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

September 28 and 29, 2021
Virtual Meeting

PUBLIC AGENDA
Draft: September 24, 2021

Day 1: Tuesday, September 28, 2021 (All times are ET.)

PUBLIC SESSION 1

WEBEX connection details for September 28 and 29:

https://nas-sec.webex.com/nas-sec/j.php?MTID=m5c5b9ba3eedce412dd16862ce35879df
Meeting number: **2761 023 3267**
Password: **NKwMw5ruQ86** (65969578 from phones and video systems)

Join by video system
Dial 27610233267@nas-sec.webex.com
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Access code: 276 102 33267

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11:00 am – 11:05 am	**Call Open PUBLIC SESSION 1 to Order and Welcome** Janice Dunn Lee, Committee Chair, and Charles Ferguson, Study Director
11:05 am – 11:30 am	**Overview of the Generation IV International Forum** Hideki Kamide, Ph.D., Chair of the GIF Policy Group
11:30 am – 12:00 pm	**Status of the SFR technology developments in the Generation-IV International Forum: Reactor Design & Fuel R&D** Gilles Rodriguez, Technical Director of the Generation IV International Forum, and Frédéric Serre, Chair of the Generation IV International Forum Sodium-cooled Fast Reactor (SFR) System Steering Committee
12:00 pm – 12:45 pm	**Q&A for Academies committee and staff**
12:45 pm – 1:15 pm	**Break**
1:15 pm – 1:45 pm	**Review of Spent Fuel Reprocessing and Associated Accident Phenomena** Fred Gelbard, Ph.D., Chemical Engineer, Sandia National Laboratories

1:45 pm – 2:15 pm	**Q&A for Academies committee and staff**
2:15 pm – 2:55 pm	**Meeting Advanced Reactors' Needs for High-Assay Low-Enriched Uranium: (1) Department of Energy's Plans and (2) Independent Report with Results from Gateway for Accelerated Innovation in Nuclear April 2020 Workshop** (1) Andrew Griffith, Deputy Assistant Secretary, Office of Nuclear Fuel Cycle and Supply Chain, U.S. Department of Energy and (2) Monica Regalbuto, Ph.D., Director, Nuclear Fuel Cycle Strategy, Idaho National Laboratory
2:55 pm – 3:25 pm	**Q&A for Academies committee and staff**
3:25 pm – 3:35 pm	**Break**
3:35 pm – 4:05 pm	**Role of Aqueous Separations in Advanced Fuel Cycles** Gregg Lumetta, Ph.D., Lab Fellow, Chemist, Nuclear Chemistry and Engineering Group, Pacific Northwest National Laboratory (*confirmed*)
4:05 pm – 4:35 pm	**Q&A for Academies committee and staff**
4:35 pm – 4:45 pm	**Public Comment Period**
4:45 pm	**Adjourn Public Session – Day 1**

Day 2: Wednesday, September 29, 2021 (All times are ET.)

PUBLIC SESSION 2

WEBEX connection details for September 29

Same connection info for BOTH days of PUBLIC sessions. (See September 28 – Public Session.)

11:00 am – 11:10 am	**Call Open PUBLIC SESSION 2 to Order and Welcome** Janice Dunn Lee, Committee Chair, and Charles Ferguson, Study Director
11:10 am – 11:45 am	**France's Strategy on the Back-End of the Fuel Cycle and the Management and Disposal of Radioactive Waste** Patrick Landais, Ph.D., High Commissioner for Atomic Energy, CEA (French Alternative Energies and Atomic Energy Commission) (*confirmed*)
11:45 am – 12:20 pm	**Q&A for Academies committee and staff**
12:20 pm – 1:00 pm	**Break**

