# POLICY CHALLENGES OF NUCLEAR REACTOR CONSTRUCTION: COST ESCALATION AND CROWDING OUT ALTERNATIVES

## LESSONS FROM THE U.S. AND FRANCE FOR THE EFFORT TO REVIVE THE U.S. INDUSTRY WITH LOAN GUARANTEES AND TAX SUBSIDIES

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## EXECUTIVE SUMMARY

### RESEARCH ISSUES AND APPROACH

Debate over the cost of building new nuclear reactors in the U.S. and abroad has returned to center stage in U.S. energy policy, as the effort to expand loans guarantees heats up in the wake of the failure to move climate change legislation forward. The French nuclear program is frequently given the spotlight because of its presumed success and because the state-owned French nuclear champion EDF has bought a large stake in a major U.S. utility and is seeking to build a new U.S. reactor with federal loan guarantees.

Missing from the current scene is information about the history and recent experience of French nuclear costs, detailed analyses of past U.S. costs or current cost projections, and a careful examination of the impact of the decision to promote nuclear reactor and central station construction on the development of alternatives.

This paper fills those gaps by analyzing these two major challenges of nuclear reactor construction -- cost escalation and crowding out alternatives -- with new data in multiple analytic approaches.

| **Type of Analysis** | **Data:** | |
|---|---|---|
| | **Cost Escalation** | **Crowding Out Alternatives** |
| Cross national comparisons | U.S. and France | Western European nations (& U.S.) |
| Qualitative Examination | U.S. & French history | Individual U.S. utility examples |
| Statistical analysis | Econometric production function | Correlation analysis of 10 variables |

### FINDINGS: COST ESCALATION

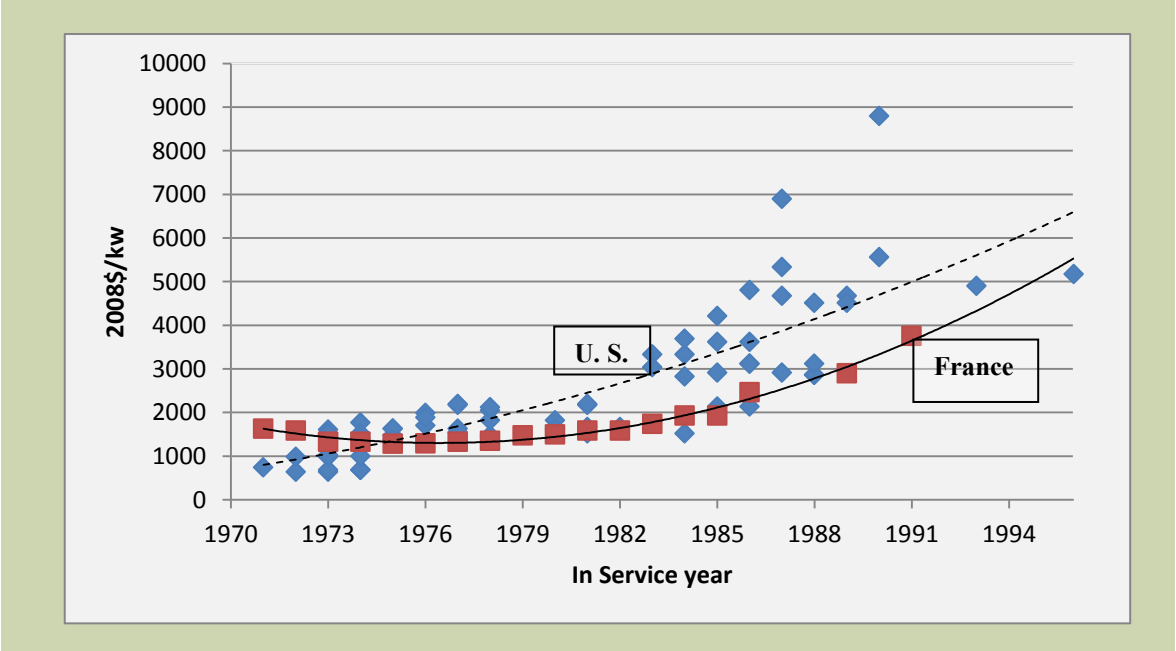
The report finds that the claim that standardization, learning, or large increases in the number of reactors under construction will lower costs is not supported in the data.

