

# Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the Waste Aspects of Advanced Nuclear Reactors

October 14 and 15, 2021

**Virtual Meeting**

## **PUBLIC AGENDA**

Draft: October 1, 2021

### WEBEX connection details for October 14 and 15:

<https://nas-sec.webex.com/nas-sec/j.php?MTID=md17b18a16a579c6a2b9fd4a6fa04c242>

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**Day 1: Thursday, October 14, 2021 (All times are ET.)**

### **PUBLIC SESSION 1**

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|----------------------------|--|
| <b>11:00 am – 11:10 am</b> | <b>Call Open PUBLIC SESSION 1 to Order and Welcome</b><br>Janice Dunn Lee, Committee Chair, and Charles Ferguson, Study Director   |
| <b>11:10 am – 11:30 am</b> | <b>Canada's Nuclear Waste Management Organization (NWMO)</b><br><b>Perspectives on Waste Acceptance from Advanced Reactors</b><br><a href="#">Paul Gierszewski</a> , Ph.D., NWMO Director, Safety and Technical Research,<br>Canada ( <i>confirmed</i> ) |
| <b>11:30 am – 12:00 pm</b> | <b>Q&amp;A for Academies committee and staff</b>   |
| <b>12:00 pm – 12:40 pm</b> | <b>Break</b>   |
| <b>12:40 pm – 1:05 pm</b>  | <b>The U.S. Government Accountability Office's Reports on Uranium Management</b><br><a href="#">Allison Bawden</a> , Director in the U.S. Government Accountability Office's<br>Natural Resources and Environment team ( <i>confirmed</i> )              |

1:05 pm – 1:40 pm	Q&A for Academies committee and staff
1:40 pm – 1:45 pm	Brief Break
1:45 pm – 2:30 pm	<b>Sodium Cooled Fast Reactor Technologies</b> <a href="#">Robert (Bob) Hill</a> , Ph.D., Program Manager, Advanced NE R&D/ Argonne Distinguished Fellow, Argonne National Laboratory ( <i>confirmed</i> )
2:30 pm – 3:15 pm	Q&A for Academies committee and staff
3:15 pm – 3:20 pm	Brief Break
3:20 pm – 3:45 pm	<b>Spent Nuclear Fuel Management and Back-End Safeguards</b> <a href="#">Rowen Price</a> , Research Assistant, Nuclear Safeguards, and <a href="#">Cindy Vestergaard</a> , Ph.D., Senior Fellow and Director, Block Chain in Practice and Nuclear Safeguards, Stimson Center ( <i>confirmed</i> )
3:45 pm – 4:15 pm	Q&A for Academies committee and staff
4:15 pm – 4:30 pm	Public Comment Period
4:30 pm	Adjourn Public Session – Day 1

**Day 2: Friday, October 15, 2021 (All times are ET.)**

## **PUBLIC SESSION 2**

**WEBEX connection details for October 15: Same connection info for BOTH days of PUBLIC sessions. (See top of agenda.)**

11:00 am – 11:10 am	<b>Call Open PUBLIC SESSION 2 to Order and Welcome</b> Janice Dunn Lee, Committee Chair, and Charles Ferguson, Study Director
11:10 am – 11:50 am	<b>Safeguards Technology Considerations and Research Needs for Thorium Fuel Cycles and Molten Salt Reactors</b> <a href="#">Louise G. Worrall</a> , Ph.D., Senior R&D Scientist, Non-Destructive Measurement Science and Technology Group, Nuclear Nonproliferation Division, National Nuclear Security Sciences Directorate. Oak Ridge National Laboratory ( <i>confirmed</i> )
11:50 am – 12:20 pm	Q&A for Academies committee and staff
12:20 pm – 12:50 pm	Break
12:50 pm – 1:20 pm	<b>Nuclear Waste from Small Modular Reactors</b> <a href="#">Lindsay Krall</a> , Ph.D., Geochemist, Swedish Nuclear Fuel and Waste Management Company ( <i>confirmed</i> )
1:20 pm – 1:50 pm	Q&A for Academies committee and staff
1:50 pm – 1:55 pm	Brief Break

