Memorandum

State of New Hampshire

GENERAL COURT

CONCORD

DATE:	**August 16, 2023**
TO:	**Honorable Sherman Packard, Speaker of the House** **Honorable Jeb Bradley, President of the Senate** **Honorable Paul C. Smith, House Clerk** **Honorable Tammy L. Wright, Senate Clerk** **Honorable Chris Sununu, Governor** **Michael York, State Librarian**
FROM:	**Representative Keith Ammon, Chairman**
SUBJECT:	**Interim Report of the Commission to Investigate the Implementation of Next Generation Nuclear Reactor Technology in New Hampshire.** **RSA 125-O:30 (HB 543, Chapter 253, Laws of 2022)**

The second Interim Report of the Commission to Investigate the Implementation of Next-Generation Nuclear Reactor Technology in New Hampshire is attached, per RSA 125-O:30 (HB 543, Chapter 253, Laws of 2022), with the exception that the filing of this interim report is delayed due to summer plans and the volume of information gathered.

I would like to extend my sincere gratitude to the commission members who have made invaluable contributions to this study thus far. Additionally, our committee wishes to express deep appreciation for the testimonies provided before the commission, which proved to be instructive and informative, as well as the overall assistance rendered in the progression of our study to date. Any unintended inaccuracies that may be contained in the interim report are my responsibility alone.

Should you have any questions or comments regarding the contents of this report, please do not hesitate to contact me.

Regards,

Keith Ammon

Rep. Keith Ammon

Enclosures

cc: Members of the Commission

Interim Report

Commission to Investigate the Implementation of Next-Generation Nuclear Reactor Technology in New Hampshire

RSA 125-O:30 (HB 543, Chapter 253, Laws of 2022)

August 16, 2023

Commission Overview

The Commission was established in 2022 to study and consider legislation or other actions related to potentially implementing next-generation nuclear reactor technology in New Hampshire. As outlined in the statute, the Commission will investigate advances in nuclear technology, including generation IV reactor designs; safety, fuel consumption, and non-electric applications of new designs; potential siting options; partnerships; obstacles; and incentives. The Commission will submit interim and final reports with findings and recommendations for proposed legislation. The purpose is to thoroughly investigate the feasibility and options for next-generation nuclear technology in New Hampshire. See Appendix A.

Commission Members

Member	**Appointing Authority**
Representative Keith Ammon, Chair	Speaker of the House
Representative Michael Harrington, Vice Chair	Speaker of the House
Senator Howard Pearl	Senate President
Cathy Beahm	NH Dept. of Environmental Services
Marc Brown, Secretary	Governor, Member of the Public
Bart Fromuth	Governor
Daniel Goldner	PUC Chair
Matthew Levander	NextEra Energy/Seabrook Station
Christopher McLarnon	Governor
Mikael Pyrtel	NH Dept. of Business and Enterprise Affairs
David Shulock	NH Dept. of Energy

Executive Summary

The Commission to Investigate the Implementation of Next-Generation Nuclear Reactor Technology in New Hampshire was established in 2022 to study and consider potential actions for implementing advanced nuclear reactors in the state.

The Commission has held eight meetings so far, hearing presentations from experts on various advanced reactor technologies like small modular reactors, high-temperature gas reactors, molten salt reactors, and microreactors. Key benefits highlighted include:

- Modular construction.
- Passive safety systems.
- Smaller emergency planning zones.
- Load-following capabilities.
- High-temperature industrial applications.
- Minimal carbon emissions.

The report provides an overview of existing nuclear power in New England and recent nuclear projects in the U.S. It summarizes the presentations on specific reactor technologies and discusses topics like the nuclear fuel supply chain, non-electrical applications, federal regulatory considerations, and public engagement.

Potential economic benefits to New Hampshire include high-paying construction and operation jobs, supply chain manufacturing, and tax revenue. National security implications of domestic nuclear capability are mentioned. Risks such as construction delays, cost overruns, and fuel supply uncertainty are also acknowledged.

The report outlines several state government policy options to advance nuclear power, including financial incentives, streamlined regulation, workforce development, and public outreach. Areas for future investigation are identified.

As this is an interim report, the Commission's final recommendations are still forthcoming. The primary purpose of this report is to document the information gathered and discussions to date regarding the feasibility and options for next-generation nuclear technology in New Hampshire.

Meetings Held to Date

1. October 11, 2022 - Organizational Meeting

The commission organized and elected leadership roles. Rep. Keith Ammon was elected Chair, Rep. Michael Harrington as Vice Chair, and Marc Brown as Secretary.

See meeting minutes.

2. November 21, 2022 - Presentations by Marc Nichol of NEI and Christopher Colbert of NuScale Power

Marc Nichol of the Nuclear Energy Institute (NEI) discussed the advantages of advanced nuclear reactors. Nuclear power contributes 20% of US electricity and over 50% of carbon-free generation. More than 20 companies, including Westinghouse and GE, are developing advanced reactors for clean and affordable energy. Safety, waste management, and job creation, and "environmental justice" were also discussed. The meeting covered licensing, funding, renewable energy backup, and spent fuel storage.

Mr. Colbert presented on NuScale's development of a small modular reactor. The reactor, approved by the Nuclear Regulatory Commission (NRC), offers an unlimited "coping period" as it can stay safe indefinitely without outside power, a smaller emergency planning zone, off-grid capability, and flexibility in power generation. NuScale aims to repurpose coal plants, reduce costs, and provide clean and reliable energy. The company has secured a project in Utah and plans for global deployment. The presentation addressed safety concerns, spent fuel storage, and cost viability.

See meeting minutes.

3. December 12, 2022 - Presentations by Meredith Angwin and Jacqueline Siebens of Oklo

Meredith Angwin, author of ***Shorting the Grid*** and a nuclear energy advocate, highlighted the importance of a reliable and sustainable electric grid. She emphasized the advantages of nuclear power and discussed the complexities of grid management, including the role of Regional Transmission Organizations (RTOs) and their impact on grid reliability. Angwin's insights provided valuable perspectives on the crucial role of nuclear energy in maintaining a solid grid.

Jacqueline Siebens introduced Oklo's advanced vision reactors prioritizing safety, cost-efficiency, and fuel recycling. Oklo's compact design, using nuclear metallic fuel and liquid metal coolant, offers flexibility in siting and requires minimal water. The reactors have a smaller footprint and can produce electricity and process heat. Drawing inspiration from the successful EBR-II reactor, Oklo aims for fuel efficiency and simplicity. Siebens addressed questions about power purchase agreements, fuel recycling, thorium, and the EBR-II reactor's closure. Oklo's presentation showcased their innovative and sustainable approach to nuclear energy.

See meeting minutes.

4. January 23, 2023 - Presentations by Michael Wentzel of NRC and David Durham of Westinghouse

Michael Wentzel of the Nuclear Regulatory Commission (NRC) discussed the NRC's efforts to become a modern, risk-informed regulator. He highlighted the past licensing work of the NRC's divisions and emphasized their vision of fostering innovation while maintaining regulatory principles. Wentzel provided insights into the licensing status of advanced reactors, engagement with industry stakeholders and showcased specific facility license applications under review. The NRC remains committed to ensuring nuclear technology's safe and efficient use through a robust regulatory framework and innovative approaches.

David Durham gave an overview of Westinghouse's role in the nuclear industry. He highlighted their global presence and extensive experience, with their technology used in over half of the world's reactors. Durham discussed their reactor technologies, including the AP1000, AP300 small modular reactor (SMR), and the eVinci microreactor. He emphasized Westinghouse's involvement in projects such as Vogtle in Georgia and the need for domestic enrichment capabilities. The eVinci microreactor gained interest from various industries, including NASA.

See meeting minutes.

5. March 6, 2023 - Presentations by Jeff Navin of TerraPower and Dan Leistikow of Centrus Energy

Jeff Navin presented on TerraPower's Natrium reactor project, a small advanced nuclear reactor using sodium coolant and a molten salt energy storage system. The Kemmerer, Wyoming project aims to create jobs and provide economic benefits to the community. Navin discussed financing, licensing, and the availability of High-Assay Low-Enriched Uranium (HALEU). TerraPower plans to load-follow and generate electricity through a steam turbine attached to a molten salt energy storage system. The cost is expected to be lower than previous projects, ranging from $55 to $60 per megawatt hour.

Dan Leistikow presented Centrus Energy's focus on high assay low enriched uranium (HALEU) production. Centrus aims to scale up HALEU production to meet the needs of advanced reactors while emphasizing the benefits of low-enriched uranium (LEU). Challenges such as the "chicken and egg" problem were discussed, and a public-private partnership was proposed to accelerate investments in enrichment capabilities. Centrus highlighted its technology readiness and timeline for HALEU production. Supply diversity and coordination within the industry were also emphasized.

See meeting minutes.

6. April 7, 2023 - Presentations by Scott Nagley and Joshua Parker of BWX Technologies and Carol Lane of X-energy

Scott Nagley and Joshua Parker presented BWX Technologies' history, operations, and focus on nuclear fuel development. They highlighted the company's experience manufacturing naval nuclear reactors and commercial nuclear components. The company operates in government and commercial sectors, contributing to nuclear power generation, fuel production, and nuclear medicine. The discussion addressed the fuel supply chain, enrichment factors, reactor technologies, supplier investments, and non-electrical applications like medical isotopes.

Carol Lane presented X-energy's focus on high-temperature gas reactors and TRISO fuel. She discussed their plans for a commercial-scale fuel facility and their selection for the Advanced Reactor Demonstration Program. X-Energy emphasized load-following capability, industrial applications, and regulatory support. The discussion covered TRISO pebble activation, heat regulation, retrofitting coal plants, and buffer zones.

See meeting minutes.

7. May 12, 2023 - Presentations by Craig Piercy of ANS and Gareth Thomas of Holtec

Craig Piercy of the American Nuclear Society (ANS) presented a detailed overview of his organization and the nuclear industry's current and future prospects. He highlighted the growing interest in nuclear energy, discussed significant investments and advanced reactor designs, addressed fuel supply and workforce development challenges, and emphasized the importance of public engagement and education programs. Piercy analyzed the industry's landscape and its transition to innovative nuclear technologies.

Gareth Thomas discussed Holtec's history and expansion into reactor decommissioning and small modular reactor (SMR) development. Their SMR 160 program aims to design a safe and reliable reactor, and they are actively pursuing the Oyster Creek, NJ site for their first commercial SMR project. The discussion covered licensing approaches, construction cost risks, federal programs, and Holtec's expertise in nuclear waste management. The company aims to obtain a Construction Permit Application and efficiently bring its SMR technology to market.

See meeting minutes.

8. June 19, 2023 - Presentations by Seth Grae of Lightbridge and Matt Wald, journalist

Seth Grae discussed Lightbridge's advanced fuel designs for existing and small modular reactors (SMRs). Lightbridge claims its fuel offers economic, safety, and proliferation resistance benefits. Partnerships with national laboratories were highlighted for fuel testing, and commercialization pathways were explored, including replacing the Russian fuel supply in Europe and targeting the SMR market. The discussion covered spent fuel, cost competitiveness, non-proliferation, and intellectual property protection. Lightbridge aims to contribute to the global energy transition with innovative fuel designs.

Journalist Matt Wald, an experienced nuclear industry writer, presented the emerging nuclear landscape and its potential for reducing carbon emissions. He discussed fusion and fission reactors, highlighting the progress and challenges of each. Wald focused on commercially available reactors like NuScale, GE Hitachi BWRX, Westinghouse AP 300, and second-wave reactors like X-energy XE 100 and TerraPower Natrium. He also mentioned other designs, such as Kairos, Moltex, and microreactors. Wald addressed topics including HALEU production, funding, and nuclear fuel resources.

See meeting minutes.

Existing Nuclear Power in ISO New England

ISO New England, the regional transmission organization (RTO) responsible for managing the electric power grid across six states in New England (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut), operates with the aid of two nuclear power stations. Together, these stations contribute to roughly 20% of the region's electricity, and both utilize pressurized water reactors (PWRs), the prevalent type of nuclear reactor in the U.S.

In Connecticut, the Millstone Nuclear Power Plant is the largest in New England. Built in the 1970s and 1980s, it consists of two reactors that can generate 2,100 megawatts of electricity. The Seabrook Nuclear Power Plant in New Hampshire follows as the second largest, boasting one reactor capable of producing 1,250 megawatts of electricity, and was constructed in 1990.

New England once housed two additional nuclear power plants, the Vermont Yankee Power Plant in Vermont, and the Pilgrim Nuclear Power Station in Massachusetts. However, these were shut down in 2014 and 2019, respectively.

Recent Nuclear Energy Projects in the U.S.

Tennessee Valley Authority, Watts Bar 2

Watts Bar Nuclear Plant in East Tennessee achieved commercial operation with Unit 2 in October 2016, marking the first new nuclear generation of the 21st century in the USA. The unit produces 1,150 megawatts of continuous electricity, enough for 650,000 homes, without carbon emissions. The completion represents a significant investment in nuclear power as a clean, safe, and low-cost energy source and supports about 1,000 full-time jobs.

On 22 October 2015, Watts Bar Unit 2 received a 40-year operating license from the NRC, the first such authorization since Watts Bar 1 in 1996. The license allows operation until 22 October 2055, following a comprehensive review that took over 200,000 hours and eight years. The site was the first to comply with the NRC's Fukushima-related orders, and the decision to issue the license brings the total number of commercial nuclear reactors licensed in the USA to 100. The licensing of Watts Bar 2 is seen as a "historic milestone" in the history of Tennessee and TVA.

Georgia Power, Vogtle 3 & 4

The Unit 3 reactor at the Alvin W. Vogtle Electric Generating Plant near Waynesboro, Georgia, has commenced commercial operation, marking the first time a new nuclear reactor has begun delivering power to the U.S. electric grid in nearly seven years. Owned primarily by Georgia Power, this Westinghouse AP1000 reactor will generate approximately 1,110 megawatts of energy, sufficient to power an estimated 500,000 homes and businesses without generating greenhouse gases. Unit 4 is anticipated to begin service in late 2023 or early 2024.

The construction at Vogtle has not been without challenges. Construction on Vogtle's Units 3 and 4 began in 2009, facing delays and cost overruns with the budget ballooning from $14 billion to $30 billion. Westinghouse identified the main contributing factors as issues with an inexperienced construction company, an incomplete design, and supply chain problems.

Despite these setbacks, valuable lessons have been learned and integrated into strategies to enhance quality control, modular construction, and supply chain management for future AP1000 projects. Notably, the AP1000 units at Vogtle have been granted a 60-year operating license initially, as opposed to the standard 40-year license, with Westinghouse expressing confidence that the units have the potential to last up to 100 years.

The successful deployment of Vogtle Unit 3 has been hailed as a milestone for the nuclear industry, reflecting a renewed interest in nuclear energy as a response to climate change. Nuclear energy contributed to 47% of America's carbon-free electricity in 2022, with expectations that Vogtle's operational reactors will further advance clean energy solutions. The experiences at Vogtle highlight both the complexities and potential long-term value of advanced reactor construction.

Project Pele

BWX Technologies is participating in Project Pele, an initiative demonstrating a microreactor for the U.S. Department of Defense at Idaho National Laboratory. The project aims to construct and operate a transportable microreactor to supply power to military bases and operations based on BWXT's BANR (BWX Advanced Nuclear Reactor) design.

This design utilizes high-assay low-enriched uranium (HALEU) fuel, with the fuel for Project Pele sourced from the strategic uranium stockpile designated by the U.S. government for national security applications.

Project Pele is one of the early real-world demonstration projects for advanced microreactor technology, aiming to validate modular construction and operational capabilities. During discussions, BWXT cited as an illustration experience with fuel supply chains and an application area for their reactor technology.

Overall, Project Pele is a significant development in the advanced nuclear industry, showcasing the potential of small modular reactors for military and remote power requirements. The success of this project can contribute to the validation of the technology and guide commercial applications in the future. Complete power testing of the Pele reactor is feasible by the end of 2023, with outdoor mobile testing at a DOE installation in 2024.

“Nuclear Enlightenment” Period

Craig Piercy from the American Nuclear Society (ANS) distinguished between today's "nuclear enlightenment" and the "nuclear renaissance" from 15-20 years ago. The nuclear renaissance refers to the period in the early 2000s when there were plans to build many new large nuclear reactors in the U.S., but only a couple of projects came to fruition. On the other hand, the Enlightenment reflects more of an awakening to nuclear power's potential role in deeply decarbonizing the electricity system while maintaining reliability. Unlike a top-down push for large, costly new nuclear plants, the enlightenment involves more grassroots interest in next-generation nuclear technologies like small modular reactors that can overcome past challenges. There is more recognition today that achieving ambitious climate goals requires a combination of renewables plus a firm low-carbon energy source like nuclear. So while the Renaissance fizzled, the Enlightenment suggests a durable shift in considering nuclear’s advantages as a carbon-free resource that can complement intermittent renewables.

Nuclear Power in Recent Popular Culture

Nuclear energy has been a hot topic in recent popular culture, with two major films released in 2023 exploring the issue from different angles.

Oliver Stone's "Nuclear Now" makes the case that nuclear energy is essential to the solution to climate change. Stone travels to France, Russia, and the United States in the film, meeting with nuclear scientists, engineers, and policymakers to underscore his argument that nuclear power can generate electricity cleanly, safely, and efficiently. The film starts with a montage depicting climate change through images of melting glaciers, rising sea levels, and wildfires, then moves on to Stone's interviews with experts in various countries. These professionals agree with Stone, emphasizing nuclear power's role in meeting the world's expanding energy demands. As the film concludes, Stone calls for a renewed commitment to nuclear power as a key means to combat climate change.

Christopher Nolan's "Oppenheimer" presents a biopic about J. Robert Oppenheimer, the scientist who headed the Manhattan Project to create the first atomic bomb during World War II. The film delves into Oppenheimer's intricate relationship with nuclear weapons and his moral struggle with the destruction his creation wrought. From his early days as a scientist to his leadership of the Manhattan Project, the story portrays Oppenheimer as both a brilliant and dedicated scientist and a man deeply troubled by the atomic bomb's destructive power.

Along with "Nuclear Now," "Oppenheimer" offers a distinct perspective on nuclear energy and raises vital questions about this technology's future.

Potential Benefits of Advanced Nuclear Technology

Several presentations heard by the commission highlighted the advantages of advanced nuclear reactor designs over traditional large reactors, emphasizing their smaller and more flexible sizing. This characteristic enables incremental capacity additions, offers siting flexibility, and allows for applications like microgrids. Advanced reactors open up new potential siting options as they can be deployed at retired fossil fuel plants, industrial facilities, and remote sites. Another advantage of these reactors is their minimal water use.

