Submission to
Her Majesty's Government
DTI Energy Review
consultation process

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AREVA

AREVA
Strategy Department

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Energy Review Team
Department of Trade and Industry
1 Victoria Street
London
WSW1H 0ET
UNITED KINGDOM

AREVA is pleased to submit the following response to the UK Government's DTI Energy Review Consultation and its document "Our Energy Challenge".

There are no issues of confidentiality with the submission.

Guillaume DUREAU
Strategy Department
Senior Vice-President

Jean-Jacques GAUTROT
International & Marketing
Senior Vice-President

27-29, rue Le Peletier - 75433 Paris cedex 09 - France
Tél. : 33 (0)1 44 83 71 00 - Fax : 33 (0)1 44 83 25 00

Executive Summary

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AREVA welcomes this opportunity to contribute to the debate on how best to supply the UK's future energy needs at a time of heightened concern about global warming.

Our comments will primarily address Q3, dealing with nuclear power, as set out on page 7 of the Energy Review consultation document, 'Our Energy Challenge – Securing clean, affordable energy for the long-term'.

1. AREVA believes that nuclear power is part of the solution to the UK's future energy needs and to meeting greenhouse gas targets; we believe that nuclear power is but one element of a diverse energy mix that should include renewables.

2. Our study of UK conditions leads us to the view that, with the modernisation and reform of planning and regulation along the lines of international best practice, new nuclear power stations can be built and operated profitably, without any government subsidy.

3. Indeed, AREVA believes standardisation of technology and recent international experience has reduced significantly the financial risk of building the new generation of nuclear power stations.

4. This leads us to conclude that nuclear power is a competitive means of generating base load electricity even before the costs of carbon are taken into account.

5. Decommissioning is not a financial obstacle to building the new generation of nuclear power stations, as costs can be provided for over the 60-year life span of the plant.

6. Similarly, global uranium supply is sufficient for investment in new generation reactors over their life span.

7. AREVA believes that the Government needs to make a clear statement about its policy towards radioactive waste produced by nuclear power stations to reassure the public and inform potential investors in new nuclear power.

8. AREVA notes that current investment decisions about the development of the UK's high voltage transmission network may affect the ability of nuclear power stations to connect to the grid and hence may act as a constraint on new nuclear build.

9. Government and industry alike should work together to drive for greater transparency within the nuclear industry, the aim being to seek a positive national consensus on the need for new nuclear power stations as an essential component of an optimal, secure, clean and balanced energy policy.

10. Finally, the above needs Government to give clear a policy commitment.

Section 1:

Government enables – Industry delivers

Securing clean, reliable and affordable energy is one of the strategic objectives the UK Government has set itself. This is not something government acting in the context of a deregulated market can simply dictate. Instead government is limited to encouraging its goals and enabling their delivery, most obviously through regulation and process.

No subsidies needed for a new generation of nuclear plants

AREVA is firmly of the opinion that there is no need for any financial support or subsidy from the Government for nuclear new build. AREVA's experience of nuclear industries around the world is that there is a clear, stand-alone economic and business case for nuclear power. See page 11 for further detail.

The economic case for nuclear power does not rely on government providing financial incentives to low-carbon technologies. However, a government commitment to carbon pricing would probably enhance the economic case for low carbon technologies (including renewables & nuclear …)

Four enablers for nuclear new build

AREVA believes if the Government puts in place four enablers, the private sector could deliver a new generation of new nuclear power plants (NPPs). These measures would not in themselves be radical changes of position or process but will enable the UK to meet its energy challenge without a negative impact on the public finances, consumers or the smooth operation of the market. These enablers would not fundamentally alter the economics of nuclear power but would make it easier for the private sector to invest in new NPPs and allow generators to diversify the UK's energy supply.

1. A strong signal of support for nuclear new build

If the Government believes nuclear power has an important role to play within a low carbon economy, and within UK's diverse generation mix, it should say so clearly. This will provide comfort to potential investors. Government does not need to state what proportion of the generation mix should be made up by nuclear power; this can be an industry decision, based in part on the regulatory framework Government establishes to support its wider energy strategy.

2. A streamlined licensing & regulatory system

The legacy of industry's most recent experience of UK nuclear new build, Sizewell B & Hinkley Point C, is concern about front end risk. A stable, clear and predictable licensing and authorisation process is a prerequisite for nuclear new build.

AREVA believes that existing regulations and law do not require change. However, both the processes implementing these regulations, and their execution, need to be re-examined in conjunction with all stakeholders. The objective must be to reduce delay and uncertainty, consistent with due process.

AREVA recommends that:

- The licensing process should incorporate information used by overseas regulators. AREVA believes this information should be actively presented by potential licensees;
- A generic process (pre-licensing) should be used to assess a reactor design's safety and environmental impact, eliminating the need to repeat the process for each design at each specific site. This should not affect the licensing processes specific to each individual site;
- Sufficient resources should be made available to the Nuclear Installations Inspectorate (NII) to enable it to undertake this significant workload in a timely manner. AREVA also suggests that a means be devised to refund the NII for any pre-licensing work it undertakes.

3. A clear policy on used fuel and waste management

AREVA urges that, following CoRWM's findings, the Government should move as quickly as possible to create a clear policy framework for long term radioactive waste management. This must be done to reassure the public that the issue has been properly addressed and to provide potential investors in new nuclear build clarity about future costs and liabilities.

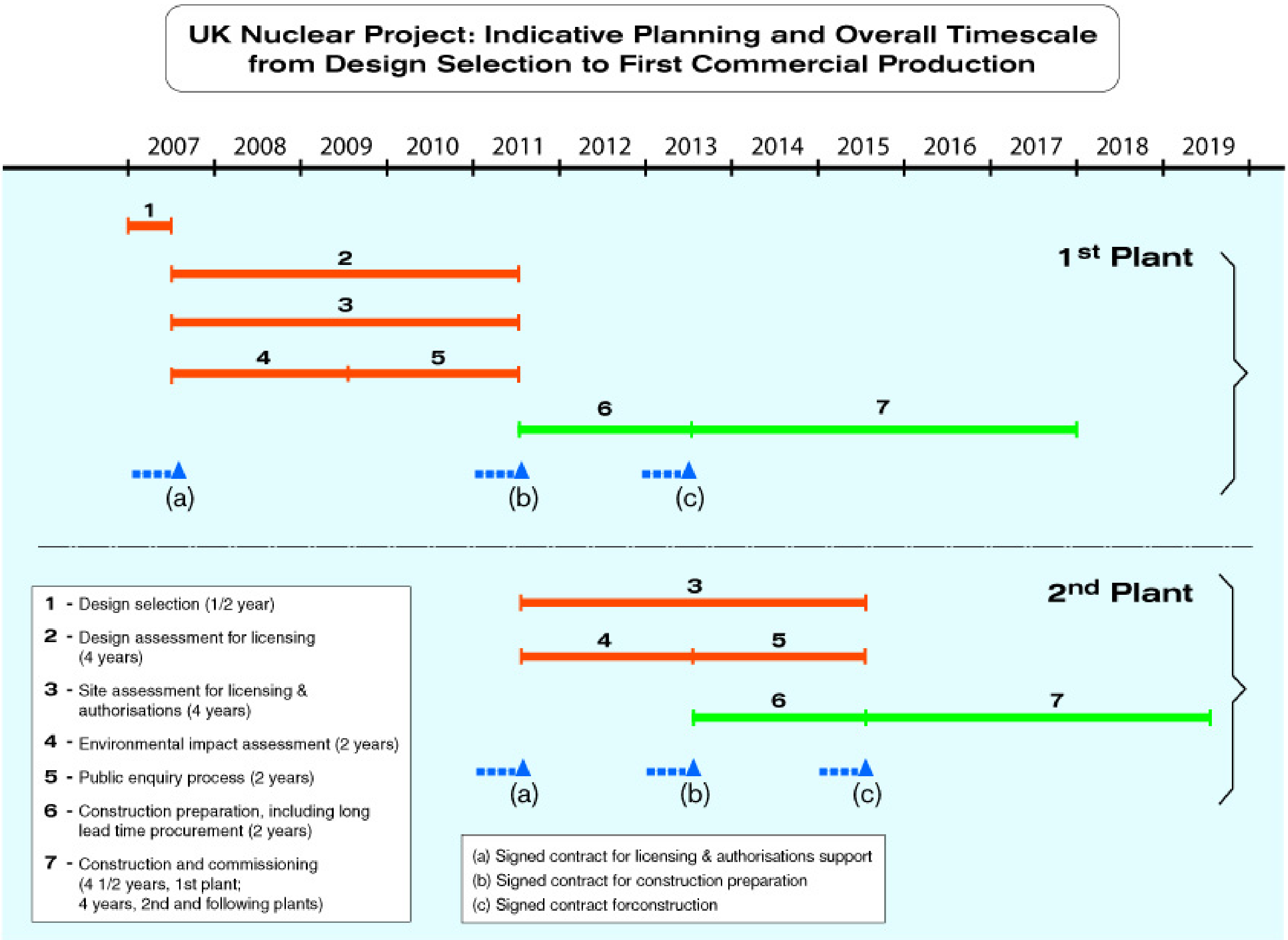
AREVA also recommends that used fuel be seen as a resource and the benefits of recycling in reducing the volume and toxicity of waste be recognised. See Section 2 for greater detail on this area.

4. Grid investment

Government should ensure that decisions made today on grid investment do not restrict the energy mix in the future. One way in which this might be achieved would be a clear signal from the Energy Review supporting the development of a grid capable of connecting generating assets with widely differing characteristics, from large capacity, stable, single location generators such as NPP, to distributed, unpredictable and low power density generators such as wind (see page 24 for further information).

Industry delivers

Should the British Government move to enable nuclear power in the ways set out above, industry will be able to deliver new nuclear power plants in a safe, timely and cost effective manner.



Although AREVA is not responsible for the licensing and regulatory phase illustrated above (in red), we believe a four year process is realistic based on our experience and international best practice in France, Finland and the USA. (See Appendix A)

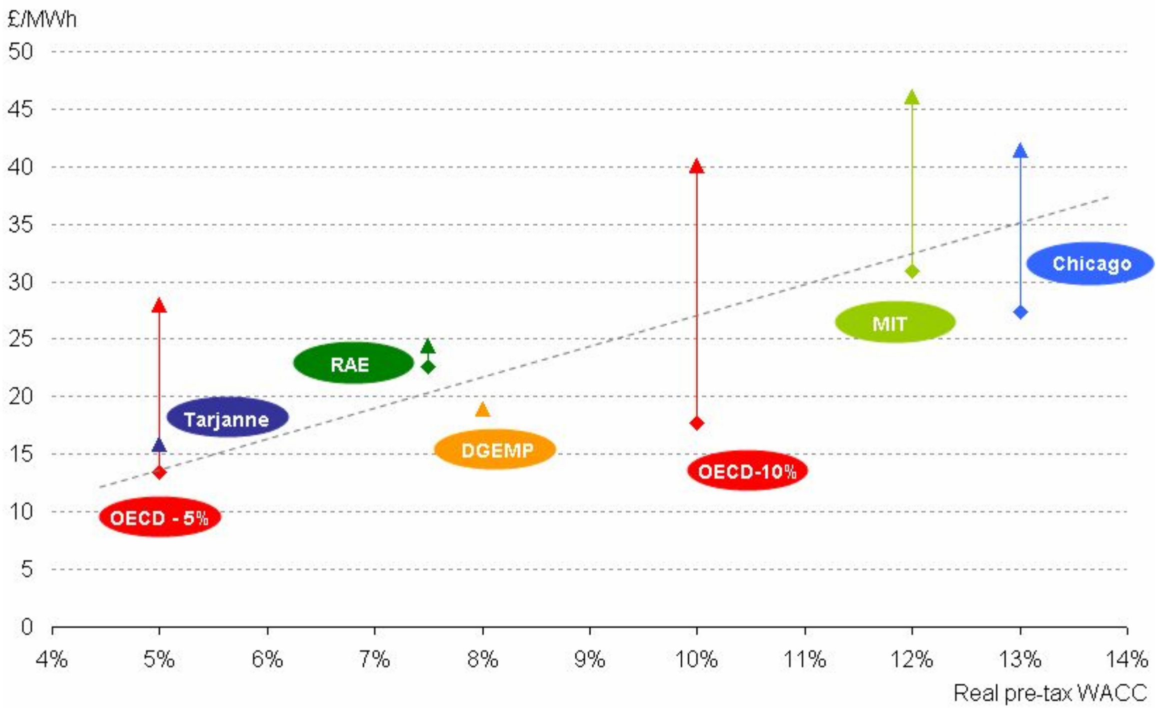
The timetable detailed above is what we see as a base case. A first reactor could be delivered up to two years earlier by beginning construction preparation (and especially by ordering long lead time parts) before the completion of the regulatory phase. However, vendors would seek guarantees from utilities for this to occur.

Financing nuclear power

With the right enablers in place, a new generation of nuclear power stations can be built in UK without subsidy from government. With 'front end' risk limited by the proposals detailed above, and a clear policy on waste, the private sector can assess accurately the potential risks and rewards of new NPPs. This assessment will be used by utilities to determine whether, over its lifespan, a nuclear power plant will deliver value.

As new NPPs are capital intensive projects their value is extremely sensitive to the cost of capital (see chart) making investors' perception of risk the key to future nuclear deployment.

Generating cost vs. real WACC before tax from recent cost studies



Note:

- OECD 1 study uses a 5% real pre-tax WACC, OECD 2 uses a 10% pre-tax WACC
- Tarjanne – author of Finnish University study
- RAE - Royal Academy of Engineering
- DGEMP – French Ministry of Industry_

In the absence of clear information on the hurdle rates used by utilities, many studies assume that nuclear plants need to generate significantly higher returns than coal or gas plants and apply an additional 3-4% risk premium to both the interest rate and cost of equity. This is unrealistic and does not accurately reflect the way generators make decisions on the technology they use.

In addition to adding significant risk premiums, some studies also suggest that capital used in new NPP projects would have to include a greater percentage of equity, which pushes up the Weighted Average Cost of Capital (WACC) and reduces nuclear competitiveness.

The following table shows the effect on WACC of the application of differing financial criteria:

		% equity	Real ROE After tax	Real ROE before tax	Income tax	Interest rate	Real WACC before tax
MIT 2003	Nuclear	50%	12%	19%	38%	5%	12%
	Coal/gas	40%	9%	14.5%	38%	5%	8.8%
University of Chicago 2004	Nuclear	50%	12%	19%	38%	7%	13%
	Coal/gas	50%	9%	14.5%	38%	4%	9.2%
EEF 2005	Nuclear						12%
	Coal/gas						7.5%
Deutsche Bank 2003	Nuclear/coal/gas						11%

This creates a vicious circle since the more risky a project is seen to be, the more costly financing becomes, in turn increasing financial risk. In this situation any capital intensive project would become less competitive.

