MINUTES

Submitted by Keith Ammon

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

June 19, 2023

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
        i. 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
        i. 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
    i. 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
    i. 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
    i. 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
    i. 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
    i. 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
    i. 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
    i. 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
    i. 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 lightwater 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
        i. 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
        i. 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
        i. 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
        i. 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
        i. 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
    i. Matt Wald mentioned the possibility of reactors like Kairos and micro reactors becoming viable in the future. He noted the specific applications of micro reactors in remote areas, mining operations, military bases, and computer centers.
g. Detailed Descriptions
    i. 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
    i. 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
    i. 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
    i. 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
    i. 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.