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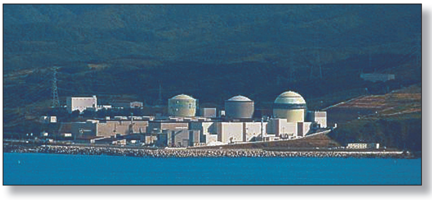
The Financing of Nuclear Power Plants



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NUCLEAR ENERGY AGENCY

The Financing of Nuclear Power Plants

NEA No. 6360

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

There is increasing recognition in many OECD countries that a greater use of nuclear power could play a valuable role in reducing carbon dioxide emissions. However, in recent years only a handful of new nuclear plants have been built in OECD countries and current plans for expansion mostly remain uncertain. One reason for this is that nuclear power plants are more capital-intensive than other large-scale power generation plants. Once in operation, the higher capital costs are offset by lower and more stable fuel costs, but the need to finance high, up-front construction costs often presents a challenge.

During the major expansion of nuclear power in the 1970s and 1980s, many nuclear projects suffered construction delays. These had several different causes, but all resulted in significant cost escalation. Furthermore, since then there has been a shift towards competitive wholesale and retail electricity markets in many OECD countries. These and other factors have heightened the financial risks perceived by potential investors.

This study examines the various financial risks involved in building a new nuclear power plant and how these can be addressed by the project's promoters, by taking steps to mitigate them and by structuring the project to ensure that risks are taken by the parties best able to control and manage them. Recognising that any expansion of a nuclear power programme will require strong and sustained government support, the report highlights the role of governments in facilitating and encouraging investment in new nuclear generating capacity, in cases where the national energy strategy supports this.

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EXECUTIVE SUMMARY

Nuclear power makes an important contribution to secure and economic electricity supplies in many OECD countries, and it is increasingly recognised that an expansion of nuclear power could play a valuable role in reducing carbon dioxide emissions. However, plans for such expansion mostly remain some way from fruition.

An important reason for this is the challenges associated with financing the construction of new nuclear power plants (NPPs). The Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle of the OECD Nuclear Energy Agency (NEA) established the Ad Hoc Expert Group on Financing of Nuclear Power Plants to prepare this study of the challenges faced in financing new NPPs, and in particular what governments could do to facilitate such financing.

The report discusses the various risk factors involved in a nuclear project and how they can be addressed by the promoters of new NPPs, by mitigating some risks and structuring the project to ensure that residual risks are taken by the parties best able to control and manage them. Recognising that any expansion of a nuclear power programme will require strong and sustained government support, a major focus is the role of governments in facilitating and encouraging investment in new nuclear capacity, in cases where the national energy strategy supports this.

Special factors in financing NPPs

While there are many common characteristics between building new NPPs and building other types of large infrastructure, there are a number of special characteristics and circumstances which make investment in new NPPs different in several important respects. It is these special features that can make nuclear financing particularly challenging. These features include:

- The high capital cost and technical complexity of NPPs, which present relatively high risks during construction (delays and cost overruns) and operation (equipment failures and unplanned outages).

- The relatively long period required to recoup investments or repay loans for NPP construction, which increases the risk from electricity market uncertainties.
- The often controversial nature of nuclear projects, which gives rise to additional political and regulatory risks.
- The need for clear solutions and financing schemes for radioactive waste management and decommissioning, which only governments can formulate.
- The need for NPPs to operate at high capacity factors, preferably under baseload conditions.

The higher capital costs of an NPP mean that its overall economics are more dependent on the cost of capital, or discount rate, which applies to the investment in its construction. With any investment, higher risks demand higher returns. Thus, the cost of capital will depend on potential investors' assessment of the risks involved. This will vary depending on who the investors are, the legal and regulatory framework in which the plant would be built, as well as national energy policy and the political background.

During the previous major expansion of nuclear power in the 1970s and 1980s, many nuclear projects suffered very large construction delays and cost overruns. These had several different causes, ranging from licensing and legal problems to technical difficulties. Given also the lack of recent experience with new NPP construction in most countries, the legacy of such problems increases the risks perceived by potential investors. In addition, despite improved public acceptance for nuclear power in some countries, it remains controversial and any project to build a new NPP is likely to face determined opposition. Investors may perceive a risk that a project will be delayed or even halted by such opposition, or that they may face a reputational risk with some consumers.

Since most existing NPPs were built the electricity markets in many OECD countries have been re-structured to introduce competition. Whereas in the past utilities building nuclear plants had a high level of certainty that they would be able to pass on the costs to electricity consumers, in a competitive market there is no guarantee that electricity prices will be high enough to provide an adequate return on investment. However, there are some countries and regions where strong, vertically integrated utilities remain, or where electricity price regulation remains in force. Financing new NPPs may prove to be more straightforward in such cases.

Impact of the present financial crisis

At the time of preparing this report, the global financial system was undergoing severe strains. Clearly, this will have a significant near-term impact on the ability to raise commercial finance for any purpose, including large-scale infrastructure. Public finances are also highly stretched in many OECD countries as governments are obliged to provide support for banks and manufacturing industry. At the same time, the resulting economic slowdown will reduce demand for energy and electricity, which will make investment in any energy infrastructure less attractive. Oil and natural gas prices have also fallen, reducing short-term incentives to invest in non-fossil energy sources, including nuclear power.

On the other hand, upward pressure on costs in the nuclear construction industry caused by shortages of skilled labour and pressure on scarce infrastructure may abate. There may also have been a change in the political consensus in some OECD countries towards greater government participation in strategic industries, including the nuclear and electricity supply industries. It is difficult to estimate the precise effect of this situation on nuclear investments in the short to medium term, since most nuclear projects being developed do not yet represent a firm commitment by their promoters to go ahead and their construction schedules remain subject to other uncertainties.

In the longer term, the case for investment in new NPPs, and the obstacles to that investment, will remain fundamentally unchanged. The main concern is that important investment decisions will be delayed. Given the long timescales needed for nuclear projects, this could mean that short-term options will have to be adopted when economic growth and energy demand pick up.

Main issues and findings

Strong and consistent government support is an essential prerequisite for initiating or expanding any nuclear programme, as part of a long-term national energy strategy. Given the long time frame involved in nuclear projects from the start of construction to the end of operating life, a broad-based political consensus is likely to be needed. Otherwise investors will be open to the risks of sudden policy shifts as governments change, potentially jeopardising their investment.

Many of the risks presented by the special factors noted above can be mitigated by appropriate government actions, which will be necessary before any NPP project can move forward to realisation. Other risks, including those inherent in any large construction project, can be transferred to or shared with other parties by appropriate structuring of the project, in order to reduce the risks to investors.

Specifically, governments need to put in place an efficient regulatory framework, which allows appropriate opportunities for public involvement but allows clear and definite decision making within a reasonable timescale. Additional legal frameworks dealing with liability issues, radioactive waste management and decommissioning are also necessary. In addition, governments have an important role in providing public information and leading national debate on the role of nuclear power, to establish the necessary political consensus.

Electricity market risks can be mitigated by long-term agreements with large consumers or electricity distributors, where these are available. Where possible, direct involvement of such consumers in the structure of the project may be an attractive option. Governments have a role here in that they set the regulations which govern electricity markets, which if badly designed can unduly favour short-term investments.

Another important factor affecting electricity markets is the cost of carbon dioxide (CO_2) emissions, which should make nuclear power more attractive by raising the costs of fossil-fired competitors. However, doubts about long-term political commitment to such policies and carbon price uncertainty may limit the benefits for nuclear investors. Again, governments may be able to take steps to reduce these uncertainties if they wish to encourage nuclear investments. Fully recognising the potential role of nuclear power in a new UN agreement to cut CO_2 emissions could be an important step in this regard.

It is the construction phase of a nuclear project which is generally considered the most risky for investors. This is especially true for "first-of-a-kind" plants and for new nuclear programmes. Large amounts of capital must be invested early on, while returns will not begin to flow until the plant enters operation some years later. Traditionally, construction risk was passed on to electricity consumers through regulated prices, but in liberalised markets this is no longer possible. To some extent, construction risk can be shared with NPP vendors and other contractors actually building the plant, either through fixed price "turnkey" contracts or through performance-related contract clauses, but in practice contractors have only a limited capacity for such risk taking. Debt investors will not normally accept such risks, and loan guarantees will not usually cover additional costs due to delays, etc.

Thus, in most cases the risks of delays and cost overruns will fall mainly on equity investors. They can only reduce these risks by choosing standardised NPP designs that are already in operation elsewhere, built by experienced and well-managed contractors. This is a possible area for targeted government support to reduce the risk to investors to acceptable levels, at least for a limited number of plants in order to start or re-start a nuclear programme.

Corporate finance is the most likely generally applicable model for new NPPs. Large, financially strong utilities will be best able to finance new NPPs, especially if they are vertically integrated. They will be able to attract loans as required, backed by their existing assets. In countries where such utilities do not exist, the need for direct government support to share in the construction risks is likely to be all the greater.

It appears that there is very little likelihood in the foreseeable future to finance a new NPP by using non-recourse or "project" financing (i.e. using only the NPP project itself as collateral). Even for schemes which include a significant proportion of equity, debt investors are unlikely to be willing to provide significant funding for a nuclear plant without recourse against the balance sheet of a strong and creditworthy utility.

It is important to note that the financing of an NPP need not remain static over its lifetime, and in particular that re-financing is likely to be possible once the plant has successfully entered operation. With the risks during construction now removed and with the plant expected to generate steady revenues over several decades, an NPP could be an attractive investment opportunity for investors with a long-term perspective.

Possible government actions to support the financing of NPPs

Key actions that should be considered by governments that wish to see investment in new NPPs include:

- Provide clear and sustained policy support for the development of nuclear power, by setting out the case for a nuclear component in energy supply as part of a long-term national energy strategy. Winning public acceptance of a role for nuclear power in meeting environmental goals while providing secure and affordable energy supplies must be accomplished at the political level.
- Work with electricity utilities, financial companies and other potential investors, and the nuclear industry, from an early stage to address concerns that may prevent nuclear investment and to avoid mistakes in

establishing the parameters for new NPPs. The government will need to take an active role in facilitating nuclear projects, even where investment is to be made by commercial entities.

- Establish an efficient and effective regulatory system which provides adequate opportunities for public involvement in the decision making process, while also providing potential investors with the certainty they require to plan such a major investment. A one-step licensing process with pre-approval of standardised designs offers clear benefits in this regard.
- Put in place arrangements for the management of radioactive waste and spent fuel, with progress towards a solution for final disposal of waste. For investors in NPPs, the financial arrangements for paying their fair share of the costs must be clearly defined. An effective framework for nuclear insurance and liabilities must also be in effect.
- Ensure that electricity market regulation does not disadvantage NPPs. Long-term arrangements may be necessary to provide certainty for investors in NPPs, reflecting the long-term nature of nuclear power projects. Where reducing CO_2 emissions is to act as an incentive for nuclear investments, the government may need to provide some guarantees that policy measures will keep carbon prices at sufficiently high levels.

In countries with large utilities with the financial strength to invest directly in new NPPs, or where there are well-resourced foreign utilities willing to make such investments, fully commercial financing may be possible. However, in other cases it may prove impossible for a nuclear project to go ahead without direct or indirect public sector financial support, in order to reduce the investment risks to acceptable levels.

This could involve supporting a state-owned utility in making nuclear investments, providing support to private sector utilities through loan guarantees, tax credits or other measures, or establishing public-private partnerships. However, it must be recognised that governments will not wish to remove too much risk from private sector investors, that investors should pay the full costs of any financial assistance they receive, and that risk-reward ratios should be appropriate for all investors.

1. INTRODUCTION

Existing nuclear power plants play an important role in providing secure, economic and low-carbon electricity supplies in many OECD countries. There is increasing recognition that an expansion of nuclear power could play a valuable role in reducing future carbon dioxide emissions. However, in recent years only a handful of new NPPs have been built in just a few OECD countries. Plans for expansion mostly remain some way from fruition.

OECD studies[1] comparing the costs of electricity generation from different sources indicate that nuclear power is competitive on a levelised cost per kWh basis (particularly when the costs of carbon-dioxide emissions are taken into account). Recent volatility in fossil fuel prices has also increased the attractiveness of nuclear's more stable generating costs. However, NPPs are more capital-intensive than other large-scale power generation plants, because they are more complex and take longer to construct. Once in operation, the higher capital costs are offset by lower and more stable fuel costs, but the need to finance high up-front construction costs presents a challenge to those wishing to invest in new nuclear capacity, particularly in areas with competitive electricity markets. Table 1 gives an approximate breakdown of levelised electricity generating costs for nuclear, coal and natural gas fired generating plants.

Recognising that this could be a significant barrier to the expansion of nuclear capacity, the NEA Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC) decided to commission a study of the challenges faced in financing new nuclear power plants, and in particular what governments could do to facilitate such financing. The Ad Hoc Expert Group on Financing of Nuclear Power Plants was established to carry out this study. The present report is the result of the group's deliberations, addressed principally to those OECD governments that wish to see private sector investment in new nuclear capacity as a contribution to their domestic energy supply.

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1. *Projected Costs of Generating Electricity*, 2005 Update, OECD (NEA/IEA), Paris, 2005.

Table 1. Approximate breakdown of levelised electricity generating costs for nuclear, coal and natural gas fired plants, at 5% and 10% discount rates

5% discount rate (%)

	Nuclear	**Coal**	**Natural Gas**
Investment costs	50	35	14
O&M costs	30	20	9
Fuel costs	20	45	77

10% discount rate (%)

	Nuclear	**Coal**	**Natural Gas**
Investment costs	70	50	20
O&M costs	20	15	7
Fuel costs	10	35	73

Source: Projected Costs of Generating Electricity, 2005 Update, OECD, Paris, 2005.

Note: These are typical values for plants in OECD countries. The exact breakdown of costs varies significantly between countries and individual plants, and is subject to fuel cost variations.

The higher capital costs of an NPP mean that its overall economics are more dependent on the cost of capital, or discount rate, which applies to the investment in its construction. Since there is always a link between risk and return, the cost of capital depends on potential investors' assessment of the risk factors involved. This will vary depending on who the investors are, the legal and regulatory framework in which the plant would be built, as well as national energy policy and the political background.

Since most existing NPPs were built there have been major changes in the structure of the electricity markets in many OECD countries, with a shift towards competitive wholesale and retail markets. Whereas in the past utilities building nuclear plants had a high level of certainty that they would be able to pass on the costs to electricity consumers, in a fully competitive electricity market there is no guarantee that electricity prices will be high enough to provide an adequate return on investment. This increases the risk to investors.