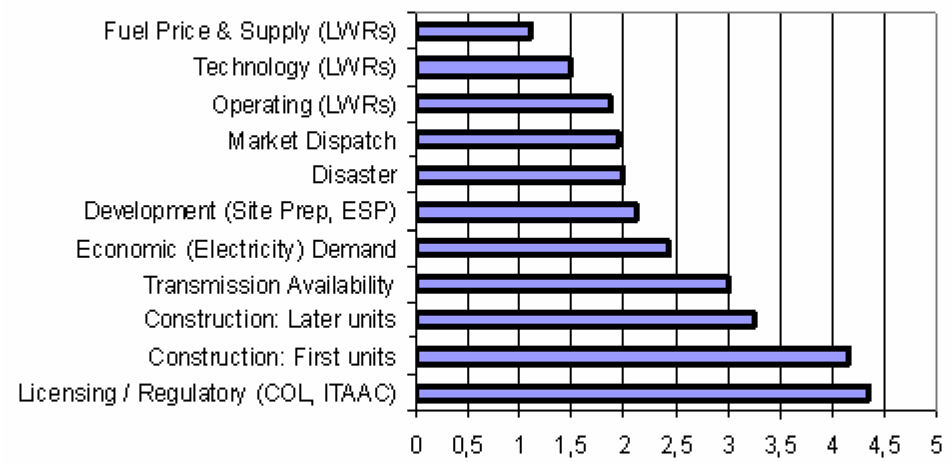
AREVA believes that to accurately assess competitiveness, nuclear should be evaluated on the same grounds as coal and gas. Applying a significant additional risk premium to nuclear projects does not recognise:

- the ways in which the enablers discussed above reduce front end risk
- the progress the industry has made by standardising its technology and adopting a fleet approach
- the ways in which nuclear power is lower risk (on marginal cost, predictability of cost, carbon pricing, security of supply and fuel sensitivity grounds) than competing fossil fuel technologies.

Perceived Risks

Research by Scully Capital, an investment banking and advisory firm, for DOE, showed US industry executives identified regulation and construction as most serious potential risk to nuclear new build. These concerns are amplified in deregulated markets where cost overruns cannot be transferred through higher electricity prices.

Industry Executives' Ratings of Critical Risk Categories



Source: Scully Capital / DOE-NE Report, October 2002
(12 interviews of senior executives from utilities, E&Cs, reactor vendors, "1"=low risk; "5"= high risk).

However, the industry has learnt lessons from the past and identified ways in which these risks can be mitigated. This chapter details some of the ways in which this has occurred:

Licensing[1]

Investors and industry need a stable, clear and predictable licensing and authorisation process. Streamlining the licensing and regulation system in the ways detailed earlier would considerably reduce front end risk as utilities would not have to commit a large amount of capital before a design had been fully approved. The USA (see Appendix A) is an example of how a licensing process can be reduced to four years, reducing financial risk and reforming a system where previously protracted and sometimes collapsing licensing procedures significantly increased the costs of new NPPs.

Dedicating sufficient resources to HSE / NII would help the licensing & regulatory process run to time. This would help ensure that new NPPs would not be treated differently to other large capital energy projects.

Greater licensing efficiency can also be achieved through increased international collaboration on design certification. The recent collaboration between Finnish and French safety authorities for the EPR is a positive indication of what can be achieved.

Construction and technology

International standardisation reduces construction risk by allowing vendors to develop best practice. By the time the UK is ready to build new NPPs, the nuclear reactor at Olkiluoto will be operational and the EPR at Flamanville

[1] Appendix A contains an overview of the licensing procedures used in the USA, Finland and France

well advanced. The UK would, therefore, benefit from vendor experience in Finland, the US and France. See Appendix A.

Assessments of construction risk should also take into account recent examples of reactor new build where new plant has been delivered on time and on budget, demonstrating the cost and time benefits of a fleet approach, ie building several plants of identical design. For example, in China, the Ling Ao 1&2 stations[2], which share their design with the two Daya Bay plants, began commercial operation significantly ahead of schedule.

Adopting a robust pre-licensing procedure would also de-risk the front end and reduce the need for significant design changes later in the process thus removing a significant cause of construction risk and cost overruns.

Modern reactors have been designed to minimise construction and technology risk. The EPR, for example, is an evolutionary design based on the most modern fleet operating in Europe today. Its systems were designed using feedback on these reactors and data from their operation; the systems were also designed in consultation with utilities and safety regulators, to reduce the amount of re-engineering needed to meet individual state's specifications.

A point worth noting is that, if approved, the construction of new NPPs in the UK is likely to coincide with the end of several other major projects (in particular the Olympics) reducing the risk of skill shortages and widening the range of project management firms with suitable 'UK competency'.

Electricity market

As price takers in the whole sale market, utilities must manage electricity market risk. Most of the utilities likely to commission NPPs in the UK are both diversified generators and vertically integrated so can use nuclear power as a hedge against fossil fuel and carbon costs.

Electricity market risk is not just an issue for capital intensive technologies, it also affects gas plants. For example, in the USA, between 2001 and 2002, excess installed capacity meant newly launched gas fired plants were forced to limit their load factors – significantly reducing investor returns.

Nuclear power is unlikely to be affected by load factor risk. As NPPs have a low marginal cost of production they are called first in the merit order[3] and benefit from the highest load factor. Gas plants have a higher marginal cost in production so are called last in the merit order and will be called on less

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[2] Plants involving two 1000Mwe pressure water reactors designed by AREVA

[3] Electricity generation takes place in a "merit order" using the plants that are available to supply power at the least cost first. Plants bid a price to generate and are called up in line with their place in the merit order, i.e. the cheapest first, until demand is met. A plant's bid will be set by its marginal cost of production. The wholesale market price is set by the bid of the last plant to be called up. The cheaper a plant's marginal cost of production, the more profitable generating will be.

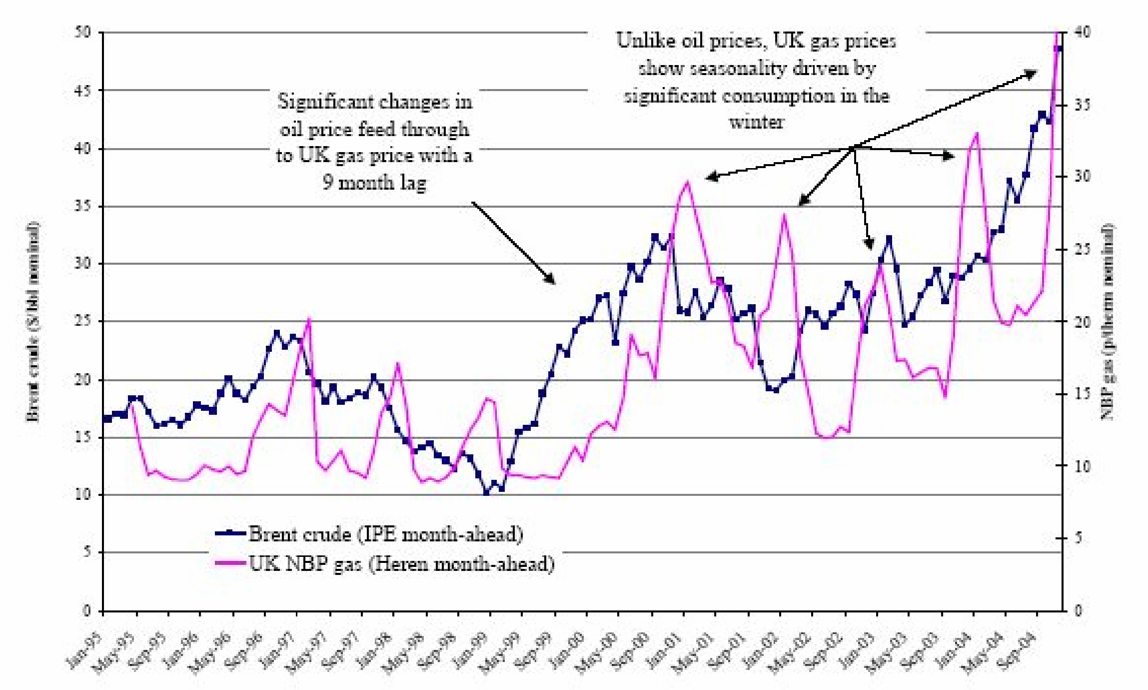
often. As a result, electricity market risk affects gas plants through load factor risk and nuclear price through electricity price risk.

Electricity price risk is lower than might be expected and is not a significant issue to nuclear new build. As gas is called last in the merit order, the marginal cost of a CCGT plant sets the minimum market price. There have been periods when the cost of generating electricity from gas fell below the cost nuclear, but these never last[4]. On the upside, the electricity price can increase above CCGT total cost of production, prompting new CCGT investments.

In their 2005 study, OXERA argues that the average long term power price in the UK should remain between £20-£40 per MWh with a central value of £30 MWh, assuming long term gas price at 28p/therm and CO_2 price at 20€/ton with no "grandfathering"[5]. This is above the generating cost for nuclear power and would result in material returns for investors.

If as many analysts suggest, long term oil prices stay above $45 - $50 per barrel, the long term gas price in the UK is likely to remain above 35p/therm, enhancing the economic case for nuclear power and suggesting investors will enjoy significant returns. (The graph below shows the link between oil and gas prices)

Monthly Crude prices compared to UK gas prices[6]



For diversified generators, nuclear power is a valuable way of hedging electricity market, fossil fuel price and currency risk. As 95% of nuclear generating cost consists of fuel preparation, plant operation and maintenance,

[4] OPECST (2003) French Parliamentary Committee for Scientific & Technology Choices Evaluation
5 OXERA (2005) Financing the nuclear option
6 Source ILEX – Gas Prices in the UK, October 2004

amortisation of investments and back-end provisions – nuclear power supplies electricity at stable and predictable prices.

New NPPs are not intrinsically more risky than other large scale energy projects and do not warrant additional risk premium. Nuclear is in many ways lower risk than fossil fuels thanks to its low and predictable marginal generating cost, high load factor, secure and reliable sources of fuel. It also carries no risk of CO_2 related costs.

Should the market in UK develop, the perception of risk is likely to fall as the first projects are delivered. With the correct enablers in place, nuclear can deliver value to investors and can be funded by the private sector without subsidy from government.

New NPPs do not warrant additional risk premium as nuclear power is, in many ways, less risky than fossil fuel generation.

The competitiveness of nuclear power

Although capital intensive, nuclear is a cost effective way of providing base loads due to low marginal cost of generation and high potential availability factors. Its limited sensitivity to fuel costs also means it has a valuable role producing electricity at a predictable cost. Hence, even without placing an explicit value on security of supply or cost stability, utilities are likely to choose nuclear power as part of their generation mix.

Over the last few years, a number of studies have examined the cost of nuclear power. In this chapter AREVA will examine some of these in light of our international experience. While many of these studies were not designed for the UK specifically, they suggest what the nuclear industry in the Britain might look like.

Generation cost splitting of different generating technologies

	Nuclear	Gas CCGT	Coal	Wind
Investment	50-60%	15-20%	40-50%	80%-85%
O&M	30-35%	5-10%	15-25%	10-15%
Fuel	15-20%	70-80%	35-40%	0%

Examining the main components of cost set out in the table above (i.e. construction, fuel, operation and maintenance, together with decommissioning) suggests that if utilities decide to build new NPPs we are likely to see:

- Fleets of near identical plants (to gain series benefits),
- Large reactors favoured over smaller reactors and used for base load (as O&M costs are not linked to plant size or the level of generation),
- Plant availability of more than 90% (based on international benchmarks),
- Plants funding their own decommissioning by provisioning over their lifetime,
- NPPs used as a hedge against fossil fuel prices as part of a diverse energy mix.

Construction / investment costs

Capital is the most significant component of nuclear generating cost and, in recent years, there has been a growing consensus on how much third generation reactors are likely to cost.

Capital costs consist of the overnight cost (OVN) which includes the costs of preliminary studies, engineering, procurement, construction and owners costs (site preparation and regulation); together with interest during construction (IDC) which accounts for financing and the timing of expenditure. Depending on the build time and WACC used, the capital cost is generally 20-30% higher than the overnight cost due to the interests during construction. First of a kind costs can have a significant impact on capital costs, sometimes estimated to be as high as 35%[7].

The impact of series benefits on both construction cost and build time suggest it will be most cost effective for a utility to build several plants of the same design. A study for the French government (updated for the OECD)[8] suggested that when building several nuclear power stations of the same design, the first plant would cost 30% more than the long run overnight cost, the second and third reactors would cost 20% more and the fourth reactor would cost 10% more.

AREVA estimates that the first EPR built in a fleet will take 54 months from pouring the first concrete to commercial operation and that subsequent units will take 48 months. This improvement in build time has a significant effect on construction costs through its impact on IDC.

EDF and TVO both estimated that the capital cost of building new EPRs, in Flamanville and Olkiluoto respectively, would be approximately £2.1bn (€3bn), the equivalent to 1275£/kW (including IDC).

Although a specific study would be needed to transpose these to costs to the UK, the final costs are likely to depend on the number of reactors built and the degree of design modification required to meet specific UK national needs.

International studies

The estimated capital expenditure of the new plants at Flamanville and Olkiluoto compares favourably with a number of international studies into the economics of new NPPs, which suggest the OVN of a Generation-3 ranges from 734-1348 £/Kw[9]. Most of the difference between these estimates is the result of series benefits (see discussion above) and different assumptions on technology.

[7] University of Chicago. The economic future of nuclear power, 2004, USA

[8] International Energy Agency, Nuclear Energy Agency. Projected Costs of Generating Electricity, 2005 Update, OECD, Paris, France

[9] This excludes the OXERA estimate for a first of a kind plant which does not reflect current market data.

Generation-3 nuclear reactor OVN cost in recent published studies

	Unit	Nuclear	Comments
OECD[10]	£2003/kW	924-1276	France, Netherlands, Finland, Switzerland, Germany, USA
OECD quotes:			
France	*£2003/kW*	*924*	*10 EPR*
Germany	*£2003/kW*	*1054*	*EPR*
Finland	*£2003/kW*	*1126*	
OXERA[11]	£2005/kW	1170-1654	nth – FOAK
Chicago[12]	£2004/kW	734-1348	nth – FOAK
MIT	£2010/kW	1360	

NB: exchange rates used: 1€ = 1.144$ = £0.68 = 40.3399BEF
FOAK = First of a kind

Those studies that focus specifically on the EPR suggest a narrower range of OVN cost: £ 925-1290/kW. AREVA believes that even if OVN costs are at the top of this range nuclear power will be competitive.

Fuel

Fuel costs on total generating cost
(excluding CO_2 cost and including back end)

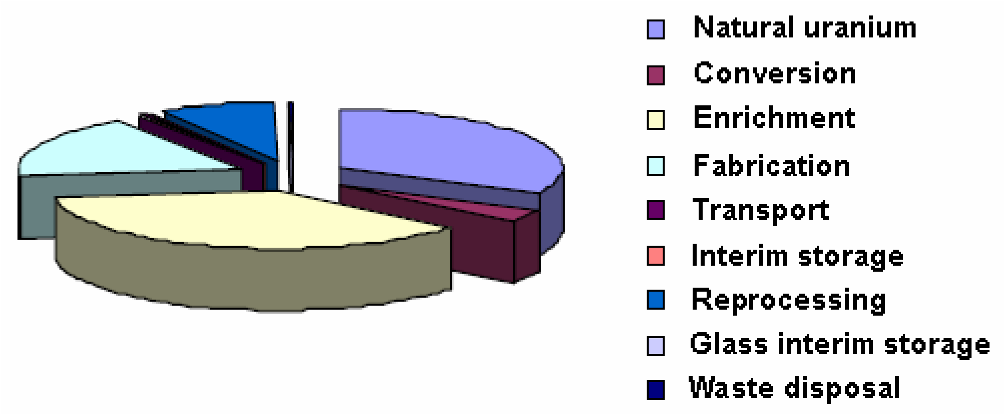
	Nuclear	Gas CCGT	Coal
Fuel (£/MWh)	3	18-22	10-15

CCGT efficiency = 60% on LHV, gas at 28-35p/therm
Coal efficiency = 42% on LHV, coal at 45-70$/ton CIF, 6000kcal/k,
1.144$ = 0.68£

Fuel is a much smaller proportion of nuclear generating cost than it is for gas or coal. As the uranium price is a relatively small percentage of the fuel cost, the overall cost of nuclear generation is not sensitive to movements in commodity prices.

