Nuclear Innovation: Projections for the Next Decade

March 2021

SUMMARY

It is largely recognized in many countries that nuclear energy will need to make a major contribution in order to enable a practical pathway towards climate change mitigation. At present, advanced nuclear technologies face significant regulatory, supply chain, and fuel supply uncertainties. However, if these issues can be addressed, and progress is achieved in fostering greater international regulatory harmonization, the widespread deployment of advanced nuclear can be realized and substantial contributions to GHG mitigations can be achieved.

From the perspective of advanced nuclear developers, there is significant optimism with regards to the future global energy market, although there are also significant challenges, including promoting efficiency in regulatory review processes, building demonstrations, etc.

- Oklo has witnessed significant recent progress in the ultimate commercialization of its micro-reactor design, and is currently working on a new design concept. In recent years, it has made rapid progress with respect to its engagements with the U.S. Nuclear Regulatory Commission (NRC) on the licensing of its unique reactor technology.
    - Submitted the first non-light water reactor license application to the U.S. NRC, which was accepted into review. This required a completely new application structure and format, which took years to develop and required NRC acceptance. Oklo anticipates a license to operate within the next few years, and is currently working on its next design.
    - Oklo is designing and developing advanced fission reactors that are completely different from current conventional nuclear reactors that are cooled by light water. Oklo has a site-use permit from DOE.
- TerraPower has been developing a sodium-cooled fast reactor design; recently, it has forged partnerships in order to facilitate the demonstration of its patented reactor concept.
    - TerraPower was founded 14 years ago by Bill Gates—the thought was that nuclear science has been under-utilized to solve the global problems and challenges today. Nuclear technology, given its public acceptance challenges, has generally been "under-harvested."
    - Under-utilization of nuclear science is not limited to energy production—for example, TerraPower recently began a medical isotope production business.
    - TerraPower has been developing its sodium-cooled fast reactor for 12 years, and is presently pursuing a demonstration reactor in the U.S. There has been a collaboration with GEH on Natrium—a sodium-cooled demonstration plant that attempts to address various Generation-IV challenges.

- Natrium is connected to a molten salt energy storage system, which allows it to be ramped up and down to be better complementary with renewable energy and renewables intermittency.
- Demonstration projects and advanced nuclear development will be difficult—new nuclear projects have been difficult to execute in the OECD, and thus, the partnership to develop Natrium was forged.

The Canadian SMR action plan that was revealed recently reflects both domestic momentum for advanced nuclear power, as well as highlights the need for increasing international engagement and coordination in this area.

- There is growing interest in nuclear power in Canada, specifically SMRs and advanced nuclear, which led to the SMR action plan in Canada.
- The action plan seeks to deploy SMRs in Canada by 2020—the plan includes and involves government, utilities, vendors, regulators, civil society, etc.
- The Canadian nuclear regulatory body's mandate is to protect the public from risk, not to pose as an unnecessary obstacle to new and advanced reactor types and technologies. CNSC is moving towards evaluating reactor technologies from a risk-informed, performance-based manner.
- There is also a strong emphasis on international collaboration, especially with other international regulatory bodies—the NRC-CNSC MOU allowed both regulatory bodies to share expertise, information, review processes, etc. in order to increase efficiencies in license reviews for advanced nuclear technologies and SMRs.
- There is currently also an MOU with the UK nuclear regulator in order to facilitate similar channels of communication and collaboration as with the NRC.
- OECD NEA is assuming responsibility in promoting international regulatory harmonization in order to develop best practices, efficiencies in reviews, etc. The ultimate goal is to foster international regulatory harmonization.
- Canada's plans are to deploy advanced and small reactors in remote areas and communities/regions that have never hosted nuclear plants before—thus, a great deal of public education and engagement will be required.

There are numerous challenges for advanced nuclear power heading into the future, including facilitating the development of regulatory review processes that are tailored for the realities of advanced nuclear designs, building appropriate public-private partnerships, and creating a robust supply chain for advanced nuclear fuels.

- Nuclear regulatory issues—the need to shift the regulatory framework and assumptions by regulators. The new Part 53 regulation for advanced nuclear licensing should be shaped and guided in the right manner, otherwise it could pose additional obstacles for advanced nuclear development.

- Public acceptance continues to be an issue for nuclear power and nuclear technology, although the advent of advanced nuclear technologies recently have boosted the image of nuclear energy generally.
- Appropriate federal support for advanced nuclear development is highly important—federal government support for advanced nuclear companies can go beyond just monetary assistance, but also in other ways: site-used permits, fuel and materials access, etc.
- Developing an appropriate fuel cycle for advanced nuclear reactors will be critical, especially as many advanced technologies will utilize higher-enrichment level fuels—specifically high-assay low-enriched uranium (HALEU). There is no supply chain for HALEU as of yet, and a robust supply chain would need to be developed in order for advanced nuclear to move forward. According to certain surveys of advanced nuclear developers, supply of HALEU is the largest concern going forward.
- Centrus Energy will begin enriching uranium (to HALEU) in Ohio under NRC licenses in 2022, but without any present demand for this fuel—the way to bridge this second valley of death is through public-private partnerships. The U.S. government has a vested interest in involving itself in this because there is a national security imperative for the U.S. to be involved in uranium enrichment.

QUESTIONS & ANSWERS

Q: *Electricity growth demand will double by 2050—what can nuclear supplier countries and newcomer countries do right now to support the deployment of advanced nuclear reactors in the future?*

A: International regulatory and licensing harmonization will be important—this has been a frequent topic of conversation, especially considering the realities of global climate change, the importance of nuclear energy for carbon mitigation, and the need to deploy nuclear safely and securely.

A: There are thorny issues of sovereignty. However, regulatory harmonization is not new in the nuclear industry, especially concerning maritime shipments and containers of nuclear-related materials and components. Newcomer countries, in engaging with mature nuclear countries and regulators in these countries, can establish the foundations for safely deploying and operating these next-generation reactors in the future. Giving newcomer countries a "gold seal" of approval from established regulators like the NRC will create greater confidence in approach advanced nuclear. For entrant states, this type of international engagement will be critical.

Q: *What are your strategies as you move to demonstrating and building FOAK? How are you engaging newcomer countries and government entities/international agencies? How are these communications and outreach activities going?*

A: First of all, it is highly important to share the vision of advanced nuclear developers with the rest of the world, especially with developing countries where growth in energy demand will be dramatic. However, this will begin with U.S. demonstration of advanced nuclear technologies.

Eventually, conversations will take place with trusted civil nuclear partners and allies, and at an advanced stage, this vision will flow to emerging markets and the developing world.

A: For Oklo, export pathways will begin with interactions/communications with nuclear newcomer countries and aspiring entrants. Most of these countries do not want to be a guinea pig or testbed—they want to import an established and proven technology. Thus, it will be important to get ducks in a row first domestically to eventually meaningfully interact with emerging markets.

***Q**: What are the implications for security and nonproliferation by a hypothetical global advanced nuclear fleet?*

A: There needs to be a strong peer review process to ensure strong global norms and standards. The U.S. has the strongest nonproliferation standards in the world, but in order to export these values, it must be engaged in the global nuclear market. There must be a balance between high security and safeguards standards and being sure not to "over-bureaucratize" these processes so as to put the U.S. industry at a competitive disadvantage vis-à-vis other international vendors and suppliers.