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World nuclear competitiveness review

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Introduction

Over the past year or so there has been a sea change in the perception of the prospects of the nuclear industry in some countries. In the USA we have seen, earlier this year, Vice President Cheney's energy review concluding that new nuclear build should be a key component of future US energy supply. In the UK the nuclear industry is hopeful that the current governmental energy review will start to pave the way for a new nuclear build programme. The picture is not uniformly positive of course. The agreement to phase out nuclear power in Germany has recently been signed and, from a domestic Japanese perspective, there have been few positive developments over the past 5 years. In addition, even before the intervention of the Bush Administration, the implementation of the Kyoto Treaty appeared unlikely to do the nuclear industry many favours in the short to medium term – despite much endeavour by many parts of the industry.

Much of the heavyweight news media in the USA and the UK is now objectively reporting the need to look seriously at prospects for major new nuclear build. The Economist magazine [1] is one of the few authoritative publications that take a clear negative position on the prospects for new nuclear programmes. What has been absent in much of this debate, well argued though some of it is, are facts, clear objective facts.

This paper fills in some of the gaps.

First, and to ground an analysis of the prospects for new nuclear build, the paper addresses the competitiveness of the current nuclear generation fleet. The following dimensions are covered:

- Safety performance.
- Production costs.
- Capacity factors.
- Stock market performance.
- Prices paid to acquire nuclear stations.
- Scope for further performance improvements.

Second, the paper examines the prospects for new nuclear build concentrating on countries where electricity markets have been liberalised. In addition to the economics of new nuclear build, the paper discusses key conditions that must be satisfied before a significant new nuclear build programme could go ahead.

Competitiveness of the Current Nuclear Fleet

Safety Performance

Almost without exception the safety record of the world nuclear industry has improved very significantly in the past decade. ***Figure 1*** shows the industrial safety accident rate as tracked by WANO [2]. As can be seen, industrial accident rates have reduced by over 70% in the past 10 years. Other industrial and radiological indicators show similar trends. The nuclear industry is one of the safest of all industries.

However, the exceptions to this record, from which the industry must take a lot of pride, are significant and tend to colour public and political opinion more than the statistics referred to above. I cite two examples. First, in Japan the tragic death of two operators as a result of a radiological accident at the Tokai fuel fabrication plant in 1999. Many organisational and managerial changes have followed in Japan as the industry seeks to address concerns of substance and perception. Second, the NII audit of safety at Sellafield published in early 2000 revealed several cultural and procedural shortcomings. Major managerial changes have resulted and important sustainable improvements have now been made.

As David Christian said at the World Nuclear Fuel Market Conference in Las Vegas earlier this year [3], the nuclear industry must accept that it is judged by higher standards than other industries. Another tragic incident well illustrates this point. On 8 August 2001 three workers were killed in a gas explosion at a CCGT plant in the North of England [4]. This event was treated by the media as a routine event, something akin to a road traffic accident. We know that our industry is safer than other energy industries; the media, the public and politicians see a very different picture.

Production Costs

Over the past decade, faced with increased competition and liberalisation at varying speeds of electricity markets, the nuclear industry has improved its efficiency dramatically. Clearly this has not come at the expense of safety. ***Figure 2*** shows the trend in production costs for the US nuclear fleet over the last 5 years [5]. A roughly 10% improvement has been achieved by those reactors in the lowest three unit cost quartiles.

Capacity Factors

Production costs are driven to a large degree by capacity factors. As would be expected, a very positive story can also be shown here. ***Figures 3 to 6*** show capacity factors, analysed by the major nuclear countries. The following observations can be made:

- Countries already at the top of the capacity factor league table – Finland, Germany, Belgium and Spain – are holding steady at around 90% or above.
- US capacity factors are now pushing up towards the best of the European fleet.
- The US capacity factor improvement in the 1990s has added the equivalent of 23 1000 MWe plants to the grid.
- Russian and Ukrainian reactors have made noteworthy output improvements.

- French capacity factors continue to be lower than technical and operational standards would indicate, due to the surplus nuclear capacity in France and the limitations on exporting the surplus to neighbouring countries.

Stock Market Performance

Despite the significant improvements in operating costs seen in most parts of the nuclear industry, profits from generation have been squeezed as electricity prices have fallen faster than costs. Supply shortages in the US have given some relief here but this is expected to be only temporary.

The share price performance of companies with a significant nuclear component in their portfolio (generation or nuclear services) gives some idea how the investment community view the current performance and profitability of nuclear activities and the prospects for the longer-term profitability of the industry. The 1NuclearPlace web site tracks two nuclear stock market indices. One, the Nuclear Index, features the average share price of 43 companies from various countries that have a significant nuclear generation or nuclear services component in their business portfolio. A second, the Nuclear Utilities Index, tracks the share prices of nuclear utilities. The composition of these indices is listed in **ANNEX 1**. ***Figure 7*** plots these indices for the past two years along with the Dow Jones Industrial Index and the Dow Jones Utilities Index. The following observations can be made from the data:

- Share prices of the nuclear utilities and the broader family of quoted companies with a significant nuclear business have under performed the Dow Jones Industrial Index and the Dow Jones Utilities Index over the period.

- Nuclear utilities have slightly out performed the broader nuclear family over the period.

- There was a measurable relative share price increase for the nuclear utilities and the broader nuclear family when the ‘pro-nuclear’ US Energy Policy was announced in May this year.

Prices Paid to Acquire Nuclear Stations

US nuclear stations started to be sold in 1998 when AmerGen, the joint venture between PECO and British Energy, announced its purchase of the Three Mile Island plant from GPU Nuclear. Since that break-through transaction a further ~9,500 MWe of nuclear generating capacity has been acquired [6] in the US, or announced as likely to be acquired. Additionally, over the same period, a further ~24 GWe of nuclear capacity has been involved in mergers and other corporate-level transactions.

