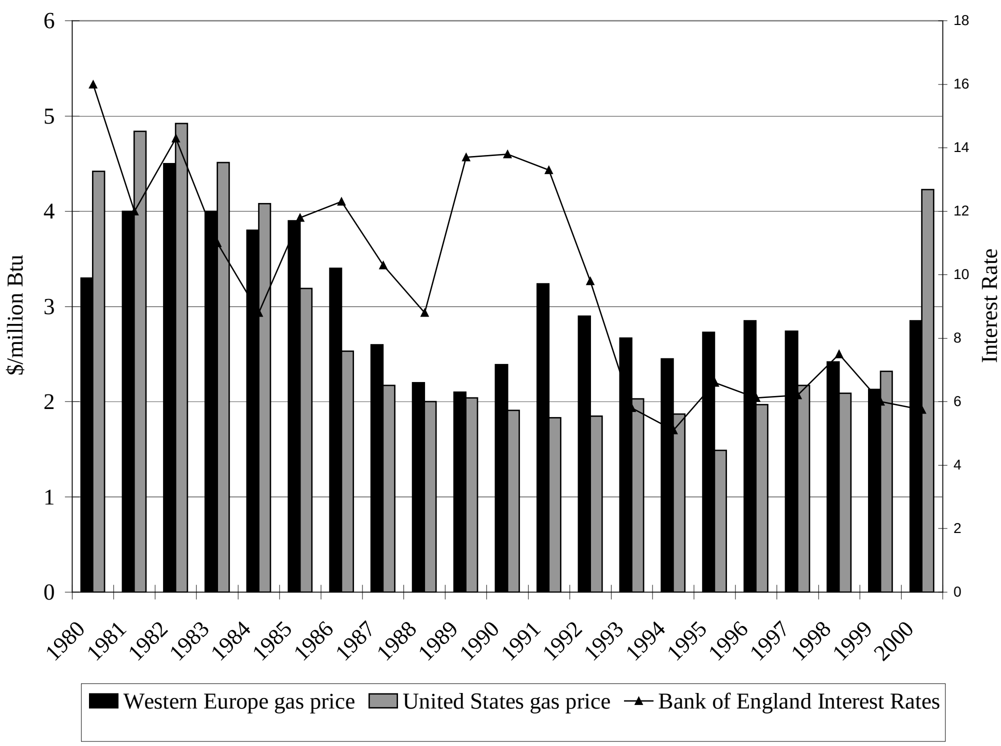
Key Variables

When comparing the cost of construction of different types of power stations it is important to look at the key factors that will influence the final price. In the case of gas fired power stations the largest cost is the price of the fuel. It is widely reported that the price of natural gas can and does fluctuate considerably, as it is connected to price of oil, which is subject to large swings often for political reasons. This situation may well change as natural gas may be "pegged" to the price of electricity, which will significantly increase its price stability. In the case of nuclear power plants, with their large upfront construction costs, one key factor is the interest rate that the operator must pay for the construction. What is not often considered is the significant changes that occur in the interest rate over time. The graph below shows the changes of these two factors over the period 1980-2000. In these twenty years, interests rates fluctuated from 16 to 5.1%, while gas prices peaked at 4.94 and troughed at 1.49 $/million Btu, roughly the same variation.

[22] Nuclear Power in the OECD, International Energy Agency, 2001, ISBN 92-64185798-8, page 132.
[23] Discussion with Centre for Alternative Technology, Wales, UK, July 2001
[24] Economic Sustainability of Nuclear Power. A. Gonzalez de Ubieta, UNESA, presented at European Seminar, Nuclear in a Changing World, October 1998, proceedings page 9
[25] World Nuclear Power, Peter R. Mountfield, Routledge, 1991 page 79

Current natural gas prices are close to an all time-high over the twenty-year period, while interest rates are extremely low. These economic conditions are most favourable for the construction of nuclear power stations, but they are not likely to last.

Historical Development of Natural Gas Prices and Interest Rates



Source: Cedigaz, BP Statistical Review, Bank of England.[26]

[26] Natural Gas in the World, 2000 Survey, table 38, page 91

Plant Life Extension

If there are no changes in policy towards nuclear power, plant lifetime is the single most important determinant of nuclear electricity production in the coming decades[27].

To counter the de facto phase-out caused by the lack of new reactors, operators are proposing to extend the operating life of existing reactors for up to forty, fifty or even sixty years, a process referred to as Plant Life Extension (PLEX). PLEX is seen by utilities as a way of circumventing the problems of site selection, large upfront construction costs and stricter regulatory requirements. With no or little chance of building new reactors, PLEX also ensures that nuclear power retains its share of the electricity market. PLEX has not yet occurred in many countries as the majority of reactors are still operating within their original operating life. However, according to the IEA, license extensions have been granted in four countries: Finland, Japan, UK and US. The most widespread life-extension programs are in the UK and US.

UK

The eight smallest Magnox reactors, four each at the Calderhall and Chapelcross sites, have all been given a ten-year life extension to allow them to operate for 50 years. Provisional life extensions have also been given to two other stations, Oldbury and Wylfa – but this will depend on the introduction of a new fuel, called Magrox, which is far from certain. In 1999 it was decided not to apply for the continued operation of Bradwell station past its 40th year, as an economic assessment of the investment needed determined that it could not be justified. Proposals are also being considered to extend the operating lives of some or all of the 14 Advanced Gas Reactors (AGRs).

US

The Nuclear Regulatory Commission (NRC) issues 40-year operating licenses, which can be extended for up to 20 years. By 2015 approximately 40% of the 103 operating reactors will have been operating for 40 years. To date six reactors - Calvert Cliffs 1 and 2 and Onconee 1,2, 3, Arkansas - have had life extensions approved. A further two nuclear power plants (Edwin I Hatch and Turkey Point) applied for life extension in 2000. Twenty more power plants are expected to apply in the next few years.[28]

Not all reactors will apply for life extension or even complete their original licensed span. However, even assuming that 20% of the US reactors are closed prematurely, the life extensions of the remainder would be the equivalent, in operational years, of an additional forty new power plants.

[27] IEA, page 300
[28] Status of Applications and Industry Activities, US NRC, http://www.nrc.gov/NRC/REACTOR/LR/applications.html

Economics of PLEX

PLEX is not only important to maintain the nuclear industry's share in the electricity market but may also be an important financial boost for the utility. In terms of capital costs, extending a reactor's life is far cheaper than constructing a new power plant. Some estimates say that the average costs of Plex is as low as $10-50 per installed kW, compared to the gas power plant costs of around $400-500/kW. In one case, at Duke Power in the US, the utility estimates that the cost for obtaining a extended license to operate would be as low as $4-6/kW[29]. Furthermore, by the end of a reactor's operating life, the decommissioning fund should be fully stocked so another large part of the nuclear operating costs may be written off, as the utility will no longer need to put funds aside to pay for decommissioning.

However, the economic viability of PLEX will depend on the investment needed to obtain the life extension license and to maintain safe operation. In a number of cases, in both the UK and US, reactors have been abandoned or proposals to undertake PLEX shelved due to economic reasons. In May 2000 the UK Hinkley A reactor was closed early for "commercial and economic" reasons. No further life extension was applied for, in contrast with plans for most of the Magnox stations[30].

Safety Problems of PLEX

PLEX may lead to a number of problems, most significantly from a nuclear safety perspective. The nuclear power plants that are currently being proposed for PLEX are the oldest ones which also have the lowest safety standards in design terms. These reactors do not include the additional safety technology incorporated into later designs as a result of accidents such as Three Mile Island. Such technology will have to be added. However, as these reactors were not designed with such technologies in mind, there may be insufficient physical space to inspect and install the required equipment and there may be compatibility problems between old and new technology. Aware of these potential controversies utilities are playing down the measures aimed at extending the operating time of the reactors and instead emphasizing the additional safety measures that PLEX will bring.

As reactors operate at high temperatures, pressure and bombardment from the radionuclides can all affect the integrity of the material of the equipment. A well-known example is the impact on the pressure vessel, which can become embrittled over time. An embrittled pressure vessel is more prone to thermal shock in the event of a loss of coolant accident, which could result in the integrity of the pressure vessel being breached.

[29] US Nuclear Power – Can Competition give it renewed Life?, Nuclear Engineering International, June 1999.
[30] BNFL Annual report and accounts 2000, page 16.

In a number of countries plans are now being developed by owners of the nuclear power plants to extend the operating lives of the oldest reactors. On the surface this makes economic sense, as construction - the major cost of a nuclear power plant - should have been paid for, giving any extended operation a much higher profit margin. The financial incentive for the utility is very large. It is therefore even more essential that the national regulators hold fast and demand the same safety standards for life extensions that would be required for new reactor constructions. This is the only way in which nuclear risk will be reduced.

Nuclear Waste Management

The long-term solution to contain radioactive waste remains one the most important challenges for the nuclear industry. It is a key factor in its public and therefore political acceptance but also plays a fundamental part in the economics of nuclear power. The nuclear industry is keen to "find a final solution" for the nuclear waste it produces, but this solution cannot be too costly.

Nuclear waste is produced at every stage of the nuclear fuel cycle: from uranium mining to fuel fabrication, to the disposal of nuclear fuel and the decommissioning of the power station. The waste produced is classified by the quantities and longevity of the radionuclides found in the material, namely: -

- Low Level Radioactive waste (LLW) makes up the largest volume – around 90% - of all waste produced, but contain much lower levels of radionuclides than other classifications. In general, but not always, the waste contains shorter-lived radionuclides. Some attempts are being made to 'declassify' some radioactive low-level wastes. In the United States this is called Below Regulatory Concern, which would enable the materials to be treated as normal industrial wastes and disposed of in conventional dump sites or re-used. LLW can be found in gaseous, liquid or solid forms.

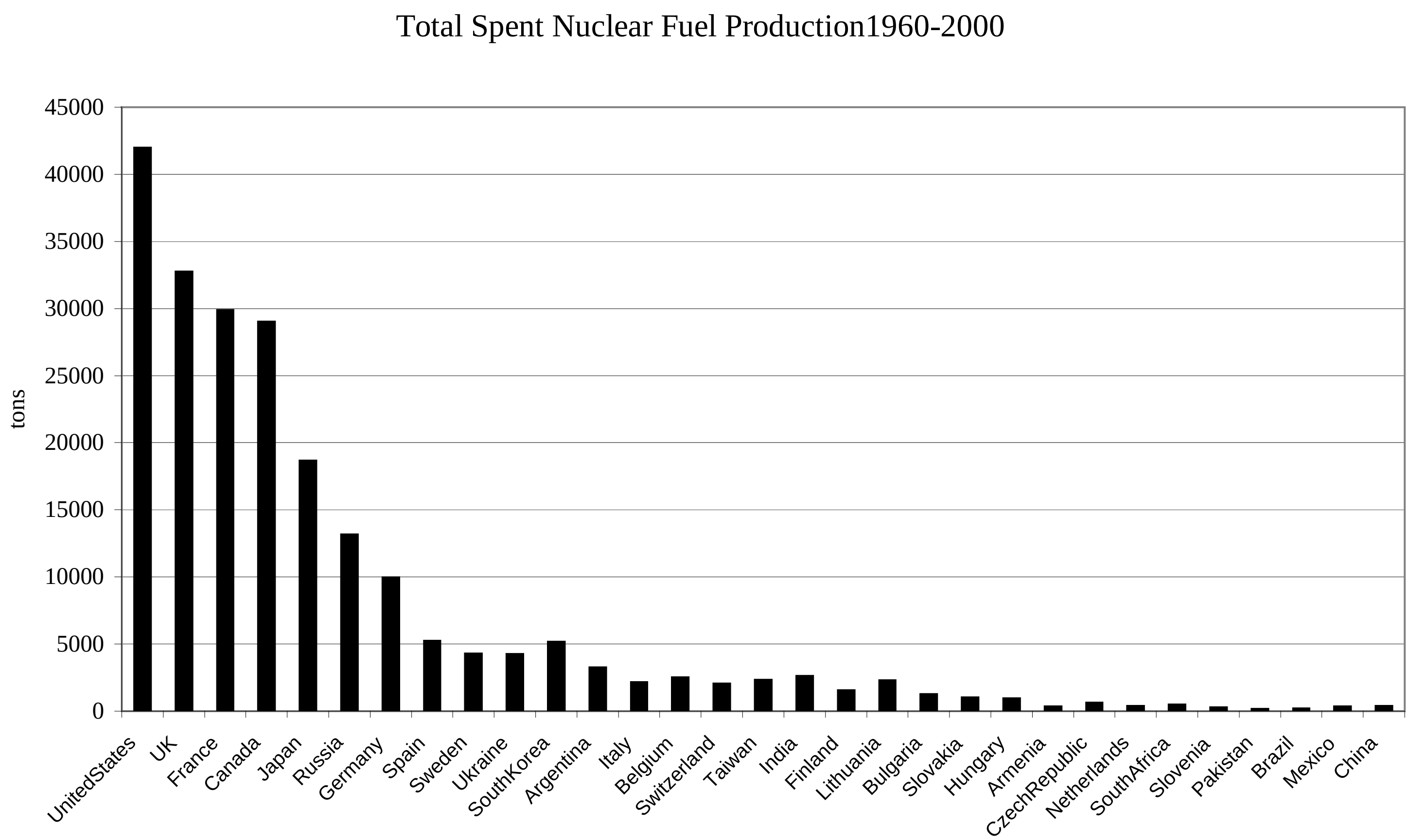
- Intermediate Level Radioactive waste (ILW) makes up about 7% of nuclear waste with approximately 4% of the radioactivity. The handling of ILW requires specialist equipment and, depending on the longevity of the radionuclides, is either buried in shallow pits or encapsulated and disposed of in a deep repository. ILW can be found in gaseous, liquid or solid forms.

- High Level Radioactive waste (HLW) tends to be either the spent fuel or its component parts following reprocessing. Spent fuel contains around 95% of the radionuclides produced in a nuclear reactor. The spent fuel not only generates heat, but also remains radioactive for hundreds of thousands of years.

Various strategies are used to manage and dispose of LLW and ILW. The final solution for HLW is still being sought globally. Despite over forty years of operation the civilian nuclear industry has yet to find any acceptable site for the permanent disposal or storage of HLW.

One of the main differences in waste management practice of HLW is whether or not a country reprocesses its nuclear fuel. Nuclear fuel is commercially reprocessed in three countries: France, Russia and the United Kingdom. (Japan is also building, very slowly, its own facility.) Nuclear fuel from a number of countries is sent to the facilities in these 3 countries. However, the option of reprocessing spent nuclear fuel is being phased out in most cases. This is because reprocessing is widely recognised as being more expensive than direct disposal. It increases the proliferation risk as it separates out plutonium and increases the environmental impact of nuclear power as it significantly increases the volume of radioactive waste produced. Furthermore, at the end of reprocessing the problem of how to dispose of HLW still remains. In Western Europe, no country, not even the UK or France, is intending to reprocess all their spent fuel. In other countries, for example Belgium and Germany, options for reprocessing additional fuel will not be taken up, and Germany will stop all shipments of spent fuel by 2005.

The graph below shows the global production of spent nuclear fuel over the last 4 decades. Not surprisingly, the large nuclear programs in the US and France, have produced the most spent nuclear fuel. However, those countries which operate reactors fueled by un-enriched or low enriched uranium also produce significantly more spent fuel. This includes the operators of Magnox (UK), CANDU (Canada, South Korea and others) and RBMK (Russia).



Research is being carried out on the storage or disposal of HLW and spent fuel in deep geological disposal. Site assessments have taken or are taking place in a number of countries, including Belgium, Canada, France, Germany, Sweden, and US. Finland has developed one of the most advanced proposals with a plan approved by the Parliament in May 2001 for the construction of a spent fuel storage facility at Olkiluoto. This will allow construction of a rock characterization facility in 2003-4 with deep assessments beginning in 2006. If all goes according to plan final construction could begin in 2010. At Yucca mountain in the US the construction of an underground exploratory studies facility is progressing. However, no final and permanent site has yet been licensed anywhere, for a number of reasons, including: -

- The science to assess the suitability of the sites is still being developed. Given the uncertainties involved in modeling the movement of radionuclides over thousands of years there cannot be any certainty. In the UK, the assessment of the potential intermediate level waste repository cost around £200 million and was rejected due to lack of certainty over the suitability of the proposed site.

- In most instances there is widespread local opposition to the possibility of nuclear waste disposal sites, as there are concerns over the impact on the environment and the financial impact on the region, especially relating to tourism, food production and property prices.
- Although there is a desire by the industry to move ahead and be able to claim that the issue of nuclear waste is solved, politicians are less willing and often suffer from the NIMTOF (Not In My Term Of Office) syndrome as they know that the siting of nuclear waste is not a vote winner.
- Many believe that any site that is licensed will be expanded to take greater volumes or different classifications of waste than originally envisaged. Small specific sites may be turned into much larger, even regional, waste dumps once planning is given.

Exporting Option

Other options are being considered in a number of countries. One proposal currently being developed is to export nuclear waste to Russia. In the 1990s, the Russian Government passed three decrees concerning the return of spent nuclear fuel to Russia. These meant that under Russian Environmental Law spent fuel could only be accepted into Russia for the purposes of reprocessing after which all waste had to be returned.[31]

In 2000 the Russian Ministry of Nuclear Energy (Minatom) began preparing a proposal to overturn the current laws. At the time of the launch of the new Law, Minatom claimed that the change would fund the further development of nuclear energy. The revised legislation has been approved by the lower and upper houses of the Russian Parliament, the Duma, and was finally approval by President Putin in June 2001. If this occurs it could open the way for Russia to become a site for the world's nuclear waste. In the past a number of companies from around the world, such as Taiwan and Switzerland have expressed an interest in exporting their radioactive waste. Russian Government sources predict that if approved the importation of nuclear waste would generate around $20 billion over a ten-year period.

The export of waste to Russia is the most advanced project considering an international site of nuclear waste disposal but it is not the only one. An Australian based company Pangea has made proposals to a number of countries to take control of the disposal of their nuclear waste. The waste would be imported into Australia. The company claims that only three other countries - Argentina, Southern Africa and China - have such suitable geological and climatic conditions for the geological disposal of radioactive waste[32]. In May 2001, Pangea announced that they would undergo a rethink of their strategy to be completed at the end of the year.

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[31] Difficult Legacy: Spent Fuel from Soviet Reactors. Thomas Cochran, Miriam Bowling, Elizabeth Powers, January 1996, Natural Resources Defense Council, page 7.

[32] http://www.pangea.com.au

Nuclear Consolidation

There are two major trends affecting the ownership of the global nuclear industry: consolidation of the ownership of power plants and the merger of nuclear construction and waste management companies.

US Ownership

The US has the most active market in trade of nuclear companies in the world. In 2000 more than 25 GW, representing a quarter of the US nuclear power plants was transferred between companies. Currently, 70% of US nuclear capacity is now owned by 12 utilities. Furthermore, during 2001/2 an additional 14.5GW is expected to change ownership[33]. These activities can be divided into three types.

Mergers

In recent months many nuclear power plants have been sold and mergers between utilities announced. The largest is the US$ 32 billion merger of Commonwealth Edison-Unicom and PECO Energy, the two largest owners of US nuclear generating capacity, to form Exelon. This has now become the largest US nuclear operator and the third largest operator in the World. This has effected the ownership of 17 reactors. In November 2000, the merger of Carolina Power & Light and Florida Progress Corporation, involving 5 reactors at 4 sites, was finalised. A number of other mergers are in preparation, including the merger of Entergy with Florida Power & Light (affecting 13 reactors) and the merger of GPU with FirstEnergy (affecting 4 reactors).

Nuclear Power Plant Management

Companies with operational experience have been brought in to oversee a number of nuclear power plants. The Nuclear Management Company (NMC) was formed in 1999 by four Midwest utilities - Alliant Energy, Northern States Power, Wisconsin Electric Power, Wisconsin Public Service – with the addition of Consumers Energy late in 2000. NMC has now taken over the full operation of the utilities' eight reactors.

Sales

A number of power plants are also being sold. As of January 2001, 14 reactors had been wholly or partly sold. The buyers include foreign utilities. One particularly active company is Amergen, which has bought three reactors to date. AmerGen is a joint venture of PECO Energy Company of Philadelphia, Pa. and British Energy, founded in 1997 to purchase and operate nuclear generation plants in the United States. The table below highlights the current purchases of AmerGen.

[33] US Nuclear Plant Sales and Ownership Consolidation, 2000 in Review. NAC Worldwide Consulting, Spring 2001.

Site	Date of Transfer/Agreement	Cost
Oyster Creek	August 2000	$10 million
Clinton	December 2000	$20 million
Three Miles Island 1	December 2000	$100 million
Vermont Yankee	Not finalised	Asset transfer agreement reached

Source: PECO[34]

What is important to note is the increasing price that companies are prepared to pay for old nuclear power stations. According to the World Nuclear Association, formerly the Uranium Institute, "the prices per kilowatt for decades-old US nuclear plants have increased ten-fold since mid-1998[35]".

The sales or mergers of power plants or utilities have so far affected about 25% of the US nuclear power plants. How much further this will go is unclear. However, a number of commentators believe that the total number of US nuclear operators is likely to drop from the 50 that began in 2000 to around 10. British Energy, active in the US market, is also involved in Canada where it has signed a longer lease to operate the Bruce A and B nuclear power plants.

Vendor Mergers

Given the current lull in orders and subsequent construction of nuclear power plants it is hardly surprising that a number of vendors of nuclear power plants have merged or been sold off by their parent companies. The major Western nuclear constructing companies remaining are: -

- Atomic Energy Canada (AECL)
- Framatome ANP (Advanced nuclear power), created by the merger of Framatome and Siemens in early 2001.
- General Atomics
- General Electric, the major manufacturer of boiling water reactors (BWRs) in the United States and in a further ten countries.
- Westinghouse Atom – formerly ABB Atom which is now part of the British Nuclear Fuels group.

[34] http://www.peco.com
[35] US Nuclear Power Industry Information Paper # 41 March 2001: http://www.world-nuclear.org

Fuel Cycle Mergers

In June 2001 the three main nuclear organisations in France finalised plans to restructure their industry. A new company called Topco will be formed from Cogema (a reprocessing plant operator), Framatome (the nuclear vendor) and the French Atomic Energy Commission (CEA). Final approval is required from the shareholders of each organisation, which is expected in September. The ownership breakdown of TEPCO is:[36]

- CEA: 78.9%
- French Government: 5.19%
- Holders of Investment certificates: 4.03%
- Minority Cogema shareholders: 5.59%
- Minority Framatome shareholders: 6.23%

In May 2001, it was reported in UX weekly, that Topco was already actively seeking a strategic partner in the US.

Recruitment

The nuclear industry was launched in the 1950s in a blaze of publicity. Atoms for Peace and the subsequent claims of nuclear powered goods and plentiful electricity made it the technology of the time. This encouraged many of the era's young scientists and engineers to enter the industry. However, nuclear technology has since lost much of its positive image and is suffering from an inability to recruit.

A report published by the Nuclear Energy Agency in 2001 reviewed levels of education and training in nuclear issues across the OECD[37]. This report concludes:

Yet the advancement of this technology, with all its associated benefits, will be threatened, even curtailed, unless the declining number of university courses associated with it, and the declining interest among students in it, is arrested.

