TAXPAYERS for COMMON SENSE

NUCLEAR REPORT

December 2021

Doubling Down: Taxpayers' Losing Bet on NuScale and Small Modular Reactors

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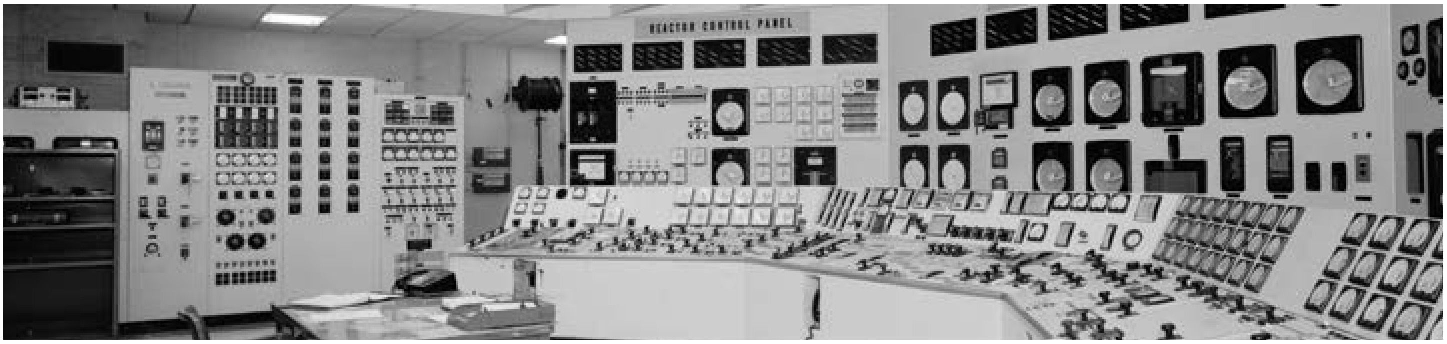
Executive Summary

After more than half a century of federal subsidization of conventional nuclear facilities, some policymakers and industry proponents are arguing for expanded subsidies for new smaller sized types of nuclear reactors — small modular reactors ("SMRs").

However, this dream of rolling mini reactors off the assembly line to compete in energy markets defies reality. The slew of current incentives has failed to foster a cost-effective nuclear reactor industry, and the timeline for deployment of new designs is far too distant to make a timely or beneficial climate impact.

After 60 years, the nuclear power industry remains heavily dependent on subsidies, faces costly and unresolved waste disposal challenges, and leaves a long trail of ongoing environmental liabilities, from uranium mining contaminants to water pollution. Meanwhile, alternatives like wind and solar power, efficiency gains, and battery storage are now cheaper than nuclear generation. Why then, should federal taxpayers consider even more federal subsidies — especially at a scale sufficient to force small modular reactors to market?

The technology used by the first nuclear power plants in the United States was developed by researchers in federal government laboratories. By assuming catastrophic accident liability, providing



©Library of Congress, *Shippingport Atomic Power Station, On Ohio River, 25 miles Northwest of Pittsburgh, Shippingport, Beaver County, PA*

enrichment services, and making advancements for industry to adopt, the federal government also continued to underwrite nuclear power as early production rose. The capacity of reactors at U.S. power plants grew over time in attempts to capture economies of scale, but their construction costs and difficulties grew too.

Utility orders for new nuclear plants dropped off in the mid-1970s, and dozens of projects were canceled, as creditors backed away from their increasingly evident cost and safety risk. With the enactment in the mid-2000s of new federal incentives, interest in building large reactors resurged, but soon withered again under the same pressures. Construction of the only two reactors underway today is years behind schedule and expected to cost more than twice its original budget — if completed.

In recent decades, policymakers and industry backers started suggesting that nuclear reactors might produce cost-effective electricity by going small instead of building for scale and standardizing manufacturing. These proposed SMRs, producing up to 300 megawatts electric (MWe) instead of the 1000 MWe common among large reactors, offered several advantages in theory.

Potential manufacturers suggested several designs, but finding investors proved challenging. The U.S. Department of Energy (DOE) stepped in to foster a few SMR test projects, and quickly lost more than $100 million on one bad bet. Taxpayers for Common Sense awarded the DOE program the infamous **Golden Fleece Award** for wasting taxpayer dollars. The agency has plowed ahead nevertheless and handed hundreds of millions of dollars to NuScale Power to get one design certified after taxpayers funded its creation in DOE labs. **DOE has spent more than $1.2 billion on SMRs to date, and now wants to give NuScale and other companies at least $5.5 billion more to develop and demonstrate SMR designs over the next decade.**

Even if DOE's gambit to get some modular reactors up and running succeeds, demand is unlikely to materialize to buy commercial units thereafter at prices that can compete with other energy sources. Bringing down SMRs' cost depends on several assumptions about their manufacture and deployment that have not been proven. At the least, it requires savings that SMR companies purport will come from serial production and operation that improves over time. Making that happen with federal spending means more decades of industry dependence and a money pit for taxpayer dollars.

To head off the worst and most costly effects of climate change for taxpayers, dramatic action needs to be taken in the next decade to reduce power sector emissions. Unproven SMRs are far from market readiness and much too costly to be the answer. The SMR company closest to commercialization in the U.S. hopes to bring a taxpayer-subsidized plant online by 2030, but delays are the rule rather than the exception for nuclear projects. With slim prospects for market adoption, and "small" power output by definition, SMRs are unlikely to make a dent in domestic energy markets for decades, if ever.

Bottom line — ever-increasing subsidies cannot solve the nuclear energy industry's costly flaws, and in this era of climate urgency, funneling more taxpayer dollars to unproven, prototype projects will not yield the immediate climate benefits we need today.

Introduction

This report presents a detailed accounting of federal subsidies for small modular reactors (SMRs) to date. These include legacy subsidies for the uranium fuel cycle SMRs depend on, federal funding for the development of SMR technologies, support during the licensing process, available subsidies for financing plant construction, a production tax credit, catastrophic accident liability coverage, and many others. To contextualize the subsidies, this report also provides a brief overview of the federal government's historical support for the nuclear power industry and the industry's failures that led to the embrace of SMRs.

As the principal recipient of taxpayer dollars spent on SMRs, special focus is given to NuScale Power, its Power Module design, and its flailing market prospects. After subsidizing NuScale Power at every step, the Department of Energy (DOE) is committed to putting up cash to construct the first power plant using the company's design. **To date, DOE has spent or obligated $520 million to help develop the Power Module and support the plant project.** Simultaneously, DOE plans to spend billions of dollars to help other companies demonstrate their SMR designs. Congress has yet to fully endorse those plans but has demonstrated willingness to subsidize SMRs at every step.

ACRONYMS & INITIALS

AEC	Atomic Energy Commission
B&W	Babcock & Wilcox
BWR	boiling water reactor
CFPP	Carbon Free Power Project
COLA	construction and operating license application
DOE	U.S. Department of Energy
FY	fiscal year
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
LCOE	levelized cost of electricity
LWR	Light-water reactor
MOU	Memorandum of understanding
MOA	Memorandum of agreement
MWe	megawatt electric
NERI	Nuclear Energy Research Initiative
NRC	Nuclear Regulatory Commission
NRIC	National Reactor Innovation Center
PTC	production tax credit
R&D	research and development
RD&D	research, development, and demonstration
SMR	small modular reactor
UAMPS	Utah Associated Municipal Power Systems

A Brief History of Federal Nuclear Industry Support

The use of nuclear energy to generate electricity for consumers started after World War II as a government project fully funded by taxpayers. Government scientists operated the first reactor to produce electricity in December 1951 at what later became the Idaho National Laboratory.[1] In Oak Ridge, Tennessee, then at Argonne National Laboratory outside Chicago, the U.S. Navy and the new Atomic Energy Commission (AEC) jointly propelled development of nuclear power technology.[2] In 1954, the Navy launched the USS Nautilus submarine, marking the first successful application of nuclear power in the U.S.

In a classic example of technological spillover, companies like Westinghouse Electric and General Electric (GE) gained dominance in nuclear power by developing the first reactors with government scientists and taxpayer-funded contracts.[3] In fact, the AEC paid Westinghouse to build the reactor for the first full-scale nuclear power plant in Shippingport, Pennsylvania, which came online in 1957 and could eventually produce 60 megawatts electric (MWe).[4]

The light-water reactor designs developed by Westinghouse, chosen by the Navy for its submarines and implemented at Shippingport, became the standard for the nascent nuclear power industry. But taxpayer funding for the first reactors and the government imprimatur for industry's early work were just the beginning of decades in subsidies for nuclear power.

