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Nuclear Power Plant Construction Costs

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Projected Nuclear Power Plant Construction Costs Are Soaring

The construction cost estimates for new nuclear power plants are very uncertain and have increased significantly in recent years. Companies that are planning new nuclear units are currently indicating that the total costs (including escalation and financing costs) will be in the range of $5,500/kW to $8,100/kW or between $6 billion and $9 billion for each 1,100 MW plant.

These new cost estimates are far higher than the industry had previously predicted. For example, as recently as the years 2000-2002, the industry and Department of Energy were talking about overnight costs of $1,200/kW to $1,500/kW for new nuclear units.[1] This range of estimated overnight costs suggested total plant costs of between $2 and $4 billion per new nuclear unit. The MIT *Future of Nuclear* Study in 2003, increased the estimated prices of new nuclear plants to $2,000/kW, not including financing costs.

However, the estimated costs for new nuclear power plants begin to increase significantly starting in about 2006-2007. For example:

- A June 2007 report by the Keystone Center estimated an overnight cost of $2,950/kW for a new nuclear plant. With interest, this figure translated to between $3,600/kW and $4,000/kW.[2]
- In October 2007, Moody's Investor Services estimated a range of between $5,000/kW and $6,000/kW for the total cost of new nuclear units (including escalation and financing costs) but acknowledged that this cost estimate was "only marginally better than a guess."[3]

Also in October 2007, Florida Power & Light ("FPL") announced a range of overnight costs (i.e., no escalation or financing costs) for its two proposed nuclear power plants (total of 2200MW) as being between $3,108/kW and $4,540/kW. FPL also estimated the total cost of the project (including escalation and financing costs) as being between $5,492/kW and $8,081/kW. These estimated costs translated into a projected total cost of $12.1 billion to $17.8 billion, for just two 1100 MW plants.[4]

Other recently announced nuclear power plant costs estimates are in the same range as Florida Power & Light. For example, Progress Energy has projected a cost of about $10.5 billion for two new nuclear units with financing costs bringing the total up to about $13-14 billion.[5] However, Progress Energy has not yet released any of the details underlying this cost estimate.[6]

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[1] An overnight cost estimate is what the plant would cost if it could be built "overnight." Overnight cost estimates are regularly used in the industry. They do not include escalation or financing costs.

[2] *Nuclear Power Joint Fact-Finding*, The Keystone Center, June 2007.

[3] *New Nuclear Generation in the United States*, Moody's Investor Services, October 2007, at page 11.

[4] Direct Testimony and Exhibits of Steven D. Scroggs on behalf of Florida Power & Light in Docket No. 07-0650, dated October 2007.

[5] "Power Market Developments – the American Way," *Nuclear Engineering International*, June 18, 2008, at page 24.

[6] "Progress Energy plans to file its estimate for two new reactors with Florida regulators," *Charlotte News & Observer*, March 11, 2008.

Georgia Power also has estimated that the cost of its 45% share of the two proposed Vogtle nuclear plants would be $6.4 billion which is about the same as Progress Energy's estimate for the cost of its two new nuclear units.[7]

These recent nuclear construction costs estimates are summarized in the following table:

Forecast	Overnight Cost	Total Plant Cost	Total Plant Cost - 2 Units
	($/kW)	($/kW)	(billions$)
DOE (2002)	$1,200		
	$1,500		
MIT (2003)	$2,000		
Keystone Center (2007)	$2,950	$3,600	
	$2,950	$4,000	
Moody's Investor Services (2007)		$4,000	
		$6,000	
Florida Power & Light (2007)	$3,108	$5,492	$12.1
	$4,540	$8,081	$17.8
Progress Energy (2008)			$14.0
Georgia Power (2008)			$6.4 for 45% of 2 plants

SCE&G has similarly estimated that the cost of building two new nuclear units at an existing power plant site in South Carolina would be $9.8 billion, exclusive of financing costs and the costs of related transmission facilities.[8]

Indeed, some companies, including Duke Energy, have refused to make public the estimated costs of their proposed nuclear power plants.

One company, MidAmerican Energy Holdings, announced at the end of 2007 that it had cancelled a proposed nuclear power plant because no longer made economic sense for its ratepayers.

Projected Nuclear Power Plant Construction Costs Are Very Preliminary and Very Uncertain

It is generally accepted that nuclear power plant construction cost estimates are very uncertain. For example, Lew Hay, Chairman and CEO of Florida Power & Light has told a meeting of the World Association of Nuclear Operators that "although suppliers keep quoting overnight costs of $2500 to $3500 per kilowatt, I believe the all-in costs are likely to be much higher – possibly twice as much once you factor in owners' costs such as land,

7 "New Wave of Nuclear Plants Faces High Costs," *Wall Street Journal*, May 12, 2008, page B1.