Figure 8 lists the acquisitions and ***Figure 9*** graphs the derived $ per kW-years prices paid for the nuclear stations. This NAC analysis [6] takes the basic purchase price, removes the component for nuclear fuel and puts the resulting prices on a consistent basis taking into account payment terms, treatment of nuclear liabilities etc. The prices are then further modified to take into account the remaining licensed lives of the plants. From these two Figures the following points can be drawn:

- Prices paid were in the US$1–2 per kW/year until early 2000 when prices jumped to nearly US$20 per kW/year, jumping to over US$25 per kW/year for transactions announced from mid 2000 onwards.

- The early transactions were clearly undertaken at ‘bargain basement’ prices when few bidders were in the market and sellers considered the plants to be potential liabilities.

- A re-evaluation of the attractiveness of existing nuclear assets and the entry of more buyers, such as Dominion Energy and Constellation Nuclear, into the market in early 2000 increased prices dramatically.

At the end of 1991, the largest 12 US utilities owned 51% of the US nuclear fleet measured by installed capacity [6]. By the end of Year 2000, on the basis of announced deals, this percentage had risen to 67% [6]. NAC projects that within five to seven years virtually all of the US nuclear generating capacity will be owned or operated by less than a dozen companies. The main business driver for this consolidation will be the delivery of sustainable value to stakeholders.

Scope for Further Performance Improvements

Starting with safety: the high profile nuclear accident must become a thing of the past if the nuclear industry is to have a good, long-term future. The industry has accepted for over a decade that another Chernobyl-type accident will signal the start of the closure of the industry. Most safety trends are going in the right direction and the potential for improvement is nowhere near being exhausted.

The variation in capacity factors between countries shows the potential for further improvement here. A 10% gap exists between the best and the worse performers if solely western and Asian LWRs operating in competitive electricity markets are considered.

Capacity factors are of course a big driver of production costs. ***Figure 2*** shows how the production costs for the US nuclear fleet vary. The average production costs for the worse quartile of performers is about double that for the top quartile. Clearly there is much scope for cost improvement here. A similar analysis of the world' s nuclear fleet would most likely reveal much scope for similar improvements.

As with many mature operating assets in other industries, opportunities exist to make slight increases to the licensed output of the nuclear fleet. Many plants in Europe have been subject to such upratings. In the US it is reported that the Nuclear Regulatory Commission expect to process 46 applications for power uprates in the next five years, adding some 1600 MWe to US capacity.

Lifetime extensions or licence renewals also add to the competitiveness of the current fleet by reducing lifetime costs and adding low cost output. Having been first to embrace nuclear power for electricity generation, the UK was first to extend the lifetime of its nuclear reactors. The initial Magnox programme was based on a 20-year life expectancy. The first of those reactors, Calder Hall and Chapelcross, are still operating safely and efficiently in their fifth decade of operation. The second generation of UK reactors, the AGRs, also have had their expected lives extended – from an initial 25 years to the current 35 years.

In the US the initial licence period for plants is 40 years. So far five reactors have received 20-year licence extensions, applications for a further nine reactors have been made and 38 other reactors are committed to making renewal applications. NRC estimate that they will receive application requests for at least 85% of the US fleet.

Elsewhere, political factors aside, there is much confidence that reactors can be licensed for 60 years operation and maybe more. Studies in Japan have found no factors that would prevent the lifetimes of the earliest LWRs being extended from 40 to 60 years. In Spain, the licenced lifetimes of the Santa Maria and Jose Cabrera plants have been extended and other plants are expected to follow. Other countries are renewing the licences for their plants as dictated by the domestic licensing regime.

The German and Swedish governments have taken decisions to prematurely shorten the lifetimes of their nuclear fleets. In Germany, the decision has recently been announced to close the Stade plant prematurely on economic grounds. Along with the announcement last year to close various Magnox reactors on economic grounds, this is the only non-political early closure for many years.

Prospects for New Nuclear Build

Reactors Under Construction or Firmly Planned

It is sometimes easy to forget that much nuclear reactor construction is currently taking place. The IAEA's database lists 31 units currently under construction and these are listed in ***Figure 10***. In addition, further units are firmly in the planning process in Japan and Korea and the latest Chinese national plans continue to feature a strong commitment to new nuclear plants.

So, there are significant new nuclear programmes under way in many parts of the world. However, these programmes have not generally passed the test of being financed by international capital markets for the sale of output into liberalised energy markets. In the West, published national and international studies have consistently shown that new nuclear build programmes do not generally represent the lowest cost option for new generation. New build programmes were cancelled in the UK in the 1990s and no new nuclear plant has been ordered in the USA since the 1970s.

Currently, the proposed new reactor in Finland can be said to be at the planning stage with support in principle from government and the sponsoring utility. In the US and the UK, there is much talk of new programmes with various licensing reviews underway in the US.

New Build Economics

In the most recently published study of generating costs for new nuclear plant, the NEA/IEA compared data provided by 18 countries on the generating costs for fossil and nuclear plants nominally to be brought into service in the 2005 to 2020 period. The study [7] concluded that:

- At a 5% discount rate the least expensive option by a margin of more than 10% is gas in three countries, coal in three countries and nuclear in five countries. In seven countries there is less than a 10% difference between the two cheapest technologies.

- At a 10% discount rate the least expensive option by a margin of more than 10% is gas in nine countries. In eight countries there is less than a 10% difference between the two cheapest technologies. Nuclear is not the cheapest option in any country.

The recent submission [8] by the Department of Trade & Industry (DTI) to the UK Energy Review contains some relevant points about nuclear economics:

- DTI estimates and work in connection with the proposed new Finnish reactor suggest that unit generation costs of ~2.5p/kWh (3.7USc/kWh) are achievable at low discount rates and with series build. These UK costs are significantly lower than the 3.7 to 4.5p/kWh quoted in governmental studies in the mid 1990s.

- Long term price expectations in liberalised electricity markets are ~2p/kWh (3USc/kWh) or below.

