Insight

The Need for Testing Advanced Nuclear Power

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Summary

- Advanced nuclear energy can help mitigate climate change by providing energy that is both reliable and free of greenhouse gases.
- Federal legislation and funding are positioning the advanced nuclear energy industry for commercialization in the coming years by supporting demonstration projects to evaluate their safety and environmental impacts.
- Moving forward, demonstration projects can go beyond reviewing safety and environmental impacts of advanced nuclear technology and consider the operational costs of these facilities to identify their role in the future energy mix.

Challenges in Commercializing

Although the emissions created by the generation of power have declined during the past five years, the power sector is the second-largest contributor of U.S. emissions.[1] Domestic energy demand will continue to grow in coming decades, too, although the mix of energy sources will shift: Power generation from renewable energy sources will continue to grow, while traditional light water nuclear and coal facilities will retire.[2]

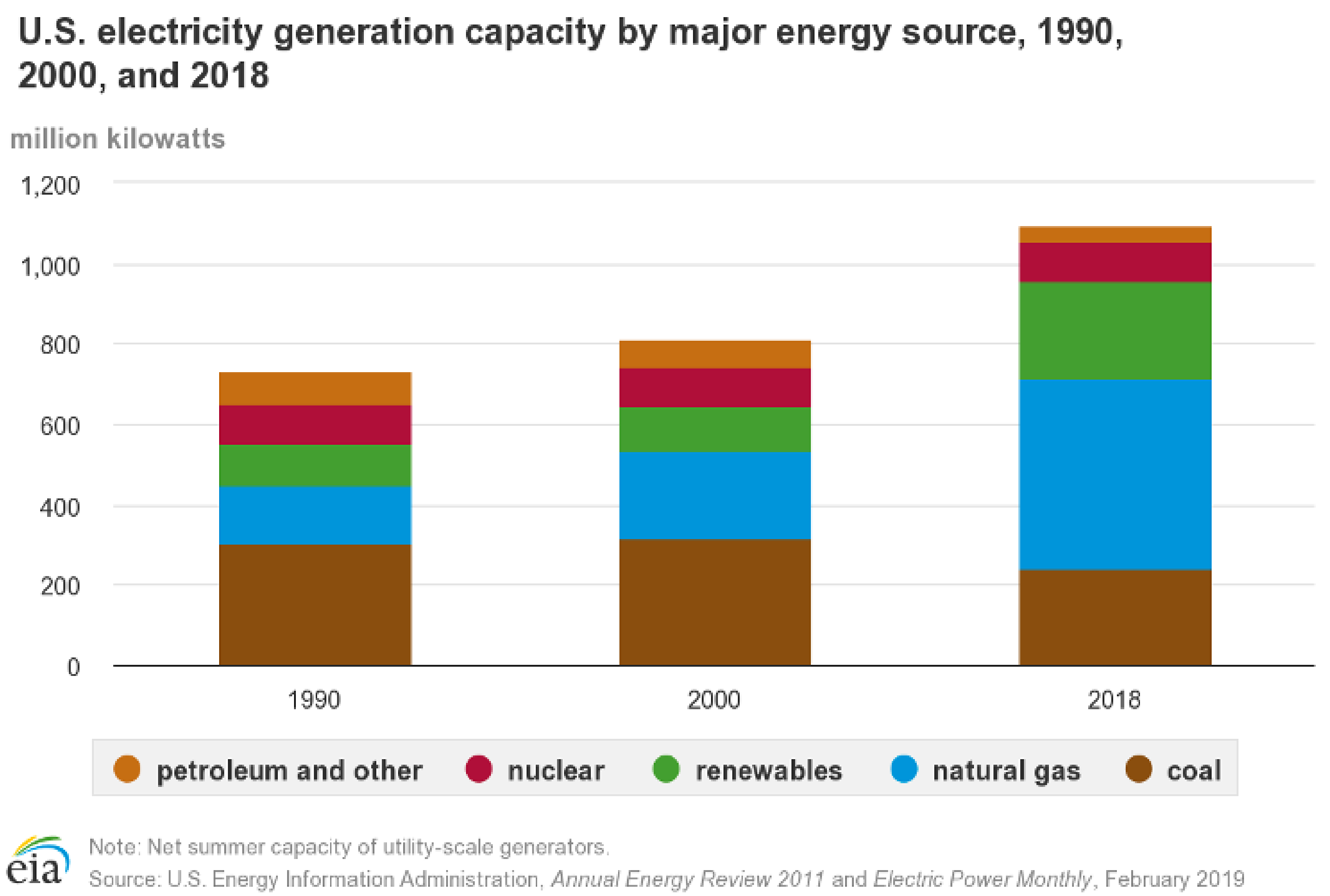
During the past decade, the Department of Energy (DOE) has made the development of advanced nuclear energy a priority with increased funding and expanded programming. Most recently, this programming has been focused on testing advanced nuclear energy designs. Due to a lack of properly equipped facilities, testing novel designs is not currently possible in the United States. Meanwhile, commercialization of advanced nuclear technology is contingent on this testing. Testing evaluates safety risks and the reliability of the design and identifies any modifications that may need to be made prior to commercialization. It is critical to companies who are developing technologies without clear federal design criteria by reducing perceived risk and establishing a proof of concept for investors.

