Nukes – Part 4

By John Benson

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1. Introduction

In the prior Nukes Papers, I indicated that (1) Gen 3 Nukes could not compete with other renewable generation technologies, (2) Small Modular Reactors (SMR) appeared to have the ability to compete with these where they were required (verses Wind, Photovoltaic (PV), geothermal plus battery energy storage and existing hydro / pumped storage), and (3) there are (at least) three SMR manufacturers that seem to have the ability to achieve economic viability.

The last two Nukes papers are linked and described below.

Nukes, Part 2: Little Nukes: NuScale's Small Modular Reactor Design appears to be viable, and thus this paper on their technology and economics. Posted in January, 2019.

https://www.energycentral.com/c/cp/nukes-part-2-little-nukes

Nukes – Part 3: Recently in a periodic review of SMR technology, I discovered that at least one new player has decided to join the party. This post reviews the new player and any additional potential SMR designs. Posted in February 2020.

https://energycentral.com/c/cp/nukes-%E2%80%93-part-3

In this post we will look at the progress that the three U.S. SMR manufacturers have made, and identify any other potential SMR manufacturers.

2. NuScale

NuScale completed Phase 6 and final phase of the U.S. Nuclear Regulatory Commission's (NRC) 4-year design certification review this month. By year's end the NRC is expected to issue draft "rules" that would essentially approve the design. This last phase is preparation of the Final SER (safety evaluation report).

2.1. Design Issues

Note that I believe the first reference below is not available to the general public. I am an AAAS member and thus can access it. Similar content may be available in other more open sites. Also, I believe I pasted most relevant content below (with slight edits).

In this last phase, *reviewers have unearthed design problems, including one that critics say undermines NuScale's claim that in an emergency, its small modular reactor (SMR) would shut itself down without operator intervention.*[1]

The issues are typical of the snags new reactor designs run into on the road to approval, says Michael Corradini, a nuclear engineer at the University of Wisconsin, Madison. "I don't think these things are show-stoppers." However, M. V. Ramana, a physicist who studies public policy at the University of British Columbia, Vancouver, and has been critical of NuScale, says the problems show the company has oversold the claim that its

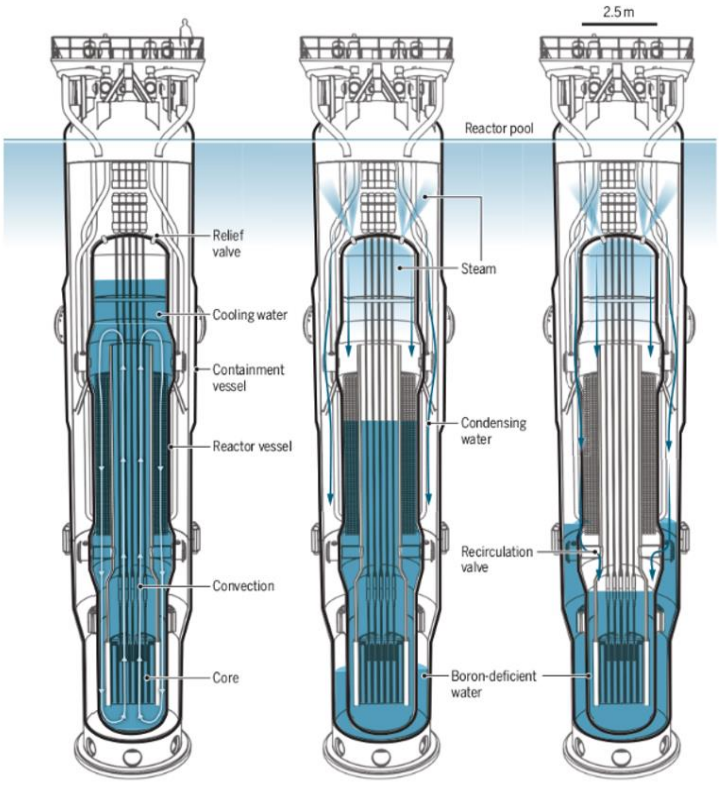
[1] Adrian Cho, Science, "Critics question whether novel reactor is 'walk-away safe'", 21 Aug, 2020, https://science.sciencemag.org/content/369/6506/888.full

SMRs are "walk-away safe." "They have given you the standard by which to evaluate them and they're failing," Ramana says.