- US conventional wisdom is that a construction cost of US$1000/kW is needed for nuclear stations to be viable. Current designs, despite major breakthroughs in recent years particularly with the Westinghouse passive designs, appear short of this. A recent IEA report [9] estimates that the capital cost for current nuclear designs is around US$2000/kW compared with US$1200/kW for coal and US$500/kW for gas. Nuclear power vendors remain optimistic that this gap can be substantially closed.

- The as yet unproven Pebble Bed reactor offers the prospect of generating costs of ~1p/kWh (1.5USc/kWh) with a capital cost [10] at or below the US target.

Assumptions about long-term gas prices are clearly critical to setting the generating cost hurdle for new nuclear plants. ***Figure 11*** shows the relationship between gas prices and CCGT generation costs in the US setting [5]. Recent gas prices in the US, in the wake of the Californian energy debacle and electricity shortages elsewhere in the US, flow through to CCGT generation costs which are much higher than projected nuclear costs based on current designs. Whether these levels of gas costs are sustainable must be doubtful.

In summary, generating costs from current licensed reactor designs do not yet hold out the prospect of being economic in comparison to the alternative generation options – although the gap is closing. Only if broader considerations of environmental impact or energy supply security are taken into account do new reactors based on current designs hold out the prospect of being the generation source of choice in liberalised energy markets.

Carbon Credits?

There are big differences in the assessed value of carbon in any taxation or investment credit regime designed to shift energy usage away from carbon-rich fuels. A typical range is US$25 to US$85 per tonne [1], the level many experts think may be needed if industrial countries are to be serious about the Kyoto emissions reduction targets. If such a regime were introduced nuclear would benefit by 0.25USc/kWh to 0.85USc/kWh. This level is material in the context of the difference between generating costs from new nuclear and the fossil-fuelled alternatives.

However, there are no current or planned fiscal mechanisms for incorporating this credit (or avoidance of a tax) into investment decisions about new nuclear build. Most regimes that purport to address climate change focus on energy taxes or target specific (non-nuclear) renewable energies. Furthermore, the US rejection of the Kyoto Treaty makes it more difficult to envisage a widespread carbon tax regime being introduced. Perhaps when the US policy on climate change is developed there may be some progress in this direction. It should be noted that at the latest Kyoto negotiating round it was agreed that no carbon credits would be earned under the Kyoto mechanisms for nuclear investments in developing countries.

External Costs?

Opponents of nuclear power accept that nuclear power provides environmental advantages with respect to carbon emissions but argue that the other environmental costs of nuclear power outweigh this advantage. Quantifying the external costs of energy sources is notoriously difficult and controversial. The ExternE studies undertaken on behalf of the European Commission since the early 1990s are amongst the most respected in this field. The most recent study [11] updates the assessment of the external costs of the major electricity sources. Based on parallel studies in the European Union countries, its main conclusions are: -

- Coal and oil have by far the highest external costs, between 4.1 and 7.3 Euro cents/kWh and between 4.4 and 7 Euro cents/kWh respectively. These external costs compare to actual (internal) generation costs of about 4 Euro cents/kWh.

- Peat comes next at between 2.5 and 4.5 Euro cents/kWh.

- Gas is the next worst 'offender', although considerably less so than other fossil fuel sources. Its average external costs work out at between 1.3 and 2.3 Euro cents/kWh.
- Photovoltaics is the subject of just one case study, in Germany, and reports external costs of 0.6 Euro cents per kWh.
- Hydro comes next, with average external costs from 0.4 to 0.5 Euro cents/kWh.
- Nuclear is assessed to have an average external cost of just under 0.4 Euro cents/kWh, including accident risks.
- Wind has the lowest average external costs, ranging from 0.1 to 0.2 Euro cents per kWh.

ANNEX *2* contains the full summary table and ***Figure 12*** gives the comparative figures for France, Germany, Spain, Belgium, Sweden and the UK.

Other Key Conditions

Project Management Risk

The previous major nuclear build programmes in the West took place in an environment of cost pass through to consumers and/or government sponsorship. Private shareholders were largely isolated from the risks of capital cost escalation and project delays. Now, in liberalised electricity markets and with reactor vendors either unwilling or unable to take much financial risk, the position is very different.

In the US, utility consolidation has created financially stronger entities, better able to bear the risk of nuclear projects. Against that, deregulation means that the industry in which they compete is less certain with higher returns demanded by investors and lower debt raising capacities resulting. The top 10 US nuclear utilities [6]:

- Have a total of ~53GWe - ~56% of US capacity.
- Have total net assets of ~US$67bn cf ~US$53bn if the capital cost of replacement is US$1000/KW.
- May be able to cope with project management risk of a proportion – say 10% of the indicative US$53bn replacement programme.
- Have an average debt to equity ratio of ~1.5 (1.15 excluding TVA).
- Operating with a debt to equity ratio of 2 (excluding TVA) could raise ~US$50bn (this compares to the estimated global utility ‘ war chest’ of ~US$550bn [12]).

A similar consolidation has taken place in Europe in recent years. E.ON, RWE, Suez Lyonnaise des Eaux and Vattenfall have emerged alongside EdF as the major pan-European utilities with significant nuclear generation holdings.

Long Term Output Contracts

Given the higher specific capital costs of nuclear investments, the length of time required to recover the cost of a nuclear investment is far greater than for a CCGT investment. ***Figure 12*** gives an indicative cash profile for a 1000 MWe nuclear plant costing US$1000/kW and having a production cost in line with the best of current US plants. For the purposes of this illustration the period of construction is taken as five years and the discount rate 5% in constant money. The figure shows that the cash payback period is 15 years, 10 years after the start of generation.

In a liberalised electricity market with no cost pass through and no certainty of selling output, long-term contracts are necessary to support investments with the characteristics of the nuclear investment described above. At present, long-term contracts are not generally favoured. This may be an indication that there are few concerns about security of supply. Clearly, nuclear power provides long-term secure supplies of electricity at predictable costs. Markets do not appear to place any value on this attribute at present. Whether this will change in the aftermath of the Californian energy debacle or other supply shortages in the US remains to be seen.