During the previous major expansion of nuclear power in the 1970s and 1980s, many nuclear projects suffered construction delays, many of them protracted. These had several different causes, ranging from licensing and legal problems to technical difficulties, but all resulted in significant cost escalation.

When coupled with the lack of recent experience with new NPP construction in most countries, the memory of such delays and cost overruns in the construction of earlier plants increases the risks perceived by potential investors.

In many cases there is significant opposition to new NPP construction for reasons which go beyond just energy policy. Despite improved public acceptance in many countries, nuclear remains controversial and any project to build a new NPP is likely to face determined opposition. Investors may perceive a risk that a project will be delayed or even halted by such opposition, or even that involvement with nuclear power may harm their reputation with some groups of consumers.

Where the lead investor is a large vertically integrated state-backed utility in a country with an efficient regulatory framework and a supportive political climate, raising the necessary capital against its existing balance sheet may be relatively straightforward. But for smaller, private sector utilities operating in more competitive wholesale markets, in countries with less certain regulatory frameworks and lacking broad political support for nuclear development, the obstacles to financing an otherwise identical NPP project may be formidable.

This report discusses the various risk factors involved in a nuclear project and how they can be addressed by the promoters of new nuclear power plants, by taking appropriate steps to mitigate the risks and to structure the project to ensure that risks are taken by the parties best able to control and manage them (either directly or through other parties, such as specialist contractors). Recognising that any expansion of a nuclear power programme will require strong and sustained government support in a number of areas, a major focus of the report is the role of governments in facilitating and encouraging investment in new nuclear capacity, in cases where the national energy strategy supports this. The report considers the role of governments in two main categories: establishing the necessary supportive policy, legal and regulatory frameworks; and providing more direct support for financing of nuclear projects.

At the time of preparing this report, the global financial system was undergoing severe strains. Several major banks and financial institutions in the United States and Europe had failed or had required large-scale financial support from governments. Clearly, this will have a significant near-term impact on the ability to raise commercial finance for any purpose, including large-scale infrastructure. Although interest rates have been cut to record low levels in many major OECD economies, capital remains scarce as banks re-build their balance sheets after losses on bad loans.

In the public sector, many governments are being obliged to provide large-scale financial support not only to banks but also to manufacturing industry (notably the automobile industry) affected by a sharp slowdown in demand. This is resulting in rapidly increasing levels of government debt. As economies recover and interest rates return to more normal levels, the costs of this debt will increase, pointing to the need for future cuts in public investment (and also to future tax increases).

In addition, the present severe global economic slowdown will also reduce demand for energy and electricity, which will make investment in any energy infrastructure less attractive in the immediate future. Oil and natural gas prices, which reached record highs in mid 2008, have fallen to much lower levels (although with some recovery by mid 2009). This has reduced short-term incentives to invest in non-fossil energy sources, including nuclear power.

It would be premature to judge how long such difficulties may persist, but it could certainly impact the prospects for financing new NPPs, in the short to medium term at least. While it does not appear that investment in any of the limited number of NPPs already fully under construction has been affected, projects just entering construction or in the planning and licensing stages are more likely to be affected.

It is difficult to gauge the precise effect in many cases, since most nuclear projects being developed do not yet represent a firm commitment by their promoters to go ahead. Many projects aspiring to enter production around 2015 may in any case have struggled to achieve this timetable. However, in South Africa, utility Eskom has blamed a delay in its planned new NPP on the financial crisis (after suffering a downgrade of its credit rating). The crisis may also have led to difficulties in financing the Belene plant in Bulgaria, which was due to enter construction in 2009.

On the positive side, the sharp slowdown in the construction industry, and in other energy industries including oil and gas extraction, may have served to reduce upward pressure on costs in the nuclear construction industry caused by shortages of skilled labour and pressure on scarce infrastructure. If loans can be obtained, lower rates of interest would clearly help reduce the costs of nuclear construction. In a more general sense, there may also have been a change in the political consensus in some OECD countries towards greater government participation in strategic industries, including the nuclear and electricity supply industries. This may make it easier for governments to support nuclear investments in ways discussed later in this report.

2. HISTORICAL PERSPECTIVES AND EXPERIENCE

In the 1970s and 1980s, finance was available for a rapid and widespread expansion of nuclear capacity, even though this was then a new technology with only a limited track record. Today it can appear very difficult to finance a very modest expansion of nuclear capacity, even when it is clear that there is growing electricity demand and/or a need to replace retiring generating capacity. This seems true even though NPP designs available today have been improved in the light of many reactor-years of operating experience, and benefit from more advanced technologies in many areas (for example, in information technology).

Clearly, there are additional factors present today which are serving to increase the risks, actual and perceived, which potential investors face when considering financing a new nuclear plant. Some of these are due to differences in the background against which nuclear investments must take place, but others are due to past experience with nuclear programmes. Investors will always examine the track record of any industry seeking investment, and thus it may be instructive to examine the legacy of the previous wave of nuclear expansion.

Nuclear generating capacity first began to make a contribution to electricity supplies in the 1960s. Early plants were mostly funded by governments as part of efforts to develop and demonstrate this new energy source, and some technology used was a spin-off from military nuclear programmes. The pressurised water reactor, mainstay of the current nuclear fleet, was developed from submarine propulsion reactors developed for the US navy.

Once the technology had reached maturity, by the 1970s, it entered the realm of commercial electricity generation. Nuclear capacity began to grow strongly as utilities in a range of countries invested in this new generating option. The expectation was that nuclear would provide a large share of electricity in most OECD and several other countries. Hundreds of NPPs were ordered and built during the 1970s and 1980s. For reasons which will be discussed below, many other NPPs were ordered but were subsequently cancelled, often after construction had begun.

At this time, in most countries electricity utilities were government-owned enterprises, as electricity supply (in common with other utilities) was seen as a government responsibility. In a few countries, utilities were privately held, but electricity markets were subject to strong government controls and competition was rare. Electricity supply was generally seen as a natural monopoly. Thus, in most cases, utilities were guaranteed revenues from electricity sales to cover their costs, plus a regulated return on capital for private-sector investors. In many cases, governments were directly involved in decision making about what type of generating capacity to build, and in financing it.

This is an important difference from the current position in most OECD countries. A monopoly electricity supplier was normally able to recoup all investment costs, even where these were higher than planned. This remained true even if electricity demand were lower than expected, as the price of electricity could be set to ensure all costs were covered. If the utility was state-owned or state-backed, investment could be financed directly through the state budget or supported by an implicit government guarantee. Where private sector utilities were involved, state regulation of electricity markets was designed to allow a reasonable rate of return (although costs deemed imprudently incurred could be disallowed in the setting of electricity prices). It was against this background that many utilities invested in new NPPs in the 1970s and 1980s. Although this does remain the situation today in some locations, in most cases the electricity market situation has changed dramatically.

Although early experience with building NPPs in the 1970s was largely positive, as expansion continued through the 1980s there were numerous cases of construction delays and cost overruns. In some cases these were very large, with plants costing several times original estimates and construction periods many years longer than expected. In the United States, typical NPP construction costs rose from around USD 200-300 per kW in the 1970s to in the range of USD 1 000-2 000 per kW in the 1980s. Although many of these plants were eventually completed and are now operating successfully, these experiences show the potential pitfalls of nuclear investment and still give potential investors reasons for caution.

As noted above, many plants that were ordered during this period were subsequently cancelled, in some cases after construction was well advanced and very large amounts of money had already been sunk into them. An important reason for this was the Three Mile Island (TMI) accident in the United States in 1979, which increased public and political opposition to nuclear plants, as well as highlighting the technological risks to investors. Partly as a result, no new orders for NPPs were placed in the United States after 1979, although some of those already ordered were later completed.

The heightened safety concerns prompted by the TMI accident in particular resulted in tougher regulatory requirements, involving expensive backfitting of existing and partly constructed plants with upgraded and often more complex safety systems. This contributed to construction delays and cost overruns, as well as the often disappointing operating performance of those plants which were completed.

Meanwhile, anti-nuclear groups became more prominent and better organised in many OECD countries, making extensive use of opportunities provided in the licensing and regulatory processes for public hearings and legal objections to delay nuclear plant construction. The Chernobyl accident in 1986, although involving a reactor type unique to the former Soviet Union, served to make nuclear power more controversial around the world and further increased political obstacles to nuclear investment.

It must also be recognised that, in addition to delays caused by opposition to nuclear power and problems with the licensing and regulatory processes, many delays were due to technical difficulties with construction itself. The plants being built during the 1970s were scaled up versions of demonstration plants built in the 1960s, and were in some cases still being designed as they were built. Although the great majority of plants built were PWRs or BWRs, the design details often differed with each unit as engineers and designers sought to make incremental improvements. It is this experience which has led to today's emphasis on standardised designs, with the aim of making the absolute minimum of changes between successive plants.

There were several other important reasons for the downturn in nuclear orders after the late 1970s. The oil price shocks of the 1970s had encouraged governments to look for alternative energy sources, leading them to support the development of nuclear power. However, oil prices fell back in the 1980s, particularly after 1986, removing much of the incentive to support nuclear expansion. Relatively low oil prices continued to prevail throughout the following period, until after 2000. In addition, in many OECD countries electricity demand growth moderated as a result of a shift from energy-intensive manufacturing industry to a more services-based economy. High interest rates in the early 1980s also discouraged capital-intensive investments. In some countries, the use of natural gas for electricity generation increased markedly, driven by the development of combined cycle turbines. At the same time, energy efficiency improvements continued. This resulted in over-capacity for electricity generation in some countries and regions.

Oil prices in 2008 experienced high levels of volatility, reaching record highs of over USD 130 per barrel in mid year before dropping sharply to around USD 50 per barrel by the end of the year; natural gas prices were similarly volatile in many markets. Concerns about future fossil fuel prices, coupled with pressure to reduce fossil fuel use in order to curb carbon dioxide emissions, have helped renew interest among governments in nuclear power. In addition, in some OECD regions (notably Europe) concerns about security of energy supply have been raised as a result of disruptions of natural gas supplies from Russia to Ukraine and other countries, and the knock-on effects of this on third countries.

Another essential factor in the reconsideration being given to nuclear power is the much improved performance of the existing nuclear fleet. As a result of both technical improvements and better management practices over time, average capacity factors rose significantly during the 1990s. Measures of plant safety have also continued to improve in parallel with performance. These improvements have been maintained in recent years, and have resulted in most existing nuclear plants now being highly profitable generating assets. For example, in the United States, which has the largest nuclear fleet, average capacity factor hovered around 60% during the 1980s, but has been consistently around 90% since 2000.

Indeed, significant investment has been and continues to be made in these existing units, to uprate their generating output and to prepare them for extended operating lifetimes. While most plants were originally expected to have operating lives of up to 40 years, for the majority of plants the present expectation is that operation for 60 years (or possibly even longer) will be technically and economically feasible.

Meanwhile, the limited nuclear construction which has taken place in recent years, principally in China, Japan and Korea, has demonstrated the benefits of new designs and approaches. A significant number of NPPs have now been constructed in these countries in five years or less (from first concrete pouring to commercial operation) and within expected costs, and have entered operation successfully. These include two BWRs at Hamaoka and Shika in Japan, four PWRs at Ulchin and Yonggwang in Korea, and two PWRs at Lingao and two PHWRs at Qinshan in China.

However, the legacy of the often poor experience with construction and early operation of this earlier wave of nuclear expansion remains a barrier to investment in a new generation of nuclear plants. Although many lessons may have been learned, resulting in improved designs and better practices in construction and operation of new NPPs, many potential investors will wish to see a track record of recent construction and successful operation (i.e. through to the first reload) of each of these new designs in a wider range of countries before they consider the risks of nuclear investment acceptable without strong government support for financing. This will be particularly true where a country lacks an existing nuclear programme and thus has no experienced nuclear operating company.

3. THE MAJOR CHALLENGES TO FINANCING NEW NUCLEAR POWER PLANTS

There are several major financial risks which potential investors need to assess before deciding whether to go ahead with construction of a new NPP, each of which can present a significant challenge to the viability of the project. These various risks can be seen in two broad categories: factors which could delay the construction or otherwise increase the capital cost of the plant before it enters operation; and factors which could affect the plant in operation and thus its ability to earn a return on investment.

For any capital investment which takes place over a period of time, in addition to the actual capital expended there is the cost of providing that capital. For loans raised to finance the construction, interest during construction (IDC) must be paid at agreed intervals to the lenders by the owners of the project. As the new plant is not yet generating any income, IDC is normally capitalised (i.e. added to the total capital cost of the project). Similarly, where the owners (equity investors) use their own funds to invest, they will apply a rate of return on that investment.

Most NPP projects are likely to involve a mixture of debt and equity financing, with equity investment normally being more expensive than debt financing. In either case, this allows for the time value of the investment over the period between when the investment takes place and when income starts to flow from the plant.

As NPPs are complex construction projects, their capital costs are higher (in the region of USD 5 to 6 billion) and their construction periods longer than other large power plants. It is typically expected to take five to seven years to build a large nuclear unit (not including the time required for planning and licensing), which is a longer period than most banks and other investors are used to. In comparison, large coal plants can be built in about half that time, while the construction time for natural gas fired plants is less than two years. This means that the economics of an NPP are especially sensitive to delays in entering operation, as IDC represents a larger share of the total capital costs.

There are several different factors which could lead to delays in entering operation. As well as construction and supply chain risks (including the availability of skilled labour and professional staff), they include legal challenges, regulatory or licensing issues, and political and policy risks. These are discussed in more detail below.

Risks which may apply to the operating phase include fuel costs, electricity market prices, plant reliability and performance, as well as political and policy risks. These risks exist for most power generation projects, but in differing proportions.

For NPPs, fuel price risks are generally much lower then for fossil-fuelled plants, since uranium and fuel cycle services can be bought under long-term contracts, with the cost of uranium amounting to only 20% to 25% of total fuel costs (4% to 5% of total generating costs). However, the costs of an unplanned shutdown may be higher for NPPs than other plants. Although NPPs have relatively low marginal costs of production and can thus generate revenues even if electricity prices are low, sustained low prices could result in insufficient revenues to service the loans used to finance their construction and/or provide an adequate return for equity investors.

Table 2 summarises some of the main types of risks involved in investing in a new NPP and possible options for mitigating them. The most important of these risks are discussed in the sections below, roughly in the order in which they arise. Approaches to mitigating these risks, and how projects can be structured to allocate the residual risks among the various parties involved, are discussed in Chapter 4. In many cases, there is an important role for governments in setting the policy and legal frameworks that will allow these risks to be controlled and minimised. These aspects are discussed in Chapter 5.

