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Thinking Small On Nuclear Power

By Josh Freed, Elizabeth Horwitz, and Jeremy Ershow

As the United States transitions to clean energy, we don't have technologies available to meet all our energy needs. Small, modular nuclear reactors (SMRs) could play a critical role in filling some of these technology gaps. SMRs can provide clean, baseload power to utilities of all sizes and will be able to supply direct heat to industrial manufacturing processes. And because many of the leading models are American-designed and can be domestically manufactured, their global deployment could mean tens of thousands of new, well-paying jobs in the United States. In the course of exploring every path to a clean energy future, we should pursue policies that facilitate the development and commercialization of these next-generation reactors.

Earlier this year, shovels broke ground for the first two new commercial nuclear reactors to be built in the United States in more than 30 years.¹ When the project is completed, it will generate enough electricity for 1.7 million households, without any carbon emissions.² This is the promise of new nuclear energy. With most of the nation's available hydropower already harnessed, only nuclear energy is a currently available technology capable of generating consistent amounts of electricity 24 hours a day—known as “baseload” power—at this scale and emissions-free.

But while the first of a new crop of large reactors is a signal moment for clean energy, they represent only part of the opportunity for nuclear energy. Deploying reactors that are smaller and/or employ different technology will give both small and large utilities and independent users like military bases access to scalable, clean, baseload power, and manufacturers will have access to emissions-free process heat.

This isn't science fiction—many models of SMRs are based on the same technology as their larger cousins. And with several leading models exclusively

designed and built in the United States, we can create jobs and grow our economy by building small reactors for domestic use and, ultimately, exporting these reactors to other countries.

THE PROBLEM

We don't have sufficient clean energy technologies to meet our baseload electricity and manufacturing energy needs.

Currently, 50% of electricity in the United States comes from coal,³ with few clean alternatives for baseload energy. Moreover, almost 100% of the heat that drives manufacturing processes is supplied by fossil fuels,⁴ and no clean energy option currently exists. Unless new, clean technologies are brought on-line to supply small-scale baseload electricity and industrial process heat, we won't be able to achieve a comprehensive shift to clean energy.

Our baseload clean power options are one-size-fits-all.

Nuclear power is the sole carbon-free electricity source that is both scalable and capable of meeting baseload power needs. But the only reactors now on the market are large enough to generate power for 750,000-1.2 million households.⁵ These reactors work very well for the larger electric utilities that own them, as well as for the small utilities and coops that partner with them, and they enable producers to benefit from the distribution of large amounts of power across the grid.

Large reactors are a critical clean energy solution for much of the nation, which is densely populated and has heavy and growing demand for electricity. They are not always the best option for smaller power producers, which provide electricity to over 41 million consumers in the United States, and each serves only several thousand customers.⁶ Small utilities and military bases do not always have the demand for electricity, the capital, the access to water, or the available land to build a new nuclear power plant. Without another baseload electricity option, these utilities or other electricity producers have little choice but to rely on fossil fuels.

We have no clean energy source to supply manufacturing process heat.

Manufacturing is a heat-intensive process requiring a lot of generated energy; consider the image of the smelting process used in the steel industry.⁷ Similar quantities of heat are needed for the production of plastics or other chemical manufacturing, or the forging of molten metal into component parts of automobiles, building structures, and windmills.

Yet despite the ubiquity of energy-intensive industries, we currently have no clean energy source deployed that can supply direct heat for industrial processes.

Instead, manufacturers are left to choose among fossil fuels which generate high emissions and air pollution and are susceptible to commodity price fluctuations. Such price fluctuations not only deny industry stable or predictable energy costs, they also raise the danger of domestic companies being undercut by foreign competitors whose governments subsidize fossil fuels.

THE SOLUTION

Help bring small, modular nuclear reactors to market.

The imperative of creating more diverse clean energy applications has spawned the design of several small reactor technologies which will enable a wide range of new clean energy uses. Known as SMRs, they vary between 1/20th and 1/4th the size of large reactors.⁸ There are two streams of development on SMRs—those based on the same concept as existing large light water reactors, and advanced reactors of varying design intended to provide new kinds of capabilities.

Light water SMRs have the scale and flexibility to provide a range of amounts of baseload power. They can incrementally expand capacity at an existing power plant or add new capacity at U.S. military installations that need independence from the grid.⁹ SMRs are financially viable for many utilities, with costs in the hundreds-of-millions of dollars per reactor.¹⁰ Because of the power conversion system of these reactors, they can be cost-effectively cooled by air rather than water. As a result, SMRs can supply cheaper baseload clean energy to arid cities in the West, like Denver or Las Vegas.¹¹ And because they can fit into a small structure and be sized to match the capacity of existing electrical infrastructure, SMRs provide a viable path to retrofitting old power plants with clean energy.¹²

Advanced reactors could open the door to intriguing new possibilities. Some advanced SMRs are being designed to supply heat directly to industrial users, as well as electricity.¹³ This would enable large manufacturers across industries to replace fossil fuels with clean energy. Micro-reactors could be used in remote locations or under circumstances where a self-sufficient energy source is needed for a limited period of time. Others could convert existing nuclear waste into electricity, dramatically reducing problems of waste storage.¹⁴

Support commercialization of SMRs near ready for deployment.