[1] **https://inl.gov/experimental-breeder-reactor-i/** (See also **https://www.energy.gov/sites/prod/files/The%20History%20of%20Nuclear%20Energy_0.pdf**)
[2] Hewlett, Duncan, "**Nuclear Navy: 1946-1962**," (1974), p. 119

[3] Cowan, R, "Nuclear Power Reactors: A Study in Technological Lock-in." *The Journal of Economic History,* Vol. 50, No. 3 (**Sep., 1990**), pp. 541-567.
[4] Hewlett and Duncan, p. 252-254

Fig. 1: Summary of Federal Subsidies and Supports for Nuclear Energy

Subsidy	20-Year Cost ($2020 – billions)
Department of Energy Nuclear R&D Funding	$9.9
Percentage Depletion Allowance*	$2.6
Exploration & Development Costs Expensing*	$1.8
Special Tax Rate for Decommissioning Reserve Funds	$10.6
Abandoned hardrock mining cleanup	$5.2
Subsidy	**Support Total**
Standby Support for Nuclear Plant Delays	$2.0
DOE Loan Guarantee Program	$12.0
Nuclear Production Tax Credit	$5.7
Uranium Enrichment Decontamination & Decommissioning	$7.5
Civil Nuclear Credit Program	$6.0
Unquantified Item	
Royalty-free uranium mining on federal lands	
Price-Anderson Act accident liability cap	

*includes subsidy to coal mines

A 2021 TCS report, *Understanding Nuclear Subsidies*, provides a more complete overview of federal subsidies for the nuclear industry,[5] but a few key supports were critical for the propagation of nuclear power plants. In 1957, the same year the Shippingport plant came online, Congress passed the Price-Anderson Act, which capped the liability of nuclear power plants for damages from catastrophic accidents. It was and remains a safety-net for the whole industry.

Taxpayers have also subsidized the fuel that nuclear power depends on through laws that predate the industry itself. The General Mining Law of 1872 still governs most uranium production on federal lands and allows companies to extract the metal without paying anything in royalties. In comparison, coal and oil and gas producers pay between eight and 12.5 percent of the value of the resources extracted from federal lands in royalties to taxpayers.

Uranium miners have also been able to write off their costs for developing a mine since 1951, and their explorations costs since 1966. Since 1954, mining companies have been able to deduct a flat 22 percent of their income through the "percentage depletion allowance." Percentage depletion disconnects what companies can deduct from their taxes from what they actually paid to dig and open a mine.

In the early decades of nuclear power, the federal government also provided all enrichment services to concentrate uranium isotopes for the fuel used by nuclear power plants. The federal government charged for its services, but the fuel was sold at subsidized prices that did not include the full cost of decommissioning its enrichment sites.[6] All these subsidies and others allowed the nuclear power industry to prosper at taxpayer expense. However, even generous taxpayer subsidies have not been sufficient to sustain an inherently cost-ineffective industry.

In November 2021, Congress acknowledged nuclear power's widespread failure to remain competitive in energy markets by creating the Civil Nuclear Credit Program. The program will provide $6 billion over five years to bailout nuclear facilities that would otherwise shutter from economic forces. The bailout comes after decades of industry decline.

The Industry Slide toward SMRs

To encourage utilities to embrace nuclear power plants after the first government-funded deployments, and to seize market share before competitors appeared, GE and Westinghouse offered to build reactors for a set price. GE published a price list to build boiling water reactors (BWRs) in 1964 that was competitive with new oil- and gas-fired power plants.[7] In total, the two companies sold 13 reactors at fixed prices, referred to as "turnkey" contracts.[8] GE and Westinghouse lost money on each turnkey plant they built and nearly $1 billion in total,[9] but the strategy generated huge demand and precipitated the "Great Bandwagon Market." By 1967, utilities in the U.S. had ordered more than 50 reactors from the vendors.[10] By 1974, utilities had ordered another 196 reactors.[11]

[5] See Taxpayers for Common Sense's report, ***Understanding Nuclear Subsidies***, Feb. 2021

[6] **https://www.gao.gov/products/130728**

[7] Maria Rosaria Di Nucci, "From Military to Early Civilian Applications. An Appraisal of the Initial Success of the Light Water Reactor Technology," *The Technological and Economic Future of Nuclear Power*. April 2019, p. 28

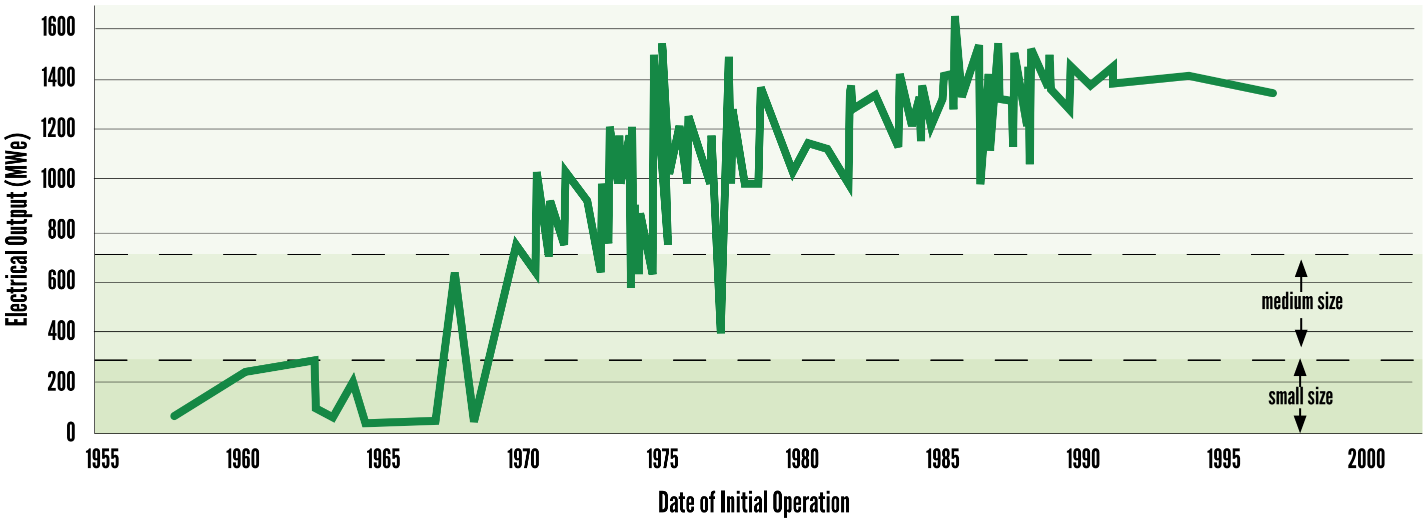
[8] Burness, H.S., Montgomery, W.D., Quirk J.P.,"The Turnkey Era in Nuclear Power," *Land Economics*. Vol. 56, No. 2 (May, 1980), 188–202 cited by Di Nucci, p. 28

[9] Burness et al., cited in Federation of American Scientists (FAS), "**The Future of Nuclear Power in the United States**," Feb. 2012

[10] International Atomic Energy Agency, "**50 Years of Nuclear Energy**," 2004.

[11] Ibid.

Fig. 2: Historical Growth of U.S. Nuclear Plant Output in Failed Attempt to Capture Economies of Scale



Source: EIA Generator Inventory; NRC Information Digest

To try and reduce the cost of electricity from nuclear plants by capturing economies of scale, utilities quickly escalated the size of reactors they ordered (See Figure 1). But the approach backfired. The bigger plants' added complexity led to delays and higher costs that more than offset any savings generated from scale.[12] In fact, the wave of nuclear plant projects experienced cost overruns that only increased over time. Construction projects started in 1966 or 1967 ended up costing twice as much as expected, while those breaking ground in 1974 and 1975 ended up costing nearly four times their original projections.[13]

Spooked by the sudden escalation in costs, many utilities ended up canceling their reactor orders placed in the early 1970s, some even after construction had started.[14] By one count, more than 120 ordered reactors were canceled.[15] Though some projects from the first wave were completed in the 1980s and 1990s, no new projects started.