Passive safety features in advanced reactors intrinsically minimize many accident risks, while their lower radioactive inventories and reduced emergency planning zones ease public concerns. Modularized advanced reactors facilitate efficient factory construction, standardized licensing, and reduced costs through fleet manufacturing.

Several advanced designs offer load-following capabilities, complementing renewables and providers of crucial grid-balancing services. High-temperature reactors are particularly noteworthy as they enable non-electric applications like thermochemical hydrogen production, desalination, and industrial process heat.

Some developers plan creative business models, such as nuclear power-as-a-service via power purchase agreements between suppliers and energy buyers. Additionally, advanced fuels and fuel cycles hold the potential to unlock vast, carbon-free energy resources from existing nuclear waste stockpiles. These features make advanced nuclear reactors promising candidates for meeting future energy demands sustainably.

Modular Design

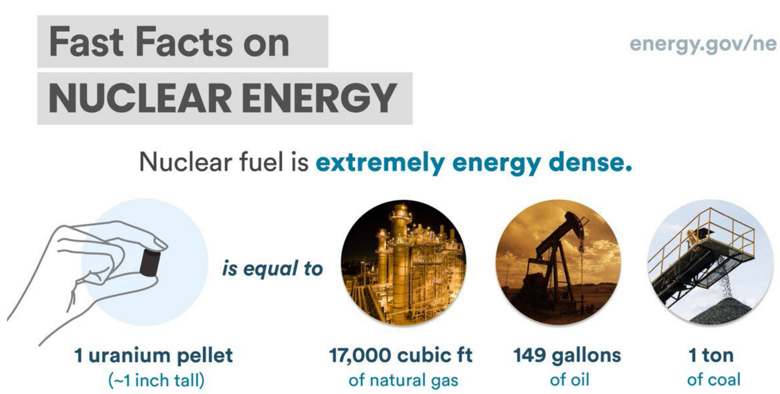
Many presentations highlighted modular construction as an innovative engineering approach that provides many advantages for advanced reactor technologies compared to traditional stick-built large reactors. By manufacturing major reactor components in standardized factory settings, then simply assembling modules on-site, modular techniques enable improved quality control, enhanced standardization, and cost reductions through continuous improvement of mass production. The smaller, modular sizes also facilitate incremental capacity expansion, flexible siting at retired fossil plants, and creative business models like nuclear power-as-a-service via power purchase agreements.

An analogy presented in several discussions compared the old method of building nuclear plants to constructing one-of-a-kind airports, often leading to cost overruns and delays. However, the new generation of small modular reactors (SMRs) offers a more efficient approach. SMRs can be manufactured in a factory setting with standardized designs, similar to airplanes produced on an assembly line. This modular construction allows for better quality control, economies of scale, and the ability to learn from each reactor's construction experience. By adopting the "airplane" model, SMRs promise to reduce costs and expedite deployment compared to the traditional "airport" model of nuclear reactor construction.

Developers highlighted that designing reactors as transportable modules takes advantage of manufacturing efficiencies, offers site flexibility, and reduces project risks, leading to faster and more affordable deployments. Several presentations cited incorporating modular designs and manufacturing as a transformative opportunity to fully realize the benefits of advanced reactors through replication, standardization, and factory-based production capabilities.

High Energy Density

Nuclear power plants provide copious amounts of reliable, carbon-free electricity from a small amount of fuel. A nuclear reactor can produce over 1,000 megawatts of power for around 1 million homes. This massive energy output comes from a few hundred fuel assemblies that must only be replaced every 1-2 years. Nuclear fuel has an extremely high energy density, meaning a small quantity releases immense heat energy during fission. For example, one uranium fuel pellets the size of an adult's fingertip contains as much energy as over a ton of coal. The high energy density of nuclear fuel, millions of times greater than fossil fuels, enables nuclear plants to generate enormous amounts of electricity from compact reactor cores constantly undergoing controlled nuclear chain reactions. This allows nuclear power plants to provide always-on, weather-independent, baseload power with minimal fuel requirements and land use footprint.



Continuous Energy Supply

Unlike intermittent sources of power like wind and solar, nuclear energy supplies steady and dependable electricity throughout the day, every day of the week, regardless of weather conditions. Operating consistently at over 90% of their capacity, nuclear plants rarely shut down, pausing only briefly every 18-24 months for refueling processes. They generate unwavering power by utilizing the intense heat emitted from continuous nuclear fission reactions within the fuel rods. With the capability to store over a year's worth of fuel on-site, nuclear plants enjoy an edge in fuel security compared to fossil-fuel-dependent plants that require regular deliveries. With its high availability and continuous generation profile, nuclear energy supplements intermittent renewable sources, playing an essential role in maintaining grid reliability. Its constant capacity and unvarying energy production provide vital baseload power and mitigate difficulties in integrating an increased percentage of renewable sources into the power generation mix.

Ability to Load-Follow

Modern nuclear reactor designs have considerable flexibility to adjust their electrical output, referred to as load-following capabilities. For example, Westinghouse stated that the AP1000 reactor could operate across a 60-100% power range to maneuver output as needed to balance the grid. The smaller size of many advanced SMR designs under development enables nimbler load-following performance. For instance, NuScale emphasized how its SMR technology can rapidly adjust output to complement intermittent renewable generation.

Several advanced reactor developers focused on engineering designs optimized for load-following nuclear plants. TerraPower highlighted the molten salt energy storage incorporated into its Natrium reactor that provides storage to sustain output during periods of low electricity demand. Holtec similarly stated that its SMR design is capable of substantial load-following to align with peak and off-peak cycles.

The load-following attributes of nuclear generation provide significant grid flexibility and reliability benefits. Nuclear’s ability to dynamically adjust output enhances the technology's economics while enabling it to balance rising renewable intermittency. Modern nuclear reactors have considerable untapped potential through inherent load-following capabilities to serve crucial electricity grid balancing roles as the generation mix evolves.

Passive Safety Systems

The presentations on advanced reactors showcased a prominent emphasis on safety innovations, particularly through the incorporation of passive systems that rely on natural forces such as gravity, convection, and conduction. The NuScale presentation highlighted their small modular reactor's passive safety features, such as cooling via natural circulation, that require no operator action. Similarly, Oklo's microreactor design capitalizes on inherent safety characteristics, eliminating the need for operator intervention. Westinghouse stressed the significant advantage of the AP1000 reactor's passive safety systems. Several advanced reactor designs were even described as having "walk-away" safety, meaning the reactor can passively shut down and cool itself safely without human or electrical intervention. Additionally, high-temperature gas reactors were praised for their excellent safety performance, largely attributable to the inert helium coolant and robust TRISO fuel particles. These technological advancements illustrate a concerted effort in the nuclear industry to simplify and enhance safety by leveraging natural mechanisms to automatically cool reactors during abnormal conditions or accidents, reducing risks and human dependency.

Small Emergency Planning Zones

Multiple presentations discussed how the smaller size and inherent safety features of many advanced reactor designs allow for significantly reduced emergency planning zones (EPZ) compared to traditional large reactors. For example, NuScale noted that their small modular reactor technology reduces the EPZ to only the site boundary versus the typical 10-mile radius. Oklo's microreactor won't require any off-site EPZ. The NRC presentation stated that emergency preparedness regulations are evolving to be scalable and performance-based to account for the lower potential consequences of many advanced designs. Minimizing or eliminating off-site emergency planning through passive safety improvements was cited as a significant advantage of advanced reactors, easing public concerns and siting challenges. With some developers even aspiring to locate advanced microreactors directly in populated areas, the dramatic reduction or total elimination of emergency planning zones was highlighted across several presentations as a transformational benefit of advanced nuclear technology.

Carbon-Free Energy Generation

Nuclear energy plays a significant role in the United States carbon-free electricity generation, constituting over 50% of the nation's carbon-free power and 20% of its total electricity production. Its prominence in carbon reduction models, which often choose nuclear for up to 43% of generation, highlights its potential as a firm, dispatchable energy source. When constrained in these models, the cost of a clean energy system can escalate dramatically, reflecting the value of nuclear in low-cost, low-carbon energy planning.

The carbon footprint of nuclear energy is comparable to that of wind power, making it one of the lowest carbon footprint technologies in the energy sector. Manufacturers have designed new advanced reactors with similar lifecycle CO2 emissions to wind, far less than solar. This compatibility with green energy goals aligns nuclear power with strategies for significantly reducing carbon emissions across the energy industry.

In addition to its electricity generation, nuclear energy's capabilities extend to industrial processes and transportation, where it can contribute to further decarbonization through hydrogen production. Its efficiency in this role may even surpass that of renewables. The design of new advanced reactors like Natrium, which can pair with renewables to create a zero-carbon grid, emphasizes nuclear's pivotal role in a carbon-free future.

Nuclear's high energy density, which allows for generating a terawatt-hour of electricity on less than 0.1 acres, offers environmental benefits and contrasts with the land requirements of wind and solar energy. Its reliability, baseload power capability, and very low carbon emissions make nuclear an attractive option in the quest for a stable, resilient, and carbon-free grid. Features like on-site fuel storage enhance reliability, while advanced designs enable smoother integration with renewable energies.

Growing public support, especially among younger generations concerned about climate change, is boosting nuclear's profile as a vital tool for carbon reduction. This trend will likely continue as the need for dependable, 24/7 clean energy grows, particularly to complement variable renewable sources. Overall, nuclear's carbon-free generation attributes make it an essential component in the effort to reduce carbon emissions in the power sector.

Potential Benefits to New Hampshire's Economy

Multiple presentations emphasized the potential economic benefits of attracting advanced nuclear projects to the state. The construction of new plants would bring an influx of high-paying jobs over several years while creating permanent operation and maintenance positions in the longer term. These job opportunities would not only boost employment rates but also contribute to the growth of the local economy.

Moreover, the state can bolster its nuclear supply chain manufacturing capabilities by sourcing components like reactor vessels from American manufacturers. This $50+ billion industry could create numerous skilled manufacturing jobs, further enhancing the state's economic landscape and fostering technological advancement.

In addition to job creation, deploying advanced reactors in retired fossil fuel or biomass plant sites could facilitate smoother workforce transitions. With operating lifetimes of 60+ years, nuclear plants provide stable and continuous local employment, contributing significantly to the state's tax base. Proactively pursuing advanced nuclear projects, the state positions itself for substantial high-tech job creation and economic gains, tapping into the potential of a reemerging nuclear energy sector.

Journalist Matt Wald discussed the potential of advanced nuclear reactors to create localized "industrial power zones," akin to the 19th-century hydropower canals that fueled manufacturing in New England before the advent of steam power or modern electrification. Historically, manufacturing clustered around hydropower sources, a pattern that may repeat with modern reactors like X-energy's Xe-100. Situating these reactors near industrial areas can directly provide electricity and high-temperature heat for various processes, possibly leading to "energy parks." This approach, which contrasts with relying solely on electricity, could increase the reactor's value and productivity. Wald suggests that this may revive the early hydropower era's co-located power and industry model, promoting nuclear-powered industrial clusters.

National Security Implications

According to Centrus Energy, a nuclear fuel manufacturer, establishing domestic production capability for nuclear fuel is essential for national security beyond commercial needs. They stated that ensuring a robust American supply chain for critical fuels like high-assay low-enriched uranium (HALEU) will help rebuild U.S. leadership in the global nuclear industry. Reducing reliance on imported fuel and enrichment services from foreign state-owned companies also advances American energy independence and national security priorities. The presentations also referenced Russia's outsized role in supplying nuclear fuel globally and concerns raised over the vulnerability of U.S. fuel supply to geopolitical dynamics. Overall, the initiative to commercialize advanced nuclear reactor technologies in America provides strategic national security benefits by catalyzing the growth of a solid domestic nuclear supply chain and reducing dependence on foreign nations for fuel and related services.

Advanced Nuclear Reactor Technologies

The commission has so far received detailed presentations on nearly a dozen individual advanced reactor technologies at various stages of design, licensing, and commercialization:

Light water SMRs

Light water small modular reactors (SMRs) apply conventional light water reactor technology using pressurized or boiling water at smaller individual module sizes. Rather than the 900-1600 MW output of traditional large light water reactors, SMRs range from around 50-300 MW per module. Critical advantages of smaller capacities are reduced financing needs, suitability to serve smaller electricity grids, flexibility for incremental capacity expansion, and enhanced siting options.

The presenters emphasized passive safety systems, modularization, and construction lessons learned as key advantages of their light water SMR designs compared to today's large reactors. The sizes range from 60-300 MW. Most target regulatory approval and commercial operation within 5-10 years.

BWX Technologies

Joshua Parker of BWX Technologies presented on his company's joint development with GE Hitachi of the BWRX-300 small modular reactor design, leveraging their boiling water reactor experience into a 300-megawatt capacity project. Based on GE Hitachi's ESBWR reactor, the design includes safety features like natural circulation emergency cooling and emphasizes constructability within 24 months through modularization and factory fabrication. Marketed as a simple, safe, and small boiling water reactor, the BWRX-300 aims to provide affordable carbon-free energy with flexible siting. The commercialization target is the mid-2020s, and several U.S. utilities have expressed interest. BWX Technologies highlighted its wide-ranging nuclear innovation capabilities, from manufacturing naval nuclear reactors and commercial components to international research reactor fuel delivery. Engaging in projects like microreactor design and medical isotope production, BWXT is eyeing emerging applications, including space nuclear propulsion, and developing the BANR microreactor being developed in the aforementioned, Project Pele, targeting commercial production by 2028. The focus remains on using proven experience and innovation to enable advanced reactor deployments.

Holtec International

Gareth Thomas, Senior Vice President at Holtec International, presented the company's light water SMR-160 design, with a capacity of 160 MW and an aim to utilize retiring nuclear plant infrastructure. Holtec completed the design certification process with the Canadian regulator and plans to apply to the U.S. Nuclear Regulatory Commission by late 2023. Lessons from recent construction projects, including those from the AP1000, have informed the design, and Holtec targets commercial operation by 2030. The company identified the former Oyster Creek nuclear site in New Jersey, which it is decommissioning, as the likely location for the first project. Although financing the first plant and attracting a customer poses challenges, Holtec believes new tax credits will enhance SMR economics. Supply chain readiness and the availability of skilled trades workers also present critical challenges. Holtec's 160 MW design offers extensive load-following capabilities, and the company anticipates strong global demand for SMRs to help meet urgent decarbonization needs. The benefits of factory manufacturing and serial project replication from modular construction further strengthen the case. Holtec aims to become an early mover in commercializing light water SMR technology.

NuScale Power

Chris Colbert of NuScale Power presented the company's light water Small Modular Reactor (SMR) technology, featuring modules that are 77 MWe (gross) each, with the capability to host up to 12 modules per plant for a total capacity of 924 MWe (gross). This design emphasizes passive safety systems, natural circulation cooling, and black start capability, contributing to its safety and resilience. The modular approach offers benefits like simplicity, efficient factory-based manufacturing, flexible siting options, versatile applications such as desalination and hydrogen production, and load-following capabilities to complement renewables. NuScale's focus on safety, modular manufacturing, and operational flexibility attracted Utah Associated Municipal Power Systems (UAMPS) as their first customer, who ordered a 12-module plant expected online in 2029. Despite recent cost escalations, NuScale's technology is considered an optimal carbon-free baseload power solution. It is supported by Department of Energy cost-sharing funding and nuclear tax credits, setting it apart from conventional large nuclear plant technologies.

Westinghouse

David Durham from Westinghouse provided an overview of their 225 MW light water Small Modular Reactor (SMR), the AP300, utilizing their successful AP1000 technology on a more compact scale. Westinghouse aims to condense the AP1000's technology into a smaller, more versatile package, taking advantage of the knowledge acquired from building and operating the larger model. Mr. Durham emphasized that this is not a first-of-a-kind technology and highlighted the passive safety features, modular construction, and projected 60+ year license term that characterize the design. Westinghouse is targeting design certification of the AP300 by 2027 with full commercialization likely in the early 2030s. Additionally, Westinghouse's presentation touched on their extensive nuclear energy experience as an industry leader, with technology in over half of the world's operating nuclear reactors. They also discussed their eVinci microreactor for remote sites and their facility in Newington, New Hampshire, which manufactures critical reactor components. Through these initiatives, Westinghouse intends to use its decades of experience to spearhead deploying next-generation nuclear technologies.

High-Temperature Gas Reactors

High-temperature gas reactors (HTGRs) use helium as a coolant and carbon in the form of graphite as a moderator. Helium is a very good coolant because it has a high specific heat capacity, which means that it can absorb a lot of heat without significantly increasing its temperature. Graphite is a good moderator because it slows down neutrons without absorbing too many of them, which allows the reactor to operate at a higher temperature. The high-temperature output enables electricity production via gas turbines and process heat applications like hydrogen generation. TRISO (tri-structural isotropic) particle fuel provides robust fission product retention at high temperatures.

X-energy

Carol Lane of X-energy explained how the company is developing the Xe-100, an 80 MWe high-temperature gas-cooled pebble bed modular reactor. The core comprises approximately 220,000 billiard ball-sized graphite pebbles containing the TRISO fuel particles. Helium flows over the pebbles, heating up to 565°C to produce steam for electricity generation or industrial process heat applications. The reactor offers inherent safety features and can load follow between 100% and 40% power in 15 minutes, providing grid flexibility. The modular design enables road-shippable factory fabrication of components and rapid on-site assembly. X-energy aims to prove the economics of the Xe-100 and deploy the first unit through the Department of Energy's Advanced Reactor Demonstration Program at a Dow Chemical facility in the Gulf Coast region, with commercial operation targeted around 2028. The reactor's compact size, passive safety, and flexibility make it well-suited for integration with industrial facilities and retiring coal plants.

Molten Salt Reactors

Molten salt reactors (MSRs) operate by dissolving fissile fuel in a molten salt mixture that serves as the coolant and chemical processing fluid. This enables high operating temperatures at low pressures, passive safety features, continuous refueling capabilities, and reduced waste generation. However, some molten salt designs have corrosion resistance and remote maintenance challenges. Molten salt reactors were discussed by two of the expert presenters at the commission meetings.

TerraPower

Jeff Navin, Director of External Affairs at TerraPower, provided insights into TerraPower's innovative molten chloride fast reactor design, emphasizing its use of liquid sodium chloride salt instead of solid fuel rods. This unique approach enables walk-away safety, load-following features, and multiple power conversion options like electricity or hydrogen production. TerraPower's Natrium reactor couples a sodium-cooled fast reactor with a molten salt energy storage system, allowing continuous variable output to integrate seamlessly with renewables. The high boiling point of sodium, used as a coolant, provides inherent safety benefits, with the reactor core immersed in a pool of liquid sodium that rises and transfers heat through a loop system. The cooled sodium then recirculates into the core, eliminating the need for mechanical pumps. Natrium's heat loop connects to a molten salt energy storage system, separating the nuclear plant from power generation and enabling flexible electricity output. With a storage capacity of 500 megawatts for 5.5 hours, the plant can vary its output between 40-500 megawatts to balance grid demand, combining steady baseload capacity with storage to complement intermittent wind and solar generation. TerraPower projects that this sodium-cooled, salt-storage design can generate electricity at $55-60/MWh when deployed at scale, competitive with other energy sources. The first commercial Natrium plant is slated for 2030 in Kemmerer, Wyoming, pending licensing and fuel supply. With Natrium's advanced design, TerraPower aims to offer clean, flexible, and cost-effective nuclear energy to contribute to decarbonization efforts.