The report says that there are fewer comprehensive, high quality nuclear programmes at universities than before. Furthermore, universities are not replacing research facilities or finding sufficient teaching and faculty staff; consequently there appears to be insufficient trainers in the industry or at research institutions. The gravity of the situation is compounded by the poor perception of the nuclear industry's future by the student population. The report calls for action to overturn the "downward spiral of declining student interest and academic opportunities".

[36] France: Nuclear Companies Finalise Industry Restructuring Plan, NucNet, June 28th 2001.
[37] Nuclear Education and Training, Cause for Concern? Summary Report, Nuclear Energy Agency and Organisation for Economic Co-operation and Development. 2001.

Staffing Levels

The onset of privatisation and liberalisation of the electricity market has forced nuclear operators to increase their efficiency and reduce costs. This has led to a streamlining of operation and in some cases a reduction in the number of employees. In the US significant reductions have been made with an estimated 26 000 workers leaving the industry over the last eight years.

The reductions in the size of the workforce have in some cases led to concerns over safety.

In the UK an audit by the Health and Safety Executive on British Energy Generation Limited and British Energy Generation (UK) Limited in 1999 made the following recommendations:

British Energy to stop the planned reduction of in-house staff numbers until it can demonstrate the forward work prediction is reliable, and demonstrate that the new Management of Change procedure will not adversely affect the safety of nuclear plants.

However, despite these concerns, there appears to be little or no intention from regulators to force the reinstatement of workers or even stop further reductions. In May 2001, due to the introduction of further changes in the electricity market, British Energy confirmed that it was to cut 400 jobs in an attempt to save $213 million[38].

Similar concerns have been raised in Sweden, where it was reported in May 2001 that the regulator was concerned that pressure to cut costs in a deregulated electricity market may "tempt license-holders to take short-cuts at the expense of safety." Furthermore the report suggests that the authorities are also concerned about nuclear plant operators being able to find enough competent personnel. To counter this the regulator is now requiring the utilities to document that they have sufficient personnel, with the needed skills, both now and in the future[39].

In 2001, the US utility Dominion Resources Inc. started the largest recruitment drive in decades at its Surrey nuclear power plant, where around 50% of its workforce were close to retirement age.

[38] Reduce Overheads by Shelving Commitments to Reprocessing at BNFL's Sellafield Plant, The Guardian, 15th May.
[39] Swedish Regulators Warn Against Risk Of Slipping Safety Level, Nucleonics Week, 3rd May 2001, page 13

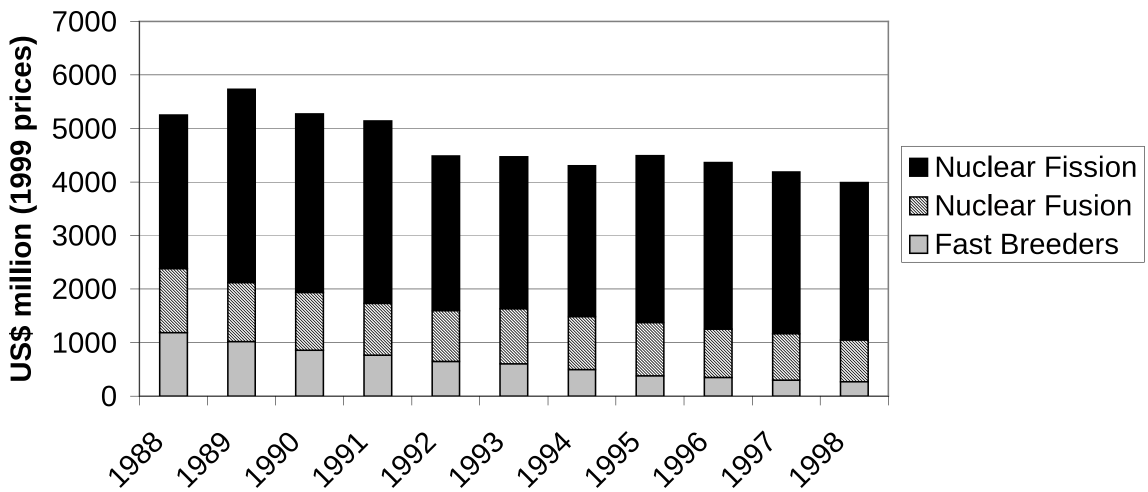
Research and Development

The trend of shrinking government energy research and development (R&D) budgets continued in the 1990s, with a decrease over the decade from US$9 billion to US$7.1 billion (at 1998 prices). Japan and the US accounted for 65% of the total government energy expenditure in IEA member countries.

The decrease in expenditure was most pronounced in two areas, nuclear (fission and fusion) and fossil fuel extraction. However, despite the decline in nuclear R&D, they still account for over 50% of the total expenditure.

The chart below shows how the overall nuclear budget has fallen over the last decade, from a high of 5.7 in 1989 to 4.0 trillion US$ in 1998, a 30% decline (compared to a 22% decline in the overall energy research and development budgets). The United States's research and development budget experienced the most radical decline, with cuts of 880 US$ million during this period.

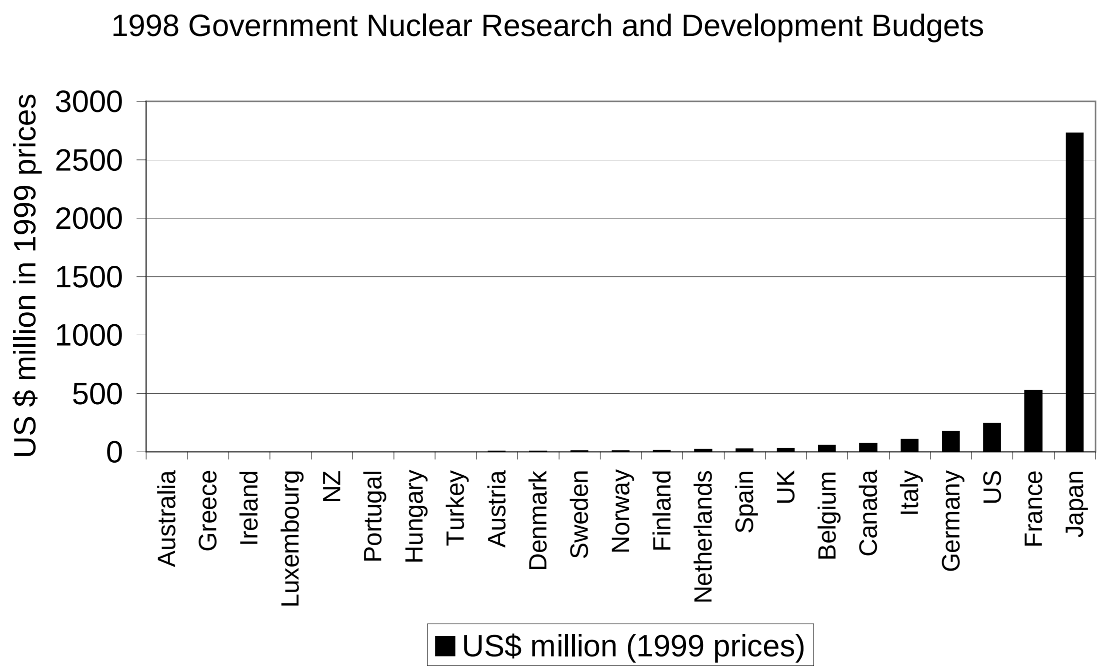
Nuclear Research and Development Expenditure by Governments of the International Energy Agency



Source: IEA[40]

[40] Energy Policies of IEA Countries, 2000 Review, International Energy Agency, 2001, page 280-3

The country breakdown for R&D (see figure below) shows the extent of Japanese investment in nuclear technology. In 1998 Japan invested 2,727 US$ million in nuclear R&D, representing nearly 70% of the world total. This is significantly more than the total for energy efficiency and renewables spent by all the IEA Governments the same year.[41]



Source: IEA[42]

R&D budgets are one mechanism open to Governments to give financial assistance to the nuclear industry. A report published by the research institute INESTENE highlighted a number of other ways in which the French Government gave financial assistance to its industry, including[43]: -

- Nuclear overcapacity, leading to exports of electricity at lower than full production costs.
- The mandatory reprocessing of spent fuel – intended as a support for Cogema.
- Limiting liability damage to Euro 91 million

In other countries other examples of Government support can be seen. One of the most notable is in Germany where the huge Decommissioning funds (worth DEM 54 billion in 1996) are tax exempt. This tax exception of nuclear fuel is seen by some as a hidden Government support for the nuclear industry.

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[41] Energy Conservation received 1151.4 and renewables 614.8 million US million
[42] Energy Policies of IEA Countries, 2000 Review, International Energy Agency, 2001, page 280-3
[43] Soutiens et subventions de L'ètat aux ènergies en France, INESTENE, Bonduelle, A, F Tuille, and S Fenet, December 1998

Financing Nuclear Power

Financial Institutions

The construction of nuclear power plants is more expensive than of conventional stations. Gas fired power stations are significantly cheaper than the nuclear option. Construction times for nuclear power plants are also much longer than for other power stations. These two factors make private financiers, who would prefer a rapid return on their investment, more likely to back gas power stations over nuclear. In addition, nuclear power plants have not been built to cost or time. The reasons for this are complex, mainly because: -

- Nuclear power plants are complex, requiring a large number of contractors, which inevitably leads to problems.
- The potential impact of a meltdown in a nuclear power station increases the public and political interest in construction and regulation of the industry.
- Globally, there have been relatively few nuclear power plants constructed – in the order of 500, which is small compared to the number of coal or gas stations. Furthermore, there have been a variety of designs and sizes. Consequently, there is less experience in building a particular reactor design.

For all of these reasons the private sector is less willing to invest in nuclear power stations and they usually require some form of State or institutional assistance.

There are two main routes open to the nuclear industry to receive financial assistance from the State. Firstly International Financial Institutions (IFIs) can give favourable interest loans. Secondly, financial credit guarantees can be awarded by national Export Credit Agencies (ECAs).

International Financial Institutions

<u>World Bank</u>

The largest global IFI, the World Bank, does not fund nuclear technology directly. Its position is made clear in a number of documents.

On the World Bank web site in 1998 it stated :

The Bank has never financed a nuclear power station. Nuclear power produces no particulates, sulphur, or greenhouse gas emissions and thus appears to offer a clean, non-fossil-fuel alternative for power generation. However, world experiences with high investment costs, time-consuming and costly approval processes, lack of sustainable waste disposal options, risks of major accidents-together with the Chernobyl disaster-have raised grave doubts about the future viability of nuclear power. Private investors shy away from such risky high-cost investments.
Financing for nuclear development is usually available from suppliers' credits and export financing agencies.

Finally, the complex nature of the technology and the diversity of reactor sizes and subsequent cost over-runs and delays.

Furthermore its Environment Assessment Sourcebook[44] lays out the options available to Task Managers when confronted by decisions concerning nuclear power. The main conclusions of the Sourcebook are:

- The Bank takes the position that, as the financier of last resort, it is unnecessary for its funds to be used for this purpose.
- Given the limited number of suppliers, procurement on the basis of International Competitive Bidding is not possible.
- Costs of nuclear projects typically come in at two to three times the original estimates, delays have been substantial, and production problems have resulted in output well below capacity.
- It is a technology, which if used safely, requires vigorous standards of construction, maintenance and operation – areas with which developing countries have serious problems.
- The economic case is clear: under present cost structures, the Bank would not finance new plants because they are uneconomic. In the unlikely event that nuclear plants become economic, the Bank would not finance them because there are other sources of funds available and, as financier of last resort, Bank funds are not required.

European Bank for Reconstruction and Development

The EBRD is the only IFI that includes a specific mandate within its energy policy to lend for nuclear projects. Its Energy policy states that:

"*In the context of such strategies, and in addition to ordinary non-nuclear resources projects suitable for EBRD financing, the Bank may also assist from its ordinary resources projects to complete or upgrade modern nuclear stations (of the VVER 213 and 1000 types), provided that they are directly linked with the closure of high-risk reactors operating in the country concerned (such linkages would be enshrined in the relevant legal agreements).*"[45]

To date, two serious attempts have been made by the EBRD to lend for nuclear power plants: Mochovce in Slovakia and Khmelnitsky 2 and Rovno 4 in Ukraine. The first was abandoned at the very last moment at the request of the Slovakian Government; the second was given provisional approval in December 2000, but conditions to make the loan effective have not yet been met.

Asian Development Bank

The Asian Development Bank has a policy not to fund nuclear technology: -

These concerns include issues related to transfer of nuclear technology, procurement limitations, proliferation risks, fuel availability and procurement constraints, and environmental and safety

[44] Environmental Assessment Sourcebook, Volume III, Guidelines for Environmental Assessment of Energy and Industry Projects, Environmental Department, World Bank Technical Paper Number 154, 1991, ISBN: -0253-7494

[45] Energy Operation Policy, 7th March 1995

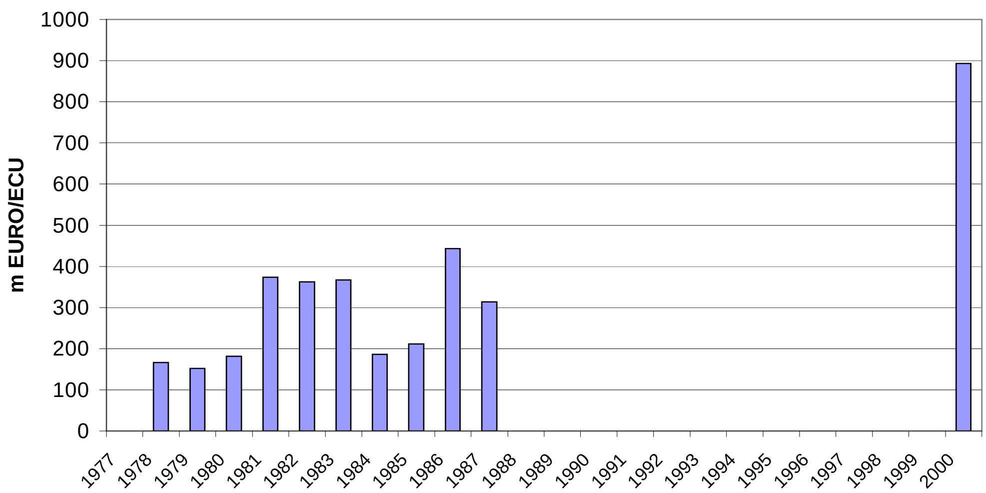
aspects. The Bank will maintain its policy of non-involvement in the financing of nuclear power generation[46].

Euratom

The Euratom Treaty is one of the cornerstones of the current EU. The Euratom Treaty, first signed in 1957, was established to promote nuclear technology as it was believed *to "represent an essential resource for the development and invigoration of industry"*. In March 1977 the Council of the European Communities agreed on "empowering the Commission to issue Euratom loans for the purpose of contributing to the financing of nuclear power stations"[47]. Initially, this was restricted to nuclear facilities inside the Union with an initial credit ceiling of 500 million European units, later raised to ECU 4 000 million. In 2001 the European Commission will discuss and possibly recommend to the Council of Ministers a proposal to increase the lending ability of Euratom.

The graph below shows the history of Euratom loans. Euratom loans were awarded in 2000, after a gap of over a decade, for the upgrading and life extension of two VVER 1000 reactors at Kozloduy and for the completion of two VVER 1000 reactors in Ukraine, Khmelnitsky 2 and Rovno 4. These combined projects cost Euro 893 million[48].

Euratom Loans Awarded 1977-2000



Source: Euratom Annual Reports.

[46] The Bank's Policy Initiatives for the Energy Sector, Policy Papers R4-95, Pub. Date: May 1995, www.adb.org, sourced May 2001.
[47] Council Decision, 77/270/Euratom, Official Journal of the European Communities, No L 88/9, 6th April 1977.
[48] 0.93 Euro=1US$ (Jan 2001). Euro and ECU are interchangable.

Export Credit Agencies

Export credit agencies are used to enable the export of reactors from vendor countries. Due to their lack of transparency it is not possible to assess the full extent of their historic involvement in reactor sales, but the extent of their current involvement can be examined. Current projects involving ECAs from the G8 are listed below.

List of current nuclear projects with ECA support[49]

Exporting Country	**Recipient Country**	**Project**	**Amount Million USD**
Canada	China Romania	Qinshan III Cernavoda II *	1 000 250
France	China Ukraine	Ling Ao 1 and 2 Khmelnitsky 2 and Rovno 4 *	2 000 136
Germany	Argentina China Lithuania	Atucha II Lianyungang Ignalina	9 128 6
Italy	Romania	Cernavoda II *	Unclear
Japan	China Mexico North Korea	Qinshan II and III Laguna Verde KEDO	280 1 923
Russia	China India Iran	Lianyungang Kudankulam Busher	1 500 ** 2 500 ** 1 000 **
UK	China Ukraine	Qinshan II Ling Ao Khmelnitsky 2 and Rovno 4*	157 822 28
US	Bulgaria China Czech Republic Lithuania Ukraine	Kozloduy 5 and 6 Qinshan II and III Temelin 1 and 2 Ignalina Khmelnitsky 2 and Rovno 4*	77 356 317 20 131

* - decision pending
** - whole project cost, ECA support unclear

As of the beginning of 2001, there were 29 reactors under construction throughout the world, 14 of which are being funded in part by ECAs.

The G8 and OECD are currently reviewing their environmental guidelines. Many hope that this will restrict or exclude further funding for nuclear projects.

[49] Financing Disaster: How the G8 Fund the Global Proliferation of Nuclear Technology, June 2001

Nuclear Power and Climate Change

Unless nuclear energy can be relevant to developing countries, it will be a mere sideshow to the main energy game of the twenty first century[50].

Over the past decade, supporters of nuclear power have attempted to promote it as one solution to the problems of climate change. These proponents point to an ever-increasing electricity demand in OECD countries, as the standard of living continues to rise, and the need for global equality in access to energy. Specifically they cite the need to provide electricity to the 2 billion people without access to the grid and the additional 3 billion people expected to inhabit the earth by 2050. In 1997, total global Co2 emissions amounted to 22 billion tonnes. It is recognised that even this level of emissions is unsustainable, necessitating urgent action as current trends will lead to significant increases in Co2 in the coming decades.

Kyoto and Beyond

At the end of the 1980s, recognition of the potential damage of burning fossil fuels on the World's climate led to two United Nations agencies, the UN Environmental Programme and the World Meteorological Organisation, to establish the Intergovernmental Panel on Climate Change (IPCC). The IPCC produced two reports or Assessments in 1990 and 1995. These reports brought together experts in many different fields associated with climate change. The second IPCC report concluded, *"The balance of evidence suggests a discernible human influence on global climate – that is we are already seeing the first signs of climate change"* In 1992 World leaders met in Rio at the Earth Summit and amongst other things signed up to the United Nations Framework Convention on Climate Change (UN FCCC). This Convention, largely at the insistence of the United States, required that countries only aim at reducing their emissions of greenhouse gases to 1990 levels by 2000.

The most well known COP (Conference of Parties) meeting was the third, also known as the Kyoto Protocol to the UN Framework Convention on Climate Change, which took place in Japan in December 1997. The Kyoto Protocol is of fundamental importance because for the first time it introduced legally binding greenhouse gas emissions for developed countries, aimed at an overall reduction in global greenhouse gases of 5% by 2008-12. Despite many shortcomings some believe that "*the Kyoto Protocol may prove to be the most profound and important global agreement of the late twentieth century*"[51]. Less favourable critics believe that the numerous loopholes in the Protocol will enable most if not all of the required atmospheric targets to be circumvented.

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50 The Future of Nuclear Energy Talk by Jan Murray Deputy Secretary General, World Energy Council to the Egyptian Council for Foreign Affairs 13 February 2000; http://www.worldenergy.org/wec-geis/publications

51 The Kyoto Protocol, A guide and Assessment. The Royal Institute for International Affairs, Michael Grubb, Christiaan Vrolijk, Duncan Brack 1999. Summary and Conclusion,

The Protocol requires specific limits on greenhouse gases from the various industrialised countries (Annex 1 countries) that are party to the agreement. These reductions in emissions are country specific (as is seen in the table below), but on average are designed to reduce the total emissions to 5% below that emitted in 1990, by 2008-12. If these targets are to be achieved nationally in OECD countries then there will the need for concerted and definitive actions.

Annex 1 Countries and their Reduction Target, % of 1990 Emissions by 2008-12									
Australia	**108**	Estonia	**92**	**Ireland**	**92**	**Netherlands**	**92**	**Slovenia**	**92**
Austria	**92**	**EU**	**92**	**Italy**	**92**	**New Zealand**	**100**	**Spain**	**92**
Belgium	**92**	**Finland**	**92**	**Japan**	**94**	**Norway**	**101**	**Sweden**	**92**
Bulgaria	**92**	**France**	**92**	**Latvia**	**92**	**Poland**	**94**	**Switzerland**	**92**
Canada	**94**	**Germany**	**92**	**Liechtenstein**	**92**	**Portugal**	**92**	**Ukraine**	**100**
Croatia	**95**	**Greece**	**92**	**Lithuania**	**92**	**Romania**	**92**	**UK**	**92**
Czech R.	**92**	**Hungary**	**92**	**Luxembourg**	**92**	**Russia**	**100**	**USA**	**93**
Denmark	**92**	**Iceland**	**94**	**Monaco**	**92**	**Slovakia**	**92**		

However, within the Protocol a number of flexible mechanisms have been introduced. The extent and definition of the mechanisms was not defined at Kyoto and is part of the ongoing process necessitating the COPs. These flexible mechanisms serve to both weaken and redistribute the Kyoto targets.

There are currently 3 recognised mechanisms that allow Annex 1 countries flexibility in reaching their emissions targets: -

Joint Implementation (JI): This will allow the transfer of emissions reductions (referred to as ERUs- Emissions Reduction Units) between Annex 1 countries when investment occurs across borders, i.e. a foreign investor may claim ERUs from the country if the project results in emissions reductions.

Emission Trading: Two Parties to the Protocol are permitted to exchange part of their emissions reduction commitment. This was one of the most controversial flexible mechanisms within the Protocol as many felt that it would enable countries with greater influence – especially the US – to gain access to the considerable emissions surplus (often referred to as 'hot air'). Some feel that the targets for a number of countries, in particular in Eastern Europe and the former Soviet Union, were set too low. This will allow emissions permits from these countries to be sold to third parties without any CO_2 abatement effort at all. By 1995, Russia had already reduced its CO_2 emissions from fuel combustion by 34% and Ukraine by 36% compared to 1990 levels**.** These reductions came about not through conscious efforts, but instead through a drop in industrial output from industries that flourished in former times, but which are now inefficient and cannot compete in today's market. Projections for 2010 indicate that more than 80% of all the potential CO_2 permits on offer, corresponding to about 2% of emissions in 1990, will come from Eastern Europe and the former Soviet Union. The biggest suppliers of 'hot air' permits are Ukraine and Russia.