1:00 pm – 1:30 pm	**Treatment of EBR II Spent Fuel** Michael N. Patterson, Program Manager, Used Fuels Treatment, Materials and Fuels Complex, Idaho National Laboratory (*confirmed*)
1:30 pm – 2:00 pm	**Q&A for Academies committee and staff**
2:00 pm – 2:45 pm	**Panel Discussion with Utility Executives** Greg Cullen, Vice President for Energy Services and Development, Energy Northwest (*confirmed*) Nick Irvin, Research and Development Director, Advanced Energy Systems, Cross Cutting Technology, and Strategy, Southern Company (*confirmed*) Marilyn C. Kray, Vice President of Nuclear Strategy & Development, Exelon (*confirmed*) Chris Nolan, Vice President of Regulatory Affairs, Policy, and Emergency Preparedness, Duke Energy (*confirmed*)
2:45 pm – 3:00 pm	**Public Comment Period**
3:00 pm	**Adjourn PUBLIC SESSION – Day 2**

Reading Materials

"Enabling Microscale Processing: Combined Raman and Absorbance Spectroscopy for Microfluidic On-Line Monitoring," published in the December 19, 2020, edition of **Analytical Chemistry,** DOI: /10.1021/acs.analchem.0c04225. The microscale processing team includes: PNNL's Hope Lackey, Heather Felmy, Hannah Bryan, Sam Bryan, and Amanda Lines, along with Gilbert Nelson (College of Idaho), Job Bello (Spectra Solutions), and Fabrice Lamadie (University of Montpellier, France).

"Sensor Fusion: Comprehensive Real-Time, On-Line Monitoring for Process Control via Visible, Near-Infrared, and Raman Spectroscopy," published in the July 2020 edition of **ACS Sensors**, DOI: 10.1021/acssensors.0c00659. The sensor fusion team includes: PNNL's Amanda Lines, Gabe Hall, Susan Asmussen, Jarrod Allred, Sergey Sinkov, Forrest Heller, Gregg Lumetta, and Sam Bryan, along with Neal Gallagher (Eigenvector Research).

Presenter Biographies

Greg Cullen, Vice President for Energy Services and Development, Energy Northwest

Greg Cullen joined Energy Northwest in 1993 and currently holds the position of vice president for Energy Services and Development. In this capacity, Greg is responsible for the operation and maintenance of Energy Northwest's non-nuclear generating plants and the calibration and environmental labs. In addition, Greg oversees the development of projects in a broad range of areas, including clean energy generation and storage, electrification, demand response and support services. Prior to joining Energy Services and Development, Greg held a variety of individual and management roles, including regulatory affairs, performance improvement, and several positions in support of the engineering, maintenance, and operation of Columbia

Generating Station, the Northwest's only operating nuclear energy facility. Greg holds a Bachelor of Science degree in Engineering Physics from Northwest Nazarene University and a Master of Science degree in Mechanical Engineering from the University of Washington.

Fred Gelbard, Ph.D., Chemical Engineer, Sandia National Laboratories

Dr. Fred Gelbard has been at Sandia for over 30 years and received his B.S. at MIT and Ph.D. at CalTech both in Chemical Engineering. Much of that time has been spent developing models of radionuclide aerosol particle generation, transport, deposition, and removal. The work has been mainly applied to modeling aerosol generated by, (1) hypothetical severe nuclear reactor accidents, (2) hypothetical explosions in nuclear reprocessing facilities, and (3) hypothetical rocket launch accidents with radioisotope thermoelectric generators exposed to propellant fires. In addition, Fred has developed methods for tracking radionuclide flow in rocks using an array of gamma detectors. Fred is currently working on modeling the chemical forms of radionuclides released from hypothetical accidents in molten salt nuclear reactors.

Andrew Griffith, Deputy Assistant Secretary, Office of Nuclear Fuel Cycle and Supply Chain, U.S. Department of Energy