3.1 Political and policy support

For any large infrastructure project, a broadly supportive policy stance by the government is an essential prerequisite; for a successful nuclear project it is essential that there is a clear policy in favour of having a nuclear programme. Certainly, no investor would contemplate proceeding with construction of a new NPP in the face of government opposition, even if it were not explicitly forbidden. But nuclear investment is also unlikely to take place in situations where the government takes a neutral or uncommitted stance.

Even where decisions on new nuclear build are to be taken by the private sector, investors will seek the comfort of political support from the government. At the very least, as discussed below, it will be necessary for the government to ensure that the licensing and regulatory system is functioning well, that arrangements are in place for the back end of the fuel cycle, and that the electricity market arrangements are appropriate for a nuclear contribution to energy supply.

Since nuclear power remains controversial in many countries it is often the subject of political debates. This is especially true where there is no consensus on nuclear policy across the major political parties in a country. The risk here for investors is that a change of government could produce a reversal of policy on support for nuclear projects. Given that there is likely to be at least one election during the construction period of any NPP, and many elections during its operating lifetime, investors will wish to see a broad political consensus across all major parties on having a nuclear programme, to minimise the risk of sudden policy changes. This will allow the necessary long-term policy measures and legislative framework to be put in place, giving confidence to investors.

Potential investors may perceive a link between risks from licensing and regulation (including how nuclear is treated in the context of electricity market regulation, climate change policy, etc.) and political risk. If the government is not favourably disposed to nuclear power, political considerations may intrude into technocratic decision making, increasing the risk of unfavourable legislative and regulatory changes.

Increasing importance has been placed on curbing emissions of greenhouse gases in recent years, to the extent that it is now an overriding consideration in energy and environmental policies in many OECD countries. This is certainly one of the main drivers behind the widespread re-evaluation of nuclear power's role in future energy supply. However, in a situation where governments are relying on market mechanisms to decide on the future generating mix, the correct financial signals need to be given to investors. In other words, there need to be mechanisms which provide financial incentives to invest in low-carbon energy sources (including nuclear, where the national energy strategy supports this).

Table 2. Summary of the main types of risk involved in investing in a new nuclear power plant

Risk type	Description of principal risks	Primary risk taker(s) and possible mitigation
Design risks	Mis-specification of design, or design does not meet specification, possibly requiring re-design during construction, licensing amendments, additional work and replacement equipment.	Owners and/or vendor, according to fault. Avoid first-of-a-kind risks by using established design, use experienced project managers.
Construction and supply chain risks	Delays by contractors or sub-contractors in completing on-site work or in supplying equipment; sub-standard work or equipment, requiring replacement; costs of work or equipment greater than expected; delays in commissioning of plant; etc.	Vendor and/or other contractors, also owners. Use appropriate contractual arrangements, with experienced contractors and established design.
Regulatory and licensing risks	Unexpected delays in obtaining construction and operating licences and permits from national and local agencies; unreasonable failure or delay in renewing operating or other permits during plant operating life.	Owners and government. Need to establish an efficient and predictable regulatory system; risks will be reduced once system is fully demonstrated.
Political risks	Change of government and/or policy towards nuclear: could result in impaired fiscal, financial or contractual arrangements; additional regulatory requirements; forced abandonment of construction or premature closure of operating plant.	Owners and government. Establish a broad political consensus on the role of nuclear power, with clear legal and contractual cover for political risks.
Financial risks	Changes in interest rates and taxes; inability to re-finance loans on favourable terms; foreign exchange risks; costs and availability of nuclear liability and other insurance.	Owners. Risk reduction through use of financial instruments; need for government to establish legal framework for nuclear liability.

Risk type	Description of principal risks	Primary risk taker(s) and possible mitigation
Natural disasters, *force majeure*	Earthquakes and other natural disasters (according to region), which could cause damage to plant and forced outages; security risks and threats of terrorism, which could add to costs.	Owners. Licensing and design requirements for seismicity, etc.; insurance; avoid politically unstable regions; physical security measures.
Operating risks	Equipment failures and incidents during operation, leading to reduced electrical output, unplanned outages, additional repairs and maintenance, etc.; delays and incidents during planned maintenance and refuelling.	Owners, also vendor and/or other contractors (including warranties). Use experienced contractors, skilled operators, proven equipment design.
Fuel supply risks	Delays in the supply of fabricated fuel elements, resulting in reduced electrical output or even closure; fuel quality issues, resulting in handling difficulties; unexpected large increases in fuel cycle costs.	Owners. Long-term fuel cycle contracts; use competing suppliers; government may need to establish nuclear agreements with supplier countries.
Electricity market and carbon trading risks	Failure to be dispatched by system operator; unexpectedly low electricity prices in market; failure of customer for power purchase or off-take contract(s); unfavourable changes in electricity market regulation or carbon trading regime.	Owners. Electricity market with suitable provisions for long-term contracts, price setting, dispatch, etc.; stable system for carbon trading or pricing.
Waste management and decommissioning risks	Failure to establish national facilities in expected time frame, with inability to move spent fuel and waste off-site; higher than expected costs due to policy uncertainty and delays; increased requirements for decommissioning cost provisions.	Owners and/or government. Need for government to establish clear and consistent policies, and suitable measures to implement them.

NPPs produce no direct CO_2 emissions, and indirect emissions from the full nuclear cycle, taking into account NPP construction and fuel cycle activities, are very low. Thus NPPs could potentially benefit from schemes being introduced or considered in a number of countries to provide incentives to reduce CO_2 emissions, usually by putting a price on such emissions. Although these generally would not provide direct benefits to NPP owners, they should serve to increase the costs of most competing electricity generators, thus increasing the market price of electricity. NPPs should be well placed to benefit from such higher prices, as their costs will not increase due to carbon pricing.

Such schemes could include carbon trading and carbon taxes, as well as legal obligations on electricity suppliers to give preference (i.e. effectively to pay higher prices) to low-carbon energy producers. To date, such obligations have only applied to renewable energies, but in principle they could be extended to include NPPs.

The leading example of a carbon trading or "cap and trade" system in effect is the European Union's Emission Trading Scheme (ETS). Each EU member country is set a limit for emissions from certain major industrial sectors (including power generation); these limits are to be gradually reduced over time. Within its limit, each country allocates emissions allowances to large industrial emitters in each sector covered. Companies which cannot operate within their allocation must purchase emission credits from others that have surplus allowances.

In this way a "carbon market" has been established, designed to encourage companies to invest in reducing emissions in order to benefit from revenue from the sale of surplus allowances. Despite some initial problems in achieving the correct balance of allocations, due in part to the political nature of the process, the scheme is being extended beyond its current trading period, which ends in 2012.

Other countries have studied the EU scheme and are considering introducing similar arrangements. In the United States active consideration being given to adopting cap and trade or similar emissions trading schemes, both at the federal level and among groups of states. In particular, the US Congress was considering legislation to introduce a federal cap and trade system, although the eventual fate of this was unclear at the time of preparing this report.

The effect of pricing carbon emissions in this way should be to increase the costs of fossil-fired generation, either through the need to purchase emissions permits to cover ongoing emissions, or through the additional capital and operational costs of carbon capture and storage (CCS). CCS technology is currently being developed and is expected to be installed in many new and some existing coal-fired plants. Although the exact costs of this remain unclear, they are expected to be significant. In principle, this should make investment in low-carbon alternatives, including nuclear, more attractive.

However, carbon trading schemes are in their infancy and are likely to be modified significantly during the next few years. This creates uncertainty for investors, which equates to risk. There is a risk that the financial benefits to an NPP which should accrue from avoiding CO_2 emissions may be reduced or even denied at some point in the future, either because the government adopts an anti-nuclear policy, or because it wishes to limit the impact on fossil fuel generating plants and takes measures to mitigate the costs to owners of such plants.

To avoid this uncertainty, carbon trading schemes should be technology-neutral, allowing carbon emissions to be reduced with the greatest efficiency. There is also the risk of large price variations in carbon markets due to unexpected changes in the availability of permits or the rules for allocating them. If governments wish to encourage investment in low-carbon technologies such as nuclear power, they should ensure that carbon trading schemes have clear long-term targets with the aim of creating stable carbon markets.

At the international level, the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC), adopted in 1997, commits most OECD countries to cuts in their CO_2 emissions from a 1990 baseline by 2012. While individual countries could make increased use of nuclear power to meet their own emissions target, nuclear was excluded from the protocol’s mechanisms which allow the transfer of carbon credits between countries.

At the time of preparing this report, a follow-on to the Kyoto Protocol was being negotiated. The aim was to reach a new agreement by the end of 2009, including legally binding commitments to reduce carbon emissions for the period after the Kyoto Protocol expires in 2012. It was unclear whether an agreement could be reached by this deadline, and what any agreement might contain.

Clearly, a broad-based international agreement on curbing carbon emissions that fully recognises the potential role of nuclear power could help to support financing of new NPPs. In particular, if nuclear projects were included in the various mechanisms for the transfer of carbon credits between countries likely to be included in any new protocol, this could make NPPs a more attractive investment option.

3.2 Nuclear licensing and other regulatory processes

In some countries, there is a history of difficulties in the licensing process for new NPPs which led to delays in bringing plants on line. Such delays contributed to significantly increased costs, and this has made potential investors wary of nuclear projects. In the most notorious case, a fully completed NPP in the United States (at Shoreham on Long Island, New York) was unable to enter commercial operation after being refused an operating licence. The plant had cost around USD 6 billion to build, effectively bankrupting owner the Long Island Lighting Company (which had to be taken over by the New York state government).

Although most countries have not experienced such severe difficulties in licensing NPPs, there have also been delays and legal challenges in some other countries, notably Germany. Furthermore, in many countries no new NPPs have been licensed for many years, so it may be unclear how smoothly the process will proceed under present conditions. The level of risk depends on the nature of the licensing process, and also on how smoothly it has been seen to work in practice in recent experience. Lack of such recent experience will clearly increase the perceived risk.

The risk that a completed plant will be unable to start up promptly (or even at all) is clearly one that must be minimised. Such problems in the past have sometimes occurred as a result of a two-step licensing process, with a construction licence issued first and a separate operating licence issued once construction is complete. In some countries, the operating licence is subject to periodic renewals. This allows multiple opportunities for the original decision to go ahead with the plant to be revisited, with a succession of opportunities for opponents to block or delay the licensing process through public hearings and legal challenges.

It is important that the licensing process is rigorous and fair to all interested parties, and that there are appropriate opportunities for public involvement, but it must also be capable of making a firm decision to go ahead or not. If investors judge that there is a significant risk that a decision to go ahead with an NPP will be overturned or that the plant will suffer delays in entering operation when all the licence conditions have been met, they are unlikely to proceed.

In general, there are expected to be some advantages in licensing a potential new NPP project if it is to be built on or near to an existing nuclear site. Many existing nuclear sites have room for additional units, meaning that the necessary land is already under the control of an existing nuclear utility. The characteristics of the site will already be well known and suitable for nuclear construction, and some existing infrastructure (notably transmission corridors) may already be in place. In most cases, levels of public support for a new nuclear plant will be higher than among the population as a whole. These factors are likely to ease passage through the licensing process.

Reforms have been made to the licensing process in some countries, most notably in the United States. Here, a one-step combined construction-operating licence (COL) has replaced the former two-step process. Standardised NPP designs and potential sites can both be pre-certified before the COL application, which should serve to speed up the licensing process, especially for follow-on plants. In principle, the new procedure appears a significant improvement, but investors are likely to attach some risk to a new and untried procedure. The first few applications were made in late 2007, and as of May 2009 a total of 18 applications had been received by the NRC covering 28 new units. Once the new procedures are seen to be working smoothly, the perceived financial risks of licensing may be greatly reduced.

In the United Kingdom reforms have also been made to the licensing process. The UK regulator is currently conducting Generic Design Assessments (GDAs) of two NPP designs. This should mean that an applicant for a licence to construct one of these designs can refer to the GDA and will not have to prove that the design meets the regulatory requirements. The government has also introduced the Strategic Siting Assessment process, which allows certain projects (including nuclear plants) to be designated as being of strategic national importance. This means that local planning applications are limited to local issues relating to the site.

One difficulty faced by designers of NPPs is the differing regulatory requirements in different countries, which often require significant design changes for different jurisdictions. This adds to costs and also increases the risks during construction, as it may not be possible to stick closely to an existing standardised design in some respects. Of course, each country remains responsible for the safety of plants within its borders, and needs to maintain its own regulatory system with an independent regulatory body. However, efforts are underway to harmonise regulatory requirements to the extent possible, notably through the Multinational Design Evaluation Programme (MDEP), which brings together regulators from different nuclear countries to improve cooperation and discuss common standards.

Such harmonisation may also help address a potential drawback of design pre-licensing. The costs to NPP vendors of obtaining design approval can be significant, and some may decide not to enter a particular market if they judge that there is only a limited opportunity to win orders. This could restrict competition and the choice of designs available, especially in smaller markets. This effect will be greater if the country has significantly different design requirements than other countries where the design is already licensed, as this is likely to increase vendors' costs.

There have been additional costs placed on NPP owners in the past as a result of changed regulatory requirements imposed after NPPs have entered operation. Such new regulations have sometimes required long outages and major backfitting. Much of this was in response to the issues raised by incidents at operating plants, notably the Three Mile Island accident in 1979 and the Chernobyl accident in 1986. However, new NPP designs which being built today have benefited from the experience with building and operating existing NPPs and already incorporate improved systems and technologies. However, some risk to investors from changes in regulatory requirements is likely to remain.

In many countries there are additional regulatory and planning requirements beyond those of the nuclear regulator, which mainly relate to the site where the NPP is to be built. These may involve other governmental agencies and state or local governments. In cases where there could be trans-boundary impacts, similar agencies in neighbouring countries may also have to be consulted. The issues covered will generally include the broad environmental impacts (water use, wildlife, new roads, etc.) on the local area around the NPP site. Such procedures will normally be applied for any large construction project, and are not specially designed for NPPs. Difficulties with such procedures are likely to be minimised if a new NPP is being built on or near an existing nuclear site.

As with nuclear licensing and regulation, there is a need for predictability and stability in these procedures to minimise financial risks. While there should be a careful consideration of the issues leading to a balanced decision, there should not be multiple opportunities for decisions to be overturned once made. Furthermore, the scope of such regulatory and planning procedures should not include issues that are more properly dealt with in the nuclear licensing process.

There is also likely to be a process for the approval of new transmission lines to serve the NPP site (unless it is an existing site with sufficient capacity in the existing transmission corridors). Again, there is a need for effective but efficient procedures to be in place to minimise the risk of unnecessary delays.

