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Can New Nuclear Power Plants be Project Financed?

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Abstract

This paper considers the prospects for financing a wave of new nuclear power plants (NPP) using project financing, which is used widely in large capital intensive infrastructure investments, including the power and gas sectors, but has not previously been used for nuclear power. It argues that the first few NPPs will have to be financed on balance sheet by large corporations because these plants need to build a positive record on construction risk. If that record can be built there is no reason in principle why large scale project financing should be denied to NPPs. The projects will probably need to have a long term power offtake project, requiring a creditworthy electricity supplier, but this is feasible even in liberalised but relatively oligopolistic power markets like the UK. Interviews with practitioners in the project finance sector confirm that banks are interested, in principle, in lending for nuclear power stations. Project finance would also readily allow multiple shareholdings in individual plants. This in turn would provide the means for power companies to diversify their plant risk and for third party financial shareholders to invest in diversified portfolios. This last feature could open up a new route for significant equity investment in NPPs. The analysis concentrates on the UK but is potentially of wider application.

Keywords Nuclear power, project finance

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1. Introduction

Plans for new NPPs have been growing since the early 2000s in response to the problem of de-carbonising electricity supply and the improving economics of nuclear power against high hydrocarbon prices. Public policy has become more supportive of NPPs, especially in the US and UK. The US Energy Policy Act of 2005 provided for federal loan guarantees for various energy technologies as well as a degree of insurance and production tax credits for the first six GW of nuclear plant capacity (Department of Energy 2005 SEC.1306 and 1703). The UK government White Paper of January 2008 sees nuclear as having "a key role to play as part of the UK's energy mix" (BERR 2008 p.4). This policy was reaffirmed in the Annual Energy Statement by the new coalition government in June 2010 (Department of Energy and Climate Change 2010). The Japanese nuclear power disaster in early 2011 doesn't seem to have changed US government policy (Platts 2011) but has led private utility NRG to drop plans for two new nuclear stations in Texas (NRG Energy Inc 2011). One scenario for a "nuclear renaissance" could see the wave of ageing reactors replaced by new stations to maintain the relative share of nuclear in the generation mix. But it is possible that nuclear will increase its relative share as it replaces coal and even some gas plants, if it can be made economic.

These potential NPP investments are some years away and invite technical, political and social challenges, not least in the choice of sites and arrangements for spent fuel storage and disposal. But there is also a financing challenge; NPPs are highly capital intensive and a rapid phase of new build would require substantial financial resources. At a time when there is a large demand for capital for other sorts of infrastructure investment, both in developed and emerging economies, nuclear build will need to be both economically viable and to use the full variety of commercial financing mechanisms if it is to be built.

The UK had about 10.9GW of nuclear capacity in 2010, scheduled to fall to 9.4GW by 2015 (National Grid 2010). The UK government used a construction cost central case of £1,250/kW for new nuclear (BERR 2008). But more recent cost estimates suggest an overnight cost figure of $4,000/kW in 2007 dollars (Du and Parsons 2009), which is about £2,600/kW at late 2010 exchange rates. So if all of this plant were replaced with new nuclear, the rough order of capital needed would be £28billion ($43.5bn) excluding the cost of interest. A programme of new build that significantly increased nuclear's market share of generation would cost far more.

Europe's largest nuclear generator and largest electricity company is EDF. EDF started the construction of a new EPR (European Pressurised Water Reactor) at Flamanville in late 2007, with a projected total cost (including EPR development costs) of Euro 3.3bn (EDF 2008). In July 2010 EDF re-estimated costs at Euro 5bn ($6.5bn)[2], or about € 3,125/kW ($4,031). At the end of 2009 EDF had total book equity (including minority interests) of Euro 32.7bn and net debt (total debt and financial liabilities, net of cash and liquid securities) of Euro 42.5bn (EDF 2009 section 39.3). Adding a single EPR with a value around Euro 5bn is therefore a material investment relative to the total group balance sheet. A programme of say four

[2] Exchange rate €1 =$1.29

EPRs in the UK would amount to a very significant investment for EDF and would almost certainly require additional equity capital.

Given that EDF is the largest potential European nuclear investor and one of the largest in the world, at least in the private sector, it is unlikely that a nuclear renaissance in the UK, let alone in other European countries, could be financed by the existing electricity companies using their own balance sheets, without substantial new equity capital. Shareholders might be willing to put up the new equity but traditional utility investors typically seek a steady return from their shares, rather wishing to put cash in. They might also see the new investment as being large and potentially too risky in relation to the existing assets.