Kairos Power

Independent nuclear analyst Matt Wald discussed Kairos Power's innovative pebble bed reactor design, the KP-FHR. Unlike other gas-cooled pebble bed reactors, Kairos is developing a high-temperature nuclear reactor that bathes pebble-shaped fuel elements in a fluoride salt coolant. This unique liquid salt design allows for very high-temperature operation and low pressure, enhancing safety. The reactor's high-temperature capacity further opens up applications like process heat for industry. Wald classified the Kairos reactor as a standout among "second wave" advanced reactor designs, such as Natrium, representing a more significant departure from conventional light water reactor technology than near-term options like those from NuScale or Westinghouse. As a result, Wald estimated that commercial deployment of the Kairos design is likely at least a decade away. However, he also noted that Kairos Power is on the verge of obtaining permission to build a test reactor in the U.S., the first non-power-focused commercial test reactor since the 1960s. This test reactor, which has received financial backing from the federal government and Ontario Power Generation in Canada, will provide vital performance data on the Kairos design.

Fast Neutron Reactors

Fast neutron reactors operate with high-energy neutrons, unlike conventional reactors that rely on slower-moving thermal neutrons to cause fission. This characteristic allows fast neutron reactors to run at higher temperatures, enhancing their efficiency over traditional nuclear reactors. In fast reactors, high-energy neutrons extract more energy from the fuel, increasing the overall energy output. One significant advantage of fast neutron reactors is that they can use spent fuel from traditional reactors as a fuel source. This approach improves fuel efficiency and offers a way to manage nuclear waste by reusing spent fuel. By combining higher efficiency with the ability to recycle spent fuel, fast neutron reactors stand out as a promising and innovative technology in nuclear energy.

Oklo

Jacqueline Siebens, Director of Policy and External Affairs at Oklo, explained her company's development of small modular fast neutron reactors called Aurora. These reactors cool with liquid sodium and use metallic fuel made from recycled, spent fuel. The small size of the reactor, ranging from 1.5 to 15 megawatts, enables flexible siting. The simplicity of the design, which has far fewer parts than conventional large reactors, aims to cut construction and operating costs. Oklo also leads a compact fuel recycling process to reuse spent fuel. Oklo's goals include providing reliable, affordable clean electricity through long refueling cycles, simple design, and recycling. The company anticipates NRC approval in the 2025-2026 timeframe and plans to sell "fission-as-a-service," providing heat or power directly to customers like companies and remote communities. The design allows for flexible siting, including in populated areas, and the compact size facilitates factory fabrication and truck transport.

Microreactors

Microreactors are very small nuclear reactors with 1-20 Mwe power outputs, designed for remote communities, military bases, or industrial applications. Their small size provides inherent safety advantages and siting flexibility. Microreactors can enable affordable, reliable off-grid power and district heating.

BWX Technologies

BWXT is working on a microreactor, the BANR (BWX Advanced Nuclear Reactor), rooted in high-temperature gas reactor technology. This reactor uses TRISO fuel compacts that contain high-assay low-enriched uranium with an enrichment level just shy of 20% U-235. Designed as a transportable and modular system, each BANR module complies with standard shipping requirements. The reactor boasts flexible power conversion capabilities and passive safety features. The modular design of BANR not only supports quick installation, refueling, and redeployment and allows the combination of multiple units for scalable power capacity. BWXT aims this technology at mobile and off-grid applications, including military bases, mining sites, and isolated communities, and even sees potential in space nuclear propulsion systems. Emphasizing the modular and factory-produced nature of the BANR, BWXT plans to reduce costs through manufacturing efficiencies and standardized licensing. As part of their efforts to showcase the technology, BWXT engages in Project Pele, which involves constructing and operating a BANR reactor to power a U.S. military base.

Westinghouse

David Durham of Westinghouse discussed their eVinci microreactor design during his presentation. The eVinci is a small, transportable nuclear battery that uses heat pipe technology and TRISO fuel. It only requires minimal staffing and security and does not need any active cooling systems. The eVinci can operate for 8+ years before needing refueling. Its compact size allows it to be shipped in three standard shipping containers and installed with minimal site preparation. Durham noted that eVinci is targeted for remote sites, military bases, and the marine industry as an alternative to diesel generators. It can provide reliable, carbon-free energy off-grid. The eVinci's passive safety, lack of melting risk, and factory-assembled and transportable design are key features enabling this flexibility. Westinghouse believes the eVinci can be cost-competitive with diesel energy and provide emission-free 24/7 power for applications ill-suited to renewable sources.

Oklo

Oklo’s 1.5 MWe Aurora project discussed above is considered a microreactor.

Other Comments on Microreactors

When discussing various advanced nuclear technologies, Matt Wald offered a perspective on microreactors. He stated that he foresees a minor role for microreactors in New England under the best circumstances. In Wald's view, these tiny nuclear plants will most likely deploy in remote communities, mining sites, and military bases that need reliable power off the primary grid. He mentioned companies like Oklo, Westinghouse, Ultra Safe Nuclear, and X-energy as developers of microreactor designs. Wald explained that microreactors could also supply resilient backup power for critical infrastructure like data centers that process financial transactions. However, due to their small size and niche applications, he cautioned against expectations of widespread microreactor adoption in regions like New England that already have robust grid infrastructure. Wald sees them as filling targeted needs for reliable, off-grid power in remote locales rather than broadly transforming nuclear power generation.

Fusion Reactors

Fusion power generation mimics the energy-producing reactions at the Sun's and other stars' core. Unlike fission, where atoms like uranium split to release energy, fusion combines light elements, typically isotopes of hydrogen such as deuterium and tritium, at extremely high temperatures and pressures. These nuclei collide at a sufficient velocity to overcome their natural repulsive forces and fuse, releasing a significant amount of energy as helium and a neutron. This process demands incredibly high temperatures, often in the tens of millions of degrees, to strip electrons from the atoms and create a plasma state where fusion occurs. Containing this hot plasma poses significant challenges, and scientists and engineers use magnetic confinement with devices like tokamaks or inertial confinement with lasers to address them. Fusion power offers a nearly inexhaustible and clean energy source with minimal radioactive waste and no carbon emissions. However, building commercial fusion power plants still represents a significant scientific and engineering challenge.

Michael Wentzel of the NRC briefly mentioned fusion when discussing the NRC's activities related to advanced reactors. He stated that the "advanced reactor" definition in the Nuclear Energy Innovation and Modernization Act includes fusion reactors. Therefore, the NRC must develop an associated regulatory framework for licensing fusion facilities. Wentzel noted that the NRC staff is currently working on options for regulating fusion reactors, which will be presented to the Commission for a policy decision when ready. He acknowledged recent advances in fusion but did not provide specifics on the timeline for commercial fusion power. The NRC aims to have a regulatory framework in place so that fusion can be licensed once the technology matures. In summary, Wentzel indicated the NRC is laying the groundwork to support the future licensing of fusion reactors, but commercial viability is still some years away.

Craig Piercy of the American Nuclear Society stated in his presentation that while there has been recent excitement around fusion energy, including an experimental milestone at Lawrence Livermore National Laboratory in California and a fusion company, Helion Energy, announcing a power purchase agreement, Piercy cautioned against hype and unrealistic timelines. He believes large-scale commercial fusion is still likely decades away, comparing it to the slow adoption of jet engines from the 1930s to the 1950s. Experimental progress is encouraging but scaling up to an economical fusion reactor will take major technological leaps and likely not happen until at least 2035-2040. In the meantime, fission reactors offer proven carbon-free energy generation that can be deployed now. Rather than directly displacing fission in the short term, fusion will take many years to realize its potential and will co-exist with fission technology for the foreseeable future. Piercy advocates a measured approach to fusion that does not assume it will solve decarbonization needs in the next 10-20 years when fission options are available.

Journalist Matt Wald tempered expectations around fusion energy, stating that while fusion development is essential to fund and could become practical, he would not count on it becoming a significant contributor to power generation in the next few decades. Wald explained that the recent fusion experiment touted as a "breakthrough" by the Department of Energy barely produced more energy than it consumed. He emphasized that in a commercial fusion plant, the reaction would need to produce fusion reactions orders of magnitude faster. Additionally, Wald noted that fusion reactors create significant radioactive waste, with components becoming intensely radioactive from neutron exposure during operation. He highlighted fusion's fuel challenges, requiring scarce hydrogen-like deuterium and tritium forms. Ultimately, Wald cautioned against holding one's breath for fusion, assigning it to the "Don't Hold Your Breath" category of nuclear technologies decades away from practical deployment. He advised that other forms of nuclear fission should be relied upon for more near-term carbon-free energy production.

Fusion was noted to not be viable for commercial deployment in the near term, in contrast to the numerous advanced fission reactors covered. While fusion is a potential longer-term nuclear energy option, the commission is focused on commercially relevant advanced fission nuclear technologies in the 2020s-2030s timespan. The commission does plan to hear from at least one fusion developer in an upcoming meeting.

Nuclear Fuel Supply Chain

Chicken-And-Egg Problem

The so-called "chicken-and-egg" problem is a central dilemma in developing advanced nuclear reactors that require high-assay low-enriched uranium (HALEU) fuel. Advanced reactor designs like TerraPower's Natrium require this specific type of fuel, but there is currently a limited commercial supply since enrichment companies are hesitant to invest without assured demand. At the same time, companies developing these advanced reactors need a reliable HALEU fuel supply before they can move forward, creating a deadlock where fuel suppliers are waiting for reactor demand and reactor developers are waiting for a reliable fuel supply.

The impact of this stalemate is far-reaching. The uncertainty in both HALEU production and reactor demand has slowed the progress of new nuclear technology, making it challenging for reactor developers to secure financing and customers. Utilities also hesitate to invest in new reactor technology if the fuel supply is uncertain. This deadlock has implications for advancing nuclear power, meeting decarbonization goals, and reestablishing U.S. leadership in nuclear technology.

Coordinated efforts and strategic planning are needed to overcome this "chicken-and-egg" problem. Proposed solutions include government involvement in providing initial HALEU supply, guaranteeing purchase contracts, and using national security needs to anchor demand. Public-private partnerships may also be a way to align incentives across the supply chain. These efforts would ensure the fuel supply infrastructure is established concurrently with reactor development and deployment, breaking the cycle, and advancing nuclear technology.

Sourcing

A prominent concern in the nuclear industry is the U.S.'s dependence on foreign sources for nuclear fuel. With 40% of the supply originating from Russia or Russia-controlled countries, this reliance raises questions about national security and economic sustainability. The call for re-establishing domestic enrichment and fuel production capabilities is gaining momentum. Reviving domestic production could reduce foreign dependency and rejuvenate American leadership in the global nuclear landscape.

Refinement

The refinement of nuclear fuel represents a significant technological advancement, and in the U.S., strides are being made in the field of high-assay low-enriched uranium (HALEU) fuel production. American Centrifuge Operating (AC0), a subsidiary of Centrus Energy Corp, is opening a plant in Piketon, Ohio and would be the sole U.S. facility licensed to produce HALEU. Full commercial-scale HALEU production is projected to be possible within a 3–4-year timeframe, contingent on offtake agreements, financing, and government support. The development of HALEU could pave the way for more advanced and efficient reactor technologies.

Disposal

Regarding disposal, the industry acknowledges the capacity to store used nuclear fuel on-site safely.

However, efforts are also underway to explore consolidated interim storage sites. One innovative approach in the disposal field is the development of spent fuel recycling processes aimed at creating affordable fuel for advanced reactors and reducing waste. This strategy addresses the waste management challenges and aligns with broader sustainability goals.

Supply Chain Outlook

The nuclear fuel supply chain encompasses diverse and multifaceted challenges and opportunities, from sourcing to disposal. While progress is evident in many areas, the overarching narrative suggests that a more comprehensive and coordinated approach may be required to fully realize the potential of nuclear energy in the U.S. Reviving domestic production, innovating in refinement, and embracing responsible disposal strategies are vital to shaping a resilient and sustainable nuclear industry.

Non-electrical applications

Nuclear energy has long been associated with electricity generation, but recent advancements in reactor technology are expanding its applications into non-electric sectors. The NEI overview highlighted that advanced reactors could provide electricity and essential utilities such as heat, hydrogen production, and water desalination. These capabilities facilitate various applications, including industrial decarbonization, synthetic fuel production, and expanded market opportunities. Companies like NuScale and TerraPower have embraced this multifaceted approach, implementing their SMR and Natrium reactor technologies to produce high-temperature steam and heat that can enable industrial processes like hydrogen production.

The versatility of nuclear energy is further evidenced by the innovative designs and applications developed by companies like Oklo and X-energy. Oklo's reactor design focuses on providing heat and electricity, supporting industrial decarbonization, and creating resilient microgrids. Meanwhile, the high-temperature operation of X-energy's Xe-100 reactor offers flexibility in providing process heat for various industrial applications. High-temperature gas reactors were also noted for their ability to provide process heat flexibly. Together, these developments mark a significant shift in how nuclear energy can be leveraged, demonstrating its potential beyond merely generating electricity and contributing to critical areas such as water purification, alternative fuel production, and enhancing industrial efficiency.

Hydrogen Production

Several presentations emphasized the growing interest and potential in utilizing nuclear energy for hydrogen production, marking a potential emerging use case for advanced reactors. NuScale, for instance, revealed that their small modular reactor (SMR) technology could generate hydrogen alongside electricity. TerraPower's Natrium reactor design was noted for its ability to produce hydrogen through electrolysis or thermo-chemical processes, thanks to the high-temperature steam it generates. High-temperature gas reactors were also cited as adaptable for flexible hydrogen production, given their high-quality process heat. Our discussions introduced the idea that new nuclear plants could substitute natural gas for emissions-free hydrogen generation in the future. However, further analysis is likely necessary to assess how competitive nuclear-powered hydrogen production might be compared to renewable or fossil fuel alternatives.

Medical Isotopes

The NRC presentation by Michael Wentzel highlighted that SHINE Technologies is building a medical isotope production facility in Janesville, Wisconsin that is nearing completion of construction. This facility will produce medical isotopes using nuclear technology. Medical isotopes are essential in various diagnostic and therapeutic applications, including cancer treatment and heart disease monitoring. Utilizing nuclear technology for isotope production offers a reliable and efficient method to meet the growing demand in healthcare. The Wisconsin facility's nearing completion signifies a step towards increased accessibility and innovation in medical treatments.

Desalination

NuScale's presentation highlighted the potential of nuclear energy for desalination and water purification. The consistent heat energy from nuclear reactors can drive water desalination processes, making them suitable for coastal or arid regions lacking freshwater resources. The modular nature of designs like NuScale's enables coupling with desalination plants to produce potable water alongside zero-carbon electricity.

Risks of Nuclear Technology

So far, the meetings regarding nuclear technology have focused primarily on the benefits of advanced reactors for clean energy production. However, it is essential to acknowledge and address potential risks associated with this technology. Some risks discussed include lengthy construction timelines, cost overruns, regulatory hurdles, nuclear fuel supply chain vulnerabilities, and spent fuel storage. These factors could lead to project delays and increased expenses. Moreover, there is a concern about grid reliability if there is excessive reliance on intermittent renewable generation. The limited perspective on inherent risks or tradeoffs suggests a more comprehensive assessment of the potential drawbacks that should be carefully weighed before the widespread adoption of nuclear technology. Recognizing and proactively addressing these risks can ensure a safer and more sustainable future for nuclear energy.

Organized Opposition

New Hampshire and the broader New England region have seen significant grassroots resistance to nuclear power over the past several decades. One of the most influential groups was the Clamshell Alliance, formed in 1976 to oppose the construction of the Seabrook Nuclear Power Plant located on the New Hampshire seacoast. The Clamshell Alliance organized large protests and civil disobedience actions, which led to the arrests of over 1,400 activists. They were ultimately unsuccessful in stopping Seabrook's construction, but their protests raised awareness about the risks of nuclear energy.

More recently, the C-10 Research and Education Foundation (C-10) is a nonprofit organization focused on ensuring public health and environmental safety around NextEra's Seabrook Station nuclear power plant in coastal New Hampshire and Massachusetts. C-10 operates a real-time radiological monitoring network and actively speaks out on safety and security concerns at the plant. C-10's funding comes from various sources, including the Commonwealth of Massachusetts, grants, and private community donations. Since 1992, the Massachusetts Department of Public Health has contracted C-10 to provide real-time radiation monitoring, funded partly by taxes paid by nuclear power plants like Seabrook Station.

Beyond Nuclear is a national non-profit organization based in Takoma Park, Maryland, that aims to educate the public about the risks of nuclear power, weapons, and waste. It advocates for an energy future free of nuclear risks, focusing on concerns like accidents, security threats, and waste management. The organization prefers renewable energy sources like wind and solar and works through press outreach, reports, and webinars to prevent new nuclear plants and promote renewable energy. Beyond Nuclear focuses mainly on policy and advocacy.

Need for Public Engagement

Some presentations the commission heard underscored the importance of conducting effective public outreach and education to foster greater awareness and acceptance of advanced nuclear power. This endeavor entails providing realistic information to improve the general understanding of nuclear technology and dispel outdated perceptions of its risks. Several speakers emphasized the need for policymakers to take on the responsibility of imparting science-based knowledge, especially concerning the health effects of radiation. Comprehensive workforce development programs spanning from K-12 education to vocational training are necessary to meet the demand for skilled talent. They can play a vital role in cultivating a capable workforce equipped for the high-demand jobs in the nuclear industry.

Additionally, establishing certification courses to facilitate the transition of workers from the oil, gas, and coal industries into nuclear roles can effectively leverage transferable skills and create new opportunities. Successful public outreach would highlight the local community benefits associated with siting advanced reactors. For the state to achieve this goal, dedicated education campaigns and resources will be necessary to engage the public, demystify nuclear science, clear misconceptions, and foster the growth of specialized workforces. The commission perceives this investment in educational initiatives as a sensible approach to empowering informed citizens and facilitating the expansion of nuclear energy.