Waste Disposal

Waste disposal and spent fuel disposal costs comprise a relatively small proportion of lifetime generating costs. For countries with large nuclear programmes these costs are typified by the ‘0.1c/kWh’ paid by US utilities. For countries with smaller programmes the disposal costs are still less than 10% of lifetime generation costs. The relevance of disposal for new nuclear build lies much more in the domain of public acceptance and on the uncertainties this can bring to operating plans and end of life liability costs.

Finland and Sweden appear to be the only two countries with robust and comprehensive plans for waste disposal, plans that have a very good measure of public and political support. Finland has also good political and public support for building a new nuclear reactor.

It is difficult to see how new nuclear programmes could proceed in the US or the UK without much more progress with implementing plans for waste disposal.

Streamlined Approvals Process

The speed and predictability of the licensing and approvals process for new nuclear plant is a major determinant of the riskiness of an investment. The US leads the way in licensing designs in advance and in addressing site-specific issues before a formal project application is made. The new US Energy Policy contains further proposals to build on this lead.

Elsewhere the approvals process is less transparent and less predictable.

In liberalised electricity markets with investor funding, it would be inconceivable that a plant costing many hundreds of millions of pounds would stand idle awaiting permission to operate for over two years after it was ready to do so. If there were a significant risk of such a situation developing, the project would not have proceeded in the first place. If new nuclear generating plant is to be built in the UK, then the licensing and approvals process needs to be overhauled to prevent a repeat of the current situation with the Sellafield MOX Plant.

Public and Political Acceptability

Even in liberalised and investor-owned electricity markets, governments will play significant roles in the nuclear industry as regulator and as back-stop insurer and waste disposal underwriter. Political support for new nuclear build – either leading public support or drawing strength from it – is essential. The new US Energy Policy represents a major step forward; other governments are more equivocal.

Safety and waste disposal, including the management of spent fuel, are key issues that must be satisfactorily managed to earn and maintain public and political support. The safety record of the industry is good, with a few notable exceptions. These exceptions must not be repeated. On waste disposal, more progress must be made.

In the aftermath of the Californian energy debacle and the publication of the US Energy Policy, measured public opinion in the US turned markedly in favour of nuclear power. Perhaps the public are starting to value some of the long-term benefits of nuclear power before electricity and financial markets do so.

Conclusions

The main conclusions are:

- The international nuclear industry has made major performance improvements in recent years.
- Much potential remains to improve the operating and financial performance of the existing nuclear fleet, while sustaining and improving the existing high safety standards. With ever increasing competition in electricity markets and the progressive liberalisation of the remaining 'closed' markets, these performance improvements will be an imperative.
- New nuclear build economics are improving but they are not yet good enough on their own to launch new nuclear programmes in the Western liberalised markets.
- If economic value is attached to the environmental benefits of nuclear power and to the improved security of supply that it brings, then the costs of new nuclear build look attractive.
- If the narrow or the broader economics look attractive, then before new nuclear programmes can be embarked upon, additional significant issues must be addressed, principally:
  - Arrangements for dealing with project management risk.
  - Securing long term electricity contracts.
  - Streamlining the approvals and licensing process.
  - Progress with long term waste disposal.
- A favourable political and public opinion climate is essential for a new nuclear build programme to proceed.
- As yet unproven designs could turn the situation on its head.

REFERENCES

[1] The Economist, 19 May 2001.

[2] World Association of Nuclear Operators' data.

[3] David A Christian, Senior Vice President and Chief Nuclear Officer, Dominion Generation at the World Nuclear Fuel Market Annual Meeting, Las Vegas, 10 – 12 June 2001.

[4] Financial Times, 9 August 2001

[5] Richard J Meyers, Director, Nuclear Energy Institute, at the World Nuclear Fuel Market Annual Meeting, Las Vegas, 10 – 12 June 2001.

[6] NAC analysis.

[7] OECD/IEA–NEA , *Projected Costs of Generating Electricity*, 1998.

[8] DTI submission to the UK Energy Review.

[9] International Energy Agency "Nuclear Power in the OECD", 2001.

[10] Pebble Bed Modular Reactor (Pty) Ltd website.

[11] European Commission summary of latest ExternE research, 20 July 2001.

[12] Financial Times, 28 June 2001.

ANNEX 1

Composition of Stockmarket Nuclear Company Indices

The 1NuclearPlace web site (http://www.1nuclearplace.com) tracks the performance of two nuclear indices. The 1NP Nuclear Index is a proprietary equal weighted index that was started in March 2001. The index comprises the following companies:

AEA Technology plc
AmerGen Corporation*
American Ecology Corporation
ATG Inc
Babcock International Group plc
British Energy plc*
Cameco
CMS Energy Corporation*
Constellation Energy Group, Inc*
Dominion Resources, Inc*
Duke Energy Corporation*
E.On*
Edison International*
Endesa SA*
Entergy Corporation*
Eurotech, Ltd
Exelon Corporation*
First Energy Corp*
FPL Group, Inc*
General Electric Company
GTS Duratek, Inc
Iberdrola SA*
International Uranium Company
Korea Electric Power Co*
Landauer, Inc
McDermott International, Inc
Perma-Fix
PG&E Corporation*
Pinnacle West Capital Corporation*
PPL Corporation*
Progress Energy, Inc*
Public Service Enterprise Group*
Rio Tinto, Ltd.
Southern Company*
TXU Corp.*
U.S. Energy Corporation
UniFirst Corporation
USEC Inc
Washington Group International, Inc
Wisconsin Energy Corporation*
WMC Limited
WPS Resources Corporation*
Xcel Energy Inc*

** The 1NP Nuclear Utilities Index comprises a sub-set of the above companies and an asterisk indicates its members.*

ANNEX 2

External Costs of Various Electricity Sources

(Euro cents per kWh)