10 International Energy Agency, Nuclear Energy Agency. Projected Costs of Generating Electricity, 2005 Update, OECD, Paris, France
11 OXERA. Financing the nuclear option: modelling the costs of new build. June 2005
12 University of Chicago. The economic future of nuclear power, 2004, USA

EPR fuel cycle cost (£2001 3/MWh (4.4€2001/MWh) source: DGEMP 2003[13])



A doubling of fuel prices would increase marginal generating cost at a gas plant by 70-80% while the cost at a nuclear power station would only increase by 5%.

EPR series generating cost (£2001/MWh)[14]

Uranium price	10$/lbU3O8	20$/lbU3O8	40$/lbU3O8
Investment	11.1	11.1	11.1
O&M	3.5	3.5	3.5
Fuel	2.5	3.0	4.0
Taxes	1.4	1.4	1.4
R&D	0.4	0.4	0.4
Total	18.9	19.3	20.3
	-2.5%	-	+5%

Source: DGEMP 2003[15], 8% discount rate, 1€ = £0.68

NB. These estimates include all front-end expenses as well as the back-end provisions needed to complete used fuel management.

NPPs therefore produce power at stable and predictable costs, reducing the volatility for utilities. Although difficult to quantify, this stability is valuable as a hedge against fossil fuel prices.

13 Ministry of Industry, DGEMP. Reference costs for the production of electricity, 2003, Paris, www.industrie.gouv.fr/energie
14 Current uranium spot price (April 2006) is circa 40$/lbU308
15 Ministry of Industry, DGEMP. Reference costs for the production of electricity,, 2003, Paris, www. industrie.gouv.fr/energie

Operation & Maintenance

Operation & maintenance costs are country-specific and depend heavily on the company which manages the plant. They include manpower costs, annual O&M investments, periodic equipment replacements, national and regional taxes, insurance and company overheads.

As O&M costs depend on a country's wages, public policy and the strategy of individual utilities, they are hard to estimate and compare internationally. The table below shows that UK O&M costs for all generation technologies are higher than for their international counterparts. However, new NPPs in the UK are likely to be owned by utilities who will bring and utilise international best practice to reduce costs over time.

O&M costs determined in different published studies for the three alternative technologies for base-load electricity supply.

	Unit	Nuclear	Gas CCGT	Pulverized Coal
France[16]	£2001/MWh	4.8	3.5	5.9
Finland[17]	£2003/MWh	4.9	2.4	5.0
UK[18]	£2004/MWh	5.4	3.2	3.2
OECD[19]	£2003/MWh	4.1 – 6.2	3.1 - 3.5	4.5 – 5.9

NB: exchange rates used: 1€ = 1.144$ = £0.68

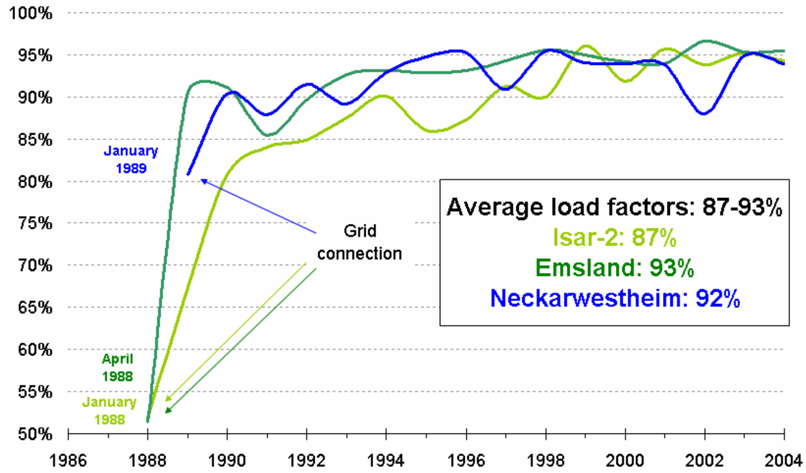
Annual O&M costs are not linked to the size of the plant or the level of electrical output. To minimise the impact of O&M on cost per MWh, utilities are likely to use larger plants to provide base load. As most O&M costs do not vary with the amount of electricity generated, a high load factor will also reduce the cost of production and improve rates of return.

The load factor is limited by a number of largely predictable outages which affect availability e.g. for reloading, inspection or maintenance. These occur throughout the life of the plant and are affected by a utility's O&M strategy. The low marginal cost of operating nuclear plants means they are likely to come ahead of coal and gas plants in the merit order and would operate at full capacity when available.

AREVA estimates that an EPR operating in the UK could achieve a load factor of 92% (note this is over its full lifecycle & if used for base load), taking into account planned outages and realistic margins for unplanned maintenance works. In comparison, Sizewell B had an average load factor of 80% between 1995 and 2004.

[16] Ministry of Industry, DGEMP. Reference costs for the production of electricity,, 2003, Paris, www.industrie.gouv.fr/energie
[17] Tarjanne R, Luostarinen K, Competitiveness of the electricity production alternatives (price level of March 2003), Lappenranta University of Technology, 20
[18] Royal Academy of Engineering. The Cost of generating Electricity, A study carried out by PB Power for the Royal Academy of Engineering, UK, 2004.
[19] For Finland, France, Germany, Netherlands and Switzerland

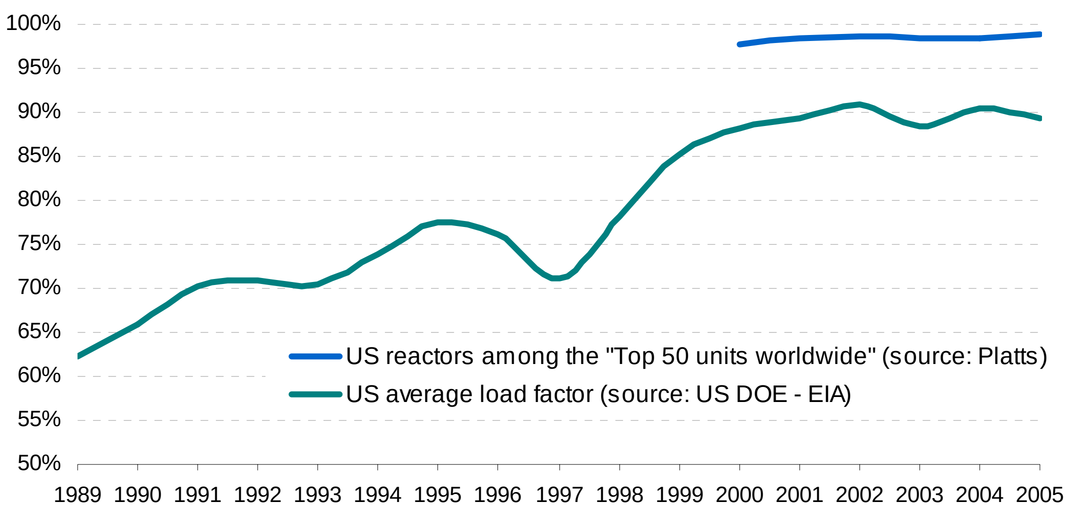
This load factor estimate is based on the availability factors of the seven operating reactors the EPR's technology is based on. Of those, four are in France (N4 reactors: ChoozB-1&2 and Civaux 1&2) and three in Germany (Isar-2, Emsland and Neckarwestheim-2). The performance of the German reactors provides a useful benchmark for availability (note, the French reactors are not only used for base load).



(Source: IAEA / PRIS database)

Internationally, availability factors in excess of 90% are increasingly common, primarily due to shorter outages for refuelling. In particular, the US has seen a significant improvement in capacity factor performance as operators have become more operationally adept.

US nuclear plants' average capacity factor (%) 1989-2004



Decommissioning

With a long-term framework in place, decommissioning is primarily a public confidence issue. Prudently managed, decommissioning costs are not a financial obstacle to nuclear new build.

The final costs of decommissioning vary significantly from country to country and plant to plant due to differences in public policy and plant design. However, as provisions are made over the lifetime of a plant (60 years in the case of the EPR), decommissioning costs do not fundamentally alter the economics of nuclear power.

Estimates of decommissioning costs for existing and planned plants range from £170/kW to £640/kW, reflecting the variety of reactor technology, series effect, country legislation and regulatory bodies involved.

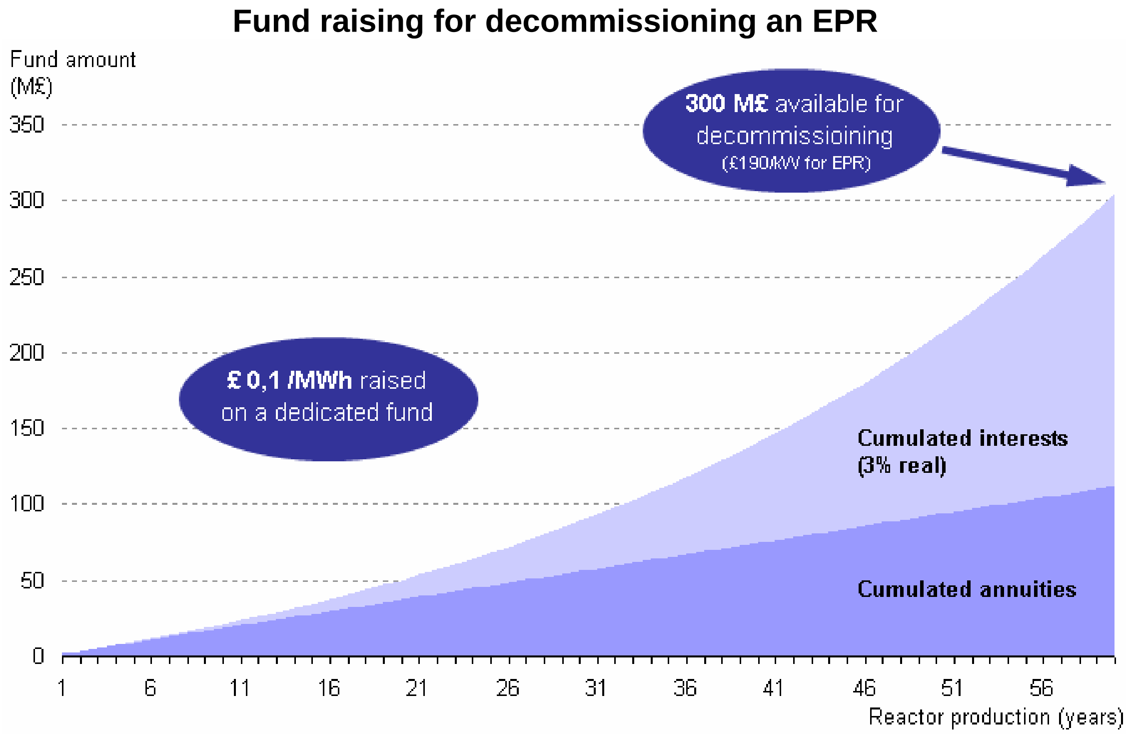
Different companies adopt different policies for estimating decommissioning costs. As an example, EDF uses 15% of total investment cost in real terms as a guide to decommissioning cost, this was recently verified by a detailed cost forecast for the decommissioning of the Dampierre plant (4x900MW Pressurized Water Reactor), which included deconstruction, engineering, monitoring, maintenance, site security and the packaging, transporting and disposal of waste.

EDF has estimated, using technical data from AREVA, that an EPR in France would cost approximately £300M[20] to decommission. This figure is drawn from a room-by-room assessment and uses information gathered from the current fleet using the cost of replacing parts to generate data. This figure is consistent with NDA estimates for currently operating Magnox reactors in the UK[21].

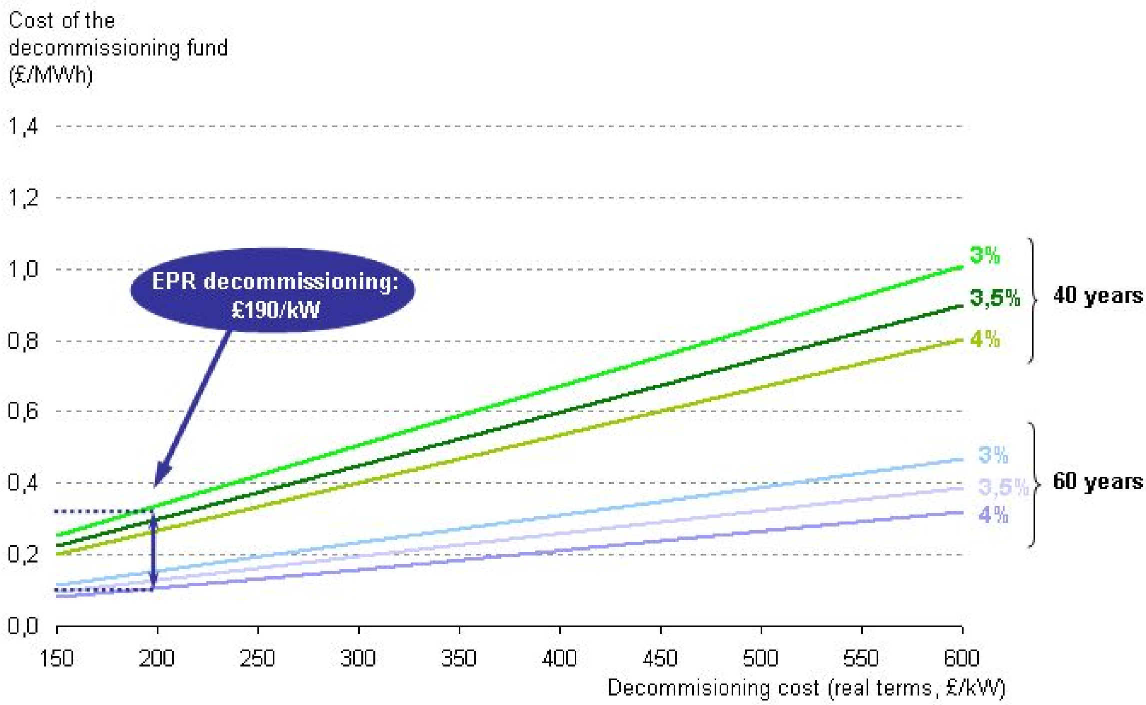
A £300M fund could be raised by saving £2M per year (equivalent to £0.1/MW) in a risk free account for the 60-year life of the reactor.

[20] EDF estimates EPR decommissioning cost at 280€^{2004}/kW, equivalent to £190/kW or £300M in 2004 money.

[21] As published by NDA on March 30th 2006, the eight currently operating Magnox reactors would cost between £240M and £430M per reactor to decommission at end of operation.