Federal Regulatory Considerations

The NRC presentation offered insight into the evolving regulatory landscape, with particular emphasis on creating more flexible and risk-informed licensing processes specifically tailored for advanced reactors, including the development of a technology-inclusive Part 53 rulemaking. A significant shift is happening in emergency preparedness rules, with a growing focus on performance-based requirements that can be scaled according to reactor size and risk profile. Physical security requirements are also being adapted to align with a consequence-based approach, recognizing the lower radiological inventories in many advanced designs compared to large traditional reactors. Efforts are being made to review advanced reactor license applications more efficiently, with several reviews already in progress. There's also a recognition of the need to develop a regulatory framework for fusion energy, something the NRC plans to work on. Moreover, discussions highlighted the possibility of the NRC learning from recent large reactor projects, aiming to apply those lessons to effectively regulate emerging technologies such as small modular reactors and non-light water designs. These regulatory changes reflect an accommodating approach towards innovations in the nuclear industry, focusing on adaptable and risk-aware policies that align with the unique characteristics of advanced reactor technologies.

Recent Federal Policy Initiatives

The following are some recent pieces of legislation introduced to advance the nuclear power generation industry in the U.S. It remains to be seen whether all of these bills will be passed into law. Still, they do indicate that there is growing support for nuclear energy in the United States.

Nuclear Energy Innovation and Modernization Act (NEIMA),

This legislation aims to enhance the transparency and efficiency of the Nuclear Regulatory Commission (NRC). Supported by a bipartisan group of Senators, NEIMA laid out provisions for the NRC to clarify its budgeting process, establish performance metrics for licensing and regulation, and develop a regulatory framework for advancing nuclear technologies. The legislation also included a pilot project for predictable fees for uranium producers. After receiving widespread backing from stakeholders and passing through the Senate and the House, President Trump signed NEIMA into law on January 14, 2019.

Infrastructure Investment and Jobs Act of 2021

Passed by Congress and signed into law by President Biden on November 16, 2021, this legislation included substantial provisions to support nuclear energy within its $1.2 trillion package. Specifically, the legislation allocated $6 billion to prevent the premature retirement of existing zero-carbon nuclear plants, ensuring that those certified as safe can continue operations and prioritizing plants using domestically produced fuel. Furthermore, $2.5 billion is earmarked for developing advanced nuclear technologies through the Department of Energy's Advanced Reactor Demonstration Program (ARDP). The Act aligns with the U.S. goal of reaching net-zero by 2050 and represents a significant commitment to nuclear energy's role in reducing carbon emissions and fostering clean energy innovation.

The Inflation Reduction Act of 2022

This legislation contained significant provisions to incentivize the construction and development of new nuclear power plants and related facilities. These incentives include a choice between a production tax credit (PTC) of $25 per megawatt-hour for the first ten years of a new plant's operation or a 30 percent investment tax credit (ITC) for new nuclear electricity facilities, with a 10-percentage point bonus for facilities in specific energy communities. The Act also expands the Department of Energy Title 17 Loan Guarantee Program, unlocking up to $40 billion for innovative, large-scale energy projects to reduce greenhouse gas emissions through September 2026. Additionally, $5 billion is provided for an energy infrastructure reinvestment financing program, $700 million for increased production of advanced nuclear reactor fuel, and $5.8 billion for advanced industrial facilities deployment. The Act also includes tax credits for hydrogen derived from nuclear power and expanded credits for domestic investments in energy manufacturing in communities affected by coal plant or mine closures.

CHIPS and Science Act of 2022

This legislation enhanced support for nuclear research and physics programs, authorizing $390 million to establish up to four new research reactors and nuclear science and engineering facilities. In addition to increasing authorizations by $75 million for nuclear science education scholarships, fellowships, and research and development projects, the Act also aims to promote the transition from coal to nuclear energy. It establishes a new Department of Energy program that provides federal financial assistance to eligible entities. It authorizes $800 million to support the research, development, and demonstration of advanced nuclear reactors at retiring or retired coal generation sites, prioritizing projects that reduce emissions and benefit the surrounding population.

International Nuclear Energy Act of 2023

would strengthen U.S. leadership in civil nuclear cooperation and exports by establishing new coordination mechanisms within the federal government, launching initiatives to provide alternatives to Chinese and Russian nuclear financing, easing restrictions on foreign investment in U.S. civil nuclear infrastructure, and promoting nuclear safety, security, and nonproliferation through Cabinet-level conferences and support for partner nations developing nuclear energy programs. It was introduced in the Senate in December 2022. The bill would establish an office within the Department of Energy to promote the export of U.S. nuclear technology. The Senate still needs to pass the International Nuclear Energy Act.

Strategic Nuclear Infrastructure Act

This bill would establish a working group composed of senior-level officials across various federal agencies to provide input on the feasibility of creating a Strategic Infrastructure Fund. The fund would support projects related to civil nuclear technologies and microprocessors that are deemed strategically important. The working group would advise on the fund's design and administration and submit a report to Congress with recommendations, including suggested legislative language, within one year of the bill's enactment. The goal is to support capital-intensive nuclear and semiconductor infrastructure projects critical to national security.

Recoup American Nuclear Global Leadership Act

This bill would strengthen U.S. civil nuclear cooperation and exports by establishing new coordination mechanisms within the federal government, providing financial assistance and support to partner nations developing nuclear energy programs, easing restrictions on foreign investment in U.S. civil nuclear infrastructure, and promoting nuclear safety, security, and nonproliferation. It aims to exert American nuclear leadership globally by launching initiatives to engage partner nations on nuclear development, establishing cooperative financing relationships, developing a 10-year nuclear export strategy, and supporting the fullest utilization of U.S. civil nuclear technologies worldwide. The goal is to provide competitive alternatives to Russian and Chinese nuclear exports and financing.

Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act

A bipartisan group of senators introduced This bill in the Senate in March 2023. The bill aims to strengthen U.S. leadership in nuclear energy innovation and exports. It establishes new regulatory efficiencies, workforce policies, and technology development initiatives at the Nuclear Regulatory Commission and Department of Energy to promote advanced nuclear reactor deployment. Key provisions include streamlining licensing and regulation of advanced reactors, extending the Price-Anderson Act nuclear liability program, enabling siting at brownfield sites, providing technical assistance for international nuclear development, authorizing R&D funding, addressing nuclear waste management, and enhancing partnerships with Canada on Great Lakes issues. The overall goals are to drive innovation in nuclear technology, preserve existing nuclear generation, and expand nuclear energy globally to address climate change. Both nuclear industry advocates and environmental groups have praised the ADVANCE Act. This bipartisan bill passed the U.S. Senate as part of the NDAA on July 27, 2023.

Input From NH’s Consumer Advocate

Donald Kreis, New Hampshire's Consumer Advocate, provided his perspective on potential new nuclear power in the state during our May 12, 2023, meeting. Having previously analyzed legal issues around the forced closure of the Vermont Yankee plant, Mr. Kreis noted he is not reflexively anti-nuclear. However, he discussed the nuclear industry's need for financial help and regulatory easing. These needs pose challenges for technology-neutral states in supporting nuclear power, though adding it to renewable standards could be an option. As ratepayer advocate, Mr. Kreis focused on who pays for energy policies, given new nuclear plants in deregulated New Hampshire would likely be merchant plants. He expressed great interest in the commission's work examining nuclear power's future role but emphasized leaning into questions around ratepayer impacts. He highlighted the competition with China and Russia in nuclear technology and the importance of supporting the domestic nuclear industry to keep pace with these nations. Overall, while intrigued by the conversations, Mr. Kreis stressed that as Consumer Advocate, a key consideration is who bears the cost of any potential new nuclear generation.

Potential State Policy Options

The commission's discussions highlighted several potential new state-level policies for developing and integrating advanced nuclear energy generation. Not all of these prescriptions may apply in New Hampshire's deregulated electric utility market, as any new generation facilities must be merchant-owned.

1. Enact legislation that designates nuclear energy as a "clean" technology under renewable portfolio standards and other state clean energy programs. By redesignating nuclear, it can qualify for the same incentives as renewables where applicable. The New Hampshire Department of Energy recommends this change in its 2021 State Energy Strategy on page 56.
2. Conduct feasibility studies to assess suitable advanced reactor sites and applications within the state and identify potential end-users such as industrial facilities or retiring coal and biomass generation plants.
3. Offer financial incentives like grants, loans, and tax credits to support advanced reactor demonstrations and deployments and mitigate first-mover costs and risks. Implementing financial incentives at the state level will likely receive significant pushback in New Hampshire's political environment.
4. Create workforce training programs and educational campaigns to increase public awareness and develop talent pipelines for emerging nuclear jobs.
5. Streamline advanced reactors' licensing and permitting process to prevent unnecessary regulatory delays.
6. Explore public and private investments in nuclear supply chain capabilities, such as fuel fabrication facilities, and support the creation of US-owned fuel production.
7. Appoint a state Nuclear Development Coordinator to guide the Governor and manage the execution of pro-nuclear policies and initiatives. This role could potentially revive the "Coordinator of Atomic Development Activities" position from a 1955 state statute (RSA 162-B) to advise the Legislature, Executive Council, and Governor.

The conversations had by the commission focused on state-level policies that correctly classify nuclear as clean energy, integrate it into renewable energy programs, investigate financial incentives, and form a supportive regulatory framework for advanced reactor deployment. The discussion identified specific policy mechanisms, including federal grants, tax credits, power purchase agreements, and demonstration project funding, as tools that states can use to encourage nuclear power adoption.

Remaining Efforts

The commission looks forward to accomplishing several key objectives in the coming months. These include exploring potential legislation and policy changes to guide the industry forward. We have scheduled meetings for August 7, September 18, October 2, November 6, and December 4. The August meeting will focus on funding, followed by a site visit to Seabrook Station in early September. The commission is also considering potential siting locations for new facilities and investigating the possibilities of fusion power. An effort will be made to hear from other manufacturers or construction companies, and they are planning to invite presentations on “large flexible loads” that can help make an advanced nuclear project economically viable. Topics such as desalinization, hydrogen production, and data centers will be particularly relevant in these discussions. They are also open to entertaining skeptical viewpoints to ensure a well-rounded understanding of the issues. The commission will issue a final report on its findings and conclusions in December 2023.

Conclusion

In conclusion, this interim report summarizes the Commission's activities and learnings as we investigate the potential for advanced nuclear technology in New Hampshire. Through expert presentations, we have gained significant insights into the latest innovations in nuclear reactor designs, their potential benefits, and remaining challenges. Key emerging themes include the enhanced safety, flexibility, and economics offered by smaller modular reactors, the national security implications of a robust domestic nuclear industry, and the need for coordinated policies and public engagement to realize nuclear's role in deep decarbonization.

Our investigation has identified promising advanced reactor technologies that could contribute clean, reliable baseload electricity generation with minimal carbon emissions. We have also outlined policy options at the state government level that could facilitate the deployment of this technology. Critical next steps will involve assessing suitable siting locations, analyzing costs and incentives, engaging nuclear development companies, and finalizing recommendations for proposed legislation to enable advanced nuclear reactors should the determination be made that they can viably provide energy and economic benefits to New Hampshire residents and businesses.

There are still areas requiring further input and exploration before we submit our final report. However, the Commission believes this interim report examines many of the motivations, complexities, and opportunities surrounding next-generation nuclear energy. We encourage constructive feedback from lawmakers, regulators, and the general public regarding this report. We look forward to completing our mandate by delivering a set of findings and recommendations to fully illuminate the realm of possibilities for responsibly leveraging advanced nuclear innovation to shape New Hampshire's energy future.

Appendix A

Commission Charge and Study Purpose

RSA 125-O:30 Commission to Investigate the Implementation of Next Generation Nuclear Reactor Technology in New Hampshire.

III. The commission shall investigate:

(a) Advances in nuclear power technology, including "generation IV" reactors, by conducting research and seeking counsel and testimony from experts in the field;

(b) The most promising generation IV designs as determined by the Gen IV International Forum:

(1) Gas-cooled Fast Reactor (GFR);

(2) Lead-cooled Fast Reactor (LFR);

(3) Molten Salt Reactor (MSR);

(4) Supercritical Water-cooled Reactor (SCWR);

(5) Sodium-cooled Fast Reactor (SFR); and

(6) Very High-temperature Reactor (VHTR);

(c) Large-scale, small-scale, microreactor, modular and breeder reactor designs;

(d) The safety of modern designs, including "passive safety systems";

(e) Various types of fuel consumption, including the ability for new designs to safely consume nuclear waste, such as the waste in long-term storage facilities;

(f) Nonelectric applications including:

(1) Hydrogen or other liquid and gaseous fuel or chemical production;

(2) Water desalination and wastewater treatment;

(3) Heat for industrial processes;

(4) District heating;

(5) Energy storage; and

(6) Industrial or medical isotope production;

(g) Potential siting options;

(h) Partnerships with industry participants or investors;

(i) Partnerships with federal agencies, such as the U.S. Nuclear Regulatory Commission;

(j) Federal incentives for nuclear power generation; and

(k) Shall identify potential obstacles with federal nuclear regulation.

Appendix B

Meetings

October 11, 2022, Meeting

Overview

The Commission to Investigate Implementation of Next Generation Nuclear Reactor Technology in New Hampshire held its first meeting on October 11, 2022. The Commission elected officers, discussed tapping into resources to learn about new nuclear technologies, and determined to direct its focus on newer, safer reactor designs. There was some skepticism expressed about nuclear feasibility in the US, but overall the Commission aims to take an open-minded, consensus-building approach to evaluating whether advanced nuclear could benefit New Hampshire.

Meeting event page: https://nuclearnh.energy/event/organizational-meeting/

Minutes

Attendance:

Commission Members: Representative Michael Harrington, David Shulock, Bart Fromuth, Marc Brown, Representative Keith Ammon, Cathy Beahm, Dan Goldner, Christopher McLarnon. Absent: Senator Bill Gannon, Alex Fries, Matthew Levander

Public: Representative Doug Thomas, Michele Roberge, Douglas Mailly, Jodi Grimblas, Bruce Berke, Vikram Mansharamani, Alvin See

Meeting:

1. Representative Harrington opened the meeting and followed with introductions from each Commission member; then members of the public introduced themselves.
2. The Commission members then voted on officers and unanimously voted for:
3. Chair — Representative Keith Ammon
4. Vice Chair – Representative Michael Harrington
5. Clerk –Marc Brown
6. A sign-up sheet was passed around for Commission members and guests.
7. Representative Ammon referenced the need to tap into resources; Representative Harrington brought a copy of Nuclear News Magazine and Marc Brown mentioned that the Nuclear Energy Institute and Georgia Power are members of Consumer Energy Alliance and could be helpful.
8. Representative Ammon emphasized that focus be on next generation technologies; Virginia Governor Glenn Younkin committed Virginia to be the centerpiece of SMR manufacturing. Hopes that this will be a consensus building process.
9. Christopher McLarnon voiced skepticism on feasibility of nuclear power in the US because we don't build nukes here; China builds them cheaply and poorly
10. Bart Fromuth asked if we are getting any components from China
11. Representative Harrington responded that the US is not getting parts from China; referenced Sumner's failures in South Carolina; brought up the success that South Koreans have had constructing reactors. Stated that SMRs are generally 50-80 MW, can be shipped via rail.

Commented that nuclear generation plant has ever been built by investors assuming risk—always been rate based. NuScale has a design approved by the Nuclear Regulatory Commission.

12. Representative Thomas stated that he is personally bullish on nuclear technology; he is a de facto member of the NCSL energy supply task force; there are no less than 80 nuclear technologies out there—which ones survive? Mentioned that abandoned coal plants are good locations for SMRs. Asked Commission to focus on PR re: “new, safe nuclear technology.”
13. Representative Harrington thought Rep. Thomas’ comments regarding PR were well-stated and mentioned Germany’s overreaction to Fukushima.
14. Representative Ammon hopes that this Commission will utilize as many relationships as possible.
15. Commission scheduled next meeting for Monday, November 21st at 8:30 AM
16. Meeting adjourned ~ 11:00 AM
    Minutes submitted by Marc Brown.

November 21, 2022, Meeting

Overview

On November 21, 2022, representatives from the Nuclear Energy Institute (Marc Nichol) and NuScale Power (Christopher Colbert). Mr. Nichol discussed the status of advanced nuclear technology and considerations for state utilization, including benefits for decarbonization and grid reliability. Mr. Colbert provided an overview of NuScale's small modular reactor technology, its projected costs and timeline, and potential applications. There was discussion of whether to define "clean energy" in legislation to potentially include nuclear. There was also discussion of whether nuclear facilities require initial public funding support and the potential they have to provide carbon-free baseload energy.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-nov-21-2022/

Minutes

Attendance:

Commission Members: Representative Keith Ammon, Representative Michael Harrington, Bart Fromuth, Cathy Beahm, Dan Goldner, Matthew Lavender, David Shulock, Christopher McLarnon (remote). Absent: Senator Bill Gannon, Alex Fries, Marc Brown

Public: Representative Doug Thomas, Bruce Berke, Vikram Mansharamani, Douglas Mailly, Alvin See, Joe Fontaine, Michele Roberge, Griffin Roberge

Meeting:

1. A quorum was established, and Rep. Ammon opened the meeting at 8:33 a.m.
2. Rep. Ammon appointed David Shulock substitute clerk.
3. The commission unanimously approved the draft minutes of the commissions October 11, 2022, meeting.
4. Rep. Harrington stated he has worked with the Nuclear Energy Institute and that it is a good resource. He also recommended the American Nuclear Society as a resource. Rep. Harrington discussed the need for nuclear generation if the region goes forward with a climate agenda, stating that approximately 3000 new MW of carbon-free generation will be required in addition to any renewable generation. Rep. Harrington stated that advanced nuclear will be more load-following than existing nuclear generation.
5. Rep. Thomas agreed with Rep. Harrington and stated that he is a member of the bipartisan Energy Supply Task Force of the National Congress of State Legislators.
6. Marc Nichol, Senior Director of New Reactors at the Nuclear Energy Institute gave a presentation of the status of nuclear technology, commercial deployments, major topics related to advanced reactors, and issues relating to interfacing with the federal government. Some key points were that it would be $449 Billion more expensive to reach 0 net carbon emissions if nuclear technology were be constrained going forward; advanced nuclear would provide black start capability to the grid; advanced nuclear builds in inherent safety features that in may cases would limit the planned emergency response to the property boundary; that waste handling technology is mature, but requires 8-10 years of licensing work prior to construction; advanced nuclear can be located on the sites of existing coal plants to take advantage of infrastructure and trained staff; and that there is strong federal support for advanced nuclear deployment. Mr. Nichol also stated that consideration had been given to lessening delay and cost overrun by integrating energy (steam) generation into the reactor design, simplifying the design, conducting more work in the factory and less in the field, and allowing for parallel factory and field construction timelines. He stated

that currently overruns are due to increases in labor and material costs over time. He stated that "one-stop" construction and operating permitting at the federal level reduces protest and litigation. He believes that state can support advanced reactor deployment by conducting feasibility studies, providing tax incentives, providing for advanced cost recovery, and working on workforce development and infrastructure. Last, there is currently a lack of fuel with the required 5-20% enrichment that will continue until sufficient demand for that level of enrichment is established.