Andrew Griffith was appointed in September 2019 as the Deputy Assistant Secretary for Nuclear Fuel Cycle and Supply Chain for the Department of Energy's (DOE) Office of Nuclear Energy. In this position, Mr. Griffith leads DOE's research and development on advanced nuclear fuel cycle technologies that have the potential to improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. In this role, Mr. Griffith also leads the DOE effort to work with industry to facilitate the improvement of the existing uranium fuel supply chain and develop the supply chain for the new fuel concepts powering the advanced nuclear reactors of tomorrow. Prior to this, Mr. Griffith served in various leadership roles in the Office of Nuclear Energy, supporting the full range of nuclear energy waste management, facility operations, and technology research missions (2003-present). He previously served in the Office of Environmental Management, primarily focusing on the management of DOE's spent nuclear fuel and high-level waste (1990-2003). Before joining DOE, Mr. Griffith served in the U.S. nuclear submarine force and continued serving in the Naval Reserve after joining DOE. He retired from the Naval Reserve as a Captain in 2009. Mr. Griffith holds a Bachelor of Science in Naval Architecture from the U.S. Naval Academy and a Master of Science in Technology Management from the University of Maryland, University College.

Hideki Kamide, Ph.D., Chair of the Generation IV International Forum Policy Group

Hideki Kamide was elected Chair of the GIF Policy Group for the period 2019-2021, succeeding Francois Gauché in this role. He was previously Vice Chair of the Policy Group. He is the Deputy Director General of the Sector for Fast Reactor and Advanced Reactor Research and Development at the Japan Atomic Energy Agency. He is Deputy Director General, Sector of Fast Reactor and Advanced Reactor Research and Development at the Japan Atomic Energy Agency (JAEA). He has worked in the field of thermal hydraulics of sodium cooled fast reactor, especially experimental studies on natural circulation, high cycle thermal fatigue, and related safety issues, for 30 years. His current work includes advanced reactor development and international collaboration on this issue.

Nick Irvin, Research and Development Director, Advanced Energy Systems, Cross Cutting Technology, and Strategy, Southern Company

Nick Irvin is the Research and Development (R&D) Director for Advanced Energy Systems, Cross Cutting Technology, and Strategy at Southern Company. In this capacity, he is

responsible for the evaluation, development, and demonstration of innovative technologies to support Southern Company's operations in the areas of advanced nuclear technology, hydrogen and alternative energy carriers, technology scouting, and R&D strategy. Previously, Mr. Irvin served as a Research Engineer, leading efforts in all areas of environmental control technologies including mercury, acid gas, carbon dioxide, particulate matter, water treatment, and carbon sequestration. He delivered many strategic projects that became focal points for the industry's effort to better understand different environmental control technologies. Mr. Irvin has represented Southern in many external alliances. He served as Chairman of the Utility Air Regulatory Group's Control Technology Committee and is a representative to the Policy Committee of the Generation IV Nuclear International Forum on behalf of the U.S. nuclear industry. A recipient of three Technology Transfer Awards from Electric Power Research Institute, Mr. Irvin has demonstrated the ability to lead change through technology innovation throughout his career. Mr. Irvin earned a B.S. in Chemical Engineering from the University of Alabama and an M.S. in Chemical Engineering from Auburn University.

Marilyn C. Kray, Vice President of Nuclear Strategy & Development, Exelon

As vice president of nuclear strategy & development for Exelon, Marilyn Kray leads major initiatives on current and advanced reactor designs to create growth opportunities that leverage Exelon's nuclear operations competency. These initiatives include pursuing operational service agreements, both domestically and internationally, as well as engaging with advanced reactor developers in order to evaluate potential business opportunities and future technology deployment. She served as president of NuStart Energy Development LLC, an industry consortium formed to develop the process for preparing the combined construction and operating license applications for the first new nuclear plant construction in the United States in over 30 years. Her in-depth knowledge of the global nuclear industry comes from years of experience including as vice president of Exelon Nuclear Partners. In this role, she led international business development. Prior to this, she served as Exelon's vice president of nuclear acquisition support, where she pioneered internal processes for due diligence and plant transitions. The result was the successful purchases of the Three Mile Island, Clinton, and Oyster Creek generating stations. More recently, she led the acquisition of the FitzPatrick nuclear power plant. Marilyn began her career with Exelon in the licensing organization for the Peach Bottom Atomic Power Station. Prior to joining Exelon, she was a reactor engineer and project manager for the U.S. Nuclear Regulatory Commission. She has testified in front of Congress on multiple occasions regarding nuclear development in the United States. Throughout her career Marilyn has served in leadership roles as Exelon's representative to the Nuclear Energy Institute and the Electric Power Research Institute. She is a graduate of Carnegie-Mellon University, with a Bachelor of Science degree in Chemical Engineering.