Instead these companies – and possibly new entrants to the sector – will probably want to make use of a well established alternative source of funding for large, capital intensive investments, which is project finance. This is a way of raising external debt and equity against the project investment itself, not the company sponsoring the investment. The main advantage of project finance is that it efficiently allocates risk among project participants, reducing the required return and allowing more debt to be raised. This paper explains what project finance is, how it could be used in the nuclear power sector and the problems in using project finance in the early stages of nuclear new build. It argues that there is no reason in principle why project finance cannot be used to fund nuclear power plants and that there are advantages to its use, including the ease with which multiple investors can be included.

2. Corporate finance and project finance

The normal source of financing for private sector investments is general corporate finance, also known as "on-balance sheet" finance. For most companies this is the only sort of finance available and consists of borrowing or raising equity against the assets of the company as a whole. A bank or bond holder which provides funds to the company has a claim against the company's whole cashflows, unless the loan is secured against a particular asset, as is common for mortgages.

So if a company builds a new power station using general corporate finance, the risk of that investment is borne by all providers of capital to that company. The only limitations for the company arise if there are covenants (legally binding contractual clauses) which limit the company from making particular types of investment or from exceeding certain financial performance ratios such as debt to equity or interest cover.

A second form of financing that may be available under some circumstances is project financing. Project financing is "financing the development or exploitation of a right, natural resource or other asset where the bulk of the financing is not to be provided by any form of share capital and is to be repaid principally out of the revenues produced by the project in question" (Vinter 1998 p.xxxi). (Esty 2004) defines project finance as involving "the creation of a legally independent project company financed with equity from one or more sponsoring firms and non-recourse debt for the purpose of investing in a capital asset".

The key feature of project financing is that a new company (known as a special purpose vehicle (SPV) or special purpose entity (SPE)), which we'll call the project company, is set up solely for the purpose of owning the project to be built. A bank or consortium of banks then lends to this project company, which in turn owns the asset, which we will assume is a power station. The company that wants to build the power station, which we'll call the sponsor, has a stake in the project company. This stake could be 100% but equally there could be other equity partners, which might include the company which will build the power station, and other interested parties, including external passive investors.

As the loans are made to the project company, not the sponsor company wanting to build the station, they are said to be "non-recourse" to the sponsor. So in the event that the project gets into trouble and is unable to generate revenues sufficient to cover the debt servicing costs, the banks may not pursue the parent company for the cash; the parent's liability is limited to its equity investment stake in the project company. In legal terms the project company is "bankruptcy remote" from the sponsor. Pure non-recourse is not always feasible but the goal of project financing is to keep the risk of lender recourse to the sponsor company as low as possible. Equivalently, project financing provides the project sponsor with a put option (or "walk-away option" as described by BP-Amoco, (Esty and Kane 2010 p.8).

Project financing provides access to a large pool of debt financing, from banks and from bond holders, and enables an electricity company to consider building more power stations than it might be able to finance through its normal corporate financing. The extra complexity and transactions costs of arranging project finance, including very detailed contracts, make it more expensive than normal corporate finance, but the benefits include:

1. reduced risk for the parent/sponsor company
2. better allocation of risks between the owners, constructors, operators and suppliers
3. the possibility of multiple equity investors.

Note that it is possible to have multiple equity investors without project financing but the typical project finance structure makes it easier for regular changes of ownership, allowing a more liquid secondary market for bonds and potentially equity investors.

The economic benefits from project finance arise from the contractual structure. Following (Modigliani and Miller 1958), leverage alone is of no benefit. There may be some value in higher tax shields arising from a higher level of debt, but in the BP case the company takes a fully consolidated view of its borrowings so project finance displaces other forms of corporate debt for no net impact (Esty and Kane 2010 p.8).

Project finance, by separating the risks of the project from those of the sponsoring company, has the potential to improve overall risk allocation. (John and John 1991) argue that the optimal allocation of debt between the sponsoring company and the project results in lower agency costs and a higher tax shield compared with conventional corporate finance (p.51).

(Shah and Thakor 1987) show that project financing can increase the value of some, typically risky projects and allow greater leverage. The benefit comes from the improved ability of creditors to appraise the project they are lending to compared with the situation where they have to appraise the whole firm, of which the project cashflows are just one part. The key is reducing the asymmetry of information between managers and lenders.

Project finance also appears to overcome the risk of underinvestment that would otherwise arise from the danger of financial distress in very large projects. (Esty 2003) argues that imperfections in capital markets caused by asymmetric information and imperfect management incentives mean that large investments might not be undertaken, even by very large companies, but for project finance.