7. Christopher Colbert, Chief Financial Officer of NuScale Power gave a presentation of his company's technology. NuScale Power has engineered the first small modular reactor to undergo licensing at the Nuclear Regulatory Commission at a cost of $500 million. The company has a goal of placing the first modular reactor online by 2029. NuScale's modular reactor would produce 77 MW of electricity. The design would allow up to 12 modules to be combined at one facility and to operate independently or in sync. NuScale's reactor has black start capability, and inherent safety features that do not require external power or support in an emergency, resulting in an impact area of approximately 300 meters. Mr. Colbert stated that the factory design takes years off of filed construction; essentially, one could build a shell structure and easily then integrate the reactor. Mr. Colbert sees the design as useful in supporting renewables, replacing coal, and creating hydrogen during a period of energy transition. NuScale has a customer that plans to bring one of its reactors online in 2029. Original forecasts for the cost of that facility were at $58 per MWh. Inflation and the rise in interest rates has driven that cost up. Mr. Colbert stated that despite the rise in cost, the reactor is still the best alternative.

8. Rep. Ammon stated that he plans on drafting the report due December 1, and that he will send the report around electronically for sign-off.

9. Rep. Thomas described an LSR that he plans on introducing next year. The bill would define clean energy, which appears numerous times in statute without a uniform definition. Rep. Thomas suggested that this committee work on a definition, and that it be similar to the European Union's definition, which Rep. Thomas stated includes nuclear energy. Rep. Harrington agreed that clean energy should be energy that reduces fossil fuel use to reduce greenhouse gas emissions. Rep. Ammon stated he found support for this in the state's 10-year energy plan.

10. Rep. Harrington stated that there has never been a nuclear facility built without taxpayer or ratepayer funding. We need to understand that we are a less regulated state now, and that all generation plants are merchant plants. Investors are unlikely to build a nuclear plant here until one has been successfully built elsewhere, and everyone sees that it can work. He stated that this is not unique to nuclear plants, that offshore wind is in a similar state.

11. The meeting was adjourned at 10:38 a.m.
    Minutes submitted by David Shulock.

December 12, 2022, Meeting

Overview

On December 12, 2022, the commission heard presentations from Meredith Angwin on how nuclear power benefits the electrical grid, and from Jackie Siebens of Oklo on their company's development of small, advanced fission reactor systems. Key topics discussed included nuclear energy's reliability, inertia, frequency response, recycling of spent fuel, and business models for advanced nuclear. The commission made plans for future meeting topics and speakers. Also discussed were updates to the nuclearnh.energy website.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-dec-12-2022/

Minutes

Attendance:

Commission Members: Representative Keith Ammon, Cathy Beahm, Dan Goldner, Matthew Levander, David Shulock, Christopher McLarnon, Marc Brown, Representative Michael Harrington, Bart Fromuth.

Representative Carry Spier (remote), Richard Steeves, Alex Fries

Absent: Senator Bill Gannon

Meeting:

1. A quorum was established. Rep. Ammon opened the meeting at 1:42pm
2. A motion was made by Cathy Beahm to approve the minutes from the November 21, 2022, meeting. Barth Fromuth seconded the motion, and the commission voted unanimously to approve the minutes.
3. Rep. Ammon invited the public to introduce themselves and share comments. No members of the public responded.
4. The first presentation was given by Meredith Angwin, author of *Shorting the Grid*. Ms. Angwin discussed the 3 components that comprise a strong electrical grid: reliable electricity, electricity that is relatively inexpensive, and a manufacturing process that creates minimal pollution and ecosystem disruption. She then went on to discuss the juxtaposition between the physical grid (the people and the infrastructure that make electricity work) and the policy grid (which is essentially how the physical grid is paid for). She then introduced the concept of a “could” grid, which explores other options such as wind and solar power.

   Ms. Angwin next discussed how energy auctions work, and the implications they have to both grids. She explained how the system works with energy payments, capacity payments, and out of market payments all contributing to the equation. The failures in the system stem from reliance on a “fatal trifecta” of renewables that start and stop on their own schedules, overdependence on neighbors for resources a given location doesn’t have (which is impacted by demand), and baseload, which is the minimum amount of power in use, or constant demand.

   She then described how nuclear is good for the grid, for several reasons:

   - It has a solid baseload
   - It has over a year of fuel stored on-site
   - Inertia keeps a nuclear system functioning during minor glitches

- It has a small footprint
- It is not weather dependent

Mr. McLarnon asked Ms. Angwin to speak a little further on inverter-based issues. She shared that although there is still research in progress on this topic, it's a matter of creating virtual inertia on an inverter-based grid. Frequency plays into it as well, but inertia is the primary driver.

Rep. Ammon asked for more information about the subject of frequency response, its importance, and its pitfalls. Ms. Angwin explained that as demand goes up, frequency goes down unless you add more supply. So, there is a very tight boundary that grid operators use to manage this, and if it's not done well, it can lead to equipment damage which can create rolling brownouts and blackouts across a grid.

Rep Spier asked what will happen with nuclear waste as the world moves to using more and more nuclear energy. Ms. Angwin explained that comparatively speaking, it's a minimal amount of waste, and is very contained. She also pointed out that there are plants that can reuse that waste.

5. Rep. Ammon introduced the next speaker, Jackie Siebens, Director of External Affairs and Policy for Oklo. Her company develops small, advanced reactor systems. Some of the benefits of the type of reactors they are building include:

   - Small carbon footprint (about the size of a single-family home)
   - Smaller inherently safe and robust safety systems
   - Greater flexibility for where to operate
   - Requires minimal water resources

   Ms. Siebens next reviewed the Aurora powerhouse, a model for this new type of reactor. She explained how it is built and how it functions. A primary change in this type of reactor is the use of fast neurons. This enables the reactor to unlock a lot more of the energy that lives in that uranium than the existing reactors are able to do. They also have the ability to recycle used fuel and are cooled via liquid sodium which is very safe and effective.

   Ms. Siebens cited several cost & operating benefits to their reactors, such as

   - Requiring 1000 times fewer parts to construct,
   - Requiring less complex and less expensive components,
   - The ability to construct offsite in a more efficient manner,
   - Site flexibility and the ability to build close to where the fuel is used.
   - They can product process heat in additional to electricity, which can be utilized across the industrial sector.

   Oklo is also planning to use a business model which allows end users the option to subscribe to fission-as-a-service. This helps to eliminate deployment hurdles and operational burdens. They are also working closely with NRC to modify the licensing process to accommodate this new reactor design.

   Ms. Siebens shared that Oklo is also working hard on projects surrounding fuel recycling. This recycling effort will be leveraged with the new reactor design to create a paradigm shift from large, complex, and expensive programs to smaller, simpler, cost-effective recycling models. Current plans include starting construction on their own pilot recycling facility in 2027 with hopes to bring it online by the end of the decade. Ms. Siebens responded that is dependent upon the location, as some locations would still require the sale of a certain percentage of the power.

Ms. Beahm asked about purchase power agreements and if that mean Oklo would have agreements with an industry or community directly and you wouldn't be part of an RTO system and how that would play into the reliability of the entire grid?

Mr. Richard Steeves asked if thorium mixed with uranium, of course, have a future in your Aurora system. Ms. Siebens stated that it does not, that they are pursuing exclusively the high-assay, low-enriched uranium, without thorium.

Rep. Spier asked if selling the recycled fuel to plants like Seabrook was part of the recycling planning Oklo is doing. Ms. Siebens responded that it is not, because of the type of reactor they are developing, and the recycling process that stems from that. Rep. Spier asked for some additional information regarding recycling policy, and Ms. Siebens agreed to provide it via email to Rep. Ammon for distribution to the commission.

Rep. Walter Stapleton asked if the experimental breeder reactor in Idaho that was mentioned is operational, or if there were other reactors in the world of similar design that are operational at this point? Ms. Siebens indicated that the Idaho reactor is not yet operational, but similar fast reactors are already in use in China and Russia.

Matt Levander discussed the Seabrook facility and potential for a recycling model there based on what Oklo is doing. He noted it could be a potential option for Seabrook for the future.

Chris McLarnon asked when the efficient products are pulled during the recycling process, do they go back to the original fuel supplier? Who takes ownership of that material? Ms. Siebens stated that this is still under discussion and development.

Mr. McLarnon also asked if Aurora was load-following. Ms. Siebens shared that while it may look a little different than traditional models, yes, Aurora is designed to be load-following.

6. Rep. Ammon asked if there was any further public comment. None was presented.
7. Rep. Ammon next gave an overview of what the monthly meetings for the next year will look like. He discussed several ideas for presenters, and members provided other suggestions, such as Tom Popik on resiliency, and the NRC for a discussion on their timeline and regulatory improvements. Ms. Beahm will get contacts for an EPA presenter, and Mr. Levander will get a contact at NRC.
8. Rep. Ammon shared updates to the nuclearnh.energy website, including commission bios. He asked each member to review theirs, and for Mr. Fries to provide a headshot. Mr. Fromuth volunteered to be the backup administrator to Rep. Ammon.
9. No other questions or issues were presented by the commission.
10. A poll of commission members will be taken to determine the next meeting date and finalize the location.
11. A motion to adjourn was made by Bart Fromuth and seconded by Marc Brown. Meeting adjourned at 3:36 PM.

Minutes submitted by Marc Brown.

January 23, 2023, Meeting

Overview

On January 23rd, 2023, public comments were heard expressing concerns about nuclear construction costs, concrete issues, and adequacy of radiation monitoring. Presentations were given by the US Nuclear Regulatory Commission on improving licensing efficiency for advanced reactors, and by Westinghouse on lessons learned from recent AP1000 projects. Westinghouse stressed the importance of complete designs, experienced contractors, and reliable suppliers. They discussed features and future plans for the AP1000 and small modular reactors. The committee was also referred to a Virginia report on assessing nuclear capacity.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-jan-23-2023/

Minutes

Attendance:

Commission Members: Representative Keith Ammon, Cathy Beahm, Dan Goldner (remote),

Matthew Levander (remote), David Shulock, Christopher McLarnon, Marc Brown (remote), Representative Michael Harrington

Absent: Senator Bill Gannon, Alex Fries, Bart Fromuth

Public: Paul Gunter, Sarah Abramson, Gary Woods

Meeting:

1. A physical quorum was not established. Rep. Ammon opened the meeting at 1:34pm
2. Rep. Ammon confirmed Marc Brown will function as clerk.
3. The commission will seek to approve the minutes of the commissions December 12, 2022, gathering at the next meeting.
4. Rep. Ammon invited the public to share introduce themselves and share comments.
    - Paul Gunter from Beyond Nuclear spoke first. He raised concerns about the failure of nuclear construction projects to reach completion, and the costs continuing to spiral out of control. Their group feels it a nationwide issue that is worsening over time.
    - The next speaker was Sarah Abramson C-10 Foundation. Her concerns lie with the State of New Hampshire's Radiation Monitoring Program, expressing that it does not seem nearly as robust or adequate as our real-time monitoring network can provide. She asked that the State makes sure it thinks very clearly and thoroughly about what radiation monitoring should look like with today's technology. Ms. Abramson also expressed concerns about concrete issues with Seabrook and other projects, and that rushing to select materials and contractors that may be less than desirable adds to these concerns.
    - Mr. Gary Woods was the final public commenter, noting he is just an interested citizen.
5. The first presentation was given by Michael Wentzel, Branch Chief at the US Nuclear Regulatory Commission (NRC). He first gave a historic perspective of where things have been, and then discussed where the NRC is headed next with respect to licensing, regulation, safety, and efficiency. He noted that improving the efficiency of licensing and shortening the licensing process, making these licensing a little bit more predictable are some of the key areas of focus. He

examined three examples of projects already in process: Shine Technologies, a medical isotope facility currently under construction in Janesville, Wisconsin that is nearly complete, and two projects, Kairos Power and Abilene Christian University, which are both licensing applications for advanced reactor concepts. Kairos and Abilene are currently in the first phase, getting a construction permit, and will be requesting an operating permit when the facility nears completion. Mr. Wentzel discussed Part 53, which proposes combining the two licenses into one in the appropriate situations. The intent is to modernize the licensing process and strike an optimal balance between flexibility and predictability by providing some clear and specific performance-based requirements that ensures an efficient and effective licensing process.

6. Rep. Ammon introduced the next speaker, David Durham, Westinghouse. He discussed the AP1000 projects, and the success Westinghouse has had with them so far. He also shared 3 major lessons learned from the Vogtle Project:

   - Don't start construction without a 100% complete design
   - Only work with a contractor experienced in nuclear construction
   - Only work with experienced suppliers to keep the supply chain flowing

   Mr. Durham shared other key data points and performance metrics such as safety and operating availability. In response to a question from Rep. Harrington, Mr. Durham explained the difference between availability factor and capacity factor, citing that capacity looks at what the reactor could be doing, and availability measures what it is actually doing, the percentage of time it's up and running.

   Mr. Durham also discussed the AP1000's ability to keep cool for 72 hours with zero human intervention and without boron cycles, as well as its ability to load follows with ramp rates faster than a gas plant, one megawatt per second. He also only reactor capable of station blackout cope, which is considered it is game-changing technology.

   Several questions were posed about potential supply chain issues, and Mr. Durham assured the commission that they are working with a global supply chain that they monitor carefully, and right now, there are no issues presenting themselves for expansion of this project. Mr. Durham also discussed future technology that is being developed to allow for non-diesel reactors that are capable of generating electricity for 8 years, and are then simply swapped with a new reactor, and the old one is taken off-site for refueling and storage of cement fuel. It is anticipated that this will be more cost-effective method of operation, with the flexibility to attract both full-scale power plant customers and customers who are looking just for electricity.

   Mr. Durham also touched on SMR application, and the role Westinghouse is having in its development. He stated that many more details are yet to come on these initiatives, as they are in the beginning of the application process with NRC. It was suggested that the Science Technology and Energy committee make a site visit to the Newington facility.

7. Rep. Ammon asked if there were any other agenda items or discussion from the committee members. Matt Levander had previously distributed Virginia Innovative Nuclear hub document, also available at https://nuclearnh.energy, for discussion. Mr. Levander explained that the State of Virginia has prioritized efforts to determine whether building nuclear is a good fit for their state, and this paper outlines some of their thought process.

8. No other questions or issues were presented by the commission.

9. A poll of commission members will be taken to determine the next meeting date.

10. The meeting was adjourned at 3:15pm.

Minutes submitted by Marc Brown.

March 6, 2023, Meeting

Overview

On March 6, 2023, the commission heard presentations from TerraPower on their Natrium advanced nuclear reactor project in Wyoming as well as from Centrus Energy on their plans to produce high-assay low-enriched uranium (HALEU) fuel. Key discussion points included the challenges around financing and fuel supply for advanced reactors, the licensing process with the NRC, and the potential to leverage national security needs to help accelerate commercial nuclear power development. The commission also discussed updates on other nuclear companies, the open Coordinator of Atomic Development Activities position in New Hampshire, and potential future meeting presenters.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-mar-6-2023/

Minutes

Attendance:

Commission Members: Rep Keith Ammon, Rep Michael Harrington, Sen Howard Pearl, Cathy Beahm, Dan Goldner, Matthew Lavender, David Shulock, Bart Fromuth (remote), Christopher McLarnon (remote)

Absent: Marc Brown, Alex Fries

Public In-Person: John Schneller

Public Remote: John Tuthill, Vikram Mansharamani, Christine Csizmadia - NEI, Andrew Richards, Karen Testerman, Connor Woodrich, Gary Woods

Meeting:

1. The New Hampshire Commission to Study Nuclear Technology meeting was called to order by Rep Keith Ammon at 1:40 pm. The commission had a quorum present.
2. Welcome New Member: Sen Howard Pearl was welcomed as the newest member of the commission. Sen Pearl introduced himself and shared maple fudge with the commission members.
3. Approval of Minutes: The commission approved the December 12th meeting minutes, with one abstention from Sen Pearl. The commission approved the January 23rd meeting minutes, with one abstention each from Sen Pearl and Bart Fromuth. The minutes will be posted on the commission's website: https://nuclearnh.energy/.
4. Presentation by Jeff Navin of TerraPower.

   Introduction:

   - Jeff Navin, Director of External Affairs at TerraPower
   - Discussing the Natrium reactor project in Kemmerer, Wyoming

   Background of TerraPower:

   - Founded by Bill Gates
   - Focused on advanced nuclear technology to address climate change and global energy poverty

   Natrium Reactor:

   - Differences from conventional nuclear reactors:
     - Uses sodium instead of water as a coolant

    - Smaller in size (345 MW compared to 1 GW)
    - Employs molten salt energy storage system
- Provides a safer, more economical, and flexible power generation solution

Project in Kemmerer, Wyoming:

- Part of the Department of Energy's Advanced Reactor Demonstration Program
- Expected to come online around 2030
- Will be licensed for 60 years with an opportunity to extend for another 20 years
- Partnership with Rocky Mountain Power PacifiCorp
- Selected site due to enthusiastic community support

Community impact:

- Kemmerer is a small town with a population of 2,700
- The Natrium project will help retain jobs from the retiring coal plant and coal mine
- 109 IBEW members currently working at the coal plant will be offered jobs at the Natrium plant
- Expected to have 200-250 full-time employees and around 1500 jobs

5. Q&A with Jeff Navin of TerraPower

Q: Rep Michael Harrington: Is Wyoming a non restructured state in that this plant would be approved by the PUC out there, and then the rate would be on the hook to fund it? Is that correct?

A: Jeff Navin: Yes, Wyoming is a regulated state, but the deal is structured to set a fixed price for the sale of the plant, and the rate payers will not be on the hook to pay for that until the plant can be delivered at that set price.

Q: Rep Michael Harrington: Where are you going to get the HALEU?

A: Jeff Navin: Currently, Centrus is producing small amounts of HALEU in Piketon, Ohio as part of a project with the Department of Energy. There is a HALEU fuel program authorized by the Energy Act of 2020 to help address the chicken and egg problem of HALEU production and customer demand. The funding for the program is around $600 million, and TerraPower is waiting for the DOE to release their draft RFP for companies like Centrus to apply. TerraPower's reactor was initially planned to come online in 2028 but has been pushed back to 2030 due to HALEU challenges. Some small amounts of HALEU might be available from the Department of Energy's weapons program through down-blending highly enriched uranium from nuclear warheads.