Several U.S. companies are in the advanced stages of developing small reactors that adapt existing technology to produce smaller amounts of baseload electricity.¹⁵ These technologies are nearly ready for deployment. Final decisions about design, siting, and regulatory approval could be made within the next five years.¹⁶ The federal government can take several steps to help make this possible.

First, economic barriers to entry must be lowered. For first movers, costs of licensing, design and regulatory approval will be comparable to those of the larger reactors because existing regulations have not yet been tailored to suit new designs. As the Nuclear Regulatory Commission (NRC) gains expertise in evaluating SMRs, and as economies of scale develop, these costs will decrease. Until this happens, the Department of Energy's new cost-sharing program for near-term licensing and deployment of light water SMRs will help reduce some of the financial impact.¹⁷⁽ⁱ⁾ The NRC also needs to continue its commitment to allocate sufficient resources and build the expertise necessary to evaluate and license SMRs in a timely fashion.

The Department of Energy (DOE) and Department of Defense (DOD) can also prime the market pump by serving as a buyer of first-of-a-kind technologies. This could include deploying SMRs on DOE-owned sites, many of which are already zoned to support nuclear power plants,¹⁸ and appropriate DOD facilities in the United States. DOD, the largest single energy consumer in the U.S., comprises 78% of federal energy use, and is the most significant energy consumer in several metropolitan areas.¹⁹ DOE should also work closely with the private sector to develop standardized designs, with the goal of achieving demonstration and licensing within a decade.²⁰

The potential market for SMRs is global. As we note in "Getting Our Share of Clean Energy Trade," whichever country emerges as the market leader could dominate a good part of the \$6 trillion global energy market.²¹ The U.S. could seize that mantle and all the jobs and exports that come with it. American reactors could be deployed within a decade domestically²² and go global soon after.

Support investment in advanced reactor R&D.

Even more advanced reactor technologies are in development. These reactors are distinguished from current SMRs mainly by the fact that their reactor cores are cooled by helium gas or liquid metal, rather than water.²³ As emerging technologies, this next generation of SMRs has a longer path to deployment, about 10-15 years.²⁴

The federal government can help bring these technologies to fruition by providing intellectual capital and funding to hasten their development. This could include DOE support of advanced SMR research and development through direct funding, as well as research partnerships with the national laboratories. Such continued R&D support is already pending in federal legislation, with a particular focus on perfecting the designs of reactors capable of recycling used fuel.²⁵ Meanwhile, the NRC should further build out its expertise in advanced reactors to be fully prepared to review design certification applications when they arrive.

■ CRITIQUES & RESPONSES

Small Reactors aren't safe.

Small light water reactors will be as safe as existing reactors, which have the safest operational record of any single energy source in the United States.²⁶ SMRs are to be buried underground with extensive containment barriers, and they will have gravity-based triggers to automatically shut-down the reactor in the event of a malfunction.²⁷

Small Reactors are too expensive.

SMRs are likely to be cheaper to manufacture than large reactors, as they can be fabricated substantially in factories. And because they are sized to match the financing capacity of the purchaser, they will not carry the heavy financing charges that large reactors do.²⁸

Although there are reasonable claims that the first SMRs to be deployed will come with relatively high price tags, this is the case with almost all new technologies. As confidence is built in SMR designs, and as a track record on licensing and regulation SMRs is created, the costs of capital for SMR projects will decrease. Economies of scale can be realized in their production and result in substantially lower prices over time.

Small Reactor technology isn't proven.

The light water technology that current SMRs use is well-established; American manufacturers have designed and built small, light water reactors for 60 years to fuel the Navy's carriers and submarines.²⁹ While advanced reactor technology is further off, innovation is necessary to complete the transition to clean energy. Advanced reactor technologies are promising technologies that we need to invest in today.

Small Reactors will be ready when they are ready—we shouldn't spend government money on them.

Getting small reactors deployed quickly is a national imperative. Our energy needs demand it, and the economic upside of becoming a leader in this space is tremendous. Moreover, the moment for economic leadership is fleeting, with emerging international competitors including designs backed by the governments of South Korea, China, India, and Russia.³⁰ The federal government has unique resources to help this happen, and we should put them to use. This includes its research and development from our national labs or the purchasing power of DOD or DOE to create first markets and help drive down costs of first-mover technologies.

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■ ENDNOTES

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