The *…safety evaluation report approving the NuScale design, is a major milestone, says José Reyes, NuScale's co-founder and chief technology officer. "This is the document that says, 'This design is safe,'" says Reyes, who hatched the idea for the reactor in 1999. NuScale will resolve the lingering technical issues before anything gets built, he says.*

…A NuScale reactor is also designed to shut itself down in a pinch. Each reactor fits within a steel containment vessel, which in turn sits in a pool of water holding up to a dozen modules. Ordinarily, the space between the reactor and containment vessel remains evacuated, like the vacuum jacket in a thermos bottle. Should the core overheat or the reactor leak, relief valves would vent steam into the evacuated space, where it would conduct heat to the pool and condense into the bottom of the containment vessel. When enough water had accumulated, it would flow back into the reactor to keep the core safely submerged. NuScale is so confident in the design that it has asked NRC to allow its plants to run without the standard 32-kilometer-wide emergency planning zone.

See the figure (from Ref 1) below.



PASSIVE SAFETY? Normally, convection circulates water—laced with boron to tune the nuclear reaction—through the core of NuScale's reactor (left). If the reactor overheats, it shuts down and valves release steam into the containment vessel, where it conducts heat to a surrounding pool and condenses (center). The water flows back into the core, keeping it safely submerged (right). But the condensed water can be low in boron, and reviewers worried it could cause the reactor to spring back to life. GRAPHIC: C. BICKEL/*SCIENCE*

In March, however, a panel of independent experts found a potential flaw in that scheme. To help control the chain reaction, the reactor's cooling water contains boron, which, unlike water, absorbs neutrons. But the steam leaves the boron behind, so the element will be missing from the water condensing in the reactor and containment vessel, NRC's Advisory Committee on Reactor Safeguards (ACRS) noted. When the boron-poor water re-enters the core, it could conceivably revive the chain reaction and possibly melt the core, ACRS concluded in a report on its 5–6 March meeting.

NuScale modified its design to ensure that more boron would spread to the returning water. The small changes eliminated any potential problem, Reyes says. However, at a 21 July meeting, ACRS concluded that operators could still inadvertently drive deborated water into the core when trying to recover from an accident. "I'm not saying that this [scenario] is going to happen," ACRS member Jose March-Leuba said, according to the meeting transcript. "I don't see a calculation that proves it wrong."

Ultimately, whoever applies for a license to build and operate a NuScale plant (possibly) *UAMPS—must devise an operating procedure that ensures such a scenario never occurs. But NuScale should provide guidance, Vesna Dimitrijević, a nuclear engineer and ACRS member, argued at the meeting.*

…ACRS found a few other problems, including one with NuScale's novel steam generator, which sits within the reactor vessel and could be prone to damaging vibrations. Still, on 29 July, ACRS recommended that NRC issue the safety evaluation report and certify NuScale's design. "If there really was a fatal flaw, ACRS would not have published a positive report," Reyes says.

NRC plans to publish its safety evaluation report (this month), *and by year's end it is expected to issue draft "rules" that would essentially approve the design. But that won't end the regulatory odyssey. The current design specifies a reactor output of 50 megawatts of electricity, whereas the UAMPS plan calls for 60 megawatts. The change requires a separate NRC approval, Reyes says, during which NuScale will resolve the outstanding technical issues. That additional 2-year review should start in 2022.*

On Aug 28 the NRC announced that it would approve the SER for NuScale based on the currently evaluated design (50 MW Modules).

2.2. Problems with First Customer

This month, NuScale Power, an Oregon-based nuclear company, learned its first customer needed to push back the timeline for when it plans to operate the first reactor from 2026 to 2029. The entire plant of 12 individual 60-megawatt reactors won't be completed until 2030, a slip from an expected 2027 time frame.[2]

Utah Associated Municipal Power Systems (UAMPS), a group of small, community-owned utilities in six Western states, cited a rise in expected costs for the NuScale reactors. The group is counting on the nuclear power to provide around-the-clock, zero-carbon electricity to replace a coal plant it plans to close, but its members say they won't need the new cleaner electricity source until later than expected.

[2] Josh Siegel, Washington Examiner, "Nuclear advocates fret as first maker of small reactors encounters trouble", Aug 24, 2020, https://www.washingtonexaminer.com/policy/energy/nuclear-advocates-fret-as-first-maker-of-small-reactors-encounters-trouble

"The setbacks are not fatal," said Erik Olson, a climate and energy analyst at the Breakthrough Institute. "But if this project falls through, that would be an enormous blow to the promised next wave of nuclear power."