3.3 Nuclear liability and insurance

Nuclear power plants are subject to special legal arrangements to cover the liability for damages caused by a nuclear accident. While a proportion of the liability is covered by governments, plant owners are also often required to have specialised insurance to cover their part of this liability. Increased requirements for such insurance have raised concerns that sufficient cover may not be available, or that it could be prohibitively expensive. This presents a potential risk to investors in NPPs.

Most countries with nuclear programmes are signatories to one of the two main international conventions on nuclear liability, known as the Paris Convention and the Vienna Convention. These commit governments to provide a certain level of liability cover, and to require plant owners to take out insurance for the remaining liabilities. The United States is a notable exception, and has its own legal arrangements (known as the Price-Anderson Act) to cover nuclear liability.

The Paris Convention has recently adopted increased insurance requirements. However, existing nuclear insurance arrangements may not be able to provide sufficient cover. It appears that the availability of nuclear insurance has become more limited in recent years, and its cost has been rising. NPPs owners could be caught between a legal requirement to have insurance, and the increasing difficulty and/or cost of obtaining it.

In addition, there are some risks that may not be covered by the existing nuclear liability regimes. For example, non-signatories to the Paris and Vienna conventions may not be covered for nuclear damages caused by a plant in a neighbouring country. This would leave plant owners with an uncovered liability, which could deter potential investors.

Other types of insurance will also be required for an NPP construction project, in common with other large projects. Investors in such a project will normally require certain insurance covers to be obtained to protect their investment. In most cases, such insurance is only available to the project owners, and will be an additional cost for them. The requirements for such insurance, and thus its cost, can depend on the financing model adopted.

In principle, investors in a new NPP could obtain insurance cover for political, regulatory and construction risks, thus transferring these risks onto insurance markets. However, the costs of such insurance will depend on the levels of risk that insurers assess in each of these areas, and could be prohibitive if the risks are deemed too high. This would impact the financial viability of the project.

3.4 Construction and supply chain risks

This has in the past been one of the most important risks of investing in NPPs, in common with most other large infrastructure projects. Although some of the construction delays, and hence cost overruns, with existing NPPs can be attributed to licensing, regulatory or political issues, many delays were caused by technical aspects of the design and construction process. Often designs were still being completed and adapted as the plant was under construction, with many NPPs having unique or unusual design features. As a result, there were many examples of NPPs taking years longer to construct than expected, with correspondingly large cost overruns.

The approach often being taken with nuclear projects today is to use a proven design, and make as few changes as possible to adapt it to a specific site. Thus the construction risks will be concentrated on the first-of-a-kind (FOAK) plant, with follow-on plants having lower construction risks (provided the FOAK project is completed without major problems). However, the problem of financing the FOAK project itself remains.

It should also be noted that there are potential drawbacks to this approach. It may mean foregoing the potential benefits (as well as the risks) of the latest technological developments and design changes based on recent experience. It may deter innovation, if there is little prospect of winning orders with a new design. In addition, choosing a standard design means working with a single lead NPP vendor (the technology holder) and its partner companies, thus reducing the possibilities for competition between suppliers once the initial choice is made.

The construction of an NPP requires a wide range of specialist expertise and manufacturing capabilities, resulting in the need for complex supply chains which often stretch across several countries. Thus, in addition to delays and costs incurred as a result of design issues, construction delays and increased costs can result from supply chain risks, i.e. constraints in the availability of skilled labour, construction materials, equipment and components. Delays can also occur in plant commissioning and start-up, after construction itself is completed and once the operators have taken over from the construction teams.

After a prolonged lack of orders for new NPPs in most OECD countries, many of the companies and facilities previously involved in the supply chains are no longer available. While there are signs that investment in nuclear supply chain capacity is increasing as nuclear and other engineering companies prepare for an expected upturn in orders, if there is a significant increase in the number of NPPs ordered it will take several years to build up supply chains to meet this increased demand.

The longest lead-time is expected to be in increasing capacity to produce the very large steel forgings which are required by the latest NPP designs. Not only is capacity very limited at present, but nuclear projects could be in competition with other industries (notably the oil industry) for the capacity that does exist. However, some countries with large nuclear programmes (including China, France, Korea and the Russian Federation) are already planning increased forgings capacity.

Construction is clearly an area where, in general, the financial risks will need to be taken by the parties involved in the commercial contracts to build the plant. These risks will be shared between the eventual owner of the plant, other investors, and the NPP vendor and other contractors who are involved in the construction process. The exact division of the risks in any particular case is a matter which is defined by the contracts put in place between the parties before construction starts. This is discussed in more detail in Chapter 4.

However, for nuclear plants these risks may be considered too great for investors to go ahead on the basis of fully commercial financing. In order to encourage the development of new NPPs, where the national energy strategy supports this, governments may need to remove or mitigate some risks for commercial investors, particularly for FOAK projects. For example, this could be done by means of loan guarantees, an approach which has been adopted for a limited number of new NPPs in the United States. In other cases, NPPs may be built by wholly or partially state-owned utilities, which gives them implicit government support.

3.5 Electricity market conditions and regulation

An important consideration for investment in any power generation plant is the ability to sell the power produced at a price which will provide an adequate return over the life of the plant. With many OECD countries now having an electricity market which is open to competition, at least to some extent, in many cases there is no guarantee that any generator will find a ready market at an attractive price.

In this respect, the way the electricity market is designed and regulated will have important consequences for the financial risk to investors in NPPs. Where NPP owners are themselves vertically integrated utilities, i.e. involved directly in electricity distribution and supply, they may have a more-or-less guaranteed market for the plant's output. But in some markets, such vertical integration is limited or even forbidden. Alternatively, NPP owners may wish to enter long-term contracts to provide power to a distribution company, or to have a long-term "off-take" contract with a third party which will guarantee to pay for a certain amount of power. However, in some markets such arrangements may be restricted as they can be considered to limit competition.

The technical characteristics of NPPs are such that they usually operate best in a baseload fashion (i.e. at constant maximum output), rather than varying their output in accordance with demand (known as "load following"). Hence they are normally considered "must run" plants, and their owners must accept the market-clearing price prevailing at any time, which is essentially set by the marginal costs of the most expensive generating capacity required to meet demand at that time (in many markets, at peak times this is natural gas-fired capacity).

Since nuclear plants have low marginal costs (with only wind and some other renewables being lower), this means that they will almost always be able to operate with at least marginal profitably. However, the risk remains that the profits will be inadequate to provide an adequate rate of return for investors.

With demand expected to grow in most countries, and/or many older fossil and nuclear plants expected to close in the coming years, in principle there should be no difficulty for suppliers of baseload CO_2-free electricity to achieve a good price. In this respect, it should be noted that the effect of carbon trading schemes will be to increase the marginal costs of fossil plants, which should be reflected by higher prices in the electricity market. However, there is always the possibility of over-capacity at certain times of the day from other non-fossil sources (for example, due to large wind power capacity being available at off-peak times) or of the year (such as from seasonal hydro resources), which may reduce prices to very low levels at times.

In addition to market price risks within the existing market structure, there is a risk of unfavourable changes in the design and regulation of electricity markets. The United Kingdom provides a clear example of this. After privatisation in 1996, nuclear generator British Energy was able to sell all its production into the electricity market "pool" and received the market-clearing price (i.e. the price bid by the most expensive generator dispatched at any given time). However, market reforms introduced in 2001 (known as the New Electricity Trading Arrangements) allowed a large proportion of power to be sold outside the pool through bilateral contracts, with the pool essentially providing a market balancing mechanism. Together with other factors in energy markets, this led to sharp falls in wholesale electricity prices. This was an important contributor to British Energy's financial difficulties beginning in 2002, and its subsequent collapse and effective re-nationalisation in 2004.

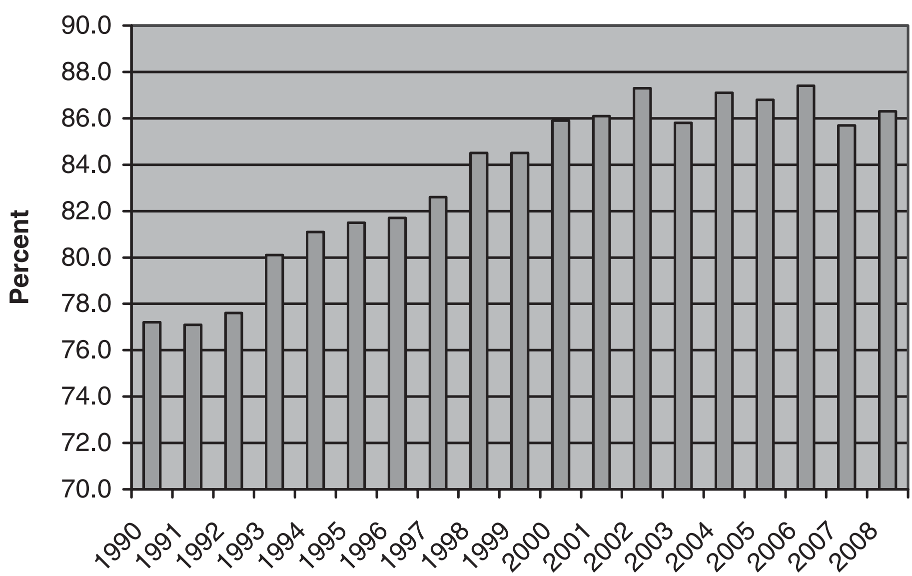
Some of the latest designs of NPPs now available do offer improved load following capabilities compared to existing nuclear plants. However, they will still take longer to respond to changes in demand than some other types of generating capacity. The relatively low fuel and operating costs, and the need to generate revenues to service capital costs, will continue to mean that NPPs perform best when operated as baseload plants.

3.6 Plant operating performance

Once a plant is built and handed over to the owner, it is clearly the responsibility of the operating utility to ensure that it operates to a high standard of safety and efficiency. Unplanned shutdowns caused by technical failures have a high cost in terms of lost sales of electricity, as well as additional maintenance costs.

During the 1970s and 1980s in particular, there were many NPPs which suffered from poor operating performance. However, the 1990s and 2000s have seen greatly improved overall performances from the existing nuclear fleets, to the extent that most existing plants are now seen as highly valuable generating assets (see Figure 1).

Figure 1. Unit capability factor (percentage of maximum generation plants are capable of supplying to the grid), 1990 to 2008



Source: World Association of Nuclear Operators.

In general, larger utilities operating at least several NPPs have proved to be the most successful, as they have the resources and the expertise needed to optimise operating performance. In the United States, a significant number of NPPs originally owned by smaller utilities have been bought up by larger operators. This consolidation has driven improved performance, since as some utilities have specialised in nuclear operations and gained more experience, they have been able to further improve performance at both their existing and newly acquired plants. Prices paid for existing NPPs have increased significantly as the full value of these plants has been recognised.

Having personnel who are experienced in operating existing nuclear plants will clearly be of great benefit to any new NPP, especially during the crucial commissioning process and early operation. This experience should ideally permeate through the entire management structure of the utility, to provide a culture which supports both safety and performance in operating the plant. Thus, the risks associated with plant operation will be reduced if an established nuclear utility is the principal sponsor of a new NPP project.

Investors will need to assess the reliability of the design which they are proposing to build, including the existing construction and operating experience. For new designs, even where they are based on well-established technologies and systems, there are additional risks over and above those associated with later plants. As with plant construction, such FOAK risks may make investors reluctant to choose new designs, even where these potentially offer significantly improvements in performance and efficiency over more established designs.

3.7 Nuclear fuel supply

The high capital costs of NPP construction, and thus the long pay-back period, mean that the availability at reasonable prices of nuclear fuel (comprising principally uranium, enrichment and fabrication) is of concern to investors. Given the long operating lifetimes of most NPPs, with new plants designed to operate for at least 60 years, this concern extends over an extended timescale compared to other energy resources. Any significant expansion of nuclear power would need to be matched by an increase in uranium production and by a matching expansion of fuel cycle facilities.

The OECD NEA and the International Atomic Energy Agency (IAEA) jointly publish a biennial report on uranium resources, production and demand, which includes an assessment of the long-term adequacy of known resources. The 2007 edition concludes that sufficient conventional resources have already been identified to allow significant growth in nuclear generating capacity in the long term, and that these could be extracted at reasonable cost.

However, it does point out the need for the uranium market to provide appropriate price signals to enable the necessary investment in uranium production to go ahead. The report also notes the existence of large unconventional resources, and the large potential for the recycling of spent nuclear fuel in the longer term (especially with the introduction of advanced nuclear technologies now under development).

In general, increased demand for nuclear materials and services will lead to increased supply in the international markets. However, such expansion may take time, and in many cases it will occur in only a limited number of countries. Some countries planning to build new NPPs do not have uranium resources, or the ability or need to invest in their own nuclear fuel cycle facilities. For uranium enrichment in particular, the technology for which is sensitive from a non-proliferation standpoint, the number of suppliers will necessarily be limited.

Thus, nuclear fuel supply can be subject to political and regulatory risks, as well as possible barriers and tariffs on international trade. To address some of these risks, the IAEA and others have initiated discussions on possible mechanisms to guarantee fuel supplies to countries without their own fuel cycle facilities, such as through an international "fuel bank". An important aim is to avoid the spread of sensitive technologies such as enrichment and spent fuel reprocessing. However, such discussions are at an early stage and face significant obstacles.

However, uranium and fuel cycle services are available on commercial terms from at least several different suppliers in different jurisdictions. Such materials and services are generally available on a non-discriminatory basis to consumers in countries which are in good standing as regards their non-proliferation credentials. For most countries, therefore, the risk of nuclear fuel supplies becoming unavailable or prohibitively expensive during the operating lifetime of a new plant should be acceptably low.

Owners of NPPs can further mitigate these risks by entering long-term contracts with suppliers. This can also provide the support needed for companies involved in uranium mining and the nuclear fuel cycle to invest in new and expanded facilities. In some cases, NPP owners have chosen to become direct equity investors in uranium production companies.

3.8 Management of spent fuel and waste, and decommissioning

This is an area where government support for nuclear power is especially important, as there needs to be a national policy framework for managing spent fuel and radioactive waste, including a process for deciding on its longer term disposition. This needs to include an acceptable financial arrangement whereby the costs of managing spent fuel and waste can be met out of current revenues as it is accumulated. The financial risk of an unknown long-term liability for such costs is likely to prove unacceptable for potential investors.

There may also be a reputational risk for some potential investors, such as investment banks that also have retail banking operations, given strong public concerns about radioactive waste disposal. This can only be addressed by the government gaining a broad political consensus for its strategy on radioactive waste, and proceeding with its implementation.