Over the 60-year life of a new NPP, uncertainty over the level of decommissioning costs, and necessary annual provision, will fall as operators gather information from the decommissioning of older plants. The level of the annual provision will also depend on the length of a plant's operating license and the interest rates available to the fund. However, as the chart below shows, the cost of decommissioning an EPR is likely to be between £0.1/MWh and £0.3/MWh, i.e. less than 1% of forecasted UK wholesale electricity price.



Nuclear as part of the energy mix

Several studies have shown nuclear can compete with gas and coal on cost a basis; see Appendix C for details. Of particular interest are those that focus on the UK.

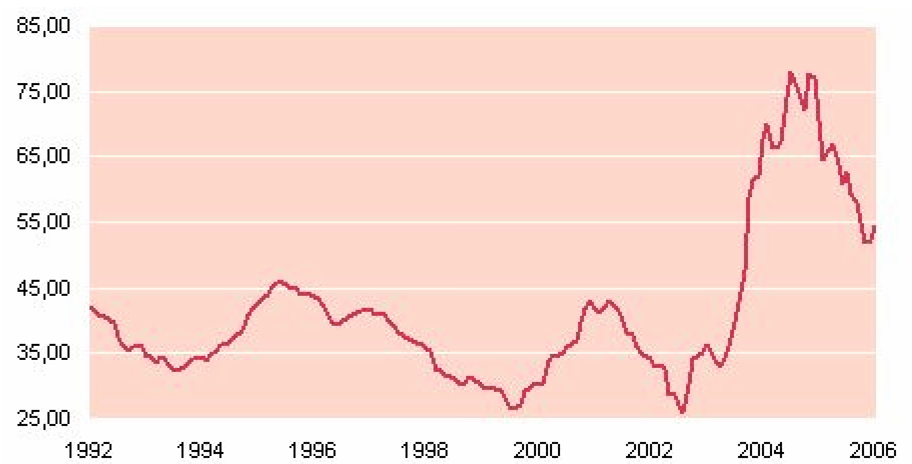
Generating costs of alternative technologies for electricity base-load estimated by the UK Royal Academy of Engineering study (2004)

(£2004/MWh)	Nuclear	Gas CCGT	Coal
Investment	13.2	3.6	10.3
O&M + Overhead	5.3	3.2	3.2
Fuel	4.0	15.3	11.6
Sub-total	22.6	22.1	25.1
CO_2	0.0	3.7	8.2
Total	**22.6**	**25.7**	**33.3**

The Royal Academy of Engineering's 2004 study showed that nuclear was as competitive as gas and more competitive than coal before carbon costs are taken into account. When the impact of carbon pricing is included, nuclear is the most cost effective technology (including provisions for decommissioning and used fuel management).

Since the report was published, significant increases in coal (see chart below) and gas prices (see chart on page 9) have made nuclear the most competitive technology (once again excluding carbon pricing).

Steam Coal Marker Price, 1992 – January 2006 (Spot CIF Price, NW Europe, \$/mt basis 6,000 kCal/kg NAR)



source: International Coal market report

And, as discussed earlier, by producing CO_2 free energy at a predictable cost and acting as a hedge to fossil fuel prices nuclear power has other advantages that suggest it should have a role in the energy mix.

Used Fuel & Waste Management

SECTION 2:

Used Fuel & Waste Management

Government policy

AREVA believes any commercial support for new nuclear power will first require a clear policy statement from government regarding responsibility for radioactive materials and waste produced by nuclear plants; investors will want to understand clearly any liabilities and responsibilities.

The Committee on Radioactive Waste Management (CoRWM) is due to make its recommendations later this year and AREVA hopes that following this, government will move as swiftly as possible to establish its position. AREVA believes it is essential that a long-term policy be established to provide confidence for commercial investors about costs and liabilities, and to provide the public with a clear and acceptable solution to one of their major concerns (see Section 5).

Various models regarding the financing of long-term used fuel & waste management have been implemented in other countries[22]. The "polluter pays" principle is a widely accepted method of managing liabilities associated with the back end of the nuclear fuel cycle, with operators accepting responsibility for the costs of long term waste management; these costs can be built into the financial model of a nuclear plant and will amount to a very small proportion of the total cost of the plant (as outlined in Section 1). Government can adopt one of these or create a model adapted specifically to the UK.

Used Fuel Management

The scale of the UK's current used fuel and radioactive materials inventory[23] is a legacy of the overall UK nuclear industry and should not be used as a benchmark for predicting future trends for the power generation industry.

New build Generation-3 nuclear power plants would generate significantly lower quantities of used fuel per unit of electricity produced due to their increased energy efficiency over current reactors. For example, Generation-3 light water reactors would produce around 30% less volume of used fuel per unit of electricity produced, thus resulting in less waste to be managed, regardless of whether all, or only part, of the used fuel is considered as waste. Moreover, the toxicity of the used fuel (and hence waste) would be relatively lower per unit of electricity produced.[24]

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[22] See, for example, "The financing of radioactive waste storage and disposal", C.J.Hearsey et al, EURADWASTE '99, for a summary of different financing schemes in Europe and North America
[23] See, for example; CoRWM's Radioactive waste and materials inventory, July 2005
[24] used fuel from a light water reactor at 60 GWd/t has a lower toxicity in comparison to that at 45 GWd/t, with the decrease ranging from a few percent at discharge to 15% in the very long term.

Used fuel can be considered as a resource since it contains valuable materials recoverable through treatment & recycling. While treatment and recycling of used nuclear fuel does not eliminate the need for a final waste management solution[25] it does reduce the physical volume of the waste to be disposed of by 80% and also the long-term radiological toxicity of the waste by 80%[26]. Treatment and recycling of used fuel is a cost-effective solution, both in comparison to 'direct disposal'[27] and because fuel back-end costs are only a small percentage of the total nuclear kilowatt hour cost.[28]

The reduced amount of waste that results from the treatment & recycling process is vitrified in a form designed to last for hundreds of thousands of years. Added to the fact that this 'vitrified waste form' contains no fissile material[29], it offers considerably more flexibility than used fuel assemblies do, as it can be safely stored in either surface or subsurface facilities.

Finally, treatment and recycling can save a significant amount of resources, up to 25% of the uranium requirement of a Generation-3 nuclear fleet. See Section 3 for more on uranium supply and Appendix D for further technical detail on Used Fuel and Waste Management.

Decommissioning

Relatively to their size (power output), current UK nuclear reactors have high costs of decommissioning. This is due to a number of factors, including non standardised designs and the large volume of waste arising from, their discrete graphite moderated design, the graphite cores, the concrete pressure vessels etc.

In comparison, new Generation-3 reactors are designed to minimise decommissioning costs. They benefit from:

- Scale effect, which ensures that decommissioning costs do not alter their competitiveness (as outlined in Section 1).
- Plant standardisation, across international new build nuclear fleets, which further contributes to reducing decommissioning costs.

As outlined in Section 1, decommissioning costs can be built into the financial model for a new build nuclear power plant and managed across plant lifetime.

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[25] The four options short-listed by CoRWM are: long-term interim storage; near surface disposal (for a limited range of wastes); deep geological disposal, and; phased geological disposal

[26] This reduction in toxicity assumes a scenario in which light water reactor fuel (at 45 or 60 GWd/t) is treated three years after reactor discharge.

[27]See, for example, study to be published by the Boston Consulting Group (2006)

[28] Relevant studies include:

The Economic Future of Nuclear Power, S-21 (August 2004), University of Chicago. Estimated back-end costs at c.2% of the overall levelised cost of electricity for nuclear energy. Stated that "differences in fuel cycle costs are not a major factor in the economic competitiveness of nuclear power".

Reference costs for power generation (April 1997) DGEMP/DIGEC (Ministry of Industry), Paris, France. Back end fuel cycle costs equal c.6% of lifetime costs.

The Economics of the Nuclear Fuel Cycle (1994) OECD. Assessed back-end costs and compared closed and open cycle costs. In this study, back-end costs amounted in both cases to approx. 6% of the total kWh cost.

[29] As defined by IAEA safeguards.

Additional Factors
in Developing
Nuclear Power

Section 3:

Additional factors in developing nuclear power

Three key additional factors are identified in this section, they are:

- Plant & Components;
- Uranium Supply, and;
- Connection & Transmission Implications.

1. Plant & Components

A number of the major components for a nuclear reactor (of any general design) require top-quality heavy forging, e.g. the pressure vessel. Stringent specifications must be met and quality must be very high. There is a limited global capacity for this work.

AREVA estimates that the general production time for some critical components of a nuclear reactor can be almost four years.

Component	Approx production time[30]	Transport to site
Steam Generators (set of 4)	4 years	2 months
Reactor Pressure Vessel	3.5 years	2 months
Main Primary Coolant Pumps (set of 4)	2.5 years	1 month

To construct a nuclear power plant, from pouring of the first concrete to commercial operation, would take approximately 4.5 years (for the first unit), dropping to 4 years (for subsequent units). Materials and manufacturing operations related to the above long-delay components have to be ordered 2 years in advance of the first concrete pouring; this is the construction preparation period (see diagram in Section 1 – Industry Delivers).

Globally there is an expectation that there will be an increase in demand for the heavy forgings required by the nuclear industry. This will be in part led by renewed nuclear new build but also by demand from the oil and gas industries, which require top quality heavy-forged components of their own.

AREVA believes that market mechanisms are likely to respond to increased demand and provide the capacity required in the medium-term. However, the UK Government should be aware that in the next decade this increased demand for heavy forgings and associated components could come to define the critical path for new nuclear build in the UK.

AREVA manufactures components but does not operate in the heavy forging sector, so to meet this expanded demand AREVA has already reserved slots for key forgings. For the Finnish EPR, AREVA is working with Japan Steel Works and Creusot Forges.

[30] Includes time for testing components.

AREVA recommends that Government examine options that would allow potential operators or licensees to confidently pre-order components with a long lead-time. Which options are best, depends on the detail of the reformed licensing processes, the utilities' approach to maximising series effects across any new nuclear fleet and on the Government's timetable for bringing new low-carbon technologies on line.

Government also has an opportunity to consider ways to promote the development of UK capacity to take advantage of the likely international demand for these high-skill and value-added products.

2. Uranium Supply

AREVA engages in uranium mining and uranium chemistry, enrichment and fabrication. This forms the basis of our understanding of the issues surrounding the fuel supply for nuclear reactors and frames our views on the 'security of supply issues'.

Generation-3 reactors are built with operational lives of 60 years. An EPR requires 255 metric tons of natural uranium per year (average) / 15,400 metric tons across 60 years. The chart below shows the relationship between numbers of EPRs, uranium required over a 60 year lifecycle and total energy produced, as a % of current nuclear fleet output.

No. of EPRs	Uranium required over 60 years (metric tons)[31]	Total energy produced (TWh per year)	Total energy produced as % of 2004 UK nuclear fleet output (% of 73.7TWh)
1	15.4k	12.9	18%
5	77k	64.5	87.5%
10	154k	129	175%
20	308k	258	350%

There is sufficient uranium to fuel the new generation of reactors for their lifespan. Global uranium demand is currently 66,000 tonnes per annum and is unlikely to develop strongly before 2013 as few new reactors will be coming on line before then. Identified resources declared to the IAEA by the member states cover 75 years of current global annual consumption.[32]

Scenarios, generated by the World Nuclear Association,[33] indicate that if world nuclear generating capacity triples (a projection that is not unreasonable, though it is only one scenario, underpinned by assumptions about global energy use & demand), global uranium demand could reach 200,000 tonnes per annum by 2050.[34] Since it takes at least 10 years to identify and characterise a uranium deposit and another 5 years to develop

[31] This table assumes an average load factor of 92%, which AREVA's experience shows is practical.
[32] IAEA 2005 Red Book
[33] WNA Market Report, 2005 edition
[34] In 2050, if capacity quadrupled the demand would be 230,000 tonnes per year.

the deposit to production, uranium mining companies, including AREVA, have already started grassroots exploration. Eventually, if the market provides sustainably higher prices, currently undiscovered or uneconomic uranium resources will be identified or become practical resources, potentially adding 10 million metric tons of uranium to the balance.

Finally, it is worth noting that within the lifespan of Generation-3 reactors it is highly probably that developments in reactor technology will lead to more efficient use of uranium for subsequent generations of reactors.

3. Connection & Transmission Implications

The UK high voltage network is well regulated. To accommodate the connection of new large scale generators, upgrades will be necessary. Nonetheless, with suitable long term planning there is no reason to assume that significant new nuclear capacity cannot be accepted onto the system. The modifications and reinforcement required can be delivered within the context of planned upgrades and are physically and economically achievable. Ensuring these upgrades are made is important if the network is to become a conduit for new nuclear capacity and not a constraint upon it.

AREVA strongly believes that consideration of the impact on, or constraints imposed by, the high-voltage transmission network must be an intrinsic part of any decision to provide additional nuclear generating capacity. It is likely that any new nuclear plant will require connection direct to the high-voltage (400kV) electricity transmission system, which is governed by a number of statutory codes and procedures[35].

To have a genuinely diverse generation mix, the UK requires a single network capable of connecting generating assets with widely differing characteristics, from the large capacity, predictable baseloads of nuclear power to distributed, unpredictable and low power density nature of wind generation. This will necessitate careful design and planning.

AREVA understands that the transmission system North to South is congested and a significant bottleneck in the Midlands means it is not practical to secure major new nuclear generation in Scotland or the North of England without major infrastructure renewals.

AREVA believes the situation East-West is less restricted and in particular the National Grid's current Seven Year Statement (2005) shows the coastal zones (Z13, Z12 and Z15) with a connection capacity of 1500MW each without major interzonal reinforcement. These zones include the existing facilities at Sizewell and Hinkley Point.

[35] The system is operated by National Grid (National Grid owns the network in England & Wales but operates it for the whole of Great Britain) under the provisions of the BETTA code. Development and operation of the system is governed, in particular, by the Grid Code, the Seven Year Statement and the Connection and Use of System Code. These codes along with others define the requirements for the connection of new generating capacity to the network and in the case of the Seven Year Statement the likely demand and impact of new generation and load centres.

It is most unlikely that new nuclear capacity will be operational within the currency of the existing Seven Year Statement. AREVA recommends that consideration of any possible future connection of nuclear generation baseload is given a high priority whilst taking decisions within the current seven year period on how to best utilise the capacity going forward.

AREVA urges that a decision concerning development or reinforcement North-South (and further reinforcement East-West) is taken in principle before the next transmission system planning cycle commences and in full cognisance of the future requirements of new nuclear capacity.

The introduction of new single large points of generation can increase the potential for transmission system instability. This instability raises a number of technical challenges, but these are well known and understood, and are not insurmountable.

AREVA has to emphasise that under current circumstances the loss of a large single point source of generation, such as a nuclear power station, would require compensatory flows North-South and East-West beyond the capability of the existing transmission network. This generic limit will, in reality, vary from location to location depending on generating reserves and system behaviour. The addition and deletion of new capacity including renewables will change the resilience of the network. In the limit, specific additional “spinning reserve”[36] could be installed to compensate but it is far too early in the process to make a definitive allowance for such reserve.

AREVA strongly believes that this limit, whilst it should be noted, should not become an artificial driver of the technology. To do so would risk either increasing the number of sites required (these are a limited commodity) or increasing the price for a given generation capacity. A decision is needed on new generating capacity, nuclear or large scale conventional, including potential sites. This will allow detailed modelling to start, which will provide a critical input to the planned reinforcement or expansion of the UK high voltage transmission system.