8 "Power Market Developments – the American Way," *Nuclear Engineering International*, June 18, 2008, at page 24.

cooling towers, switchyard, etc., interest during construction and cost escalation due to inflation and cost overruns. And of course we have to have a contingency as well."[9]

Moody's Investor Services also has specifically warned about the short-comings of nuclear power plant cost estimates: "All-in fact-based assessments require some basis for an overnight capital cost estimate, and the shortcomings of simply asserting that capital costs could be "significantly higher than $3,500/kw" should be support by some analysis. That said, Moody's can not confirm (and all of our research supports our conclusion) definitive estimates for new nuclear costs at this time. Moody's can assert with confidence that there is considerable uncertainty with respect to the capital cost of new nuclear and coal-fired generating technologies…"[10]

Moody's further noted that "Throughout our due diligence process, Moody's has not been able to make a finite determination of the range for the all-in cost associated with new nuclear. As a result, we believe the ultimate costs associated with building new nuclear generation do not exist today – and that the current cost estimates represent best estimates, which are subject to change."[11]

A recent article in *Public Utilities Fortnightly* has emphasized the very preliminary and highly uncertain nature of current nuclear plant cost estimates:

> Ground hasn't been broken for a new nuclear power plant in the U.S. for more than 30 years, but today more than 20 companies have announced plans to build new nuclear plants, both regulated and unregulated … The ultimate question is how many actually will be built? Detailed engineering is well less than 50 percent complete for most U.S. conforming designs, with some entrants less than 20 percent complete. Millions of engineering man-hours are required before cost estimates become reliable enough to allow original equipment manufacturer (OEM) and engineering, procurement and construction (EPC) contract-cost negotiations to fully define cost and performance risk parameters across all parties.
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> While simplified nuclear steam supply system (NSSS) designs and innovations in modular construction suggest the potential to build plants more economically, a confluence of largely uncontrollable forces are pushing preliminary factor cost estimates upward. These include commodity price escalation, engineering, and craft labor shortages and manufacturing and shipping constraints. Combined with uncertainties about executing engineering and construction, overnight cost estimates (that exclude the costs of escalation and financing) for proposed plants are increasing and the range of estimates is wide – between $3,000 a kilowatt and

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9 "How much, for some utilities, the capital costs of a new nuclear power plant are prohibitive," *Nuclear Engineering International*, November 2007, at page 27.

10 *New Nuclear Generation in the United States*, Moody's Investor Services, October 2007, at page 8.

11 Id, at page 10.

$4,500/kW, depending on the dollar date. Cost variability, and consequently financing uncertainty, threatens the overall economic attractiveness of nuclear development.[12]

Most of The Designs Being Proposed for New U.S. Nuclear Power Plants Have Not Been Built or Operated Anywhere in the World

The nuclear industry is considering building four new reactor designs in the United States:

- the Advanced Boiling Water Reactor (ABWR)
- the Evolutionary Pressurized Water Reactor (EPR)
- the Westinghouse AP 1000
- The General Electric Extra Simplified Boiling Water Reactor (ESBWR)

The Nuclear Regulatory Commission has pre-approved the design for the ABWR and AP1000. Applications for pre-approval of the other designs are currently being reviewed by the Nuclear Regulatory Commission.[13]

However, there is absolutely no construction or operating experience in the U.S. or anywhere in the world with the AP1000 and ESBWR designs.

And there is only limited construction experienced with a third design, the EPR. One plant with an EPR design is under construction in Finland, Olkiluoto 3. Construction of this plant is currently several years behind schedule and the currently estimated cost of the plant has increased by between 33% and 50% or about $2 billion. Construction of a second EPR has just begun in France. According to Business Week, that project was temporarily halted in May, 2008 due to quality concerns.

Four ABWRs have been built in Japan and two more are under construction in Taiwan. However, the two ABWRs in Taiwan are now five years behind schedule. Their estimated cost has grown from $3.7 billion to between $7.4 and $9.1 billion.

Given this relatively limited amount of experience, it is reasonable to expect that currently unanticipated problems may be encountered during the construction and operation of nuclear plants with new designs that will affect the costs of building and/or the operating costs or performance of plants with the same or similar designs.

The Reasons for the Dramatic Increases in the Estimated Costs of New Nuclear Power Plants

The increased estimated costs for today's new generation of nuclear plants are due, in large part, to a fierce worldwide competition for the resources, commodities and manufacturing capacity needed in the design and construction of new power plants. This competition has led to double-digit annual increases in the costs of key power plant commodities such as steel, copper, concrete, etc.

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12 "Navigating Nuclear Risks: New Approaches to Contracting in a Post-Turnkey World," *Public Utilities Fortnightly,* July, 2008, at page 39.

13 "AREVA files application with NRC for certification of US-EPR design," *Nucleonics Week*, December 13, 2007, at page 5.