(Esty and Kane 2010) provide a detailed analysis of the costs and benefits of project finance as seen by BP. Project finance is typically more expensive because it involves additional bank fees and third party consultancy and legal fees. These can amount to 200-300 basis points (bps) as upfront costs and an additional 150-200 bps on the annual interest rate. But, in some cases, this is more than offset by the value of protecting the company from exceptionally large risks and facilitating the involvement of outside partners (Esty and Kane 2010 p.6-8).

(Kleimeier and Megginson 2000) study a large sample of project and corporate syndicated loans. They find that "the project financing structure reduces important agency costs that are inherent in the creditor/borrower relationship, and that PF is a very effective method of providing monitoring for large projects with relatively transparent cashflows" (p.87).

3. Some data on project finance deals

Table 1 shows some recent large project financing examples, illustrating the debt/equity financing and the sectors that are attracting substantial financing.

Table 1. Examples of Major Project Financings 2007-2010 ($bn)

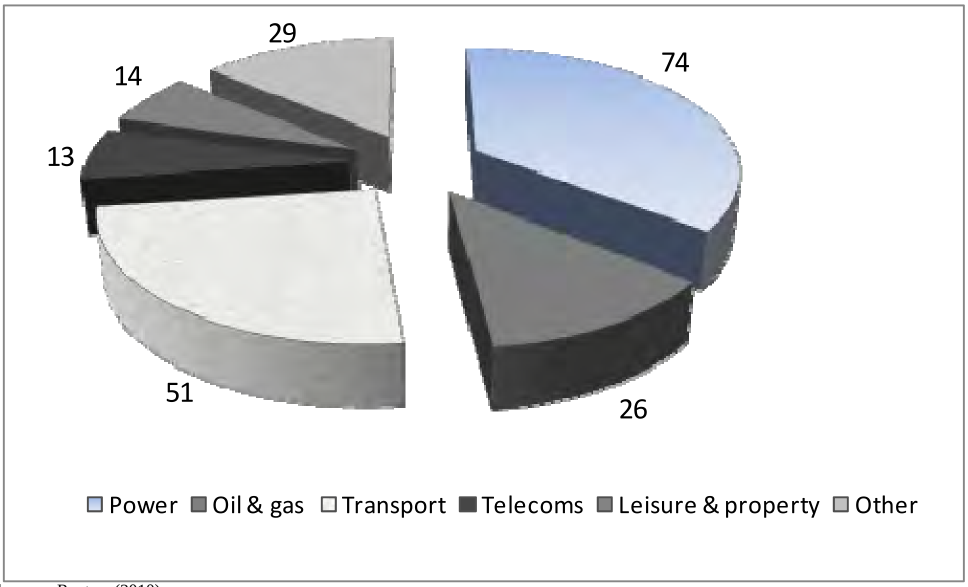
Location	Project	Year	Debt	Lenders	Sponsor(s)
Fujairah F2 , Abu Dhabi	Power plant & desalination plant	2007	2.8	Calyon, Citigroup, SMBC	Abu Dhabi Water & Electricity Authority, International Power, Marubeni
Sakhalin II, Russia	Liquefied natural gas & oil development	2008	5.3	Japan Bank for International Cooperation + commercial banks	Gazprom, Royal Dutch/Shell, Mitsui, Mitsubishi
Exeltium	Virtual power project	2009	2.2	BNP Paribas, Societe Generale, Natixis and Credit Agricole	Various energy-intensive manufacturing companies in France
PNG LNG	Liquefied natural gas	2009	4.5	Exxon Mobil and commercial banks	Exxon Mobil, Oil Search, PNG Govt & others
Nord Stream	Gas pipeline	2010	5.0 (1)	BBVA, Bank of Tokyo-Mitsubishi UFJ + 24 others	Gazprom, BASF, E.On, Gasunie,
Jubail, Saudi Arabia	Oil refining & petrochemical plant	2010	8.5	Credit Agricole, Société Générale, KfW - IPEX Bank & several others	Saudi Aramco, Total

Sources: Company websites and press releases; (1) Phase 1 - total project €13.9bn ($17.9bn)

Note that many of these "large" projects are around the same size as a single NPP (with the exception of Jubail in Saudi Arabia).

The total volume of project financing in 2010 was $207 billion, up from $143 billion in 2009 (Thomson Reuters 2010). The largest sectors were power, oil and gas, transport and leisure and property (figure 1).

Figure 1. Global Project Finance in 2010 by Sector (%)



Source: Thomson Reuters (2010)

The ten largest project financings to close in 2010 are shown in table 2. The relatively high share of transportation in the totals for the year is explained by the combination of the Taiwan High Speed Rail deal and the privatization by the UK government of High Speed Rail 1.

