U.S. promotion of nuclear power during the Biden administration

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The Biden Administration allied with nuclear-power and climate activists in Congress to sustain nuclear power in the U.S. by subsidizing the operation of existing nuclear power plants, co-financing the construction of prototypes of small-modular reactors, and refurbishing and bringing back on line large power reactors that utilities had retired.

The administration also attempted to remove a political albatross hanging on the nuclear power industry's neck: the inability of the U.S. to site a deep underground spent fuel repository, by promoting research on spent fuel reprocessing and plutonium recycle. Previous Democratic administrations had opposed reprocessing since 1974, when India used plutonium separated with US assistance to test a "peaceful" nuclear explosive.

The Biden Administration also joined with the nuclear energy industry in promoting the production of "high-assay" low-enriched uranium (HALEU) to fuel some of the small modular reactors whose success it was betting on.

Subsidies for continued operation of US nuclear power plants

Seventeen of the fifty U.S. states have deregulated electricity markets.[1] In those states, powerplants must compete by price while, in regulated states, if a powerplant is licensed for construction, the owners are guaranteed a fixed return on their investment.

In many of the deregulated states, the operating costs of aging nuclear power plants are higher than the costs of new natural-gas-fired or wind or solar power plants. As a result, thirteen of about one hundred U.S. nuclear power reactors were shut down between 2013 and 2022.[2]

To slow this process, between 2017 and 2019, five states (New York, Illinois, Connecticut, New Jersey and Ohio)[3] began to subsidize the continued operation of reactors at a rate of about $100 million per reactor-year.[4] The motivations for these subsidies included the fact that nuclear power plants are much more climate friendly than fossil-fueled power plants and a desire to preserve the 500 to 800 high-paid local jobs associated with each nuclear power reactor.[5]

The Illinois and Ohio subsidies were also associated with utility bribes to legislative leaders resulting in prosecutions and cancellation of the Ohio subsidy.[6]

State subsidies have become less necessary, however, since Congress allocated up to $6 billion in the 2021 Infrastructure, Investment and Jobs Act to subsidize the continued operation of nuclear power plants that otherwise would be shut down.[7] In 2023, California, which had combined its nuclear phaseout policy with promotion of renewable energy and energy efficiency, accepted a $1.4 billion federal loan to enable its last nuclear power plant, Diablo Canyon, to operate for at least an additional five years.[8]

Refurbishing and bringing shutdown nuclear power plants back on line

In September 2024, the Biden Administration provided Holtec, a spent-fuel-cask production company that has expanded its business into nuclear power plant decommissioning, with a $1.3 billion subsidy and a $1.5 billion loan guarantee to bring back on line the shutdown Palisades 800-MWe nuclear power reactor in Michigan.[9]

Tech companies, projecting enormous power requirements for data centers required by artificial intelligence, are also looking into the possibility of bringing not-yet-decommissioned nuclear power plants out of retirement. Recently, Constellation Energy announced plans to spend $1.6 billion to revive Three Mile Island Unit I (adjacent to the decommissioned Unit 2, whose core melted in 1979) after entering into a 20-year contract to provide electric power to Microsoft.[10]

No new large power reactors

Vogtle 3 and 4, the last two large power reactors completed in the United States (1.1 GWe each) went into operation in Georgia in 2023 and 2024, seven years behind schedule. Their final cost was about $16.5 billion per gigawatt (GWe) of generating capacity – double the estimate on which the state regulators originally based their approval of the construction permit.[11] According to Lazard, the cost of the electricity being generated by these two reactors is five to six times that from natural-gas-fired, solar or on-shore wind plants.[12]

Construction of two other reactors of the same design (Westinghouse AP-1000) in adjoining South Carolina was abandoned after an expenditure of $9 billion. Westinghouse Electric Company, which pioneered the design and construction of pressurized water reactors and built more power-reactor capacity worldwide than any other vendor, was bankrupted by billions of dollars in penalties.[13]

Small modular reactors

The US Department of Energy's Office of Nuclear Energy has shifted to the promotion of "small modular reactors" (SMRs) with generating capacities of a tens to hundreds of megawatts (MWe) and "microreactors" with capacities of a few MWe in the hope of better results. Thus far, that has not been the case.