The worldwide demand also is straining the limited capacity of EPC (Engineering, Procurement, and Construction) firms and equipment manufacturers. The limited number of manufacturers and suppliers could cause bottlenecks in construction if, as expected, there are multiple orders for new power plants in the U.S. and abroad.

For example, there are only two companies that have the heavy forging capacity to create the largest equipment/components in new nuclear plants – Japan Steel Works and Creusot Forge in France.[14] The demand for heavy forgings will be significant because the nuclear industry will be waiting in line alongside the petrochemical industry and new refineries for the material.[15]

At the same time, two decades ago there were about 400 suppliers of nuclear plant components and 900 so-called nuclear stamp, or N-stamp, certifications from the American Society of Mechanical Engineers. Today there are fewer than 80 suppliers in the U.S. and fewer than 200 N-stamp certifications.[16] Indeed, the chairman of the Nuclear Regulatory Commission has said publicly (in early 2007) that it appears now there will be a great reliance on overseas companies to manufacture plant systems and components.[17] He said that the NRC would need to inspect the quality of the manufacturing programs in foreign firms to ensure substandard materials or equipment don't end up installed in plants. He also cautioned that it would take more time to inspect foreign-made components than it would to check quality control of U.S.-manufactured components. The heavy reliance on overseas suppliers also will lead to cost increases due to the continuing weakness of the U.S. dollar relative to other currencies.

The worldwide competition for power plant design and construction resources, equipment and commodities means fewer bidders for work, higher prices, earlier payment schedules and longer delivery times. Long lead times (six years or so) are expected for key plant components. The demand and cost for both on-site construction labor and skilled manufacturing labor also have escalated.

Moody's has summarized the increased risks associated with the international competition for power plant resources as follows:

> Dramatic increases in commodity prices over the recent past, exacerbated by a skilled labor shortage, have led to significant increases in the over-all cost estimates for major construction projects around the world. In the case of new nuclear, the very detailed specifications for forgings and other critical components for the construction process can add a new element of complexity and uncertainty. As noted previously, labor is in short supply and commodity costs have been extremely volatile. Most importantly, the commodities and world wide supply network associated with new nuclear projects are also being called upon to build other

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14 "Supply chain could slow the path to construction, officials say," *Nucleonics Week*. February 15, 2007, at page 13.

15 Id.

16 Id.

17 Id.

> generation facilities, including coal as well as nuclear, nationally and internationally. Nuclear operators are also competing with major oil, petrochemical and steel companies for access to these resources, and thus represent a challenge to all major construction projects."[18]

There is no reason to expect that the worldwide competition for design and construction resources or the existing supply constraints and bottlenecks that have affected nuclear power plant cost estimates in recent years will clear anytime in the foreseeable future. For example, recent experience has shown that the costs of new coal-fired power plants have increased significantly when the owners have actually gone out for bids for plant equipment and for plant design and construction contracts.

At the same time, construction firms are unwilling to commit to fixed price contracts with fixed schedules. They want recovery of actual costs, including overruns, and a fair return. This means that the risks of cost overruns will be borne by the owners of the plants and their customers.

It is Reasonable to Expect That The Costs of Building New Nuclear Power Plants Will Be Even Higher Than The Industry Is Now Projecting

Until the 1970s, building new nuclear power plants appeared to be a relatively low risk investment because construction and operating costs were relatively stable and easy to predict. However, starting in the 1970s, the costs of building new nuclear power plants began to spiral out of control. As a result, the actual costs of new plants were two to three times higher than the costs that had been estimated during licensing or at the start of construction.

As a result, the nuclear industry has a very poor track record in predicting plant construction costs and avoiding cost overruns. Indeed, as shown by data in a study by the Department of Energy, the actual costs of 75 of the existing nuclear power plants in the U.S. exceeded the initially estimated costs of these units by over 200 percent. The following table shows the overruns experienced by these 75 nuclear plants by the year in which construction of the nuclear power plant began.[19]

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18 *New Nuclear Generation in the United States*, Moody's Investor Services, October 2007, at page 9.

19 This table was taken from the May 2008 report by the Congressional Budget Office, *Nuclear Power's Role in Generating Electricity,* at page 17.

Projected and Actual Construction Costs for Nuclear Power Plants

Construction Starts		Average Overnight Costs[a]		
Year Initiated	Number of Plants[b]	Utilities' Projections (Thousands of dollars per MW)	Actual (Thousands of dollars per MW)	Overrun (Percent)
1966 to 1967	11	612	1,279	109
1968 to 1969	26	741	2,180	194
1970 to 1971	12	829	2889	248
1972 to 1973	7	1,220	3,882	218
1974 to 1975	14	1,263	4,817	281
1976 to 1977	5	1,630	4,377	169
Overall Average	**13**	**938**	**2,959**	**207**

Source: Congressional Budget Office (CBO) based on data from Energy Information Administration, An Analysis of Nuclear Power Plant Construction Costs, Technical Report DOE/EIA-0485 (January 1, 1986).