	Coal / lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
Austria	-	-	-	1-3	-	2-3	0.1	-	-
Belgium	4-15	-	-	1-2	0.5	-	-	0.6	0.05
Denmark	4-7	-	-	2-3	-	1	-	-	0.1
Germany	3-6	-	5-8	1-2	0.2	3	-	0.6	0.05
Finland	2-4	2-5	-	-	-	1	-	-	-
France	7-10	-	8-11	2-4	0.3	1	1	-	-
Greece	5-8	-	3-5	1	-	0-0.8	1	-	0.25
Ireland	6-8	3-4	-	-	-	-	-	-	-
Italy	-	-	3-6	2-3	-	-	0.3	-	-
Netherlands	3-4	-	-	1-2	0.7	0.5	-	-	-
Norway	-	-	-	1-2	-	0.2	0.2	-	0-0.25
Portugal	4-7	-	-	1-2	-	1-2	0.03	-	-
Spain	5-8	-	-	1-2	-	3-5	-	-	0.2
Sweden	2-4	-	-	-	-	0.3	0-0.7	-	-
UK	4-7	-	3-5	1-2	0.25	1	-	-	0.15
Total	**49-88**	**5-9**	**22-35**	**15-28**	**1.95**	**14-18.8**	**2.63-3.33**	**0.6**	**0.8-1.05**
Average	**4.1-7.3**	**2.5-4.5**	**4.4-7**	**1.3-2.3**	**0.4**	**1.2-1.6**	**0.4-0.5**	**0.6**	**0.1-0.2**

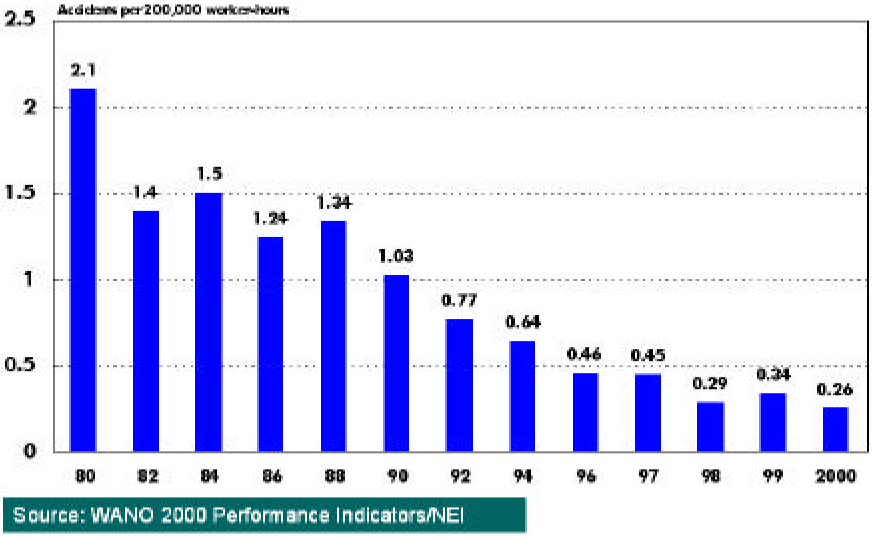

Figure 1: Industrial Safety Accident Rate

The industrial safety accident rate tracks the number of accidents that result in lost work time, restricted work or fatalities per 200,000 worker-hours. The nuclear industry continues to provide one of the safer industrial work environments. The 2000 value continues to achieve the 2000 goal

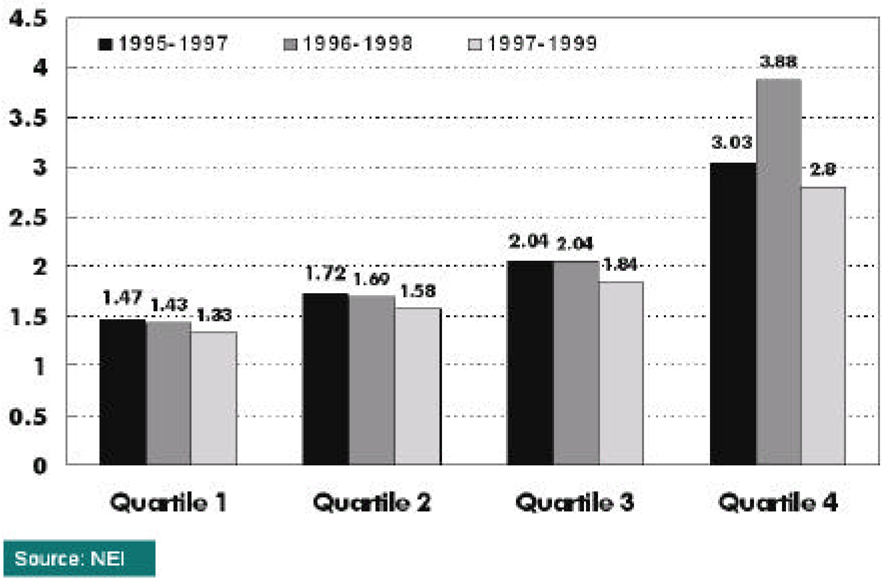

Figure 2: Production Costs (Cents per kWh)