UAMPS… could still abandon the project altogether. It is planning to convene in mid-September to approve a budget and could decide then to quit. The group says it is in negotiations with the Energy Department for the federal government to provide a $1.4 billion grant, which the utilities say they need to defray the rising cost of buying nuclear power.

LaVarr Webb, UAMPS's spokesman, said the grant is "very important for the success of this project" and suggested the group could pull out if it doesn't get the funding.

At Least one of the UAMPS members has decided to call it quits.

The Lehi City Council voted unanimously Tuesday to withdraw the city from a multiagency nuclear power project that would provide nuclear power to cities across Utah, citing concerns over increasing costs.[3]

The Carbon Free Power Project is an initiative by Oregon-based NuScale Power, the Utah Associated Municipal Power Systems and the United States Department of Energy to build a small modular reactor power plant at the Idaho National Laboratory.

… E*arlier this month, the Utah Taxpayer Association called on cities to withdraw from the project ahead of the Sept. 14 deadline after a closed-door virtual town hall meeting on July 21 where officials warned of project delays, increased costs to cities and towns involved, and "dependence on unpredictable federal subsidies."*

"The UAMPS project will lock in 27 municipalities in Utah and several in surrounding states for a share of billions of dollars in costs and unclear risk in the pursuit of a cluster of small modular reactors (SMRs) touted by Oregon-based NuScale Power, which repeatedly has delayed timelines and increased costs associated with its SMRs," Utah Taxpayer Association Vice President Rusty Cannon said in an Aug. 4 news release. "The risky project with massive cost escalations is being conducted largely out of the public eye."

…The Energy Department is already a collaborative partner on the UAMPS project. The department has invested more than $300 million into NuScale since 2014, spanning the Obama and Trump administrations.

It has signed on to buy power from two of the 12 reactors, which are being built at the Energy Department's Idaho National Laboratory.

Energy Department Deputy Secretary Mark Menezes told the Washington Examiner the agency remains committed to NuScale and is supportive of the partnership with UAMPS, but he could not comment on negotiations over the grant.

[3] By Connor Richards, Daily Herald, "Lehi City Council votes to back out of nuclear power project contract", Aug 26, 2020, https://www.heraldextra.com/news/local/govt-and-politics/lehi-city-council-votes-to-back-out-of-nuclear-power-project-contract/article_0af6e67c-24e5-5427-9029-e52b9f9d63ae.html

NuScale management has indicated that the cancellation of the project by UAMPS would be disappointing, but not fatal. They indicated that there were other potential customers in line behind UAMPS.

I would guess, if UAMPS cancels the project, the project at Idaho National Labs may be scaled down to a two-unit reactor rather than a 12-unit design (the current plan is to commission one unit at a time). It is also possible that another utility (or utilities) will step in to take UAMPS place. There are several large investor-owned utilities in the Northwest, and these may be less risk-averse than UAMPS.

3. GE-Hitachi (GEH)

GE-Hitachi's SMR is the BWRX-300. This is an evolution of the GE BWR design, and this process was described in detail in Nukes – Part 3. The following are steps along the path of implementation that GEH has taken. Note that most of the text below is heavily-edited excerpts from the GEH press releases referenced.

3.1. GE Hitachi Begins NRC Licensing Process

In December of this 2019 GEH submitted the first licensing topical report (LTR) for the BWRX-300 to the U.S. Nuclear Regulatory Commission (NRC). GEH expects this LTR to serve as a foundation for the development of a Preliminary Safety Analysis Report that could potentially be submitted to the NRC by a utility customer.[4]

3.2. GE Hitachi Canadian Nuclear Safety Commission Vendor Design Review

In May of last year GEH initiated a Vendor Design Review of its BWRX-300 small modular reactor with the Canadian Nuclear Safety Commission (CNSC).[5]

The Vendor Design Review is an optional service provided by the CNSC to provide early feedback to the reactor vendor during the design process with the objective of verifying, at a high level, whether a plant design meets Canadian nuclear regulatory requirements and expectations. The combined Phase 1 and 2 review by the CNSC will focus on identifying any issues that could become fundamental barriers in a licensing process for a new build project in Canada while assuring that a resolution path exists for any issues that may be identified.