Notes: Electricity-generating capacity is measured in megawatts (MW); the electrical power generated by that capacity is measured in megawatt hours (MWh). During a full hour of operation, 1 MW of capacity produces 1 MWh of electricity, which can power roughly 800 average households.
The data underlying CBO's analysis include only plants on which construction was begun after 1965 and completed by 1986.
Data are expressed in 1982 dollars and adjusted to 2006 dollars using the Bureau of Economic Analysis's price index for private fixed investment in electricity-generating structures. Averages are weighted by the number of plants.

a. Overnight construction costs do not include financing charges.
b. In this study, a nuclear power plant is defined as having one reactor. (For example, if a utility built two reactors at the same site, that configuration would be considered two additional power plants.)

Thus, the **average cost overrun** for these 75 nuclear units was **207** percent. In other words, the actual average cost of the plants was about triple their estimated costs.

In fact, the data in the previous table understates the cost overruns experienced by the U.S. nuclear industry because (1) the cost figures do not reflect escalation and financing costs and (2) the database does not include some of the most expensive nuclear power plants built in the U.S. – e.g., Comanche Peak, South Texas, Seabrook, and Vogtle. For example, the cost of the two unit Vogtle plant in Georgia increased from $660 million to $8.7 billion in nominal dollars – a 1,200 percent overrun.

There were a number of significant consequences as a result of these cost overruns. First, only one-half of the nuclear power plants that were proposed were actually built and ratepayers frequently had to bear many millions of dollars of sunk costs for abandoned projects. Second, the cost of power from completed nuclear power plants became much more expensive for ratepayers than the proponents had claimed. In some instances this led to rate increases so large that they spawned the term "rate shock.".

Rising construction costs also led to severe financial problems for many of the utilities that were building the nuclear power plants. For example, one company, Public Service Company of New Hampshire, went bankrupt due to financing difficulties associated with the Seabrook nuclear plant. Several other companies nearly went bankrupt due to financial difficulties from their nuclear power plant construction projects. In addition, the Washington Public Power System defaulted on $2.25 billion in municipal bonds in 1983 after it had failed to complete construction of two nuclear power plants.

Rising nuclear power plant costs also led to more than ten billion dollars of write-offs and cost disallowance from utility rate bases. Finally, when many expensive nuclear power

plants were sold or divested to affiliates during restructuring efforts in some states, ratepayers were left paying hundreds of millions of "stranded" plant costs.

Given the industry's poor track record in estimating plant costs and the substantial uncertainties associated with building new nuclear power plants (as I have discussed above), it is reasonable to expect that the actual costs of new plants will be much higher than the industry now claims. At the same time, it does appear that the nuclear industry has learned some important lessons from the problems experienced during the building and operation of the existing generation of nuclear power plants and, therefore, can be expected to avoid some of those problems.

But even just a 100 percent cost increase (i.e., a doubling of cost) would mean that a new nuclear power plant would be extremely expensive, perhaps costing as much as $15 billion and $20 billion, or more, for just one unit. Such an increase of only 100 percent would be substantially below the 200 percent to 300 percent overruns that the industry experienced in building the nation's existing nuclear power plants.

The Commitment of the Nuclear Industry to Build New Power Plants is Very Heavily Dependent on Obtaining Federal Subsidies

The nuclear industry has acknowledged that its claimed nuclear renaissance is heavily dependent on obtaining federal loan guarantees from would shift the risks of rising plant costs from plant owners onto the federal government. For example, David W. Crane, the CEO of NRG has been quoted by Business Week as saying that "Without the loan guarantees, I think it would be very difficult for the first wave of plants to move forward."[20]

Approximately 20 proposals for new power plants are being advanced by companies seeking to gain the federal incentives and loan guarantees contained in the Energy and Policy Act of 2005. However, it is very uncertain what incentives and/or federal loan guarantees any single builder of a new nuclear power plant actually will receive because these incentives and loan guarantees are limited.

For example, Congress has so far set a limit of $18.5 billion on the loan guarantees for new nuclear plants. With estimated costs of $7 to $9 billion per unit, this $18.5 billion will not stretch very far to guarantee the loans that companies say they need to pursue new plants. Thus, any single applicant can expect to receive a guarantee for only a fraction of its cost of building a new nuclear plant – not the 80 percent of the total project costs allowed by EPACT 2005. Wallace. With the currently estimated construction costs, this would remain true even if Congress were to raise the level of loan guarantees to $50 billion or more.

[20] *Nuclear's Tangled Economics,* Business Week, June 26, 2008.