[36] Power plants can be run below their normal output, ready to increase the amount they generate almost instantaneously. This allows quick replacement of lost generation, e.g. if a plant went offline unexpectedly, and is termed 'Spinning Reserve'.

SECTION 4:

Climate and Generation Mix

Climate change is a serious and urgent global issue, as shown by the work of the Intergovernmental Panel on Climate Change, the Hadley Centre and others[37].

The UK is not the largest contributor to the world's CO_2 emissions (only 2%) and is not very likely to become so. Nonetheless, the UK's commitment to reducing CO_2 emissions by 60%[38] by 2050 was an important national step towards tackling the international climate issue. The outcome of this Energy Review should reinforce support for this commitment.

Nuclear and tackling CO_2

AREVA believes that there is a stand-alone business case for nuclear energy in the UK. There is also a clear benefit in tackling CO_2 emissions.

Nuclear energy's contribution to the 2050 goal will be limited but important. It is limited because, whilst nuclear energy provides 20% of the UK's electricity, generating electricity accounts for only 40% of the energy used in the UK; in other words nuclear power is involved with only 8% of the total energy use of the UK. It is important because nuclear is a proven and practical low carbon and large scale electricity generation technology; the lifecycle (construction, maintenance, fuel production and decommissioning) CO_2 emissions of nuclear plants are estimated at 0.16tCO_2/MWh[39] compared to 0.356tCO_2/MWh for gas and 0.891tCO_2/MWh for coal[40]; the direct (from electricity generation alone) CO_2 emissions of nuclear power plants are zero.

There are a number of other viable low carbon technologies, wind and marine energy being two with considerable potential for the UK. Like nuclear, both have CO_2 emissions associated with construction and operation but not the actual production of electricity. Also, like nuclear they both have their major capital costs up front and, for wind, planning permission is proving increasingly problematic. Therefore some of the measures outlined in Section 1, which would help nuclear energy develop its potential in the UK, would also benefit other low carbon generation technologies.

Also, as noted in Section 1, the economic case for nuclear power means that government financial incentives for low-carbon technologies are not

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[37] At the time of writing, preliminary figures from the US National Oceanic and Atmospheric Administration indicate a significant rise concentration of CO2 in the atmosphere during 2005, up 2.6 parts per million (ppm), pushing it to 381 ppm, which is 100 ppm above the pre-industrial average and a new record level. The official figure will be released when NOAA releases its Annual Greenhouse Gas Index sometime in April 2006.
[38] From 1990 levels.
[39] Paul Scherrer Institute (2000) GaBe Project – Comprehensive assessment of energy systems.
[40] DTI (2005). Energy Trends – March 2005

necessary to underpin new NPPs but would inevitably enhance the economic case for new nuclear build.

Nuclear as one part of a diverse generation mix

The future generation needs of the UK will be best catered for by a diverse mix of power plant technologies, drawing on coal, gas, nuclear and renewables. Dependence on a single type of generation would create an inflexible system, less able to adapt to changing circumstances, be these the daily or seasonal fluctuation of domestic energy demand over base-load demand or events in non-domestic markets (global for gas but more regional for coal), which led for example to the recent surge in gas prices.

A mix of generation technologies allows the various positive and negative attributes[41] to be balanced out and provides flexibility, so that should gas prices rise, greater use can be made of coal or nuclear power to limit the impact on the price of electricity to UK plc. Nuclear power's unique contribution to the diversity of the UK's energy mix is its ability to provide a consistent and low cost baseload of electricity (with no direct carbon emissions), e.g. one nuclear power plant of 1,500 MWe saves annually about 10 million tons of CO_2 compared with current coal power stations and about 5 million tons compared to combined cycle gas turbine CCGT.

Tackling CO_2 outside generation

UK electricity generation accounts for some 30% of the UK's CO_2 emissions; nuclear, renewables and new approaches to fossil fuel (co-burning with biomass, high efficiency coal fired power plants or coal fired power plants with carbon capture and sequestration) will all play a part in reducing that level without reducing energy output. However, the other 70% of the UK CO_2 emissions must also be addressed. Although this falls outside our core areas of expertise, AREVA would support government action to deal with emissions from the relevant sectors, e.g. transport, industry and agriculture.

UK electricity generation accounts for some 40% of the UK's energy use. Wasted electricity still produces CO_2[42], and more efficient usage could mitigate future growth in the UK's demand for electricity, thus contributing to reaching the 2050 CO_2 target. The case for increased energy efficiency, not

[41] In broad-brush terms, each technology has characteristics that are problematic. Coal and gas produce considerable CO2, even in their cleanest forms. Nuclear is best adapted for base load power generation (although in France it also performs a load following function). Renewables such as wind or wave power cannot generate at all times because of variable climatic conditions. Changes in fuel prices affect some technologies far more than others: fuel accounts for 70% of the final cost of electricity generated by coal or gas, compared to just 5% for nuclear and nothing for wind etc.. There are always potential solutions but they would be expensive and/or dependent on currently undeveloped technologies, e.g. one could have an almost entirely renewable based generation industry if i) enough capacity was built and ii) there was an effective electricity storage technology that could smooth out the peaks and troughs in electricity generated.

[42] E.g. The Energy Saving Trust's estimate that UK electrical appliances in 'sleep mode' are now using roughly 7TWh of energy and emitted around 800,000 tonnes of carbon each year.

just efficiency with electricity, has already been well made by government[43]; additional resources should go into communicating the energy efficiency message to all audiences and incentives to encourage the desired behaviours should be strengthened.

[43] In 2002 the PIU identified that energy efficiency of up to 30% across the board was technically possible by 2050, which would reduce emissions by some 40MtC.

Acceptability of
Nuclear Power

Section 5:

Acceptability of Nuclear Power

Public concerns

Public concerns regarding nuclear power are real, e.g. 72% feel that there are risks to people in Britain from nuclear power whilst only 49% feel that there are benefits to people in Britain from nuclear power.[44] AREVA believes that government needs some sort of positive national consensus on nuclear power before it can act to enable new build.

The public must be convinced not only that nuclear power is safe but that, as part of a mix of diverse generation technologies, it directly addresses two other key concerns: CO_2 levels and security of supply. Though government would play a part in developing this consensus, e.g. explaining the need for a nuclear element in the nation's generation mix, the energy industry itself must take a leading role. This will require a considerable investment by industry in both time and resources.

AREVA's view on safety

AREVA believes that nuclear power is a safe and practical form of energy generation. Safety is the condition of our business; without real and provable safety in nuclear power we would not be able to operate. This is why we are committed not only to safety but to transparency in our industry.

As examples of the transparency that the nuclear industry can and should undertake, AREVA:

- Created of an independent committee of international experts, public authorities, NGOs and AREVA staff, to analyse and estimate the impact of our La Hague plant on its environment;
- Ensured that each AREVA nuclear site in France has its own committee for local information, where local political representatives, associations and inhabitants can ask AREVA any questions (such committees are now a legislative obligation within France);
- In 1999, connected dozens of webcams inside its La Hague plant as part of the "We have nothing to hide" campaign. This was a world first but had to be disconnected following 9/11. It will be re-established as soon as the authorities agree to reconnection;
- Committed to total availability for all forms of debate, be it in public meetings, in the press, etc.

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[44] E.g. Poortinga W., Pidgeon, N.F. and Lorenznoi, I. (2006) Public Perceptions of Nuclear Power, Climate Change and Energy Options in Britain: Summary of Findings of a Survey Conducted during October and November 2005. technical Report (Understanding Rick Working Paper 06-02). Norwich: Centre of Environmental Risk.

AREVA's commitment to being transparent is based on experience. AREVA knows that past failures by all actors in the nuclear industry helped generate mistrust; regaining that trust requires genuine and total transparency. Government should encourage the nuclear industry to adopt the highest levels of transparency and openness if new build goes ahead.

Expert views on safety

AREVA has a considerable understanding of the whole range of activities that underpin the industry. Based on this experience AREVA knows that the regulatory regimes and the technology developed over the last five decades have created a system more than capable of reducing and managing risk, thereby preserving the wellbeing of industry workers, the public and the natural world.

The safety of nuclear energy is constantly under review by a number of international expert groups. Their conclusions are that nuclear is a safe source of power:

The French Academy of Medicine, said in July 2003, "Risks for health of the use of nuclear energy must be compared with the risks of the other types of generation. It must be recalled that the use of fossil fuel (coal, oil, gas) has the drawback of producing, through the process of combustion, CO_2 (contributing to green house effect), carcinogenic agents and other pollutants. In that respect, the use of nuclear energy really looks like one of the less polluting and less risky for health way to generate electricity."

The World Nuclear Association said in January 2006, "Only two major accidents have occurred in some 12,000 cumulative reactor-years of commercial operation in 32 countries. The risks from western nuclear power plants, in terms of the likelihood and consequences of an accident or terrorist attack, are minimal compared with other commonly accepted risks. Nuclear power plants are very robust."[45]

Please see Appendix E for additional information on the EPR, the SWR and reactor safety.

[45] http://www.world-nuclear.org/info/inf06.htm

Appendices

Appendix A

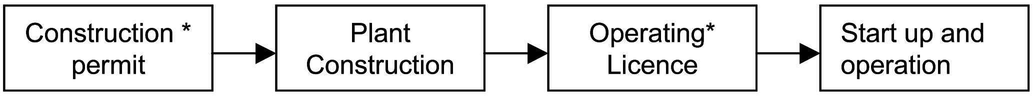
Appendix A:

Licensing

This appendix provides a summary of the changes to the licensing regime in the USA and an overview of the processes in Finland and France.

USA – Changing process to reduce front end risk

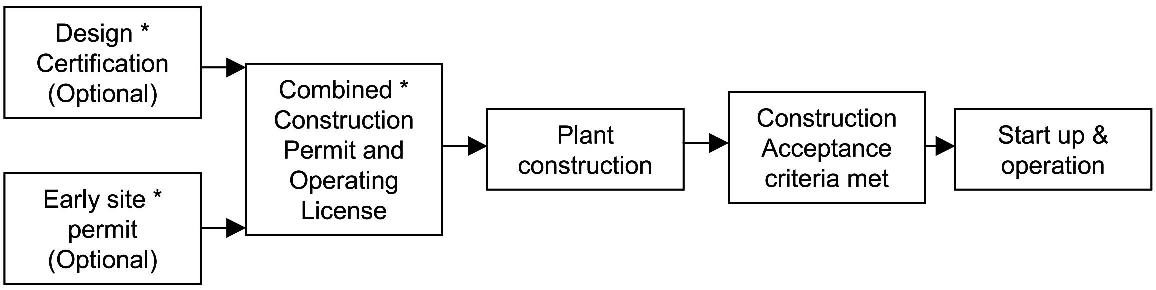
Old System



*opportunity for public consultation

Under the old process, the safety of a new plant's design was not approved until significant investment had been made. This allowed the NRC to ask for design changes after construction had started, significantly increasing the possibility of cost of runs and delays The old method also allowed the public to raise fundamental siting and design issues after the plant had been built. At Shoreham this resulted in the nuclear power plant being abandoned shortly after construction was completed.

New System



*opportunity for public consultation

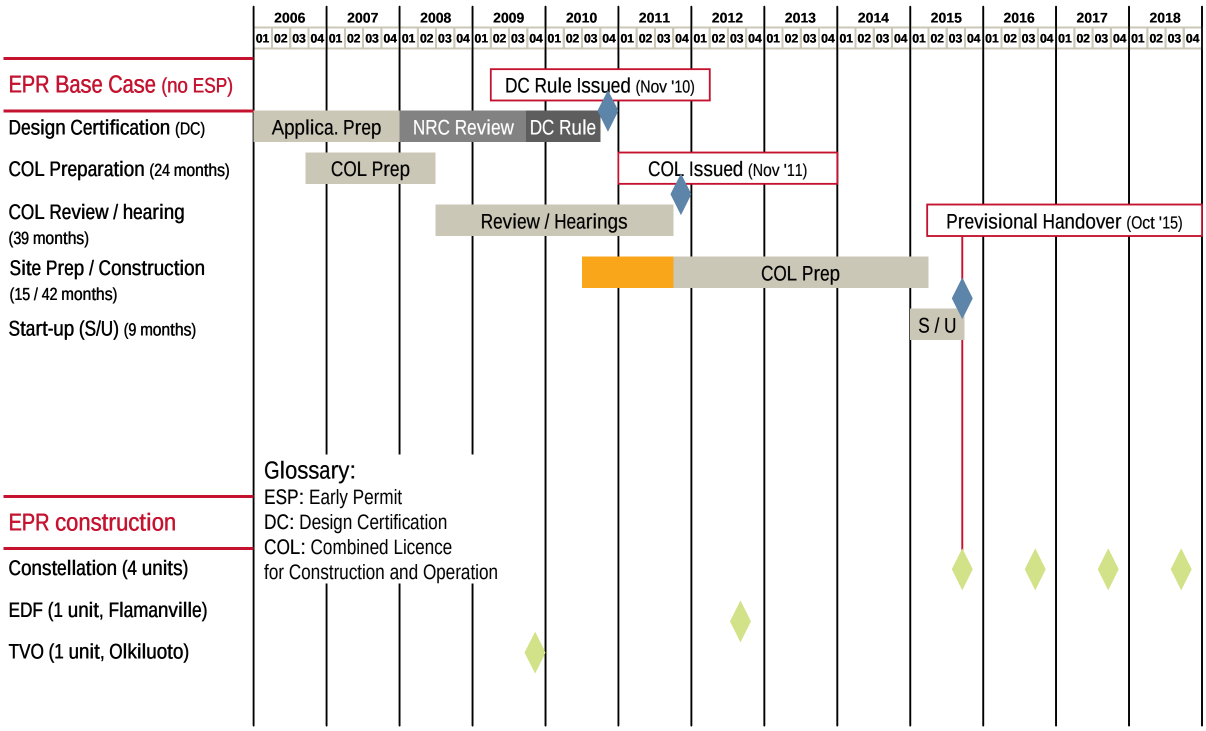
The new system assesses public concern and approves plant design before construction takes place. The result is a much more predictable process and significantly less financially risky projects.

