MIT Center for Advanced Nuclear Energy Systems

Symposium: No Fuel? No Party

October 2024

Technical summary, post-symposium:

To throw a nuclear party, you need the right fuel. That message echoed throughout MIT's October symposium, where experts from across the nuclear energy landscape gathered to confront a rapidly evolving sector driven by technological advances, updated regulation, shifting geopolitics, and pressing questions about fuel supply.

Thursday morning opened with remarks from MIT Professor Emilio Baglietto. He welcomed attendees to MIT and offered thoughts about the aims of MIT's Nuclear Science and Engineering Department, calling attention to its innovative faculty and its embrace of computational techniques. Robert Armstrong, Director Emeritus of the MIT Energy Initiative, situated nuclear energy in the larger landscape of growing electricity demand and the need for carbon-free industrial heat.

MIT's Jacopo Buongiorno followed by setting the stage for the rest of the symposium, noting that Western nations face particularly acute supply constraints that are driving up fuel costs, while highlighting the urgent need for international collaboration and investment in infrastructure especially for HALEU fuel. He considered the recent spike in uranium prices stemming from geopolitical shifts and decades of underinvestment. Professor Buongiorno's recommendations: a program for joint enrichment with US allies, a strategic LEU/HALEU reserve, and relaxed regulation of the cross-border movement of spent fuel. He also emphasized the need to reduce the fabrication cost of advanced fuels, such as TRISO particles or metallic fuel, and select fuel forms based on an integrated cost analysis for the reactors, noting that for some advanced reactors, fuel may no longer be the lowest contributor to their levelized cost of electricity.

The symposium continued with a deeper dive into fuel cost economics and supply challenges, chaired by MIT Associate Professor Koroush Shirvan. INL's Dave Petti provided a history of various fuels and the problems they set out to solve, calling particular attention to the specific challenges in scaling the production of TRISO for microreactors. As a contrast, BWXT's Andrew Davidson emphasized his company's unique position as the sole production-scale TRISO manufacturer and described the Category 1 facility in Lynchburg, Virginia where they're currently producing TRISO for the DoD's Project Pele reactor.

The symposium next offered a panel about the status of HALEU and implications of fuel reprocessing. UxC President Jonathan Hinze stressed the current absence of commercial-scale HALEU infrastructure as a critical challenge for advanced reactor deployment. Magnus Mori of Urenco described his company's recent expansion of LEU production but conceded that there's not yet a market for HALEU. Nima Ashkeboussi of Global Laser Enrichment agreed about the lack of a HALEU market but noted that their advanced laser enrichment facility – currently focused on LEU and LEU+ – is working toward commercial HALEU production by 2030, anticipating a supply crunch. Finally, Argonne Director Temitope Taiwo emphasized how reprocessing spent nuclear fuel, particularly from HALEU, could make nuclear energy nearly inexhaustible.

Over lunch, MIT's R. Scott Kemp offered a provocative session about whether HALEU constitutes a proliferation concern. A lively Q&A followed.

The afternoon opened with a panel discussion chaired by MIT Assistant Professor Ericmoore Jossou exploring the need to match fuels to specific reactor missions. MIT's Koroush Shirvan detailed the comparative advantages of TRISO versus LEU UO2 fuels for different applications, while INL's Randall Fielding outlined ongoing DOE efforts to advance metallic fuel fabrication. NEI's Al Csontos described the industry's push toward Accident Tolerant Fuels (ATF), which incorporate new cladding materials and fuel designs to better withstand severe accident conditions while improving performance through higher enrichment and extended burnup. Last, Constellation's Jason Murphy explored why more than 50% of nuclear sites are considering coupling ATF with power uprates that would enhance reactor performance and increase generation without the need for new facilities.

The day's final session considered long-term advanced fuels with a panel chaired by INL's Daniel Wachs. Andy Nelson of Oak Ridge discussed new fuels and techniques, including loading TRISO into 3D printed matrices that are optimized with genetic algorithms. MIT's Lance Snead explained how advanced moderators like beryllium oxide and magnesium oxide composites could enhance reactor performance beyond traditional graphite. General Atomics' Christian Deck presented on SiC/SiC composites (silicon carbide materials used for accident-tolerant fuel cladding), including advanced modeling approaches and the regulatory pathway for licensing such materials. Joseph Pegna of Free Form Fibers rounded out the session with a presentation about additive fuel forms that leverage microelectronic manufacturing.

Attendees then had the opportunity to tour the MIT Reactor and Fuel Research Lab Space. Designed for experiments in neutron science and materials testing, MIT's research reactor has been operational since 1958.

Over dinner, Duke Energy's Chief Nuclear Officer Kelvin Henderson outlined the company's path to net-zero carbon emissions by 2050, including plans for SMR deployment by the early 2030s, while addressing challenges in nuclear fuel markets and opportunities through advanced fuel designs and production innovation.

Friday morning concluded the symposium with a session addressing one of the key challenges from earlier discussions: how to accelerate fuel development to meet pressing supply chain demands. In a panel chaired by UTK's Brian Wirth, experts explored how computational advances could compress the traditionally decades-long fuel qualification timeline. Following Thursday's focus on gaps in supply, this panel considered how advanced modeling could close these gaps faster. LANL's Chris Stanek presented on integrating data-centric methods with atomic-scale simulations in nuclear fuel design and qualification with a focus on multiscale modeling to predict performance. MIT's Ericmoore Jossou discussed combining advanced fabrication with quantum mechanical calculations and machine learning while MIT's Emilio Baglietto walked listeners through advances in computational fluid dynamics with reference to high-fidelity simulations. Finally, Wirth demonstrated how the modeling of multiscale materials could streamline qualification timelines.

The symposium wrapped with Professor Buongiorno's assessment of different fuel types and whether each was ready to supply the various "parties" that the nuclear ecosystem would like to throw in the coming decades. As the world grapples with the dual challenges of energy security and climate change, his playful metaphor underscored a serious reality: the innovations discussed at this symposium will shape the future of clean energy. Two days of frank discussions among leaders from across the nuclear fuel cycle revealed both the scope of our challenges and the depth of expertise and collaboration available to address them.

-Steve Moore