Table 2. Largest Project Finance Deals of 2010

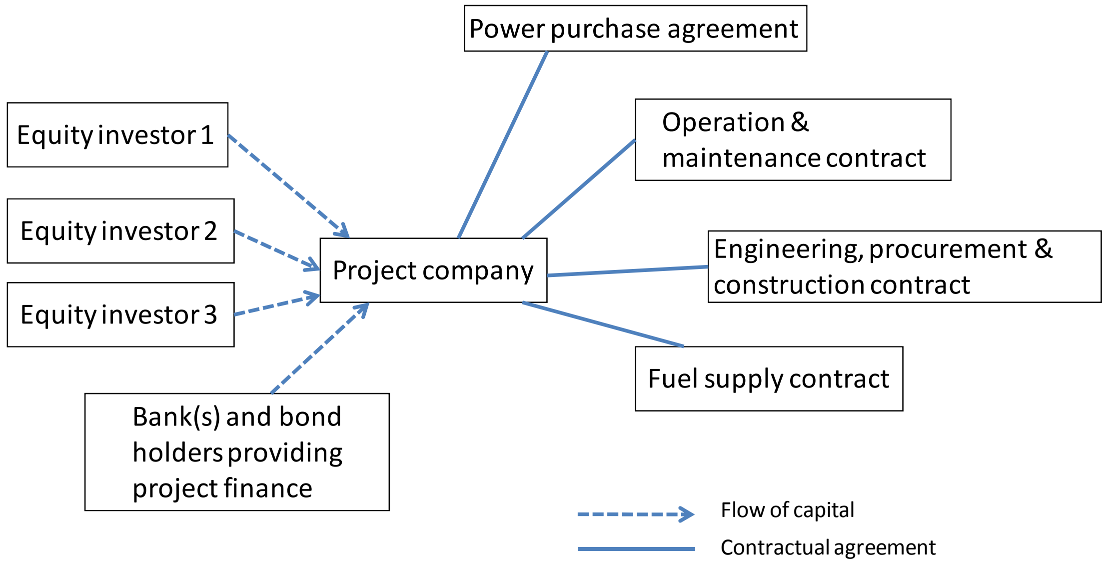
Borrower	Domicile	$bn
Taiwan High Speed Rail	Taiwan	12
Jubail Petrochemical	Saudi Arabia	5.8
Nord Stream (gas pipeline)	Switzerland	5.4
Hongsa Power	Laos	2.9
Perenco Petroleum	UK	2.8
KSK Mahanadi Power	India	2.7
HSBC Rail acquisition	UK	2.7
Exeltium Virtual Power Station	France	2.5
High Speed 1 Rail Sale	UK	2.2
Coastal Andhra Power	India	2.1

Source: Thomson Reuters (2010)

4. The practicalities of project finance

An idealised project finance investment is shown in figure 2. This example is based closely on the use of project financing in the wave of new combined cycle gas turbine (CCGT) power stations built in the UK during the 1990s, following the liberalisation of the British power generation market and of the ending of the European Union's restriction on the use of gas for power generation (Helm 2003 p.167-69).

Figure 2. Illustration of Power Project Financing Structure



Source: Author

The goal of the financing structure is to optimise the allocation of risk in such a way as to maximise the probability of the loans being repaid and serviced on time, consistent with an adequate equity return for the project investors. The banks (or bond holders) which provide the project finance loans need to be confident that the risks to the cashflows out of which their loan will be serviced are robust and that the key identifiable risks to those cashflows are clearly and legally enforceably allocated to parties that can bear them.

The project company will therefore need to have the following main contracts in place before lending is feasible (Vinter 1998 ch.3).

1. an engineering, procurement and construction contract
2. a supply agreement (for fuel and other inputs)
3. a sales contract (e.g. a power purchase agreement)
4. an operating and maintenance contract.

The *engineering, procurement and construction (EPC) contract* requires a separate company to undertake to build the station to a specific time and cost. Over-runs on either score are potentially very costly and the project company will seek clear indemnities against this risk, meaning the construction company will have to be creditworthy enough for such indemnities to be credible. The construction company will turn seek indemnities from the key equipment manufacturers. In the UK CCGT expansion of the 1990s, some new turbine designs had teething problems which led to commissioning delays and consequential damages being paid to the project company by the turbine manufacturer.

The *supply agreement* is a contract to cover the volume and price of the power station's key operating inputs. For a CCGT this is essentially the gas supply. The economics of a CCGT boil down to the spread of the power price over the gas price (known as the "spark spread") given a fixed efficiency of conversion through the turbine and a relatively small fixed cost of operations. The optimal risk position for the lending bank is that both prices are contractually fixed to provide a guaranteed profit margin for the length of the loan. Some degree of variation may be acceptable subject to a minimal likelihood of the revenue failing to cover the debt service cost. A typical take or pay contract for gas in the 1990s in the UK specified a minimum volume and a price index which allowed for some linkage to the oil price. This entailed some risk of a price mismatch and consequent losses but the banks were confident that the margin of error was large enough to protect their debt interest, the risk being therefore borne by the equity shareholders.