Clean Development Mechanism (CDM): While JI projects must involve only Annex 1 countries, joint projects can be undertaken that involve developing countries. CDM projects are required to 'benefit' the recipient country and the Annex I country may use the project to 'contribute to compliance with part of their quantified commitments'. The COP 6 meeting in 2000 is scheduled to assess what projects are suitable within the CDM framework, including whether or not to include nuclear power project.

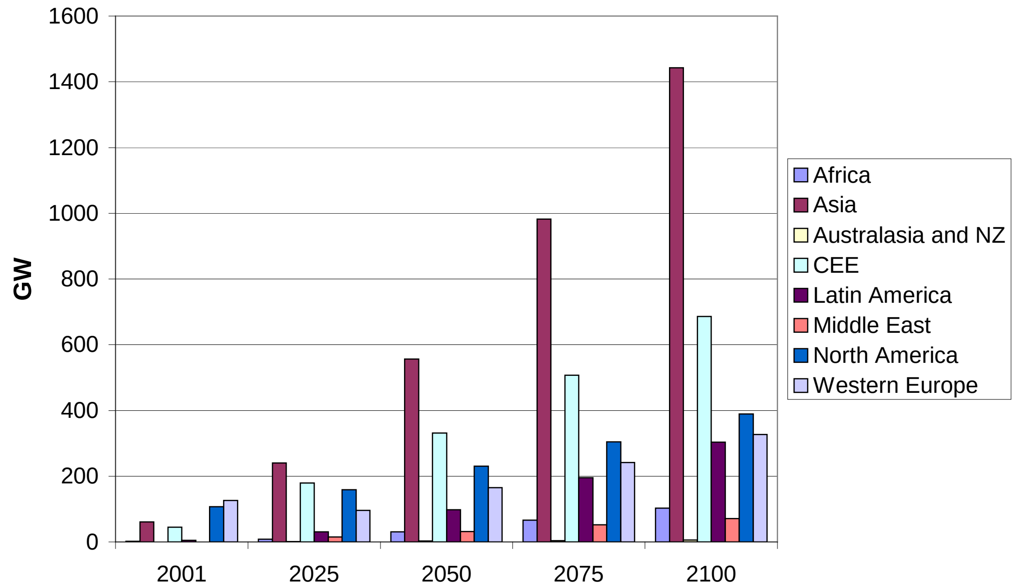
Although the Kyoto Protocol is usually thought to relate just to Co2 emissions it also includes five other Greenhouse Gases. These are Methane; Nitrous Oxide; Hydrofluoro-carbons; Perfluoro-carbons; and Sulphur hexafluoxide. Despite their inclusion, the additional gases do not make significant changes to the commitments of Annex 1 countries, except for Japan and Iceland.

The ability of the Kyoto Protocol to lead to a global reduction in Co2 emissions was significantly undermined in 2000, when the incoming US President George W Bush confirmed that the US would not ratify the agreement. How this affects the future Protocol and the flexible mechanisms is still unclear.

Nuclear Power and Climate Change

The intergovernmental Panel on Climate Change produced a report in 1996 that looked at technical and policy options to mitigate Climate Change. This reviewed a number of scenarios for the rapid introduction of technologies and their impact on the climate. Clearly, one area to be reviewed was nuclear power. One scenario looked at a significant increase in nuclear power plant operation through until 2100. This would result in nuclear power contributing 47% of the world's electricity. This would require, by 2100, the operation of over 3000 reactors. Even assuming an operating life of around 50 years (beyond the current design life-time of most operating reactors), it would require the construction of around 7000 reactors in the next century, or 70 reactors per year. Given that, at the peak of the global nuclear industry in the 1980s, the highest number of reactors connected to the grid in a year was 33, this scenario is extremely optimistic. Furthermore, current conditions do not meet this scenario. The graph below illustrates the expansion that would be needed.

Rate of Growth of Global Installed Capacity in IPCC Nuclear Intensive Scenario

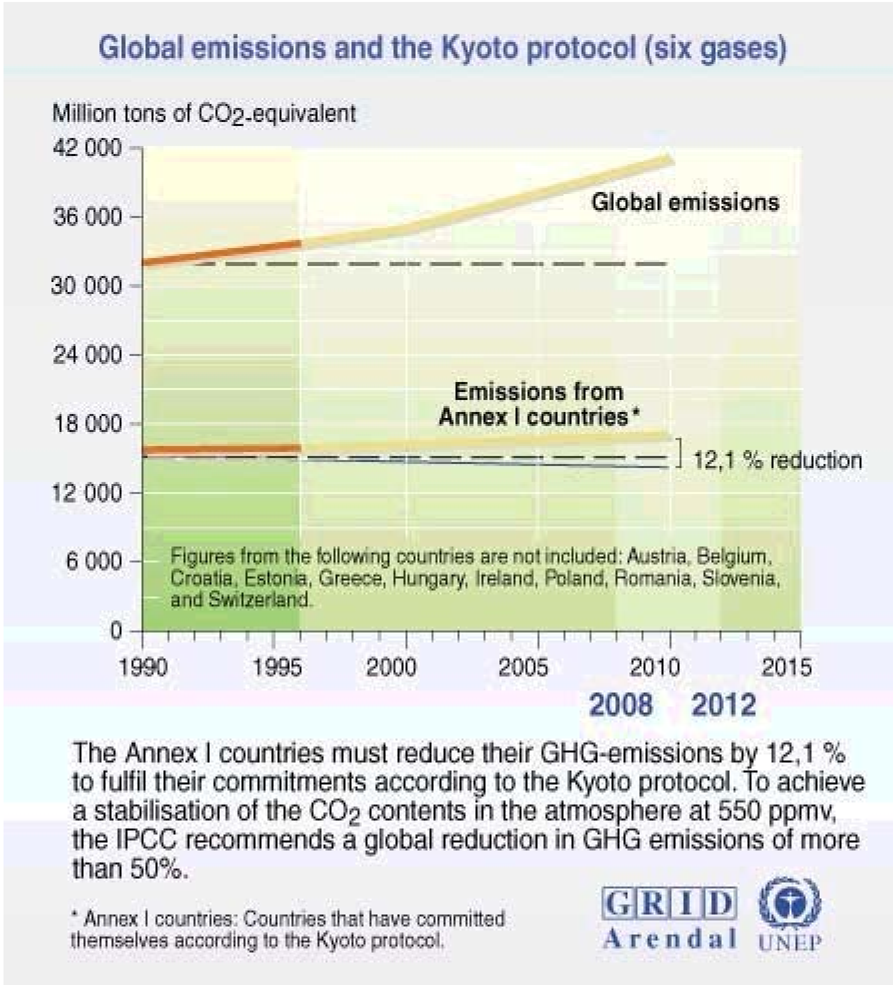


Source: IPPC, November 1996[52]

As well as the unfeasibly large construction program that such a large number of reactors would need, it would have significant environmental and proliferation concerns. Even ignoring the risk implications for ten times more reactors; the environmental cost of the waste production would be huge. According to the IPCC around 6.3 million tonnes of spent fuel would be produced. This would include approximately 50 000 tonnes of plutonium, 250 times the total stockpiles of the US and Russian military. (Plutonium from spent fuel is not directly comparable with military plutonium as it is a different isotope and is less readily useable for weapons.) The IPCC scenario assumes the use of breeder technology that requires the separation of plutonium from spent fuel - which would increase the proliferation risk.

The graph also shows the extent, to which nuclear power must become established in Asia, in particular in China. Co2 emissions are expected to increase dramatically in non-Annex 1 countries over the coming decades. The picture below shows the extent of this. Emissions from Annex 1 countries are predicted to be stable, while total emissions show a sharp increase.

[52] Technologies, Policies and Measures for Mitigating climate Change. Interngovernmental Panel on Climate Change: Energy Supply Mitigation Options, page 632, table 19-8. November 1996



Currently, in Non-Annex 1 countries there are only 43 reactors in operation, representing around 10% of world's reactors. Nuclear power has not proved popular in many developing countries, as its large up front costs, long construction times and large size of projects make it less attractive than alternative energy sources.

Supports of nuclear power are lobbying very hard for the abandonment of a technology specific list for the CDM or JI programs. This would de-facto allow nuclear projects to be included. To date this has not occurred and nuclear power has so far been excluded from the programs. In his June 2001 text the Chairman of the negotiating process stated that "A majority of Parties indicated that they wished to exclude nuclear from the CDM".

In June 2000 the EU Environment Council concluded "[for the CDM] COP-6 should adopt a positive list of safe, environmentally sound eligible projects based on renewable energy sources, energy efficiency improvements and demand side management in the fields of energy and transport". This is taken by most to exclude nuclear power. The UK Government stated "Ministers agreed that eligibility for the Clean Development Mechanism should be on the basis of a positive list of safe environmentally sound projects, which excluded nuclear".[53] On 7th November the Environment Ministers of the EU reaffirmed the resolution of June 2000. Following this meeting EU Environment President Voynet stated, "the position of the EU Environment Council is crystal clear on this…nobody wants to exchange the greenhouse effect for a nuclear chain reaction." A similar position was adopted by the EU's environment commissioner Margot Wallström who stated to the European Parliament in November 2000 that it 'is not envisaged' to include nuclear power in any future emissions trading scheme[54].

The COP6 negotiations in November 2000 failed to broker a final agreement but did agree a number of key issues, one of which was on the status of nuclear power.
"Annex 1 Parties declare that they will refrain from using nuclear facilities and new large hydro-power plants for generating certified emissions reductions under the CDM and JI".[55]

<u>COP 6 Part 2</u>

At the Bonn meeting in late July an agreement was reach to explicitly exclude nuclear power from both the CDM and JI mechanisms.

Article 6 (JI)
2. To recognise that Parties included in Annex I [ie industrialised countries with emissions reduction targets] are to refrain from using emission reduction units [carbon credits] generated from nuclear facilities to meet their commitments under Article 3.1

Article 12 (CDM)
2. To recognise that Parties included in Annex I are to refrain from using certified emission reductions [carbon credits] generated from nuclear facilities to meet their commitments under Article 3.1"

This language was passed due to the strong desire from the European and G77 representatives desire to see nuclear power excluded. The main countries opposing the language were the Japanese and Canadian. The nuclear lobby was furious and made its position clear: -
"*The political exclusion of nuclear electricity undermines the environmental integrity of this international effort to address global warming".* (John Ritch, World Nuclear Association)
Nuclear Energy Institute response to language: "*We are frankly astonished...."*
Foratom: *"... it is regrettable that, for purely political reasons, delegates agreed to two clauses that exclude nuclear power projects from two of the flexible mechanisms under the Kyoto Protocol - the CDM and JI."*

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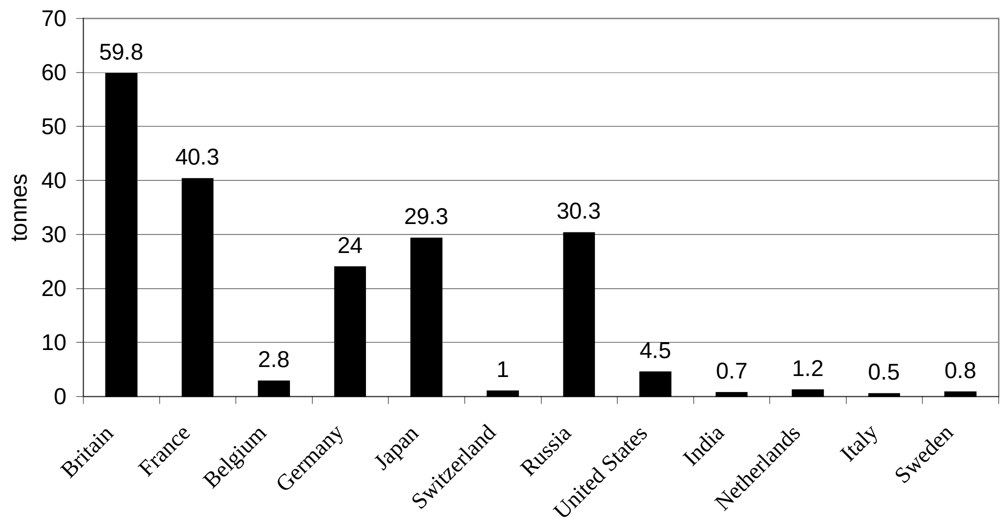
[53] Written answers to Parliamentary Question on the Environment Council by Michael Meacher, 4th July 2000.
[54] EU Commissioner Rules Nuclear Out of Emissions Trading, NucNet November 1st 2000
[55] EU Amendments to Paper Distributed by Chairman Pronk, 12:15 AM 25th November 2000

Plutonium and Nuclear Weapons Dismantling

The countries in the G8 have an estimated 430 tonnes of plutonium which has been separated and is ready for use – 242 tonnes of military plutonium and 188 tonnes of civilian plutonium. In addition they have produced an estimated 800 tonnes of plutonium which remains in used or spent fuel.[56]

As the graph below shows twelve countries own separated plutonium. Russia and America hold the largest stocks from military sources, while the UK and France hold the most separated civilian plutonium. Bearing in mind that it requires only 0.006 tonne of plutonium to make a warhead, even the smallest amount held is potentially of political or military significance.

Separated Civilian Plutonium



Source: ISIS

The production of military plutonium has all but stopped. However the production of separated civilian plutonium continues and is increasing to such a degree that it is outstripping demand. It is currently estimated that ten tonnes per year of plutonium are separated in civilian reprocessing plants that will not, under current plans, be utilized in Mox fuel.

In April 1996 at a specially organised Summit on Nuclear Safety the G8 developed a political framework for the development of a plan to dispose of 'excess' plutonium from Russia and the USA. This plan has taken five years to develop and a concrete proposal, with attached financing plan, was expected to be approved at the G8 Summit in 2001. In September 2000 the US Vice-President Al Gore signed the US part of an agreement which would see the disposal of 34 tonnes of plutonium from each of the US and Russian military stockpiles. The agreement allows the

[56] Tracking Civil Plutonium Inventories: End of 1999, by David Albright and Mark Gorwitz, Plutonium Watch, October 2000: www.isis-online.org/publications

plutonium to be disposed of in Mox fuel or to be immobilised through vitrification (embedding in glass).

The schedule assumes that by the end of 2007 Mox production or immobilisation facilities will be constructed that will enable at least 2 tonnes per year to be disposed of by each country. It is then envisaged that a second stage will be developed to allow up to five tonnes per year to be disposed of.

The vast majority of politicians and the public believe that there is an unacceptably large stockpile of plutonium which needs to be reduced. Furthermore, the current over-production of "civilian" plutonium is adding to the global plutonium stockpile.

Despite the lack of capacity to utilise the existing civilian plutonium, the G8 is preparing a proposal to take the excess military plutonium from the Russian and US programs and convert it into Mox for use in civilian reactors. Officials from G8 countries have for a number of years been working on a proposal to allow old and unlicensed equipment from Germany to be dismantled and shipped to Russia for the production of plutonium fuels. If the fuel fabrication plant is reassembled in Russia, the plutonium fuels – or Mixed Oxide Fuels (Mox)- will be loaded into Russian reactors and possibly shipped for use in reactors in the EU. The process is already expected to take decades to complete and even then will only affect around a quarter of Russia's military plutonium.

The bilateral agreement between Russia and the USA calls for the disposal of a minimum of 4 tonnes of Plutonium per year by 2007. Given this time-table it will take approximately twenty years to carry out the agreement. Although it is assumed that a second phase will be introduced to at least double the annual rate of production of Mox, this is dependent not only on the availability of production facilities but also on the availability of reactors to utilise the Mox fuel. Due to plutonium decay, Mox fuel cannot be stored indefinitely before use and so production must be linked to use. There are only a limited number of Russian reactors, the VVER 1000s, which will be modified to use Mox fuel; therefore either additional reactors need to be constructed or the Mox fuel exported. Although the US-Russian bilateral agreement would require US agreement for any export of Mox fuel from Russia, it is clearly advantageous from a disarmament perspective to have rapid utilisation of the Mox fuel. However, Western European Mox manufacturers are extremely worried that this may impact significantly on their market and prices.

Within the bilateral agreement it is currently proposed that only around 10% of the plutonium is directly immobilised. The US assumes that around 7 tonnes would be subject to this method. The Russian side have refused to include any immobilisation plans, saying that plutonium is a fuel and thus cannot be wasted. Increasing the percentage of immobilisation would remove the obstacle of insufficient reactors to burn the Mox fuel and could accelerate the rate of plutonium disposition.

French (Cogema) and German (Siemens) nuclear fuel companies have been negotiating with their Russian counterparts for joint ventures in the Mox field for about a decade. Their further involvement has been limited by a lack of financing. However, the current proposal would see taxpayers from the G7 and EU countries footing the bill. The cost was initially thought to be around $1.8 billion for the Russian side and around $4 billion for the US. A minimum of $830 million will be required[57] for the construction of the Russian facilities to dismantle the warheads and produce the Mox fuel. The current known pledges made by are:

- US: $400 million ** ($217 million)
- UK: $105 million
- France $58 million
- Japan $33 million

The EU is also said to have pledged $100 million. However, problems are emerging in the United States, the main driving force of the initiative. The US press has reported that President Bush has cut the budget for Russian disarmament initiatives by around US$ 400 million, including a reduction in the Plutonium disposition program of nearly $200 million.[58]

In addition to a funding shortfall the proposal lacks an institution to host it. The European Bank for Reconstruction and Development (EBRD) was unofficially proposed by some G8 officials, but it strenuously denies its desire or suitability to host the project.

Now that the proposal has dropped its twin track approach (immobilisation and Mox use) it can be seen purely as an exercise to give additional subsidies to the plutonium industry. At best, the proposal will reduce the excess military plutonium stockpile at the cost of increasing the civilian stockpile; reactors in Europe using Mox fuel will switch from sources from civilian plutonium to those from military plutonium. Furthermore, the use of Mox fuel finances and encourages the development of the plutonium economy and continuing reprocessing, increasing proliferation risks further.

The initial time-scale was that a firm proposal would be developed for the Genoa G8 Summit in July 2001. However, insufficient progress was made and the project was not even mentioned in the final communiqué of the Heads of State, but was relocated to the statement from the Foreign Ministers. This statement called for "*all donors intending to contribute substantially to the Russian Federation disposition program to join in completing an international financing plan and in initiating negotiations on a multilateral framework for the programme*".
As well as loss of political momentum the project is already suffering from spirally costs. In March 2001, the Joint-US working group analysing costs produced revised estimates. Their current project resulted in a 300% increase in construction costs, to $2.9 billion[59].

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[57] Nucleonics Week, 11th December 2000
[58] Bush Targets Russia Nuclear Program for Cuts, People Daily, 19th March 2001
[59] Cost Estimate for the Disposal of Weapons-Grade Plutonium from Russian Nuclear Military Programs, 2nd Report of the Join-US Russian Working Group on the Cost Analysis and Economics of Plutonium Disposal, March 2001, page 56, table 21.

Country Overviews

Argentina

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
2	935	1	692	5.73	7.26

Source: IAEA

There are two reactors in operation in Argentina: Embalse and Atucha 1. The Argentinean experience of nuclear power is not a positive one.

Embalse

In 1972 Atomic Energy of Canada Limited (AECL) submitted a bid to Argentina's Comision Nacional de Energia Atomica (CNEA), in partnership with an Italian firm, to build a 600 MW CANDU at Embalse. The CANDU is fuelled by natural uranium and is made exclusively by AECL. At the time the total cost of the project was reported to be $420 million, of which AECL would undertake work worth $150 million. Canada provided a $129 million loan from its Export Development Corporation (EDC), repayable over 25 years, once the reactor had entered into service. In 1978 EDC awarded a further loan of $25 million. The reactor was finally completed in 1984, ten years after the start of construction.

Atucha

The first reactor at Atucha started construction in May 1968 and entered commercial operation in June 1974. As Siemens supplied the reactor, it was in part financed by Export-credit guarantees from the German Government. There are still some proposals to complete the second unit at an estimated cost of US$700 million. Financial and technological co-operation from US companies is considered essential to the project, while contracts have already reportedly been signed with Iberdrola and Endesa of Spain.

Privatisation Plans

It is reported that the Government wished to sell the nuclear industry to private investors in 2000, but a revised date of end of 2001 has now been proposed. It is currently unclear what would happen to the part built Atucha 2 reactor in any privatisation proposals.

Armenia

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
1	376	-	-	1.84	33.0

Source: IAEA

Armenia currently has one operating VVER 440-230 reactor. This is the earliest design of VVER which is targeted for early closure by the international community. Armenia remains the only country to re-open a VVER 440 reactor citing lack of energy. The Medzamor nuclear power plant is situated less than 30 Km from the centre of Yerevan, the capital of Armenia. Given that VVER 440s do not have a secondary containment system, the reactor has been highlighted as one that poses the greatest threat to public health in the world. In 1995 a US Department of Energy document stated, "*In the event of a serious accident, however, the reactor's lack of a containment and proximity to Yerevan could wreak havoc with the lives of millions*[60]*"*.

Due to its proximity to the capital a referendum was held in 1988 which resulted in an agreement to close the then two operating VVER 440-230 reactors. In December 1988 Armenia suffered a major earthquake which killed around 25 000 people and resulted in the rapid closure of the reactors in March 1989. During the early 1990s and following the collapse of the former Soviet Union, a territorial dispute between Armenia and Azerbaijan resulted in an energy blockade against Armenia. This led to significant power shortages and in 1993 the Government decided to re-open Unit 2, the younger of the two units. The assessment on the restart of Medzamor was paid for by the European Commission, in 1992, and undertaken by the French firm Framatome. By granting this funding the European Commission went against what at the time was G7 policy.

"*Except for an offer to assist Armenia's fledgling nuclear regulatory body, Armgosatomnadzor, the G-7 has steadfastly refused Armenia's request for assistance. The G-7 is hoping that Armenia will not have the means to re-open Metsamor-2, which it considers unsafe.*[61]"

In total the EU have granted at least 10 million Euro to facilitate the reopening of Medzamor, unit 2, with the US Government providing a further $5 million. However, the main support came from the Russian Government, which provided between $70-100 million of technical assistance and nuclear fuel, funded by barter and credit. In 1995, in conjunction with Western consultants (in this case Lahmeyer International), the Armenia Government prepared a program to develop the power sector through until 2013. This proposal envisaged the closure of Medzamor by 2005, with the construction of an additional nuclear power plant between 2005-2010. In 1999, the EU signed an agreement that stipulated the closure must occur in 2004, provided replacement power can be found. In March 2001 Varatan Movesian, head of an advisory group to the Ministry of Energy, said that replacement would require the import of an extra 2000 tonnes of fossil fuels per day. Consequently, the Energy Ministry says that the power stations will have to operate until 2010, as it cannot find power replacements for the reactor.

[60] Most Dangerous Reactors, A worldwide compendium of reactor Risk. US Department of Energy, Office on Energy Intelligence, May 1995

[61] DOE-May 1995, page 2.

Belgium

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
7	5712	-	-	45.40	56.8

Source: IAEA

Belgium has a comprehensive nuclear program which, in addition to its seven reactors has well-developed fuel cycle facilities, including fuel fabrication – in particular Mox fuel- and a large research facility. The table below shows more details of the country's seven nuclear power stations.