To revive the prospects for nuclear power, some corners of the industry started focusing on scaled-down reactor designs. In a 1995 report, the International Atomic Energy Agency (IAEA) reported increased interest among its Member States for power plants employing small and medium reactors.[16] That report and many since suggest several possible advantages for smaller reactors including some that could help overcome the loss of economies of scale. The latter include the need for a smaller site footprint and fewer personnel, the ability to deploy multiple units at one site, shorter construction time, faster process learning from higher volume production, and incremental demand matching.[17] Crucially, smaller reactors' purported economic efficiencies also depend on their simplified designs. This allows for standardization of manufacturing, less sophisticated fabrication expertise, and more off-site construction. Several of these supposed and sometimes overlapping benefits are entailed by the concept of *modularity*.

The term *modular* has multiple senses. It implies multiple sub-units that are assembled into a single functioning unit, in this case a nuclear reactor. It can also refer to independent reactors that can be combined into a larger assembly to increase the power output at a single site.

[12] DOE, Energy Information Administration, "**An Analysis of Nuclear Power Plant Construction Costs**," Jan. 1986

[13] Congressional Budget Office, "**Nuclear Power's Role in Generating Electricity**," May 2008, citing Ibid.

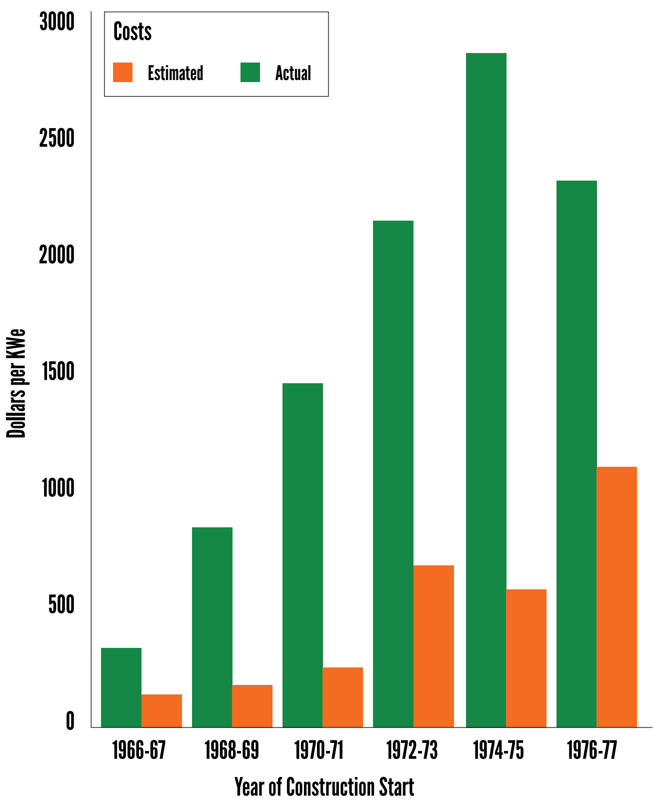
[14] FAS – 2012

[15] **https://web.archive.org/web/20120201194615/http://clonemaster.homestead.com/files/cancel.htm**

[16] For decades, the initialism 'SMR' was commonly used in reference to small and medium reactors, defined as those producing up to 700 MWe; IAEA, "Design and development status of small and medium reactor systems 1995," **May 2006, IAEA-TECDOC-881**

[17] See: Ingersoll, "**Deliberately small reactors and the second nuclear era**," Progress in Nuclear Energy, May 2009; Carelli, Trucco, Ricotti, et al., "Economic Comparison of Different Size Nuclear Reactors," **Jan 2007**; Mignacca, Locatelli, "Economics and finance of Small Modular Reactors: A systematic review and research agenda," *Renewable and Sustainable Energy Reviews*, **Feb 2020**.

Fig. 3: Nuclear Plants Construction Costs – Actual Costs Dwarfed Estimates Over Time



Source: EIA – An Analysis of NuclearPower Plant Construction Costs (1986)

In the past two decades, the nuclear industry has generally coalesced around modularity as the key to driving theoretical cost savings for smaller plants. Several companies began developing their own SMR concepts. The U.S. government then got into the game, and federal government support for SMRs has shifted from a small part of the federal push for new nuclear power to becoming its primary focus.

The Department of Energy Dives into SMR Development

After the failure of large reactor projects in the last decade, DOE has concentrated its nuclear spending on SMR research and development (R&D) and demonstration projects, most notably, the NuScale Power Module. DOE spending has supported SMRs at every stage — from concept-level research and design development to licensing preparation and now reactor demonstration. The U.S. fleet of large commercial nuclear reactors has foundered despite decades of DOE-subsidized nuclear R&D. DOE's recent pivot to promoting SMRs is unlikely to yield better results.

The DOE and its predecessors — the Atomic Energy Commission and the Energy Research and Development Administration — enabled nuclear energy with reactor R&D funding for decades. More than 56 percent of the agencies' R&D funding between fiscal year (FY) 1948 and FY2000 was devoted to nuclear energy, or a total of roughly $98 billion in 2020 dollars.[18] Tracking the course of the nuclear industry in general, DOE spending on nuclear R&D withered in the late 1980s and early 1990s before resurging in the 2000s.

Near the turn of the millennium, government reports suggested SMRs as an area for R&D focus for the first time. In 1997, President Bill Clinton's Committee of Advisors on Science and Technology recommended the creation of a Nuclear Energy Research Initiative at DOE to support, among other things, "lower-output reactors for use in settings where large reactors are not attractive."[19] In its appropriations for FY1999, Congress provided $19 million for the Nuclear Energy Research Initiative, which was the first in a string of DOE programs over the last two decades to support SMR development.[20]

In September 2000, a report accompanying the Senate's FY2001 Energy & Water appropriations bill provided $1 million for DOE to study the feasibility of small modular reactors for deployment in remote communities.[21] In response, DOE published a seminal report in May 2001 that became the foundation for SMR assessment in academic literature.[22] The report documented the development of related technology in the past and other countries and painted a rosy picture of SMRs' prospects. But economical SMRs available for deployment "before the end of the decade" have not materialized 20 years later, contrary to the report's predictions.

[18] Congressional Research Service (CRS), RS22858: "Renewable Energy R&D Funding History: A Comparison with Funding for Nuclear Energy, Fossil Energy, and Energy Efficiency R&D," Jan 26, 2011.
[19] The President's Committee of Advisors on Science & Technology, "Federal Energy Research and Development for the Challenges of the Twenty-First Century," Nov 1997, p. ES-20, available at: **https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-nov2007.pdf**
[20] P.L. 105-245, "Energy and Water Development Appropriations Act, 1999," Oct 7, 1998, See Conference Report, **H.Rept. 105-749**, p. 94
[21] **S. Rept. 106-395** accompanying H.R.4733 (106th Congress), later included by reference in H.Rept. 106-988 accompanying H.R. 4635 (106th Congress) enacted into law as P.L. 106-377
[22] DOE, "Report to Congress on: Small Modular Nuclear Reactors," May 2001.

Fig. 4: Congress Splurging on SMR R&D Program above Agency Requests by Fiscal Year

($ in millions)

Advanced SMR R&D	2019	2020	2021	2011-2021 Total
Requested	54	10	10	180
Enacted	100	100	115	392
Excess Appropriations over Request	+46	+90	+105	+212

In October 2000, DOE started developing a roadmap for the Generation IV Technology program. Its goal was to identify and establish R&D projects for nascent, next-generation nuclear technologies that could be deployed no later than 2030, per the recommendation of the Nuclear Energy Research Advisory Committee.[23] The concluding report, *A Technology roadmap for Generation IV Nuclear Energy Systems*,[24] finalized in December 2002, identified SMRs as one of the potential paths for crosscutting economics R&D. The near-term deployment section[25] of the Generation IV Technology Roadmap prompted DOE to create the Nuclear Power 2010 program, the goal of which was to bring new commercial nuclear power plants online in the U.S. by 2010. The Nuclear Power 2010 program funded development of standardized nuclear plant design, while the Generation IV R&D program spent millions of dollars on one SMR concept, the Lead-Cooled Fast Reactor.

DOE first requested funding for SMR-centered R&D programs in its FY2011 budget request. Since then, the agency has administered several programs in support of SMR development:

- **Advanced SMR R&D** — a subprogram of DOE's Reactor Concepts Research, Development and Demonstration (RD&D) program to facilitate non-Light Water Reactor (LWR) reactor designs. Congress did not grant DOE's original $38.9 million request, but DOE later reported starting the program by spending $3.1 million in FY2011.[26]
- **Advanced Reactor Demonstration** — supporting the National Reactor Innovation Center (NRIC) to test and assess reactor performance in DOE labs and cost-share agreements to demonstrate two advanced reactors. Congress created the program in FY2020.
- **SMR Licensing Technical Support** — providing design certification and licensing support for two LWR SMR designs through cost-sharing agreements with industry partners to accelerate deployment of SMRs. The program first received funding in FY2012.