<b>1:55 pm – 2:25 pm</b>	<b>Hazards Associated with Molten Salt Reactor Systems</b> <a href="#">Joanna McFarlane</a> , Ph.D., Chemist, Nuclear Energy and Fuel Cycle Division, Oak Ridge National Laboratory ( <i>confirmed</i> )
<b>2:25 pm – 3:00 pm</b>	<b>Q&amp;A for Academies committee and staff</b>
<b>3:00 pm – 3:30 pm</b>	<b>Westinghouse’s Lead Cooled Fast Reactor</b> <a href="#">Paolo Ferroni</a> , Ph.D., Fellow Engineer and Technical Lead, Westinghouse Lead Fast Reactor Project, Westinghouse Electric Company and <a href="#">Fausto Franceschini</a> , Ph.D., Consulting Engineer, Westinghouse Mangiarotti, Westinghouse Electric Company
<b>3:30 pm – 4:00 pm</b>	<b>Q&amp;A for Academies committee and staff</b>
<b>4:00 pm – 4:15 pm</b>	<b>Public Comment Period</b>
<b>4:15 pm</b>	<b>Adjourn PUBLIC SESSION – Day 2</b>

## Reading Materials

U.S. Government Accountability Office, “[Uranium Management: Actions to Mitigate Risks to Domestic Supply Chain Could Be Better Planned and Coordinated](#),” GAO-21-28, December 2020.

U.S. Government Accountability Office, “[Nuclear Weapons: NNSA Should Clarify Long-Term Uranium Enrichment Mission Needs and Improve Technology Cost Estimates](#),” GAO-18-126, February 2018.

U.S. Government Accountability Office, “[Department of Energy: Interagency Review Needed to Update U.S. Position on Enriched Uranium That Can Be Used for Tritium Production](#),” GAO-15-123, November, 2014.

Robert Hill, [Sodium Cooled Fast Reactors](#), Presentation, Generation IV International Forum, December 15, 2016. This previous presentation provides useful background information. Dr. Hill will give an updated presentation at the October 14 meeting.

Donald N. Kovacic et al., “[Safeguards Challenges for Molten Salt Reactors](#),” Oak Ridge National Laboratory, 2018.

Louise G. Worrall et al., “[Safeguards Considerations for Thorium Fuel Cycles](#),” Oak Ridge National Laboratory, 2016.

## Presenter Biographies

**[Allison Bawden](#)**, Director in the U.S. Government Accountability Office’s Natural Resources and Environment team

Allison Bawden is a Director in GAO's Natural Resources and Environment team. She is one of two directors responsible for our international nuclear security and cleanup work — specifically

GAO's work related to the U.S. nuclear weapons stockpile, the security of radiological materials, environmental cleanup at former and current weapons research and production sites, and Department of Energy management and contracting issues. Allison began her career at GAO in 2004 where she initially focused on the U.S. defense industrial base. Prior to joining GAO, she managed programs and special projects at a Washington, DC-based think tank. Allison graduated cum laude from Dartmouth College with a bachelor's degree in anthropology, and earned a master's degree in public administration from American University. She also completed graduate course work in national security studies at the United States Naval War College and a specialization in design thinking and innovation through the University of Virginia's Darden School of Business Executive Education program. Recently, Allison became an adjunct professional lecturer in American University's Master of Public Policy and Administration Program, where she instructs the program's capstone practicum.

**Paul Gierszewski, Ph.D., NWMO Director, Safety & Technical Research, Canada**

Dr. Paul Gierszewski is Director, Safety and Technical Research, at the Nuclear Waste Management Organization. The NWMO has the national mandate for the safe, long-term management of Canada's nuclear fuel waste. Paul has been working in nuclear waste management since 1999, first with Ontario Power Generation and then subsequently with NWMO after it was formed. Prior to that time he was part of the Canadian fusion energy research program. He has an undergraduate degree in Engineering Science from the University of Toronto (1978), and a doctoral degree in Nuclear Engineering from M.I.T. (1983).

**Paolo Ferroni, Ph.D., Fellow Engineer and Technical Lead, Westinghouse Lead Fast Reactor Project, Westinghouse Electric Company**

Dr. Paolo Ferroni is a Fellow Engineer at Westinghouse Electric Company and Technical Lead of the Westinghouse Lead Fast Reactor (LFR) project. In this role, Paolo oversees design and testing activities aimed at developing an economically competitive and versatile Generation IV plant based on LFR technology. With main expertise in reactor thermal-hydraulics and core design, Paolo joined Westinghouse in 2010 and since then he has been involved in multiple development programs, both domestically and internationally, in the field of advanced reactors and encompassing both Light Water and non-Light Water Reactors. Paolo holds a PhD and a MS in Nuclear Science and Engineering from the Massachusetts Institute of Technology, and a MS in Nuclear Engineering from Turin Polytechnic (Italy).