The key features of the new licensing process include:

- **Design Certification (DC)** - fully resolves all safety issues associated with standard plant designs after public consultation
- **Early Site Permit (ESP) -** resolves all issues (e.g safety, environmental protection) around the suitability of a site for a new NPP. Companies can apply for pre approval and keep the permits for future use
- **Combined construction permit / operating licence (COL) –** addresses remaining concerns about the ownership and operation of the plant
- **ITAAC –** ensures the finished plant meets licence criteria

The process in the licensing process in the US is now expected to take between four and five years

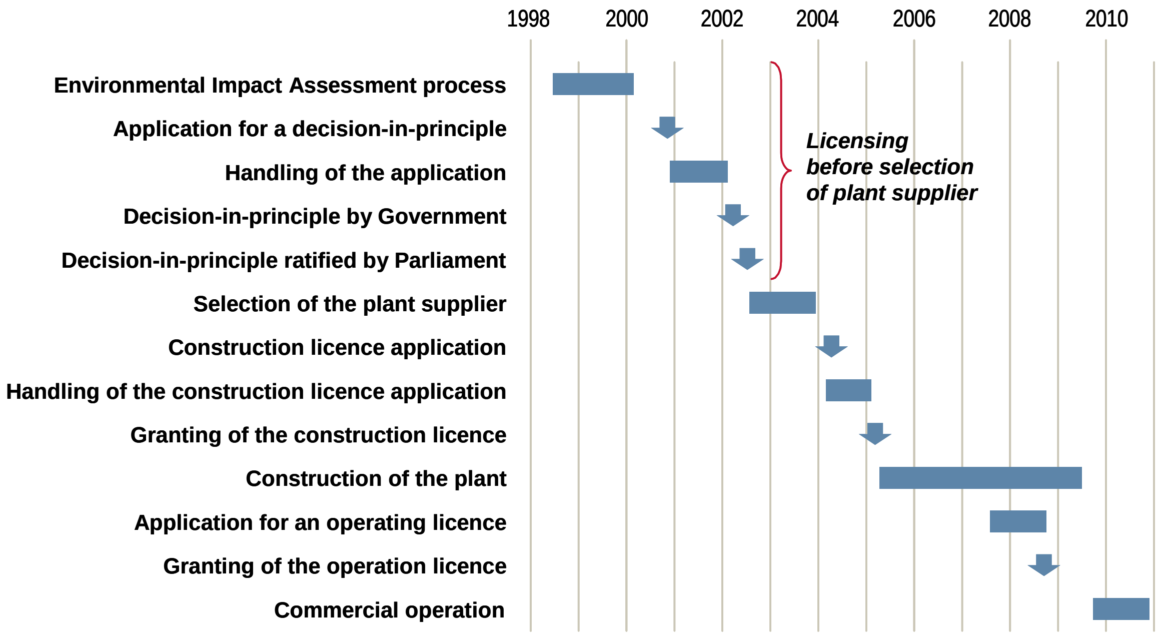
US EPR Design Certification Time schedule



Finland

Finland has also adopted a two-stage process – approving plant design before granting a construction licence

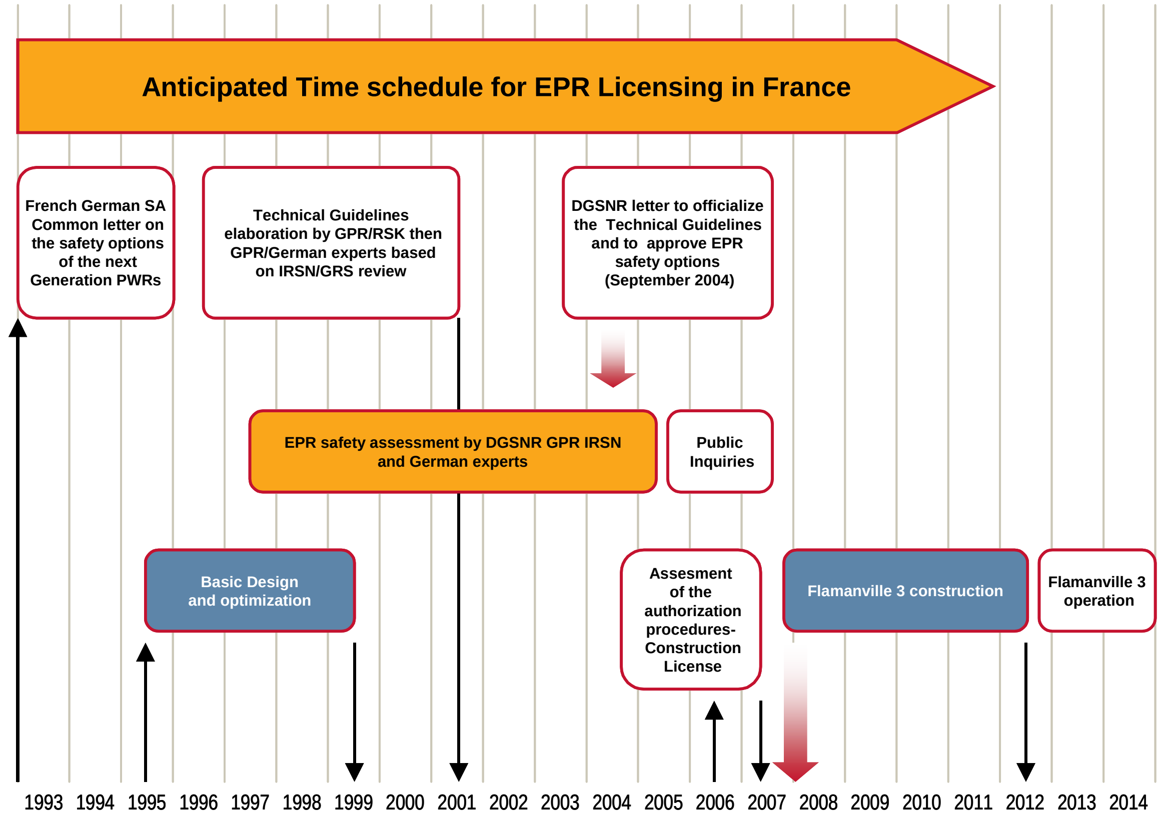
Phases of Licensing process and construction for the Olkiluoto 3 project



Source: Finnish Minister of Trade and Industry (MTI)

France

In France, the procedure is as follows:



DGSNR: French Nuclear Safety Authorities - GPR: French Advisory Group
RSK: German Advisory Group - IRSN: French Technical Support Organization
GRS: German Technical Support Organization

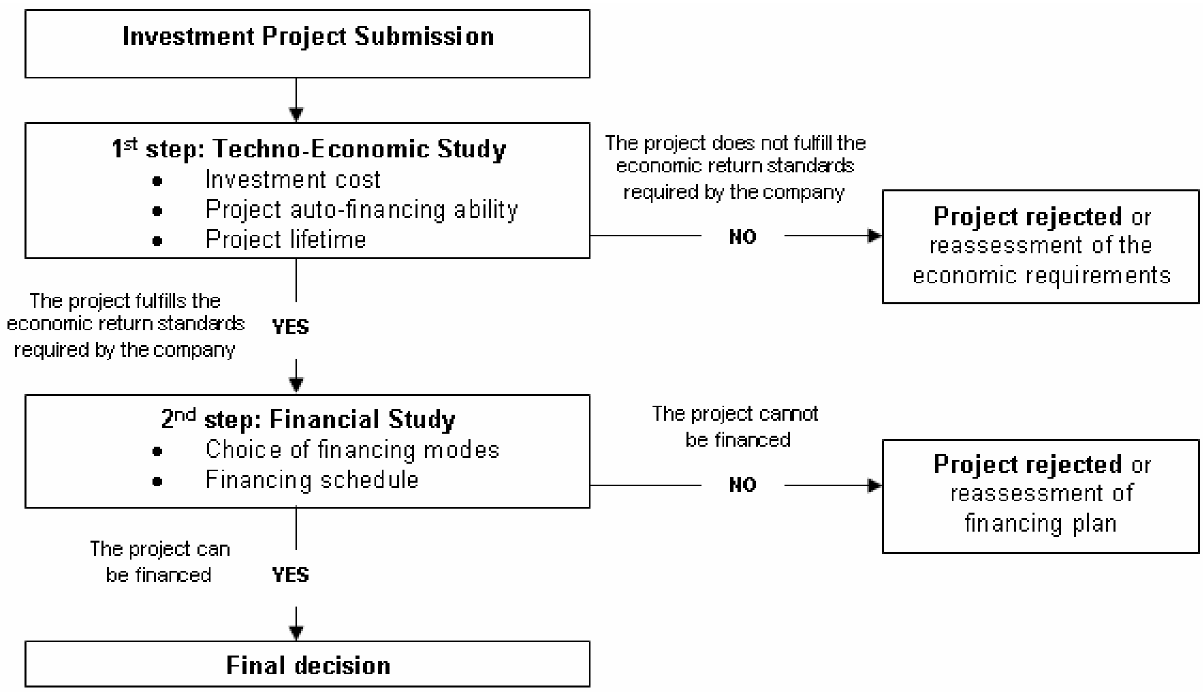
Appendix B

Appendix B:

Economic & Investment Tools

The economic assessment of any investment decision involves different question on the investor's strategy and the conditions of investment. The basic method used is illustrated below.

Criteria commonly used to decide on an investment



The first step of the decision structure is often called a techno-economic study. This aims to compare the benefits expected from project to its costs. At this stage, only the technical aspects are studied and not the project implementation conditions that would be required for a business plan study (income tax, financing structure, etc.). A techno-economic study, therefore, generally considers the following expenses and revenues:

- investment costs;
- operating & maintenance (O&M) costs (incl. operating taxes where appropriate);
- fuel costs;
- revenues expected from the sale of electricity to the grid.

External costs, related to the costs of generation on health and the environment, not paid by consumers or the producers, are not dealt with in this paper.

A techno economic study aims to compare cash received and cash spent, taking into account when the inflows and outflows occur. A plant's costs and revenues can not just be summed over its life time as individuals and companies value cash today more than cash tomorrow (even assuming no inflation) i.e. they would rather have £100 today than £100 tomorrow. To reflect investor preferences, an assessment of a particular project should take into account the time value of money.

Two main methods are used to carry out techno-economic assessments of power generation technologies:

- the Levelized Lifetime Cost Methodology which is used in particular by the OECD for its Projected Costs of Generating Electricity studies and by the French DGEMP-DIDEME for its Reference Costs of Electricity Production studies,

- the Constant Annuity Methodology which is also used in many reference studies and makes it possible to carry out calculations with a smaller number of parameters than the previous method.

The following sections will present these methods and underline their differences. They will show that these methods are relatively similar and lead to similar results as long as the input parameters are consistent.

The Levelized Lifetime Cost Methodology

The levelized lifetime cost methodology calculates costs on the basis of net power supplied to the electricity grid. This method is based on the concept of discounting. The economic theory behind this is that the value attributed today (the Present Value PV) of a cash-flow CFn that will happen in n years from now is given by Equation 1:

$$PV = \frac{V_{time=n}}{(1+d)^n} \qquad (1)$$

where d is an economic parameter known as the discount rate. The discount rate is the linchpin of any economic calculation. Applying a discount rate takes into account the time value for money, i.e. a sum earned or spent in the past or in the future does not have the same value as the same sum (in real terms) earned or spent today.

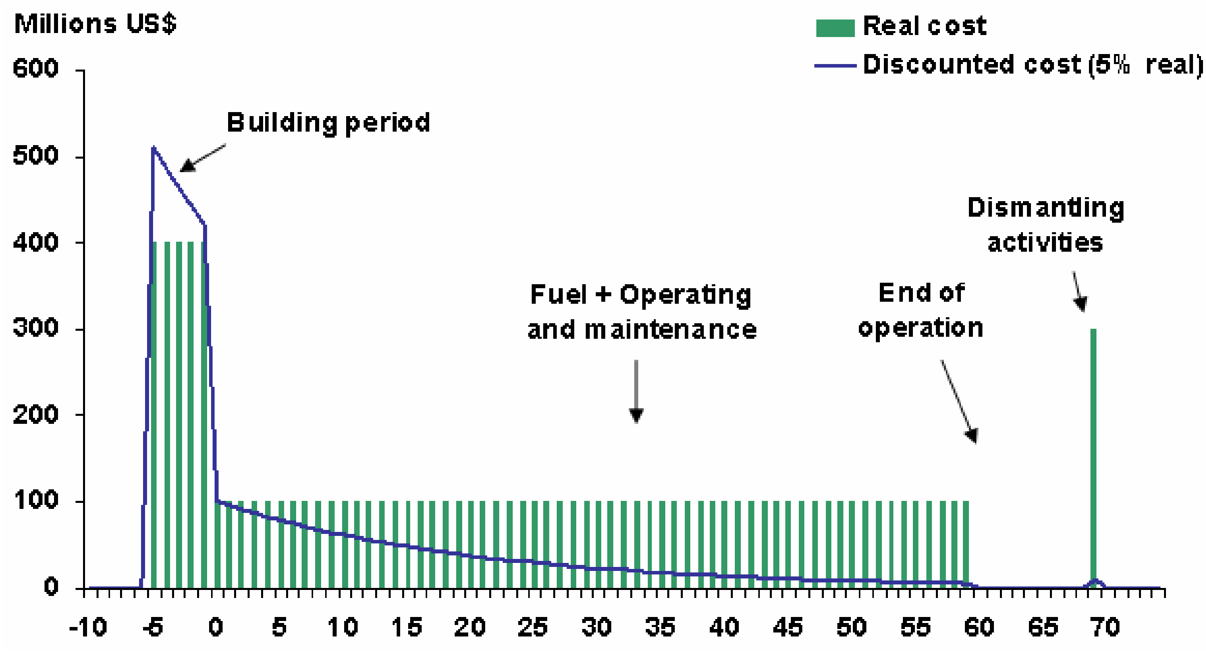


Figure 1: Lifetime cash flows of an illustrative power plant

This methodology discounts the time series of the expenses and revenues to their present values in a specified base year by applying a discount rate. Cash flows and discount rates are either all expressed in real money (i.e.$2005) or in nominal money (i.e. $ of the current year). However, the real money method is more commonly used.

The date selected as the base year for discounting purposes does not affect the levelized cost comparison between different plants. The methodology defines the Net Present Value (NPV) of the project, which is the sum of the discounted cash-flows year after year during the entire lifetime of the project, which extends beyond the plant economic lifetime (N years). The NPV is calculated using Equation 2:

$$NPV = \sum_{n=-T_C}^{Decom.} \frac{p_n \times E_n - (I_n + O\&M_n + F_n)}{(1+d)^n} \qquad (2)$$

where: pn = Price of electricity generated in year n [$/MWh]
En = Electricity generation in year n [MWh]
In = Investment = Share of the overnight cost spent in year n [$]
O&Mn = Operation and Maintenance expenditure in year n [$]
Fn = Fuel expenditure in year n [$]
d = Discount rate [%]
∑ = Summation over the entire lifetime of the project, from the start of construction (-TC) to decommissioning (Decom.).

Applied to generation costs, the result of the levelized lifetime cost methodology is a Levelized Cost of Electricity (LCOE). This LCOE is the price at which the investor/operator will have to sell its electricity to the grid in order to repay all its expenses fully and ensure a rate of return equal to the discount rate (this cost is exclusive of Value Added Tax). The LCOE is defined as the constant average value of pn which makes NPV equal to zero:

$LCOE = p_n$ so that $NPV = 0$ (3)

The LCOE can be split into three different parts - the investment costs per unit of electricity produced, the O&M costs per unit of electricity produced and the fuel cost per unit of electricity produced:

$$LCOE = \frac{\sum_n \frac{I_n + O\&M_n + F_n}{(1+d)^n}}{\sum_n \frac{E_n}{(1+d)^{n}}{}_t} = Inv. + O\&M + Fuel \qquad (12)$$

where:

$$Inv. = \frac{\sum_n \frac{I_n}{(1+d)^n}}{\sum_{nt} \frac{E_n}{(1+d)^n}}, \qquad O\&M = \frac{\sum_n \frac{O\&M_n}{(1+d)^n}}{\sum_t \frac{E_n}{(1+d)^n}}, \qquad Fuel = \frac{\sum_n \frac{F_n}{(1+d)^n}}{\sum_n \frac{E_t}{(1+d)^n}} \qquad (5)$$

As far as O&M and fuel costs are concerned, the annual electric output is often assumed to be constant in techno-economic studies and as soon as O&M costs and fuel cost are also taken as constant over the operating time of the plant, Equation 4 can be simplified as follows:

$$O\&M = O\&M_v + \frac{O\&M_f}{365 \times 24 \times k}, \qquad Fuel = \begin{cases} Nuclear \rightarrow Fuel_{n=0}[\$/MWh] \\ Gas \rightarrow \dfrac{Fuel_{n=0}[\$/MBtu]}{0.293[MWh/MBtu] \cdot \eta \cdot 0.91} \\ Coal \rightarrow \dfrac{Fuel_{n=0}[\$/ton]}{HHV[MWh/ton] \cdot \eta \cdot 0.95} \end{cases}$$

(7)

where O&Mv is the variable part of the O&M costs in $/MWh, O&Mf is the fixed part of the O&M costs in $/kW (we will come back to this cost structure of O&M costs in the following part), k is the capacity factor in %, Fuelt=0 is the constant price of fuel assumed (we do not detail the economic evaluation of the nuclear fuel cycle cost which is outside the scope of this paper), HHV[1] is the High Heating Value of coal and η is the thermal efficiency of the plant in %.