Q: Rep Michael Harrington: In normal operations, would you be putting the 345 megawatts out on the grid, and then when there was a lot of solar or a lot of wind, would you continue to produce 345 and dump that into thermal storage or load follow?

A: Jeff Navin: TerraPower intends to load follow. The heat from the reactor will go through an intermediate loop heat exchanger and be used to heat up the salt in the molten salt energy storage system. All electricity generation will come from a steam turbine attached to the molten salt energy storage system, and the system can ramp up and down from about 40 to 50 megawatts up to 500 megawatts.

Q: John Schneller: Is there a minimum baseline number of acres where a production facility could be built, and what level of stability would be required for that site?

A: Jeff Navin: The current layout for TerraPower's reactor is 44 acres. While they try to keep it as compact as possible, there might be some flexibility to accommodate a smaller site. The Nuclear Regulatory Commission process requires a robust site assessment, including geological and meteorological studies, to determine the feasibility and safety of the site.

Q: John Schneller: How would the construction and operation of a nuclear power plant with a useful life of over 60 years be financed?

A: Jeff Navin: The financing of new nuclear power plant construction is under active discussion. In the past, the costs of reactor construction were spread out over the plant's life through rate basing in regulated markets. The financing mechanisms for nuclear power plants are still being developed for the current market situation. The government's Advanced Reactor Demonstration Program has stepped in to help finance the first plant with a federal cost-share. TerraPower also has a memorandum of understanding with Rocky Mountain Power to build five additional plants, which could help drive down costs and develop financing mechanisms for future projects.

(Jeff Navin's connection dropped. More questions were asked of him later in the meeting.)

6. Presentation by Dan Leistikow of Centrus Energy.

Introduction:

- Dan Leistikow from Centrus presents an overview of the company and its history.
- Centrus is the only publicly traded uranium enrichment company in the world.
- They are working on high assay low enriched uranium (HALEU) production in Ohio.

Company history:

- Centrus grew out of the Manhattan Project.
- It operated the US government's enrichment plants until the last one shut down in 2013.
- Centrus played a significant role in the "Megatons to Megawatts" program to repurpose Soviet nuclear material for civilian use.

HALEU production:

- Centrus is working on deploying its HALEU technology in Piketon, Ohio.
- The goal is to scale up production to meet the needs of advanced reactors.

Nuclear fuel enrichment process:

- Uranium is mined, converted into uranium hexafluoride (UF6), and sent to enrichment plants.
- Centrifuges separate U-235 from U-238, increasing the U-235 content to usable levels.
- The enriched UF6 is sent to fuel fabrication facilities to be turned into fuel rods for nuclear power plants.

Enrichment levels:

- Natural uranium is less than 1% U-235.
- Low enriched uranium (LEU) is enriched to just under 5% U-235, which is used in

Benefits of LEU Plus

- Allows for fewer refueling outages

- Increases power production efficiency

US Government Requirements

- Need for additional HEU for naval reactors
- Need for LEU for tritium production
- Importance of non-proliferation and safety standards

Challenges

- Chicken and egg problem: Private capital hesitant to invest without customers, customers need fuel supply

Public-Private Partnership Proposal

- Accelerate investments in enrichment capabilities
- Reestablish US leadership in nuclear fuel production
- Leverage government investments for commercial requirements

Centrus Technology Readiness

- 3.5 million machine operation hours
- Full-scale cascade production capability
- 42-month timeline to HALEU production

Importance of Supply Diversity

- Greater global market resilience
- Reestablish American producer presence

Centrus Unique Position

- Able to meet both commercial and US government requirements
- Demonstration cascade in Piketon to begin production by year-end

7. Q&A with Dan Leistikow of Centrus Energy

Q: John Schneller: What is the total capital investment that you need to start the 36 month LEU production?

A: Dan Leistikow, Centrus: They haven't talked about specific dollar figures, and as a publicly traded company, they have to be careful about disclosing financials. It's hard to give a precise number because it varies depending on what they are deploying. Large enrichment plants producing large amounts of LEU are multi-billion dollar projects.

Q: Rep Michael Harrington: When the fuel is no longer useful, what's the end of cycle enrichment left with the fuel?

A: Dan Leistikow, Centrus: It varies a lot based on the reactor design, and there's no definitive answer provided.

Q: Rep Michael Harrington: Is there any talk of the processing or would this fuel be just handled the same way that the lower level enrichment fuels handle that?

A: Dan Leistikow, Centrus: Some advanced reactors have the ability to burn off used fuel. There is discussion about reprocessing, but Centrus doesn't see a big need for it and doesn't consider it a viable solution. They believe the priority should be on making investments to produce fresh HALEU through enrichment.

Q: Rep Michael Harrington: Is the NRC's licensing for reactors using HALEU an issue?

A: Dan Leistikow, Centrus: Centrus had a good experience with the NRC in their project and already received their license for HALEU. However, the NRC still needs to look at the reactor designs themselves.

Q: Rep Keith Ammon: Where will the demonstration reactors that are being planned get their fuel?

A: Dan Leistikow, Centrus: It's up to the reactor developers to determine their own fuel sourcing, but Centrus would like to be their source of supply. They need to get started quickly to meet the timelines for these developers.

Q: Rep Keith Ammon: Is there any coordination inside the industry to solve the chicken and the egg problem?

A: Dan Leistikow, Centrus: Centrus has been talking to many companies about this issue, but it's challenging because reactor developers invest their capital in building reactors while Centrus invests in building enrichment. A public-private partnership is needed to solve the problem, leveraging national security requirements to provide a source of fuel.

Q: Rep Keith Ammon: Were the 36 months for LEU and 42 months for HALEU consecutive timeframes?

A:Dan Leistikow, Centrus: No, they are not consecutive timeframes. It would take 36 months for LEU and 42 months for HALEU. They can do both at the same time, but with LEU, there would be a much larger deployment.

8. Q&A resumed with Jeff Navin of TerraPower.

   Q: Rep Michael Harrington: Does TerraPower expect to spend as much as NuScale for their design approval by the NRC, and does the use of HALEU present any particular hard spots with the NRC?

   A: Jeff Navin, TerraPower: TerraPower does not anticipate their licensing fees to cost anywhere near what NuScale spent. They don't think HALEU will be a particular issue. They are working with the NRC during the pre-application process to identify issues to focus on. TerraPower expects to submit their license for their construction later this year.

   Q: Rep Michael Harrington: Has TerraPower solved the issue of material corrosion with their molten salt reactor design?

   A: Jeff Navin, TerraPower: The US has successfully operated sodium-cooled test reactors at Idaho National Laboratory for many decades. Sodium is not particularly corrosive with the materials used. TerraPower has been running many loops of salt through different materials in their laboratory to understand the interactions. Advances in material science since the sixties and advanced computing help TerraPower design their reactor.

   Q: John Tuthill: Is the $500 million figure total cost for the NuScale project or just the licensing cost?

   A: Rep Michael Harrington: The $500 million figure includes engineering and licensing costs combined. It is not just what NuScale paid the NRC, but also what they paid engineers to develop their design and do calculations before talking to the NRC.

   Q: Rep Keith Ammon: Can a Natrium plant be built from scratch without requiring retrofitting an old coal plant?

A: Jeff Navin, TerraPower: TerraPower's plans are not to retrofit the plant, but they will use the workforce, grid interconnect, and water resources from the existing coal plant. Building a nuclear reactor on an existing coal site presents some challenges, and in some cases, older infrastructure or adjacent activities (like blasting in a coal mine) might pose problems.

Q: Rep Michael Harrington: Is TerraPower's project in Wyoming in the same ballpark range of about $89 a megawatt hour like NuScale's contract in Utah?

A: Jeff Navin, TerraPower: TerraPower plans to be quite a bit lower than that. They anticipate being in the $55 to $60 a megawatt hour range with integrated energy storage included in the cost, after they have built a few reactors.

9. The members discussed the importance of resolving the fuel issue for nuclear power and tie it to national security needs.
10. The members discussed updates on NuScale power and a failed bill in Virginia related to SMR production.
11. The Coordinator of Atomic Development Activities position in New Hampshire is brought up, and they discuss filling the position and making it a tie-in for the commission's reports.
12. Southern Company is a potential presenter for the next meeting, and there are suggestions for future meetings with X-Energy and a company that may make disposable reactors.
13. The meeting was adjourned at 3:15 pm.

Minutes submitted by Keith Ammon.

April 7, 2023, Meeting

Overview

On April 7, 2023, the commission heard presentations from BWX Technologies and X-energy on advanced nuclear reactors and fuel technology. Discussion topics included supply chain issues, retrofitting coal plants, safety mechanisms, medical isotope production, hydrogen generation, regulatory matters, and decommissioning costs. Plans were made to draft an interim and final report with commission member input. Suggestions for future speakers were provided and the potential benefits of hydrogen energy storage were noted. The meeting concluded with intentions to continue coordination over the summer and identify opportunities to update relevant statutes.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-apr-7-2023/

Minutes

Attendance:

Commission Members: Rep Keith Ammon, Cathy Beahm, Dan Goldner, Marc Brown, David Shulock, Bart Fromuth (remote), Christopher McLarnon

Absent: Rep Michael Harrington, Sen Howard Pearl, Alex Fries, Matthew Lavender

Public In-Person: Rep Alvin See, Douglas Mailey, Richard Barry, Vikram Mansharamani

Public Remote: Carol Lane - X-energy, Christine Csizmadia NEI, Connor Woodrich, Dave Pyles, Don Bettencourt, Gary Woods, Jackson Bouley, John Tuthill, John Valentino, Joshua Parker, Karen O'Neil-Roy NH DHHS/EPRR, Paul Gunter, Scott Kopple - BWXT, Scott Nagley - BWXT, Rep Walt Stapleton

Meeting:

1. The New Hampshire Commission to Study Nuclear Technology meeting was called to order by Rep Keith Ammon at 10:35 am. The commission had a quorum present.
2. BWX Technologies Presentation: Scott Nagley, Vice President of Business Development, and Joshua L. Parker, Director of Business Development, presented the information.

   Company Overview:

   - BWXT is a leading nuclear technology innovation company known for manufacturing naval nuclear reactors for U.S. submarines and aircraft carriers.
   - The company has a workforce of over 6,600 employees and achieved $2.1 billion USD in revenues in 2021.
   - BWXT operates 12 major manufacturing facilities totaling 3.9 million square feet.
   - They have over 60 years of experience in manufacturing naval nuclear components and reactors and have produced over 300 commercial nuclear steam generators and 1.5 million Canada Deuterium Uranium (CANDU) fuel bundles.

   BWXT's Reach:

   - Apart from manufacturing, BWXT is involved in U.S. Department of Energy (DOE) laboratories, environmental cleanup projects, and NASA sites.
   - They have delivered more than 8,000 fuel elements to national laboratories, universities, and international customers.
   - BWXT has joint ventures with several organizations for specialized projects and operations.

Company History:

- BWXT has a 165-year history of innovation, including contributions in the non-nuclear sector such as the invention of the water tube boiler.
- Their nuclear history dates back to 1946 when they were awarded their first contract with the U.S. Navy for propulsion systems.
- BWXT designed components for the first nuclear-powered submarine in 1953 and has been involved in the manufacturing of commercial nuclear power plant components since 1956.
- The company has made recent advancements in various fields, including nuclear plant design and manufacturing, space technology, medical isotope production, and advanced nuclear fuel manufacturing.

Business Operations:

- BWXT operates in both government and commercial sectors.
- In the government sector, they are involved in naval nuclear propulsion, nuclear environmental restoration and site management, and space and defense nuclear power and propulsion.
- In the commercial sector, they contribute to nuclear power generation, nuclear manufacturing, nuclear fuel production, and nuclear medicine.

The Nuclear We Need:

- BWXT emphasizes the importance of nuclear power in various applications and technologies, including space exploration, defense, and medical isotope production.
- They are developing advanced microreactors, which are scalable and transportable, to meet energy needs in off-grid and remote military applications.

Fuel Development and Manufacturing:

- BWXT has rapid product development capabilities, enabling efficient progression from R&D to full-scale production.
- They focus on design and fabrication development, utilize advanced techniques such as Sol-Gel kernels and PVD coatings, and have production capabilities for reactors and fuel elements.
- Fuel production facilities are strategically located across multiple facilities, including NOG-L and the BWXT Innovation Campus, and specialize in the development and testing of novel fuel concepts.

BANR Technology:

- The BANR reactor is based on HTGR design, offers passive and inherent safety features, and has a flexible power conversion capability.
- It is a modular system, and each module conforms to standard shipping requirements.
- The BANR technology enables rapid modular installation, refueling, and deployment of reactors.

Cost Reduction and Target Markets:

- BWXT focuses on increasing core power and extending core life to reduce the number of reactors needed and associated costs.
- They aim to improve manufacturing throughput, reduce operations and maintenance costs, and expand target markets to include mining/oil

3. BWXT Q&A:

Rep Keith Ammon: Excellent. Are there concerns about delays or issues you might have to overcome in the fuel supply chain and regulatory hurdles?

Joshua Parker - BWXT: We are currently facing supply chain issues with Project Pele, but the Department of Defense is providing funding for that. We are vertically integrated and manufacture various components for the reactor. The fuel for the reactor is sourced from the strategic stockpile of enriched material. Regulatory hurdles are being addressed, and we have the necessary licenses for fuel manufacturing.

Rep Walt Stapleton: What kind of enrichment factor do you use in these reactors? Is it variable depending on the application?

Joshua Parker - BWXT: We primarily use high assay, low enriched uranium with enrichment just below 20 weight percent uranium 235. We may slightly adjust the enrichment for specific power requirements, but the target is up to 28% enrichment.

Rep Walt Stapleton: Is the gas reactor replacing the water reactor? Are you phasing out water reactors in favor of gas reactors?

Joshua Parker - BWXT: Gas reactors, specifically high-temperature gas reactors, are not intended to replace light water reactors. Light water reactors have their role and are being extended in operation. Gas reactors are focused on industrial processes that require higher temperatures. Different reactor technologies, including gas, molten salt, and liquid metal-cooled reactors, are being developed to meet different market demands. Light water reactors will continue to play a role in electricity generation.

Paul Gunter - Beyond Nuclear: How do you plan to overcome the issue of suppliers not investing in new capacity without strong order books from your company?

Joshua Parker - BWXT: We are having discussions with end users who recognize the limitations of renewable energy sources like solar and wind. Nuclear power provides energy density and reliability, which becomes valuable for customers who need consistent power. The economics of green energy and decarbonization are being considered, and as the market grows, suppliers will find opportunities to invest in new capacity.

Rep Keith Ammon: What are the non-electrical applications of your technology, particularly in medical isotopes?

Joshua Parker - BWXT: Nuclear reactors can be used to generate medical isotopes. Our focus is on producing medical isotopes through processes involving reactors like the CANDU reactors in Canada. We have the expertise to handle fuel and materials safely, which aligns with our fuel manufacturing capabilities. Medical isotopes are an important application of our technology.

4. X-Energy Presentation:

Carol Lane, Vice President of Government Relations and John Valentino, Director of Customer Relationship Management presented on behalf of the company.

X-energy Overview:

- X-energy is a reactor design and fuel manufacturing company established in 2009.
- The company focuses on high-temperature gas reactors and TRISO fuel.
- X-energy was founded by Dr. Kam Ghaffarian, who recognized the need for accessible and clean electricity globally and saw the potential of high-temperature gas reactors.
- X-energy has experienced significant growth, currently employing over 440 people.

High-Temperature Gas Reactors:

- X-energy's high-temperature gas reactor is a grid-scale reactor known as the "four pack" consisting of four modules.
- The pebble bed reactor design allows for high burnup of the fuel, with pebbles cycling through the reactor multiple times.
- X-energy has been working on making TRISO fuel and operates a pilot manufacturing facility.
- The company plans to build a commercial-scale TRISO fuel fabrication facility in Oak Ridge, Tennessee.

Advanced Reactor Demonstration Program:

- X-energy was selected as one of the awardees for the Department of Energy's Advanced Reactor Demonstration Program.
- The program provides a bridge for customers to adopt advanced reactors without taking on the risks of being the first adopter.
- X-energy is designing a four-pack reactor for deployment with Dow Chemical at a Gulf Coast site.
- The company is also constructing a commercial-scale TRISO fuel facility in Oak Ridge, Tennessee.

Other Initiatives and Advantages:

- X-energy is involved in strategic government R&D initiatives for space nuclear reactors and small terrestrial reactors.
- The company aims to modularize and standardize components to enhance manufacturability and supply chain resilience.
- X-energy's reactors offer load-following capability, providing flexibility to blend loads with renewable energy sources.
- The high-temperature steam produced by the reactors has various industrial applications, including clean hydrogen production.

Regulatory and Political Support:

- X-energy has been in discussions with the Nuclear Regulatory Commission since 2018 for both reactor and fuel facilities.
- The company has submitted topical reports and white papers, with plans to submit a construction application in late 2023.
- The federal government has shown bipartisan support for advanced nuclear through initiatives like the Advanced Reactor Demonstration Program and funding for HALEU fuel production.
- X-energy is closely following changes in state environments and is open to collaborating with stakeholders.

Future Plans:

- X-energy aims to deploy its reactors within the next few years.
- The company is currently engaged in fundraising efforts and plans to go public in 2023.
- X-energy is working on operator training simulation and building a plant support center for operational training.

Closing Remarks:

- Carol Lane concluded her presentation by emphasizing the potential of advanced reactors to address energy challenges and contribute to decarbonization efforts. She highlighted the power and energy density of nuclear reactors and expressed X-energy's commitment to advancing the deployment of advanced nuclear technology.

5. X-energy Q&A:

   Q: Cathy Beahm: Is the Maryland generation study on converting coal plants to nuclear readily available?

   A: Carol Lane - X-energy: Yes, there is a public version available on the Maryland Energy Administration website. I can send you a link to it and also provide the PDF if needed.

   Q: Cathy Beahm: Can you explain how the TRISO pebble becomes an active power source once it's in the reactor?

   A: John Valentino - X-energy: The TRISO pebbles contain uranium 235, and when they are exposed to a neutron field in the reactor, some of the uranium 235 splits, releasing heat. The heat is then extracted by pumping helium or water over the pebbles.

   Q: Rep Keith Ammon: How is the heat regulated in the reactor and what are the safety mechanisms?

   A: John Valentino - X-energy: The heat is regulated by controlling the fluid flow, either helium or gas, over the pebbles. In case of a shutdown, control rods are inserted into the reactor core to absorb the neutrons and prevent further reactions and heat generation.

   Q: Rep Keith Ammon: Is there any waste of heat or energy during load-following that could be utilized for other purposes like hydrogen production?

   A: John Valentino - X-energy: During load-following, if there is excess heat generated, it can be diverted to other uses such as hydrogen production, thermal storage systems, or desalination plants, depending on the setup. The goal is to avoid wasting heat and maximize efficiency.

