The Economics of Nuclear Power

Presentation at a conference: Economical aspects of nuclear power Prague, March 28th 2006

Steve Thomas (stephen.thomas@gre.ac.uk)
PSIRU (www.psiru.org)
University of Greenwich

Outline

- The World Market for Nuclear Plants
- US developments: Nuclear Power 2010
- Current Designs
- Key Determinants of Nuclear Economics
- Why perceptions in Eastern Europe may be different
- Recent Studies on Nuclear Costs
- Need for and Extent of Public Subsidies
- Conclusions

The World Market for Nuclear Plants (1)

- Reports of a revival in nuclear ordering are premature
- Only 22 units are under construction worldwide compared to 441 already in service
- Of these, 16 use Indian, Russian, or Chinese designs
- For 6 of the plants, construction started before 1990

The World Market for Nuclear Plants (2)

- The Western vendors active in Europe—Areva & Westinghouse—have one order: Olkiluoto
- China and Japan have consistently over-estimated their ordering rate for 25 years
- Orders in China and Korea delayed several times and construction in Taiwan now 6 years late
- Resumption of construction of plants in the former Eastern Bloc also consistently delayed

The US Initiative: Nuclear Power 2010

- $450m available to pay for licensing approval at three sites
- Several groups have declared an interest, eg, 'Nustart' consortium and Dominion but progress slow and no commitment to order plants
- CEO of Dominion (Thomas Capps) said:
- "We aren't going to build a nuclear plant anytime soon. Standard & Poor's and Moody's would have a heart attack [referring to the debt-rating agencies]. And my chief financial officer would, too."
- This reflects the reality that decisions on nuclear orders can only be taken with the implicit support of the financial community. No company would place a nuclear order if it was likely to lead to a significant increase in the cost of their borrowing or a significant fall in their share price.

Current nuclear designs

- Westinghouse AP-1000. Full certificated by NRC but no orders yet
- Areva EPR. One order (Olkiluoto) and second order (Flamanville) likely. Design not expected to be submitted to NRC before December 2007
- GE ESBWR not now expected to get NRC Certification before 2010
- System 80+, APWR, ABWR and AES-91 WWER-1000. Not likely to be offered in the West
- Westinghouse BWR-90+, Areva SWR, Candu ACR-700/1000 and PBMR all either a long way from being ready to order or have no likely market

Why there is no agreement on costs

- There has always been an assumption that new plants would be much cheaper and more reliable than existing plants
- Forecasts of nuclear costs and performance are generally made by those with a vested interest in nuclear and have invariably been optimistic
- Few orders have been placed in the past two decades on which to base forecasts
- Very little real data on construction and operating cost is published
- All the designs being considered in the West are unproven. Only one plant worldwide of modern design is being built (Olkiluoto started in summer 2005)

Most important economics factors

- Construction cost and time. Repaying construction cost and interest is expected to account for about two thirds of the cost of power from a nuclear plant
- Cost of capital. Nuclear power is the most capital intensive generation option. For a publicly owned company in a monopoly, the cost of capital is low (5-8%) but for a private company in a market, it is high (>15%). Utilities with guaranteed markets will be rare in future
- Operating performance. The reliability of the plant (load factor) determines how much output it produces. The more output, the more thinly fixed costs can be spread. Load factors were expected to be about 90% but only in a few countries has this level been reached

Other important factors

- Operations and maintenance (O&M) cost. Many people assume nuclear power is essentially free once the plant is built. British Energy went bust because it could not even cover its operating cost from revenue.
- Decommissioning & waste disposal provisions. If the cost is accurately forecast and provisions are collected and invested safely, this is not a major cost. But there is no experience of high-level waste (HLW) disposal and little experience of decommissioning so cost estimates are guesses. Britain's decommissioning provisions have been lost 4 times and there few provisions for HLW disposal

Less important factors

- Assumed lifetime. Especially with high costs of capital, the expected economics are determined by what happens in the first 10-15 years.
- Fuel cost. Nuclear fuel purchase is a small part of the generation cost. Spent fuel disposal costs are expected to be relatively small but are very uncertain
- Insurance and liability cover. International treaties mean governments bear the risk.
- Output rating. Earlier generations of plant often did not operate as designed, for example, not reaching their design rating. This is now less likely to happen

Why perceptions in E Europe are different

Pro

- The alternatives to nuclear power seem to lead to greater dependence on Russian gas
- Exporting surplus power, especially to W Europe, seems very attractive
- The nuclear industry is so desperate for orders it may offer low prices and cheap loans
- Existing plants in Eastern Europe (esp WWER-440) have been reliable electricity generators

Why perceptions in E Europe are different

Con

- Existing plants were purchased at far below world prices
- Do current Russian designs meet Western standards?
- Will the prices bid reflect the final cost – are ‘turnkey’ prices really on offer
- Few waste disposal facilities exist: are the estimated costs realistic?
- Are the risks of a competitive electricity market fully understood