Most often, the reference date for discounting is the commercial operation date. Thus, since investment expenses occur before that date, equation 5 shows that the discounted value of the investment is superior to the investment cost, as if it was spent in one night (called overnight cost). This difference is known as the interest during construction (IDC) which increases with the discount rate used.

$$IDC = \sum_{n \le 0} \frac{I_n}{(1+d)^n} - \underbrace{\sum_{n \le 0} I_n}_{overnight \cdot \cos t} \qquad (5)$$

When this method is applied, the economic merits of different power plant technologies are derived from the comparison of their respective LCOEs. The method allows sensitivity analyses showing the impact of different parameter variations on the relative competitiveness of the alternative technologies considered.

The Levelized Lifetime Cost Methodology can also be used to calculate economic tools other than the LCOE, for example:

- the pay-back period of the investment, given a certain electricity price;
- the internal rate of return of the project, given a certain electricity price.

The Constant Annuity Methodology

The Constant Annuity Methodology is relatively close to the Levelized Lifetime Cost Methodology. In particular, the generating cost can be also split into three different types of expenses:

$$Generating \cdot \cos t = Inv. + O\,\&\,M + Fuel \qquad (6)$$

This method very often assumes constant long-term values for O&M costs and fuel costs. Thus the equations used to calculate these costs are similar to those used in the previous method.

The main difference between this method and the previous method is the way the investment cost is calculated. The annuity method assumes that the total investment cost is paid through a type of loan which is paid back in constant annuities during the economic lifetime N of the plant. During this economic

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[1] The figures *0.91* and *0.95* are the conversion coefficients between the High Heating Value and the Low Heating Value of fossil fuels. These values come from thermodynamics and are independent of economics. These values are taken into account here due to the fact that there are two ways of calculating the heating value of fossil fuels, depending on whether or not the heat content of steam condensation is taken into account. In reality, prices or heat contents given by people selling fossil fuels always refer to the High Heating Value whereas thermal efficiencies given by plant construction companies are almost always based on the Low Heating Efficiency.

lifetime, the annual cash income will cover exactly all the annual cash expenses (O&M + Fuel) as well as the payment of loan interest and the loan repayment.

$$Inv. = \frac{I_0}{365 \times 24 \times k} \times \frac{i}{1-(1+i)^{-N}} \qquad (7)$$

where I_0 is the investment cost of the project (overnight cost + interest during construction) in $/kW, k is the capacity factor in %, i is the real loan interest rate in % and N is the plant economic lifetime, equivalent to the duration of the loan in years.

It has to be noted that since this method does not directly take into account the effect of time on investment costs, then the assumed value for I0 has to take into account the interest during construction.

Unlike the LCOE, this methodology does not reflect in a straightforward manner the return on equity required by private investors. However, the future price difference between the actual electricity market prices and the marginal cost of producing electricity will determine the profitability of the investment.

Definition of the "return" required by private investors

Time discounting is usual practice for the assessment of cash flows generated by a new project over its total lifetime. The main criteria used for investment choices and decisions are the Net Present value (NPV) and the Internal Rate of Return (IRR) of the project.

Capital is supplied by a combination of equity funding and bank loan. The resulting cost of financing will depend on returns required by investors: return on equity (ROE) for equity and interest rate r for loan. Income tax has a particular importance, depending how financing of the investment is ensured (relative shares of equity and debt). The pre-tax Weighted Average Cost of Capital (WACC) is function of the equity ratio:

$$WACC = e \times \frac{ROE}{(1-tax)} + (1-e) \times r \quad \text{where} \qquad e = \frac{equity}{debt + equity}$$

The Return On Invested Capital (ROIC) of any project should be at least equal to WACC, in order to create value. It means the WACC is identified to the discount rate setting the Net Present Value at 0 for a given sales price.

Appendix C

Appendix C:

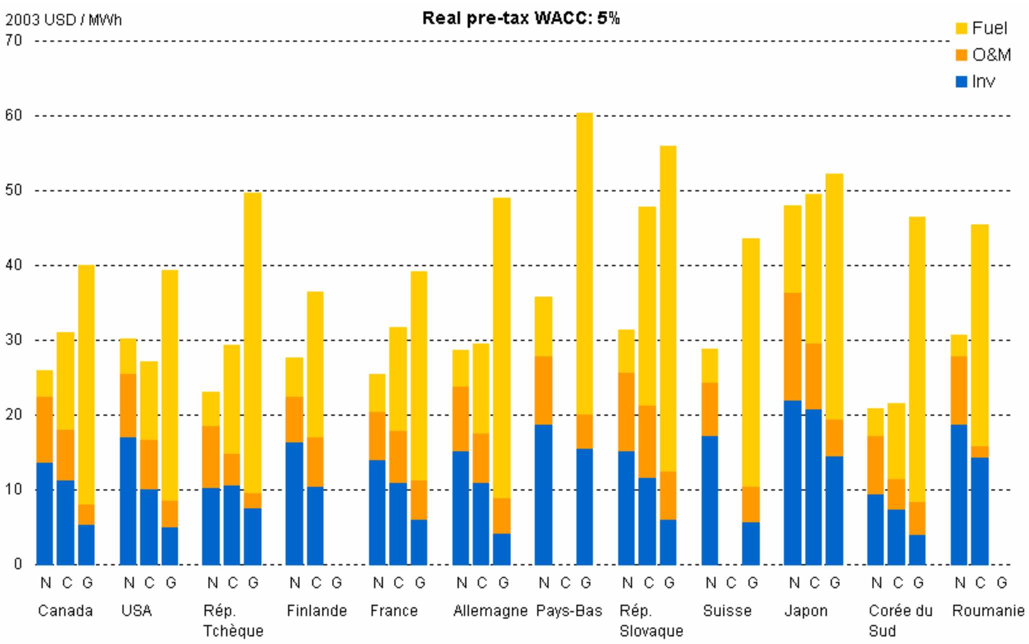
International studies on the cost of nuclear

The results of the following international studies are relevant:

1.

OECD 2005

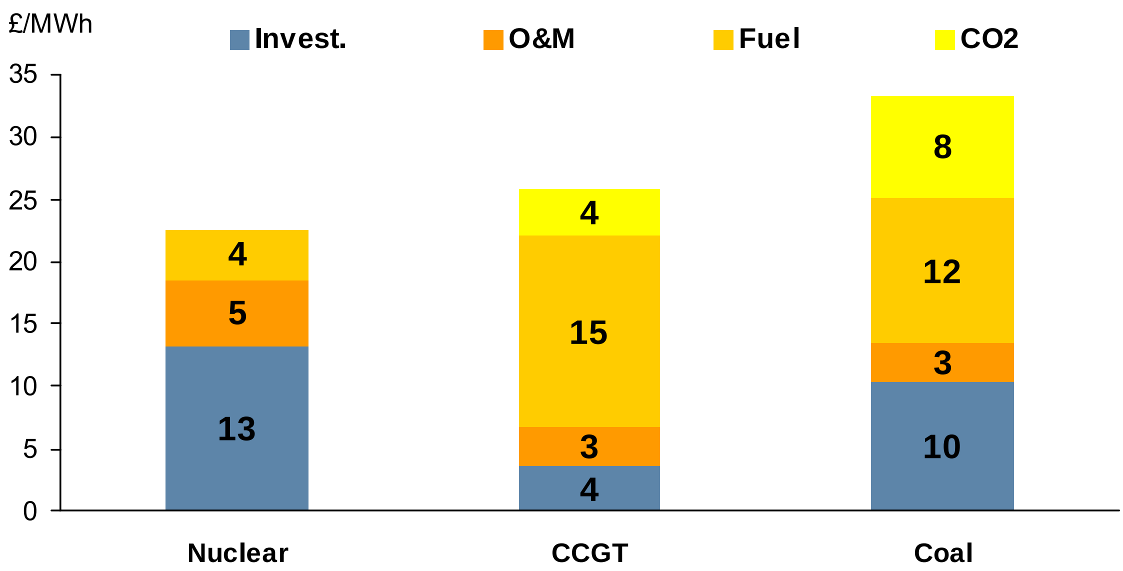
Study showing the international competitiveness of nuclear power at a 5% real pre-tax WACC and 10% real tax WACC



2.

Royal Academy of Engineering 2004
Break down of electricity generation costs

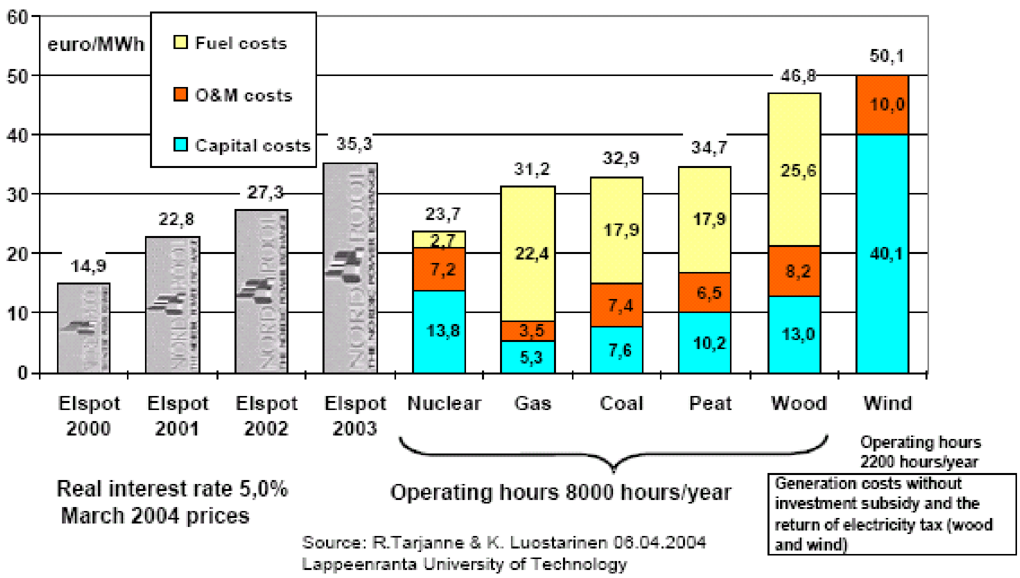
UK study showing the competitiveness of nuclear. Since it was published, gas and coal prices have increased significantly.



3.

R. Tarjanne and K. Luostarinen
Lappeenranta University of technology

Chart showing competitiveness of nuclear power in Finland

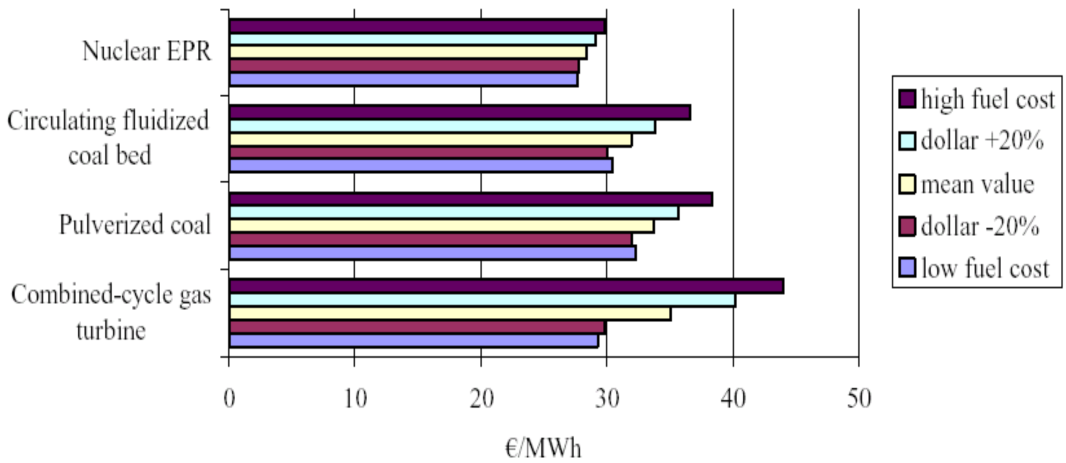


4.

DGEMP study: sensitivity to Fuel prices and €/$ Exchange Rate

The following graph shows the sensitivity of production costs (excluding tax and externalities) to fuel prices and the euro dollar exchange rate and illustrates nuclear power's value as a hedge.

The 8% discount rate adopted here was the rate used by the French Planning office and is compatible with the profitability requirements currently used in the electricity sector.

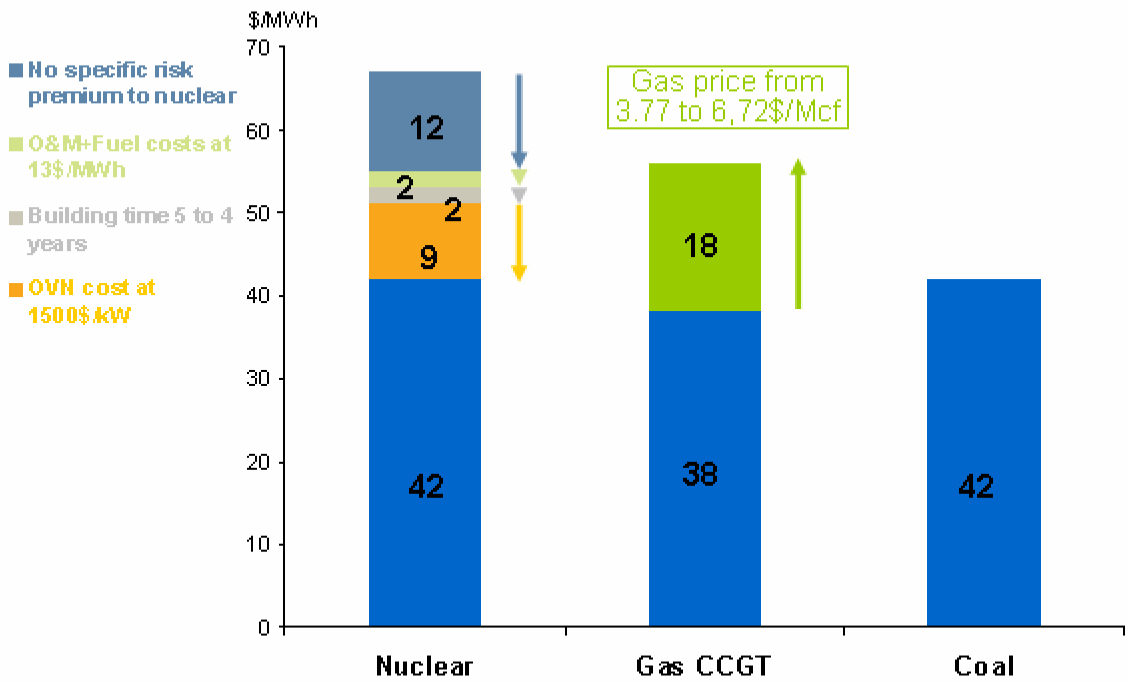


(Figure 3: Sensitivity of production costs (excl. tax) to dollar rate and fuel cost for a year-round production [2015 and 8% discount rate])

5.