The *sales contract* is a long term contract (typically 10-15 years) for a volume and price for the power. This contract provides the revenue out of which the project lending will be repaid. The banks will not want to take either volume or price risk, so a buyer for the power must be found. In the UK market of the 1990s, the project sponsors were typically regional electricity companies which had supply businesses enjoying an actual or de facto monopoly retail customer base. In a liberalised market however, the entity buying the power has no monopoly and takes the risk that it will be forced to pay for power that it can only sell at a loss. So the buyer will again need to be a creditworthy and probably large company to satisfy the banks that it will not renege.

The last piece of the jigsaw is the *operation and maintenance (O&M) contract*. The plant must be run properly so that it can deliver the power specified under the sales agreement. The operator takes a fee for operating the plant and takes the risk that if it fails to deliver the power, other than because of a failure of the fuel supply, it is liable to pay compensation to the power buyer.

If the contract is correctly specified and the various parties are creditworthy and competent, the project company has successfully laid off the various risks of the power project to the parties best able to bear them. The project financier can then be confident that it will be repaid and make the loan. Because the risks have been effectively allocated the residual equity risk should be quite low so a high level of leverage (ie debt to equity) is feasible, which means the overall cost of capital is minimised.

But the residual risk is never zero. The remaining risks include (Sharma and Tanega 2000. ch.2):

1. *counterparty risk*: the danger that one or more of the contract counterparties ceases to be creditworthy
2. *political risk*: the local or national government may intervene in the project in a damaging way
3. *legal and structural risk*: the contracts are signed under a particular legal and fiscal framework that may be affected by later legislation which either invalidates them or more likely reduces the tax efficiency.

These risks are not merely theoretical, especially in emerging economies with less robust legal procedures. A key reason for the rapid loss of enthusiasm by US and European utilities for emerging market investments after the 1990s was the dismal record of contract enforcement and political interference in the power and water sector in Latin America and India in the 1990s (Lamech and Saeed May 2003; Annez November 2006).

5. Nuclear power and project finance

Conceptually there is no difference between a nuclear power project and a CCGT project. But there are important differences of scale and in the information needed to make the contracts feasible.

Table 3 shows they key points of comparison between a CCGT and nuclear power plant. The most important difference at the time of writing is that project finance is all but impossible until there is a credible track record for the construction of new nuclear plants. The construction risk is by far the main economic risk because of the complexity of a nuclear power station and the truly dreadful history of construction delays and cost over-runs (Nuttall 2005 ch.1). The commissioning problems of new gas turbines in the UK CCGT boom were relatively small compared with the costs of nuclear construction over-runs. While delays can occur in any large construction project, banks are very unlikely to finance nuclear construction risk until there is some proven record of construction and sound operation. This record would need to be specific to each technology type so that for example it might take four or five separate EPRs (European Pressurised Water Reactors) to be built before lenders would be reasonably confident about the risk of future delays. A successful track record for one reactor type would be helpful for other types but very likely insufficient to achieve project lending until that type had established its own track record.

The only way in which project lending might be feasible for the earliest NPP new build would be if some other party bears the construction risk. But in that case the risk is separated from the reward and it is unclear why any part would take on the main risk without a commensurate stake in the upside potential.

Table 3. Comparison of CCGT and Nuclear Power for Project Finance

	CCGT	Nuclear	Comment
Approximate scale of capital investment ($m)	150-750	5,000-7,000	CCGTs can be small, and are of low capital intensity
Construction risk	Well defined	Not well defined owing to lack of recent track record	Makes project finance impossible for early stations
Technology risk	Low for proven turbines; significant for newer designs	Substantial for new designs until operating record built up	Decays as operating hours rise; type specific
Fuel supply contract	Very important; terms available	Less economically important but also a less liquid market	Likely to be bundled with operations agreement
Sales contract	Very important	Very important; scale makes multiple buyers likely	Requires substantial retail supplier(s) with strong balance sheet
Operating and	Plenty of potential	Very few potential	

maintenance (O&M) contract	operators	operators; likely to be project sponsors	
Political risk	Low	Significant; high in some countries	
Regulatory risk	Low	Significant; high in some countries	

Source: Author

The other points of difference between nuclear and CCGTs are as follows.