Reactor	**Design Type**	**Start Construction**	**Date of Commercial Operation**	**Owned by**
Doel 1	PWR	1969	1975	Electrabel
Doel 2	PWR	1971	1975	Electrabel
Doel 3	PWR	1975	1982	Electrabel (96%), SPE (4%)
Doel 4	PWR	1978	1985	Electrabel (96%), SPE (4%)
Tihange 1	PWR	1969	1975	Electrabel (32.5 %) Electricité de France 67.5%
Tihange 2	PWR	1975	1983	Electrabel (96%), SPE (4%)
Tihange 3	PWR	1977	1985	Electrabel (96%), SPE (4%)

Source: Nuclear Engineering International

The country's power sector is dominated by Electrabel, which was formed in 1990 from the merger of three utilities. In 1995 Electrabel combined forces with the public company Societe Cooperative de Production d'Electricité (SPE) to form a new company Societe pour la Coordination de La Production et due Transport d'Electricité (CPTE), which controls 96% of the generation capacity.

The ownership of individual reactors in listed in the table above; however, Electrabel operates them all. What is particularly noteworthy is that Electricité de France (EdF) owns the dominant share of Tihange 1. There is reciprocity to this ownership, as Electrabel owns 25% of two units at the French power plant Chooz. EdF is state owned, making Tihange 1 a rare example of a reactor owned (mostly) by a foreign government. Electrabel is also active in the European electricity market and now has subsidiaries in a number of countries, including: -

- Electrabel Nordic (Sweden and Norway)
- EPON (Netherlands)
- Deutsche Tractebel (Germany)
- Electrabel France (France)
- Electrabel España (Spain)
- Alpenergie Italia (Italy)

The Belgium power program is also unusual in the small age range of its nuclear fleet. All of the reactors become operational within a ten-year period. This has already created problems about the simultaneous aging of the power plants, the converging of part replacement schedules and the timing of the phase out of the power plants – and will continue to do in the future.

Since the completion of the last power plant in 1985 successive Governments have acted to limit the role of nuclear power in the country. In 1988 the Government cancelled the construction of a fifth reactor at the Doel nuclear power plant. This was followed in February 1992 by government confirmation of an indefinite moratorium on the construction of nuclear power plants in the country. In 1999 a new Government was elected which for the first time contained the Green party as part of the ruling coalition. Within a few months it announced that the operating lives of the reactors would be limited to 40 years. If this decision holds it will lead to the phase out of nuclear power in Belgium between 2015-25.

The spent nuclear fuel produced by the country's power stations has been sent to the Cogema's La Hague reprocessing plant in France. However, in 1993 the Government decided that the reprocessing of nuclear fuel and direct disposal should be given equal weight. As a result of this decision the post 2000 contracts, signed in 1991, were suspended in December 1993. Despite this cancellation and its own use of plutonium in Mox fuel, Belgium has built up a significant surplus of plutonium. Current estimates suggest that this is around 40 tonnes.

The Belgium nuclear power program is characterised by its highly developed fuel cycle, in particular its involvement in Mox fuel. Belgonucleaire has been operating a MOX fabrication plant at Dessel/Mol since 1973 and has been supplying a significant proportion of Europe's plutonium fuel since the mid - 1990s, in particular to French, German and Swiss utilities and in recent years to Japan.

Despite the apparent phase-out of nuclear power in Belgium, concern remains over the possibility of future Governments overturning the current administration's 40 year licensing decision. Furthermore, the replacement of the steam generators in a number of the reactors has increased the capacity of the power plants by around 10%.

Brazil

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
2	1855	-	-	5.55	1.4

Source: IAEA

Brazil has two operating nuclear power plants, both at the Angra power station. Unit 1 is a 626 MW PWR largely built by Westinghouse. Remarkably it took fourteen years to build and only went into commercial operation in January 1985.

In June 1975 the Governments of Germany and Brazil signed an ambitious agreement to launch a civilian nuclear development plan for Brazil. Brazil ordered 8 nuclear power plants, a Uranium enrichment plant and a conversion plant from German companies, with financial support from the German government. Despite confirmed suspicions that the Brazilian regime was planning to use this technology for military purposes, Siemens started to build Angra 2 in 1976. The reactor started operation as Brazil's second nuclear reactor in October 2000, taking 14 years with an estimated project cost of 10 billion US$ (at least three times more expensive than planned). To date this reactor is the only outcome so far of the German-Brazilian agreement.

Construction was started on another Siemens reactor, Angra 3. The foundations had been excavated and the first parts delivered when President Franco stopped Angra 3 in 1993. By this time many Hermes guarantees for Angra 2 and 3 had been issued, for an overall sum of 4,150 billion DM. Now that Angra 2 is operating, the Brazilian company Electronuclear has to start repaying the loans.

In the past few years, efforts have been made to complete Angra 3. This would require further investment of at least $1.7 billion and take 4-5 years. It is estimated that the reactor is approximately 30% complete with investment so far amounting to $1.3 billion. Due to the current financial situation of Brazil, this is not likely to happen without a guarantee from an ECA. Initially Siemens made an application for a Hermes guarantee in 1998. However, given that Framatome is now a major shareholder in the new company Framatome ANP, it is possible that if the project goes ahead it will be with ECA support from the French Government – Coface. An application for new exports for Angra 3 has already been submitted. Press reports in Brazil suggest that a decision on whether or not to complete the reactor will be taken in June or July 2001. However, it has been reported that the International Monetary Fund has attempted to dissuade the Government from completing the reactor.

Bulgaria

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
6	3538	-	-	18.18	45.0

Source: IAEA

There are six operational reactors in Bulgaria, all located at the Kozloduy site, in the North West of the country. There are 4 reactors of the VVER 440-230 design and two of the VVER 1000-320 type. Following the political changes in Central and Eastern Europe in the early 1990s Kozloduy was often in the news due to increased access to the site and the general realisation that the reactors posed a real danger.

<u>Kozloduy 1-4</u>

These are VVER 440-230 reactors, the earliest of the Soviet designed Pressurised Water Reactors; they lack much basic safety equipment and have been targeted for early closure by the international community. These reactors, along with the RBMK (Chernobyl type), are often referred to as high-risk reactors. As a result of the international attention the Bulgarian authorities asked for assistance to carry out a $1 billion modernisation of the oldest reactors, units 1-4. In June 1991, the International Atomic Energy Agency added to the general fear of Kozloduy when it released a report recommending that the first 4 units be closed on safety grounds. This was the strongest statement ever made by the IAEA on reactor safety. At a press conference in August 1991, the German Environment Minister went further and said that Kozloduy 1 and 2 "must be closed down".

The resultant headlines and desire for action led to the European Community approving an ECU 11.5 million nuclear safety program, under the PHARE programme. This was the first initiative to be undertaken on a multilateral level. Despite recognition of the program's importance, the first contracts were not agreed until February 1991. It was said that part of the delay was caused by the intense bidding undertaken by Western firms as "*rival bidders see them as both the only game in town and – perhaps more importantly – an instrument by which to preserve company prestige and perhaps gain new business in Eastern Europe*".[62]

In June 1993, Kozloduy was the recipient of the first funds from the Nuclear Safety Account (NSA): ECU 24 million was awarded for short term operational improvements of units 1 –4. The agreement called for the Bulgarian Government to "*stop electricity generation at Units 1 and 2 of the Kozloduy NPP as soon as the Chaira Pumping station is put on line, and rehabilitation of either Units 5 and 6 at the Kozloduy NPP or the Varna Power Station is completed in order to increase their safety and reliability, which is expected to happen not later than 1 April 1997*". Furthermore, the Grant Agreement called for the cessation of operation of units 3 and 4 as soon as the energy situation allowed it, but in any case "*as soon as Units 5 and 6 of the Kozloduy NPP are rehabilitated and conversion of Sofia, Kostov and Republika district heating plans to combined cycle co-generation of heat and power is completed. Subject to necessary financing being available, the Government expects this to be feasible by the end of 1998*"[63].

[62] Nucleonics Week, February 6th, 1992.
[63] Article III – Obligations of the Government and the Recipient, of the Nuclear Safety Account Agreement, June 16th 1993.

Despite the agreement it was soon clear that Bulgarian Authorities did not respect the scheduled closure dates – they have now passed without the reactors being closed.

Kozloduy 5 and 6

On 18th April 2000 the European Commission approved a 212.5 million Euro loan for the upgrading of the two VVER 1000 reactors at Kozloduy, Units 5 and 6. This is the first loan awarded by Euratom for over a decade and its first ever in Central Europe. The Euratom loan is part of a 540 million Euro project, which is scheduled for completion by 2004/5. The other financial sources are the Bulgarian Electricity Company (NEK) (180.5 million Euro – including contingency); Russian Export Credit Agency (72 million Euro); US Export Credit Agency (75 million Euro). Euratom will fund the work of the European Consortium Kozloduy (ECK), composed of Siemens (Germany), Framatome (France) and Atomenergoexport (Russia) which signed a 314 million Euro contract with NEK in July 1999. Initially it was envisaged that export credit agency funding would also be used from France and Germany, but this has now been dropped. A separate contact worth 75 million Euro has been signed with Westinghouse. Contracts between Framatome and the Bulgarian authorities were finally signed in mid 2001.

Kozloduy and the Enlargement of the EU

At the EU summit in Helsinki in December 1999 Bulgaria, Lithuania and Slovakia were formally invited to begin negotiating entry into the EU. The closure of the high-risk reactors was therefore an issue that needed to be resolved in the months leading up to the summit. Bi-lateral negotiations took place between the Commission and the countries concerned. This resulted in new closure dates for Kozloduy: Units 1 and 2 in 2003 and units 3 and 4 in 2006.

However, it has become clear that the proposed closure dates for units 3 and 4 will be ignored and they will be operated until 2010. This is not a new statement but has been repeated publicly in Bulgaria since the Euratom Loan was signed. In May 1999, the head of the Bulgarian Energy Commission, Ivan Shilyashki, stated *"We will not close them earlier (before the end of their operational life)...as they are safe and operating them is safe*"[64].

In June 2001 the EBRD established a decommissioning fund for units 1-4. So far six countries (Denmark, Greece, Ireland, Netherlands, Switzerland and UK) and the EU have made contributions totalling Euro 100 million.

Bulgaria has an additional part built nuclear power plant at Belene, which was to be a VVER 1000 when construction was abandoned in 1993. Reports persist that the project will be restarted, although in April 2001 it was reported that the IMF was opposed to the completion of an additional nuclear power plant in the country.

[64] Bulgaria Says Kozloduy Reactors Safe, Will Not Close Russia: May 27, 1999 – Reuters

Canada

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
14	9998	-	-	68.68	11.8

Source: IAEA

The owner of all the Canadian reactors is Atomic Energy of Canada Limited (AECL) which operates Candu (Canadian Deuterium Uranium) reactors. Their generic name is Pressurised Heavy Water Reactor (PHWR). In Candu reactors, heavy water is used as a coolant and moderator, and fuel bundles are inserted in horizontal tubes (instead of in one large pressure vessel, as in light water reactors). The use of heavy water makes CANDU reactors more expensive than other reactor designs. After ten to twenty years, the CANDU design faces an increasing risk of a major Loss of Coolant Accident (LOCA) due to tube failure. This occurred in 1983 at the Pickering station in Ontario, when an accident forced the shutdown and re-tubing of all four reactors at Pickering A over a period of ten years. A decline in performance is typical for CANDU reactors after 12 to 13 years of operation.

<u>Pickering Nuclear Stations</u>

In August 1964, AECL and Ontario Hydro reached an agreement to build two 500 MW CANDU reactors at Pickering, Ontario. The release estimate for all four reactors in 1965 was $508 million (dollars of the year), while the total cost for all four Pickering A units was $716 million (dollars of the year). The four Pickering A reactors maintained reasonable performance until August 1983, when a disastrous pressure tube rupture occurred in Pickering Reactor 2, and all four reactors were shut down in succession to have their pressure tubes replaced. The re-tubing of the four reactors cost about $1 billion (dollars of the year) -- more than their original capital cost. In 1974, construction started on the four Pickering B reactors immediately beside Pickering A. The 1974 release estimate for the four Pickering B reactors was $1.585 billion, and the final cost in 1986 was $3.846 billion.

<u>Bruce Nuclear Stations</u>

The 1969 release estimate for the four Bruce A reactors was $930 million (dollars of the year) and the final cost was $1.8 billion (dollars of the year). Performance was reasonable until the late 1980s but by 1993 Bruce A performance had decayed to an abysmal load factor of less than 40%. The initial release estimate for Bruce B in 1976 was $3.929 billion and the final cost was $5.994 billion (dollars of the year). In July 2000, Bruce A and B were leased to the Bruce Power Partnership, 80% owned by British Energy PLC, for £279 million for an 18 year period.

<u>Gentilly 2 Nuclear Station</u>

Hydro Québec undertook an agreement in 1973 with the federal government to build Gentilly-2, a CANDU-6 reactor. The federal government agreed to finance 50% of the estimated $302 million capital cost at a special low interest rate. However, they were less willing to accept the financial burden and subsequent risk of the project. Thus Hydro Québec was solely responsible for the billion dollar cost overrun which saw the capital cost soar to $1.36 billion by the time the plant achieved first criticality in September 1982, a quadrupling of the original estimate.

Point Lepreau Nuclear Station

AECL and New Brunswick Electric Power Commission signed an agreement in January 1976 to build a 635 MW(e) CANDU-6 at Point Lepreau. The Point Lepreau release estimate was $400 million, and the final cost was $1.215 billion. It is envisaged that the reactor will have to be shut down or re-tubed between 2008 and 2010.

Darlington Nuclear Station

Work began on Darlington in 1978, a year before the Three Mile Island accident. For the first time in Ontario, construction of a nuclear station prompted large opposition demonstrations and it remained highly controversial during its construction in the 1980s and 1990s. An early cost estimate for Darlington in 1973 was $2.5 billion, and the initial release estimate in 1978 was $3.950 billion. The final cost in 1993 escalated to a staggering $14.4 billion (Cdn) (dollars of the year).

1997 Ontario Hydro Reactor Shutdown

On August 13, 1997, Ontario Hydro announced that over the next 6 months it would temporarily shut down the Pickering and Bruce reactors. (One Bruce reactor had already been closed in 1995.) It was the largest single shutdown in the international history of nuclear power -- over 5,000 MW of nuclear capacity. Ontario Hydro called for the "phased recovery" of its nuclear reactors, including "extensive upgrades" to the operating stations Pickering B, Bruce B and Darlington, before bringing all the Pickering and Bruce reactors back into operation. A controversial environmental assessment on the restart of the four Pickering A reactors was approved by the Canadian Nuclear Safety Commission in February 2001. It excluded any review of severe accident with widespread radioactive fallout, as well as any review of alternatives. Pickering A restart requires a license amendment scheduled for mid-2001. Actual restart would occur over the following two years. In April 2001, Bruce Power (owned by British Energy PLC) announced its intention to restart reactors 3 and 4 of the Bruce A station by the summer of 2003.

Electricity Market Restructuring

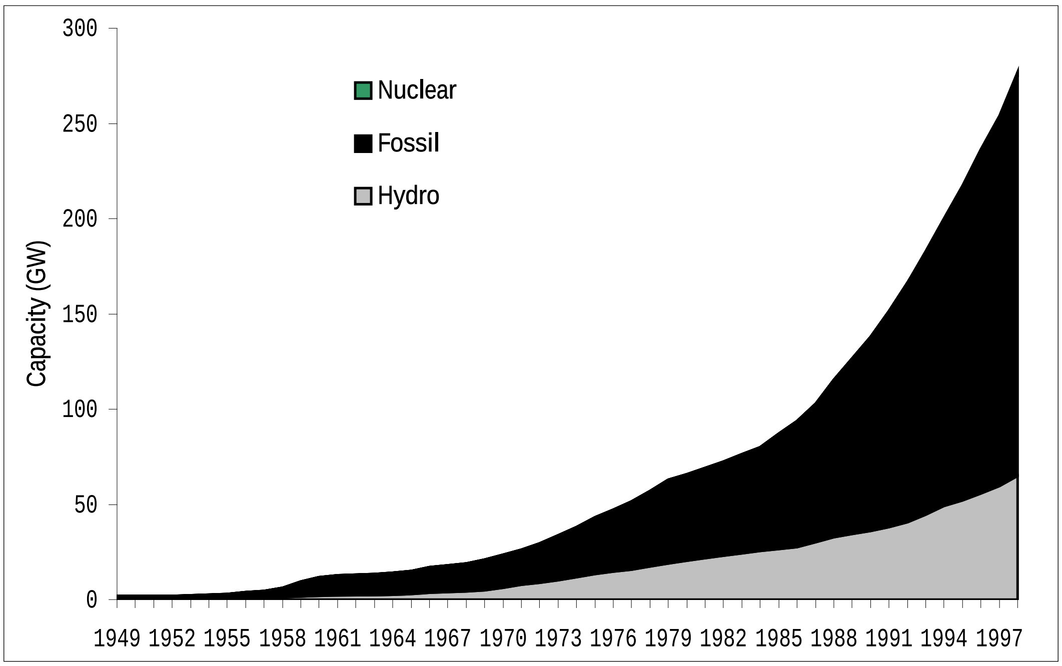
There are significant differences between Canada's provinces in their proposals to open up their electricity markets to competition. Currently only Alberta and Ontario have firm plans to implement full retail access. However, proposals in Ontario have once again been delayed and it is unlikely that market opening will begin in 2001.

China

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
3	2167	8	6420	16.00	1.2

Source: IAEA

Globally China has more reactors under construction than any other country, although nuclear power still supplies only a small percentage of the country's electricity. Even with the current reactors under construction nuclear power will not be a significant contributor to China's energy needs. The graph below highlights the development of the power sector; where nuclear has played an insignificant role so far.



Source: China Energy Databook 2001[65]

All the Chinese reactors operating and under construction have been built by foreign firms and funded, at least in part, by foreign banks with the support of national Export-Credit Agencies.

The operating reactors are at Guangdong (also known as Daya Bay), where there are two Framatome constructed 1000 MW PWRs and at Qinshan, where there is a 300 MW PWR built with support from Mitsubishi. In both cases the Export Credit Agencies of the respective Governments gave financial support.

The eight reactors under construction, representing 25% of the global total, are being built by contractors from various countries:

[65] China Energy Data-book, Lawrence Berkeley National Laboratory, Energy Research Institute, May 2001,

- Lingoa 1 and 2: Russia
- Qinshan II 1 and 2: Japan, UK, US
- Qinshan III 1 and 2: Canada and Japan
- Tianwan (Lianyungang) 1 and 2: Germany

The Chinese market for new construction is very important to the global industry and there is considerable interest and competition between the different constructors to gain the business. The Chinese Prime Minister, Zhu Rongji has said that China will needs to "moderately develop nuclear power" during its 10th five-year plan (2001-5). How this will be interpreted is yet to become clear.

Nuclear Co-operation Agreements

Within the European Union, a number of countries have signed nuclear co-operation agreements with China, including Belgium, Germany, France and the UK. In June 2001, the Vice-President of the European Commission, Loyla de Palacio, visited Beijing. Prior to this visit the European Commission proposed an agreement for nuclear co-operation with China, for approval by the Council. This document notes the following: -

It is clear that China will continue to select foreign partners to participate in the planned continuing development of nuclear power in China and that this will in turn provide important and increasing business opportunities for the EU nuclear industry.

On a formal level, bilateral nuclear co-operation agreements are already in force between China and, respectively, Belgium, Germany, France and the UK. A general complementarity and consistency of those agreements with a potential Euratom/China agreement has been identified. For example, it can be noted that all those agreements provide for co-operation in nuclear R&D and nuclear power technology (including reactor safety). Moreover, the (more recent) agreements with France also includes within its scope the supply of nuclear materials, equipment, installations and technology.

Euratom Loans

During 2001-2 the European Commission is proposing to extend the current lending ability (ceiling) of its Loan facility and revise the type of projects which can be supported. The Commission is currently preparing a proposal for the Council to extend the loan ceiling by a further 2 billion Euro – a decision is expected by the end of the year. Following the extension of the loan facility the Commission will review and probably extend the scope of the loan facility. No documentation has been publicly circulated to indicate what these changes will entail, but indications suggest that this may include the production of plutonium fuels in Russia and loans to additional countries. Currently loans can only awarded to EU and accession countries or former Soviet Union States. This may well be enlarged to include China.

It is unclear what further orders for new reactors will be placed in the coming years. In 2000 it was reported that the Chinese Government had placed a five-year moratorium on the ordering of new reactors. However, in March 2001 it was reported that reactors had been ordered in the Shangdon, Zhejiung and Guangdong districts.

Czech Republic

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
5	2569	1	921	13.59	18.5

Source: IAEA

There are four reactors, all VVER 440-213s, currently operational in the Czech Republic, sited at Dukovany in Southern Moravia. In addition, two reactors of the VVER 1000 design are under-construction at Temelin, in Southern Bohemia. Unit 1 was completed in 2000, but is still suffering from technical problems and has not yet entered full commercial operation. Full commercial operation of block 1 is at present scheduled for February 2002, for block 2 in autumn 2002. Both nuclear power stations are owned by the Czech Electricity Utility CEZa.as which has majority (67%) state ownership. Privatisation negotiations have started and are likely to be closed before summer 2002. Interest has been shown by French, German, Brittish, Italian, Belgian and US buyers. Most likely candidates for privatisation include EdF and E.On. Since late 2000, CEZ is also retained a majority share in the transmission grid operator REAS, and six of the eight regional electricity distribution and service companies that supply and distribute electricity to the final consumers. The two others (South Moravian and South Bohemian electricity companies) are in majority owned by E.On and the Austrian Energie A.G.

Dukovany

Relative to other Soviet designed reactors the VVER 440-213 has a good operating record and Dukovany is no exception. Since the early days of their operation the reactors have been exposed to international attention. Between 1984-6, Siemens of Germany was involved in the supply of equipment to all units. Proposals were put forward in 1990 to replace the original instrument and control technology with one built by Siemens/KWU. Although delays have occurred it is expected that this will still occur. In 1998, CEZ announced that a substantial 35 billion CZK (750 million Euro) modernisation program would be undertaken by 2005. The upgrading program is designed to extend the life of the reactors from 30 to 40 years. This will enable the last reactor at the station to be closed in 2027. In 2000, Dukovany had an operation efficiency of 85%.

Temelin

In 1980 it was proposed to construct four VVER 1000 reactors at Temelin. The reactors were ordered from the Soviets in 1982. Following the political changes in November 1989 the situation was reviewed and in 1990 the project was reduced to two reactors. Originally it was expected that each reactor would be constructed in 60 months, with the first construction permits being issued in November 1986 on a total budget of around 28 billion Czech Crowns.

On March 10, 1994, the US Ex-Im Bank approved a decision to guarantee a loan of $317 million for work performed by Westinghouse Electric Corporation. However, it was only at the end of October 1996 that the Czech Government finally approved the state guarantee. $280 million was loaned by CitiBank International and the remainder through Belgium’s Generale de Banque. The CitiBank received a credit guarantee from Ex-Im. In addition a credit Guarantee was given by the Belgium export credit agency, Office National du Ducroire. Further investment was covered from CEZ reserves, freed by credits from –

amongst others – Deutsche Bank, Bayerische Landesbank and World Bank for emission reduction from coal fired power plants.