- The increasing complexity of nuclear reactors and the site-specific nature of deployment make standardization difficult, so cost reductions have not been achieved and are not likely in the future. More recent, more complex technologies are more costly to construct.
- Building larger reactors to achieve economies of scale causes construction times to increase, offsetting the cost savings of larger reactors.

Comparing Pressurized Water Reactors, which are the main technologies used in both nations, we find that both the U.S. and French nuclear industries experienced severe cost escalation (see Exhibit ES-1).

- Measured in 2008 dollars, U.S. and French overnight costs were similar in the early 1970s, about $1,000 per kW. In the U.S. they escalated to the range of $3,000 to $4,000 by the mid-1980s. The final reactors were generally in the $5,000 to $6,000 range.
- French costs increased to the range of $2,000-$3,000 in the mid-1980s and $3,000 to $5,000 in the 1990s.

**EXHIBIT ES-1: OVERNIGHT COSTS OF PRESSURIZED WATER REACTORS (2008$)**




**Source: Cooper, 2009a, database, updated; Grubler, 209.**

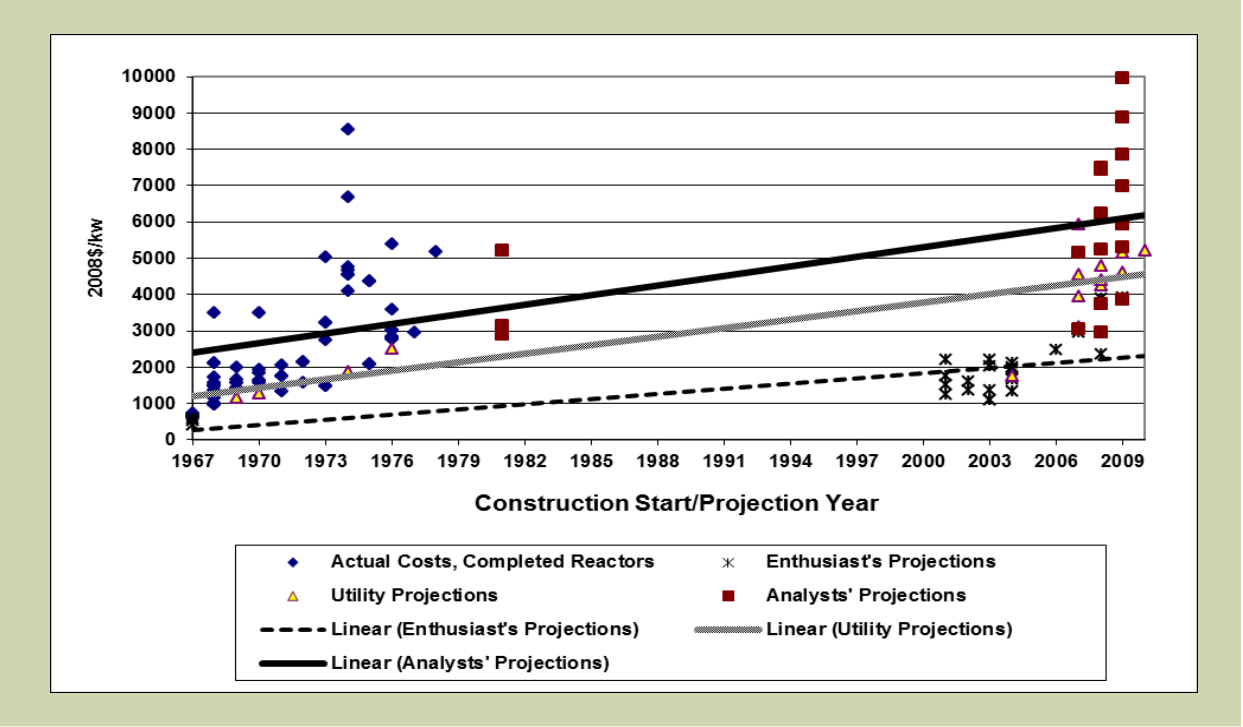
Cost projections in both nations have proven to be unreliable, particularly so in the U.S., where vendors compete to convince utilities to buy their designs. In France, the state-owned construction company builds reactors for the state-owned utility. In the U.S., as shown in Exhibit ES-2, cost projections by vendors have been lower than those of utilities, which have been lower than projections from independent analysts. In the past, the analysts' projections have been closer to the actual costs.

