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Futuristic nuclear energy tech is here, but the risks of bombs and another Chernobyl remain

Microreactors promise climate resilience and military-tech might — but proliferation and pollution concerns linger

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James Walker thinks it's time to change the story we tell ourselves about nuclear energy in the United States.

"It's got the worst public relations history of any form of energy really," Walker tells me in a video call from his office. "If you take all methods of generating energy — whether it's wind, solar, gas, coal, everything — and if you want to look at deaths per gigawatt hour, nuclear beats out everything. It is the safest form of energy already. So that's a good way to start."

Walker is the CEO and head of reactor development at NANO Nuclear Energy. And he may have gotten his wish on Wednesday when President Joe Biden rolled out his administration's multi-billion-dollar funding plan for U.S. nuclear energy projects, all aimed at meeting the country's 2035 goal of a carbon-free power sector. The plan includes large plant development, like Georgia's $36.8 billion Plant Vogtle expansion, as well as a fleet of cutting edge small-nuclear tech.

NANO makes small modular reactors (SMRs) and microreactors. Basically, these are advanced nuclear power plants that can produce an astonishing 7.2 million kilowatt hours per day depending on the model, but can still fit inside the trailer of an 18-wheeler. While most microreactors can output up to 20 megawatts in order to reach that number, NANO's models emphasize the micro — with output capped at about 5 megawatts of thermal energy for conversion to electric.

For context, you can power between 400 and 900 homes per day on just 1 megawatt (MW.) Even at its lightest, an average military base has a hefty critical power load of about 20 MW daily. Data centers have even greater range, using between 10 and 200 MW to keep servers running for the apps we tirelessly doomscroll. Meanwhile, U.S. mining operations — like those digging 20,000 metric tons of zinc out of the Arctic each day — use up to 450 MW. Biden, along with industry barons and military-minded Republican allies in Congress, is banking on SMRs and microreactors to satisfy the colossal energy appetite of all four.

"The way this began was actually a conversation with mining companies because their remote operations are heavily reliant on diesel. It needs sort of a daily importation of that and there are tens of thousands of mines that obviously produce the minerals that we all subsist on. But they're very energy intensive and they use a lot of diesel and that can kill the economics of the operation," Walker explains.

Though military SMR tinkering has occurred since at least 2008, the four industries together have driven a surge in nuclear development amid the climate crisis and oil-trade politicking of the past decade. Now, with its initial offering in May and a board that includes former New York Gov. Andrew Cuomo, NANO has become the first microreactor company in the U.S. to go public.

"There are five major companies we're talking to. One of the big majors we're talking to is looking for microreactor solutions to power electric vehicles because they have decarbonizing mandates," Walker said. "The process heat that a reactor generates could concentrate more, and in more remote locations, so you have to move less. So the amount of

diesel they would save would be tremendous. They would really like to have a very beneficial impact on lowering overall emissions across the world if you were to replace all these systems."

Big Tech's data center surge may be dwarfed by the mining companies that feed gadget-factory production lines, but not for long. There are around 30,000 data centers across the U.S. and Europe, and a February study from the International Energy Agency found that "electricity consumption from data centers, artificial intelligence and the cryptocurrency sector could double by 2026."

Biden's COP28 proposals have already faced criticism earlier this year from college Democrats and other climate-focused groups over the Willow Project, an Alaskan oil and gas drilling project. In his latest bid to "reestablish U.S. leadership" in nuclear energy, the president also included a hefty tax credit for it. Recent industry research from The Rhodium Group estimates that by 2035, these credits could result in a 29% to 46% cut in greenhouse gas emissions — or roughly 300 to 400 million toens — compared to no tax credits.

Biden's playbook on climate change includes less risky green energy like wind and solar, seeming to position small-nuclear as a transitionary energy source in some areas. But if regulations are slipshod, a plutonium-producing gamble in a warhead-hungry world could lead to incalculable losses — at a speed far faster than that of our melting glaciers.

Question: How does nuclear waste become a nuclear bomb?
At the heart of the controversy around retrofitting America for nuclear energy is a decades-old global bulwark against nuclear weapons proliferation: We manage spent nuclear reactor fuel with extreme surveillance and we don't want everyone to commercially reprocess it because that's how you get atomic bombs.