In 2013, during the Obama Administration, the US Department of Energy began promoting SMRs with $0.1 billion to incentivize a partnership between BWXT, which builds propulsion reactors for the U.S. Navy, and Bechtel, a construction and project-management company.[14] The companies were unable to attract private investors, however, and quietly dropped the effort in 2017.[15]

DOE's next effort, in 2020, focused on a design for a small light-water-cooled power reactor (LWR) developed by its remaining nuclear-energy laboratory, the Idaho National Laboratory (INL), in partnership with Nuscale, a nuclear startup.[16] DOE committed up to $1.4 billion to Nuscale to build a cluster of these small LWRs – initially a dozen 50 MWe reactors and later six uprated to 77 MWe – on the INL site.[17] The project was abandoned three years later, however, after the projected cost of its electric power rose above what local utilities were willing to pay.[18]

In the meantime, INL convinced DOE's Office of Nuclear Energy to look at other reactor types that had been explored in the 1960s and 1970s but abandoned then as not competitive with light water reactors. INL urged in particular that liquid-sodium and helium-cooled reactors deserved another chance.

In late 2020, Congress authorized an "Advanced Reactor Demonstration Program"[19] under which DOE has committed matching funding of up to $2 billion to a Bill Gates nuclear startup, *Terrapower*, to build a 340-MWe liquid-sodium-cooled *Natrium* power reactor in Wyoming.[20] The design is based on INL's Experimental Breeder Reactor II, which the Clinton Administration shut down in 1994.

DOE also committed up to $1.2 billion to another nuclear startup, X-energy, to build a "four-pack" of 80-MWe *X-100* helium-cooled reactors with "pebble-bed" cores based on a design developed but not commercialized in Germany. The design had previously been picked up by nuclear engineers at China's Tsinghua University and used in a twin-unit 150-MWe demonstration plant, Shidao Bay 1, that went into operation in 2023. The plant's construction took several years longer than originally planned, however, and the original plans for an additional nine twin units have not been implemented.[21]

Congress' authorizing legislation required that the reactors be completed within seven years of DOE's funding commitment[22] (i.e. in early 2028). As of mid-2024, however, Terrapower had just submitted a construction application for *Natrium* reactor to the US Nuclear Regulatory Commission,[23] and X-Energy was still in a pre-application stage.[24]

In parallel, the U.S. Department of Defense has been required by Congress to fund the development of "microreactors" to power some of its military bases. The Air Force awarded a contract for a prototype 5-MWe reactor at an Alaska base but had to withdraw it because of contracting irregularities.[25]

The Department of Defense is also funding construction of a prototype 1 to 5 MWe gas-cooled portable microreactor to be tested at the Idaho National Laboratory for potential use "at U.S. Military Forward Operating Bases, Remote Operating Bases, and Expeditionary Bases".[26] Critics question the wisdom of siting reactors in conflict zones. Also, IAEA safeguards are required on the fuel of reactors located in non-nuclear-weapon states.[27]

High-assay low-enriched uranium (HALEU) fuel

Traditional water-cooled power reactors are fueled with uranium enriched to less than 5 percent U-235. Many of the reactor designs currently being backed by DOE's Office of Nuclear Energy, however, require higher enrichment. The *X-100* reactor core is expected to be 15.5% enriched[28] and that of *Natrium* "up to 19.75%."[29]

The IAEA does not consider uranium enriched to less than 20% as "direct-use" material that can be used to make a nuclear weapon without further enrichment.[30] Recently, an article in *Science* magazine pointed out that this conclusion was originally associated with a quantity limit of of 31 kg for the amount of 20% enriched uranium that could be provided in research reactor fuel to a country. *Natrium's* initial core will contain 15 to 20 *tons* of HALEU.[31]

The article therefore called on the National Nuclear Security Administration (NNSA), which oversees the U.S. nuclear-weapon laboratories, to commission an independent study of whether the widescale commercial use of fuel with an enrichment above 10 or 12 percent could significantly lower the bar to nuclear proliferation or terrorism.[32] At the end of the Biden Administration, NNSA Administrator Jill Hruby announced she would ask the National Academies of Science to do such a study.[33] The contract had not been finalized, however, by the time the Trump Administration took over.