   Q: Rep Keith Ammon: How would you retrofit a coal plant to accommodate nuclear power generation?

   A: John Valentino - X-energy: Retrofitting a coal plant involves evaluating the existing infrastructure, transmission systems, and trained workforce. Some equipment may be reusable, while specific nuclear components would need to be added. The focus is on utilizing existing resources and adapting them for a new purpose.

   Q: Rep Keith Ammon: What is the required buffer zone or population distance around your reactor?

   A: John Valentino - X-energy: The buffer zone is typically measured by distance, and for our reactor, it is around 400 meters, which is much smaller than the current 10-mile zone around reactors like Seabrook.

   Q: Paul Gunter – Beyond Nuclear: Can X-energy provide confidence in its containment strategy by not participating in the Price Anderson Act?

   A: Carol Lane - X-energy: We are still in the final design phase and going through the regulatory process. The decision regarding containment strategy and liability coverage will be made between us and our customer in the future.

6. Discussion:

Richard Barry expressed his concerns about the amount of money that has been invested in the decommissioning of the Seabrook Nuclear Power Plant. He suggested that the government should take action to mitigate the costs associated with decommissioning. The possibility of modular reactors was also mentioned, with the understanding that the dynamics and costs may differ from traditional reactors.

Cathy Beahm proposed creating a grid that outlines the different speakers and their respective reactors and tools covered in the discussions. Rep Keith Ammon supported this idea and mentioned the possibility of involving an intern to help with the task.

Douglas Mailey, a member of the public, asked about the final objective of the session and whether specific recommendations or an overview report would be produced. Rep Keith Ammon clarified that one aspect would be to propose adjustments to state statutes and to explore the potential for the industry's development in the state. The engagement of the federal delegation and the availability of funds for the industry were also discussed.

Vikram Mansharamani shared his conversation with the management team of Oklo, a nuclear energy company, and their potential interest in exploring opportunities in New Hampshire. Rep Keith Ammon expressed interest in keeping in touch with Vikram to stay updated on any progress.

Various potential future speakers were mentioned, including representatives from the Department of Nuclear Energy, Holtec, Q Hydrogen, and LightBridge. The importance of understanding the supply chain ecosystem, desalination, and hydrogen as an energy storage option was also emphasized. The potential involvement of the federal government and the need to update relevant statutes were discussed.

Rep Keith Ammon provided updates on his request to the executive council regarding the vacant position responsible for monitoring atomic energy. He shared that the request was acknowledged, and that the governor's office was looking into the matter. He also mentioned a report issued by the Department of Energy, titled "Pathways to Commercial Liftoff for Advanced Nuclear," which outlines the federal government's vision for advancing nuclear technology.

Rep Keith Ammon proposed drafting an interim report due in July and a final report due in December, with the intention of including input from all commission members. He suggested taking a break during the summer and continuing to plan future meetings. Attendees were encouraged to provide suggestions for potential speakers and connections.

Lastly, the meeting concluded with a discussion on the potential benefits of hydrogen as an energy storage solution and the viability of pump storage systems.

7. The meeting was adjourned at 12:20 PM.
   Minutes submitted by Keith Ammon.

May 12, 2023, Meeting

Overview

On March 6, 2023, the commission received presentations from the American Nuclear Society and Holtec International on the current state and future prospects of nuclear energy. Key topics discussed included growing interest in nuclear energy, new investments in advanced reactor technologies, challenges related to fuel supply, waste management, and workforce development, the potential of small modular reactors, and the importance of nuclear energy as a reliable, resilient, and clean source of electricity. The commission also had discussions regarding nuclear education programs, engaging the public on nuclear topics, and ratepayer interests.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-may-12-2023/

Minutes

Attendance:

Commission Members: Rep Keith Ammon, Cathy Beahm, Marc Brown (arrived 9:18 AM), Pradip Chattopadhyay (substitute for Golder), Bart Fromuth, Rep Michael Harrington, Christopher McLarnon, David Shulock

Absent: Alex Fries, Daniel Goldner (Chattopadhyay was substitute), Matthew Lavender, Sen Howard Pearl

Public In-Person: Hon Richard Barry, Rep Steven Bogert, Mailly Douglas, Donald Kreis, Vikram Mansharamani, Rep Alvin See, Rep Doug Thomas

Public Remote: Craig Piercy - ANS, Gareth Thomas - Holtec, Tanya Donnelly, Guido, Paul Gunter, Jeremy Hitchcock, Pat O'Brien, Joy Russell, Timothy Smyth, Rep Carry Spier, Rep Walt Stapleton, John Starkey, John Tuthill

Meeting:

1. The New Hampshire Commission to Study Nuclear Technology meeting was called to order by Rep Keith Ammon at 9:05 am. The commission had a quorum present.
2. Rep Ammon introduce PUC Commissioner, Pradip Chattopadhyay, who filled in for Daniel Goldner.
3. Approval of the minutes from the March 6th meeting was moved by Rep Harrington, seconded by Bart Fromuth. The minutes were approved by unanimous voice vote.
4. Approval of the minutes from the April 7th meeting was moved by Cathy Beahm, seconded by Chris McLarnon. The minutes were approved by unanimous voice vote.
5. Craig Piercy, the Executive Director and CEO of the American Nuclear Society, presented before the New Hampshire Commission to Study Nuclear Energy Technology. He discussed the current state and prospects of nuclear energy, highlighting its relevance in the context of climate change and the need for decarbonization. Piercy provided insights into public opinion, investments, reactor designs, challenges, and the role of nuclear energy in a renewable energy grid.
   A. American Nuclear Society (ANS):
      - ANS serves as the Technical and Professional Society for Applied Nuclear Science.
      - It supports its 10,000 members through meetings, publications, professional development, and engagement with policy and journalism.
      - ANS is expanding its programs to improve K-12 education programs related to nuclear science.

   B. Growing Interest in Nuclear Energy:

- Piercy noted that nuclear energy is currently experiencing a surge in interest and popularity.
- He mentioned examples of recent events, such as the premiere of the movie "Nuclear Now" and the support expressed by influential figures like Elon Musk.

C. Nuclear Renaissance vs. Nuclear Enlightenment:
   - Piercy differentiated between the previous "nuclear renaissance" era and the current "nuclear enlightenment" phase.
   - The nuclear enlightenment focuses on addressing the challenges of climate change, decarbonization, and maintaining a reliable grid with increased renewable energy penetration.
   - Nuclear energy is recognized as a proven source of clean, firm power in a carbon-constrained world.

D. Historic Investments and Generation IV Technologies:
   - Piercy highlighted the significant public investments in nuclear energy, particularly through the Inflation Reduction Act and the Infrastructure and Jobs Act.
   - These investments support the expansion and development of new nuclear technologies.
   - He discussed various reactor designs, including Generation III+ light water plants, high-temperature gas reactors, pebble bed reactors, heat pipe reactors, and fusion energy.

E. Challenges and Focus Areas:
   - Fuel Supply: Piercy discussed the challenges related to low enriched uranium (LEU) and high assay LEU (HALEU). He mentioned efforts to establish domestic supply chains and the development of enrichment technologies like laser enrichment.
   - Regulatory Readiness: Piercy acknowledged the challenges faced by the U.S. Nuclear Regulatory Commission (NRC) in adapting its regulatory framework for advanced reactors. He expressed confidence in the NRC's ability to handle future license applications.
   - Nuclear Waste: Piercy noted that nuclear waste management faces policy challenges, despite the safety of current storage methods. Private companies show interest in extracting usable uranium from spent fuel rods.
   - Skilled Workforce: The nuclear industry faces the challenge of attracting and retaining skilled professionals. ANS is working on expanding education programs and developing certification programs for professionals from adjacent industries.

F. Nuclear Energy as a Grid Anchor:
   - Piercy emphasized the importance of nuclear energy as a reliable and resilient source in a grid with high penetrations of intermittent renewable energy.
   - He encouraged the commission to consider the role of nuclear energy in creating a reliable and resilient grid and its feasibility in meeting clean energy goals.

G. Conclusion: Piercy concluded by highlighting the need for timely action and strategic decision-making regarding the incorporation of new nuclear generation into energy plans. He emphasized the advantages of nuclear energy in terms of reliability, resilience, and its potential contribution to decarbonization efforts. Piercy expressed readiness to address any questions from the commission members.

6. Gareth Thomas, Senior Program Manager for Holtec, introduced himself and discussed the purpose of the speech. Holtec is a technology development company specializing in nuclear fuel storage.

A. Holtec's History and Core Business

- Holtec was founded in 1986 by the current owner and CEO, initially focusing on heat exchanges and plant equipment.
- The company transitioned to solving the storage issue of spent nuclear fuel, starting with underwater racks and high density racks, and later moving to dry gas storage.
- Fuel storage became Holtec's core business for the past 15 to 20 years.

B. Expansion into Reactor Decommissioning and SMR Development
- In the last five years, Holtec expanded its operations to include reactor decommissioning and small modular reactor (SMR) development.
- The SMR 160 program began in 2010, aiming to design a fail-safe and walk-away-safe reactor using existing technology.
- Holtec developed a 160-megawatt electrical pressurized water reactor (PWR) suitable for single or multiple units on one site.

C. Progress and Current Focus
- Holtec completed the Canadian VDR phase one and received a DOE fund under the Advanced Reactor Demonstration Program.
- They are working on developing the licensing documentation and preparing to submit a Construction Permit Application.
- Engaging with the NRC for feedback and ensuring a smooth construction permit application process.
- Identifying the location for the first commercial SMR project, with the Oyster Creek site in New Jersey as the primary candidate.

D. Commercial Project Challenges
- Securing power purchase agreements and ensuring competitive electricity prices.
- New Jersey's historically competitive and stable power market poses challenges in pricing the electricity.
- Exploring other potential sites owned by Holtec and initiating discussions with utilities in the southern US.

E. Construction and Cost Considerations
- Holtec is partnering with construction company Kiewit to refine the plant design and cost estimates.
- Focusing on achieving an executable status for the design and ensuring high confidence in the project budget.
- Striving to stay on budget and on schedule for the first plant, while aiming for competitiveness in construction costs.

F. Conclusion and Future Prospects
- Holtec's goal is to obtain a Construction Permit Application and license the first SMR under the standard process.
- The company is actively pursuing the Oyster Creek site for the first commercial SMR project.
- Challenges include first-of-a-kind risks, keeping projects on time and on budget, and reducing costs over time.
- Holtec aims to bring their SMR technology to market efficiently, capitalize on cost reductions, and expand their project portfolio.

7. Holtec Q&A:

Rep. Michael Harrington: Why did Holtec choose a two-part licensing approach instead of a combined license like Vogtle?

Gareth Thomas, Holtec: The combined construction and operating license can have its challenges. At Vogtle, they certified the design but encountered difficulties in making design changes during construction. They had to go back to the NRC for approval, which caused delays. So we opted for a two-part licensing approach to avoid such issues.

Rep Michael Harrington: Does Holtec take on the construction cost risks in the PPmodel? Would you bear the consequences of cost overruns or benefit from cost savings?

Gareth Thomas, Holtec: Yes, in the model we presented for the Oyster Creek project, we would be liable for the construction costs. We would negotiate power purchase agreements (PPAs) with a utility, and any cost overruns or savings would be our responsibility.

Rep Michael Harrington: This seems like a significant change in the way nuclear plants are built. Could you elaborate on that?

Gareth Thomas, Holtec: Indeed, it is a substantial change. Traditionally, nuclear plants have involved owner-operators and risk-sharing approaches. However, currently, there aren't many owner-operators in the US willing to build the first-of-a-kind SMRs. We are exploring options and engaging with potential partners. If those discussions don't progress, we have the Oyster Creek project as an option.

Rep Michael Harrington: Could you provide more information about the Oyster Creek project and its implications for the merchant plant model?

Gareth Thomas, Holtec: The Oyster Creek project follows a merchant plant model. It involves negotiating with utilities and assuming the risks associated with construction costs.

Rep Michael Harrington: New Hampshire is a merchant plan market as well and would have to explore a similar model for its nuclear projects.

Rep Keith Ammon: How is Holtec interfacing with recent federal programs like the Inflation Reduction Act?

Gareth Thomas, Holtec: We have been evaluating the impact of the Inflation Reduction Act and other federal programs on our projects. While I may not have all the details, it has allowed us to assess the potential financial benefits, such as the tax credit. The exact dollar amount per megawatt hour is something we have been analyzing, and it appears that with the Inflation Reduction Act and associated credits, the cost could increase from around $45 to potentially $80 or $90 per megawatt hour. I recommend reaching out to me offline, and I can connect you with the relevant person at Holtec for a more detailed answer.

Rep Keith Ammon: Holtec has expertise in handling nuclear waste, as seen with the recent project in New Mexico for temporary storage. Could you share some insights on this aspect?

Gareth Thomas, Holtec: Our owner has been passionate about consolidating spent nuclear fuel at a central facility instead of storing it at multiple sites across the country. This approach allows for the decommissioning of sites and frees them up for redevelopment or other purposes. Licensing a central facility provides our existing clients, like those in California looking to exit nuclear, with the option to move their fuel to our facility in New Mexico. For the sites we acquire and decommission, it enables us to transfer the fuel to the central facility and release the site for other uses or SMR development. We have obtained the license, and the next step will be identifying the first customer, which will determine the construction timeline.

8. American Nuclear Society (ANS) Q&A:

Rep Doug Thomas: How does Holtec plan to introduce the nuclear science curriculum to schools across the states?

Craig Piercy, ANS: We have already developed a K-12 curriculum in partnership with the Department of Energy and Discovery Education. This curriculum, called Navigating Nuclear, is available on our website ans.org and covers elementary, middle, and high school levels. It aligns with the Next Generation Science Standards. While each state has its own specific education policies, our goal is to provide teachers with the necessary resources and materials to teach nuclear science effectively. We are working on expanding our resources, including physical materials like Geiger counters and cloud chambers, to support teachers in delivering the curriculum. Additionally, we have programs like nuclear ambassadors and the Pathways to Nuclear program to further engage students and provide them with additional resources for their interests in nuclear science.

Rep Keith Ammon: Does the curriculum implementation depend on individual state education policies?

Craig Piercy, ANS: Yes, the implementation of the curriculum can be influenced by state education policies. Our focus is on providing materials and training for teachers, but to ensure successful adoption, engagement at the state level is important. We need to work together to ensure that standards-aligned lessons can be taught and encouraged in classrooms as much as possible. While we are not currently at that stage as an organization, we are open to exploring opportunities and ideas to assist schools in New Hampshire or any other state.

Rep Keith Ammon: Are there programs available at the university level that address workforce development needs for nuclear plants?

Craig Piercy, ANS: Our curriculum development primarily focuses on the high school level. However, we are working on certification activities for professionals interested in transitioning into the nuclear field. This certification program aims to provide the necessary knowledge in nuclear science, regulatory systems, reactor operations, fuel cycle, radiation, and radioactivity. Our goal is to support professionals from related fields, like electrical engineers, who can bring their expertise to the nuclear industry with a solid understanding of its broader context. While universities play a significant role in nuclear education, including nuclear engineering programs, workforce development for tradespeople necessary for plant construction is also a priority. Programs supported by the Nuclear Energy Institute, Nuclear Regulatory Commission, and Department of Energy at two-year institutions are helping to increase the supply of qualified workers.

Rep Michael Harrington: Considering past challenges with projects like Vogtle, is this our last opportunity for non-government funded nuclear plants?

Craig Piercy, ANS: While it may be too stark to say it's the last chance, there is a recognition that we need to learn from past mistakes. We have to improve business practices and regulatory approaches to ensure projects are completed on time and within budget. Small modular reactors (SMRs), especially those built in a factory environment, offer opportunities for increased efficiency and cost competitiveness. However, industry must set realistic expectations and regulators must act in a timely manner. While it's challenging, the combination of lessons learned, improved practices, and factory production can provide a good opportunity for success.

Rep Michael Harrington: With safety-related components in SMRs, how do you see the qualification of these parts through part 21? Will there be a third party involved or will each designer and manufacturer need to qualify the parts themselves?

Craig Piercy, ANS: While not my area of expertise, I believe it will be a combination of both. There is an opportunity for companies within the industry to specialize in qualifying safety-related parts and providing those services. It may involve a mix of third-party qualifications and internal qualification efforts by designers and manufacturers like Westinghouse and Holtec.

Bart Fromuth: What can we do at a state level to promote nuclear technologies in New Hampshire, such as changes in our renewable portfolio standard?

Craig Piercy, ANS: State policies should be technology neutral and avoid barriers to nuclear development. Changes to the RPS/CES to support clean firm dispatchable energy in a technology-neutral manner would be beneficial. Engaging with interested entities and creating an environment that prioritizes clean firm dispatchable energy will foster competition and encourage nuclear technologies to be ready to compete.

Marc Brown: What contributes to South Korea's success in building economically viable nuclear plants?

Craig Piercy, ANS: South Korea's success cannot be solely attributed to nuclear technology itself. While projects like Vogtle in the US face challenges, it is not a fundamental issue with the technology. South Korea has shown efficient execution of projects, and similar plants in China are built on time and on budget. The US needs to address the execution of large-scale projects to improve outcomes and cost-effectiveness. The focus should be on project execution rather than inherent problems with nuclear technology.

Pradip Chattopadhyay: Can you provide more information about heat pipe reactors and nuclear batteries?

Craig Piercy, ANS: Heat pipe reactors are small, self-contained reactors with no moving parts that can be deployed in remote locations. They generate heat and can provide clean energy without operator intervention for several years. Nuclear batteries are a concept where small reactors are used to power individual homes or facilities for extended periods. These technologies are being developed by companies like Westinghouse and Oklo, although they are not yet commercially available.

Paul Gunter, Beyond Nuclear: What is the American Nuclear Society's position on consensus-based sighting for high-level radioactive waste repositories, specifically in relation to the Cardigan Pluton site in New Hampshire?

Craig Piercy, ANS: The Department of Energy is pursuing a consent-based process for interim storage facilities rather than new repositories. The focus is on finding willing host communities for storage rather than selecting new sites. The American Nuclear Society emphasizes the importance of defining safety standards and engaging in discussions about repository options. At present, there is no active discussion within the DOE about selecting a new repository. The emphasis is on innovation and giving technology time to develop.

9. Discussion:

During the discussion, Rep Keith Ammon mentioned a question raised in the Zoom chat by Timothy Smyth about restarting the Seabrook Science Center. Rep Michael Harrington and Rep Keith Ammon reminisced about their past visits to the center. Rep Steven Bogert, a visitor from the Public Works Commission, shared his experience visiting a nuclear reactor in North Carolina and emphasized the importance of educating the public to alleviate fears and prevent legal complications.