Advanced SMR R&D

Over the last decade, R&D funding advancing SMR concepts and technologies appeared in several of DOE's nuclear energy programs, though tracking SMR-specific funding is difficult because of the lack of transparency in DOE's budget and overlapping priorities between programs. But a few things are clear — SMRs have received bipartisan support in both Republican and Democratic administrations, and regardless of where the funds are directed Congress awards significantly more than DOE's budget requests.

- **The Advanced SMR R&D subprogram** was funded independently with $77 million from FY2012 to FY2014 before being consolidated under the **Advanced Reactor Concepts subprogram in FY2015**.
- **The Advanced SMR R&D subprogram re-emerged** as an independent line item in DOE's FY2019 budget justification, where DOE outlined a new one-year effort focusing on early-stage design and technical assistance through cost-sharing agreements. Congress appropriated $315 million for the program in FY2019-2021.

[23] NERAC, an independent formal federal advisory committee
[24] Generation IV International Forum, "A Technology roadmap for Generation IV Nuclear Energy Systems." December 2002. **https://www.gen-4.org/gif/upload/docs/application/pdf/2013-09/genivroadmap2002.pdf**
[25] DOE, NERAC, "A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010" Oct 31, 2001
[26] FY2011 Current appropriation, according to FY2013 DOE budget justification.

Fig. 5: Recent DOE Awards to SMRs and Advanced Reactors

Funding Opportunity	Award	Awardee	Technology	DOE Share	Industry Share	Note
U.S. Industry Opportunities for Advanced Nuclear Technology Development	First-of-a-Kind (FOAK) Nuclear Demonstration Readiness Project	NuScale Power LLC	SMR	$40,000,000	$40,000,000	2018 1st Round
		NuScale Power LLC	SMR	$7,000,000	$7,100,000	2018 2nd Round
		SMR LLC	Passive Safety System Performance of SMRs	$1,624,729	$1,624,729	2018 3rd Round
		Westinghouse Electric Company, LLC	eVinci™ Microreactor	$12,879,797	$15,675,350	2019 1st Round
	Advanced Reactor Development Projects	GE-Hitachi	BWRX300 small light water reactor	$1,925,038	$481,260	2018 2nd Round
		Holtec International	Hybrid Laser Arc Welding (HLAW) for Nuclear Vessel Fabrication, Including Small Modular Reactors	$6,314,612	$6,314,612	2018 2nd Round
Advanced Reactor Demonstration Program (ARDP)	Advanced Reactor Demonstration Projects	TerraPower LLC	Advanced nuclear reactor	$1,600,000,000	$1,600,000,000	over 7 years
		X-energy	Advanced nuclear reactor	$1,600,000,000	$1,600,000,000	
	Risk Reduction for Future Demonstration Projects	Kairos Power, LLC	Hermes Reduced-Scale Test Reactor	$303,000,000	$326,000,000	
		Westinghouse Electric Company, LLC	eVinci™ Microreactor	$7,400,000	$1,900,000	
		BWXT Advanced Technologies, LLC	BWXT Advanced Nuclear Reactor (BANR)	$85,300,000	$21,300,000	
		Holtec Government Services, LLC	Holtec SMR-160 Reactor	$116,000,000	$31,500,000	
		Southern Company Services Inc.	Molten Chloride Reactor Experiment	$90,400,000	$22,600,000	
	Advanced Reactor Concepts-20 (ARC-20) Projects	Advanced Reactor Concepts, LLC	Inherently Safe Advanced SMR	$27,500,000	$6,900,000	
		General Atomics	Fast Modular Reactor Conceptual Design	$24,800,000	$6,300,000	

In the past few years, Congress has aggressively supported SMR R&D by consistently appropriating more money than DOE requests (see Figure 4).

The aggressive funding of the Advanced SMR R&D program, at a level significantly more than requested, has not eliminated the substantial hurdles to SMR deployment. In its FY2021 budget request, DOE acknowledged that "*Significant risk remains in developing advanced SMR and micro-reactor designs.*" A year later, the agency repeated: "*A range of significant technological challenges remain in developing advanced SMR designs…*"

Advanced Reactor Demonstration Program

Congress created the demonstration program in FY2020 to propel commercialization of SMR and other reactor concepts through cost-share agreements with the industry. There are three pathways through which industry partners can apply: (1) Advanced reactor demonstrations, which will support the development of advanced nuclear reactors that are expected to be fully functional within seven years of the award; (2) Risk reduction for future demonstrations, which will fund up to five additional teams resolving technical, operational, and regulatory challenges to prepare for future demonstrations; (3) Advanced reactor concepts 2020 (ARC 20), which will support designs that could potentially commercialize in the mid-2030s. In October 2020, DOE announced TerraPower, LLC and X-Energy, LLC as the awardees of the program's first grants worth $160 million. DOE also committed up to $3.2 billion to the two companies over the next seven years, subject to future appropriations. The full list of awardees and amounts of DOE funding is shown in the chart above. In the Energy Act of 2020, enacted with the FY2021 Omnibus, Congress authorized $2.14 billion for the Advanced Reactor Demonstration Program from FY2021 to FY2025, paving the way for appropriations to match DOE's commitments.

In November 2021, Congress enacted the "Infrastructure Investment and Jobs Act," which simultaneously increased authorized funding for the program further to $3.2 billion and provided $2.48 billion in appropriations to DOE specifically for the TerraPower and X-Energy grants. The law spreads the appropriations over four years, leaving lawmakers time to claw back taxpayer support for the risky projects.

SMR Licensing Technical Support

The SMR Licensing Technical Support program "provide[d] support for design, certification, standards and licensing."[27] DOE planned to

[27] DOE, Budget Justification FY2012, Volume 3. **https://www.energy.gov/sites/default/files/FY12Volume7.pdf**

Fig. 6: SMR Licensing Technical Support Appropriations

$ in millions	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	TOTAL
Annual Spending	$67.0	$67.4	$110.0	$54.4	$62.5	$95.0	$456.4

select two companies and their utility partners for financial cost-sharing agreements with a minimum of 50% contribution from industry partners for two designs to expedite SMR commercialization. The total cost of this SMR licensing effort was set at $452 million, all of which was eventually expended over six years. The SMR Licensing Technical Support program officially started in FY2012 and ended in FY2017.

In 2012, DOE issued the first Funding Opportunity Announcement for its SMR Licensing Technical Support program and selected Generation mPower LLC, subsidiary of Babcock & Wilcox (B&W), and its utility partner, the Tennessee Valley Authority as the first applicant to be awarded cost-share funding for their 180 MWe SMR design. Babcock & Wilcox would receive the first half of the $452 million.

After selecting only one applicant to the first solicitation and lower than expected appropriations, DOE announced a second solicitation in March 2013. The second solicitation offered the second half of the $452 million total committed to the program. In response, all three of the SMR developers that did not get selected under the first solicitation reapplied. In December 2013, DOE selected NuScale Power for the second SMR Licensing Technical Support Award.[28]

In February 2014, B&W reported it was unable to find any investor interested in acquiring a majority stake in Generation mPower, the company's SMR subsidiary.[29] B&W CEO Jim Ferland conceded "…investors that want to take even minority positions are relatively hard to find." As a result, B&W decided to cut its investment in Generation mPower from $60-$80 million per year to less than $15 million.[30] Due to B&W's corporate decision, DOE suspended the project but provided limited extensions of the cost-sharing agreement through November 2014. DOE maintained the option of continuing the Generation mPower award at some level though 2016 if B&W could secure investors and resume the minimum funding commitment of at least 50% of the project.

In June 2014, the House Appropriations Committee passed a bill that cut back spending for DOE's Licensing Technical Support Program, concluding that taxpayers should not invest more in Generation mPower or its SMR design if its parent company was cutting funding for the project. However, legislators could not recoup what DOE had already spent on Generation mPower, which stood at approximately $101 million through March 2014.[31] Before they decided to divest, B&W and its partners including DOE had spent more than $400 million on the project over the previous five years.[32]

OTHER DOE SUPPORTS

Savannah River National Laboratory public-private partnerships

In March 2012, DOE's Savannah River site and Savannah River National Laboratory (SRS) signed three Memorandums of Agreement (MOA) for public-private partnerships with small modular reactor companies to commercialize SMR technologies. Located in South Carolina, DOE's SRS provides support ranging from technology demonstration to design certification and licensing assistance. This support is in addition to the SMR program.