As the Bulletin of Atomic Scientists put it in 2023, "effective nonproliferation must begin much earlier, not only by suppressing demand for nuclear weapons but also by restricting supplies of the fissionable materials necessary to build them in the first place."

When making fuel for nuclear reactors, the first step is to dig up a bunch of uranium ore and haul it to a processing outfit like the White Mesa Mill in Utah — our only such facility. There, the ore gets turned into uranium oxide or what is commonly known as "yellowcake" because of its bright lemony color.

The yellowcake is then converted for enrichment. Here, two roads diverge: you can either create highly-enriched weapons-grade yellowcake, or low-enrichment yellowcake for nuclear reactor fuel. Now that Biden has banned enriched uranium imports from Russia, his nuclear revival could mean a lot more mining of the stuff.

Walker says the enrichment and explosion risks of advanced nuclear reactors are far less than what they were in the Eisenhower era. He's not worried about a terrorist trying to blow up a reactor.

"A reactor can't blow up is the first thing I would say. It's not enriched to a level where that could happen. Like you would need a weapons-grade material, at like 90-plus percent enrichment. Conventional reactors are enriched to like two to three percent. And even the advanced reactors that are enriched to 20%, if you were to fire or miss all of those things, they would not blow up," Walker explained, pointing out that nuclear power is only generated by getting a critical mass of material together. "It actually becomes cooler and less dangerous, which is kind of ironic."

"The uranium is not a problem actually in a dirty bomb. The initial homemade device that you built is the more dangerous thing," Walker added. His experience working with submarines has put him in close enough contact to test this himself.

"Uranium could be picked up, as an example, like fuel plates that go into submarines that are enriched to a much higher level," he said. "You can handle those, and I've handled those things in the past."

But even when you take the low-enrichment road, the risk isn't over. About a fifth of U.S. energy is already being generated by 93 commercial nuclear plants. And those are adding 2,000 metric tons of spent nuclear fuel each year to the 88,000 metric tons of waste already being stored at 79 sites across 35 states. That's not counting the additional load of low-level and intermediately radioactive waste the plants produce.

The compelling thing about spent fuel is it still has a lot of power that can be used. In some cases, a nuclear reactor uses only 10% of the potency in fuel, meaning some waste can still retain a tantalizing 90% of its original potency. Storing this waste is already a volatile and risky business. Transporting it for either storage or reprocessing — as one would need to for modular, moveable reactors — it is even riskier.

Like plutonium. You get plutonium by separating it from spent reactor fuel. Excluding France and Russia, the U.S. has been successfully clamping down on nuclear proliferation ever since India used Canadian-gotten plutonium for its 1974 atomic bomb test. In 1977, then-President Jimmy Carter joined with Canada's former Prime Minister Pierre Elliot Trudeau (yes, that's Justin's daddy) on a hard-won campaign to halt commercial spent-fuel processing across the globe.

Now, SMR companies like Oklo — the nuclear energy company backed by OpenAI CEO Sam Altman — want to reprocess and recycle that used reactor fuel, deploying their commercial tech "on a global scale." Biden's nuclear renaissance, meanwhile, includes $87 million in funding for 30 projects in the Energy Department's advanced nuclear research program "with the aims of lower capital costs, lower (operation and management) costs, and reducing spent fuel."

For all the climate concerns expressed by the administration, the push for nuclear microreactors is also undeniably about fueling the Defense Department's staggeringly large energy consumption more cheaply as relations with America's oil suppliers remain uncertain. The DOD eats more than 10 million gallons of fuel per day and burns through more than 30 terawatt hours of electricity per year. And, as reported by Business Insider, the department projects that number to grow significantly over the next few years.

In January of this year, Republican lawmakers were already pushing the Pentagon's U.S. Indo-Pacific Command admiral to ask for more nuclear microreactors in his 2025 budget request.

Here, nuclear science calls for pause. It takes less than 20 pounds of plutonium to make a simple nuclear weapon. It's so dense that if you wanted to build a replica of the atomic bomb the U.S. dropped on Nagasaki, you would only need a chunk of plutonium about the size of an arcade Skee-Ball.

And based on the science we're currently working with, the entire cycle of nuclear power creation from start to finish is still a hyper-sensitive process with razor thin safety margins. It currently relies on a web of federal infrastructure — from roads to waterways, to the vehicles and casks used to transport and store nuclear waste — whose regulation has been eroded by decades of Congressional starve-the-beast funding cuts and multi-industry lobbying efforts which have paid off in self-policing regulatory policies.