It is generally considered that while governments need to take responsibility for establishing national organisations and infrastructure for radioactive waste and spent fuel management and disposal, or at least regulating and overseeing the process to ensure its adequacy, the costs should be borne as part of the costs of nuclear-generated electricity. Clear legal and institutional frameworks need to be in place if the financial risks to investors are to be minimised. This should allow the future costs of waste management and disposal to be assessed with some certainty by potential investors in new NPPs.

The financial arrangements for the decommissioning of NPPs at the end of their operating lives can also present some risk to investors. Generally, the costs of eventual decommissioning should be met with funds put aside from the plant's revenues during its operating life. The mechanism for this can vary, particularly over the allowable uses of the funds in the meantime (i.e. who should hold the funds and how they can be invested).

The management and regulation of decommissioning funds during the plant's lifetime is clearly important to ensure that adequate funding is available when the time comes for decommissioning (which will be some years after the plant has ceased to produce revenues). In some cases, this could involve "ring-fencing" the funds to ensure that they remain available for their intended purpose even if the plant's owners face bankruptcy or its ownership changes. Furthermore, since the exact costs of decommissioning are not known in advance, the amounts put aside must be based on estimates, which can change over time.

In general, investors in new NPPs will wish to be assured that their long-term liabilities will be limited to the reasonable estimated costs of decommissioning, and that suitable mechanisms exist for the collection and investment of funds.

4. STRUCTURING AND FINANCING NUCLEAR PROJECTS

The methods and sources of financing potentially available for nuclear power projects are not in principle different from those available for any other large power sector or infrastructure project. The first step for those seeking to promote a nuclear project is to mitigate the financial risks involved in building and operating a nuclear plant in the country concerned to the extent possible. It is then the residual financial risks, and how the project is structured to allocate these risks among the various parties involved, which determines whether the project can be successfully financed.

4.1 Approaches to risk mitigation

Starting from the earliest planning stages of a project to build a new NPP, the putative owners will seek to define the project in such a way that financial risks are, to the extent possible, kept to a minimum or even eliminated. In particular, they will seek to ensure that risks from external sources outside their direct control are minimised.

However, the costs of financing the project will also be affected by who the promoters of the new plant themselves are. If the project enjoys the involvement of one or more large, financially strong utilities with a high credit rating, with experience of managing and operating existing NPPs, then raising finance will be easier (and less expensive) then if a less creditworthy entity is backing the project alone.

The project's promoters will also make numerous choices about the proposed new plant which will directly and indirectly affect some risks. Foremost among these is the design of the NPP itself, and the associated choice of vendor and other contractors. Clearly, choosing an established, standardised design (of which there are several examples already in operation or under construction), will reduce the risk of technical problems during construction and early operation. Using an experienced team of contractors, that has already built the same design of plant elsewhere, will also reduce risk.

It should be noted, however, that this must be balanced against the opportunity cost of building a plant which is not state-of-the-art and thus may not have the potential to perform as well as the latest designs and may lack passive safety features. In practice, the choice of a design involves balancing these two factors. Furthermore, in many cases even established designs will need some modification to meet the requirements of national regulations and local site conditions, which can risk losing some of the benefits of standardisation.

The choice of a site for the plant also has a bearing on some risks. Of course, any site must fulfil regulatory requirements relating to factors such as seismicity, hydrology and proximity to population centres, as well as be suitably located for grid connection and proximity to centres of electricity demand. In addition, given the controversial nature of nuclear projects in some countries, the choice of site can affect risks of delay due to public and political opposition. It is generally accepted that building a new NPP on a site adjacent to or nearby an existing NPP is advantageous for a number of reasons, including that local public and political acceptance is likely to be higher in areas which already host a nuclear plant.

For any large project involving a significant proportion of imported content there will be exchange rate risks. Which parties bear these in what proportions will depend on the currency of the contracts, and the currency or currencies in which costs will be incurred by the suppliers. However, the risks here are not nuclear-specific and can be reduced or eliminated through currency hedging.

4.2 The structure of a nuclear project

Although there are many different ways to structure a project, there are only two basic types of finance: debt and equity. Most infrastructure projects involve a combination of these two types of financing, in different proportions. As discussed below, financing can also be divided into that which is backed by collateral provided by existing assets of the project's promoters, and that where the financing is backed only by the project itself (known as "project financing" or "limited recourse financing"). However, this latter type of financing has not been used for a nuclear plant, and this seems likely to remain the case in the foreseeable future for the reasons discussed below.

In debt financing, a bank or other lender makes a loan for some proportion of the expected cost of the project to the project's promoters, against which some security or collateral is provided (normally recourse against some or all of the assets of the borrowers). The loan is to be repaid, with interest, in accordance with the loan agreement. While in principle this could place some of the project's risks with the lender, the interest rate and the timing of the repayments are essentially agreed in advance and do not depend on the project's performance; this limits the risks to the lender. The cost of the loan will depend on the overall creditworthiness of the borrower(s), i.e. on such factors as their assets, profitability and existing indebtedness.

In equity financing, an investor provides funding in exchange for an ownership share in the project; such an investor will receive returns from the sale of electricity once the plant is in operation. Equity investment is a riskier (and therefore more expensive) option, as such an investor is exposed to the full risks of the project with no security or recourse in the event things go badly wrong, as equity investors are subordinated to debt investors. On the other hand, of course, such investors stand to benefit fully from the success of the project. Normally the project's promoter(s) (including the operating utility) would be expected to take a significant equity stake in the project themselves.

In some cases, the distinction between equity and debt may be blurred, as the money needed to make an equity investment may itself be borrowed, for example from a general purpose credit facility made available by banks to a large utility. In such cases, the banks will have made the loans against the general creditworthiness of the utility, and will have full recourse against its total assets. Companies may also raise finance by issuing corporate bonds, preference shares and subordinated debt, which have varying levels of recourse against the company's assets in the event of corporate failure.

A nuclear project will normally be led by a large utility, often one experienced in the field of nuclear operations, possibly joined by other partners. These may include other utilities which will also own rights to sell a proportion of the electricity produced, non-utility investors whose only role is to provide finance, and even large electricity consumers who take a proportion of the plant's output for their own use. In any event, there will be other parties to the project, including at least the nuclear industry companies contracted to actually build the plant. These other parties will be expected to share some of the risks of the project, even if they do not directly provide financing.

The lead utility (and its partners, if any) can raise financing for the project from its own resources, i.e. from a mixture of cash in hand, current revenues, and loans taken against existing assets. The availability and cost of such financing depends on the strength of the balance sheet(s) of the project participant(s). The utility (and any partners) will directly own the NPP as an asset, and will also operate the plant and earn revenues from its output. Insofar as financing is provided by banks and other financial institutions, these loans are secured against all the assets of the utility and any other partners, not against the nuclear project itself. While loans could be secured against a more limited pool of assets by ring-fencing parts of the corporate structure, the more limited the collateral the more expensive the loan will become, and lenders will not be willing to provide loans at all if the collateral is considered insufficient.

Table 3. Approximate market capitalisation of leading US utility companies

Utility	**Market capitalisation** (USD billion)
Exelon Corporation	30
FPL Group	22
Southern Company	22
Dominion Resources	18
Duke Energy Corporation	17
Public Service Enterprise Group	16
Entergy Corporation	14
PG&E Corporation	13
American Electric Power	12
PPL Corporation	12
Firstenergy Corporation	11

Source: Yahoo Finance.
As of May 2009.

Table 4. Approximate market capitalisation of selected European utility companies

Utility	**Market capitalisation** (USD billion)
Électricité de France	88
GDF-Suez (France)	82
E.ON (Germany)	65
RWE (Germany)	42
ENEL (Italy)	35

Source: individual company websites.
As of May 2009.
Exchange rate: EUR 1 = USD 1.37.

The drawback of such financial arrangement is that it places the assets of the utility and any partners directly at risk if there should be problems with the project. With the investment in an NPP amounting to several billion US dollars, unless the utility is a very substantial company such an investment would in itself have a negative effect on the company's credit rating, increasing its cost of capital across the board. Clearly, the failure of the project could put the company in danger of bankruptcy.

Table 3 shows the market capitalisation of the largest utilities in the United States as of May 2009. Clearly, even for the largest of these, the investment required for a twin-unit nuclear station (in the region of USD 10 to 12 billion) would be a very large percentage of their market capitalisation. In contrast, the largest US oil companies have market capitalisations roughly ten times larger. However, there are several large European utilities which are likely to have the financial strength to invest in new NPPs, as shown in Table 4.

Another structure which is commonly used to finance some types of infrastructure, known as "project finance", is to establish a separate corporate entity to own the project, with shares in this company being bought by participants in the project. The company may also obtain loans in its own right to pay for part of the construction cost, with the only collateral being the shares in the company itself. Such a stand-alone arrangement has the advantage for the equity holders in that it does not place their other assets at risk, but it is considerably riskier for the lenders, whose only security is the assets of the project company itself. Thus it will normally be much more difficult and expensive to obtain loans from banks and other investors with such a structure.

For a new NPP project, the only significant asset of such a company would be the new nuclear plant itself. Hence if problems with the project resulted in loans not being repaid on time, the lenders would have little recourse. Some security might be provided by contracts guaranteeing a future revenue stream from sales of electricity, but these would be of little value in the event that the plant could not operate for some reason. In practice, the difficulties in allocating and managing the risks involved mean that such project finance or limited recourse arrangements have not so far been used to construct a nuclear plant. Furthermore, for the same reasons such a project structure is unlikely to be possible at least until there is a strong track record of successfully building and operating NPPs with a standardised design.

The key aim in the financial structuring of a nuclear project is to allocate the various risks to those parties which can directly control them, or which are best placed to minimise or manage them. This will reduce the total financing costs of the project. For example, the nuclear industry companies which are the main contractors for the construction phase may be best able to manage at least some of the construction risks, as these are directly within their control. Similarly, risks involved with the operation of the plant are best taken by an experienced nuclear utility, and electricity market risks are best taken by electricity distribution companies which have a direct outlet for sales of power to end users.

There are different contracting and payment models that can be used in contracts for new NPP projects. The details of the model adopted will affect which parties are taking which risks of the project; this can in turn affect the financing options and costs.

There are several different ways to structure the contracts for a nuclear project. In some cases, the main engineering, procurement and construction (EPC) contract is awarded directly to the NPP vendor, who then appoints sub-contractors as necessary (often in consultation with the owners). In other cases, the plant owner appoints a specialist contractor (known as an EPC contractor or architect-engineer) to manage the entire project (or possibly, a defined proportion of it), with this contractor then managing the sub-contractors appointed to carry out various parts of the project, and being responsible to the owners for delivery of the plant. In a few cases, utilities may carry out this architect-engineer function in-house, engaging sub-contractors directly.

Payment options range from fixed price “turnkey” contracts, where a vendor and its partners agree to build a plant for a fixed price, through to various types of cost reimbursement models, where the contractors are reimbursed based on the actual costs of the project with a fee being paid for their services (with only the fee at risk, subject to satisfactory performance). In practice, for many projects these risks will be shared between the parties by combining elements of both main models.

Risks during construction can in principle be wholly or mainly passed to the vendor and other contractors through a turnkey contract. However, such a fixed price contract will cost more than a cost reimbursement one, as the contractors will need to include some contingency in the price, and will expect to be rewarded for the additional risks they are taking. Contractors must also make a return on the project during the construction phase, while the owners have the operating lifetime of the plant to recover their investment.

In addition, the construction risks may be too great to be absorbed entirely by the contractors, as most lack the financial strength required. A more common route is to share these risks through performance clauses in the contracts to build the plant, with penalties for construction delays. Hence, at least some (and normally a significant proportion) of the risks during construction are likely to remain with the plant's owners.

There are a number of models for "public-private partnerships" for investment in large infrastructure projects, including (non-nuclear) power sector projects. Essentially, a government decides on the infrastructure that is required and invites private investors (often through a bidding or tendering process) to finance the construction in return for being able to operate the facility after completion under a pre-agreed contract. Such models are discussed in more detail in Section 5.2.

4.3 Sources of finance

Traditional investors in power plants of any kind are, of course, utilities. Their core business is the generation and sale of electricity, and they need to maintain and where possible expand their capacity to sustain this business. However, there are other types of investor who may consider investment in a new NPP. The nuclear industry companies that design and build NPPs may be potential candidates, although this is not their normal business model and many of them lack the financial resources to become significant investors. Hence, this is not expected to become a widely used source of finance. However, even without being direct investors, the terms of their contracts are likely to mean they effectively share some of the construction risks.

Banks and other commercial financial institutions will be willing to offer loans on commercial terms to nuclear projects given sufficient collateral. As discussed above, it is likely to be very difficult and costly for loans to be taken backed only by the NPP itself as an asset, at least until the plant is built and in operation. Normally the project participants will be required to provide other assets as security for such loans, or to use loans provided against the overall balance sheet (i.e. all the assets) of the company.

Another possibility is general equity investors, who are simply seeking an investment which can offer them an appropriate balance of risk and reward. In principle, nuclear investments, being by nature long term, should be well-suited to certain types of long-term investor, including pension funds and insurance companies. However, nuclear investments may be perceived as highly risky and investors may therefore seek large returns, making such financing unattractive. It is possible that this perception will change over time, given sufficient positive experience with nuclear investments.

An alternative approach for equity investors could be “asset pooling”, where a group of investors creates a joint fund, which then invests in a range of assets. This reduces the exposure of each individual investor to any single investment, which could facilitate nuclear investments.

It is important to note that the ownership and financing of an NPP does not have to remain static over the project’s long lifetime from the start of construction through to decommissioning. Indeed, re-financing could take place more than once during this period of 70 or more years. In particular, once the construction phase is complete and the plant enters operation, many of the initial financial risks may no longer exist or will be much reduced. This changed risk profile may allow new investors to take a stake in the project, or new loans to be raised by existing investors at reduced cost (for example, by the sale of corporate bonds). However, this will depend on several factors, including the performance of the plant, the electricity market outlook, and the state of the financial markets at the time of re-financing.

In some countries, governments may be direct or indirect investors. They may wholly or partially own a utility which is building a nuclear plant, or they may provide some other kind of financial assistance or guarantee. Government ownership of a project, even indirectly through a commercial utility in which the government holds a majority stake, will usually make it much easier to raise debt finance, as lenders will take comfort from knowing that, as a last resort, the loan is effectively guaranteed by the government.

Alternatively, in some cases governments may provide loan guarantees to provide backing for otherwise commercial arrangements between lenders and the plant’s owners. While such guarantees do have a cost, which will normally be passed on by the government to the parties benefitting from them, as the government is taking some of the risk away from the lenders the overall cost of the loans will be reduced.

