

Small modular reactors in Puerto Rico? Caveat Emptor

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A little background on nuclear in the US

- ▶ About 120 nuclear power reactors were built in the United States until the 1990s. The only reactors to have been commissioned since then, Watts Bar 2 in Tennessee, in 2015, started construction in 1973. No post three Mile Island reactors have been completed and commissioned.
- ▶ About 100 reactors were ordered and then cancelled in this first wave of nuclear orders.
- ▶ The financial losses were so huge that Forbes magazine stated on its February 11, 1985 cover: “The failure of the nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale....[O]nly the blind, or the biased, can now think that most of the money [invested in nuclear power] has been well spent.”
- ▶ In the mid-2000’s a “nuclear renaissance” was announced with great fanfare. More than 30 applications for new reactors were made with the NRC.

What happened on the way to the nuclear “renaissance”?

- ▶ Construction was actually begun on only four new reactors - two in South Carolina (Summer Units 2 and 3) and two in Georgia (Vogtle Units 3 and 4) - all of the Westinghouse AP1000 design. Ratepayers were forced by state law in both states to pay for the much of the cost of the reactors in advance whether they were completed or not.
- ▶ The Summer reactors were abruptly cancelled in 2018 after Westinghouse declared bankruptcy, and large cost overruns and delays. Originally supposed to cost under \$10 billion to completion, the project was less than 40% complete after spending about \$9 billion.
- ▶ Vogtle 3 and 4 construction continues but the issues are the same - multi-year delays and costs skyrocketing from an estimated \$14.3 billion to around \$27 billion. Household electricity bills have averaged about \$100 per year more to pay for this construction.
- ▶ This has been a managerial disaster in South Carolina and Georgia. The only reason there wasn't a second national nuclear managerial disaster is that all the other announced new “renaissance” reactors were suspended or cancelled.
- ▶ Perhaps the best testimony to the collapse of the “nuclear renaissance” is the statement of William Von Hoene, VP for strategy of Exelon, which owns more US nuclear plants than any other company: "I don't think we're building any more nuclear plants in the United States. I don't think it's ever going to happen."

SMRs - the new nuclear hope?

- ▶ Enthusiasm for Small Modular Reactors rose as the problems, costs, and delays of “renaissance” reactors - all large -- mounted.
- ▶ In going from 1,000 MW+ reactors to less than 300 MW, and as small as a few tens of megawatts, significant economies of scale are abandoned. Reactor power increases with reactor vessel volume; materials, welds, etc., increase with surface area. All else being equal, small reactors would cost more per kilowatt than larger ones.
- ▶ The theory of SMR cost is: Assembly-line production of “small” transportable reactors would make the parts cheaper, enable quick onsite construction and reduce risks and delays, and make up for loss of economies of scale.
- ▶ This theorizing is based more on wishful thinking than solid facts and does not take into account the risks of mass manufacturing.

Some relevant SMR facts

- ▶ No SMRs have been certified by the US Nuclear Regulatory Commission (NRC). One reactor, NuScale, is in the certification process. Paperwork is due to be completed in 2020. No date for certification has been estimated.
- ▶ It is highly unlikely that any other reactor approach, such as a gas-cooled reactor or a liquid fuel reactor, can be certified in less than ten years in the United States. The NRC would likely take a decade to even write rules for such designs.
- ▶ No SMRs have been built in the US.
- ▶ There is no mass manufacturing supply chain and no assembly line. The scale required would be the same order of magnitude as a Boeing Dreamliner or Airbus 350 supply chain and assembly line.
- ▶ There is a circular reasoning problem with the economics: no supply chain and assembly line to demonstrate the economics can be built without scores or hundreds of orders; but orders on that scale will not materialize until the economics can be demonstrated.

Cost estimates

- ▶ Estimates that SMRs will produce electricity at a reasonable cost are speculative, even fanciful.
- ▶ The comprehensive 2016 report by Parsons-Brinkerhoff, done for the Nuclear Fuel Cycle Royal Commission (South Australia), estimated SMR electricity at US\$140 per MWh (2 reactors, 180 MWe each) for larger SMRs and US\$159/MWh for smaller reactors (6 reactors of 47.5 MWe each) - more costly than conventional reactors, which are more costly than solar or wind or combined cycle natural gas.
- ▶ Or consider the assessment of Von Hoene of Exelon: "Right now, the costs on the SMRs, in part because of the size and in part because of the security that's associated with any nuclear plant, are prohibitive. It's possible that that would evolve over time, and we're involved in looking at that technology. Right now they're prohibitively expensive."
- ▶ The Wall Street firm Lazard estimates that conventional nuclear, which is likely less expensive than SMRs, is far more costly than utility scale solar and wind.
- ▶ Of the assessment of the engineer in charge of the TVA SMR project: "So the concept is that you got to have an assembly line cranking out repeatable parts...[But] I don't want to pay for B&W's factory with automation to crank out repeatable parts. So that creates a contracting challenge... So as you scratch your head and puzzle how does this work, *remember the math won't work on one unit.*" (as quoted in Makhijani 2013, p. 5)
- ▶ If the cost escalations and delays that have been typical of the nuclear industry are factored in, SMRs are not only a gamble at this point; they are a bad bet.

What to do if there are recalls?

- ▶ Consider one common feature of mass manufacturing, recalls; it is a feature of everything from hamburgers to Fords and Toyotas to Boeing Dreamliners.
- ▶ What happens if a common flaw is discovered in mass manufactured SMRs. Would they be shipped back with all their radioactivity? Fixed on site? Abandoned?
- ▶ We already know one major vulnerability of Integral Pressurized Water Reactors (iPWRs) like NuScale or mPower: their steam generators are on the inside, unlike present commercial PWRs in operation.
- ▶ Steam generators are the most common major element of commercial PWRs that had to be replaced before initial license period expiry. External steam generators are far less difficult to replace than would be the case with steam generators inside the reactor vessel. The latter will be much more radioactive and very difficult or impossible to access.
- ▶ How would recalls affect reliability? Consider the current global crisis around a new model one of the best established commercial jet aircraft - the Boeing 737 Max 8. Would all reactors be shut?
- ▶ The issue of recalls has not been addressed seriously at all even though it is continuing problem with well-established industries that do not have to deal with radioactive environments.

Suggestions for Puerto Ricans

- ▶ A feasibility study for Puerto Rico is highly premature. There is little or no empirical or experience basis to estimate cost or reliability of mass manufactured reactors.
- ▶ The indications are that SMRs will be more costly. A decision by Puerto Rico to proceed with SMRs would be highly risky, especially given the already difficult situation with electricity. If Exelon is not ready to go for SMRs, why is Puerto Rico considering them?
- ▶ Puerto Rico with nuclear should evaluate the experience as bad or worse experience than South Carolinians or Georgians as part of any nuclear feasibility study.
- ▶ Let the technology be certified and demonstrated elsewhere, like the mainland United States before considering feasibility. If a feasibility study is done in the near future, SMR nuclear industry advocates should pay for it.
- ▶ Any study should cite independent cost estimates and make comparisons with solar and wind costs, including storage.
- ▶ Reliability of an SMR project in the PR grid should be compared with solar microgrids with storage for instance.
- ▶ Puerto Rico's situation is not very different from Hawaii which aims for 100% renewable electricity by 2045. Such a course should also be evaluated for Puerto Rico.

Questions?