The nuclear reactor development of today is not taking place on freshly built New Deal highways and utility lines, but on a network of infrastructure worn threadbare in many places and currently teeming with an undiscoverable number of cyber-intruders. The science and safety have advanced, yes, but so has municipal deterioration and the surface area for new kinds of attacks. And plutonium is still plutonium.

Answer: Oversight

The problem with SMRs and Biden's nuclear plant renaissance is not just that radioactive nuclear waste can be weaponized into plutonium. It's also that nuclear waste has effectively already been weaponized against poor communities in the U.S. through the deathsome sprawl of federal superfund sites still poisoning both humans and ecosystems across the country. Another problem is that federal nuclear regulators have already been producing urgent reports about current spent-fuel safety risks — some of which even feature images of the Titanic sinking and the letters "SOS."

Biden's nuclear energy rebranding effort brushes past SMR waste safety concerns by pointing to "stringent federal regulation that keeps nuclear plants and neighboring communities safe" under the Energy Department's Nuclear Regulatory Commission.

"Many advanced reactors plan to use advanced fuel designs that have the potential to further improve the safety and operation of nuclear plants," the Office of Nuclear Safety said Wednesday in its new primer. The new fuels are "also expected to perform even better than current nuclear fuels and could extend the time between refueling, which would reduce the amount of spent fuel generated over the lifetime of a reactor."

Advanced reactor types range, the office said, but "one thing they share in common is the ability to achieve enhanced efficiency, safety, and versatility over conventional reactor designs."

It's true that some industry analysts claim SMRs produce less waste than traditional reactors, but the full slate of SMR models in the Biden plan haven't been completely tested. A May 2022 study from Stanford researchers debunked a number of industry analyst claims, proving most models' spent-fuel risks and hidden waste-reprocessing costs often far exceed those found in popular estimates.

"Our results show that most small modular reactor designs will actually increase the volume of nuclear waste in need of management and disposal, by factors of 2 to 30 for the reactors in our case study," said Stanford's Lindsay Krall, the study's lead author and a former MacArthur Postdoctoral Fellow. "These findings stand in sharp contrast to the cost and waste reduction benefits that advocates have claimed."

On May 28, the U.S. Nuclear Waste Review Board echoed some of those concerns and pointed to risks still posed by older sites' fuel management ahead of Biden's newly planned slate of fuels. In an 11-page letter, Board Chair Nathan Siu cautioned the DOE that while current types of spent nuclear fuel can be transported and stored without compromising national safety standards, verifying safe storage for such a wide range of new spent-fuel types would require private companies to show their cards.

"It is not yet clear that the results of the (spent fuel) Data Project testing for irradiated pressurized water reactor assemblies will bound all existing or new types of spent nuclear fuel … which will soon join the inventory," Siu wrote, suggesting that safety-testing these new types could "include accessing commercial fuel vendor data."

The same document points out that commercial plants have already been caught producing wastewater that fails safe-storage radiation standards by a significant margin. In one case, a damaged heap of commercial spent-fuel rods from Michigan's Big Rock Point nuclear power plant were over-stuffed into some casks that were meant to be taken to a storage site via train. But it was discovered that the casks contained so much radioactive water that the whole transport operation had to be paused in 2001 — for years.

"Eventually, the casks were approved for transportation by the NRC and were shipped by rail from the West Valley Demonstration Project to Idaho in July 2003," Siu wrote, adding that "the Board notes that this is an extreme example, due to the large number of damaged [spent fuel] rods included in the two casks. Given these examples, there continues to be uncertainty."

Not a place of honor

Of greater concern is the DOE's lack of technical data on dry waste storage conditions. They were most recently detailed in 2019 by the Nuclear Regulatory Commission in a 60-page report, accompanied by a damning slideshow from 2021 that opens with an image of the letters "SOS."

Above an illustration of the Titanic sinking, the report advises: “Transporting uninspected thin-wall canisters across the country will no more solve our nuclear waste problems than rearranging the deck chairs on the Titanic would have stopped it from sinking.”