1. The supply contract is proportionately much less important for an NPP. Whereas the cost of gas is around 60% of a CCGT's operating costs and physical availability is very important because of the cost of storage or alternative fuel back up, for an NPP fuel is only about 7% of the cost and long inventories are feasible (MIT 2003 tables A-5.5.5 and A-5.5.6). Gas can be bought in a fairly liquid competitive market in the US and UK so in principle can be procured at short notice. By contrast, although uranium is relatively plentiful and can be procured in many different countries, the markets for fabricated uranium fuel are much more specialised. The cost of mined uranium makes up about one quarter of the total fuel price (World Nuclear Association 2010). The rest of the cost is the fuel enrichment and fabrication process, which is subject to much less competition and is more closely bound up with the operations of the plant. So it is likely that the fuel supply contract would be combined with the operations contract, with the operating company taking the whole risk on. In future, if the nuclear renaissance really happens on a large scale, hedging or otherwise protecting against uranium price or volume risk might become a more important feature of NPP investment.

2. The operation and maintenance contract for a nuclear power plant is a much more important matter than for a gas plant because it is regulated more stringently. It is very likely that the sponsoring company would be the O&M contractor and that this would be a condition of achieving an operating licence from the nuclear regulator.

3. Political risk is significantly higher for a nuclear plant because of the higher sensitivity that nuclear power has. Countries including Italy, Germany and Sweden have in the past elected governments that have decided to reverse their predecessors' nuclear policy (Taylor 2007 ch.16). With nuclear stations having much longer lives than CCGTs the risk of a damaging change in policy is higher.

The main reason is that an event that causes public concern at a nuclear power station in another country could cause a forced shutdown or closure in the home country, even if the technology and operating context were quite different. This "contagion" risk doesn't apply to the same degree to other sorts of technology. But project finance has successfully been used in other projects with significant political and/or regulatory risk, for example the $3.2 billion Baku Tbilisi Ceyhan oil pipeline (Center for Civic Initiatives 2005).

4. Regulatory risk is higher for an NPP but much of that risk can be dealt with before a project commits substantial capital. Indeed only if the regulatory approvals are certain would a project proceed.

We conclude that, once a particular reactor technology has proven that it has a reliable construction record – which of course could take many years if plants are build sequentially rather than in parallel – then there is no reason in principle why nuclear power should not attract project finance, eventually.

6. Early build is different

Section 4 argues that there is nothing unique about NPPs that rules out project finance, once the construction and operation of a particular reactor type is proven. But for a new type it will take a number of stations to be built and operated successfully for banks to have sufficient confidence in the project estimates that they will lend.

The "first of a kind" problem is not unique to nuclear power. As noted above, some combined cycle gas turbine technologies in the 1990s experienced severe operating difficulties. That risk had to be borne ex ante by the equipment manufacturers and was the price those manufacturers paid for getting one or two successful operating units that could be used to showcase further sales. In principle an NPP equipment manufacturer could provide similar indemnities but that would still not take care of the construction risk, which was not typically a problem for the CCGTs, because they were relatively quick to build (less than two years) and their construction represented only a small evolution from other similar construction projects. By contrast the capital cost of an NPP is much more sensitive to construction delays and each reactor type has more idiosyncratic risk than a CCGT. The first ever EPR under construction at Olkiluoto in Finland is three years behind schedule and some 60% over budget (Hollinger 2010).

The plant is being built under a turnkey fixed price contract, under which cost over-runs should be borne by the manufacturer and contractor, Areva NP, which is majority owned by the company Areva, itself majority owned by the French government. One can question whether the NPP buyer would sign such a contract with any entity lacking the backing of either a very large, creditworthy company or a government.

The second EPR, under construction at Flamanville in France, is also about 50% over budget and likely to be delayed by two years (EDF 2010). In this case the construction risk is being borne by EDF itself.

Two further EPRs began construction in China in 2009 and 2010, for the state owned China Guangdong Nuclear Power Group, where they are reportedly on time and budget (Reuters 2011). Initial construction of two Westinghouse AP1000 reactors in China also appears to be on track, as are General Electric Advanced Boiling Water Reactors in China and Taiwan. With four units operating, three more under construction and several more planned, the ABWR is closest to establishing the track record needed for project financing (GE Energy website 2010).

This implies there is no realistic way of getting banks to project finance NPPs until at least "a few" have been successfully built to time and cost, or the project sponsor is willing to provide guarantees that cover the risks of delay. It is likely to take at least three and probably four successful completions before project finance is available on commercially attractive terms.

The first few of a kind NPPs will therefore almost inevitably be financed on the general corporate balance sheet of large integrated electricity companies that have a substantial supply arm which will market the power produced. Some risk sharing may be feasible between the equipment manufacturer and construction company but it is unlikely that there would be any outside finance specifically for the project itself.