The role of export credit agencies (ECAs) should also be noted here. Many governments have such agencies to support major export orders for their domestic industry, including nuclear industry companies. Essentially, ECAs provide a government loan guarantee for an investment in another country, on the basis that it is supporting exports by domestic industry. Hence ECA support reduces the financial risk and therefore the overall cost of loans for the project.

Most relevant ECAs are subject to the Arrangement on Officially Supported Export Credits, organised under the auspices of the OECD. This is intended to ensure that ECAs from different countries are each able to offer similar terms in support of their domestic industry. The arrangement has a specific agreement covering the nuclear sector, important revisions to which came into force in July 2009. The changes include increasing the maximum term of loans from 15 to 18 years, allowing mortgage style fixed repayments (rather than repayment of principal in equal instalments), allowing more flexible repayment terms (possibly reducing the need to make repayments during construction), and reducing the minimum interest rate margins to be applied. Overall, these changes should help reduce the financing costs of a nuclear project with ECA support.

One model for private-sector financing of a new NPP, which has been adopted for the Olkiluoto 3 plant under construction in Finland, is for major electricity consumers to invest in the plant. In this so-called Finnish model, several large industrial electricity consumers are jointly investing in the new plant (as they did in the two existing units at Olkiluoto) through their TVO joint venture. Each TVO shareholder contributes a proportion of the costs of building and operating the plant, in return for electricity supplies (principally for their own use, with any surplus being sold in the Nordic electricity market).

The Olkiluoto 3 project is a form of equity investment financed by corporate loans taken out by the shareholders, with support from the French export credit agency. The latter is possible because the plant is being built under a fixed-price turnkey contract with French company AREVA. This model could potentially be used in other countries, where there is sufficient concentration of energy intensive industries to make it an attractive option.

The other current example in Western Europe, the Flamanville 3 project in France, is being funded in a more traditional way, with Électricité de France (EDF), the dominant majority state-owned national utility, providing most of the finance from its current revenues and strong balance sheet (with ENEL of Italy also participating).

EDF also intends to make nuclear investments outside France. The company completed its purchase of the UK main nuclear generator, British Energy, in early 2009 and is planning to invest in at least four new NPPs in that country. Separately, EDF has reached an agreement with US utility Constellation Energy to acquire almost 50% of Constellation's nuclear generation and operation business, through which it is expected to invest in new NPPs in the United States. It is expected that EDF's financial strength will facilitate the financing of such plants. However, the scale of these recent acquisitions has reduced EDF's credit ratings to some extent, despite its strong government support and 85% state ownership.

A further possibility for financing in some cases (particularly for non-OECD countries) is multilateral financial institutions, such as the World Bank and regional development banks. These are intergovernmental organisations which provide financing to major projects, mainly in developing countries. Even if such a loan was not a very significant proportion of the total investment, the involvement of a development bank could encourage other lenders to support the project, as it would be seen that the project had met certain lending criteria. It may also be beneficial for public acceptance of the plant.

However, at present the World Bank has a policy not to finance nuclear projects, and this is matched by most other development banks. Reasons for this include the often controversial nature of nuclear power developments (which some member governments oppose), as well as the scale and the nature of nuclear projects. Furthermore, at present most such institutions lack the necessary expertise to enable them to assess potential nuclear projects (an exception may be the European Bank for Reconstruction and Development (EBRD), which has financed nuclear projects in Eastern Europe).

Within the European Union, there is a facility for the European Commission, acting on behalf of Euratom (the European Atomic Energy Community), to provide loans to nuclear projects in member countries, within an overall ceiling. These may be complemented by loans from the European Investment Bank (EIB), an independent arm of the EU. In both cases, the funds are raised from commercial sources and passed onto the project, effectively providing a form of indirect loan guarantee. Bulgaria has indicated its intention to apply for a Euratom loan to support the Belene project. If there were to be significantly increased demand for such loans, the overall ceiling for loans would need to be raised, which would require agreement of all EU members.

5. THE ROLE OF GOVERNMENTS AND OTHER PUBLIC BODIES

5.1 Setting the policy and legal framework

No utility or other investor is likely to consider financing a nuclear project without a clear and sustained government commitment to having nuclear power as part of the long-term energy mix. In most cases, a broad political consensus or acceptance of this policy will be required, to give confidence that political and policy support will be maintained for the life of the project. Such government support provides certainty and security for investors. Public acceptance is also vital for a successful nuclear programme. Where nuclear power is part of the national energy strategy, it is the task of government and politicians to lead public debate and contribute to ensuring that the nuclear programme has the confidence of the public at large.

Experience with earlier nuclear construction has shown that there are some risks that are outside the control of investors and which could make nuclear projects unviable. In particular, these include licensing risks (essentially, the risk of delays due to issues in the licensing process) and risks associated with the costs of waste management and decommissioning. Governments wishing to encourage investment in nuclear will need to take steps to mitigate certain of these risks which are within their control. They may also need to put in place clear, long-term arrangements for carbon pricing or trading. Thus, in addition to providing overall policy and political support, there is also a clear role for governments in setting the legal and regulatory framework within which nuclear investments can take place.

The financial risks associated with construction and operation of any industrial facility should, of course, normally be borne by the investors and other parties to the project, and the costs of such risks should be incorporated in the overall costs of the project. Most such risks are directly within the control of the investors or their contractors, or are inherent in the nature of the business concerned. Building new NPPs is clearly economically viable in the right circumstances, and financing will be available from commercial sources where the appropriate balance of risk and reward is available for investors.

However, given the size and nature of nuclear investments, the risks involved may in some cases be too large to be taken entirely by commercial entities. The timescale of nuclear projects, with unusually long payback periods, presents particular risks. Targeted government support may thus be necessary to get nuclear projects off the ground. For those governments which wish to see nuclear power maintain or increase its contribution to electricity supply in their country, this can present a challenge. How can they encourage investment in new nuclear capacity within the framework of competitive electricity markets which have been developed over recent years?

Various policies and measures are now being considered and introduced in several OECD countries in an attempt to achieve this. These are discussed in more detail in Chapter 3 and in Appendix 1. In general, they mainly include:

- Reforming the licensing and planning processes to reduce the risk of delays (and additional costs) in the lead-up to the start of construction, during the construction period itself, and between construction and operation.
- Clarifying policies regarding radioactive waste management and decommissioning (in particular of the financial arrangements involved), and making progress in their implementation.
- Reviewing electricity market regulation to ensure that it provides a level playing field for long-term investments such as nuclear power that contribute to energy diversity and security.
- Designing policies on climate change intended to cut CO_2 emissions so that they provide incentives for investment in nuclear power as well as in renewables and energy efficiency.

It should also be noted that, despite the trend in recent years towards competitive electricity markets in many OECD countries, there remain a significant number of countries (and regions within larger countries, notably the United States) where electricity markets remain regulated. It may be that financing nuclear projects in such regions will prove more straightforward than in regions with more competitive electricity markets.

Electricity prices in regulated markets are set or approved by regulatory agencies, to allow utilities a fair return on investments made in the electricity supply system. Provided the costs of a new NPP are deemed to be prudently incurred, the utility is able to recoup them from electricity consumers. The utility’s risks are thus essentially limited to those during the construction phase, with risks during operation effectively being passed to electricity consumers.

One problem for utilities in such circumstances has been that this cost recovery often did not begin until the plant entered operation, with the utility having to pay interest on loans in the meantime. However, in some US jurisdictions consideration is being given to allowing some recovery of construction costs to begin while the plant is still under construction. This would have the effect of transferring some construction risk from the utility to the electricity consumers, as well as reducing the financing costs.

5.2 Providing direct support for financing

Even where governments have established a supportive policy, legal and regulatory framework, as discussed above, this may still be insufficient to overcome investor uncertainties about the risks of constructing new NPPs. This may especially be the case for first-of-a-kind nuclear plants, for the first new NPPs in a country where there is no existing nuclear programme, or where there have been no new NPPs built for many years. At the present time, this covers most countries where nuclear construction is being considered.

In such circumstances, governments wishing to encourage or expedite a new phase of nuclear construction involving private sector investments may wish to consider other kinds of support to potential investors, including direct or indirect financial assistance. The clearest example of such support to date is the measures adopted in the United States to encourage investors in the first few new NPPs. These include loan guarantees for up to 80% of the cost of the project, risk insurance for construction delays caused by licensing or litigation delays, and production tax credits for the output from the plants in the first years of operation.

The US Congress has approved up to USD 18 billion of such loan guarantees for new NPPs. However, the Department of Energy, which is administering the scheme, received applications for over USD 118 billion-worth of guarantees. Questions also remain over how this scheme will work in practice. In particular, it may prove difficult to raise finance for the unguaranteed part of the cost, and it is not yet clear which party will be responsible for meeting any cost overruns on the project and whether such amounts will also be guaranteed in the same proportions.

The export credit agencies (ECAs) of major nuclear exporting countries (including France, Japan and the United States) could play an important role in facilitating the financing of new NPPs where significant contracts are placed with their domestic industry, and there are several cases where this is occurring or is under consideration. This is discussed in more detail in Section 4.3 above.

“Public-private partnership” (PPP) arrangements could be considered for new NPPs in some countries. Such arrangements have been used for various other types of investment, for example, water and energy supply, environmental projects, roads and bridges, hospitals, prisons and schools. The government decides what infrastructure is required and invites proposals from the private-sector to build the facility and to operate it (either indefinitely or for a defined period). Depending on the nature of the facility, this can be in exchange for payments from the government over the life of the project, or for the right to collect tolls or to sell the output at prices set according to a pre-agreed contract.

For a nuclear plant, a PPP could be envisaged that would allow the investors to sell the plant’s output under a pre-agreed contract involving a fixed or minimum price level. This would effectively eliminate electricity market risks for the investors. However, the investors would still bear the risks of construction and operation, which are likely to be the largest risks in a nuclear project. It would also mean the government acting as a guarantor if electricity market prices were insufficient to provide an adequate return on the investment.

Private-sector participation models (similar to PPPs) can also be applied to foreign investment in developing countries, when they are usually referred to as build-own-operate (BOO) or build-own-operate-transfer (BOOT) schemes. These have been used for various types of infrastructure investment, including (non-nuclear) power sector investments. In such an arrangement between the government and a foreign investor, the investor builds a plant in the country concerned, operates the plant and sells the output under a pre-agreed contract, either for an indefinite period (BOO) or for a defined period before transferring it to local ownership (BOOT).

To date, such an arrangement has not be used for a nuclear project. As noted above, the investors would still have to bear the construction and operation risks. There could also be additional political risks associated with developing countries, exacerbated by the long period required to earn a return on investment and the often controversial nature of nuclear projects. Investors may not have the appetite for such a large and long-term commitment, particularly when there may be other projects offering a more attractive risk/reward ratio.

It is worth noting that the United Kingdom Government has stated that it does not intend to provide any direct financial incentives for investors in nuclear plants. Once the government has set the necessary supportive policy and legal framework, it intends to leave investment decisions to commercial investors, who will have to meet the full costs of the project on a commercial basis. Nevertheless, the UK Government is playing an important role as a facilitator of new nuclear investment, clearly signalling its intention to see nuclear investments go ahead.

6. CONCLUSIONS AND RECOMMENDATIONS

Nuclear power plant construction projects have many characteristics in common with other types of large infrastructure investment, both within the power generation sector and elsewhere. However, nuclear power itself has a number of special characteristics and circumstances which make investment in new NPPs different in several important respects from other large projects. It is these special features that can make nuclear financing particularly challenging.

These features include:

- The high capital cost and technical complexity of NPPs, which present relatively high risks during construction (delays and cost overruns) and operation (equipment failures and unplanned outages).
- The relatively long period required to recoup investments or repay loans for NPP construction, which increases the risk from electricity market uncertainties.
- The often controversial nature of nuclear projects, which gives rise to additional political and regulatory risks.
- The need for clear solutions and financing schemes for radioactive waste management and decommissioning, which only governments can formulate.
- The need for NPPs to operate at high capacity factors, preferably under baseload conditions.

Many of the risks presented by these special factors can be mitigated by appropriate government actions, which will be necessary before any NPP project can move forward to realisation. Other risks, including those inherent in any large construction project, can be transferred to or shared with other parties by appropriate structuring of the project, in order to reduce the risks to investors.

Strong and consistent government support is an essential prerequisite for initiating or expanding any nuclear programme. Given the long time frame involved, a broad-based political consensus is likely to be needed on a nuclear contribution to energy supply as part of a comprehensive long-term national energy strategy.

Specifically, where nuclear is part of the national energy strategy, the government needs to put in place an efficient regulatory framework, that allows appropriate opportunities for public involvement but allows clear and definite decision making within a reasonable timescale. Additional legal frameworks dealing with liability issues, radioactive waste management and decommissioning are also necessary. In addition, the government has an important role in providing public information and leading national debate on the role of nuclear power, to establish the necessary political consensus.

Electricity market risks can be mitigated by long-term agreements with large consumers or electricity distributors, where these are available. Where possible, direct involvement of such consumers in the structure of the project may be an attractive option. Governments have a role here in that they set the regulations which govern electricity markets, which if badly designed can unduly favour short-term investments.

Another important factor affecting electricity markets is the cost of carbon dioxide emissions under the various carbon trading schemes being introduced in many OECD countries. This should benefit nuclear power by raising the costs of fossil-fired competitors. However, doubts about long-term political commitment to such policies and carbon price uncertainty may limit the benefits for nuclear investors. Again, governments may be able to take steps to reduce these uncertainties if they wish to encourage nuclear investments.

However, it is the construction phase of a nuclear project which is generally considered the most risky for investors. This is especially true for "first-of-a-kind" plants and for new nuclear programmes. Large amounts of capital must be invested early on, while returns will not begin to flow until the plant enters operation some years later. Traditionally, construction risk was passed on to electricity consumers through regulated prices, but in liberalised markets this is no longer possible. This is a possible area for targeted government support to reduce the risk to investors to acceptable levels, at least for a limited number of plants in order to start or re-start a nuclear programme.

To some extent, construction risk can be shared with NPP vendors and other contractors actually building the plant, either through fixed price "turnkey" contracts or through performance-related contract clauses, but in practice vendors have only a limited capacity for such risk taking. Debt investors will not normally accept such risks, and loan guarantees will not usually cover additional costs due to delays, etc. Thus, in most cases the risks of delays and cost overruns will fall mainly on equity investors. They can reduce these risks by choosing standardised NPP designs that are already in operation elsewhere, built by experienced and well-managed contractors.