**Fausto Franceschini, Ph.D., Consulting Engineer, Westinghouse Mangiarotti, Westinghouse Electric Company**

Dr. Fausto Franceschini is a Consulting Engineer at Westinghouse Mangiarotti with 20 years of experience in the nuclear industry, and a Fellow of the American Nuclear Society. During his tenure in Westinghouse Dr. Franceschini has made several contributions in the areas of advanced fuel and core design and advanced modeling and simulation, in support of the current and future fleet. He currently leads the Westinghouse LFR core design and safety analysis activities.

**Robert (Bob) Hill, Ph.D., Program Manager, Advanced NE R&D/ Argonne Distinguished Fellow, Argonne National Laboratory**

Robert Hill completed his Ph.D. in Nuclear Engineering at Purdue University in 1987. He has worked at Argonne National Laboratory for over 25 years with research focus on reactor physics, fast reactor core design, plutonium disposition, and waste management. In his current position, he manages Advanced Nuclear Energy Research and Development within the Nuclear Science and Engineering Division of Argonne National Laboratory. He has previously led Nuclear Engineering

Division research groups working on reactor physics analysis, advanced modeling and simulation, fuel cycle and systems dynamics modeling, criticality safety, and nuclear data. Dr. Hill is National Technical Director for multi-Laboratory advanced reactor R&D activities in current DOE Programs; this work includes small modular reactors, advanced structural materials, energy conversion technology, safety and licensing, and system integration. He also serves as U.S. representative for the Generation-IV Sodium Cooled Fast Reactor. Previous Program contributions include extensive transmutation and fuel cycle analysis activities in DOE Fuel Cycle Programs.

**Lindsay Krall, Ph.D., Geochemist, Swedish Nuclear Fuel and Waste Management Company**

Dr. Lindsay Krall is a geochemist at the Swedish Nuclear Fuel and Waste Management Company, where she focuses on using natural (radio)isotopes to trace the hydrogeochemical evolution of bedrock systems that are utilized for the geologic disposal of nuclear waste. She holds a bachelor's degree in Industrial and Operations Engineering (University of Michigan) and a Ph.D. in Geology (Stockholm University). From 2017 to 2020, Lindsay was a MacArthur Postdoctoral Fellow at George Washington University and at the Center for International Security and Cooperation (Stanford University). During this time, she assessed the technical credibility of proposals to dispose of spent nuclear fuel in deep boreholes and characterized the radioactive waste streams that might be generated in advanced nuclear fuel cycles.

**Joanna McFarlane, Ph.D., Chemist, Nuclear Energy and Fuel Cycle Division, Oak Ridge National Laboratory**

Joanna McFarlane (PhD in Chemistry, 1990, University of Toronto, Canada) has been with Oak Ridge National Laboratory since 2001. Before then, she worked at the Atomic Energy of Canada Ltd Whiteshell Laboratories, Manitoba, Canada. While at Whiteshell, Dr. McFarlane researched the physical chemistry of fission products, ran Knudsen cell experiments on fission product simulants (e.g.,  $\text{Cs}_2\text{U}_2\text{O}_4$ ), investigated aerosol chemistry related to severe reactor accidents, and studied the transport of fission products in reactor primary heat transport systems using thermodynamic modeling. At ORNL, Dr. McFarlane is in the Process Engineering Group of the Isotope and Fuel Cycle Technology Division. Her recent experience in nuclear research is related to the chemistry of fission products in molten salt reactors, the purification and characterization of molten salts, and the measurement of thermochemical and thermophysical properties. She has also assisted with the separation of Pu-238 from irradiated Np-237 target materials supporting NASA's future deep space missions. In particular, she studied the dissolution kinetics of aluminum alloy cladding and the spectroscopic detection of hydroxylamine nitrate, its reactivity in nitric acid, and its reaction kinetics as a function of temperature. She has also participated in a wide variety of projects: the magnetic separation of  $\text{UO}_2$  particles; the production of biodiesel using a centrifugal contactor; the development of a high temperature organic heat transfer fluid for concentrating solar power; and has ongoing interest in fluid-rock interactions relevant both to nuclear waste disposal and petroleum extraction.