Once a station is built and running successfully it would be possible to sell it to a project finance company, allowing the original sponsor to take a one off gain as compensation for the construction risk.

The nearest to NPP project financing to the author's knowledge was the now-abandoned South Texas Project units 3 and 4. The proposed two new units were sponsored by the US utility company NRG Energy. The project was owned by a company Nuclear Innovation North America (NINA), which was majority owned by NRG and minority owned by a subsidiary of the Japanese corporation Toshiba, whose Advanced Boiling Water Reactor would have been used. NINA in turn signed procurement contracts (with Toshiba being part of the construction consortium too) and was intending to sign long term power purchase agreements that would have provided the backing for project finance and access to US government federal loan guarantees. NINA, critically, was "bankruptcy remote" to NRG (NRG Energy Inc. 2011 p.20) In April 2011 NRG terminated its involvement in the project and wrote off the $331m equity it had invested in NINA, citing the Fukushima incident in Japan (NRG Energy Inc 2011).

7. A nuclear project financing structure

This section sketches a likely structure for a project financed NPP in the liberalised market context of the UK. The main change from the CCGT project structure shown in figure 2 is that a single project sponsor would probably be the main shareholder, the O&M contractor and the power purchaser. This company, which we'll call DCE Power, would have to be a large, creditworthy company with a significant electricity supply business. In the UK, EDF, RWE and E.ON all fall into this category as well as having nuclear operating experience (RWE and E.ON's UK intended nuclear interests are held in a 50/50 joint venture company called Horizon Nuclear Power[3]).

DCE Power would deal with the project company in three separate guises:

1. the parent company would invest in the equity, taking a large though not necessarily majority share, so long as a shareholder agreement gave it veto over sales of the other shareholdings;
2. DCE's generating arm would sign the O&M contract;
3. And DCE's power supply arm would sign the power purchase agreement.

Construction would be handled by a third party contractor, linked to the manufacturer, and would have to take most or all of the risk of cost over-runs and delays, to provide comfort to bank lenders. This third party would therefore need to be highly creditworthy, or receive guarantees from export credit agencies or similar state-backed entities.

[3] http://www.horizonnuclearpower.com/

The financial credibility of this structure would depend on the project lender's confidence in the creditworthiness of the overall DCE company to stand behind each of the agreements in the event of difficulties. A power purchase agreement in a competitive supply market involves a company committing to buy a commodity at a fixed price or index of prices, without any guarantee that it can sell the power profitably. A large and well capitalised supplier (which is the norm in Europe's mostly oligopolistic and vertically integrated power markets) would reassure the project lenders that the contract would be honoured even if there periods when the market price of power fell below the price in the contract.

DCE Power need not contract for all of the power from the NPP. It might well sign long term power contracts with other suppliers who want to include nuclear in their portfolio but don't want any equity investment or operating involvement. These suppliers contract for a share of the power off-take from a new NPP without having any financial exposure to the operations or profitability of the plant. A range of European manufacturing companies with sites in France contracted in 2010 for 24 year power contracts from EDF through a special purpose vehicle company called Exeltium.[4] The Olkiluoto NPP under construction in Finland is backed by several long term power contracts with Finnish paper manufacturers. But the UK, among other countries, lacks a significant industrial demand for long term power, so any long term contract would need to be signed by the supplier itself, which would leave it partially exposed to price risk.

8. Advantages of project financing NPPs

There are two main benefits of using project finance in NPPs: 1) allowing a nuclear company to manage its risk while investing in several stations at once; and 2) an easier method for bringing in additional equity shareholders.

As noted above, even very large utility companies like EDF would need to raise substantial new equity to fund a large programme of NPP construction. While this might be possible, shareholders might prefer that they offset some of the potential return in exchange for limiting the risk. EDF has many other potential investments to make and shareholders may prefer not to have an excessive amount of risk tied up in one concentrated area.

A second benefit of setting up a separate project finance company is that it facilitates external equity shareholdings. As NPPs are large, physically indivisible units, there is a long history of multiple shareholdings, especially in the USA. Relatively small utilities which could not take on the ownership of a whole plant instead often sought to take a minority stake. Much of the consolidation of the 1990s took the form of reversing these multiple ownership stakes, which had often led to management conflicts and inefficiencies (World Nuclear Association 2010).

Project finance makes multiple equity ownership easier because the management of the plant is explicitly contracted out. The shareholder agreement can allow for sale of the stakes without disrupting any of the contracts that affects the plant's operations or financial stability.

[4] http://www.linklaters.com/News/LatestDeals/2010/Pages/20100419.aspx

The growth of infrastructure funds and sovereign wealth funds, alongside the pension funds that are traditional owners of long term assets, means there is a potentially large pool of equity finance available for NPPs, so long as investor can diversify their country and reactor type risk. This is possible in principle through conventional joint ventures but would be easier and more flexible, potentially allowing a liquid secondary market in investments, through project finance structures.