The Nuclear Energy Regulatory Commission (NRC) is actively working to develop new review processes to evaluate the safety and environmental impacts of advanced nuclear technology. Since advanced nuclear reactor designs are based on novel technologies, unique processes and criteria for the review of such facilities are necessary. The development of this new regulatory scheme, however, requires data on the performance of these technologies.

The DOE and NRC, as a result, have entered into a memorandum of understanding (MOU) to evaluate the new technology, and specifically its safety and environmental impacts, through demonstration projects. The demonstration projects also serve as an opportunity to better inform the government about the financial aspects of their operations. This additional information is important because changes in market conditions and operational issues drove traditional nuclear generators to incur unsustainable operating costs that placed them at risk of closure. This additional information, which has not yet been well documented, is necessary to inform the commercial deployment of advanced nuclear energy in the long term to establish nuclear's role in the generation mix and prevent the same issues that impacted traditional light water reactor operations.

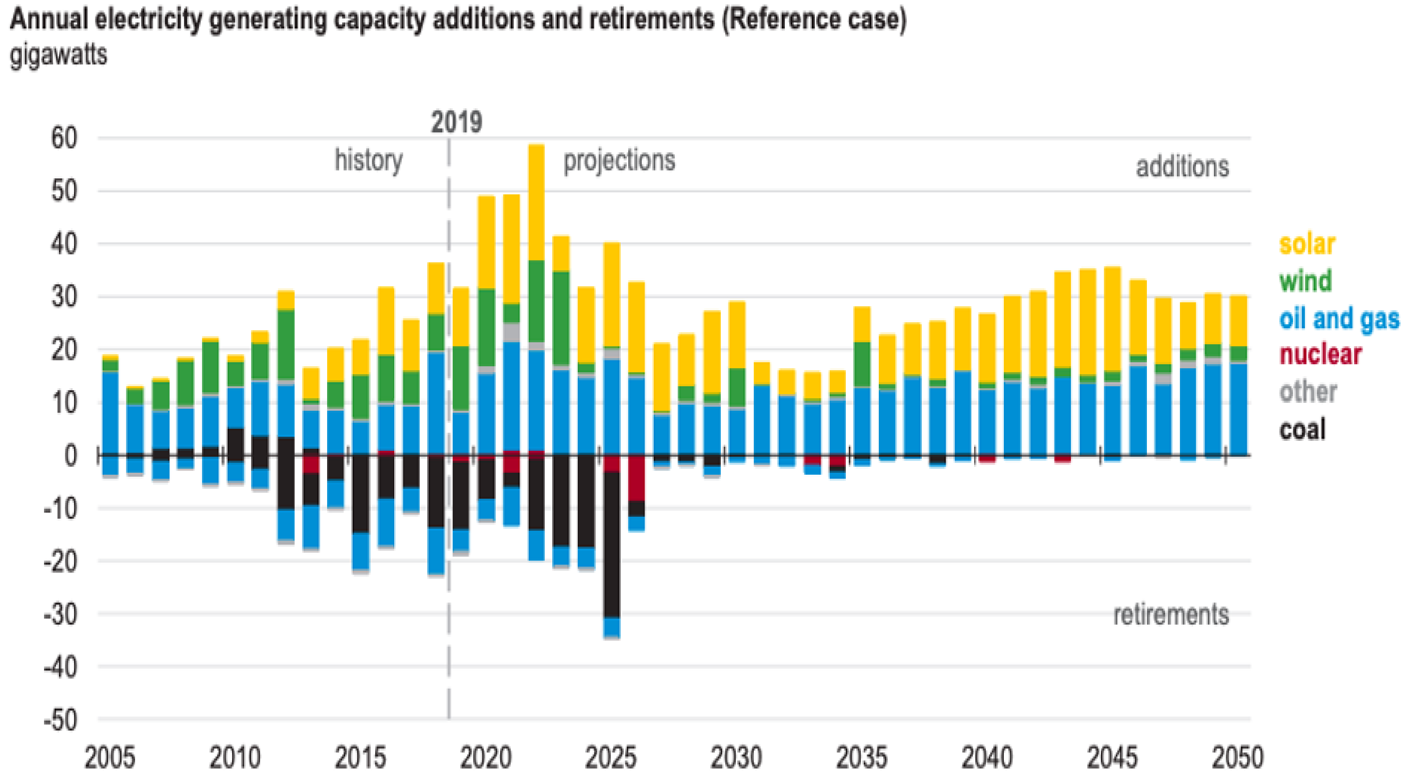
A Clean Energy Opportunity

Traditional light water nuclear energy has provided about 20 percent of generation in the United States for decades. Historically, these nuclear power plants have served as baseload capacity. Baseload capacity is produced by facilities that can provide consistent energy around the clock to ensure that no matter the time of day the grid is electrified.[3]



Source: Energy Information Administration

The development and commercialization of traditional light water reactors over 60 years ago was rapid, but the industry encountered issues in the decades following initial deployment. These include inefficient review processes and their revision, shifting geopolitics and constraint of the supply chain, lack of nuclear waste facilities, and resulting high operational costs. As a result, existing nuclear reactors are now more likely to be subject to retirement than expansion, as can be seen in the chart below.



Source: Energy Information Administration