Spent fuel reprocessing

Advocates of reprocessing in the U.S. argue that recycling the plutonium and uranium in spent fuel could ameliorate public resistance to hosting deep underground radioactive waste repositories. However, Japan has been as unsuccessful in siting a repository for its reprocessing waste as the U.S. has been for spent power reactor spent fuel. Furthermore, because of the relatively insolubility of plutonium and other transuranics in deep ground water and their low absorptivity from the human gut, it appears that long-lived fission products and radium from the decay of U-238, not transuranics, dominate the hazard from deeply buried spent fuel.[34]

Nevertheless, in 2021, DOE's Advanced Research Projects – Energy (ARPA-E) funded eleven nuclear-reactor startups, national laboratories and universities "to develop and demonstrate breakthrough technologies that will facilitate a 10x reduction in waste volume generation or repository footprint."[35] The following year, 2022, ARPA-E funded a dozen more research projects "to advance [used nuclear fuel] recycling, reduce the volume of high-level waste requiring permanent disposal, and provide safe domestic advanced reactor fuel stocks," i.e. to recycle plutonium.[36]

As already noted, the Biden administration's *laissez faire* attitude toward reprocessing was a departure from that of all previous Democratic administrations since 1974, the year India tested a "peaceful nuclear explosive" with plutonium separated with spent-fuel reprocessing technology supplied by the United States. After that "wakeup" event, the US State Department discovered that Brazil, Pakistan, South Korea and Taiwan – all under military governments at the time – were also pursuing nuclear weapons via reprocessing under the cover of civilian nuclear energy R&D.

There was no cost-benefit analysis by either the Trump or Biden administration before they began their promotion of reprocessing.

The poor economics of reprocessing and plutonium recycle have been demonstrated in France, Japan and the United Kingdom. The French and UK nuclear establishments originally saw reprocessing other countries' spent fuel as an opportunity to earn foreign exchange from the expertise they had developed in separating plutonium for their nuclear weapon programs. But plutonium recycle turned out to be not economic and the customer countries did not renew their contracts.

France forced its government-owned domestic nuclear utility, Électricité de France (EDF), to continue to recycle plutonium in order to sustain its government-owned reprocessing complex. The UK tried to do the same but its nuclear utility had been bought by EDF, which, while it could not say "no" to its own government, was able to refuse in the UK. The UK shut down its reprocessing complex and recently decided that it will dispose of the 117 tons of its own civilian plutonium that it had separated at great expense plus (probably) the 24 tons of foreign, mostly Japanese, separated plutonium marooned in the UK. The government announced that the process of mixing the plutonium into a form suitable for burial will "support thousands of skilled jobs during the multidecade design, construction and operational period." In other words, it will be extremely costly.[37]

Japan's involvement with reprocessing has been equally disastrous. It is still attempting to complete and license a large reprocessing plant that was originally supposed to go into commercial operation in 1997. The construction cost of the plant has reached $21 billion and its estimated lifetime cost, including operation and decommissioning, is now estimated at about $100 billion.[38]

Conclusion

Nuclear power is not economically competitive today in most countries, including the United States. With the exception of China, its economics are worsened by the low rate of construction of nuclear power plants and thereby the loss of nuclear-qualified workers.

The huge costs of the two new AP-1000 reactors in Georgia and the cancellation of the construction of two in South Carolina appears to have ended the era of construction of large power reactors in the United States. Nuclear power advocates have shifted their focus to smaller reactors and political coalition building to support government investments to accelerate the transition away from fossil fuels has resulted in government cost-sharing for some nuclear startup projects. The first project has been abandoned, however, and the next two are delayed. Thus far, only government subsidies for the continued operation of some aging U.S. conventional power reactors has had any impact in slowing the decline of U.S. nuclear generating capacity.

The first market for small modular reactors may be to power the massive data centers that are being built by the big information technology (IT) companies racing to exploit artificial intelligence. Hundreds of billions of dollars are being spent in this competition and there is little evidence of serious analysis of the economics of small modular reactors in comparison with other climate-friendly alternatives.

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