More generally, with NPPs being of a scale similar to the large capital intensive investments shown in table 2 above, ruling out the use of project finance would risk limiting the scope of NPP expansion. Infrastructure spending more broadly is widely expected to grow substantially in the next twenty years, owing to economic growth in low and middle income countries and a need for replacement of ageing infrastructure in high income countries. One study seems a more than doubling of real infrastructure spending globally (McKinsey Global Institute 2010). For the US, one (possibly not disinterested) source sees a need for $2.2 trillion of infrastructure spending in the next five years (American Association of Civil Engineers 2011). NPPs, at best, are one form of this broader infrastructure capital spending. Unless they can become seen as "normal" they are likely to face higher capital costs than other, competing investments.

9. Practitioner views

The author conducted loosely structured interviews with six representatives of major project finance banks and two specialist energy finance investment banks in 2010 (so before the Japanese earthquake and tsunami of early 2011. The questions are shown in the appendix. While this is statistically a tiny sample, the banks concerned represent over a quarter of the global project finance business.

The overall conclusions were very consistent. First, all banks are open to nuclear-related lending and in most cases already have some exposure. They see a major new business opportunity potentially opening up if NPP construction booms globally and are keen not to miss out. But few have a large team of people in place as the opportunity is still some years away.

Second, there is very little that is special about nuclear in principle.. The practitioners see nuclear as a somewhat extreme case (capital intensity, technical complexity) of a spectrum. They would apply similar underlying lending criteria and structures to those used in other lending decisions. They are more concerned about managing the commercial or market risk in liberalised power markets than in the generation source itself. The financial damage done by the electricity price collapse in the UK in 2001-2002 (Taylor 2007 ch.10) ch.10) has scarred the power finance sector for some time.

Third, nuclear is different in principle in so far as it still represents an unusually sensitive public policy issue. As one banker put it, "We don't want people protesting outside our offices". This translates into not wanting to lend unless nuclear is felt to command public consent or support. Non-nuclear energy investments are potentially as controversial or more so than nuclear, as shown by the protests against wind-farms, additional transmission lines to service wind-farms and against plans for a new coal power station at Kingsnorth in Kent, UK (Harvey 2009).

Fourth, the main practical objection to lending against new nuclear stations is the construction risk. This is always the highest risk part of a project finance venture but the industry's very poor track record, reinforced by the problems of the EPR, make it impossible to envisage project financing at the construction phase for some time. The banks were mostly European and highly aware of the EPR experience. A few cited the far better construction record in South Korea, Japan and China as evidence that NPPs may be bankable sooner. Nearly all bankers saw early potential for using project finance for NPPs once they were fully built and operational, so long as the reactor type had some operating record. This, so-called phased financing model is reportedly being considered for NPPs in China (Borovas, Mauel et al. 2010).

Fifth, both bankers and advisers saw the potential for a large new market in both equity finance and bond finance for NPPs. Equity finance could come from the "new" investors such as infrastructure funds and sovereign wealth funds. Bond finance could come from existing bond investors seeking a wider range of investment opportunities, especially in the long term (10 years and more) part of the market. This market might need some "leadership" from quasi-state lenders such as the World Bank or European Bank for Reconstruction and Development to get going but NPPs are a potentially attractive new sub-asset class.

10. Conclusion

This paper has argued that any substantial wave of investment in NPPs will need access to project finance, as other large capital intensive projects do. It argues that there is no intrinsic barrier to project finance for nuclear but that banks will only lend after the industry has built a successful track record of construction. The advantages of project finance are a lower overall cost of capital and a superior allocation of risks among interested parties. Without project finance, investment will be limited to very large, well capitalised power companies and these will probably build fewer new plants than they would if project finance were available. NPP investment would be disadvantaged in competition with a likely boom in other forms of infrastructure investment. Interviews by the author (before the Fukushima disaster) with a number of project finance lenders and investment banks confirm that there is no nuclear-specific reason for project finance to be denied to NPPs.

Appendix. Questions put in interviews

1. Would your bank ever lend to a company in the nuclear sector?
2. Do you see nuclear power stations having any distinctive features compared with other types of asset from a credit point of view?
3. Does your bank have any nuclear-specific policy, distinct from other credit policies?
4. Do you believe that new nuclear plants could be project financed and if so when?
5. Do you believe that existing or post-construction new nuclear power plants could be project financed, and if so when?
6. Where do you see potential sources of third party equity investment in project finance companies investing in nuclear power?

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