## FINDINGS: CROWDING OUT ALTERNATIVES

The commitment to nuclear reactors in France and the U.S appears to have crowded out alternatives. The French track record on efficiency and renewables is extremely poor compared to similar European nations, as is that of the U.S.

States where utilities have not expressed an interest in getting licenses for new nuclear

**EXHIBIT ES-2: INITIAL COST PROJECTIONS VASTLY UNDERESTIMATE ACTUAL COSTS**




**Source: Cooper, 2009, database.**

reactors have a better track record on efficiency and renewable and more aggressive plans for future development of efficiency and renewables, as shown in Exhibit ES-3. These states:

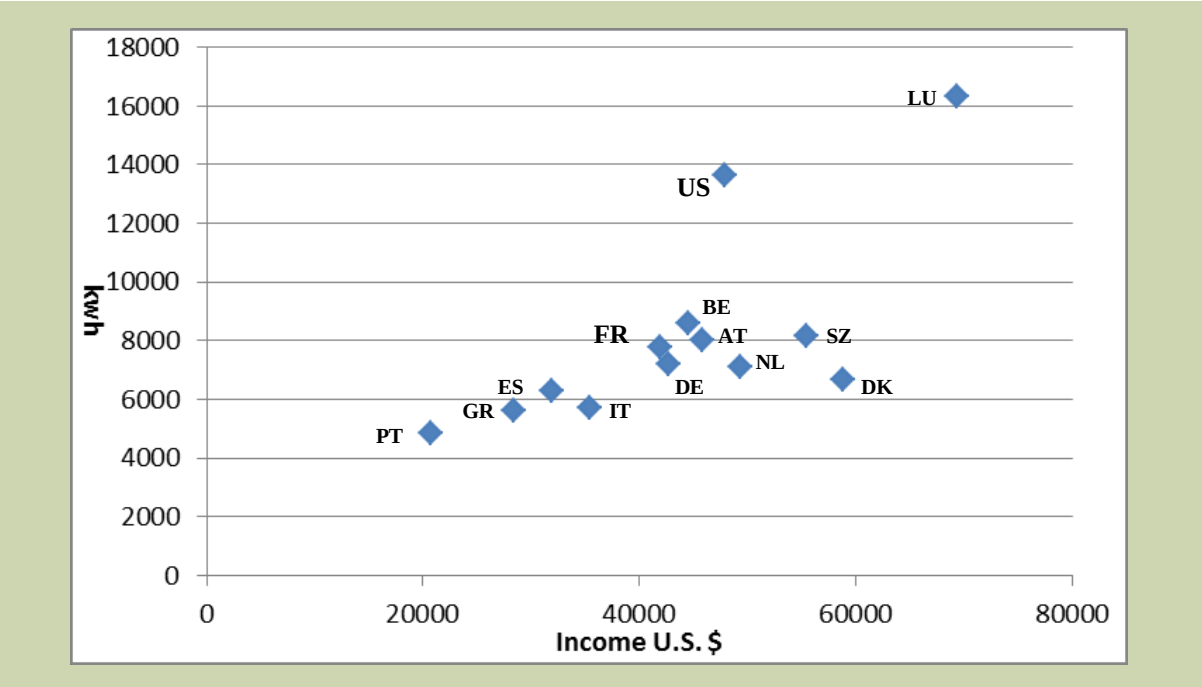
- had three times as much renewable energy and ten times as much non-hydro renewable energy in their 1990 generation mix and
- set RPS goals for the next decade that are 50 percent higher;
- spent three times as much on efficiency in 2006;
- saved over three times as much energy in the 1992-2006 period, and
- have much stronger utility efficiency programs in place.