ARPA-E

A project on transportable Modular Reactor, HolosGen, received $2.8 million through the Advanced Research Projects Agency – Energy (ARPA-E), an agency under DOE first created by the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act of 2007, or the America COMPETES Act.

[28] DOE, Budget Justification FY2015, Volume 3 https://www.energy.gov/sites/prod/files/2014/04/f14/Volume%203.pdf
[29] Downey, J. No sale: Babcock & Wilcox can't find buyer for Generation mPower. The Business Journal, Feb 28, 2014. http://www.bizjournals.com/charlotte/blog/power_city/2014/02/no-sale-babcock-wilcox-can-t-find-buyer-for.html
[30] Guidehouse Insights, mPower Pullback Stalls Small Nuclear. Forbes, Apr 28, 2014. http://www.forbes.com/sites/pikeresearch/2014/04/28/mpower-pullback-stalls-small-nuclear/ http://www.forbes.com/sites/pikeresearch/2014/04/28/mpower-pullback-stalls-small-nuclear/
[31] Taxpayers for Common Sense, Funding a Fantasy. Jun 20, 2014. https://www.taxpayer.net/energy-natural-resources/funding-a-fantasy/
[32] andyk, M. Generation mPower continuing with new leadership, without DOE. S&P Global, Mar 10, 2016. https://www.spglobal.com/marketintelligence/en/news-insights/trending/ufhw6irwhcnnsryylircdq2

Instead of rescinding the rest of the mPower grant, DOE funneled the money to the Tennessee Valley Authority (TVA) which had intended to construct the mPower plant. In FY2015, DOE entered into an interagency agreement with TVA to complete "site characterization activities" in preparation for a permit application to the NRC.[33] Of the $452 million that was spent from FY12 to FY17, more than $100 million was wasted on one of the two SMR designs supported by the program.

Doubling Down on the NuScale Design

With Generation mPower out of the picture, NuScale stands as the only company to possibly reach commercialization, after extensive DOE support. DOE has subsidized the development of NuScale's Power Module design from its inception and now intends to prop up its deployment by handing over more than a billion dollars in additional taxpayer funds.

The history of NuScale and its SMR is an ongoing saga of endless federal subsidies and project setbacks.

» 1999-2008

The NuScale design first evolved from the Multi-Application Small Light Water Reactor (MASLWR) project carried out by the Idaho National Environment & Engineering Laboratory, Oregon State University researchers, and Nexant, a Bechtel Corporation subsidiary.[34] DOE's Nuclear Energy Research Initiative (NERI) funded the project in its first round of awards in FY1999 with a $2 million grant. Other NERI projects also focused on SMR concepts, including one working on passive safety features that likely contributed to the NuScale design.[35] After the NERI projected ended in 2003, Oregon State University transferred rights to the power plant design to the nascent NuScale Power company in 2007. In 2008, NuScale announced that a SMR plant could be producing electricity by 2015-2016, but the dates kept getting pushed back.

» 2010-2014

In 2010, NuScale submitted a letter of intent to the NRC for a design certification application in 2012, but it would take another four years before it was finally able to submit the application.[36] In the fall of 2011, Fluor Corporation, a multinational engineering contractor with some history in the nuclear industry, paid $27 million to acquire the controlling interest in NuScale Power. In 2012 and 2013, Fluor reported spending $116 million on NuScale.

As noted above, DOE gave NuScale one of its Licensing Technical Support cost-sharing awards worth up to $226 million in December 2013. Despite the award, Fluor sought to sell some of its ownership stake in NuScale, just as other SMR developers like B&W[37] and Westinghouse[38] were reducing their SMR spending because of poor prospects. The nuclear services company, Enercon, took some equity position in the company in March 2014[39] and NuScale has since partnered with several firms, but Fluor still owns 91 percent of the company as of today. DOE's initial grant to NuScale was intended to help the company further its design development and prepare an application to the NRC for design certification. But DOE quickly found other ways to subsidize the company as it attempted to get the Power Module to market. According to Fluor financial filings, NuScale has spent more than $1 billion since 2014. Of that, DOE covered $447 million, while Fluor and other noncontrolling interests covered the rest.

[33] DOE Office of Nuclear Energy, SMR LTS Site Permitting and Licensing Projects. **https://www.energy.gov/ne/smr-lts-site-permitting-and-licensing-projects**

[34] S. M. Modro et al., "Multi-Application Small Light Water Reactor Final Report," DOE NERI – Idaho National Engineering and Environmental Laboratory (2003) **INEEL/EXT-04-01626**

[35] Oregon State University – Engineering Out Loud Podcast, "Partners in nuclear power," S4E3, Oct. 2017, in which NERI Project 01-094 led by Dr. Reyes is referenced.

[36] NRC, "In the Matter of NuScale Power, Inc. and All Other Persons; Who Seek or Obtain Access to Safeguards Information Described Herein; Order Imposing Safeguards Information Protection Requirements for Access to Safeguards Information (Effective Immediately)," 75 FR 37479–83

[37] Guidehouse Insights, mPower Pullback Stalls Small Nuclear. Forbes, Apr 28, 2014. **https://www.forbes.com/sites/pikeresearch/2014/04/28/mpower-pullback-stalls-small-nuclear/?sh=7d10a0ce4ef5**

[38] Litvak A. Westinghouse backs off small nuclear plants. Pittsburgh Post-Gazette, Feb 1, 2014. **https://www.post-gazette.com/business/2014/02/02/Westinghouse-backs-off-small-nuclear-plants/stories/201402020074**

[39] Sickinger, T. NuScale Power gets new partner to help develop small-scale nuclear reactor. OregonLive, Mar 18, 2014. **https://www.oregonlive.com/business/2014/03/nuscale_power_gets_new_equity.htm**

In 2014, NuScale calculated that the construction cost of a 12-module power plant would be around $3.1 billion but the estimated construction cost started to balloon as time went on.[40]

» 2015

In 2015, NuScale and its utility partner, Utah Associated Municipal Power Systems (UAMPS), launched the Carbon Free Power Project (CFPP).[41] The project plans to construct the first SMR power plant in the US using NuScale's design at an 890 square-mile site owned by DOE at the Idaho National Laboratory. In the same year, DOE awarded $16.7 million to NuScale for the preparation of a combined construction and operating license application (COLA) for the CFPP.

Utah Associated Municipal Power Systems (UAMPS), according to its website, "provides comprehensive wholesale electric-energy, transmission, and other energy services, on a nonprofit basis, to community-owned power systems through the Intermountain West." UAMPS' 48 member towns are located in Utah, California, Idaho, Nevada, New Mexico and Wyoming.[42] The proposed plant originally planned to have 12, 50MWe modules to generate 600 megawatts of electricity if operating at full capacity.

» 2016

In February 2016, DOE issued a site use permit to UAMPS for CFPP, allowing UAMPS to pick potential locations for the proposed power plant within the 890-square mile Idaho National Laboratory (INL) site in Idaho Falls. In December 2016, NuScale finally applied to the Nuclear Regulatory Commission for certification of its SMR design, four years later than it had originally planned.

» 2017

INL, UAMPS and NuScale proposed that DOE should reserve or purchase two of the 12 SMR modules for research and demonstration programs at the Idaho National Laboratory. In December 2017, UAMPS signed power sales contracts with 34 of 45 UAMPS members who elected to participate in CFPP.

The outlook for the first SMR power plant in the US using the NuScale reactor remains uncertain. Despite hefty subsidies, the planned plant still faces

THREE MAIN HURDLES

1) During the 2020 offramp, a period during which participants can exit the project, multiple UAMPS members dropped out of the project for fear of being locked in a billion-dollar project. An unexpected offramp in July 2021 after project downsizing demonstrated the continuing lack of subscriber interest. In addition, the operator for the CFPP, Energy Northwest, also dropped out of the project, forcing UAMPS to look for a replacement.

2) The CFPP may have jeopardized its $1.4 billion award from DOE when it downsized from 12 modules to six modules. The $1.4 billion subsidy is less justifiable for a smaller plant but remains necessary for the CFPP to reach its price target.

3) The project has already experienced cost overruns and project delays and may run into similar problems again.