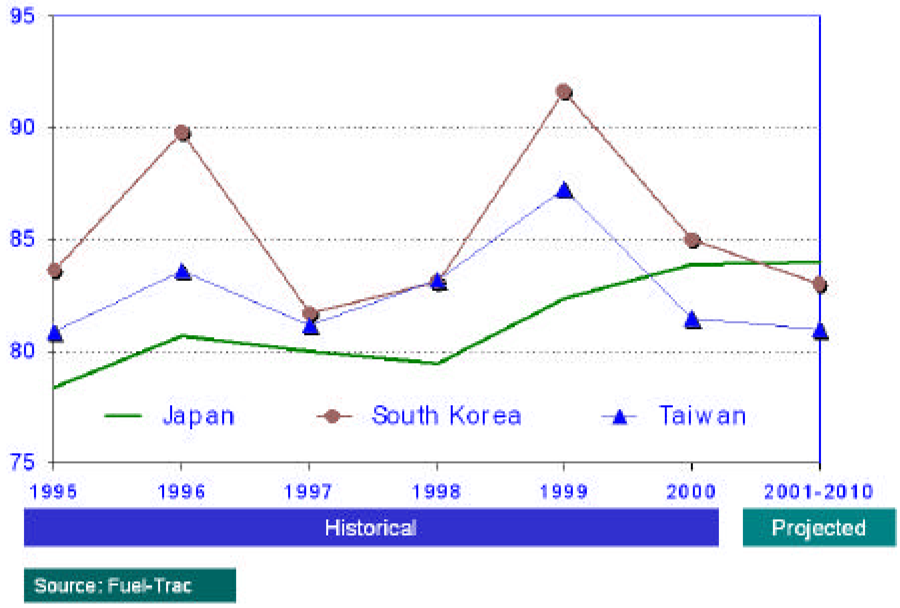

Figure 3: Capacity Factors
Historical versus Projected Capacity Factors for Major Countries in Asia

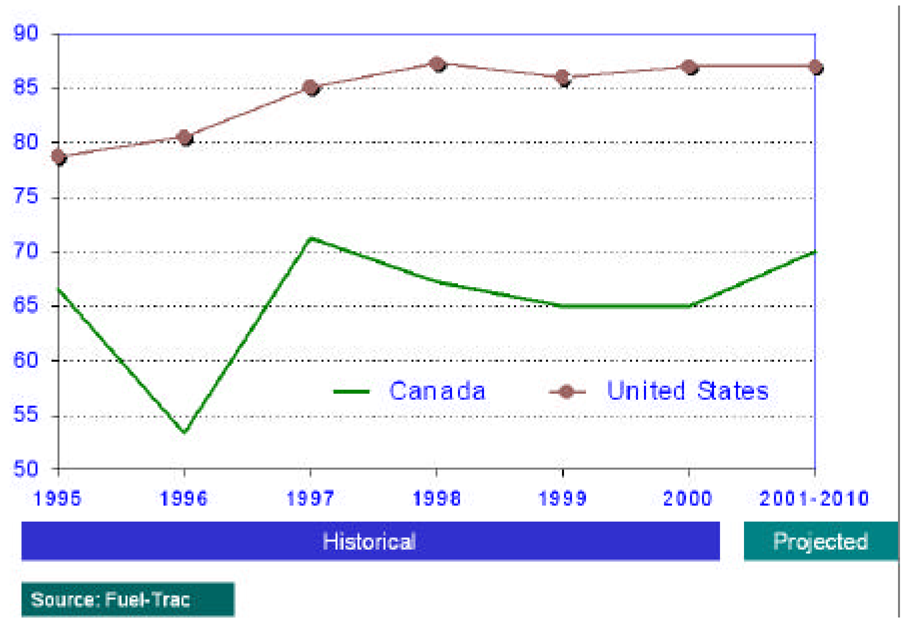

Figure 4: Capacity Factors
Historical versus Projected Capacity Factors for Major Countries in North America

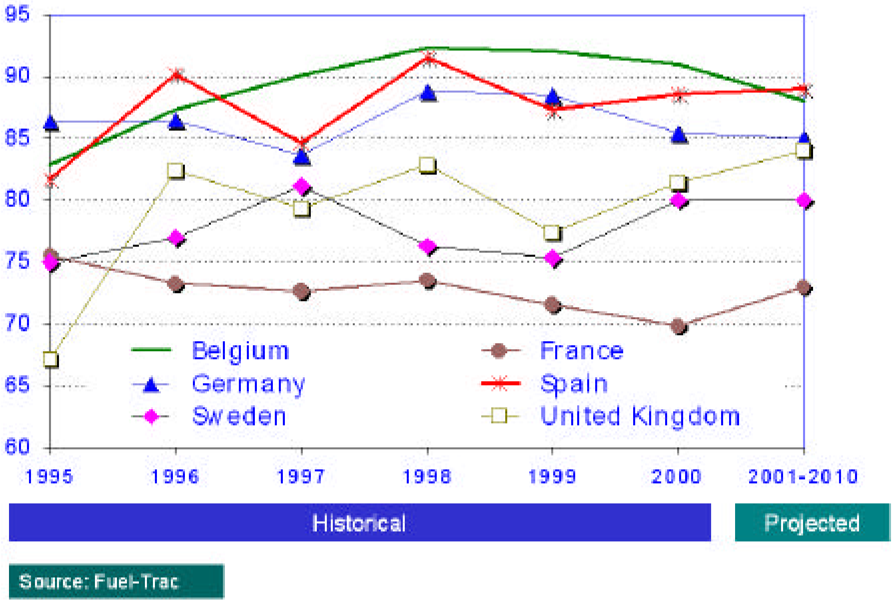

Figure 5: Capacity Factors
Historical versus Projected Capacity Factors for Major Countries in Western Europe