Coal powered generation, however, has provided a majority of baseload capacity. Like light water reactor generators, coal powered generators are retiring or simply running their facilities less often.[4] In response, natural gas fired generation provides an increasing amount of generation capacity, which has contributed to the net decrease in emissions in recent years as gas generation has replaced coal. Nonetheless, natural gas generation produces greenhouse gases, and as the amount of energy generated by these facilities increases so does the amount of emissions.

While advanced nuclear technology can serve as zero-emissions baseload capacity like its predecessor, light water reactors, it also comes with a host of other desirable characteristics such as improved safety, flexibility in the amount of energy generated, and the ability to meet the generation needs of a wide range of market sizes. These characteristics are particularly valuable as the amount of energy generated by renewable resources increases.

While solar energy is dependent on the availability of sunshine during the day, wind power is more effective at night when breezes pick up. Advanced nuclear technologies can counter this variability and continue to deliver the level of dependability necessary to provide baseload capacity while providing additional flexibility and passive safety systems. Advanced nuclear energy, however, is not included in the Energy Information Administration's (EIA) Annual Energy Outlook as a source of energy.[5]

The EIA prepares annual forecasts of the energy sector under various scenarios, but it does not include the adoption of advanced nuclear in its projections. While supporting demonstration projects, the DOE can develop a similar outlook that accounts for the role of advanced nuclear in coming decades. This outlook can also be based on various scenarios that consider the performance of other generators in the energy mix, as well as economic conditions. To forecast most effectively, the demonstration projects should consider potential operational issues that may impact advanced nuclear reactors.

Overcoming the Testing Hurdle

The DOE provides grant, loan, and voucher programs to support the development of innovative nuclear technology. During the Trump Administration, appropriations dedicated to nuclear have continued to increase. The fiscal year 2020 appropriations included $1.49 billion for the DOE's Office of Nuclear Energy, up from $1.02 billion in 2017. An advanced reactor demonstration program was allotted $230 million, as well as $20 million for a public-private partnership program and $65 million for design of a versatile test reactor. In addition, DOE's science program budget, which includes the National Labs, increased by an additional $415 million for a total of $7 billion in funding.