**Rowen Price, Research Assistant, Nuclear Safeguards, Stimson Center**

Rowen Price is a Research Assistant with the Nuclear Safeguards program and the Partnerships in Proliferation Prevention program. Her particular research areas are emerging or "advanced" reactors, spent fuel management, and WMD nonproliferation through the implementation of UN Security Council Resolution 1540 obligations. She holds a B.A. with summa cum laude honors in Political Science and Chinese from Middlebury College.

**Cindy Vestergaard, Ph.D., Senior Fellow and Director, Block Chain in Practice and Nuclear Safeguards, Stimson Center**

Cindy Vestergaard is a Senior Fellow and Director with the Nuclear Safeguards and Blockchain in Practice Programs. Her research on nuclear safeguards focuses on the impact of evolving international obligations and emerging technology on states and facility operators while her research on blockchain technology considers and tests the potential for the tech to increase transparency, security and reporting in nuclear safeguards, nuclear security, the trade of dual-use chemicals and export controls. Before joining Stimson in 2016, Vestergaard was previously a senior researcher at the Danish Institute for International Studies (DIIS) in Copenhagen, Denmark. Prior to DIIS, she worked on non-proliferation, arms control and disarmament policy and programming at Canada's foreign ministry. Positions among others included Senior Policy Advisor, Global Partnership Program; Senior Policy Advisor, Foreign Intelligence Division; and Political Officer at Canada's Mission to Hungary and Slovenia. Dr. Vestergaard has been an external lecturer at the University of Copenhagen, a regular contributor to media outlets and presents nationally and internationally on weapons of mass destruction, proliferation and disarmament issues. She has a B.A. in International Relations from the University of British Columbia, M.A. in International Relations and European Studies from Central European University (Budapest, Hungary) and Ph.D. in Political Science from the University of Copenhagen.

**Louise G. Worrall, Ph.D., Senior R&D Scientist, Non-Destructive Measurement Science & Technology Group, Nuclear Nonproliferation Division, National Nuclear Security Sciences Directorate, Oak Ridge National Laboratory**

Dr. Louise Worrall is an R&D Scientist at Oak Ridge National Laboratory and holds the position of Adjunct Assistant Professor of Nuclear Engineering at North Carolina State University. Louise has more than 11 years of professional experience in the field of non-destructive analysis (NDA) science and safeguards technology development in the European commercial nuclear sector and at two leading U.S. national laboratories. Louise holds a B.Sc. in Physics with Biomedical Physics (2004), M.Sc. in Nuclear Reactor Physics and Technology (2005), and Ph.D. in Nuclear Physics (2009) from the University of Birmingham in the United Kingdom. Her research interests include safeguards technology development for emerging nuclear technology, neutron NDA analysis method development, and  $^{233}\text{U}$  measurement science. Louise began her research career as a Gap Expert in the former AREVA Research and Innovation Division; and performed research into neutron NDA systems as a Postdoctoral Research Associate at Los Alamos National Laboratory before joining ORNL in 2012. At LANL, she completed the original physics design of the Euratom Fast Collar (EFC), which was adopted for testing for field implementation by the Euratom Safeguards Inspectorate. Prior to her work at LANL, Louise gained industrial product development experience through a project to develop a new nuclear calorimeter. Since joining ORNL in 2012, she has gained experience in coordinating and implementing multi-disciplinary research projects, including serving as the technical lead and project manager on the high purity  $^{233}\text{U}$  preservation effort. At present, Louise serves as the Principal Investigator on projects funded by DOE NNSA's Office of Defense Nuclear Nonproliferation Research and Development, DOE NNSA's Office of International Nuclear Safeguards, and DOE NE's Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. Louise also serves as a member on the ORNL Distinguished Staff Fellowships Committee. Louise has over 50 publications in the NDA field. She was the recipient of the 2015 Institute of Nuclear Materials Management (INMM) Early Career Award and is the Associate Editor of the Materials Control and Accountability (MC&A) Section of the INMM *Journal of Nuclear Materials Management*. Louise is the immediate past Chair of the European Safeguards Research and Development Agency (ESARDA) NDA Working Group.