US should begin laying the foundation for new and advanced nuclear reactors, says new report

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New and advanced types of nuclear reactors could play an important role in helping the U.S. meet its long-term climate goals, but a range of

technical, regulatory, economic, and societal challenges must first be overcome, says a new report from the National Academies of Sciences, Engineering, and Medicine.

Development, testing, and widespread deployment of these reactors could take several decades. The report makes recommendations for the U.S. Department of Energy, the Nuclear Regulatory Commission, other federal and state agencies, and private industry to lay the groundwork required for advanced reactors to become a viable part of the U.S. energy system.

Currently, the U.S. electricity system includes large light water reactors (LWRs) that produce electricity for commercial use. LWRs use water to cool the reactor and moderate the speed of the nuclear chain reactions taking place.

Many advanced reactor concepts use conventional fuels, materials, and manufacturing methods, but some also employ a wide array of new coolants, designs, fuels, materials, and technologies. Among these are modular LWRs that are smaller, simpler, and rely mainly on passive safety features. Other examples include reactors that use liquid metal, molten salt, or high-temperature gas as coolants.

The U.S. electricity system is already undergoing massive shifts, but economy-wide decarbonization efforts will span decades, and electricity demand is projected to continually grow over that period. Advanced nuclear technologies likely will not be able to markedly contribute to electricity generation until the 2030s at the earliest, the report says, but there are opportunities for them to compete with other energy technologies in the long term.

Innovative ideas for reactors, if fulfilled, may provide on-demand power generation to complement variable sources of energy, such as solar and

wind energy, and help decarbonize challenging industrial sectors by providing high-temperature heat for chemical processes, such as hydrogen production.

Some advanced nuclear reactor concepts, due to their size or the way they are to be produced, offer new ways for nuclear power to be used, including:

- Major portions or even the entirety of the reactor system could be produced in factories, potentially reducing project costs and uncertainties and increasing quality.
- Existing power generation sites using fossil fuel (e.g., coal plants) could be repurposed for nuclear power generation.
- Small reactors or microreactors could be transported to meet off-grid emergency needs.
- Reactors could produce localized thermal energy for industrial applications that otherwise have hard-to-abate emissions because of high temperature requirements, such as cement, hydrogen, and steel production; for district heating (heat distributed through pipes to keep residences or businesses warm); or for desalination.

"Our report shows new and advanced nuclear reactors could play an important role as the U.S. works to decarbonize the economy," said Richard A. Meserve, Senior Of Counsel for Covington & Burling LLP, former chair of the Nuclear Regulatory Commission, and chair of the committee that wrote the report.

"But there are significant hurdles that must be overcome to enable advanced nuclear reactors to succeed and reach commercial and globally competitive viability—among them, economic challenges, technological challenges, regulatory changes, and societal acceptance. If we want the ability to pursue this option, the U.S. should address these barriers now."

Meeting the technological promise

There are many differences between nuclear reactors currently in use and proposed advanced nuclear reactors. For advanced reactors to be able to compete in a decarbonized economy, the report makes a range of recommendations, including:

- DOE's Office of Nuclear Energy should initiate a research program that sets aggressive goals for improving performance of fuels and materials used to build or operate reactors.
- The nuclear industry and DOE should fully develop a structured, ongoing program to ensure the best-performing technologies (as measured by technical, financial, regulatory, and social acceptance milestones) move rapidly through demonstration.
- DOE should expand its efforts in advanced construction technology research and development and make advanced construction technologies broadly available to reduce costs.
- Significant incentives, such as those that have nurtured solar and wind technologies, should be provided to enable the wide commercial deployment of advanced reactors.
- Widespread deployment of advanced reactors will require more skilled workers. DOE should initiate a whole of government partnership, and work with labor organizations, industry, regulatory agencies, and other organizations to identify gaps in critical skills, and fund training and development solutions.

Policies and regulations for economic competitiveness

Nuclear power reactors are tightly regulated by the NRC in all phases of their life cycle—design, construction, operations, and decommissioning. The report says that the NRC must maintain its overarching commitment to safety, but regulations governing existing reactors are not suitable for

advanced reactors, which could present novel regulatory issues, particularly reactors that use new coolants, have advanced safety capabilities, or are factory made or transportable.

Congress should provide the NRC with more resources to enhance its capability to deal with these differences and create efficient, effective, and flexible regulatory processes.

In addition, differing regulatory requirements between countries can discourage international sales, which may be an essential part of making nuclear vendors' business plans competitive. The report urges broader international regulatory harmonization, in the short term through bilateral arrangements—such as the U.S. agreement with Canada—and in the long term through engagement with the International Atomic Energy Agency and Nuclear Energy Agency.

There are considerable regulatory and economic risks that can deter potential investors in the advanced nuclear industry, including uncertainties around whether the NRC might reject a new approach, impose new design or operational requirements, or bring about added costs through delayed action. Some regulatory risks are particularly difficult for industry to evaluate because there is often no past guidance that would apply to novel reactor designs, so more regulatory certainty will help industry and its investors make informed plans.

Federal and state governments should take actions that enable the industry to be cost-competitive with other low-carbon energy technologies, including through tailored financial incentives, the report says. The U.S. should also foster a healthy international market for advanced nuclear technologies, and better equip itself to swiftly negotiate nuclear cooperation arrangements. The report recommends steps for Congress and the federal government to help U.S. vendors compete with state-owned and state-financed vendors in the international

energy market.

Assurance of safety, security, and safeguards

New deployment scenarios can introduce new physical and cyber risks, which should be dealt with through safety, security, and safeguards requirements as appropriate. NRC staff have proposed significant modifications to the physical security requirements for nuclear facilities to take into account novel designs and operations of advanced reactors. However, clear regulatory guidance is still needed, the report notes, and the NRC will need sufficient expert staff to provide this guidance.

Earning societal acceptance

While nuclear power must be safe and secure, it must also be accepted by society and by the communities in which new reactors are built. The advanced nuclear industry should adopt consent-based approaches for new facilities, adjusted for place, time, and culture, the report says. Consent-based processes—still nascent in the industry, where plans for new reactors are typically only reviewed after design and siting are completed—should include participatory site selection methods and incorporate more value-focused thinking. Industry should adopt research-backed approaches to community engagement, enduring through the life of a project, and these should be treated with the same seriousness as technological development. The report charts a path forward for better engagement, recommending a set of best practices for the industry.

A 2022 National Academies report, written by a separate committee, discusses nuclear fuel cycle options for both existing and advanced reactors, nonproliferation and security considerations for these fuel cycles, as well as issues related to the waste associated with advanced nuclear reactors.

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