Most recently, the National Reactor Innovation Center (NRIC), established under the National Energy Innovation Capabilities Act of 2017, was launched. This act requires DOE to develop a versatile test reactor (VTR) that could help develop fuels and materials for advanced reactors and authorizes DOE National Labs and other sites to host reactor testing and demonstration projects "to be proposed and funded, in whole or in part, by the private sector." The NRIC's programming, hosted at Idaho National Laboratory, will assess reactor performance in an effort to more rapidly license and commercialize advanced nuclear technologies.[6]

TerraPower, in conjunction with GE Hitachi Nuclear Energy, responded to Battelle Energy Alliance's call for a cost-sharing partnership on behalf of the DOE to design and implement the VTR. Energy Northwest, a utility, has also supported the partnership. The VTR will provide the DOE with a reactor that is capable of testing materials, fuels and components at higher neutron energies and fluxes than what is available today. A final decision to proceed with the currently proposed fast-spectrum test reactor is anticipated in mid-2021, with a completed reactor as early as 2026.[7]

The recently funded demonstration program, on the other hand, has not yet been well defined. The DOE issued a request for information to aid in the development of a Funding Opportunity Announcement, which is expected to be released in spring of 2021. The DOE intends to award two teams $80 million with a cost share of no less than 50 percent from non-federal sources with the intention to be operational within five to seven years of the award. The selected demonstration projects can be part of a utility's system or operate independently.[8] The opportunity to pair with existing industry players and choosing to operate on the grid could prove critical to the success of advanced nuclear, as it would ensure that a market exists for the electricity produced.

The demonstration projects, as well as the VTR, can inform the NRC's development of a licensing scheme for advanced technologies, leading to the development of more efficient regulations for emerging advanced reactor technologies in the short term. Historically, the NRC's review of reactor projects has included both environmental and safety criteria that aim to identify the reactors potential impact on its surroundings and the local community. Rather than relying on data extrapolated from hypothetical models, the NRC will be able to rely on data collected from the DOE's operational advanced reactor facilities to more realistically identify the risks posed. These regulatory efficiencies could reduce the review time for first-of-a-kind reactors currently navigating the regulatory environment without a framework, and as a result, reduce the costs incurred in research and development.

The demonstration programs, however, could provide information on far more than the safety and environmental impact of these reactors. By better understanding the costs associated with operating a facility, such as the costs of its fuel source, the disposal of resulting waste, or the staffing needs, industry and the government will have a better sense of the markets best served by advanced nuclear. This information could be used to better inform how to approach climate change mitigation on a national level.

Conclusion

The continued growth of low-emission and emissions-free energy generation is inevitable as companies, consumers and governments seek solutions to address climate change. The new testing programs and facilities should provide much-needed information about advanced nuclear technologies and the role it can play in energy production. Only by improving the information available about advanced nuclear will the government and other groups then be able to plan and project its production in the coming decades.

[1] https://www.c2es.org/content/u-s-emissions/

[2] https://www.eia.gov/outlooks/aeo/pdf/AEO2020%20Full%20Report.pdf

[3] https://www.eia.gov/todayinenergy/detail.php?id=30972#tab2

[4] https://www.niskanencenter.org/coal-fired-power-plants-reduced-operation-paves-way-for-cleaner-and-cheaper-alternatives/?utm_source=Digest&utm_campaign=82aa8d4de9-EMAIL_CAMPAIGN_2020_03_16_06_24&utm_medium=email&utm_term=0_b57b3ffb8c-82aa8d4de9-536374073

[5] https://www.eia.gov/outlooks/aeo/pdf/AEO2020%20Full%20Report.pdf

[6] https://www.energy.gov/ne/downloads/national-reactor-innovation-center-fact-sheet

[7] https://www.geekwire.com/2020/bill-gates-terrapower-ge-hitachi-team-proposal-build-nuclear-reactor-research/

[8] https://beta.sam.gov/opp/4171c5254c014855b65f29990c25d981/view