Rep Michael Harrington highlighted the difference between vertically integrated utilities like Duke in North Carolina, which can pass on education costs to ratepayers, and merchant plant states like New Hampshire, where such costs come directly from profits. Marc Brown suggested exploring funding options for education, possibly through the Department of Energy.

Dick Barry clarified his question about spending on spent fuel reserves, mentioning a friend who served on nuclear-powered submarines without any issues from radiation. Rep Keith Ammon and Dick Barry discussed the safety of living near a nuclear reactor for extended periods in a submarine underwater.

Rep Michael Harrington brought up the analysis group report on Seabrook that highlighted potential cost savings for Massachusetts ratepayers through long-term contracts with Massachusetts utilities. Don Kreis, the State Consumer Advocate, expressed interest in the commission's work and emphasized the industry is expressing a need for government support to de-risk the advanced nuclear industry financially.

Rep Keith Ammon mentioned the possibility of adding nuclear power to the state's renewable portfolio standard, and Don Kreis expressed his duty to ensure that New Hampshire ratepayers are not burdened by the energy policies of other states. They discussed the importance of addressing ratepayer interests and securing clean, baseload power.

Rep Keith Ammon informed the attendees about the premiere of Oliver Stone's Nuclear Now movie, which explored the history and potential of nuclear power. He mentioned he will notify the group if when finds out the movie available for streaming.

Rep Keith Ammon provided an update on the vacant position in existing NH statutes related to the "peaceful use of atomic energy," stating that he will follow up further with the Executive Council and Governor's office for further information and report any updates.

10. A motion to adjourn was made by Rep Harrington and seconded by Bart Fromuth. The motion passed by voice vote and the meeting was adjourned at 11:10 AM. Minutes submitted by Keith Ammon

June 19, 2023, Meeting

Overview

The June 19, 2023, meeting featured presentations by Lightbridge Corporation on their advanced nuclear fuel design using high assay low enriched uranium, and by Matthew Wald on emerging fission and fusion reactor technologies. Other agenda items included an overview of the refueling process at Seabrook Nuclear Power Plant, a proposed site tour for commission members, discussion of potential topics for future meetings, public comments, and planning for the next monthly session in early August.

Meeting event page: https://nuclearnh.energy/event/regular-meeting-june-19-2023/

Minutes

Attendance:

Commission Members: Rep Keith Ammon, Cathy Beahm, Bart Fromuth, Daniel Goldner, Rep Michael Harrington, Matthew Levander, Christopher McLarnon, Mikael Pyrtel

Absent: Marc Brown, Sen Howard Pearl, David Shulock

Public In-Person: Mailly Douglas, Rep Alvin See

Public Remote: Matthew Abenante Lightbridge, Christine Csizmadia NEI, Brendan Flaherty, Seth Grae Lightbridge, Andrew Harmon, Jeremy Hitchcock, Vikram Mansharamani, Nathan Raike, Walt Stapleton, John Tuthill, Matt Wald,

Meeting:

1. The Commission to Investigate the Implementation of Next Generation Nuclear Reactor Technology in New Hampshire meeting was called to order by Rep Keith Ammon at 9:03 am. The commission had a quorum present.
2. Rep Ammon welcomed new member, Mikael Pyrtel, representative for the NH Department of Business and Economic Affairs.
3. Approval of the minutes from the May 12th meeting was moved by Bart Fromuth, seconded by Chris McLarnon. The minutes were approved by voice vote. Dan Goldner and Mikael Pyrtel abstained.
4. Presentation by Seth Grae of Lightbridge Corporation
    a. Introduction
    - Seth Grae, the CEO of Lightbridge Corporation, introduced himself and provided an overview of the company's focus on designing advanced fuels for existing and small modular reactors. He expressed his pleasure in joining the Nuclear New Hampshire Study Commission and acknowledged the presence of Matt Wald, a renowned analyst and writer in the nuclear power industry. Seth Grae mentioned his readiness to address any questions and comments from the attendees.

    b. Overview of Lightbridge's Fuel Design and Benefits
    - S.G. shared detailed information about Lightbridge's fuel design. He explained that the company aims to reimagine and redesign nuclear fuel by utilizing new metallurgy and scientific advancements. The fuel is designed to enhance the economics, proliferation resistance, and safety of nuclear power. S.G. discussed the ability of Lightbridge fuel to support the load-following capabilities of reactors, enabling them to work in conjunction with renewable energy sources on a zero-carbon grid.

    c. Potential Application of Lightbridge Fuel

- S.G. discussed the applicability of Lightbridge fuel in existing reactors and small modular reactors (SMRs) with similar technologies. He presented images of fuel rods and fuel assemblies developed by Lightbridge, emphasizing the use of high assay, low enriched uranium (HALEU). This type of fuel allows for longer fuel cycles, reducing the frequency of reactor shutdowns and increasing electricity production. He highlighted the absence of a fuel clad gap in Lightbridge fuel, reducing the risk of burst release of radioactive materials.

d. Partnerships with National Laboratories

- S.G. provided an update on Lightbridge's strategic partnerships with Idaho National Laboratory and Pacific Northwest National Laboratory. He explained that the company is manufacturing fuel samples and conducting testing at these facilities. The long-term partnership with Idaho National Laboratory and the US Department of Energy is a pioneering collaboration that allows for data utilization in the licensing process and industry acceptance of Lightbridge's fuel.

e. Commercialization Pathways and Target Markets

- S.G. discussed the commercialization pathways for Lightbridge fuel. He mentioned the interest in replacing Russian fuel supply in central and eastern Europe with fuel from friendlier countries. He also highlighted the potential market for Lightbridge fuel in small modular reactors, emphasizing its economic advantages, improved power output, and reduced cost per unit of electricity produced. He mentioned ongoing evaluations of different reactor types to determine the best commercial customers for Lightbridge fuel.

f. Role of Small Modular Reactors in the Energy Transition

- S.G. expressed his belief that small modular reactors (SMRs) are crucial for the global energy transition. He discussed the energy density advantage of nuclear power and its importance in meeting clean energy goals. He presented an image of NuScale's Voyager SMR and explained Lightbridge's collaboration with MIT and NuScale for fuel development. He emphasized the potential benefits of SMRs in various industries, such as industrial processes and desalination, and their ability to support local grid resilience.

g. Coal-to-Nuclear Transition and SMRs

- S.G. discussed the feasibility of transitioning retired coal plant sites to small modular reactors. He shared insights on the benefits of repurposing existing infrastructure and grid connections, potentially reducing costs and accelerating the deployment of SMRs. The economic and environmental advantages of utilizing SMRs in areas where coal plants are being retired were examined, with a focus on job creation and carbon emissions reduction.

h. Economic and Strategic Advantages of Lightbridge Fuel

- S.G. addressed questions regarding the cost competitiveness of Lightbridge fuel compared to other fuel designs. He highlighted the potential for reduced operational costs and increased revenue from longer fuel cycles, leading to enhanced profitability for nuclear power plant operators. The strategic benefits of domestic fuel supply and reduced dependence on foreign sources were also emphasized.

i. Milestones and Timeline for Lightbridge's Fuel Development

- S.G. provided an update on recent milestones achieved by Lightbridge in fuel development. He discussed the progress in manufacturing fuel samples and the ongoing testing programs at Idaho National Laboratory and Pacific Northwest National Laboratory. He presented a timeline that outlines the key steps leading to the commercialization of Lightbridge fuel.

j. Conclusion

- S.G. addressed inquiries regarding the regulatory approval process, intellectual property protection, and the potential impact of Lightbridge fuel on non-proliferation efforts. He encouraged questions and comments from the attendees and provided Lightbridge's contact information for further communication (ir@ltbridge.com).

5. Lightbridge Q&A:

Rep Keith Ammon: For the spent fuel, what happens to it? Could you provide more details on its life cycle?

Seth Grae, Lightbridge: The fuel is designed to be handled similarly to current fuel. After use, it would be stored in spent fuel pools at reactors or transferred to dry cask storage. Eventually, it would be sent to a high-level waste repository or interim storage. The fuel could also undergo pyroprocessing, a non-proliferative method of reprocessing, which keeps plutonium mixed with other isotopes that are difficult to separate. Lightbridge fuel produces significantly less plutonium than current fuel and in a non-weaponizable isotopic mixture, even if reprocessed. Independent studies have confirmed the non-weaponizability of Lightbridge fuel, and we are further exploring its benefits in reprocessing our own fuel and handling reprocessed materials from other fuels.

Rep Michael Harrington: The average wholesale price you mentioned seems high compared to recent prices. Can you explain?

Seth Grae, Lightbridge: The price figure we presented is based on a 15-year average and forward projections. At any given moment, prices may vary regionally. However, we are considering a long-term perspective spanning a hundred years. The figure is based on government agency data and forecasts, taking into account different factors influencing pricing.

Rep Michael Harrington: Regarding load-following capabilities, how does the design address the limitations posed by existing reactors with pressure vessels and the ability to heat up and cool down quickly?

Seth Grae, Lightbridge: Load-following capabilities in existing reactors would see some improvement, but it would still be limited due to the existing equipment's constraints. However, in small modular reactors (SMRs) specifically designed to handle power surges and fluctuations, the load-following capabilities would be significantly enhanced. SMRs equipped with Lightbridge fuel could effectively integrate with renewable energy sources on a zero-carbon grid.

Rep Michael Harrington: The fuel source is a concern. Where will the enriched uranium come from? Is there a market for it?

Seth Grae, Lightbridge: The enrichment level required depends on the reactor type. For pressurized heavy water reactors like CANDU, our fuel uses less than 5% enrichment, which is readily available worldwide. For light water reactors such as PWRs and BWRs, our fuel uses high assay, low enriched uranium up to 19.75% enrichment. The uranium enrichment infrastructure currently exists but needs to be expanded to meet future demand. Companies hesitate to invest in capacity expansion without clear market signals. However, Urenco, for example, is actively considering additional enrichment capacity in New Mexico, awaiting increased demand from the industry. Building more capacity is a matter of time and investment rather than new technology.

Daniel Goldner: How does patenting your IP protect it from foreign entities copying it?

Seth Grae, Lightbridge: Patenting our intellectual property provides several advantages. It facilitates easier public discussion, release of data, and independent confirmation. While it is possible for foreign entities to access the technology through other means, patenting allows us to manage and protect our IP more effectively. In the nuclear fuel market, there are few producers worldwide, and even countries like Russia and China have become more responsible in handling IP, especially as they seek to expand their exports. Global patenting restricts their ability to export to countries where we hold patents, even if they intended to violate them.

6. Presentation by Matthew Wald
   a. Introduction
   - Matt Wald introduced himself as a non-engineer with extensive experience in the nuclear industry. He mentioned his affiliations with the American Nuclear Society and the Breakthrough Institute but clarified that he was not representing them in the meeting. He provided an overview of his experience with various reactors and new designs.
   b. Emerging Nuclear Landscape
   - Matt Wald discussed the growing demand for nuclear energy due to the need to reduce carbon emissions. He presented a chart from the Nuclear Energy Institute showing utility pledges to decarbonize electricity production. He highlighted the potential role of advanced nuclear reactors in meeting these goals.
   c. Fusion Reactors
   - Matt Wald mentioned the recent breakthrough in fusion reactor technology by the Department of Energy. He clarified that fusion reactors still face significant challenges in terms of scalability and fuel requirements. He noted the production of highly radioactive waste by fusion reactors.
   d. Fission Reactors
   - Matt Wald described the different categories of fission reactors based on innovation and nearness to commercialization. He introduced three reactors (NuScale, GE Hitachi BWRX, Westinghouse AP 300) as the closest to being commercially available. He highlighted their use of commercially available fuel, light water for neutron moderation and heat transfer, and their smaller and more flexible designs.
   e. Second Wave Reactors
   - Matt Wald presented two reactors (X-energy XE 100, Natrium) as more innovative and representing the second wave of new reactors. He discussed the unique features of these reactors, such as higher temperatures, alternative cooling methods, and the ability to provide process heat.
   f. Future Developments
   - Matt Wald mentioned the possibility of reactors like Kairos and microreactors becoming viable in the future. He noted the specific applications of microreactors in remote areas, mining operations, military bases, and computer centers.
   g. Detailed Descriptions
   - Matt Wald provided a detailed description of NuScale's reactor design and its advantages in terms of safety, ease of manufacturing, and flexible power output. He explained the features of GE Hitachi BWRX and Westinghouse AP 300 reactors, emphasizing their use of existing technology and passively safe designs.
   h. Natrium Reactor
   - Matt Wald discussed the Natrium reactor's ability to provide steady power and balance intermittent renewable energy sources like solar. He explained its use of a thermal battery system with a salt heat transfer medium. He highlighted its potential to reduce the reliance on natural gas power plants for grid stability.
   i. Pebble Bed Reactors

- Matt Wald introduced X-energy's pebble bed reactor and its advantages, such as high-temperature operation and continuous refueling without shutdown. He mentioned the challenges related to fuel enrichment and the need for further development.

j. Other Reactor Designs

- Matt Wald briefly mentioned Moltex and Terra Power's molten fluoride salt reactors, which are still in the early stages of development. He highlighted the common characteristics of emerging reactors, including black start capabilities, lower-pressure systems, and modular construction.

k. Conclusion

- Matt Wald concluded the presentation and provided contact information for further inquiries (Matthew.L.Wald@gmail.com).

7. Matt Wald Q&A

Rep Michael Harrington: Can you provide any additional information on Centrus obtaining NRC approval for their uranium and HALEU production demonstration plant?

Matt Wald: Centrus is a company that emerged from bankruptcy after the government sold off the enriched uranium production business. They have a design divergence in their centrifuges, which are taller and more efficient compared to other models. Centrus has a preliminary cascade set up but requires significant funding to begin production. They would likely take enriched material from Urenco and further enrich it to meet the demands of new reactors. However, this process stops short of reaching military-grade levels.

Rep Michael Harrington: How will the chicken and egg scenario of HALEU production and reactor development be resolved? Will the federal government or private industry step in to fund it?

Matt Wald: The federal government is providing substantial subsidies to private industry, such as X-energy and Natrium, for the construction of advanced reactors. The government will act as a middleman, ordering a certain amount of HALEU and selling it to bridge the gap between HALEU production and reactor development. However, the budgetary challenges and dysfunction in Congress may delay the process, making it difficult to predict the timeline for government intervention.

Rep Michael Harrington: Is the federal government the primary source of funding for these endeavors, or can private industry like Dow Chemical contribute as well?

Matt Wald: Private industry, like Dow Chemical, is receiving significant funding from the federal government for their nuclear projects. The government's role in making low enriched fuel available incentivized private industry to enter the nuclear sector. However, the government will likely have to play a crucial role in providing funding and ensuring a market for HALEU until the industry reaches a self-sustaining point. The exact timing of government intervention remains uncertain due to budgetary challenges and political dynamics.

Rep Keith Ammon: Are there any other options or resources available to address the challenges in nuclear fuel production and supply?

Matt Wald: The government has resources at its disposal but has not effectively deployed them in the past. For instance, there is a surplus of weapons-grade plutonium that could be utilized in fast reactors to alleviate the shortage of enriched uranium. However, the technical complexities and cost considerations have hindered progress in this area. It is crucial to develop alternative sources of enriched uranium, as relying solely on unstable suppliers like Russia poses risks to the supply chain.

Rep Keith Ammon: Does fusion, despite being a future prospect, produce any radioactive byproducts?

Matt Wald: Yes, fusion reactions do produce radioactive byproducts. When atoms fuse, neutrons are released and can be captured by surrounding metal elements, causing them to become radioactive. While fusion does not generate residual heat like fission reactors, it does produce radioactive materials.

Rep Keith Ammon: In the recent heralded fusion experiment, did they achieve more energy output than the input?

Matt Wald: Yes, in the recent fusion experiment, they managed to achieve slightly more energy output than the input. However, it is important to note that fusion as a practical energy source is still uncertain. While investments should be made to explore its potential, it is advisable not to solely rely on fusion and consider other economically viable alternatives.

8. Discussion of Seabrook Refueling Process
    a. Matt Levander, who works at Seabrook, provided an overview of the refueling process at the power plant. He explained that Seabrook refuels every 18 months, with typical industry refueling outage duration ranging from 20 to 40 days. During this period, maintenance tasks that cannot be performed while the plant is operational are carried out. One-third of the core is replaced, while the remaining two-thirds continue to operate. The replaced fuel is stored in a spent fuel pool for several years before being transferred to dry cask storage on-site. Matt Levander highlighted specific maintenance work conducted during the recent 38-day refueling outage, such as reactor vessel head peening and steam generator bowl drain weld overlays.
    b. Rep Michael Harrington inquired about the consideration of longer fuel cycles and increased energy output at Seabrook. Matt Levander mentioned that although such options have been explored in the past, Seabrook is not currently pursuing two-year fuel cycles. He acknowledged that other NextEra-owned plants might be considering this approach but was uncertain about the reasons behind Seabrook's decision.
9. Potential Tour of Seabrook Nuclear Power Plant
    a. Rep Keith Ammon proposed organizing a tour of Seabrook for the commission members in July. He emphasized that participation would be voluntary but encouraged the members to take advantage of the opportunity to witness the turbines, buildings, and potential expansion areas at Seabrook. The tour could provide valuable insights into the power plant's operations and potential future developments.
10. Future Meeting Schedule and Topics
    a. Rep Keith Ammon discussed the upcoming meetings scheduled from August to November. He suggested selecting a regular meeting day, preferably the first or second Monday of the month. The proposed meeting time was 9:00 AM. Cathy confirmed that this timing would work for her.
    b. Rep Keith Ammon mentioned several topics to be covered in future meetings, including presentations on federal funding opportunities, siting considerations for interconnections with the grid, and discussions on large flexible loads, such as hydrogen production and molten salt energy storage. He also mentioned having representatives from fusion companies, such as Helion and Zap Energy, present to the commission. Rep Michael

Harrington raised the idea of exploring energy storage systems, and Rep Keith Ammon acknowledged its significance.

11. Public Comment
    a. Douglas Mailey raised a question about load leveling and whether it was necessary to have non-renewable sources, such as gas or nuclear, balancing the intermittent output of renewable energy. Rep Michael Harrington explained that the current push for renewable energy, coupled with the intermittent nature of wind and solar, necessitated backup sources to ensure a stable power supply. He highlighted the importance of striking a balance and the challenges associated with solely relying on renewables. Rep Keith Ammon mentioned the subsidies and guaranteed purchase power agreements associated with offshore wind projects and how the cost factors influenced.
12. The meeting was adjourned at 10:58 AM. A vote to adjourn was not taken due to a fire drill occurring. Members had to immediately vacate the building.
    Minutes submitted by Keith Ammon.