“As long as NRC allows unsafe dry storage standards, quality vendors with quality products will have problems competing against inferior products,” the NRC says, noting the high risk of physical cracks in containers with already degraded conditions. Some of which are already 35 years old with 40-year licensing limits.

The report says it is “unknown if normal train vibrations will cause fuel rod failure,” but that an interim plan to “return leaking canisters to senders” on America’s perilously degraded rail lines faces immediate problems for companies who have no means of safely handling the waste. The report also notes that there’s a “limit to how long a leaking canister can stay inside transport casks before overheating” but that the canisters may need “decades of cooling” before they can meet transport regulations.

“One canister holds roughly the Cesium-137 released from [the] 1986 Chernobyl disaster,” the report warns. “This is a NOW problem. We cannot kick these ‘Chernobyl cans’ down the road any longer. Consequences are too high.”

The president and the swarm of private companies angling for new reactor contracts — whether micro or massive — face another reality-check in cities like St. Louis, which played a critical role in the Manhattan Project war effort. In July of last year, it took a three-outlet consortium of journalists from the Mississippi Independent, the Associated Press and MuckRock scouring reams of public records to expose federal regulators’ 75-year history of intentionally concealing the lethality of a superfund site.

“Presented with details of the newly-revealed documents, Dave McIntyre, a spokesperson for the NRC, said in a statement that the agency conducted numerous investigations and studies at the West Lake Landfill over a period of almost 20 years that were ‘extensively documented.’ It transferred authority to the EPA in 1995 and directed further questions to the agency,” reports the Missouri Independent’s Allison Kite.

Even with these urgent risks exposed, and many unknowns lingering, nuclear energy proponents argue radioactive waste issues can’t be worse than fossil fuel hazards. Despite the whataboutism of the counter-accusation, they’ve got a point. Fossil fuel emissions in 2023 accounted for 36.8 billion metric tons of heat-trapping carbon dioxide, and are estimated to cause one in five deaths worldwide.

In fact, the heaps of fly ash waste produced by coal-processing power plants are often just as — if not more radioactive — than nuclear waste sites. And few are corralled by the immense regulatory framework of nuclear waste management. Class action lawsuits have begun emerging in recent years as the evidence of toxic ash exposure in children mounts higher.

“If you were to take all the hundreds of reactors that have been produced in the United States, from the inception of nuclear energy in the ‘50s — and that's all the submarines, aircraft carriers, all the nuclear power that's powered the country for 70 years or whatever it is — and you were to take all the waste from all of those, and put it in one place, it wouldn't fill a football field,” Walker said.

“It's the safest form of energy,” he continued. “It generates the least amount of waste. And it's also a type of waste where it gets less dangerous over time, unlike other forms of waste that are generated by fossil fuels and hydrocarbon industry which are permanent — and permanently toxic. And the way of dealing with those things is relatively simple. It can go in concrete, it can sit there, and it just gets less dangerous over time. And there's not very much generated.”

Time, however, is relative. And waste that gets less dangerous over time will still be deadly for at least 10,000 years. In 1993, the Sandia National Laboratory compiled a series of messages and physical warning systems that might withstand the

millenia to warn descendents away from the sites, preparing for all future outcomes, including one in which language is radically different from today.

“We considered ourselves to be a powerful culture,” the message reads. “This place is not a place of honor. No highly esteemed deed is commemorated here. Nothing valued is here. What is here was dangerous and repulsive to us. The danger is still present, in your time, as it was in ours.”

“The danger is to the body, and it can kill,” it continues. “The form of the danger is an emanation of energy. The danger is unleashed only if you substantially disturb this place physically. This place is best shunned and left uninhabited.”

The designs included a salted-black landscape of thorns over rubble fields, oddly shaped spikes bursting through an incongruent grid of stone blocks, an unsettling off-pattern of roads which go nowhere, menacing symbols like lightning bolts visible from nearby high-ground — all meant to signal the most primitive, instinctual fear of danger in humans. All meant to terrify descendents with the wordless horror of blighted land and trigger the inexplicable rise of hairs on the backs of their neck.

But as dark and apocalyptic as this vision is, it is indeed a hopeful act. To take such pains in composing from the past a message of immutable and timeless horror for the future is to have faith that there will be a future at all. Moreover, that there will be an audience. And that we can somehow convince them — for all our wrongs — we tried to save them too.