» 2018

In April, NRC finished the Preliminary Safety Evaluation Report (SER) for NuScale Power's SMR design, the first and most extensive phase of safety review. In December 2018, DOE, UAMPS and Battelle Energy Alliance (BEA, a company that manages the INL for DOE) signed a Memorandum of Understanding (MOU) that allocated one of the SMR modules strictly for RD&D activities for INL, referred to as the Joint Use Modular Plant (JUMP) program.[43] The JUMP module would have been the first module to be deployed at the Carbon Free Power Plant. The JUMP program aimed to support the development demonstration of the use of nuclear technologies beyond the electricity sector.[44] The MOU also outlined a power purchase agreement to draw electricity from another module to meet INL's power needs. The JUMP program agreement was anticipated for a 15-year term with the potential

[40] MM.V. Ramana, Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Reactors, Oregon Physicians for Social Responsibility, September 2020. https://sppga.ubc.ca/wp-content/uploads/sites/5/2020/09/EyesWideShutReport_Final-30August2020.pdf

[41] Idaho National Laboratory, What is the Carbon Free Power Project? https://inl.gov/article/frequently-asked-questions/

[42] Utah Associated Municipal Power Systems (UAMPS), About UAMPS. https://www.uamps.com/

[43] DOE Office of Nuclear Energy, DOE Office of Nuclear Energy Announces Agreement Supporting Power Generated from Small Modular Reactors. https://www.energy.gov/ne/articles/doe-office-nuclear-energy-announces-agreement-supporting-power-generated-small-modular

[44] Idaho National Laboratory Leadership in Nuclear Energy (LINE) Commission Briefing, Jan 23, 2019. http://web.archive.org/web/20210424030416/https://line.idaho.gov/wp-content/uploads/sites/12/2019/02/2019-0123-joint-use-modular.pdf

Fig. 7: CFPP Struggles to Find Power Purchasers

for renewal for another 15 years.[45] DOE also awarded UAMPS and NuScale $16.5 million to perform site selection and prepare a COLA to the NRC.

In June 2018, NuScale announced its modules could produce 20 percent more power than expected, changing the plans for CFPP to a 12-module, 720 MWe plant. In the UMAPS CFPP 2018 Budget & Plan of Finance, the estimated total cost increased to $4.2 billion. NuScale failed to disclose this increase to the public and as recently as November 2019, the cost estimate listed on their website was still the $3.1 billion calculated back in 2014.

» 2019

In July 2019, the preferred INL site was selected for the CFPP. UAMPS anticipated beginning construction in 2023.[46]

» 2020

In July, UAMPS pushed the dates back and revealed that the power plant was then expected to be fully operational by 2030 in a project update.[47] In the update, UAMPS and NuScale increased the estimated cost of construction once again to $6.1 billion,[48] with the expectation that DOE would award the project $1.4 billion in place of the Memorandum of Understanding (MOU) signed in 2018. And on October 16, 2020, DOE approved the nine-year, $1.4 billion award to the CFPP to help demonstrate and deploy the 12 NuScale modules.[49] However, the award only serves as a funding vehicle and is subject to future appropriations by Congress. Since the award replaced the MOU that established the JUMP program, DOE would no longer draw electricity from the CFPP. As a result, more than 600MW remained to be purchased, since the UAMPS members had only committed to purchasing 213MW of the plant's output at the time.[50] Consequently, UAMPS began considering a six- or eight-module plant to replace the original 12-module design.

October 31, 2020 was the deadline for the first UAMPS member offramp, a period during which members can opt out or by default stay in the Carbon Free Power Project. Despite the announcement of the $1.4 billion award from DOE,

[45] Ibid.
[46] UAMPS, UAMPS achieves key Carbon Free Power Project milestone, Jul 17, 2019. **http://web.archive.org/web/20200122123023/https://www.uamps.com/file/aee8613f-fe43-4c29-9705-25a096b54edb**
[47] NuScale, A Cost Competitive Nuclear Power Solution. **https://www.nuscalepower.com/benefits/cost-competitive**
[48] *See* City of Idaho Falls meeting minutes, Aug 13, 2020. *Available at*: **https://www.idahofallsidaho.gov/AgendaCenter/ViewFile/Minutes/_08132020-1004**
[49] DOE Office of Nuclear Energy, DOE Approves Award for Carbon Free Power Project,Oct 16, 2020. **https://www.energy.gov/ne/articles/doe-approves-award-carbon-free-power-project**
[50] McAuliffe, M. Municipal power group awaits $1.4 billion from DOE for Idaho nuclear plant. S&P Global, Aug 13, 2020. **https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/081320-municipal-power-group-awaits-14-billion-from-doe-for-idaho-nuclear-plant**

Fig. 8: Cost Estimates for the NuScale/UAMPS SMR Power Plant

Year	Cost ($, Billions)	Note
2014	3.1	NuScale's original estimate of construction cost of a 12-module plant.
2018	4.2	UMAPS CFPP 2018 Budget & Plan of Finance
2020	6.1	UMAPS CFPP 2020 Budget & Plan of Finance, $1.4 billion expected to come from taxpayers.
2021	???	UAMPS has not publicly disclosed the new cost estimate after reducing the plant size from 12 modules to 6

several members pulled out of the CFPP, which further increased the cost share burden for the remaining participating members. Eight member towns withdrew from the project entirely; 24 members reduced their share entitlement; and one utility joined the project for the share of only 1MW. Members that dropped out cited cost as their main concern as small cities cannot afford to be locked into a project with potential billion-dollar cost overruns. The offramp was only the first of three for the CFPP. The next offramp is scheduled for 2022, when UAMPS and NuScale are expected to submit their COLA. The final offramp is likely to be scheduled in early 2024, before UAMPS begins construction for the Carbon Free Power Project.[51] In November 2020, after the offramp closed, NuScale announced the expected output from its modules had risen again to 77 MWe.

» 2021

In March 2021, UAMPS announced that the operator for the CFPP, Energy Northwest, also backed out of the project. As a result, UAMPS is looking for a replacement.

In June, UAMPs and its participating members voted to downsize the power plant to a six-module, 462MW plant.[52] Due to the decision, the price per megawatt benchmark that would allow municipalities to withdraw from the project later increased from $55/MWh to $58/MWh. As a result, the project opened another offramp period in July to allow members to withdraw from the project.

Although UAMPS claimed they had received multiple letters of interest and would be able to reach full subscription after downsizing, the July offramp reflected continued lack of subscriber interest. None of the letters of interest have resulted in actual subscription. The subscription level now stands at 103MW[53], only 22.3% of the plant capacity. UAMPS previously said it would not proceed with the CFPP unless all the electricity it would generate was fully subscribed.

The Handouts Continue

The CFPP will likely only be operational with further financial assistance from DOE. UAMPS has stated that it would not move forward with the project if the levelized cost of electricity (LCOE, the cost of electricity generated over the lifetime of the power plant) does not reach the price target of $55/MWh. This price target has now increased to $58/MWh due to downsizing the plant to six modules.

Yet estimates from other utility companies as well as researchers has put the LCOE number much higher than $55/MWh or $58/MWh. PacifiCorp, an electric services company, estimated the cost of energy for a 12-module, 570MW plant at $95/MWh[54] and Idaho Power, another electric power utility, put their levelized cost of energy estimate of a 60MW SMR plant at $121/MWh.[55] Even NuScale has estimated that a 12-unit, 60MWe plant would achieve a LCOE of $65/MWh, which is still more expensive than the price level UAMPS said they would achieve. The economic model used by UAMPS factored in DOE funding of $1.4 billion as well as potentially available DOE loan guarantees. However, the exact pricing model was not revealed.

[51] Patel, S. Shakeup for 720-MW Nuclear SMR Project as More Cities Withdraw Participation. POWER Magazine, Oct 29, 2020. **https://www.powermag.com/shakeup-for-720-mw-nuclear-smr-project-as-more-cities-withdraw-participation/**

[52] Los Alamos County, BPU and Council to Consider Continued Participation in CFPP. Jul 13, 2021. **https://www.losalamosnm.us/news/b_p_u_and_council_consider_c_f_p_p_participation**

[53] *See* Los Alamos County Council Agenda July, 27, 2021., *available at* **https://losalamos.legistar.com/LegislationDetail.aspx?ID=5067210&GUID=0F614E0D-5DED-4877-9986-3C7DC0D48E5E**

[54] *See* PacifiCorp's 2019 Integrated Resource Plan, Table – 2019 Supply-Side Table (2018$) (PDF p.8) (Total Resource Cost column for Small Modular Reactor 12 ($94.62)), *available at* **https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2019-irp/2019-irp-presentations-and-schedule/2018-10-092%20-%20Supply-Side%20Resource%20Table.pdf**.