The cost and availability of alternatives play equally important roles. In both nations, nuclear reactors are substantially more costly than the alternatives. The U.S. appears to have a much greater opportunity to develop alternatives not only because the cost disadvantage of

## EXHIBIT ES-3: TESTING THE CROWDING OUT HYPOTHESIS IN THE U.S.

| Category Means | Renewable % of 1990 Generation | Non-hydro Renewables as % of 1990 Generation | RPS Goal (%) 2010 | Efficiency Spend as % of 2006 Revenue' | Energy Saved % of total Energy | ACEEE Utility Efficiency Program Score 92 – '06 |
|---|---|---|---|---|---|---|
| **Central Station Plans 2009** | | | | | | |
| None | 19.23 | 0.61 | 16.22 | 0.95 | 2.78 | 9.08 |
| Nuke or Coal | 7.48 | 0.02 | 11.26 | 0.46 | 1.13 | 5.21 |
| Nuke & Coal | 4.04 | 0.0 | 7.36 | 0.29 | 0.60 | 1.79 |
| **Nuke License: State** | | | | | | |
| None | 15.09 | 0.40 | 14.33 | 0.82 | 2.29 | 7.72 |
| Pending | 6.66 | 0.03 | 9.58 | 0.25 | 0.58 | 3.38 |
| **Nuke License Utility** | | | | | | |
| None | | | | 0.47 | 2.42 | |
| Pending | | | | 0.06 | 0.94 | |
| **Correlation (Significance)** | | | | | | |
| Central station as % of Total 1990 Generation | -.50 (.002) | -..06 (.696) | -.10 (.477) | -.28 (.012) | -.37 (.0070 | -.27 (.052) |
| Central Station Plans | -.29 (.039) | -.19 (.178) | -.29 (.037) | -.34 (.016) | -.39 (.051) | -.42 (.002) |
| Nuclear License Pending State Utility | -.18 (.039) | -.10 (.491) | -.20 (.166) | -.30 (.033) | -.33 (.017) | -.34 (.009) |
| | | | | -.20 (.046) | -.13 (.186) | |

## EXHIBIT ES-4: ANNUAL ELECTRICITY CONSUMPTION IN WESTERN EUROPE AND THE U.S.




**Sources and notes: World Bank per capita electricity consumption and Gross National Income.**
**http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC**
**http://data.worldbank.org/indicator/NY.GNP.PCAP.CD**

nuclear in the U.S. is greater, but also because the portfolio of potential resources is much greater in the U.S. The U.S. consumes about 50 percent more electricity per dollar of gross domestic product per capita than France, which have the highest electricity consumption among comparable Western European nations (see Exhibit ES-4).

- The U.S. has renewable opportunities that are four times as great as Europe.
- Design problems and deteriorating economic prospects have resulted in a series of setbacks for nuclear construction plans and several utilities with large nuclear generation assets who had contemplated building new reactors have shelved those plans because of the deteriorating economics of nuclear power relative to the alternatives.

## POLICY IMPLICATIONS

The two challenges of nuclear reactor construction studied in this paper are linked in a number of ways. Nuclear reactors are extremely large projects that tie up managerial and financial resources and are affected by cost escalation, which demands even greater attention. The reaction to cost escalation has been to pursue larger runs of larger plants in the hope that learning and economies of scale would lower costs. In this environment, alternatives are not only neglected, they become a threat because they may reduce the need for the larger central station units.

The policy implications of the paper are both narrow and broad.

Narrowly, the paper shows that following the French model would be a mistake since the French nuclear reactor program is far less of a success than is assumed, takes an organizational approach that is alien to the U.S., and reflects a very different endowment of resources.

Broadly the paper shows that it is highly unlikely that the problems of the nuclear industry will be solved by an infusion of federal loans guarantees and other subsidies to get the first plants in a new building cycle completed. If the industry is relaunched with massive subsidies, this analysis shows the greatest danger is not that the U.S. will import French technology, but that it will replicate the French model of nuclear socialism, since it is very likely that nuclear power will remain a ward of the state, as has been true throughout its history in France, a great burden on ratepayers, as has been the case throughout its history in the U.S., and it will retard the development of lower cost alternatives, as it has done in both the U.S. and France.