In February of this year GEH made the first submittal to CNSC.[6]

3.3. DOE Awards Two Projects Utilizing the BWRX-300

The U.S. Department of Energy (DOE) announced awards to two teams of industry experts to develop tools to transform the operations and maintenance of advanced

[4] GE Hitachi Press Release, "GE Hitachi Nuclear Energy Begins NRC Licensing Process for BWRX-300 Small Modular Reactor", Jan 30, 2020, https://www.ge.com/news/press-releases/ge-hitachi-nuclear-energy-begins-nrc-licensing-process-bwrx-300-small-modular

[5] GE Hitachi Press Release, "GE Hitachi Initiates Vendor Design Review of its BWRX-300 Small Modular Reactor with Canadian Nuclear Safety Commission", May 22, 2019, https://www.ge.com/news/press-releases/ge-hitachi-initiates-vendor-design-review-its-bwrx-300-small-modular-reactor

[6] GE Hitachi Press Release, "GE Hitachi Progresses Vendor Design Review in Canada for BWRX-300 Small Modular Reactor", Feb 26, 2020, https://www.ge.com/news/press-releases/ge-hitachi-progresses-vendor-design-review-canada-bwrx-300-small-modular-reactor

nuclear reactors through the use of artificial intelligence-enabled digital twins using the GE Hitachi (GEH) BWRX-300 small modular reactor as a reference design.[7]

The two teams will be led by GE Research and MIT. These teams have been awarded grants through the DOE's Advanced Research Projects Agency-Energy (ARPA-E) Generating Electricity Managed by Intelligent Nuclear Assets (GEMINA) program.

The GE Research-led team consisting of Exelon Generation, Oak Ridge National Laboratory (ORNL), the University of Tennessee-Knoxville and GEH will build a digital twin of BWRX-300 critical components and utilize artificial intelligence predictive technologies to make risk informed decisions. Exelon, which operates the largest U.S. fleet of nuclear power plants, will provide historical data based on significant experience to inform the model and targets which are aimed at reducing the operating and maintenance costs of advanced reactors.

The MIT-led team consisting of GE Research and GEH will advance and demonstrate new predictive maintenance approaches and model-based fault system detection techniques. The digital twins will address mechanical and thermal fatigue failure modes which drive operations and maintenance activities.

4. Holtec

We reviewed this company's SMR-160 in Nukes – Part 3 (linked in the Introduction), Section 3.1. I continue to be impressed with this design, but the development of their SMR is well behind NuScale and GEH, at least in the U.S.

The only recent news follows:[8]

- Holtec's SMR successfully completed Phase 1 of the Canadian Nuclear Safety Commission "Pre-Licensing Review of a Vendor's Reactor Design".
- Kiewit Power Constructors Co. Joins Team Holtec with Mission to Make SMR-160 Commercially Competitive and Construction-Friendly.
- Holtec Selects Framatome to Supply Fuel for SMR-160 Small Modular Reactor.

It sounds like Holtec may be focusing on international markets for their SMR rather than the U.S.

5. Advanced Reactors

A SMR is basically a scaled-down and simplified Gen1 through Gen 3 light water reactor (LWR). In spite of some pre-Gen 2 issues with safety, this is a well-understood technology. SMRs seek to remedy the safety and economic issues while building on previous LWR technology.

[7] GE Hitachi Press Release, "U.S. Department of Energy Awards Two Advanced Reactor Projects Utilizing the BWRX-300 Small Modular Reactor Design, May 14, 2020, https://www.ge.com/news/press-releases/us-department-energy-awards-two-advanced-reactor-projects-utilizing-bwrx-300-small

[8] Holtec International SMR Press Releases page, https://holtecinternational.com/products-and-services/smr/news-videos/

Then there are a class of reactors generally called advanced reactors. They do not use water for cooling, heat transfer, and reactivity control, but instead use some other fluid. In my opinion, this amounts to opening up a new can of worms.

I reviewed one of these companies in Nukes 3, Advanced Reactor Concepts, LLC, and came to the conclusion that they had little chance of ever building a licensed reactor. There are other Advanced Reactors being considered: Oklo Power, LLC (so far the only one to submit construction or operating license application to the NRC), TerraPower, Terrestrial Energy and Moltex Energy.

In spite of claims by the above companies that the above designs are intrinsically safe, I don't buy it. I'm not going to review any advanced reactor designs in future Nukes, unless they are able to define a true breakthrough design that I can believe. I worked the first five years of my career in the nuclear industry – first on an "Advanced Reactor" (Clinch River Breeder Reactor), then on GE Gen 2 BWRs (LWR). I know of what I write.