Corporate finance is the most likely generally applicable model for new NPPs. Large, financially strong utilities will be best able to finance new NPPs, especially if they are vertically integrated (i.e. they have direct access to electricity consumers). They will be able to attract loans as required, backed by their existing assets (balance sheet). This is the model followed in France, and which is expected to be used in the United Kingdom and other European countries. In countries where such utilities are rare or non-existent, such as the United States, the need for direct government support to share in the construction risks is likely to be all the greater.

In addition to the standard equity and debt modes of financing, there may also be more innovative financing arrangements which can be used in specific circumstances (such as for Olkiluoto 3 in Finland, discussed in Section 4.3). Although the details of these will usually be specific to local circumstances, some aspects may be more widely applicable (for example, the concept of investment by large electricity consumers could be extended to NPPs in other locations). Where governments themselves are willing to provide backing for investment in NPPs, but also wish to involve the private sector, some form of public-private partnership could be envisaged. However, the details of any such arrangement would require detailed negotiation and are likely to be tailored to local circumstances.

It appears that there is very little likelihood at the present stage of development of nuclear technology and the nuclear construction industry to finance a new NPP by using non-recourse financing (where a stand-alone project company raises the capital it needs to build the plant using only the NPP project itself as collateral). Even for hybrid schemes which include a significant proportion of equity, debt investors at present are unlikely to be willing to provide significant funding for a nuclear plant without recourse against the balance sheet of a strong and creditworthy utility.

It should be noted that the financing of an NPP need not remain static over its lifetime, and in particular that re-financing is likely to be possible once the plant has successfully entered operation. For example, a company owning an operating nuclear plant may be able to issue corporate bonds and use the proceeds to repay loans taken out to finance the plant, where this reduces the overall cost of borrowing. With the risks during construction now removed and with the plant expected to generate steady revenues over several decades, an NPP could be an attractive investment opportunity for investors with a long-term perspective, such as pension funds. In particular, nuclear investments may be of interest where such investors use "asset pooling" to make long-term investments.

Key actions to be considered by governments that wish to see investment in new NPPs include:

- Provide clear and sustained policy support for the development of nuclear power, by setting out the case for a nuclear component in energy supply as part of a long-term national energy strategy. Winning public acceptance of a role for nuclear power in meeting environmental goals while providing secure and affordable energy supplies must be accomplished at the political level.
- Work with electricity utilities, financial companies and other potential investors, and the nuclear industry, from an early stage to address concerns that may prevent nuclear investment and to avoid mistakes in establishing the parameters for new NPPs. The government will need to take an active role in facilitating nuclear projects, even where investment is to be made by commercial entities.
- Establish an efficient and effective regulatory system which provides adequate opportunities for public involvement in the decision making process, while also providing potential investors with the certainty they require to plan such a major investment. A one-step licensing process with pre-approval of standardised designs offers clear benefits in this regard.
- Put in place arrangements for the management of radioactive waste and spent fuel, with progress towards a solution for final disposal of waste. For investors in NPPs, the financial arrangements for paying their fair share of the costs must be clearly defined. An effective framework for nuclear insurance and liabilities must also be in effect.
- Ensure that electricity market regulation does not disadvantage NPPs. Long-term arrangements may be necessary to provide certainty for investors in NPPs, reflecting the long-term nature of nuclear power projects. Where reducing CO_2 emissions is to act as an incentive for nuclear investments, the government may need to provide some guarantees that policy measures will keep carbon prices at sufficiently high levels. Allowing nuclear projects to generate carbon credits could also provide incentive, provided the policy was sufficiently long-term.

For countries which have one or more large utilities with the financial strength to invest directly in new NPPs, or where there are well-resourced foreign utilities willing to make such investments, fully commercial financing may be possible. But where there are no sufficiently strong established utilities, and/or the government wishes to move ahead rapidly with NPP designs which have not already been built elsewhere, some form of direct or indirect public sector financial support is likely to be necessary if investment in a new NPP is to proceed.

This could involve supporting a state-owned utility in making nuclear investments, providing support to private sector utilities through loan guarantees, tax credits or other measures, or establishing public-private partnerships. However, it must be recognised that governments will not wish to remove too much risk from private sector investors, that investors should pay the full costs of any financial assistance they receive, and that risk-reward ratios should be appropriate for all investors.

Appendix 1

BACKGROUND ON FINANCING NPPS IN SELECTED COUNTRIES

Bulgaria

The contract for the design, construction and installation of units 1 and 2 of the Belene NPP was signed in January 2008 between Bulgaria's National Electric Company (NEK) and Atomstroyexport of Russia. This followed government approval of the project in April 2005, and a subsequent tending process organised by NEK. Construction officially began in September 2008, following earlier preparatory site work.

The original Belene project began with site works in 1981, with construction of two VVER-1000 units starting in 1987. Work was halted in 1991 with unit 1 about 40% complete and about 70% of equipment delivered. The existing works have been subject to a care and maintenance regime since that date. Under the new contract, Atomstroyexport has the right to buy back equipment supplied in the 1980s which is not needed for the present project.

The decision to re-start the Belene project was consistent with the National Energy Strategy adopted in 2002, which included maintaining the nuclear share of electricity production in order to meet environmental and security of supply policy objectives. A new nuclear energy law was passed in 2002, and the Nuclear Regulatory Agency was established to replace the former regulatory body. This was followed in 2004 by updating of the national regulatory requirements in line with international guidelines, and the adoption of a national strategy for spent fuel and radioactive waste management.

The present project comprises two VVER-1000 reactors of an updated design (designated AES-92/V466), with I&C provided by a consortium of AREVA and Siemens. The contractual construction costs will be around EUR 4 billion, with the total investment expected to be in the range EUR 6 to 7 billion. State-owned NEK has a 51% stake in the project, intended to be financed by debt. Bulgaria indicated its intention to apply for up to EUR 600 million of Euratom and European Investment Bank loans, while the remainder was to be raised from commercial banks. BNP Paribas was appointed as lead bank for the financing.

The remaining 49% of the project is equity financed. After a lengthy selection process, it was announced in October 2008 that RWE (a large German utility) had been selected as the "strategic partner" for this 49% stake. The Belene Power Company (51% NEK, 49% RWE) was established in December 2008. The project is now under technical review in advance of final regulatory approval. However, by mid 2009 it had become clear that obtaining loans for the project during the financial crisis that began in late 2008 was proving difficult. The government was considering whether to restructure the project, possibly reducing NEK's stake. Meanwhile, on-site work remained confined to preparatory work. The target date for start-up of the first unit is 2013, but this may now be delayed.

The Bulgarian electricity supply industry has been undergoing a process of liberalisation and privatisation since 2000. NEK's distribution assets have been privatised in three main regional groups, along with most generating assets; the existing Kozloduy NPP remains state-owned but operates as an independent generating company. NEK retains the transmission system, along with some hydro and pumped storage plants. It remains a major wholesale buyer of power under PPAs at prices set by an independent regulator. Power is also sold on a balancing market and through bilateral contracts with freely negotiated prices.

France

During the latter part of the twentieth century, Électricité de France (EDF) was, as most European power utilities, a state-owned vertically integrated utility with a near-monopoly on electricity production and supply, operating within a clear regulatory framework. Investment was decided on an economic rate-of-return basis set by the government, which varied in the 8% to 9% range. Electricity tariffs for a given load curve were set according to the full cost of developing the optimal mix of power capacity for this curve, including the set rate-of-return on capital (cost-plus pricing).

Before 1980, the French government financed part of EDF's investments directly through capital increases (the remainder was financed with cash-flow). From 1980, EDF was authorised to borrow up to EUR 40 billion from commercial sources without government guarantees. The company was rated AAA, and lenders were confident they would be repaid due to EDF's position as a monopoly electricity supplier. In fact, electricity consumers were taking most of the risks and rewards of the utility's policies and management through the setting of tariffs. The government controlled the sharing of risks between consumers and EDF.

In the 1990s, French electricity rates were far lower (and more stable) than in most European countries. Thus, having taken the financial risks, consumers were rewarded through lower prices. The technical success of the nuclear programme was a major contributor to the viability and efficiency of this model. EDF chose an established and standardised design, set up an appropriate industrial organisation and kept construction costs and schedules under control. The government provided support through a clear and constant policy in favour of nuclear generation. But the financial scheme also explains a part of the price gap with other countries. Nuclear power, a highly capital intensive technology, fits especially well in this system.

In November 2005, EDF shares were listed for the first time on the Paris stock exchange. As of the end of 2008, the government retained some 85% of EDF stock, with employees holding 2% and other investors about 13%. Although further sales of government-held stock have been considered, there appears to be little political support for further privatisation and the government is expected to continue to hold a large majority of EDF stock for the foreseeable future. Under current law, the state's holding in EDF must be at least 70%.

Meanwhile, the gradual introduction of competition in the French electricity market will also lead to changes in the system. Risks will no longer to be borne only by the consumer, who will increasingly be able to choose another supplier. This means that the arrangements for risk sharing and financing of new projects will have to be redefined. Nevertheless, EDF can be expected to retain a dominant position in the French electricity market, and one of the largest players in the wider European market.

The legal framework

The French government has set a solid legal framework for nuclear energy, which has continued to evolve over time. Recent legislation includes the 2006 Act on the Sustainable Management of Radioactive Waste, and the 2006 Act on Nuclear Transparency and Security.

The Act on Nuclear Transparency and Security (TSN) addresses three main issues:

- Creation of the Nuclear Safety Authority (ASN), an independent administrative body charged with ensuring nuclear safety and supervising radioprotection, and providing public information on these matters.

- Transparency of the nuclear sector, with increased public access to information.
- Revision of the legal framework for nuclear activities and their control, covering the safety of installations and transportation of nuclear materials.

Maybe the most important element is the nuclear safety authority. The TSN law increases the independence and legitimacy of the regulatory body with respect to those in charge of promoting, developing and carrying out nuclear activities, giving ASN a status comparable to that of its counterparts in other industrialised nations. This includes enhanced powers to penalise violations and take all necessary urgent measures. ASN carries out inspections and may impose sanctions, including suspension of operation of an installation. It is also responsible for radiological surveillance of the environment and for overseeing exposure to ionising radiation of workers and the public.

The Act on the Sustainable Management of Radioactive Waste implements a national policy on radioactive waste management, covering all types of such waste. It establishes a research programme and sets out the main goals to be reached in the next 20 years. An important overall aim is to simplify the storage and the disposal of radioactive wastes by reducing their quantity and/or toxicity. It also has provisions for increased transparency and public involvement, and addresses financing issues linked to waste management and decommissioning policy.

The Act secures the financing of research on a deep geological repository and on interim storage by establishing a tax to be paid by waste producers into a special fund for this purpose. It also establishes a legal framework for the assessment and funding of long-term nuclear liabilities. Operators of nuclear installations are required to assess their long-term liabilities (including dismantling, spent fuel management, re-conditioning of legacy wastes, and radioactive waste management), to make corresponding financial provisions, and to constitute a dedicated portfolio of financial assets (a segregated internal fund). A transitional period has been given until mid 2011 for the earmarking of the necessary assets.

After the transitional period, the market value of the dedicated portfolio has to at least match the value of the discounted provisions. This means that for a new reactor, the necessary assets to cover its dismantling cost should be earmarked as soon as it enters operation. Each operator has to provide a complete report every three years on its cost assessments, provisions, assets, and internal oversight. The public authorities overseeing these requirements (advised by the ASN) can address remarks, prescribe audits or corrective measures, and sanction operators if needed. A report will be made to parliament every three years on the adequacy of financial coverage for long-term nuclear liabilities. However, the operators remain responsible for their own decommissioning strategies and for the management of their fund.

Flamanville 3

EDF has commenced construction of a new nuclear plant, its first EPR, at Flamanville (an existing site which already hosts two 1 300 units). The new plant was considered necessary to assess the new EPR design, to renew the know-how of the ageing nuclear engineering workforce, and to prepare for the eventual replacement of the existing nuclear fleet.

Proposals were made to international partners to join the project, partially to share the development costs but essentially to obtain the widest support possible for the project. However, the only agreement that has been signed is with Italian utility ENEL, as part of a broader agreement including present nuclear production and other investments. Although EDF will fully own the new plant, the agreement is a full economic partnership in which ENEL and EDF share the risks and rewards, with limited exceptions.

As the 59th nuclear plant in EDF's French fleet, Flamanville 3 is being financed from the corporate resources of the company. The expected EUR 3.3 billion (2005 euros) of investment over five years, including interest, spare parts, fuel stock, and pre-operational spending, will absorb as capital employed less than 10% of EDF's cash-flow. Thus, apart from the ENEL share, Flamanville 3 is being financed on a purely corporate basis. It is a large investment, but it will not have a striking impact on the company's financial ratios.

Mexico

There are no firm plans for additional NPPs in Mexico, but the state-owned Comision Federal de Electricidad (CFE) is carrying out technical and economic feasibility studies for an additional nuclear plant at the existing Laguna Verde site.

Under present legislation, all nuclear power activities in Mexico must be conducted by the state. Hence, CFE is the only body authorised to build and operate nuclear plants. CFE has a statutory duty to plan infrastructure investments in the electricity sector; its present programme calls for the addition of 4 000 MWe of generating capacity (from all sources) by 2018. Once the plans are approved by the government and Congress, the necessary funding is included in the federal budget. Any loans taken by CFE to finance projects are sovereign debt.

The normal contracting model for any generating plant is a turnkey arrangement, with the vendor financing most of the construction work until completion. This requires the vendor to take most of the financial risk, either directly or through guarantees provided by an export credit organisation or international agency. The government guarantees the eventual payments from CFE on project completion.

Nuclear regulation in Mexico closely follows the US NRC model, and it is expected that the Mexican NRC will adopt the revised licensing process of the US NRC for any new projects. There is no competitive electricity market in Mexico, with CFE supplying all consumers at prices set by the government. Independent power producers, which are permitted to own and operate non-nuclear plants, must sell all their output to CFE.

Slovak Republic

A firm decision to complete two partly built VVER-440 units at Mochovce was taken Slovenské Elektrárne (SE) in early 2007. A commitment to complete the units was a condition of the sale by the Slovak Government of 66% of SE to ENEL of Italy. The present schedule is to complete the two units in 2012 and 2013.

The Mochovce project dates back to 1983 when construction of four units at the site was started, but work was halted in 1992 due to lack of funds. Construction of units 1 and 2 recommenced in 1996, incorporating numerous safety upgrades from the original design; these units entered service in 1998 and 1999. Units 3 and 4, with 70% of civil works and around 30% of technical installations completed, have meanwhile been kept under a care and maintenance regime. Major long-lead items (reactor pressure vessels, steam generators and pumps) are already on site and partly installed.