Patrick Landais, Ph.D., High Commissioner for Atomic Energy, CEA (French Alternative Energies and Atomic Energy Commission)

Dr. Patrick Landais is an engineer in geosciences and holds a doctorate in geochemistry (1981). After working for Elf and Cogema, he joined the CNRS (French National Centre for Scientific Research) in 1987 and became Research Director in 1991. In 2001, he was appointed as scientific Director of ANDRA, the French national agency for radioactive waste management. In this role, he defined the scientific policy and strategy, set up partnerships and R & D programs and monitored the scientific production of national reports on waste management. For his studies on the feasibility of geological disposal, he received in 2013 the Grand Prix Dolomieu. In 2005, he became a member of the CNRS executive committee. He returned to Andra in 2006 as director of R & D before becoming scientific director the French geological survey in 2013 where he was responsible for the development and implementation of the strategy as well as of the coordination of the scientific activities of the survey. In 2016, he joined Andra as Chief Technology Officer, where he took in charge the development, innovation, international relations

and knowledge management. He was appointed High Commissioner for Atomic Energy on January 30, 2019. Dr. Landais has published a hundred scientific papers, is a member of several scientific committees and Chevalier of the Légion d'Honneur and in the National Order of Merit.

Gregg Lumetta, Ph.D., Lab Fellow, Chemist, Nuclear Chemistry & Engineering Group, Pacific Northwest National Laboratory

Dr. Gregg Lumetta is recognized nationally and internationally as an expert on chemical separations, especially as applied to nuclear and radiological materials. His research is focused on the study of solvent-extraction and ion-exchange systems that are being developed for advanced nuclear fuel cycles, the treatment of radioactive waste streams, radiological decontamination, and hydrometallurgy. The breadth of his work spans from the investigation of the fundamental coordination chemistry that underpins solvent extraction systems, to laboratory-scale testing of separation processes. In taking this broad approach, he has pioneered work in the separation of transuranic elements from both legacy nuclear waste and from used nuclear fuel. His research in separating americium and curium from used nuclear fuel has led to the development and testing of new processes that are internationally recognized. Dr. Lumetta is also an expert in actinide chemistry and leads efforts in synthesizing plutonium compounds for use in nuclear forensics. In this area too, his research spans from understanding the fundamental mechanisms by which such species form, to preparation of plutonium materials at the scale of hundreds of grams. His research influences a variety of U.S. Government agencies including the DOE Office of Nuclear Energy, DOE Office of Environmental Management, and the Department of Homeland Security. He holds a B.S., Chemistry, University of Missouri, and a Ph.D., Inorganic Chemistry, University of Missouri.

Chris Nolan, Vice President of Regulatory Affairs, Policy, and Emergency Preparedness, Duke Energy

Chris Nolan is Vice President of regulatory affairs for Duke Energy's Nuclear Generation organization. In this role, he has fleet responsibilities in the areas of licensing, regulatory compliance, policy, and emergency preparedness. He assumed this role in July 2012. Previously, Nolan served as fleet Director for Duke Energy's nuclear safety assurance organization. He was responsible for providing programmatic oversight for the fleet in the areas of security, emergency preparedness, performance improvement, licensing, and regulatory compliance. Before that, Nolan served as the licensing manager in nuclear plant development for Duke Energy, where he was responsible for managing licensing, site characterization and project development activities for new nuclear interests in Duke's Carolinas and Midwest service territories. Mr. Nolan joined Duke Energy in 2006 after serving the U. S. Nuclear Regulatory Commission (NRC) for nine years. During this period, he held positions of increasing responsibility in the Office of Nuclear Reactor Regulation, Office of Nuclear Security and Incident Response, and the Office of Enforcement. Nolan was chief of the New Reactors Environmental Projects Branch in the Office of Nuclear Reactor Regulation when he accepted a position with Duke Energy. Prior to his service with the NRC, Nolan was a senior design engineer at Calvert Cliffs Nuclear Power Plant where he worked for nine years. Additionally, Nolan was a qualified operator in the U. S. Navy's nuclear power program while employed at the Knolls Atomic Power Laboratory for General Electric Co. A native of Garret Park, Md., Nolan graduated from the University of Maryland where he earned a Bachelor of Science degree in mechanical engineering. He is a graduate of the U. S. Navy's Nuclear Power School and holds a master's degree in engineering management from the University of Maryland. He is a registered professional engineer in Virginia.