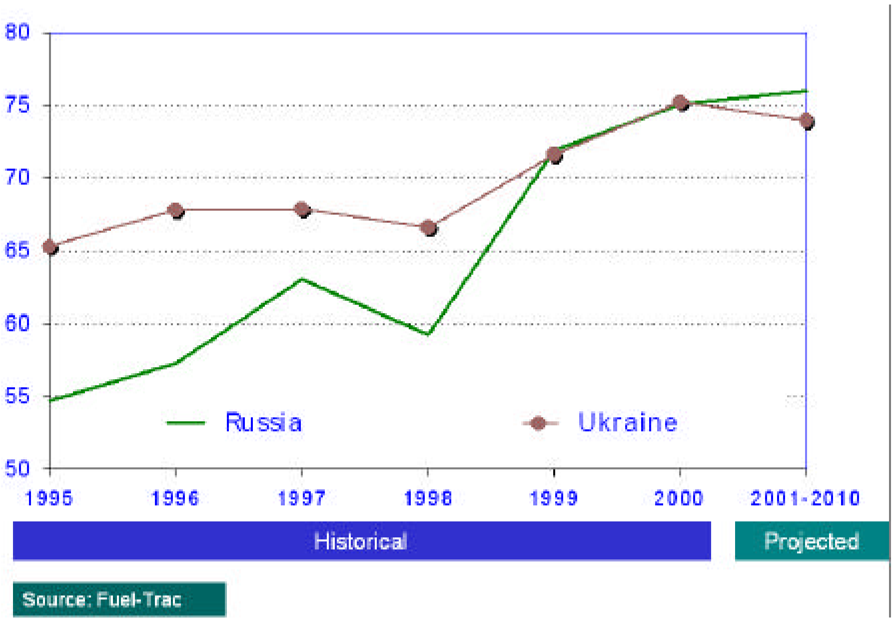

Figure 6: Capacity Factors
Historical versus Projected Capacity Factors for Major Countries in the FSU

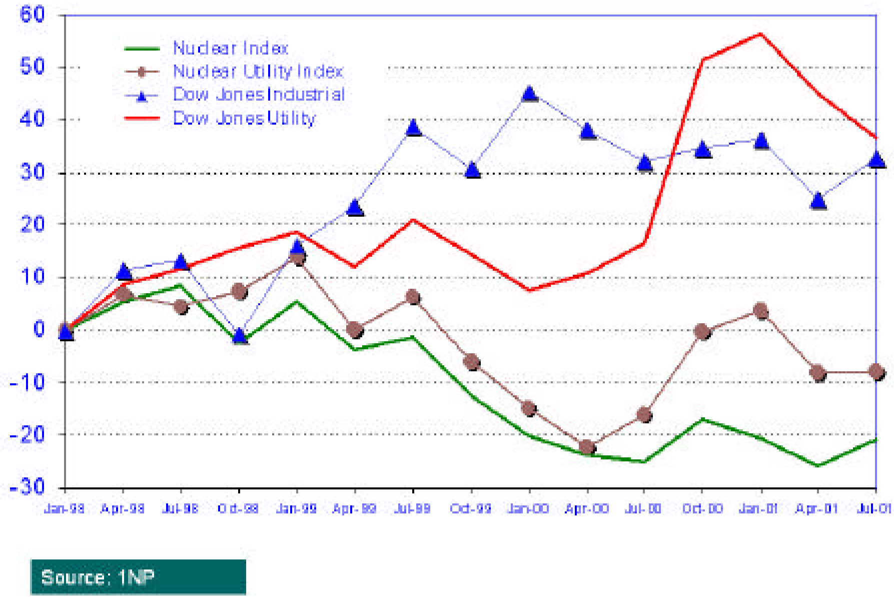

Figure 7: Share Price Performance
1NP – Historical Index

Buyer	Seller	Reactors Involved	Net MWe Transferred	Announced	Completed	Derived Purchase Price ($/KW)	Derived Purchase Price ($/KW-yr)
PECO/AmerGen	GPU Nuclear	Three Mile Island	786	July 1998	Dec. 1999	29	1.86
Entergy	Boston Edison	Pilgrim	670	Nov. 1998	July 1999	19	1.43
PECO/AmerGen	Illinois Power	Clinton	794	Apr. 1999	Dec. 1999	25	.92
PECO/AmerGen	GPU Nuclear	Oyster Creek	619	Sept. 1999	Aug. 2000	16	1.58
PECO and PSEG Power	Delmarva Power & Light	Peach Bottom 2 & 3; Salem 1 & 2	331	Sept. 1999	Jan. 2001	28	1.50
PECO and PSEG Power	Atlantic Energy	—	377	Sept. 1999	Mid-2001	28	1.50
Entergy	New York Power Authority	Fitzpatrick and Indian Point 3	1,747	Mar. 2000	Nov. 2000	280	18.39
Pinnacle West	Southern California Edison	Palo Verde 1, 2 & 3	579	May 2000	—	423	16.48
Dominion Energy	Northeast Utilities	Millstone 2 & 3	1,947	Aug. 2000	March 2001	613	29.74
Entergy	Consolidated Edison	Indian Point 2	951	Nov. 2000	Mid-2001	528	41.13
Constellation Nuclear	—	Nine Mile Point 1 & 2	1,536	Dec. 2000	Mid-2001	480	25.24
Entergy	Vermont Yankee	Vermont Yankee	504	Aug. 2001	Spring 2002	288	27.18

Figure 8: Nuclear Reactor Sales

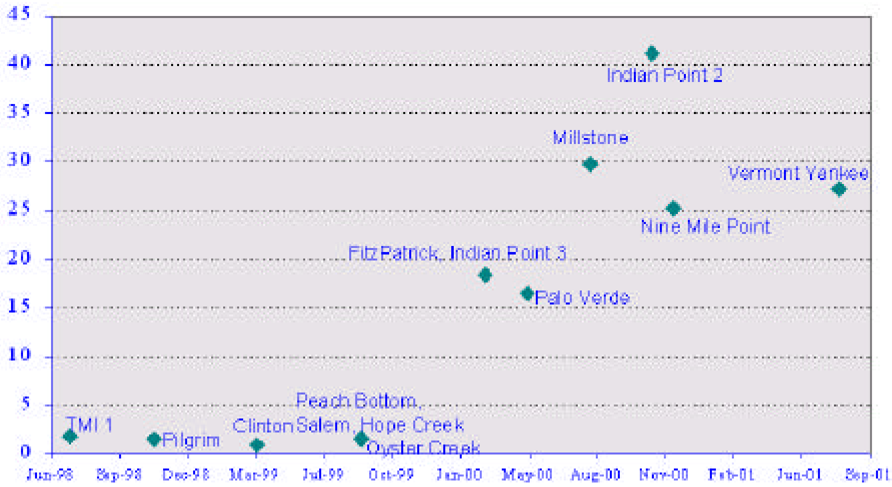

Figure 9: Nuclear Plant Sales/Recent Offers *(Derived Purchase Price $ per kW-yr)*