The project to complete the Temelin nuclear power plant has been afflicted with considerable delays and cost over-runs. These problems have been caused by the political, social and economic changes in the Czech Republic, the bidding procedures and securing financing, but most recently due to the technical problems that have arise as a result of the design changes. Construction started in 1983, with plans to start operation in 1991. The cost and time overrun problems significantly increased from 1993, when CEZ contracted Westinghouse to implement certain safety upgrades. The unexpected and serious technological complications resulting from the combination of different Russian and American components and technologies stalled the project during the 1990s. The accumulated delays now amount to 5 years and the cost overruns are 30 billions CZK (900 million Euro). The necessary re-routing and retrofitting of the cabling system in order to comply with Western standards has proved to be one of the most costly and difficult ongoing problems at the Temelin plant. Estimates of the amount of cabling needing reinstallation have continually increased even within a relatively short period of time. An additional 300 holes for the cabling had to be drilled through the existing concrete structure, which further added to the cost and delays.

Unit 1 of the Temelin nuclear power plant was complete in mid 2000 and was loaded in July. The first chain reaction took place on October 9th. However, even at this late stage problems were coming to light over construction malpractice and equipment defects. It was said that these were ignored due to the commercial and political pressure of getting Temelin operating, but the rush to operate Temelin may prove disastrous for CEZ. In January 2001, problems were reported in the turbine of Unit 1 that only increased until it was decided to overhaul the turbine installation completely in May 2001. The reactor was supposed to come back into operation in July 2001 and into full commercial operation in September, a period that was delayed with another month. Only on 10 August, the Temelin was made critical again. At that moment a new testing phase of the turbine started, which should bring the reactor on 55% of its capacity. In addition CEZ is coming under pressure from its international customers. CEZ is second to France in its international sales and exchanges of electricity. However, two of its key clients, E.ON and RWE, are pulling back from CEZ, due to domestic market and political pressures in Germany. Further clients, like the US based Enron, are coming under similar pressure.

Based on a bilateral treaty between the Czech Republic and Austria from December 2000, known as the Melk Protocoll, Temelin was to undergo a comprehensive safety analysis and Environmental Impact Assessment before its commercial operation. EIA and safety documentation were produced in May, but caused a stream of criticism on the Austrian side. Under Austrian pressure, two more studies were done to a possible mothballing scenario (called "zero variant") and effects of past design large accidents. The Austrian government worked out a highly critical assessment of this documentation. The safety analysis was cut short by the European Union facilitators of the dialogue with a report that closes 9 out of 29 safety questions, comes with proposals to address 10 of them and shifts discussion of another 10 into the future. Also this report got a very critical reception in Austria. The Czech side keeps stressing that Temelin has been assessed by the IAEA and WENRA and found safe enough to operate.

In July 2001 the German Government formally joined the Austrians in opposing the completion of the Temelin nuclear power plant and called for its closure on the basis of the argument that basic design problems would make the plant unsafe and that it would not be able to receive an operation permission under German regulations.

Finland

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
4	2656	-	-	21.60	32.1

Source: IAEA

Finland is the only country in the European Union that has plans to construct a new nuclear reactor. The Government has given its approval for the proposal, but as yet there is no parliamentary approval. If ordered and built the reactor would be the fifth in Finland. The other four are located at two sites, Loviisa (where there are two VVER 440-213 reactors) and Olkiluoto (where there are two BWR reactors).

The Loviisa reactors are currently the only Russian designed reactors in operation within the European Union and were supplied by the Soviet firm Atomenergoexport, who continue to supply nuclear fuel. Finland stopped sending its used fuel to Russia in 1996, soon after Finland joined the European Union. The Finnish VVER 440 reactors were the subject of significant design changes and consequently have a number of additional safety features over the other operational VVER 440-213 reactors, including an enhanced containment system.

In 1998 the company Fortum was created by the merger of the Government utility – which owned Loviisa (IVO) - and the oil and gas company Neste. Fortum is majority owned by the Finnish Government, with the remaining shares owned by Teollisuuden Voima Oy (TVO) –the owner of the Olkiluoto nuclear power plants. Fortum has become a global player in energy markets and now operates in 30 countries. In 2000 its turnover was around 11 billion Euro (up from around 8 billion Euro in 1999) with an operating profit of nearly 1 billion Euro.

Fifth Reactor

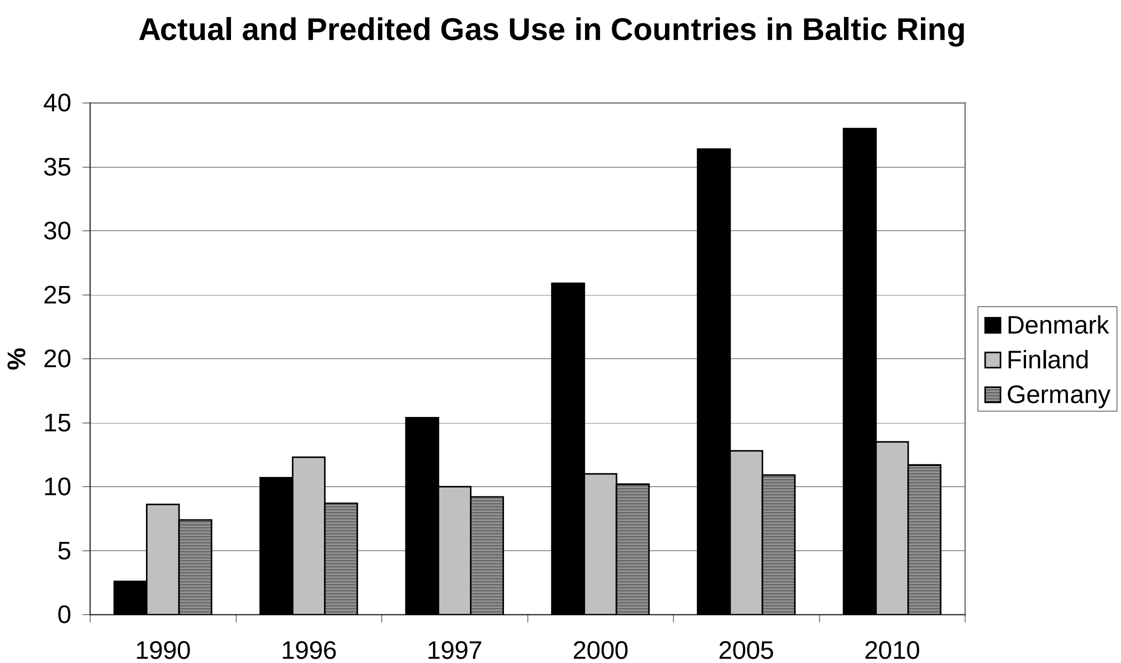
In 1992 an application was made to construct a 1000 MW reactor at either Loviisa or Olkiluoto: in March 2001 the town of Loviisa was reported to have agreed to site the reactor. This resulted in a number of bids being put forward for its construction. However, in September 1992, the Parliament rejected the application. In November 2000, TVO made a formal application to the Ministry of Trade and Industry for the construction of a new reactor, with an installed capacity of between 1000-1600 MW depending on the design. At the time of the bid TVO suggested that the total cost of the projects would be between 1.7 and 2.5 Billion Euro, depending on the reactor size and design. TVO will finance the reactor, but no funds will be committed until the Council of State and the Parliament approve the application. No decision is expected in the Parliament during 2001. The Prime Minister, who is in favour of the project, has recently described moves by other countries to give up nuclear power as “economically absurd”.

TVO claims that the decision to move ahead with the nuclear application will help Finland meet, along with renewable energy, their Kyoto commitments and ensure that there is sufficient domestic production capacity to bring stable and predictable electricity prices. Somewhat surprisingly, TVO also claim that nuclear power’s low production costs – and in particular low fuel costs – make it suitable for the open Nordic electricity market. This claim goes against the Swedish experience, where the drop in the Nordic electricity price has resulted in the electricity price falling below production costs of the nuclear power plants. As has been discussed previously, nuclear power plants are very susceptible to decreases in electricity prices given their large upfront costs.

It is clear that the issue of the economics of nuclear power will be central to the discussion prior to and during the parliamentary debate on nuclear power. At the Russian nuclear Society Conference in St Petersburg in June 2000, a report was presented which stated that nuclear power would produce cheaper electricity than coal, gas or peat fired power stations. This analysis has been used across Europe in an attempt to counter the claim that nuclear electricity is more expensive than alternatives.

However, this report goes against international experience in power production, where the general picture is that nuclear power is more expensive than coal and oil. However, the construction costs of 1749 Euro/kW ($1500/kW) are significantly above the target figure for new construction in the US, of $1000/kW.

With significant hydro capacity in Finland a large percentage of their electricity comes from renewable sources. However, Finland lags far behind its neighbours in other renewable energy sources. There is concern in Finland about building more gas fired power stations, as it will increase their dependency on imported natural gas. However, Finland is less dependent on gas than neighbouring countries as can be seen the in graph below.



Source: IEA 1999[66]

[66] Energy Policies in IEA Countries, 1999 Review, International Energy Agency 2000

France

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
59	63073	-	-	395.00	76.4

Source: IAEA

France's nuclear program began in the 1950s, initially in the form of military projects and then via the building of reactors for civilian use. The first reactor to be built expressly to produce electricity was started in 1952 at the Marcoule facility. During the 1960s Electricité de France (EdF), the Government run utility, took over operations and began ordering a new design of reactors: the PWR.

In the 1970s, France embarked on a massive nuclear power program of PWRs. All of the reactors in this series were built by Framatome, under a license agreement from Westinghouse adapted to the French context, at the end of the 1970s. This included:

- 1970: six reactors were ordered (two for Fessenheim and four for Bugey).
- 1974: after the 1973 oil crisis, sixteen 900 MW reactors were ordered.
- 1975: 4 orders for 1300 MW PWR reactors.
- 1976: 12 additional 900 MW reactors were ordered.
- 1976: launch of fast breeder program Superphénix-1 (1200 MW).

In the 1980s, the PWR program continued. The problems encountered in the development of fast breeder reactors led the authorities to abandon the launch of Superphénix-2.

- 1979-1983: orders for 16 new 1300 MW reactors.
- 1984: orders for two new even more powerful PWRs (series N4, 1450 MW) at Chooz.

In the 1990s, the over-capacity of the installed base of reactors led to a slowing down and then a freeze on the PWR program. In 1999, the last reactor in France was completed at Civaux. This meant that for the first time in France, and in fact in the EU, there were no reactors under construction since the launch of civilian nuclear power. No other series was developed and R&D efforts were concentrated on the European Pressurised Reactor (EPR) project, a joint collaboration with Siemens. Due to pressure from the Greens, a coalition party in the current socialist led Government, proposals for the construction of the EPR have been abandoned until at least after the 2002 election. The industry optimistically forecasts that they will begin construction in 2003.

In 1998, one of the major symbols of the French nuclear program and the reasoning behind France's massive reprocessing industry, the Superphenix, was finally abandoned. According to the "Cour des Comptes" [Government Accounting Office] Superphenix cost 60 billion francs by the time EdF finished paying interest at the end of 2000. In addition significant running costs (800 million francs per year) are being spent to preserve the facility including the expense of heating sodium in order to keep it in a liquid form[67].

[67] France. Plutonium Investigation, No 19, November 2000, WISE-Paris: http://www.wise-paris.org

At present, EdF operates all of the 58 PWRs that were built (although 12 include foreign electricity companies among their minority shareholders – these shares may rise as Edf complies with the EU Electricity Market Directive and increases competition in the French electricity market). The only other power reactor operated in France is Phénix, the CEA's fast neutron reactor, temporarily shut down since November 1998.

Today, France has the second largest installed nuclear base in the world (second to the USA) and EdF is the largest producer of nuclear generated electricity, producing 395 TWh in 2000 (for a net electricity consumption in France of 441 TWh in that same year). This nuclear power over-capacity allows EdF to export electricity massively to its European neighbours (72.7 TWh in 2000). Framatome ANP have for a number of years been developing their next generation of reactor, the European Pressurised Water Reactor (EPR). In November 2000, under pressure from the Green coalition partners, the French Prime Minister, Lionel Jospin announced that now was not the right time to decide whether or not to order a EPR. This postponement was said to be the cause of a 20% reduction in the workforce at the Framatome ANP headquarters in Paris.

The plutonium industry

France's nuclear industry has induced a very high level of vertical integration in the fuel cycle. Although natural uranium is now no longer extracted in France, all of the other stages in the cycle are carried out on French territory: from conversion to reprocessing and manufacturing plutonium-based fuel. Clearly, France originally developed this option of the later stages of the cycle for its military needs, then for its fast breeder program. Since the abandonment of that program, a part of the separated plutonium has been re-used in the form of MOX (Mixed Oxides) fuel in PWRs. France has a number of operating reprocessing plants including Marcoule and UP2-400, UP2-800, UP3: "Usines Plutonium" 2 and 3, La Hague, operated by CEA (then COGEMA) since 1966, 1994 and 1989 respectively. France also operates two MOX fuel manufacturing plants (mixed uranium and plutonium oxides from reprocessing): the ATPu facility at Cadarache and the MELOX facility at Marcoule.

These reprocessing and MOX plants have been, or are still, operated for both French and foreign clients (Australia, Belgium, Germany, Japan, Netherlands, Spain, and Switzerland). France, via COGEMA, now occupies a central position internationally in the increasingly controversial plutonium industry.

Electricité de France

EdF is Europe largest utility. In 2000 its revenue was 34 billion Euros. EdF retains a virtual monopoly in France and the Government is blocking moves by the European Commission and other Member States to accelerate the opening of the electricity market to competition. The Government with strong support from parts of the trade union movement, in particular the CGT, is strongly resisting the opening up of the electricity market and is refusing to allow EdF to become active non-electricity sales. Despite lack of competition in its domestic market EdF is increasingly active on the international stage. Over the past three years EdF's share of revenue from international activities has increased from 12% in 1998, to 23% in 2000. However, this is not the end of EdF's international ambitions and by 2005 it plans to source 50% of its revenue from outside France. To date it has invested nearly 11 billion Euros in some twenty countries in Europe, Latin America, Africa and Asia. Abroad, it owns, alone or in partnership, a total capacity amounting to 32,700 MW (installed or under construction) and supplies more than 20 million customers. The geographical breakdown of its generation and distribution investments is shown in the table below.

EdF distribution of investment (%):	**Generation**	**Distribution**
Europe	74	44
Asia	12	-
South America	8	49
Africa	2	4
Maghreb/Middle East	4	3

In June 2001 the European Commission announced an inquiry into EdF subsidies for its nuclear program. This follows complaints from a number of countries, including Italy, Germany and Spain, that EdF is taking advantage of its state support while buying up utilities in other countries. To fund further expansion plans EdF plans to raise 190 billion francs ($26.7 million). This will not be in the nuclear sector as they announced during 2001 that no new nuclear capacity will be required for the next 20 years.

Germany

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
19	21122	-	-	159.60	30.6

Source: IAEA

There are currently 19 reactors in operation: 13 PWRs and 6 BWRs. The German nuclear industry has tried a number of other designs all of which have largely failed or been abandoned. These include:

VVERs: The re-unification of Germany resulted in the closure of all Soviet-designed reactors, the five VVER 440s at Greifswald (four 230 designs and one 213 reactor), and the non-completion of the partially built VVER 440-213 and VVER 1000 reactors at Greifswald and Stendal respectively. The VVER 440-230 reactors were closed soon after unification. No decision was immediately taken on the VVER 440-213 and VVER 1000 reactors, but the German Safety Agency, the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), made detailed assessments. These assessments outlined the redesign and backfitting work necessary for the project to be awarded an operating licence in Germany. Following this technical assessment expected costs were calculated and the reactors were offered to Western German utilities, however, the offer was not taken up and the projects subsequently abandoned. Their closure was and has been seen as a benchmark for the safety of the VVER reactors as the standards used in the assessments measured not only the viability of such reactors operating in Germany, but also by implication the whole of the European Union.

The *High Temperature reactor* (HTR) was developed at the research facility in Jülich in 1969. The Thorium-HTR in Hamm Uentrop operated only between 1985 and 1987. The project cost risen from an initial estimate of 690 million DM to more than 4 billion DM, with construction time rising from an estimated 61 months to an actual 164 months. Technical problems, especially with the fuel pebbles, lead to frequent shutdowns so that the project was abandoned.

The *Fast Breeder* was intended as the product of a trilateral co-operation between West Germany, Belgium and the Netherlands. A syndicate of Interatom, Belgonucleaire and Neratom started to build the SNR-300 prototype in Kalkar in the early 70s. Although almost completed the last license needed for operation was never given for technical, economical and political reasons. On March 21 in 1991 the Fast Breeder project was finally terminated. The estimated project cost rose to 7 billion DM.

The nuclear industry has also abandoned a series of fuel cycle facilities. The three most significant are: -

Wackersdorf Reprocessing Plant was abandoned in 1989. The total project cost was estimated to have been around 10 billion-DM, of which 4 billion was thought to have been lost when the project was abandoned.

Hanau Mox Facility, which was abandoned in the early 1990s after a long legal battle with the Hessen regional Government.

Morsleben Waste Disposal facility. . The operation of the waste disposal site in former Eastern Germany was stopped by a court ruling in 1998 and in May 2001, final agreement was reached to abandon and begin decommissioning the Low and Intermediate waste disposal facility. By this time 35 000 cubic meters of waste had been placed in the facility.

Governmental Agreement

In September 1998, a new Government was elected comprising a coalition of the Social Democrats and the Green Party. The coalition promised a nuclear phase-out in Germany and proposed to negotiate with the national energy suppliers to shut down all remaining nuclear reactors within 20 years. In June 2001, the government and four main utilities finally signed a phase-out plan, the main points of which are: -

- A fixed quantity of electricity can be produced in each reactor. This equates to an operating life of around 35 years, although "the operating life" of a reactor can be transferred between reactors.
- A ban on the construction of nuclear power or reprocessing plants.
- A ban on shipment of commercial nuclear fuel to reprocessing plants after July 2005.

The agreement is expected to be ratified by the Parliament in the first half of 2002. As part of the agreement RWE, the operators of Muhlheim-Karlich, announced that they would not restart the reactor. Furthermore the Stade reactor will be the first plant to be closed in 2003, with the others following over the next 20 years or so.

Reprocessing and Waste Transports

In the summer of 1998 it was revealed that in a number of cases the outside of the flasks used to transport used nuclear fuel were contaminated. This resulted in the suspension of all waste export from Germany. This was only resumed in 2001 after extensive analysis and compromise. Furthermore, the French Government refused to take any more spent nuclear fuel until some of the high level waste (HLW) accumulating at the La Hague plant was taken back to Germany. In March 2001, a third shipment of HLW was sent to the Gorleben interim storage facility. Like the first shipment there was massive protest which, despite the deployment of 30 000 police, managed to delay the waste for 24 hours. Following the HLW shipment, spent nuclear fuel was once again sent to France and the UK.

Electricity Market

Following the introduction of the EU's Electricity Market Directive, the German Government fully opened its electricity market to competition. Historically, Germany has had a large number of power generators. However, market liberalisation has reduced this and will continue to do so. The most high profile example of this was in June 2000 with the creation of E.on, with an annual turnover of EUR 93 billion and roughly 187,000 employees, which has become Germany's third-largest industrial group. It was formed by the merger of two energy companies, VEBA and VIAG. E.on currently owns or has part ownership of 12 of the country's reactors. It is reported to be interested in buying interests in the US nuclear industry and is already very active in the European Power market. The company has shareholdings and joint ventures in more than a dozen European countries including the Netherlands, Sweden, Switzerland, the Baltic states, Russia, Austria, Hungary, the Czech Republic, and Italy.

Hungary

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
4	1755	-	-	14.72	42.2

Source: IAEA

Hungary has four VVER440-213 reactors at one operating nuclear power plant at Paks, close to the Danube in the centre of the country south of Budapest. Construction started on the reactors between 1974-9 and they become operational between 1983-7. The Hungarian and Soviet Union governments first reached agreement on the construction of a nuclear power plant in Hungary in 1966. One of the primary motivations for the project was to utilise the Hungarian uranium deposits and thus decrease energy import dependency. However, Hungary never developed its own uranium enrichment facility and had to rely on the Soviet Union and then Russia for its fabricated nuclear fuel as well as for its nuclear fuel disposal. Paks is owned by the State under the company name of Paks Nuclear Power Plant Ltd. The Hungary Electricity Board Ltd (MVM) owns 99% of the shares, with the remaining shares owned by the local authorities.

In July 1998 MVM stated that they were considering applying for the extension of the operating life of the reactors for a further twenty years above the original 30-year design life. This would allow the reactors to operate through until 2022-27. The licenses for Paks are awarded for ten-year periods by the Hungarian Atomic Energy Agency (HAEA). the HAEA awarded ten-year operating permits to Paks units 1 and 2, in 1997 and to units 3 and 4 in 2000. It is expected that HAEA will begin reviewing the next life extension license for units 1 and 2 in 2002.

Throughout the operating life of the Paks reactors Western firms have been involved in upgrading and training programs. These include IVO (now Fortum) of Finland, the Spanish firm Tecnoatom and Siemens. In September 1996 Siemens was awarded the DM 40 million contract for the installation of new computerised instrument and control equipment, to be installed in each reactor between 1999 and 2002. This contact is part of a 60 Billion-Forint (Euro 250 million) investment plan proposed by MVM. This program is expected to increase the output of the station by 10-15%. According to HAEA the majority of this project is safety-related, but is also expected to increase the output and potentially the lifetime of the reactors.

At the end of February 1999 the State owned Hungarian Power Companies (MVM Rt) announced that two smaller gas fired power plants had been chosen, in preference to an expanded Paks, for satisfying medium term demand needs. The gas stations were a 191 MW gas fired combine cycle combustion turbine and a 110 MW co-generation plant. Paks initially put in three bids for the construction of a VVER 640, Westinghouse AP 600 and Candu 6 by AECL.

India

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
14	2503	-	-	14.21	3.14

Source: IAEA

According to the IAEA India has fourteen reactors in operation with none under construction. These figures differ somewhat from those produced by the Indian nuclear power operators, but overall nuclear power is not yet a major contributor to India's power needs. However, during 2000, four reactors were finally connected to the grid, significantly increasing nuclear's contribution.

In addition, according to NPCIL (see below), two further reactors are under construction at the TAPS power plant. The first concrete was poured for both reactors in May 2000. These reactors are notably larger than previous reactors, both being 500 MW and also PHWR reactors. Further reactors are reported to have been ordered from Atomstroyexport of Russia. Two VVER 1000 reactors are planned at the Kudankulam power plant. It is reported that commercial contracts have been signed and financing, arranged through the Russian Export Credit Agency.

All of India's nuclear power plants are constructed and operated by the state-owned enterprise Nuclear Power Corporation of India Limited (NPCIL). The company was established in September 1987. According to the NPCIL web site, company profits are rising rapidly as their output rises. Profits have risen from 2530 million Rupees in 1997 ($53 million) to 3615 million Rupees ($76 million) in 1999.