Forecast	Construction cost ($/kW)	Construction time (months)	Cost of capital (% real)	Load factor (%)	Non-fuel O&M p/kWh	Fuel cost (p/kWh)	Operating life (years)	Decommissioning scheme	Generating cost (p/kWh)
Sizewell B	4050 5400	86	-	84	2.07	1.26	40	Part segregated, part cash flow	6 ?
Rice University									5.0
Lappeenranta Univ	~2340		5	91	0.9	0.36	60		1.6
Performance & Innovation Unit	<1500	-	8 8 15	>80			30 15 15		2.31 2.83 3.79
Scully Capital	900 1080 1260 1440	60		90	1.0	0.5	40	£260m accrued over 40 year life of plant	
Massachusetts Institute Technology	2000	60	11.5	85 75	1.5	-	40 25		3.7 4.4
Royal Academy of Engineers	2070	60	7.5	90	0.80	0.72	40	Included in construction cost	2.3
Chicago University	1000 1500 1800	84	12.5	85	1.0	0.54	40	£195m	2.9 3.4 3.9
Canadian Nuclear As	1920	72	10	90	0.88	0.45	30	Fund. 0.03p/kWh	3.3
IEA/NEA	2000-4500	60-120	5 10	85	0.68-1.6	0.27-1.17	40	Included in construction cost	1.2-2.7 1.8-3.8
OXERA	2925 first plant 2070 later unit			95	0.63	0.54	40	£500m in fund after 40 years life	

How are low costs produced? Olkiluoto

- Construction cost reported to be €3.2bn, €2000/kW, higher than all the forecasts
- Will this cost be met? Is the cost fixed whatever happens?
- Is it a ‘loss-leader? German utilities are reported to have been asked 25% more to participate in Flamanville
- Bayerische Landesbank (BLB) gave €1.95bn loan (60% of cost) at 2.6% nominal

How are low costs produced? Olkiluoto

- TVO, customer, is a not for profit organisation owned by energy intensive companies
- Output is contracted long-term to TVO owners
- Are these conditions representative and the cost repeatable?
- After less than a year's construction, the plant is already 6 months late

How do forecasts give low costs?

- The UK PIU (2002) used construction cost <€1200/kW. Sizewell B cost >€4200/kW and Olkiluoto is forecast to cost at least €2000/kW
- Scully Capital (2002) had 4 construction cost scenarios, €700-1100/kW
- MIT (2003) assumed €1540/kW and O&M costs 25% less than current plants
- RAE (2004) assumed 7.5% cost of capital and O&M costs a third of current UK plants

How do forecasts give low costs?

- Chicago University (2004) assumed construction cost of €770-1400/kW
- Canadian Energy Research Institute (2004) assumes construction cost of about €1400/kW
- IEA/NEA (2005) has a range of scenarios with very low options, eg 5-10% cost of capital
- OXERA (2005) assumes O&M costs are less than a third of current UK plants and load factor is 95%

Need for and extent of public subsidies

- The areas where subsidies and guarantees might be required would be particularly those which are not fully under the control of the owner. These include:
- Construction cost. The government might therefore have to place a cap on the cost a private investor would have to pay;
- Operating performance. Reliability is largely under the control of the owner and it is not clear whether developers or vendors would be sufficiently confident in their abilities to take the risk of poorer than expected reliability;

Need for and extent of public subsidies

- Non-fuel operations & maintenance cost. This is largely under the control of the owner and they may bear this risk;
- Nuclear fuel cost. Purchasing fuel has not generally been seen as a risky activity. The cost of spent fuel disposal is contentious and nuclear owners might press for some form of cap on disposal cost similar to the US arrangements;
- Decommissioning cost. The cost of decommissioning is hard to forecast, but the costs arise far into the future. Private developers might therefore seek some 'cap' on their contributions.

Conclusions (1)

- The factors that lead to performance improvements and cost reductions for most technologies, such as learning, technical change, scale economies and economies of number have not yet had much impact on nuclear costs. Why?
- There is little recent experience of building and operating new nuclear plants on which to base forecasts
- Even where there is experience, costs are not available or not reliably reported
- Some costs, such as waste disposal and decommissioning can only be guesses because of lack of experience
- Liberalisation of electricity industries is bad for nuclear because it raises the cost of capital and shifts some economic risk on to share-holders, but most renewables are also capital intensive

Conclusions (2)

- The circumstances of the Finnish order are unique. In any other country where electricity liberalisation has started, a nuclear order would need public subsidies and guarantees
- The favourable forecasts of nuclear costs published in the past 3-4 years have all been based on highly optimistic assumptions
- Guarantees are needed to deal with the economic risks. These might be required on construction cost, and waste disposal cost and would also probably be needed on market and price paid