	No. of Units	Total Net MWe
Argentina	1	692
China	7	5,420
Czech Republic	1	912
Iran	2	2,111
Japan	4	4,515
South Korea	4	3,820
Romania	1	650
Russia	3	3,375
Slovakia	2	776
Ukraine	4	3,800
TOTAL	31	29,891

Figure 10: Reactors Under Construction or Firmly Planned
IAEA's database shows that 31 units are currently under construction

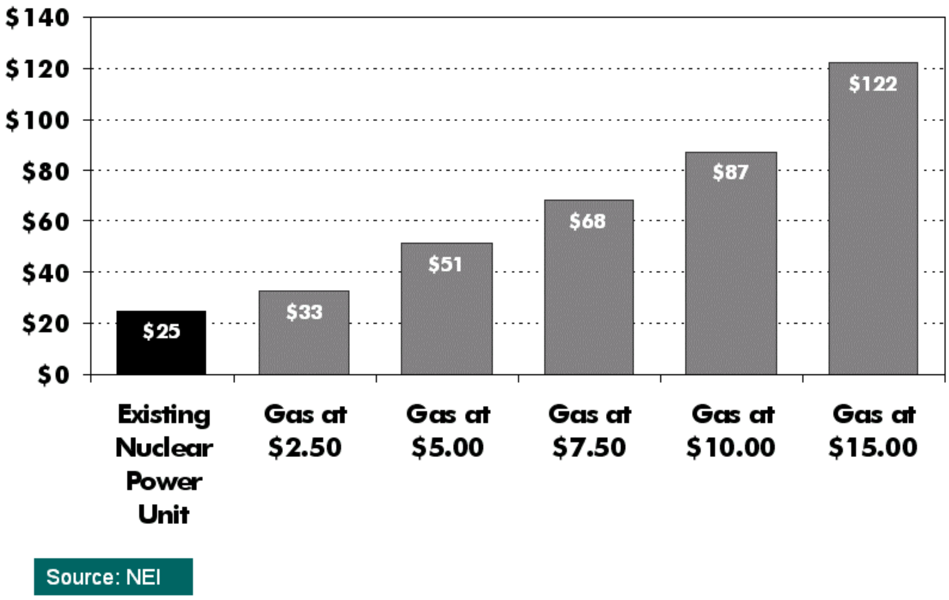

Figure 11: Impact of Gas Prices on Target New Nuclear Costs

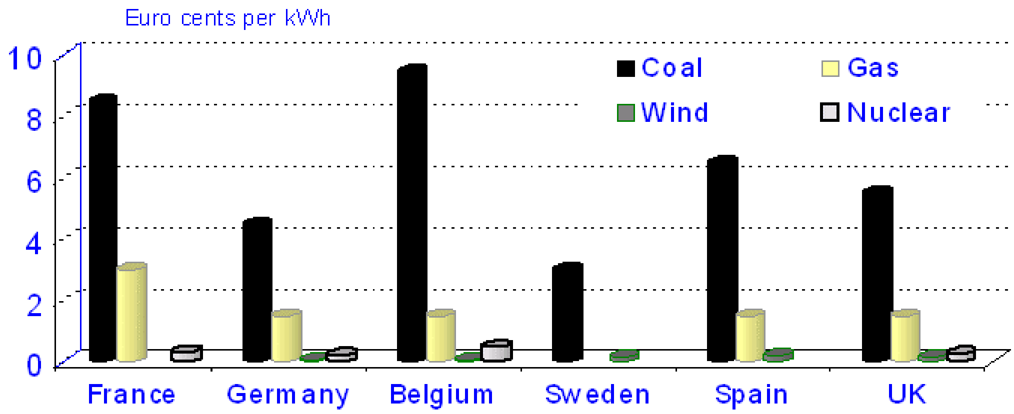

Figure 12: External Costs

- *Recent study by the European Commission updates the assessment of the external costs of the major power sources*
- *Nuclear emerges with an average cost advantage of 1.4 Euro cents per kWh over gas and 5.3 Euro cents per kWh over coal*

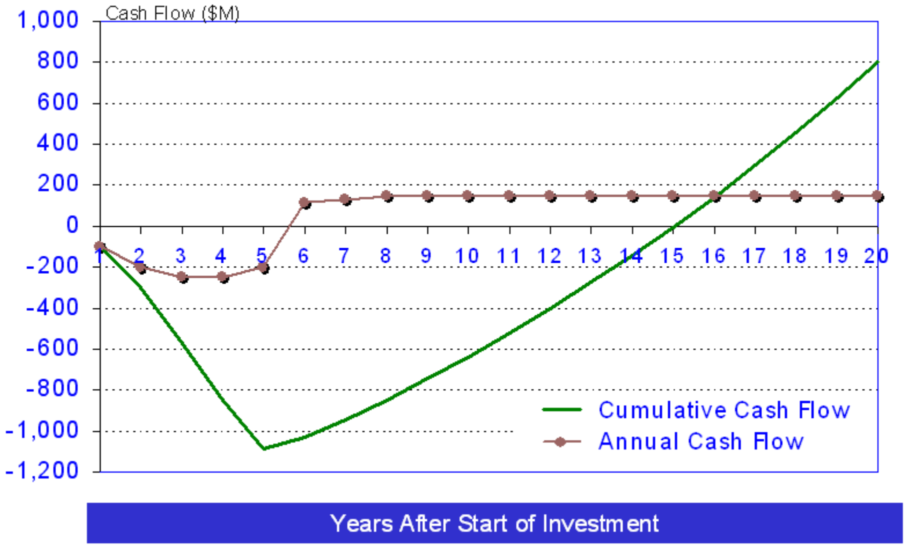

Figure 13: Long-Term Output Contracts:
Indicative Investment Cash Flows for a New Reactor