At the inauguration of the RAPS 3 and 4 reactors in March 2001 the Government reconfirmed its plans to significantly increase its fleet of nuclear reactors. The Government claims that over the next decades an additional 10 GW of power each year will be required to meet India's growing energy demand. Nuclear power is hoping to supply 2 GW of this. NPCIL is now said to be preparing to expand its installed base to meet the commitment of 20,000 MW or more by the year 2020. Two units of 540 MW are currently being built at Tarapur. Another two 220 MW units are also proposed at Kaiga and 2 units of 1000 MW at Kudankulam (Tamil Nadu). In the 10th five-year Plan, it is proposed to commence construction of another four units of 540 MW capacity at Rawatbhata. The ultimate aim of the corporation is to double its installed capacity every seven years. In April 2001 the Atomic Energy Commission announced that it wanted to start construction of a 500 MW prototype fast breeder in December 2001.

One of the key areas of improvement seen in recent years in the Indian power program is in its capacity factor of its nuclear reactors. In the early 1990s India's nuclear power plants were recording the lowest efficiency of any nuclear power program in the world. However, over the last few years this has consistently increased and now NPCIL report an average capacity factor of 82% (up from 60% in 1995).

Iran

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
-	-	2	2111	-	-

Source: IAEA

In July 1976 Germany and Iran signed a nuclear co-operation agreement and the following year a guarantee was issued by the Government Export Credit Agency -Hermes- for the construction of a 1300 MW PWR at Busher. At that time it was assumed that the German share of the project would be 1.43 billion-DM (approximately 700 million Euro at current exchange rates). However, the following year the agreement was cancelled.

A Russian-Iranian agreement on the construction of nuclear plants was signed on August 25, 1992. This included the completion of one VVER-1000 nuclear reactor at Busher and training for Iranian specialists. According to Russian government sources, the estimated total cost of the deal was US$ 1 billion, including US$ 850 as payment for the construction of the reactor. Up to 20% of the project cost was to be repaid to Russia in the form of goods.

In 1994 about 150 Russian nuclear specialists started research on the potential location of the nuclear plant. In March 1998, the Russian Vice-Minister for Atomic Power Valery Bulgak announced that Russia and Iran had reached an agreement in principle on the construction of two additional nuclear reactors.

In December 1998, the Russian national reactor operator Rosenergoatom agreed with Atomstroyexport to provide English translations of technical documentation for the Russian Balakovo nuclear plant, the model for Busher, at a cost of US$ 515,000. In 1999, US$ 162,500 was extracted from the budget for implementation of this agreement. In June 1999, Rosenergoatom also signed an agreement with Atomtehenergo for the organisation of training of Iranian specialists at a cost of US$ 740,000. In 1999, about US$ 76,300 was extracted to start this work, and the Russian Balakovo nuclear plant and Kalinin nuclear plant accepted two groups of Iranians.

In 1998 Russia and Iran agreed that the nuclear plant should be finished within 52 months. Russian companies were pessimistic about keeping to this date, but the Iranian side demanded the completion of the project to this timetable or else its cancellation. In order to keep the contract, the Russians signed it even though, according to Kozlov’s interview in the Russian paper “Vremya novostey”, there was no chance of finishing construction within the allotted 52 months. Iran paid approximately 5% in advance to Russian companies to start manufacturing equipment for the Busher plant, but this amount was not enough to start implementing the agreement. Nuclear Engineering International report that unit 1 is now 90% complete and will be completed in 2003.

Japan

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
52	45082	4	4663	304.87	33.82

Source: IAEA

Japan's nuclear power industry is comprised of five groups, each of which corresponds to one of the old financial cliques (zaibatsu) dismantled following the Second World War. Of the five groups, those involved heavily in commercial nuclear power are the Toshiba/Mitsui Group of the former Mitsui Zaibatsu, the Tokyo Atomic Group (Hitachi Group) and the Mitsubishi Group of the former Mitsubishi Zaibatsu. The first two groups are working on Boiling Water Reactors (BWRs) through a technology alliance with America's General Electric Co. (GE), while Mitsubishi is working on Pressurised Water Reactors (PWRs) through a tie-up with America's Westinghouse Electric Corp (WH). These partnerships were originally formed for thermal power plants but were later extended to nuclear plants.

Japan's first commercial reactor, Tokai I (166MW), was a gas-cooled reactor (GCR). The reactor, which was imported from General Electric Co. Ltd. of the U.K., began operation in 1966. It stopped in 1998, as it had become very costly to operate and it was too expensive to build any more GCRs. Tokai I was the only GCR built in Japan. All subsequent commercial reactors built have been light-water reactors (LWRs). Between 1970 and 1997, 28 BWRs and 23 PWRs started operation in Japan. There are ***4*** BWRs currently under construction, but no PWRs. Mitsubishi has built or is building 23 of these reactors, Toshiba ***21*** and Hitachi 12 (which includes reactors built with the U.S. manufacturer as the major contractor, or built jointly with a U.S. manufacturer).

In recent years the Japanese nuclear industry has had a number of serious accidents, which have severely dented the public’s faith in the industry, this includes: -

<u>Tokaimura:</u> On 30th September 1999 workers treating a uranium solution at the JCO Co. conversion test plant in Tokaimura caused a criticality accident due to mixing too high a concentration of uranium. As a result of this, two workers received a fatal dose of radiation with a further 119 people receiving a radiation dose of over 1 mSv. The accident resulted in an off-site release of radiation. The IAEA stated that the accident was a result of "human error and serious breaches of safety principles".

<u>Monju:</u> ***On*** 8th December 1995, the fast breeder reactor at Monju suffered a fire caused by a sodium leak, which is used to cool the reactor. The secrecy and attempts to cover up the accident by its operators compounded the problems caused by the accident. The reactor has yet to reopen and in June 2001 approval was given to undertake yet more safety analysis. This will take a further 17 months and cost an estimated $137 million.

Lack of confidence in the nuclear industry was dealt a further blow when it came to light that Mox fuel delivered to Japan from the BNFL plant in the UK had its safety verification records falsified. As a results eight Mox fuel elements had to be returned. Furthermore, in May 2001 the Kaiwa village voted in a local referendum against the use of Mox Fuel in the Kashiwazaki-Kariwa 3 reactor.

The Government stated in its long-term outlook of energy demand and supply report released in July 2001 that its proposals to build between 16 and 20 new nuclear power plants by 2010 were now unrealistic due to opposition following the Tokai Mura accident and corrected the number of power plants to 10-13.

Power Sector Reform

Reform of the power sector is currently underway, in part to reduce the price of electricity in Japan - the highest in the OECD. In March 2000 competition was introduced into the electricity market, with large users of electricity able to choose their electricity supplier. This should result in up to 30% of the electricity market being open to competition. Other measures that will be taken include the introduction of a bidding system for the development of the thermal power sector, increased transparency in transactions and simplification of administrative procedures. The impact of these reforms will be reviewed in 2003. Currently, there are 10 vertically integrated utilities servicing the power market. Excluding the Okinawa Electric, nine of these have at least one nuclear power plant. Since 1995 independent power producers have been able to operate, but to date not one has become a major force in the market.

Nuclear utilities are already fearful that competition from cheaper fuels, such as natural gas and (natural gas is cheaper than coal in Japan***)*** coal will prevent them passing on the additional costs necessary to build new nuclear power plants.

Nuclear Industry Restructuring

Japan's nuclear industry has been suffering from a decrease in domestic orders, and a feeling of uncertainty for the industry's future. The industry is now going through major rationalisation and reorganisation. According to the Japan Atomic Industrial Forum, Inc.'s (JAIF) 1999 fiscal survey on the nuclear industry, sales of the entire industry rose over the previous year to 1.68 trillion yen. This increase was the largest for four years, though the amount has still not even reached the level of 2 years ago. The JAIF report states: "The future is still unclear."

The subsidiary companies established by each of the major companies in the industry for handling only nuclear power-related businesses have been re-absorbed by their parent companies. In 1989, Nippon Atomic Industry Group Co. Ltd. (NAIG) was absorbed by Toshiba, and in 1995, Mitsubishi Atomic Power Industries, Inc. (MAPI) was absorbed by Mitsubishi Heavy Industries. In the mid 1980s, Mitsubishi Heavy Industries had about 5,000 employees, including those of MAPI, working for its nuclear power division. This dropped to about 3,500 by the end of 1990s. Sales slumped to half or even a third of their peak level.

Hitachi and Toshiba are also cutting the number of employees working in their nuclear power divisions by about 1,000. In 1997, Hitachi and Toshiba jointly established the Asian ABWR (Advanced BWR) Promotion Organisation in order to begin exporting ABWRs, which was jointly developed by GE of the U.S. and the Tokyo Electric Power Co. (TEPCO). Furthermore, Hitachi, Toshiba, and GE are considering ways to strengthen their relationship, such as launching a nuclear power joint venture firm. In January 2000, the nuclear fuel divisions of Hitachi, Toshiba and GE were united to form Global Nuclear Fuel (GNF). Following this, Japan Nuclear Fuel (JNF), which was jointly capitalised by the three companies, became GNF's subsidiary.

Kazakhstan

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
1	52	-	-	0.091	0.1

Source: IAEA

Kazakhstan has just one Fast Breeder reactor in operation at Aktau, which is a BN 350 design and was the world's first commercial fast breeder reactor in 1973. Proposals are said to be being developed to replace the facility with three VVER 640 reactors. In addition it is said that they are reviewing the VNM 170 modular FBR.

Currently, the facility contributes very little to the country's electricity supply and is more of a research facility. A number of countries, including France, Japan and the UK have given grants or expressed an interest in the work undertaken at the facility.

It has been reported that the head of the nuclear firm Kazatomprom, Mukhstan Dzhakishev, wanted to allow the import of Low Level Radioactive Waste into the country as a source of revenue. It is hoped that this could generate revenue of up to $40 billion.

Korea Rep of

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
16	12990	4	3830	103.50	40.7

Source: IAEA

Republic of Korea, or South Korea, is one of the few countries in the world with what can be described as an active construction program for nuclear power. The country has 16 reactors in operation with a further 4 under construction. Currently approximately 40 percent of the electricity in South Korea is nuclear generated, but that figure will go higher if plans to build thirty to fifty reactors by the year 2030 are realised.

All of South Korea's operating or planned reactors are of Western design, with Westinghouse and Combustion Engineering of the United States being the most visible. However, South Korea also has two operating CANDU (Canadian deuterium uranium) reactors, with another two under construction.

In January 1975, AECL and the Korean Electric Power Company (KEPCO) signed a deal for a 600 MW CANDU. The total cost of the reactor was $576.5 million, of which $430 million was arranged by the Export Development Corporation of Canada. This included a $250 million loan under the Canada Account and $180 million under the Corporate Account. The Wolsong-1 deal was odd in two ways -- first, Korea had not issued a call for international bidding, and second, it was a dramatic shift in nuclear technology for Korea. Their first nuclear power reactor had been a 560 MW Westinghouse Pressurised Water Reactor (Kori-1) ordered in 1970. The reason for the surprising decision is that AECL influenced the decision through bribery. AECL President Lorne Gray had agreed to pay an ‘agent’ (Shaul Eisenberg of Tel Aviv) a fee of $17 million plus another $3 million at a rate of $500,000 a year for six years. Despite the public outcry over this blatant corruption, Eisenberg's ‘commission’ was only reduced to $18.5 million, and AECL retained him to negotiate the sale of a second reactor.

South Korea, the United States, and Canada have also established a tripartite committee to look at reusing uranium and plutonium from conventional light-water reactors in the CANDU reactors. This proposal raises concerns because safeguards have not been developed for uranium and plutonium separated from spent fuel. In order to develop the nuclear fuels needed for this new CANDU system, a new research reactor, the Korean Multipurpose Research Reactor, is scheduled to begin operation in December. According to the Korean Atomic Energy Research Institute (KAERI), this reactor will be used in the development of plutonium fuels (mixed oxide fuels, MOX) for use in light-water reactors and plutonium breeder reactors. It is unclear where the plutonium for these fuels will come from. Additionally, North Korea has accused South Korea of using this reactor as part of a nuclear weapons program. Details about the reactor are not available.

Nuclear waste disposal remains a problem and the Korean Hydro and Nuclear Power Company (KHNP) in June 2001 extended an eight month consultation process for a second time as they had been unable to find a community to host a Low Level Waste facility.

Proposals are currently being developed to privatise the State run energy company, KEPCO. A phased approach is envisaged: -

Phase 1 - Preparation (December 1998 - December 1999)

- Preparation, including legislation, valuation and separation of KEPCO's assets, formation of generation subsidiaries (Gencos) and development of a wholesale power pool

Phase 2 - Competition in Generation (October 1999 - December 2002)

- Privatisation or divestment of KEPCO's generation subsidiaries
- Competition between Gencos in a wholesale power pool (one-way bidding)
- Formation of new distribution companies
- By the end of this phase, commencement of privatisation of distribution companies and introduction of two-way bidding

Phase 3 - Wholesale Competition (2003 - 2009) - Preparation for retail competition

Phase 4 - Retail Competition (After 2009) - Gradual elimination of supply franchises

KEPCO aims to ensure a smooth transition and the introduction of a successful market structure for the Korean electricity industry, thus marking another achievement in its history.

Assuming that this timetable is adhered to, it is hoped that by 2010 the process will have raised $4-7 billion to enable greater investment. It is envisaged that there will be six generating companies, one of which will be the nuclear operator. The generating companies will be privatised in 2002 but the nuclear generator will remain in Government hands.

In December 2000 the Government announced that it would build two more reactors at Wolsong (units 5 and 6) based on the existing PWR design. In the longer-term they envisage the commissioning of a further six reactors by 2015, none of which will be CANDUs. Four of these reactors are expected to be of the new Korean next generation of reactors (KNGP) design, with an estimated capacity of 1400 MW. The Government also embarked on the development of another generation of PWRs, the System-Integrated Advanced Reactor (SMART), which will be built in prototype form by 2007.

The Democratic People's Republic of Korea

In 1994 DPRK concluded an "Agreed Framework" with the United States. In this it agreed to alter its current nuclear power construction program, from two 250 MW gas graphite reactors to two 1000 MW light water reactors. In addition the agreement foresaw the supply of 500 000 tons of fuel oil each year until the reactors become operational. Most of the funding for the $4.6 billion project is expected to come from South Korea ($3.2 billion) and Japan ($1 billion) with smaller contributions from the US and European Union. The deal was designed to reduce the proliferation of nuclear materials as graphite reactors produce more plutonium than light water reactors. However, as a European Parliament report notes, "*It is certainly more difficult to extract plutonium from the spent oxide fuel of LWRs .. but it is by no means impossible nor beyond the skills of the DPRK*"[68]. DPRK will in theory benefit from 2000 MW of new capacity; however, it is suggested by the Parliament report that DPRK does not have grid capacity to deal with the volume of power produced by the reactors. Although it is expected that DPRK will construct the necessary power lines the Parliament report notes "though the chances of a bankrupt country in the throes of a famine managing to do [so] seem slight".

Unsurprisingly the project is already delayed, up to seven years, and the reactors are not expected to be completed until 2010. There has been serious congressional scepticism and criticism of the Agreed Framework in the United States. The new U.S. administration does not fully endorse the agreement and implementation may be further delayed, if not abandoned. Congressional pressure is already being brought to bear on various aspects of the pact, slowing funding required to purchase heavy fuel oil for North Korea, and constraining U.S. Nuclear Regulatory Commission safety training and regulation assistance for Pyongyang. Further key parts for the reactor cannot be transferred until the United States and North Korea negotiate an Agreement for Nuclear Co-operation. Such a pact already faces considerable opposition in Congress and may take years to negotiate and approve, further delaying implementation of the Agreed Framework. In June 2001, the International Herald Tribute reported that North Korea had threatened to resume building its old nuclear reactors due to delays.

Advisors to President George W Bush are reported to be reconsidering the whole program as they are becoming increasingly concerned over the proliferation risk of the proposed LWR reactors. A bill was introduced into the US Congress to redirect US funding into the program away from nuclear and into coal fired power stations.

[68] Report on the Agreement on terms and conditions of the Accession of the European Atomic Energy Community to the Korean Peninsula Energy Development Organisation (KEDO) (C4-0483/97) Committee on Foreign Affairs, Security and Defence Policy Rapporteur: Mr Leo Tindemans, 26 February 1999 A4-0104/99

Lithuania

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
2	2370	-	-	8.40	73.68

Source: IAEA

Lithuania is host to the world's largest nuclear reactors, at Ignalina, where two RBMK 1500 MW models are located. These are the only RBMKs of this size in operation anywhere in the former Soviet Union. Initially four reactors were planned at Ignalina but only two were completed. Construction of the third reactor was halted in 1989, due to public opposition and in 1993 dismantling of the structure began. Ignalina was built as a regional reactor in the time of the Soviet Union and was largely operated and controlled by Russians. Following the political changes Lithuania assumed ownership of the reactors on 27^{th} August 1991. The reactors supply nearly 80% of Lithuania's electricity. In 1993, the reactors contributed nearly 90% of the country electricity, the highest share of nuclear electricity ever recorded in a country. The peak in domestic consumption correlates to decreases in electricity export for political and financial (lack of payment) reasons.

In February 1994, Ignalina became the second site to receive funding from the NSA, when an agreement for an ECU 35 million project was signed. The project involved the introduction of a number of short-term safety upgrades in the following areas: new reactor trip signals; fire protection devices; a training simulator; and environmental monitoring equipment. The parties also agreed that the lifetime of the Ignalina units would not be extended by the replacement of the fuel channels. At the time of the agreement it was expected that unit 1 would be closed prior to 2004.

As Ignalina was built as a regional reactor, its capacity is too large for Lithuania. Even today a large percentage of the reactor's output (about 70% of one unit) is used for export,. This electricity is sent to Belarus, the Baltic States and Russia. However, cash payments for the electricity export is low either because of non-payment or because the contracts involve barter. In the case of Belarus, part of its electricity payments ($32 million worth of electricity in 1999) is met by the Russian supply of fuel to Ignalina. Thus the operator and Lithuanian Government are keen to export electricity to other countries, in particular to Western Europe, to increase the cash payment and price for the electricity.

In February 1999 EU officials told the Lithuanian Economy Ministers that if Lithuania did not close Ignalina by 2005 then it could not begin negotiations to join the European Union. Prior to the EU summit in Helsinki in December 1999 closure dates for both units were agreed, reactor 1 by 2005 and 2 by 2009.

Recent reports suggest that the Lithuanian Government wish to extend the life of unit 2 and are considering operating the reactor until 2012-15. It is unclear how serious these intentions are, and this may only be clarified prior to the 2005 decision of the reactor's closure date. The incoming Prime Minister, Rolandas Paksas, said in November 2000 that his government would fight to save Ignalina from closure.

Mexico

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
2	1360	-	-	7.92	3.86

Source: IEAE

Mexico is a net exporter of energy (crude oil), but with 90% of its energy use dependent on hydrocarbons, oil and gas, it has recently being trying to diversify. The National Commission for Nuclear Energy (CNEN) was established in 1956. Electricity generation is the responsibility of Federal Electricity Commission (CFE). In early 1969 CFE invited bids for a 600 MW nuclear power plant. General Electric was awarded the contract in 1972, with construction of the Laguna Verde power plant beginning in 1975. Two 654 BWRs were built at the site, with unit 1 completed in 1990 and unit 2 in April 1995.

The last national energy plan was outlined in 1990 and does not envisage the construction of any more nuclear power plants.

A repository for low and intermediate level nuclear waste exists, but is expected to be closed soon. High level waste – in the form of spent fuel – is currently stored at the nuclear power plant. It is proposed to construct a repository for its disposal, but this has not occurred to date.

International experts have questioned the safety of the power plant. In 2000 a report by the World Association of Nuclear Operators was leaked. Analysis of the report by the Union of Concerned Scientists suggests that there were very serious safety implications from the problems documented. As a result of the report’s release an independent safety review panel was established.

Netherlands

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
1	449	-	-	3.70	4.0

Source: IAEA

The Dutch energy market is rapidly heading for full liberalisation. In the electricity sector full liberalisation is envisaged in 2004. The country has only ever had two nuclear power plants, Dodewaard and Borselle.

Dodewaard

This started operation in 1969 and was a 56 MW Boiling Water Reactor. In 1992, it was envisaged that the plant would close in 1995 due to the lack of an adequate safety report and inadequate public consultation. After a revised consultation process and further discussions with plant operators and designers, the reactor was given a temporary operational license. However, it was finally closed in 1997.

Borssele

This started operation in October 1973 and is a 452 MW PWR. In November 1994 the Parliament decided that the reactor should close by 2004, by a slim margin of 77-73 votes. An opinion poll conducted at the time also showed that 80% of the Dutch population was opposed to nuclear power. However, from 1997 a $230 million retrofitting program was begun. Some believe that with this upgrading program the operation of the reactor can be extended until at least 2007. A court will rule in September 2001 whether or not the Government can insist on the 2004 closure date, as the Dutch utility EPZ says that they are not contractually bound to close the facility.

Once Borssele is closed the balance in the European Union between nuclear and non-nuclear countries will shift: eight of the current EU Member States will be non-nuclear. The Netherlands will join Italy as the only country to have abandoned a nuclear power programme.

Both Dutch utilities operating nuclear power plants have had reprocessing programmes for their spent fuel. The Dodewaard fuel was sent to Sellafield in the UK. Starting in the 1970s, the operator of the Borssele reactor signed three reprocessing contracts with the French company COGEMA. These contracts cover the period 1970-2010. Due to the imminent closure plans of the country's remaining reactor, there is no plan to use Mox Fuel. It has been estimated by WISE-Paris that if all the reprocessing contracts are honoured it will result in 1.67 tonnes of plutonium being separated. 670 Kg has already been used in the European fast breeder program, but the final destination or use of the remaining 1 tonne is unclear.

Pakistan

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
2	425	-	-	1.08	1.65

Source: IAEA

In Pakistan, nuclear power is insignificant in terms of total energy production and requirements, supplying only 1.65 percent of the country's electricity. It has one small (125 MWe) Canadian PHWR nuclear power reactor from 1971 which is under international safeguards, and a 325 MWe PWR supplied by China under safeguards, which started up in March 2001. A third one, a Chinese PWR, is planned. Enriched fuel for the PWRs will be imported from China.

In 1964 an agreement was made between Canadian General Electric and Pakistan to build a 137 MWe CANDU reactor near Karachi. The reactor, known as the KANUPP (Karachi Nuclear Power Project) cost $63 million, $51 million of which was financed by Canada. Half came as external aid at 3/4% interest over 40 years, with 10 years' grace; the other half at 6% over 15 years with 5 years' grace. Canada ended nuclear co-operation with Pakistan on January 1, 1977, shortly after its December 1976 decision that nuclear trading partners with Canada must sign the Non Proliferation Treaty. Loan payments continued despite the end of nuclear co-operation between Canada and Pakistan.

Pakistan's concentration is on weapons technology, particularly the production of highly enriched uranium suitable for nuclear weapons, utilising indigenous uranium. It has at least one small centrifuge enrichment plant. In 1990 the US Administration cut off aid because it was unable to certify that Pakistan was not pursuing a policy of manufacturing nuclear weapons. In 1996 USA froze export loans to China because it was allegedly supplying centrifuge enrichment technology to Pakistan. Indian opinion is in no doubt about Pakistan's nuclear weapons capability.