MIT Study (2003)

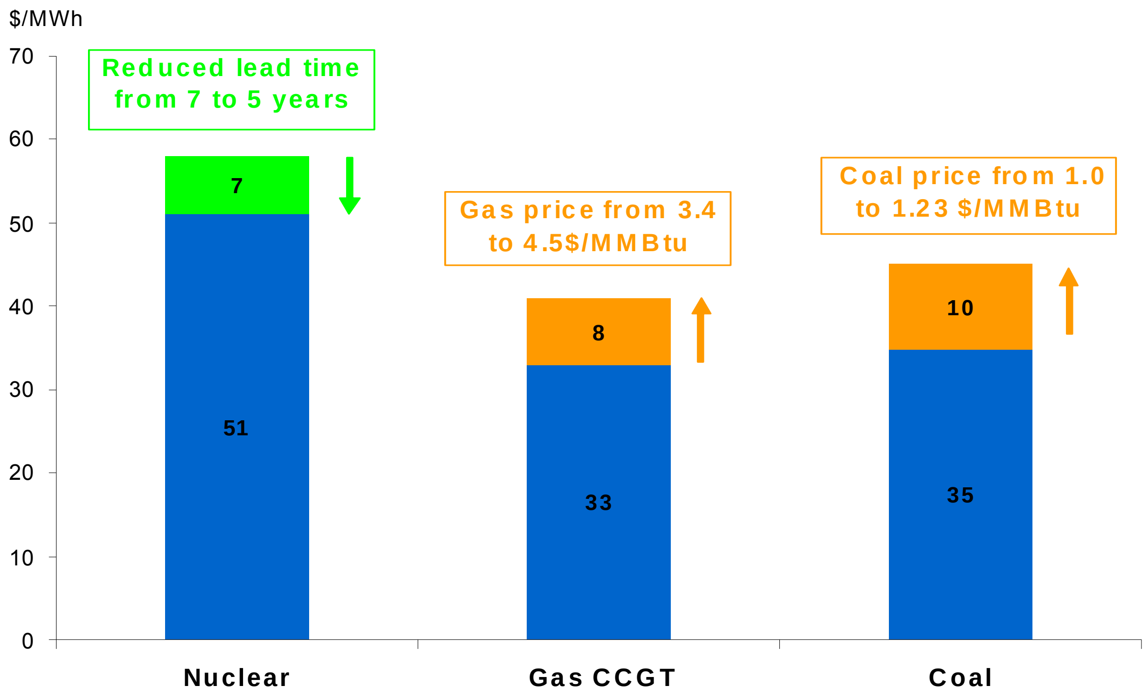
The chart below shows the impact of adjusting the 2003 MIT study to reflect market data on nuclear capital costs and build time together with Gas CCGT O&M cost. Also removes the additional risk premium attributed to nuclear that does not reflect the benefits of standardisation.



6.

University of Chicago (2004 study)

Chart showing results of University of Chicago study adjusted to reflect current information on build times and fossil fuel prices.



Appendix D

Appendix D:

Used fuel and waste management

AREVA believes that closing the nuclear fuel cycle through the treatment and recycling of used fuel will become increasingly necessary in order to sustain an expansion in domestic or worldwide nuclear power. It is an economically and environmentally responsible choice, based on the preservation of natural resources through the recycling of used fuel. It provides a safe and secure management of our wastes while minimising the duty left to future generations.

Ensures a sustainable resource management by recycling valuable fissile materials

With uncertainties in future uranium costs triggered by the global nuclear renaissance, and keeping in mind that each third-generation reactor will require fuel for at least 60 years, used nuclear fuel should today more than ever be considered as a valuable and important energy resource.

96% (95% uranium and 1% plutonium) of the material contained in a used fuel assembly[2] can be recycled into fuel (e.g. mixed oxide or MOX fuel) that can replace standard uranium fuel, thus saving up to 25% of uranium resources.[3]

Optimises final waste management

A closed fuel cycle does not eliminate the need for a final waste management solution. Nonetheless, a treatment-recycling policy can significantly optimise the use of a repository/storage facility by reducing the physical volume and the thermal output of the final waste to be stored:

- **Physical volume:** in treatment-recycling, the uranium and plutonium are recycled, leaving only the fission products and minor actinides to be vitrified, and the hulls and end fittings of the fuel assembly to be compacted, in their respective ultimate waste packages, resulting in a total volume of roughly 0.4 m3/tU. This represents a reduction in volume by a factor of five as compared to direct disposal.
- **Thermal load:** a given repository or long-term storage facility can only absorb a given amount of heat over a given amount of time. The long-term (thousands of years) thermal output of used fuel is dominated by the plutonium and its decay product americium; the removal of plutonium (and hence its decay product) via treatment can thus significantly reduce the

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[2] All figures in this document refer to light water reactors and fuel assemblies
[3] This figure is based on the current light water reactor park in France in a single recycle scenario

thermal output of the ultimate waste form for disposal and allow for increased densification.

Treatment and recycling facilitates the long-term radioprotection of a final repository through:

- A reduction of over 80% of the long-term radiological toxicity per TWh of electricity generated; [4]
- The encapsulation of waste in a stable, homogeneous, and durable ultimate waste form (borosilicate matrix) with a long-term predictable behaviour through vitrification, an industrially proven process. It is worth keeping in mind that fuel elements, prior to encapsulation, are designed for roughly four years of reactor operation, while glass matrices are specifically designed to last for the time that it takes for the radioactivity to decay, that is, for hundreds of thousands of years.

In brief, treatment and recycling provides significantly greater flexibility in a context in which the final waste management option has not yet been chosen or suffers unpredictable delays.

Is a cost-effective solution

The decision to follow an "open" or "closed" fuel cycle has little economic impact as the back-end of the fuel cycle represents a small fraction of the total nuclear kilowatt hour cost. The 2003 MIT report on the future of nuclear power said, "…it should be noted that the cost increment associated with [treatment] and thermal recycling is small relative to the total cost of nuclear energy generation".[5] Furthermore, a very recent study[6] by the Boston Consulting Group based on a scenario in which recycling is introduced in the US by 2020 concludes that "it shows comparable economics to a once-through solution".

Treatment and recycling is already industrially implemented. 20 % of all the spent light water reactor fuel to date has been treated on a commercial treatment and recycling basis since the early 90s[7], and recycling in the form of MOX fuel has been carried out industrially for over two decades. On the other hand, the conditioning and direct disposal of used fuel is still mostly at a development stage. Project costs are on an upward trend, with, for example, the US Yucca Mountain's life cycle cost last estimated in 2001 at $57 billion[8].

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[4] This assumes a scenario in which light water reactor fuel (at 45 or 60 GWd/t) is treated three years after reactor discharge

[5] J. M. Deutch and E. J. Moniz et al, "The future of nuclear power: an interdisciplinary MIT study", Massachusetts Institute of Technology, 2003, p.44

[6] BCG, "Economic Assessment of Nuclear Fuel Recycling in the United States", to be published (2006)

[7] Approximately the same quantity of used fuel is currently stored pending treatment.

[8] U.S. Department of Energy, Office of Civilian Radioactive Waste Management, "Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program", May 2001

Has no significant environmental impact

It has been sometimes argued that the benefits of treatment-recycling would only be attained at the expense of increasing short-term health, safety, and environmental risks. Operating records at both the industrial treatment facility La Hague and the MOX fabrication facility MELOX in France clearly tell a different story:

- Over 20,000 metric tonnes of used nuclear fuel have been treated at La Hague over the past twenty years, and over 2,000 MOX fuel assemblies have been fabricated at MELOX over the past decade;
- Both La Hague and MELOX have negligible radiological impact on the environment with their respective activities both falling well under 1% of the European Union limit for the general public of 1 mSv per year, keeping in mind that the average annual dose from background radiation in France is 2.4 mSv;
- The occupational exposure to radioactivity is minimal, with the average annual individual intakes at La Hague and MELOX falling far below (0.5% and 9%, respectively) the European Union limit which is 20 mSv per individual employee per year;
- Both La Hague and MELOX are certified ISO 9001/2000 and ISO 14001, and have extensive third party verified monitoring of the surrounding environment. Total monitoring for 2004 amounts to some 83,000 analyses from 26,000 samples taken at La Hague, and 30,000 analyses from 17,000 samples taken at MELOX.

Minimises proliferation risks

All fuel cycles incorporate proliferation resistance features but do so via different balances between intrinsic and extrinsic measures. It is worth recalling that proliferation resistance, like safety, is not an absolute but instead a relative notion that evolves over time: "…simply placing [used] nuclear fuel into a geologic repository does not “solve” the non-proliferation problem. The radiation barrier surrounding the [used] nuclear fuel continually decays away [leading to] what some people refer to as a “plutonium mine” if left in place long enough. The intrinsic proliferation resistance of the once-through cycle clearly decreases with time."[9]

In contrast, the vitrified waste (destined for final storage/disposal) produced in today's treatment-recycling facilities does not contain IAEA-safeguarded fissile materials. Moreover, treatment and recycling of the plutonium in MOX fuel not only consumes roughly one third of the plutonium but also significantly degrades the isotopic composition and thus the potential weapon quality of the remaining plutonium after reactor discharge.

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[9] A. E. Waltar and R. P. Omberg et al, "An Evaluation of the Proliferation Resistant Characteristics of Light Water Reactor Fuel with the Potential for Recycle in the United States", Pacific Northwest National Laboratory, 2004, p.21

Aside from the above intrinsic proliferation resistance guarantees, extrinsic measures are taken such as strict safeguarding of the facilities and the separated fissile material. It is important to note that diverting fissile nuclear material from commercial used fuel treatment and recycling facilities has never been the route to a nuclear weapon.

Moreover, treatment-recycling could be integrated into a broader non-proliferation scheme, in which a few selected facilities could be used to treat used fuel from other countries, and the fresh recycled fuel could be made available to selected nations that agree to strict controls. This would be a credible and robust approach to increase global proliferation resistance by avoiding both the dispersion of technology and the accumulation of disseminated plutonium inventories.

In the specific case of the UK, a closed fuel cycle policy is even more pertinent since it provides a robust solution for the separated plutonium stockpile of over 100 tonnes with the added benefit of generating electricity.[10]

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[10] Recycling the existing 100t separated plutonium stockpile would correspond to enough MOX to fuel 10 GWe of new NPP (charged with 30% MOX) for approximately 20 years.

Appendix E

Appendix E:

An outline of Generation-3 safety

The Generation-2 water reactors that are currently operated in OECD's countries are extremely safe industrial facilities. Their safety systems are based on defense-in-depth, which comprises a succession of barriers of different technologies and human interventions, each capable of taking over from the previous one in the event of a failure.

For the past 30 years, none of these reactors has ever faced a major accident with impact on the environment. Even in the case of the Three Mile Island accident (1979, USA), the protection system prevented any release of radioactivity outside the reactor building.

After Chernobyl (1986, USSR) the public in the West demanded that even the worst scenarios, all the way up to a highly unlikely severe core meltdown, would have no detrimental consequences for the people and the environment around the plant. All new Generation-3 reactors, including AREVA's EPR and SWR (boiling water reactor design), have been designed to meet this demand.

Additional measures to prevent the occurrence of events likely to damage the core

The EPR's safety functions are performed by a variety of simple, redundant systems. They are more highly automated than the Generation-2 equivalents. Each of the main safety system is subdivided into four identical sub-systems that perform the same function when an abnormal operating situation occurs, in particular to cool the core. Each sub-system is capable of performing the entire safety function on its own. The sub-systems are totally independent and are housed in four separate buildings, each with its own individual protection system. They have been kept strictly separate. Thus, whenever the slightest fault occurs in one system due to internal or external incidents, another system will take over and continue plant safe operation.

The SWR's safety systems have been simplified by introducing passive safety features which function according to basic laws of physics such as gravity and natural convection. Incorporation of this passive safety equipment together with proven active safety systems provides an optimum combination offering several advantages compared to today's BWRs, among them: reduction of dependance on external power supplies, lower susceptibility to human factor, lower cost and effort for inspection and maintenance.

The likelihood of core damage occurring in existing reactor systems is extremely remote but the new EPR and SWR safety system architectures reduces this significantly further.

Extremely robust, leaktight containment

In the improbable event of core damage occurring, EPR and SWR preventive measures protect the public and the environment from all possible consequences.

The containment building housing the reactor is extremely robust. It is designed to withstand the effects of temperature and pressure which could result from an accident and to remain leaktight.

Even in the highly unlikely event of a core melting accident affecting an EPR, with the melt core piercing and then escaping from the steel reactor vessel in which it is housed, it would be contained in a dedicated spreading compartment. This compartment would be then cooled to remove the residual heat. The SWR is designed in such way that in a situation of core melt, the core would be retained inside the reactor pressure vessel (RPV) by cooling the RPV exterior using water from the core flooding pools located inside the reactor building.

With the EPR and the SWR, this type of extreme event would not extend beyond the reactor containment. The immediate vicinity of the plant, the subsoil and the water table would be fully protected.

Nuclear Power & Terrorism

All nuclear power stations have stringent security regimes and their basic design means any attack is exceedingly unlikely to release nuclear radioactive materials.

Typically, nuclear power stations are initially protected from intrusion by fencing, security patrols and surveillance systems. Access authorizations are required to get on site and the nearer to sensitive areas one goes, the more restrictive the authorizations and access conditions increasingly difficult. Access to sensitive areas is controlled by very sophisticated detection and remote monitoring systems (cameras, metal detectors, biometry, etc.). In the case of UK civil nuclear sites, policing is provided by the Civil Nuclear Constabulary, an armed specialist police force.

Studies carried out in the US[11] and France indicate that a 9/11 style attack on a nuclear power plant would only succeed in forcing the plant to close down and would not lead to the release of nuclear radioactive materials. In the US study it was found that no part of the aircraft would penetrate the containment around a reactor, even with a direct hit by a fully fuelled Jumbo Jet.

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[11] *EPRI Dec 2002 report Deterring Terrorism: Aircraft Crash Impact Analyses Demonstrate Nuclear Power Plant's Structural Strength*

With manufacturing facilities in 40 countries and a sales network in more than 100, AREVA offers customers reliable technological solutions for CO2-free power generation and electricity transmission and distribution. We are the world leader in nuclear power and the only company to cover all industrial activities in this field.

Our 58,000 employees are committed to continuous improvement on a daily basis, making sustainable development the focal point of the group's industrial strategy.

AREVA's businesses help meet the 21st century's greatest challenges: making energy available to all, protecting the planet, and acting responsibly towards future generations.

www.areva.com

AREVA
27 - 29 , rue Le Peletier
F - 75433 Paris cedex 09
Phone : 33 (0)1 44 83 24 34
Fax : 33 (0)1 44 83 25 52