Political and public support for the nuclear power continue to be strong. The country has an established nuclear programme with an excellent operating record. There is a need for additional generating capacity, with the main alternative to nuclear being lignite. The basic reactor system for Mochovce 3 and 4 (VVER-440 V-213) is already in operation in the country, and SE already holds a construction permit for the units (which has been renewed as necessary during the project's suspension).

The project, expected to cost EUR 1.8 billion, is to be developed within the long-term investment plan of SE, not as a standalone project. The company has a general credit facility for EUR 800 million with a consortium of nine international banks, which could potentially have been used to finance the Mochovce project. However, following pressure by anti-nuclear groups, two banks requested that this facility not be used to finance the project. As a result, the project will use a simple corporate financing scheme whereby the necessary funds are made available from or guaranteed by present and future cash flows generated by the company. The project will not benefit from any state aid provisions or specific tax exemptions other than those stipulated in existing laws.

In general, project risks will be borne by SE, although some cover for construction risk will be provided in the construction contracts. However, the fact that the civil works are 70% complete with major components already on site should limit the risks of major schedule disruptions. The project is covered by a specific package of nuclear liability and insurance coverage which is structured for the construction and commissioning periods. The cost of coverage is significant.

Nuclear fuel will be supplied under well established market arrangements which apply to the fuel for the company's four existing units of identical design. Arrangements for spent fuel and radioactive waste will also be the same as those for existing units. All waste management is carried out by a dedicated state-owned company, with costs being borne by waste producers through fees based on both installed capacity and energy produced. In addition, SE is creating its own reserves for back-end fuel cycle management.

Once complete, the new Mochovce units will be an integral part of SE's generating fleet. The company is the major generator in the Slovak market, selling its production to large customers, distribution companies and the wholesale power market. Hence, plant operating performance risk will be borne by SE.

Ukraine

Two VVER-1000 plants at Khmelnitsky and Rivne, construction of which had been suspended when 80% complete in 1990, finally entered service in 2004. Loans to finance the completion project had been sought from the EBRD and Euratom, and also from Russian sources. However, after protracted negotiations, the completion costs of about USD 1.26 billion were financed by the government and state-owned nuclear utility Energoatom (in part by a bond issue). EBRD and Euratom loans amounting to USD 125 million were eventually agreed to finance modernisation works after start-up, although the funds were only made available in 2007, once a series of conditions had been met.

Despite political upheavals and instability in recent years, the country's heavy reliance on Russian gas and oil supplies has led all major political parties support the continued expansion of nuclear power. The government's energy strategy to 2030 envisages significant nuclear construction, both to expand capacity and replace older units as they are shut down. The immediate priorities include two additional units at Khmelnitsky (for completion by 2015-16), as well as dry storage facilities for spent fuel. Energoatom estimates that about USD 2 billion per year will be needed for this programme from 2011.

The financing for further nuclear construction remains uncertain. Direct funding from the state budget is unlikely to provide a significant proportion of the finance. Energoatom is expected to be in a position to use its balance sheet to provide finance, using both internal revenues and debt. However, Energoatom is keen to share financing risks with other investors, so equity participation by private-sector investors is expected to be sought.

Ukraine has a partially liberalised electricity market, but prices paid to Energoatom for nuclear electricity are fixed according to a regulated cost-of-service approach. This may change in the near future to a system based on direct contracts with customers and distributors. The country has excess generating capacity at present and is a significant exporter of electricity, to Russia and EU countries. However, the Ukrainian grid is synchronised with the Russian system, and exports to the EU are restricted by limited inter-connections.

United Kingdom

The United Kingdom has had a large nuclear programme, mainly based on gas-graphite units constructed by domestic suppliers. However, life extension of these units has proved to be less attractive than for the light-water reactors more commonly used elsewhere, meaning that many of the existing units have already closed or are expected to do so within the next few years. The nuclear contribution to the UK electricity supply peaked in 1998 at about 28% of all power generated, but has since declined rapidly as plant closures have reduced capacity. In 2007, nuclear provided only about 16% of all electricity generated, and further declines are expected in the coming years as closures continue. All the gas-graphite reactors are expected to close by 2023, leaving only the single PWR of the existing fleet in operation.

In a major review of energy policy issued in 2006, the UK Government identified the need for new nuclear capacity to maintain a nuclear component in the country's energy supply, in order to provide diversity and help limit carbon emissions. The government made clear that it was not prepared to provide direct financial support for a new nuclear programme, but that it was prepared to take other steps to encourage investment in new nuclear capacity. A white paper released in 2007 set out in more detail the government's thinking on energy policy, and a public consultation on new nuclear build was also launched. Following the consultation, a further white paper on nuclear power was issued in January 2008; this confirmed the government's position that nuclear has an important role to play in the UK energy supply, and that the government should take steps to facilitate this.

The government also signalled its commitment to new nuclear build by establishing an Office for Nuclear Development, now within the new Department of Energy and Climate Change. It also established the Nuclear Development Forum, a joint industry-government consultative body chaired by a senior minister. The government has issued a timeline for new nuclear build, showing the first new plants in operation by 2018. Thus, although it will not be investing in new nuclear capacity itself, the government is playing an important role in supporting and coordinating the process.

The government has thus set out its strong policy support for new nuclear build, and has backed this up with a series of steps to address potential obstacles in such areas as licensing and regulation, siting, waste management and decommissioning, and the availability of skilled labour. It has also expressed its preference for there to be more than one consortium involved in building and operating new nuclear plants in the United Kingdom. Although United Kingdom engineering companies would be expected to participate as sub-contractors in new nuclear projects, there is no UK nuclear reactor vendor, meaning that the market is open to competition between international vendors.

The main regulatory agencies involved, the Nuclear Installations Inspectorate (NII) and the Environment Agency, are working together to streamline the regulatory process. In particular, a new Generic Design Assessment (GDA) process has been introduced, allowing reactor vendors to submit their designs in advance of site selection for regulatory assessment. Four designs were submitted for the first stage of the GDA process; two of these were later withdrawn or suspended by the vendor, leaving two designs (AREVA's EPR and Westinghouse's AP-1000) to go forward to the second stage. Meanwhile, the government commissioned a review of the adequacy of the resources available to the NII (which has had difficulty in recruiting and retaining sufficient staff for the GDA process). This reported in early 2009, and the government has responded with several short- and medium-term measures to strengthen the regulator.

The government has made clear that the owners of new nuclear plant will have to pay their full share of waste management and decommissioning costs. To achieve this, the government is assessing methods to calculate these costs, so that potential investors will have a clear understanding of the costs that they will be expected to meet. New legislation is planned which will ensure that plant owners make adequate provision to meet their share of these costs during the plant's operating lifetime.

It is generally accepted that the most attractive sites for new nuclear build are adjacent to the sites of existing nuclear plants. These sites are well located relative to major demand centres and the transmission system, and also have high levels of local public acceptance. Most such sites were either directly under government ownership through the Nuclear Decommissioning Authority (NDA), or were owned by nuclear utility British Energy, in which the government held approximately a one-third stake.

To facilitate the availability of suitable sites to potential investors, the government put its stake in British Energy up for sale, resulting in the company's take-over in early 2009 by EDF Energy, the wholly owned UK subsidiary of Électricité de France (EDF). A deal has also been reached for Centrica, a major UK energy company, to take a 20% stake in British Energy, with EDF retaining 80%. EDF has announced plans for British Energy to build four EPRs (with a total capacity of 6.4 GWe) at two sites. Under EDF agreement with the government, British Energy will sell some of the potential sites it controls to other investors, subject to satisfactory progress with its preferred sites.

Separately, the government has directed the NDA to auction a number of other suitable sites which it owns, with EDF Energy being excluded from bidding for some of these sites, to encourage other potential investors in new nuclear to enter the UK market. In April 2009 it was announced that a consortium involving the UK subsidiaries of German utilities RWE and EON had successfully bid for two of these sites. This consortium has announced preliminary plans for 6 GWe of new nuclear capacity at these two sites by around 2020.

To facilitate planning applications for these potential nuclear sites, the government has legislated for a Strategic Siting Assessment process. This allows the government to designate certain projects (including nuclear plants) as being of strategic national importance, meaning that (for designated sites) local planning applications only deal with local issues relating to the site. In the past, nuclear planning enquiries spent considerable time and effort assessing the national need for the new nuclear plant; under the new arrangements, the government will take such strategic decisions in advance.

The government has pointed out that if all these announced new build plans go ahead, the total of 12.4 GWe of new capacity will more than replace the retiring nuclear capacity, and will provide around 25% of the UK electricity sometime after 2020.

United States

The United States has the world's largest fleet of nuclear power plants in operation and the longest history of civilian nuclear power. Although the federal government has always played a strong role in nuclear research and development, most of the investment in commercial nuclear power plants has been made by private sector utilities. However, under present circumstances it is clear that an activist government policy is essential for a successful nuclear renaissance even in this mature and robust nuclear marketplace.

One reason why government action is needed is that the market capitalisation of US utilities is rather small, relative to the projected financial cost of developing a new nuclear project. As a result, US utilities are unable or unwilling to finance such projects on their balance sheets, thereby leaving a modified project financing approach as the only viable option. On the other hand, commercial banks are unwilling to project finance new nuclear power plants in the United States in the absence of government guarantees. Recognising that there is no history of project financing of nuclear power projects, the government's policies are seen as a means of bridging the gap between the utility position and the financial industry position.

The US Government, federal regulatory agencies, and the US Congress have instituted a number of initiatives in recent years to promote nuclear power. At the policy level, the Nuclear Power 2010 Program, launched by the US Department of Energy (DOE) in 2002, is a joint government/industry programme to address the obstacles to new nuclear projects, including siting, the design and licensing of new reactor designs, and establishing the business case for such projects. It includes an ongoing dialogue between DOE and the nuclear industry, and aims to have the first new nuclear units in operation by the mid 2010s.

On the regulatory side, the Nuclear Regulatory Commission (NRC) has made important reforms to its licensing process, introducing the Combined Construction Permit/Operating License (COL) application process, as well as the Early Site Permit (ESP) and Design Certification processes. These processes have been designed to streamline the review and approval process, avoiding lengthy regulatory delays, multiple intervention opportunities, and redesign requirements after commencement of construction, which have previously increased both the completion schedule and the overall costs of nuclear projects in the United States.

In order to provide more direct support for the financing of new nuclear plants, the US Congress acted to encourage nuclear investments by including four key elements for the nuclear industry in the Energy Policy Act 2005:

- Loan guarantees to support investment in clean energy, including nuclear plants.
- Standby support to provide insurance against the cost of regulatory delays.
- Production tax credits for the first new units to enter operation.
- Extension of the Price-Anderson nuclear liability regime.

These are described in more detail below.

Loan guarantees

Loan guarantees by the federal government are intended to allow utilities to project finance new nuclear power plants, by making financing available and by reducing financing costs. In accordance with the provisions in the Energy Policy Act 2005, the US Department of Energy (DOE) has established a Loan Guarantee Program. Presently, this is able to provide USD 18.5 billion of guarantees for nuclear projects, and applies to loans covering up to 80% of project costs. The repayment period on loans covered by the programme will be thirty years from initial drawdown on the financing.

In October 2008, 19 loan applications from 17 utilities to support the construction of 14 nuclear power plants were submitted to the DOE under the Loan Guarantee Program. As of mid 2009, no guarantees had been awarded. The aforementioned applications totalled USD 122 billion (amounting to 28 800 MWe of capacity with a total cost of USD 188 billion), which is well in excess of the allotted USD 18.5 billion.

In analysing applications, the DOE is undertaking a credit assessment of each project, including the probability of default and the recovery value on the asset. It will then determine a subsidy charge to be assessed (separately from the financing provided) on each recipient. The credit subsidy cost can be thought of as the present value of the expected cost/risk to the US Government of providing the guarantee.

It should be noted that currently the Loan Guarantee Program terms do not fully align with the OECD protocols governing Export Credit Agency (ECA) financing, especially with respect to full *pari passu* (i.e. equal) treatment of lenders. A particular concern for some ECAs is the current DOE requirement that it has a superior right to the project assets, which means that, although all lenders would receive *pari passu* treatment, the DOE would control the disposition of all project assets.

Standby support

Standby support, effectively insurance against regulatory delays due to the licensing process or litigation, is available for the first six new reactors. Delays in regulatory approvals would push out the commercial operation date for the nuclear power plant, having serious effects on the financing schedule of the project. This standby support will help the project to meet its debt service obligations that come due prior to the start of commercial operation. Specifically, covered delays would include the failure of the NRC to comply with schedules for review and approval of inspections or the conduct of hearings, in addition to litigation that delays full-power operation.

The first two plants to enter the scheme will be eligible for up to USD 500 million of support, with the next four plants eligible for up to USD 250 million of support (but only with coverage for 50% of delay costs). Covered costs include principal and/or interest on debt coverage, along with the difference on the fair market price of replacement power and the contractual price of power from the plant. However, any costs that result in a failure of the project sponsor to take any action required by law or regulation, or any events within the sponsor’s control, will not be covered.

Production tax credits

Production tax credits are intended to enhance the financial attractiveness of a project by improving returns in the early years of commercial operation. The first 6 000 MWe of new nuclear generation are eligible for production tax credits in the amount of USD 18/MWh. Up to USD 125 million per 1 000 MWe per year is available, which will be distributed on a pro rata basis if more than 6 000 MWe of capacity is eligible.

To be eligible, projects must have submitted a COL application to the NRC by 31 December 2008, must have begun construction by 1 January 2014, and must have started commercial operation by 1 January 2021. The tax credit is available for an eight year period. The allowable credit is reduced by reason of grants, tax exempt bonds, subsidised energy financing and other credits, but such reduction cannot exceed 50% of the allowable credit.

Extension of Price-Anderson Act

The US nuclear liability system, known as Price-Anderson, which provides in excess of USD 10 billion of nuclear liability coverage, was extended through 2025. Maintenance of a robust nuclear liability regime provides economic certainty to project participants, as well as a source of recovery to injured third parties.

Appendix **2**

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The Financing of Nuclear Power Plants

Many countries have recognised that greater use of nuclear power could play a valuable role in reducing carbon dioxide emissions. However, given the high capital cost and complexity of nuclear power plants, financing their construction often remains a challenge. This is especially true where such financing is left to the private sector in the context of competitive electricity markets.

This study examines the financial risks involved in investing in a new nuclear power plant, how these can be mitigated, and how projects can be structured so that residual risks are taken by those best able to manage them. Given that expansion of nuclear power programmes will require strong and sustained government support, the study highlights the role of governments in facilitating and encouraging investment in new nuclear generating capacity.

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