[55] *See* Idaho Power Amended Integrated Resource Plan (January 2020), Figure 7.6 p.94 (Levelized cost of energy (at stated capacity factors) in 2023 dollars), *available at* **https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/2019/2019_IRPUpdated.pdf**.

TREASURY-BACKED LOAN GUARANTEES

In Title XVII of the Energy Policy Act of 2005, Congress created the Department of Energy (DOE) Loan Guarantee Program to support financing for projects employing 'innovative' technology that would "avoid, reduce, or sequester," air pollutants of greenhouse gas emissions. Qualifying facilities including advanced nuclear energy facilities can then find financing at discounted rates and reduce overall costs. But by guaranteeing that loans to eligible projects would be repaid by DOE even if the project owners defaulted, the program shifted risk from lenders to taxpayers.

In June 2008, DOE published solicitations for $30.5 billion in loan guarantees, including $18.5 billion for nuclear power facilities, and $2 billion for nuclear fuel cycle "front-end" facilities. The Vogtle Electric Generating Plant in Burke County, Georgia building two new nuclear reactors (Units 3&4) eventually received guarantees. DOE initially awarded the Vogtle project $8.3 billion in loan guarantees, and then another $3.7 billion after significant setbacks. The Vogtle project is now more than $14 billion over budget and five years behind schedule.

DOE still has nearly $11 billion dollars in loan guarantee authority available for other nuclear projects, including SMRs. In January 2020, DOE reissued its solicitation for loan guarantee applications that need financing to deploy advanced nuclear technology. The solicitation explicitly lists SMRs as projects eligible for nearly $9 billion in loan guarantees. With large reactors discredited by the experience of the Vogtle plant and the now-shuttered reactor construction at the V.C. Summer power plant in South Carolina, SMR developers, UAMPS and NuScale in particular, are poised to take advantage of the subsidy.

NUCLEAR PRODUCTION TAX CREDIT

Another lucrative incentive for new SMRs is the nuclear production tax credit. For advanced nuclear plants that come online, including any new SMR plant like the CFPP, the tax code provides a credit against income taxes for every kilowatt hour of electricity produced.

Unlike tax incentives for most early-stage energy industries, this tax credit will never expire. The credit is available in perpetuity for the next nuclear plants to come online until the cumulative nameplate capacity of new reactors reaches 6,000 MWe. If future SMRs produce 60MWe each, the credit will be available to the next 100 reactors. In total, the nuclear PTC could cost taxpayers up to $6 billion.

It is important to note that the $1.4 billion is subject to future appropriations. After the reduction in plant size, it is harder to justify the same magnitude of taxpayer subsidy for a project at only half its original scale. Without the $1.4 billion from DOE, it is unlikely that UAMPS can reach its price target of $58/MWh. UAMPS has also made it clear that the DOE share will be used in the earliest stages of the project when the risk is highest, so if the project fails it will be taxpayers' money that is lost first.

What should also be concerning for taxpayers is the lack of transparency from UAMPS and NuScale. Ballooning construction costs were not revealed to the public in real time. UAMPS has also failed to disclose the decision to downsize, the unexpected offramp and their operator dropping out. Until recently, UAMPS has also refused to disclose what methodology they use to conduct their Economic Competitive Test (ECT) that provides their target price, leaving the general public with no way to verify the numbers they publish.

Including the initial NERI grant, DOE has spent $450 million through at least six different grants to develop and support the NuScale Power Module. The agency has obligated another $30 million already and plans to funnel $1.4 billion to NuScale and UAMPS. Even with the tenuous $1.4 billion, the fate of the CFPP remains uncertain.

The Steep Path to SMR Production

In 2015, the Government Accountability Office (GAO) published a report evaluating the status and challenges of SMR development and deployment.[56] The report identified several technical, safety, regulatory, and economic hurdles to achieving commercial viability. It noted that light-water SMRs' claims of economic competitiveness will be undermined if developers can't prove their

[56] GAO, Technology Assessment: Nuclear Reactors: Status and Challenges in Development and Deployment of New Commercial Concepts. GAO-15-652. Published: Jul 28, 2015. Publicly Released: Jul 28, 2015. https://www.gao.gov/products/gao-15-652

reactors can operate safely with reduced security and operations staff and without added design complexity that drives up construction and maintenance costs.

However, even with NRC approval of their Design Certification Application — and potentially billions of dollars of DOE support — NuScale and UAMPS still face the problems of project delays and cost overruns. Their example reaffirms the GAO report's assessment of potential risks for SMRs — long timeframes, high costs and uncertainties.

The argument that SMRs are more economical than conventional reactors is based on the economies of mass production, and a steep, positive learning curve, according to M.V. Ramana, a physicist and professor at Princeton University and the University of British Columbia:[57]

> ***"SMR proponents argue that they can make up for the lost economies of scale two ways: by savings through mass manufacture in factories, and by moving from a steep learning curve early on to gaining rich knowledge about how to achieve efficiencies as more and more reactors are designed and built. But, to achieve such savings, these reactors have to be manufactured by the thousands, even under very optimistic assumptions about rates of learning. Rates of learning in nuclear power plant manufacturing have been extremely low. Indeed, in both the United States and France, the two countries with the highest number of nuclear plants, costs went up, not down, with construction experience."***

The economics of SMRs are almost a "Catch-22":[58] the economies of mass production cannot be proven until SMR units are being mass produced, but producing SMRs at scale requires investment that is not forthcoming because the technology and business case are still unproven.

Recent developments of large-scale, gigawatt-level nuclear power plants would seem to bolster proponents of SMRs. After almost 30 years of no new nuclear plant, two projects started construction but both experienced significant setbacks. The Vogtle reactors in Georgia are more than five years overdue and $14 billion over budget.[59] In South Carolina, the V.C. Summer plant project was abandoned after its contractor, Westinghouse Electric Company, LLC filed for bankruptcy in 2017,[60] by which point $9 billion had already been spent on the project, leaving ratepayers with a huge debt obligation which will likely be reflected in power bills.[61] These project failures make the SMR argument of smaller upfront construction cost and economies of mass manufacturing sound convincing. However, NuScale also has a history of design delays and the cost of the CFPP project ballooned from $3.1 billion to $6.1 billion from 2014 to 2020. The construction of the first SMR plant is capital intensive and faces the prospect of further delays and cost overruns, which should raise similar concerns for policymakers, taxpayers, and stakeholders.

To date, there is no general consensus on the construction cost of SMRs, or the levelized cost of electricity[62] that SMRs will produce, due to different methodologies and assumptions of the learning curve — or how big of an effect of economies of scale will play. A study funded by DOE in 2011[63] calculated the LCOE of the First-Of-Its-Kind plant that consists of 6 units of 100 MWe SMRs at $91.17/MWh in 2011 dollars and the Nth-Of-A-Kind plant at $60.95/MWh in 2011 dollars. PacifiCorp, an electric services company, estimated the cost of energy

[57] M.V. Ramana, "Are thousands of new nuclear generators in Canada's future?", The Tyee. Nov 7 2018. **https://thetyee.ca/Opinion/2018/11/07/Nuclear-Generators-Canada-Future/**

[58] Edwin Lyman, Small Isn't Always Beautiful: Safety, Security and Cost Concerns about Small Modular Reactors. Union of Concerned Scientist. September 2013. **https://www.ucsusa.org/sites/default/files/2019-10/small-isnt-always-beautiful.pdf**

[59] Taxpayers for Common Sense, DOE Loan Guarantee Program: Vogtle Reactors 3 & 4, Mar 21, 2019. **https://www.taxpayer.net/energy-natural-resources/doe-loan-guarantee-program-vogtle-reactors-3-4-2/**

[60] Taxpayers for Common Sense, Westinghouse Bankruptcy Shows Cost of Energy Department Ignoring Risk, Apr 6, 2017. **https://www.taxpayer.net/energy-natural-resources/westinghouse-bankruptcy-shows-cost-of-energy-department-ignoring-risk/**