Pakistan has made it clear since early 1996 that if India staged a nuclear test it would immediately start assembling its own nuclear explosive device. It is now assumed to have enough highly-enriched uranium for up to 40 nuclear warheads.

In April 1998 Pakistan test-fired a long-range missile capable of reaching Madras in southern India, pushing home the point by naming it after a 12th Century Muslim conqueror. This development removed India's main military advantage over Pakistan.

Pakistan's security concerns derive from India's possession of a nuclear weapons capability, Indian development of short and intermediate-range missiles and, since their partition in 1947, its defeat by India in two of three wars, notably in East Bengal, now Bangladesh.

Romania

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
1	650	1	650	5.05	10.86

Source: IAEA

In Romania there is currently one CANDU-6 reactor operating at Cernavoda, which is 180 km east of Bucharest. The reactor is designed and part built by Atomic Energy Canada Limited (AECL) and is the only one of its kind operating in Europe. Negotiations surrounding the sale of reactors from Canada to Romania began in the late 1970s, with the signing of a licensing agreement between AECL and the Romanergo. In 1979 a framework agreement was signed for the construction of five reactors at Cernavoda, but detailed agreements were initially made only for the first reactor. The Canadian export credit agency – Export Development Corporation (EDC) – were scheduled to loan \$680 million and a consortium of banks a further \$320 for the first five reactors. However, the loan was not fully dispersed and was suspended in June 1982 having only allocated \$176 million. In August 1983 this suspension was lifted but due to the already large national foreign debt only \$237.4 million of the \$ 1 billion was taken up.

Despite the lack of foreign funds, over the next decade construction went ahead without significant input from AECL. In early 1990 the nuclear regulator in Romania suspended the licenses of the Romanian contractors and equipment suppliers for Cernavoda. In January 1990 the nuclear authority – the State Committee for Nuclear Energy- was abolished and the newly created Romanian Electricity Authority (RENEL) became accountable for the whole of the country's energy program. The Nuclear Power Group (GEN), a department of RENEL, assumed responsibility for the nuclear power program. In 1991 RENEL contracted AECL and Ansaldo of Italy to head a consortium to manage the completion of Unit 1 at Cernavoda. As a result, a review of the existing structures took place, which led to the replacement of a substantial amount of the equipment. In February 1992, EDC provided a second loan of \$283.7 million, which was matched by \$150 million from the Italian Financial Institution, Medio Credito Centrale. At this time the reactor was expected to be completed in December 1994. However, delays occurred and as a result in March 1995 the Industry Minister sacked the head of RENEL and its entire Board of Directors. Eventually, the loading of fuel into the reactor's core began in May 1995, but due to further technical problems, criticality – the start of the chain reaction inside the core - was not reached until April 12th 1996. The Canadian Prime Minister officially opened the plant on April 24th 1996.

The second reactor is under construction and in May 2001 commercial contracts were signed between the Romanian Government and the Canadian and Italian Ambassadors in Bucharest to complete the power plant. The funding of the project is proposed to come from Romanian sources and the EU's Euratom loan facility, with additional funds being secured using the Export Credit Agencies from Canada and Italy. Each institution's share of the funding has not yet been finalised.

The third, fourth and fifth reactors at Cernavoda are officially no longer under construction. Their relative states of construction are unit 3 (12%), unit 4 (5%) and unit 5 (3%).

Russia

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
29	19843	3	2825	119.65	14.95

Source: IAEA

Nuclear power contributes 15% of the country's electricity supply. Over the past few years nuclear's contribution to the overall electricity supply of the country has gradually increased, as efficiency has improved and other generators have been closed down. However, the level of nuclear power falls far short of that envisaged. In 1985, before the Chernobyl accident, Soviet planners assumed that by 2000 nuclear power would contribute 20% of the country's electricity. During the 1990s only two reactors were completed, Smolensk 3 and Balakovo 4. In March 2001, Rostov 1 was completed. There are currently three reactors under construction, Kalinin 3, Kursk 5 and Rostov 2. Kursk 5 is an RBMK (Chernobyl style reactor) which was started prior to the accident in 1985. Kalinin 3 was ordered in 1985 and Rostov 2 in 1980. The Ministry of Nuclear Energy in Russia (Minatom) have announced that they wish to see Kursk 5 completed in 2003 and Kalinin 3 in 2005. Since the Chernobyl accident no reactors have been ordered – although reports continue to suggest that a new generation of reactor, the VVER 640, is being slowly built at Sosnovy Bor. The operating reactors in Russia break down into the following designs: -

- 4 VVER 440-230s
- 2 VVER 440-213s
- 7 VVER 1000-320s
- 11 RBMKs
- 4 Graphite moderated BWR reactors
- 1 Fast Breeder Reactor

There are 15 reactors of VVER 440-230 or RBMK in operation that the international community wishes to be closed due to their design deficiencies. However, the Russian Government is not preparing closure plans and is undertaking major overhauls of its RBMK fleet (re-channeling) to allow the reactors to operate for up to 40 years. Despite the disagreement over the objectives of nuclear safety, Russia continues to receive significant funds from the EU, EBRD and bilateral sources to improve nuclear safety in the country. Approximately 40% of all funds allocated for nuclear safety in CIS and CEE go to Russia. It is estimated that approximately $800 million in grants have been awarded since 1991.

Minatom is reported to have an ambitious new construction program. They wish to see nuclear power plants producing 220 TWh of electricity by 2010 and 350 TWh by 2020– nearly three times the current production level. Minatom is proposing that a variety of new reactors should be built, including the VVER 640, a new generation of fast breeder reactor and even floating reactors. In March 2001, Minatom announced that they would soon begin the construction of Beloyarsk 4, BN 800. Minatom expect that this will be completed by 2009 and cost $1.2 billion. The first floating reactor is expected to be operational by 2005, at a cost of $108 million. A number of other reactors, in addition to those recognised by the IAEA, are said to be under construction, including that at Kostroma. To fund these expansion plans Minatom has a number of initiatives to generate income. These include waste import and electricity export.

<u>Waste Import</u>

In 1995, the Russian Government passed three decrees affecting the return of spent nuclear fuel to Russia. As a result, under Russian Environmental Law it is only possible for spent fuel to be accepted into Russia for the purposes of reprocessing after which all waste must be returned. However, in 2000 Minatom began preparing a proposal to overturn this 1995 Law. At the time of the launch of the new Law, Minatom claimed that the change would fund the further development of nuclear energy.

The revised legislation has been approved by the Lower House of the Russian Parliament and was approved by President Putin in June 2001. However, there was a procedural mistake in adopting these Laws as they were not considered by the Council of Federation (Upper House of the Parliament), which is required for all laws which relate to "customs regulations". If the law is enacted it will open the way for Russia to become a site for the world's nuclear waste. In the past a number of companies from around the world, such as Taiwan and Switzerland, have expressed an interest in exporting their radioactive waste.

<u>Electricity Export</u>

The Russian electricity system is controlled by the majority state-owned Unified Energy Systems (UES), run since May 1998 by Anatoly Chubais. UES controls 70% of the country's distribution systems and oversees Russia's 72 regional electricity companies and the fossil fuel power plants. It is widely recognised that between $6-11 billion per year of investment is needed in Russia's electricity sector until 2005, to carry out existing expansion and modernisation plans. However, with continual problems of non-payment, raising capital on the international markets is difficult.

According to the United States Department of Energy, Russia has the potential to export between 100-150 TWh of electricity per year. Furthermore, in 1999 Russia signed 16 bilateral agreements, mostly with Western countries, but also with private energy companies in Poland, the US, Switzerland and Japan. UES has a number of projects, which it claims it is interested in developing further. These include:

- Increasing Export to Central and southeastern Europe via Ukraine.
- East-West Power Bridge.
- Increasing export to the countries of Central and Western Europe through power grids of Belarus, Ukraine, and Poland
- Less developed projects for export of electricity to Japan and China

Plans have been approved by Minatom to extend the operating lives of all their VVER 440 reactors. This would enable their proposed replacement with a third generation of VVER plants (VVER 640) to be delayed.

Slovak Republic

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total Electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
6	2408 2640	-	-	16.49	53.432

Source: IAEA

Slovakia has two nuclear power plants, Jaslovske Bohunice and Mochovce. Bohunice has four operating nuclear reactors and Mochovce has two.

<u>Bohunice</u>

Outside of Russia, Bohunice was the first nuclear power plant within Eastern Europe and the NIS. In 1958 construction started on the A-1 reactor. This was a gas cooled heavy water reactor that began commercial operation in 1972, but was closed in 1977 following a partial meltdown of the core. The plant is still awaiting decommissioning.

The V-1 reactors have a nominal design life of 30 years and therefore are expected to close in 2008-12. These reactor designs are classified as first generation and as such are targeted for early closure by the International community. As part of the agreements for the proposed funding of the completion of the Mochovce nuclear power plant (see below for further details), the Slovakian Government signed a resolution on the 14th May 1994. This committed Slovakia to closing V-1 as soon as Mochovce entered commercial operation, or by the year 2000 at the earliest. Despite this, in April 1999 the Government formally announced that the 2000 closure deadline had been abandoned and that the reactors would operate as long as they were safe. No alternative plan for closure was drawn up. The Government also argued that an increase in electricity demand in Slovakia made the closure of the reactors impossible. In reality, however, Slovakia started in 2000 to export electricity, mainly to the Czech Republic and Hungary, and this export has significantly increased in 2001.

Between 1991-3 V-1 was subject to what has been called a small backfitting program. This involved the implementation of 81 safety measures and cost around 2 billion Slovak Koruna (Sk) (45 million Euro). The program continuously passed into the big backfitting program (so-called gradual reconstruction) which started in 1993 and finished in June 2000. The reconstruction was done by the consortium of Siemens and VUJE, Slovak Nuclear Research Institute. Its costs increased by 30% and finally reached 8.5 billion Sk (200 million Euro). As part of the accession process negotiated in the run up to the Helsinki EU Summit in 1999, agreement was reached on the closure of Bohunice V-1, by 2006 (1st reactor) and 2008 (2nd reactor). However, even these dates look unlikely, with respect to the enormous pressure of plant operator, Slovak electricity utility (SE) and decision-makers in Slovakia. In July 2001, Slovak Nuclear Regulatory Authority agreed with the V-1 further operation after the large backfitting program has finished, stating the V-1 operational safety "is good, comparable with nuclear units of the same vintage operated in the developed Europe countries". The IAEA performed several missions and consultations to Bohunice during 2000-01 and backed up the Slovak government in its decision to keep the plants operating. At presence, the backfitting programe of the V-2 reactors is being starting which should extent its life time up to 2025, i.e. by 10 years longer then originally anticipated.

Mochovce

Construction started in 1982 but gradually stopped in 1990 due to a lack of funds, at which time there were four reactors under-construction. In 1991 the Czechoslovakian Government asked the EBRD to consider funding completion of units 1 and 2. In 1992 Electricité de France (EdF) began an extensive audit of the existing plant infrastructure and equipment with the Slovak electricity utility (SE). Bayernwerk AG also became involved in the project and proposed that they provide funds, expertise and a completion guarantee to finish Mochovce to international safety standards.

In May 1994 the project sponsors made a formal request that the EBRD and one of the potential co-funders Euratom consider financing the completion of units 1 and 2. The project sponsor was a company called EMO a.s. which was jointly owned by SE and EdF. EdF had control over the company with 51% of shares; it was proposed that EMO might later also include the Russian Ministry of Atomic Energy (MINATOM) and Bayernwerk. EMO was to repay the loan by leasing the plants to SE once the project was complete. The estimated cost of this project was some 1.4 billion-DM. The funding for the project was expected to come from a variety of national and international sources including the EBRD/Euratom, French and Germany Export Credit Agencies and the Slovakian Government. Despite opposition from outside and inside the EBRD, the Bank's Board of directors was scheduled to discuss and vote on the project in March 1995. A number of countries, led by Austria, were expected to vote against the project. However, a week before the Board discussion the Slovakian Government asked for the project to be suspended. The project was formerly withdrawn from the Bank on the 5th September 1996. The Slovakian Government removed the project because it claimed that it found the conditions that the EBRD and other Western funders were placing upon them "unacceptable", and that more advantageous contracts were possible.

Towards the end of 1995 a second series of financial and construction consortiums was prepared which were eventually to complete Mochovce. The new consortium was reportedly able to complete the project for 1.1 billion DM (about 24 billion Sk), 30% less than the previous estimate. The new consortium included French, German, Czech and Slovak banks, and included export credit guarantees from their governments. The general contractor for the project completion was Czech Skoda with Siemens and Framatome delivering safety equipment. EdF also became involved as in June 1996 they signed a technical assistance and co-operation agreement with Mochovce. Despite the originally stated costs, the completion finished at minimum 34 billion Sk (about 1.6 million DM).

In April 1998 the first fuel was loaded into unit 1 of Mochovce. SE claimed that the safety standard of the reactor was based on analyses from the IAEA and the IPSN/GRS joint venture Riskaudit and that 70% of the measures recommended had been implemented. The operation started in August 1998. The second unit was initially scheduled for completion in April 1999, but was delayed until December.

In November 1998 Economy Minister Ludovit Cernak visited Mochovce and said that the third and fourth reactors of the Mochovce should not be completed. After hard fight inside the country (State administration, political parties, economic-political lobbies, NGOs) in April 2000, the Slovak Government approved the resolution stating that it does not agree with providing of the State guarantee in any form to the Mochovce 3-4 completion. With respect to the SE financial situation this practically means the project cancellation. However, the strong lobbies are still pressurising decision-makers to change the Government decision. The strongest opposition parties HSDZ (of former Prime Minister Meciar) and Smer have announced to possibly reconsider this decision when they will win the 2002 elections.

Slovenia

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
1	676	-	-	4.54	37.38

Source: IAEA

Slovenia has one Westinghouse 632 MW reactor situated on the banks of the Sava River, 75 km from Ljubljana located at Krsko. Krsko is in a unique position in that it is owned jointly by two countries, Slovenia and Croatia, each having a 50% stake, with each supposed to receive half the electricity produced. In 1974 an agreement was signed between Elektroprivreda of Croatia and Savskega elektrarne of Slovenia giving each partner the right to 50% of the electricity produced and making legal provisions in the event that either partner withdrew or caused delays in construction. In December 1974 Josip Tito laid the first symbolic parts of the foundation. Despite the reactor going critical in September 1981, commercial operation was not achieved until 1983, due to regulator and technical problems.

Since its operation, two significant safety reviews have been undertaken at the plant. The first was the International Commission for Safety Analysis of Nuklearna Electrarna Krsko (NEK – the reactor's owner and operator). The Commission was paid for by the governments of Austria, Italy and Slovenia and published their report in 1993. This made 74 recommendations on technical and procedural changes required to increase the safety operation of the plant, which were made mandatory by the Slovenian authorities. In 1994 a program was undertaken to assess whether the reactors conformed to the US NRC requirement of 1973. At the end of 1995 degradation of the two steam generators was detected and led to a decision to replace them. Delivery of the Siemens/Framatome replacement units occurred in 2000 and cost 205 million DM ($115 million). NEK undertook a 6% power uprate (45 MW) along with the new steam generators.

The Slovenian Government has a long-term policy of phasing out nuclear electricity and it is therefore not anticipated that any more nuclear power plants will be constructed. In October 1995 a proposal in the National Assembly calling for a referendum on the shutdown of Krsko was defeated following the withdrawal of support by the Liberal Democracy of Slovenia Party.

In 1998 a dispute occurred over the non-payment of bills – especially the surcharge for decomissioning and waste disposal - and the tariffs being charged by NEK to the Croatian utility. This led in early August to NEK cutting the 300 MW of supply to Croatia and the subsequent export of electricity from Slovenia to Italy. However, the dispute over commercial arrangements is a small part of a much bigger dispute. In July 1998 NEK announced that it planned to finance the replacement of the steam generators by itself and declared that the Croatian utilities did not own half of Krsko. However, in July 2001 an agreement appeared to have been reached by which a 50:50 split in ownership was confirmed with a similar division of costs and output.

South Africa

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
2	1800	-	-	12.99	6.58

Source: IAEA

South Africa has two French (Framatome) built reactors. Construction started in the 1970s and they are both at the Koeberg site, east of Cape Town. The reactors are the only operating reactors in the African continent.

The main points to note about the nuclear program in South Africa are:

- that it formerly developed nuclear weapons and then abandoned its program.
- the current discussions about the construction of a new generation of reactor, the Pebble Bed Modular Reactor (PBMR). There is global interest in this design of reactor, in particular in the United States. Although currently unlicensed, it is said by some to be the design for the new generation of reactors.

The PBMR are much smaller reactors, around 100 MW each, and have been called "pocket reactors" by their promoters. By being smaller it is proposed that they can be built in series, the objective being to fit load requirements more flexibly. There is considerable international interest in the reactor design and BNFL has invested $15 million to obtain a 20% equity stake in the enterprise. Peco Energy of the US has acquired a 20% stake.

In March 2001 a contract was awarded for the further development of the design to Nukem Nuclear of Germany, BNFL and Engineering Management Services of South Africa. If all goes according to plan, construction on a pilot reactor will begin in mid 2002 with operation by 2005. This timetable appears extremely ambitious and concerns have been raised about the speed at which the reactor's design is being introduced. In May 2001 the International Nuclear Safety Advisory Group (INSAG) stated that it had 'some misgivings' over the 'rushed' safety evaluation that might lead to compromises on safety.

During the first part of 2001 proposals for the restructuring and privatisation of parts of the country's Nuclear Energy Corporation were being finalised to be presented to the Cabinet for approval. If adopted the proposal will see the current organisation divided into two. The Pelindaba Nuclear Institute and the research reactor, Safari-1, would remain state owned. The commercial activities would be corporatised and eventually privatised. It is anticipated that it would take at least 18 months to prepare the new company for privatisation, at a value of between 120 and 150 million Rands

Spain

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
9	7512	-	-	59.30[69]	27.63

Source: IAEA

Spain's nuclear program began under the Franco regime and the first law on nuclear power was established in 1964. Construction on the country's first nuclear power plant began in 1965 at Zorita. Currently there are nine commercial power plants, with a design output of 7,400 MWe.

The only reactor to have closed is Vandellos 1, which was the site on 19 October 1989 of Spain's worst accident involving nuclear power. A fire broke out in the turbine room, which resulted in the operating license being suspended pending the outcome of an inquiry. When the results were published in the following spring, the regulator called for 15 significant changes to the plant. The Industry Ministry declared that the implementation of these measures would have to be paid for by the owner of Vandellos and not the taxpayer. The owner decided against this investment and in May 1990 the industry minister announced the permanent closure of the reactors.

As in the United States in the early 1990s, there are a large number of owners of nuclear power plants, with ten separate companies having at least part ownership in one reactor. The Government in Spain is moving ahead with the liberalisation of the country's power sector, and requiring must faster and broad reaching change than that required by the EU's Electricity Market Directive.

Currently there are only four electric utilities: ENDESA, IBERDROLA, UNION FENOSA, and HIDROCANTABRICO. Two big ones: ENDESA and IBERDROLA (that control about 80% of the sector), and two small ones. All of them are active in the international market for power companies. In 2000 ENDESA and IBERDROLA proposed a merger. However, the merging process was aborted by the IBERDROLA Administration Council after being informed of the restrictive conditions imposed by the Government (in particular they would have been forced to sell an important number of facilities, to create new operators and "increase" competition). It was in this process that ENDESA announced that it would sell its shares in ALMARAZ I and II and TRILLO nuclear power plants.
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After this merger failed, the Government stated that there should be at least 5 electric utilities operating in the Spanish sector to assure adequate competition. In this context, ENDESA announced that (in order to facilitate the creation of a 5th operator) it would sell its shares in a number of power plants (coal, hydro, nuclear). If this occurs it will be the first time in Europe that nuclear power capacity had been put up for bids on the open market.

A decision by the high level Ministerial Council in October 1983 resulted in the halving of the original nuclear generation program from 10,535 MW to 5,725 MW. Then in May 1991 energy minister Claudio

[69] This figure is provided by the IAEA, but varies from that provided by Red Electrica Española (REE, the Spanish grid operator) in its annual report about the Operation of the Electric System in year 2000, whereby nuclear production in 2000 was 62.1 TWh, accounting for between 37.9 and 31.7% of electricity depending if international exchange is included.

Aranzadi announced that no new nuclear plants would be commissioned before 2000. A new electricity planning law passed by the Spanish Parliament (Cortes) in 1995 led to the definitive cancellation of the five nuclear plants whose construction had been frozen by the Socialist government in the 1984 moratorium.

In November 1998 Environment Minister Isabel Tocino presented a plan to Parliament to combat climate change. It was endorsed by Spain's National Climate Council in December 1998, and called for an extension of the operational lives of the existing nuclear plants. There is currently no fixed operating life for the reactors, rather the regulator grants renewals of the operating license. Initially these renewals are every two years, but can be extended for five or even nine years.

Sweden

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
11	9432	-	-	54.80	39.0

Source: IAEA

The country's first nuclear power station Oskarshamn 1 was ordered in 1965 and began commercial operation in 1972. It was the first LWR to be built in Europe not under license from a US vendor. Over the next fourteen years eleven more reactors were constructed and began operating.

Following the accident at Three Mile Island in 1979, there was a referendum on nuclear power in 1980. This resulted in a proposal to only operate the reactors as long as their operating life – at that time it was assumed to be 25 years. Parliament adopted the results of the referendum, banned the construction of any more nuclear power plants and assumed a complete phase-out would occur by 2010. Following the referendum insufficient planning was undertaken and few steps were put in place to begin the phase-out. In 1995, a Government sponsored report concluded that a phase-out of nuclear power by 2010 would be economically and environmentally unfavourable. Instead they proposed to start the phase-out in 1998.

The current Prime Minister Goran Persson, said in March 16 1996, upon accepting his party's nomination to head the Social Democrats "I would like to make Sweden into a model country for ecologically sustainable development. A new energy system is a precondition for a sustainable Sweden. It is from that perspective the decision to close down nuclear power stations must be seen. For me it is not some political relic from the beginning of the 1980's. On the contrary it is a commitment and it is a challenge which can strengthen Sweden." Then in March 1997 the Government proposed legislation, which was ratified in June 1997, to close Barseback 1, by July 1998, with the second unit to close three years later. Sydkraft failed in an appeal to the Supreme Court to overturn the decision, but was allowed to operate the reactors until November 1998. As compensation the state-owned Vattenfall transferred an interest in the Ringhals plant to Sydkraft. The twin unit Barseback-2 will continue operation under a new joint production company: Ringhals-Barseback, in which Sydkraft will have a 25.8% share (though Barseback-2 contributes only 14.5% of the capacity). If a decision is taken to close the reactors, Sydkraft will receive an increased share of the Ringhals plant. In April 2001, the Swedish Prime Minister said that the 2003 closure of Barseback 2 would only occur if replacement power were available.