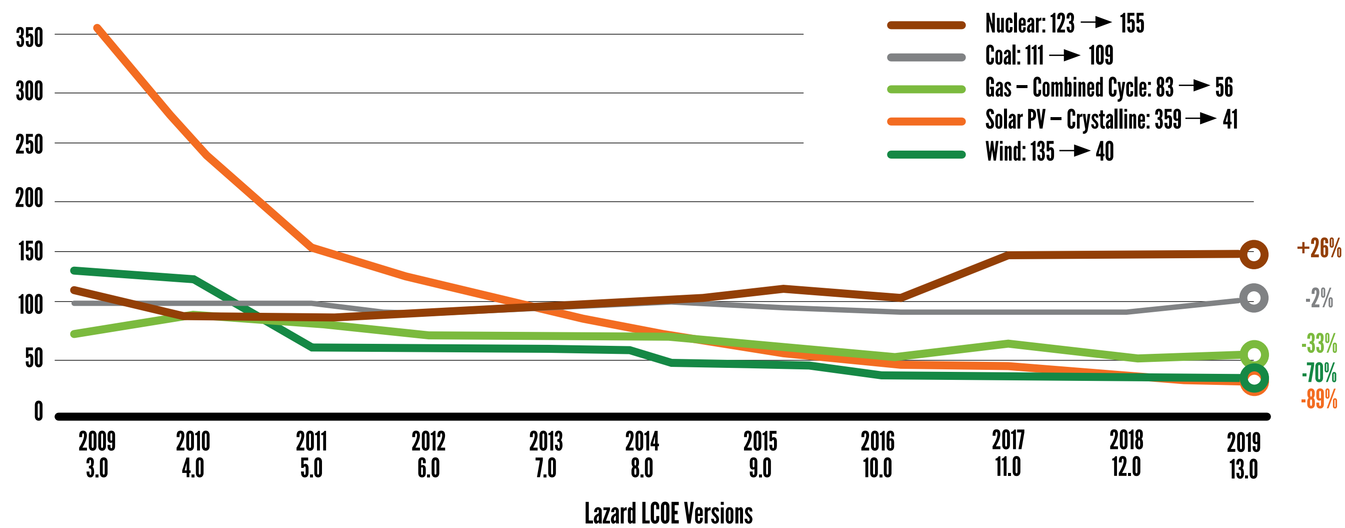
[61] M.V. Ramana, Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Reactors, Oregon Physicians for Social Responsibility, September 2020. **https://sppga.ubc.ca/wp-content/uploads/sites/5/2020/09/EyesWideShutReport_Final-30August2020.pdf**

[62] Levelized cost of electricity (LCOE) measures lifetime costs divided by energy production and calculates the present value of the total cost of building and operating a power plant over an assumed lifetime. **https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf**

[63] R. Rosner and S. Goldberg, Small Modular Reactors — Key to Future Nuclear Power Generation in the U.S. Energy Policy Institute at Chicago. The Harris School of Public Policy Studies. November 2011. **https://www.energy.gov/sites/prod/files/2015/12/f27/ECON-SMRKeytoNuclearPowerDec2011.pdf**

Fig. 9: Selected Historical Mean Energy Costs by Technology

LCOE values in US $/MWh*



*Reflects total decrease in mean LCOE since Lazard's LCOE VERSION 3.0 in 2009

for a 12 module, 570MW plant at $95/MWh[64] and Idaho Power, another electrical power utility, put their levelized cost of energy estimate of a 60MW SMR plant at $121/MWh.[65]

Moreover, according to Lazard, a financial advisory and investment bank, traditional nuclear is nowhere near competitive compared to other energy sources and it remains uncertain whether SMR plants can really be cheaper than traditional nuclear plants. Even if UAMPS and its CFPP plant can achieve a levelized cost of $58/MWh, it will still be barely competitive against gas, wind and solar, as illustrated by Figure 3 above.

Advanced Reactors — SMRs and Beyond

Although the future of SMRs remains uncertain, the nuclear industry and Congress are ready to fund more projects with "advanced" nuclear reactors. Advanced reactor concepts research and development has been funded for years, since FY2011, and the program evolved from DOE's previous R&D effort, Generation IV. The SMRs discussed in this report still use the light-water reactor technology used by all existing nuclear plants in the United States. Advanced reactors refer to non-light-water reactors that use other cooling methods like liquid sodium, helium gas, or molten salts instead of water. DOE announced X-energy and TerraPower as the two awardees under the program, with each receiving $80 million in grants. DOE committed to providing up to $3.2 billion to X-energy and TerraPower for the total duration of the award — anticipated to last seven years.

The future of advanced reactors is even more uncertain than the prospects for SMRs broadly. The 2015 GAO report[66] assessed that new (non-light-water based reactors) face even more challenges in terms of timeframes, high costs and uncertainties than light-water based SMRs. Existing NRC regulations were designed for existing light-water-based reactors and have not been adapted for nuclear technologies significantly different from light water reactors. High upfront capital costs stretched over long periods, and intensive research, development, and licensing applications make it difficult for

[64] *See* PacifiCorp's 2019 Integrated Resource Plan, Table – 2019 Supply-Side Table (2018$) (PDF p.8) (Total Resource Cost column for Small Modular Reactor 12 ($94.62)), *available at* **https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2019-irp/2019-irp-presentations-and-schedule/2018-10-092%20-%20Supply-Side%20Resource%20Table.pdf**.

[65] *See* Idaho Power Amended Integrated Resource Plan (January 2020), Figure 7.6 p.94 (Levelized cost of energy (at stated capacity factors) in 2023 dollars), *available at* **https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/2019/2019_IRPUpdated.pdf**.

[66] GAO, Technology Assessment: Nuclear Reactors: Status and Challenges in Development and Deployment of New Commercial Concepts GAO-15-652 Published: Jul 28, 2015. Publicly Released: Jul 28, 2015. **https://www.gao.gov/assets/files.gao.gov/assets/gao-15-652.pdf**

advanced reactor projects to find investors. A recent paper by the Union of Concerned Scientists[67] assessed the safety, sustainability, and proliferation risk of advanced reactors compared to conventional light-water based reactors. It found that even though some advance reactor designs can be more sustainable in terms of waste generation and resource efficiency, the improvements cannot justify the increased safety and nuclear proliferation risks; many advanced reactor designs call for high-assay, low-enriched uranium fuel (uranium enriched to between 10 and 20 percent), which has higher proliferation risk than the lower-assay enriched uranium (enriched to less than 5 percent) used by current light-water reactors. A recent GAO report[68] highlighted similar problems faced by microreactors, which are reactors with an output less than or equal to 50 MWe with either conventional light-water reactor designs or advanced reactor technologies. Again, the microreactors based on advanced reactor technologies would need high-assay, low-enriched uranium (HALEU) which has greater security and proliferation risks. Furthermore, HALEU is not commercially available in the United States. The regulatory challenges persist since the last GAO technical assessment on new reactors came out in 2015.

[67] Lyman, Edwin. 2021. "Advanced" Isn't Always Better: Assessing the Safety, Security, and Environmental Impacts of Non-Light-Water Nuclear Reactors. Cambridge, MA: Union of Concerned Scientists. **https://doi.org/10.47923/2021.14000 https://ucsusa.org/resources/advanced-isnt-always-better**

[68] GAO, Science & Tech Spotlight: Nuclear Microreactors GAO-20-380SP Published: Feb 26, 2020. Publicly Released: Feb 26, 2020. **https://www.gao.gov/assets/gao-20-380sp.pdf**

Conclusion

The SMR closest to commercialization in the U.S. enjoys lavish ongoing support from federal taxpayers, can expect to claim millions of dollars in available tax breaks, benefits from uranium fuel-cycle subsidies and liability protections, and yet, its prospects remain precarious at best.

Delays and cost increases that inevitably accompany first-of-a-kind projects will only worsen the SMR's economics and deter future investors. Other advanced reactor designs face even higher hurdles to viability.

Confronting the climate crisis, policymakers are quick to embrace nuclear innovation and protectionism as one theoretical answer as the Department of Energy and Congressional appropriators continue to pour billions of dollars into nuclear industry development while contemplating enormous bailouts for existing plants.

However, nothing suggests that taxpayers or the global climate will realize a tangible return on the costly nuclear investment. Propping up unproven, advanced nuclear reactor concepts at enormous costs to taxpayers, only to have one or two new plants produce power in the next 20 years, fails to meet the basic tests of prudent policymaking.

ABOUT
Taxpayers for Common Sense

Taxpayers for Common Sense is a national budget watchdog and independent taxpayer advocate dedicated to increasing transparency and exposing wasteful and corrupt government spending. Founded in 1995 as a 501(c)(3) organization, Taxpayers believes the federal government should operate efficiently and live within its means.

Taxpayers promotes government spending decisions that reflect national priorities and encourages common sense solutions to complex policy problems.

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