As part of the discussion on the future of nuclear power an inter-political party agreement was concluded in December 1997, which decided that, the final 2010 date for closure of all reactors would no longer be applied. In other words, the government now considers that the technical life of a power reactor is 40 years, as opposed to the 25 years assumed at the time of the original phase-out legislation.

Switzerland

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
5	3192	-	-	24.95	38.18

Source: IAEA

There are currently five nuclear power plants in operation in Switzerland, which are operated by four separate utilities. The oldest is Beznau 1 which became operational in 1969. The others are Beznau 2 (1972), Muhleberg (1972), Gosgen (1979) and Leibstadt (1984).

In 1990 there was a referendum which rejected a phase-out of nuclear power, but placed a moratorium on the construction of new nuclear power plants for 10 years. In October 1999 the federal energy minister confirmed the plan, that any future construction of nuclear power plants should be put to a referendum. At the same time the Government announced that Muhleberg would be given an extension of its operating life, to allow it to function until 2010.

In February 2001 the Government sent a revised Atomic Energy Law to Parliament for approval. The main elements of the law are: -

- There should be no set limits on the operating lives of the country's reactors.
- That reprocessing of spent nuclear fuel should be banned once the existing contracts have expired.
- Transport by air of material containing plutonium should be banned.
- All Swiss nuclear operators should be required to make additional payments into a central nuclear waste disposal fund.
- Construction of new nuclear power plants will require approval from a national referendum.
- Licensing procedures will in future be co-ordinated centrally, with objectors having the chance of recourse to an independent court.

Currently Swiss electricity utilities have signed reprocessing contracts with French and British companies. The total amount of fuel to be reprocessed is between 1,000 and 1,100 tonnes, which corresponds to about one third of the total quantity of fuel produced by the five power plants. Plutonium is fabricated into Mox and is burned at Beznau (1 and 2) and Gosgen reactor. However, the limited use of Mox fuel will not use all the Swiss plutonium separated.

Towards the end of 2002 two further referendums on the future of nuclear power will be held.

The first (Strom ohne Atom) demands a phase out of nuclear energy (Beznau I and II and Muehleberg within two years, Leibstadt and Goesgen after a lifetime of 30 years). That would mean that Leibstadt would be the last nuclear power plant to be shut down, in 2014. Furthermore the referendum demands the immediate ban on reprocessing and greater support of renewable energy. It will also require public approval for nuclear waste storage facilities

The other (Moratorium plus) requires a moratorium on new nuclear power plants for the next ten years and demands among other things a public referendum on plant life extensions after a life time of 40 years.

Taiwan

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
6	4884	2	2600	37	24

Taiwan has six operating reactors: four built by General Electric, which are BWRs, and two built by Westinghouse, which are PWRs. The reactors are located in pairs at three sites, Chinshan (BWR), Kuosteng (BWR) and Maanshan (PWR). Two of these power stations are located close to Taipei. All the reactors are owned and operated by the Taiwan Power Company.

Two more reactors were ordered in March 1999. These reactors, to be located at Lungmen, were at the time of order said to cost $5.3 billion and are of the Advanced Boiling Water Reactor design, being built by General Electric – two similar reactors are in operation in Japan. The reactors were scheduled to be completed by 2006. However, in October 2000, the Premier Change Chun-Hsiung, stated, *"For the sake of the future generations of Taiwan… we halt the construction of the new Nuclear Power Plant number 4"*[70]. In making his announcement the Premier cited both a lack of urgent need for new power plants and the expected liberalisation of the power sector encouraging construction of additional power plants. Finally, it was said that the production of nuclear waste and the threat of an accident made nuclear power environmentally unacceptable for Taiwan. The Premier of Taiwan announced that for the sustainable development of Taiwan the country must become nuclear free.

However, in February 2001 the decision was overturned, as the Parliament had not been adequately consulted. The Parliament subsequently passed a resolution that called for investigations into the actions of the Premier and Minister for Economic Affairs. The three month suspension was said to have caused a ten month delay in the expected completion date of the reactors, as a number of contractors were unwilling to return to the project due to political differences.

Further legal challenges against the plant cannot be ruled out, especially some relating to environmental and safety concerns. Further complications may arise as environmental activists claim that the site could be of special importance to the indigenous Katagalan culture.

Nuclear waste is also an issue, especially the disposal of low level radioactive waste. Originally, the proposal was to build a facility at Orchid Island. In the face of opposition, alternative proposals were investigated to export the waste first to North Korea and then to Russia. The likely changes in the Environmental Law in Russia, which will allow the import of radioactive waste into the country, may allow a preliminary contract to be finalised. According to documents dated May 19th 1998 200 000 barrels of waste will be shipped to Russia via Japan over 10 years. Taipower will pay $800 million.

[70] The Statement of Premier Chang Chun-Hsiung on Halting Construction of Nuclear Power Plant No. 4 Taipei, October 27th 2000

Ukraine

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
13	11207	2	1900	72.40	47.28

Source: IAEA

What is now known as the Ukrainian nuclear industry was, prior to the end of 1991, controlled from Moscow. On November 1st 1991 the Ukrainian Parliament first took control of the nuclear facilities on its territory and began to install the necessary regulatory and legal framework. This involved the formation of Ukratomenergoprom in 1992 - the state owned nuclear power plant operating organisation. In 1993 the State Committee for the Use of Nuclear Power, Goskomatom, replaced Ukratomenergoprom and became responsible the running nuclear power plants and determining the role of nuclear power in the country's energy program. This was changed again in October 1996 when Energoatom was established, which is now responsible for the operation of all nuclear power plants except Chernobyl. Ukraine is the site of the Chernobyl nuclear power plant, which suffered the world's worst accident involving a nuclear power plant on April 26th 1986. In December 2000, the final reactor at the Chernobyl nuclear power plant was closed. This leaves thirteen remaining operational reactors at four power plants, Khmelnitsky (one operating reactor), Rovno (three), South Ukraine (three) and Zaporozphe (six).

<u>Operating Nuclear Power Plants:</u>

In May 1999 the Accounting Chamber – the Ukrainian Court of Auditors – claimed that Energoatom's status violates the government's decree that created it, because it fails to assume ownership for the power plants. Consequently, Energoatom and therefore the nuclear power plants are infringing on tax and other laws. The other main elements of the Accounting Chamber report were: -

- That Energoatom used 2.2 million hyrnva earmarked for new nuclear units to meet its own administrative needs.
- That Energoatom, the nuclear stations, Goscomatom, and the energy Ministry have failed to pay into the fund for creation of a national nuclear fuel cycle. Between 1994-9, instead of contributing 1.2 billion Hryvna, the power plants only contributed 4.5 million Hryvna to the fuel cycle fund.
- That Goscomatom failed to pay the state budget 361.4 million Hryvna it owed from funds received connected to the compensatory fuel from Russia.

<u>Financial Problems: non-payment of Electricity:</u>

One of the main problems facing Energoatom is the level of cash payment for the electricity it produces. This averaged around 5% during 1998, down from 7% in 1997. Similar levels were recorded for 1999 and most of 2000. In June 1999, the World Bank finally abandoned its $318 million Electricity Market Development Project, which had been suspended for over a year, citing lack of reform in the sector as its rationale. Cash collection is said to have risen significantly in the first part of 2001, although it is unclear how long this will last. The Ukrainian news agency Unian reported in July 2001, Prime Minister Dubina saying that 87.4% of all electricity delivered to consumers at the first half 2001 is paid with 72% of electricity was paid in monetary terms. Money raised is used to pay for coal, fresh nuclear fuel and spent fuel transport to Russia.

It is clear that the past and present financial situation has implications for safety. The Ukrainian Nuclear Society stated in April 1999 that the situation was getting worse and that managers had such funding problems that virtually all safety related maintenance had stopped. Not even all the safety improvements required by law are currently being implemented. In 1997 around $5 million was spent on safety related improvements and in 1998 this had dropped even further to $3 million. As a consequence 1998 saw a 20% increase in incidents at power plants and a decrease in capacity from 71.3% to 66% over the previous year.

In December 2000, the last remaining reactor at Chernobyl was finally closed. The closure largely conformed to a Memorandum of Understanding (MoU) signed between the EU/G7 and Ukrainian Government in 1995, which called for around $US 2.3 billion of investment in the energy sector, through loans and grants as compensation for its closure. These new energy projects were to be based on least cost planning principles. The proposed projects included the completion of two reactors Khmelnitsky 2 and Rovno 4 (known as K2/R4), as well projects for thermal and hydro rehabilitation, pump storage and energy efficiency. Importantly, the MoU does not state that K2R4 will be funded but rather "the investment program will identify least-cost power supply investments to meet Ukraine's future power requirements in the context of a competitive market based sector".

The completion of K2R4 and its potential financiers has involved a long running and highly political discussion. In January 1996, President Chirac of France wrote to the President Larosiere of the European Bank for Reconstruction and Development (EBRD) stating "we [the G7] expect the EBRD's active engagement in securing financing together with the European Investment Bank (Euratom Loans)". However, the EBRD's President was not so keen and appointed an independent Panel to review the economics of the project in September 1996. The international Panel, under the Chairmanship of Professor John Surrey from the University of Sussex, stated "We conclude that K2/R4 are not economic. Completing these reactors would not represent the most productive use of $US1bn or more of EBRD/EU funds at this time". Despite the categorical rejection by the Panel and opposition from senior staff, further analysis was commissioned from Stone and Webster. Their analysis, released in May 1998, concluded that the completion of K2 and R4 by 2002 would be likely to form part of the least cost development program for Ukraine. This result was obtained by using input data provided by the Ukrainian authorities and the Western consultants involved in preparing the project. It is clear that the Stone and Webster Report has a very different starting point from the Independent Panel.

In December 2000, just prior to the final closure of Chernobyl, the EBRD's Board of Directors gave their conditional approval of their $170 million share of the $1.5 billion project. This triggered a similar decision by Euratom, the other international institution involved. However, since then the conditions placed by the EBRD Board have not been met and the loan has not moved forward. Furthermore, a new Government was formed in Ukraine in June 2001 and for the first time Government Ministers have expressed opposition to the project. In March 2001 Energoatom said that they would complete K2R4 without international assistance by 2010-14. In December 2000/1 the project director at Energoatom, Henadiy Szonov, said there were no current plans to complete units 3 and 4 at Khmelnitsky. Furthermore, if these reactors were completed they would not necessarily be VVER 1000 designs, as originally intended, but rather their completion would be put to international tender.

United Kingdom

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
35	12968	-	-	78.30	21.94

Source: IAEA

There are three reactor designs operating in the UK - Magnoxes and Advanced Gas Cooled reactors, both graphite moderated and carbon dioxide cooled, and one PWR at Sizewell in Suffolk. There are no further reactors planned or under construction in the UK. However, the industry has recently been pushing for new nuclear construction and further life extension, using climate change as the basis of their argument that nuclear power is environmentally sound.

The decision to abandon new construction followed a failed attempt to privatise the nuclear power industry along with the rest of the electricity supply industry in 1990. The AGR reactors and Sizewell B were finally privatised in 1996 under the ownership of British Energy, although ownership of the Magnox reactors was transferred to British Nuclear Fuels Ltd (BNFL), and remains in public hands.

The most controversial part of the UK's nuclear industry is undoubtedly BNFL, the owner of the Sellafield reprocessing plant in Cumbria. The controversy surrounding the company has largely centred on its environmental record and performance, although broader safety, economic and proliferation issues have also caused concern. Most recently, concern has focused on the discovery that BNFL had fabricated safety data on MOX fuel rods made for export to Japan. A subsequent inspection of the Sellafield site found that safety levels were '*only just tolerable*'[71]. The company is currently waiting for Government consent to open a new MOX fabrication facility, the Sellafield MOX plant. In May 2001, the German utility E.on signed a preliminary contract for the production of Mox.

BNFL is wholly owned by the UK Government, with the Department of Trade and Industry holding all but one share in the company. The Treasury owns the remaining share. Despite this, BNFL is meant to function as an independent Public Limited Company.

The third major nuclear company in the UK is UKAEA, which owns the Dounreay site in northern Scotland. Although the fast breeder reactors and reprocessing plants are now closed, the environmental legacy of dealing with the resulting nuclear wastes remains. AEA have been criticised for not addressing past mistakes at the site, as well as failing to manage new problems adequately. UKAEA's research and development and consultancy components were privatised in 1996 as AEA Technology.

The industry plans to build deep dumps for much of their low and intermediate wastes. Following the rejection of their application to build the first phase of such a dump in 1997, there are no proposals about where this should be done, or when. Similarly, there are no plans to site or build a dump for High Level Waste in the UK.

[71] Health and Safety Executive Team Inspection of the Control and Supervision of Operations at BNFL's Sellafield Site, HSE/NII, February 2000, http://www.hse.gov.uk/nsd/team.htm

Future Strategies

Increasing competition in the UK's electricity market has led to a change of strategy for British Energy. It has purchased a coal-fired station in the UK and is moving into the emerging offshore wind power market. It is also contracted to operate nuclear power stations in the US and Canada on a lease system. These include the notorious Three Mile Island station. UKAEA and AEA Technology have, by contrast, distanced themselves from operational issues and are concentrating on decommissioning and clean up contracts.

BNFL is the only remaining UK nuclear operator with overt intentions of expanding its nuclear activities. Over the past few years, the company has expanded from a solely UK-based fuel cycle operation to an increasingly global force. Partly this has been achieved through the expansion of its core activities, especially nuclear waste management in the US through BNFL Inc, but it has also bought up other nuclear companies. In 1999, BNFL bought Westinghouse, which has provided nearly 50% of the world's nuclear power plants, either directly or through its licensees. This was followed by the purchase of ABB's nuclear businesses in 2000. These acquisitions mean that BNFL has a strong capability in both the Boiling Water Reactor, and the Pressurised Water Reactor, markets. BNFL has also invested in the South African Pebble Bed Modular Reactor design. BNFL now has offices in 14 countries other than the UK (Belgium, Bulgaria, China, Czech Republic, France, Germany, Japan, Korea, Slovenia, Spain, Sweden, Taiwan, Ukraine and the United States.

BNFL also has reprocessing contracts for its THORP plant at Sellafield with a number of other countries, including Germany, Japan, Switzerland, Spain, Italy, Netherlands and Canada. The contracts include the return of the separated plutonium to the country of origin, although the extent of the return of other nuclear wastes created by reprocessing remains undecided. In addition, Magnox fuel from the exported Italian and Japanese reactors has been reprocessed.

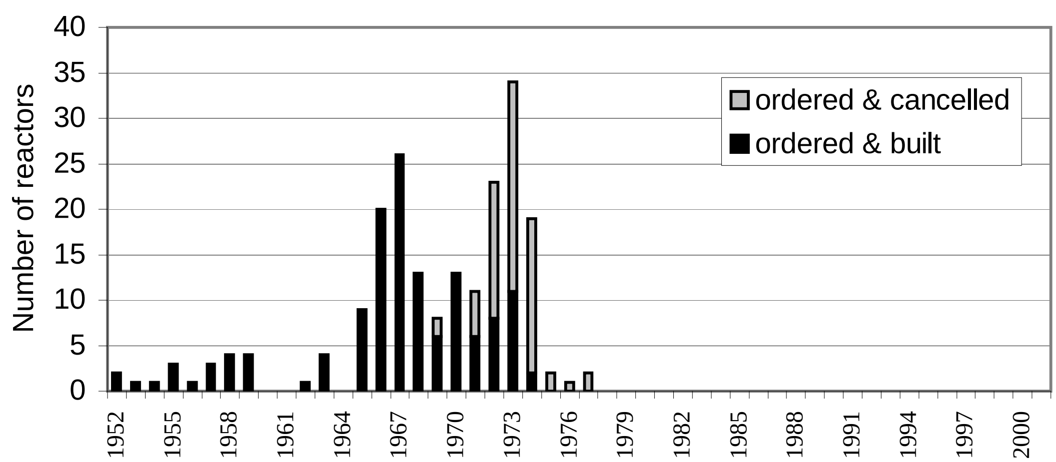
Both British Energy and BNFL are lobbying for new UK reactors. New nuclear construction in the UK would be conditional on some support mechanism: the Government's response so far has been to reassert the position that new construction remains uneconomic at the moment, and state that neither company has yet put forward proposals. However, in June 2001, the Government launched a six-month review of the long-term energy policy which will explicitly consider the future role of nuclear power in the UK. British Energy hopes that this will enable them to build seven or eight new reactors. However, it is unclear what subsidies the Government could give to enable this to occur.

USA

Operating Reactors		Reactors Under Construction		Electricity Produced in 2000 (TWh)	% of total electricity Produced
Number	Installed Capacity (MW)	Number	Installed Capacity (MW)		
104	97411	-	-	753.90	19.83

The United States has the largest number of operating reactors in the world - nearly a quarter of the global total. Despite this, for a number of years the US has not been perceived as strongly committed to nuclear power. This is because although there is a large number of operating reactors, the number of cancelled projects (119) is even larger. It is now 21 years since a new reactor was ordered and even longer, 1974, since a reactor was actually completed. The graph below shows the history of reactor ordering.

U.S. Reactor Orders



The problems of the nuclear industry in the US were compounded though not caused by the near disaster at Three Miles Island in 1979. The main problems of the industry were economic; problems in construction and opposition to them led to increased construction times and subsequently increased construction costs. The estimated cost of building a nuclear power plant rose from less than $400 million in the 1970s to around $4000 million by the 1990s, while construction times doubled from the 1970s to 1980s. These facts led the US business magazine Forbes to describe the industry as “the largest managerial disaster in US business history”, involving $100 billion in wasted investments and cost overruns, exceeded in magnitude only by the Vietnam War and the then Savings and Loan crisis.

During the 1990s support for the nuclear industry continued to decline. Government support through its research and development program fell from $644.5 million in 1990 to $18.5 million in 1999 (in constant 1999 prices)[72]. Even the nuclear industry believed that a large number of nuclear reactors would be forced to close early. Analysis in the 1990s from the Washington International Energy Group predicted that up to one third of reactors in North America would be closed in five years due to the liberalisation of the energy markets.

[72] Energy Policies of IEA Countries, 2000 Review, International Energy Agency, table B6, 2000

George W Bush, a new Era for Nuclear Power?

However, with the election of the George Bush in 2000, many believe that the future of the industry has fundamentally changed. In May 2001, the National Energy Policy Development Group, chaired by Vice-President Cheney, released its report. This called for investment in all sectors in the supply and demand side. On the question of nuclear power it recommended "that the President support the expansion of nuclear energy in the United States as a major component of our national energy policy". Most specifically, it called for: -

- Encouragement of the NRC (Nuclear Regulatory Commission) to both expand the capacity and extend the operating lives of the existing reactors.
- Support for legislation ensuring that decommissioning funds are exempt from taxes.
- Assurance that the NRC will give a high priority for environment and safety issues when preparing licenses for new designs of reactors.
- Consideration of the development of new reprocessing technologies.

The Vice President has been unequivocal in his support for nuclear power when he said, *"Part of our energy policy obviously has to involve nuclear energy"*[73]. This led to rapid calls by the nuclear industry for its expansion. The Nuclear Energy Institute published its Vision of the Future, in which it saw the construction of 50 reactors in the next two decades. Nuclear reactor constructors and utilities have begun talking up the advantages of their new reactors. Most prominent has been the Exelon company, which, along with French and British firms, is developing the Pebble Bed Modular Reactor in South Africa. Exelon say that they will apply for a design license to build the reactor in 2001, with licenses taking between two and three years to be awarded Two other designs of the new generation of reactors, the Westinghouse AP600 and the General Electric Advanced Boiling Water Reactor, already have generic building licenses. The industry is hoping that construction of the first reactor will begin in the next five years.

However, it is far from clear if any new reactors will really be ordered and if there is actually increased political support for nuclear power. This can be seen three ways:

1) According to Platts, there is already an estimated 183 GW of new capacity planned to be built over the next three years. This will cost $130 billion and add about 20% to current installed capacity. None of this will be nuclear power plants.
2) Even assuming that the construction costs and times of the new generation of reactors is significantly reduced, it is unlikely that they will be able to compete with the costs of building gas stations. Until this happens investors and shareholders will prefer gas fired power stations.
3) The Congressional budget for the development of new reactors is decreasing under the Bush administration going from US million 277.5 to 223.2.

There is no doubt that there is some positive movement for the nuclear industry in the US, with increased efficiencies of operating reactors, increasing number of reactors applying for extensions of their operating lives and a more pro-nuclear White House. However, it is far from clear that these factors will enable politicians and investors to support the construction of new reactors and without this the industry has no future.

[73] US: Cheney Stresses Role of Nuclear in Bush Energy Plan, NucNet News, 23rd May 2001.

Nearly and Ex Nuclear Countries

Cuba

During his visit to Cuba in early 2001, Vladimir Putin was told that the country was no longer interested in completing the two VVER 440-213 reactors at Juragua. The reactors were started in 1982 but work was suspended in 1992 as Russia could not longer give sufficient support to the project.

Italy

In the mid-60s Italy had the third highest nuclear power capacity in the world after the United States and the United Kingdom. The Italian government completed its first three nuclear power plants – each equipped with only one reactor – at Latina in 1964, at Garigliano in 1964 and at Trino Vercellese in 1965, giving a total installed capacity of 500 MW. In 1977 plans for 20 more nuclear power plants were considered. In 1978 the fourth Italian NPP located at Caorso was connected to the grid.

The Italian nuclear power programme was suddenly curtailed following the Chernobyl tragedy in 1986. On 8 November 1987 65.5% of the Italian people voted in favour of a referendum promoted by environmental associations over the future of nuclear power in Italy. In the referendum, 80% of the voters supported the closure of Italian NPPs and the ending of public funding of nuclear power. The referendum was able only to call for the restriction and freezing of the nuclear programme, namely a "nuclear protection". Soon afterwards the Italian government decided to put a five-year moratorium on all nuclear activities, including projects, power plants and research reactors.

Following the results of the referendum, the House of Deputies of the Italian Parliament passed a motion on 12 December 1987 calling for the final shut down of Latina and Garigliano NPPs, a halt of any construction work at Trino II, and a freezing of operations at Trino I and Caorso and construction works at Alto Lazio.

Turkey

In 2000, the Turkish Government announced that it was abandoning plans to develop a nuclear power plant at Akkuyu. Prime Minister Bulent Ecevit said the Government could not afford the $3-4 billion to develop the project. The International Monetary Fund had advised against investing in the project.

References and Resources

To footnote all sources for this section of the report would not have been possible. However, a number of key sources were used, these were: -

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Nuclear Engineering International : www.connnectingpower.com
Nucleonics Week and Nuclear Fuel -Platts Energy Publications: www.platts.com
NucNet: www.worldnuclear.org
US Department of Energy: www.eia.doe.gov/emeu/international/contents.html
World Nuclear Association (formally the Uranium Institute): www.world-nuclear .org

NGOs

A number of NGOs provided advice and information, including:

Citizens Nuclear Information Centre	www.cnic.or.jp
Greenpeace	www.greenpeace.org
Institute for Science and International Security	www.isis-online.org
Nuclear Information Resource Service-Wise	www.nirs.org
Sierra Club of Canada	www.sierraclub.ca/n
Urgewald	www.urgewald.de
WISE-Paris	www.wise-paris.org