Michael N. Patterson, Program Manager, Used Fuels Treatment, Materials and Fuels Complex, Idaho National Laboratory

Michael N. Patterson manages projects and programs related to the treatment and management of used fuel inventories at the Materials and Fuel Complex (MFC), most notably the sodium bonded inventory from the EBR-II reactor. Currently, Mr. Patterson has been leading the research effort to reduce contaminant levels in uranium recovered from irradiated EBR-II fuels as a consideration for High Assay Low Enriched Uranium (HALEU) feedstocks. Mr. Patterson has been involved in the application of molten salt systems and pyrochemical techniques in the treatment and management of sodium bonded fuel for over ten years. Mike is a certified Project Management Professional and holds a bachelor's degree in mechanical engineering from the University of Arizona. Prior to joining INL, Mike held project management positions in the chemical production industry as well as custom metal fabrication.

Monica Regalbuto, Ph.D., Director, Nuclear Fuel Cycle Strategy, Idaho National Laboratory

Dr. Regalbuto is a leader in the development of nuclear fuel cycle technologies, combining her knowledge in separations, computer simulations, and proliferation risk reduction. She has over 30 years of experience in radio-isotope processing, recovery and immobilization for environmental remediation, resource conservation and medical applications. She currently leads the integrated fuel cycle strategic initiative at the Idaho National Laboratory. In this role, she serves as the lead for the high assay low enrich uranium (HALEU) program, ensuring there is an adequate supply of HALEU fuel for advanced reactors and other applications. Dr. Regalbuto has served in multiple national leadership roles. In 2015, she was appointed by President Obama and confirmed by the Senate as Assistant Secretary for the Office of Environmental Management for the U.S. Department of Energy (DOE). In this capacity, she was responsible for managing the environmental cleanup resulting from weapons production as well as special nuclear materials. This responsibility involved an annual budget of over $6B per year with a geographically dispersed workforce of over 20,000 federal and contractor employees. She managed 16 sites across 11 States. As DOE-EM Assistant Secretary she oversaw management, operations and strategic directions for the Savannah River National Laboratory, an applied research and development laboratory of DOE. As the Deputy Assistant Secretary for Fuel Cycle Technologies with DOE's Office of Nuclear Energy, Dr. Regalbuto managed the nation's research and development fuel cycle portfolio with a budget of about $185 M and a federal staff of about 50 employees. At Argonne National Laboratory, Dr. Regalbuto served as the head of the Process Chemistry and Engineering Department in the Chemical Sciences and Engineering Division and managed a group of 30 researchers. Dr. Regalbuto has contributed to the development of innovative energy technologies. As a researcher at Argonne National Laboratory, she has made key contributions to nuclear fuel cycle technology, beginning with the TRUEX process for removing transuranic elements from aqueous acidic solutions such as those found at DOE waste sites throughout the United States, followed by the development of advanced separations processes as alternatives for recycling spent fuel. She led the development of AMUSE, a computer model used by researchers to optimize processes for separating dissolved spent nuclear fuel. Under Dr. Regalbuto's leadership, Argonne conducted highly successful process demonstrations, the CSSX process, a process for separating cesium-137 from high-level radioactive waste at DOE's Savannah River site and the UREX+ processes, a suite of solvent extraction processes for the recovery of actinides and fission products from spent fuel. During her tenure at Amoco Oil company, as a member of the Hydroprocessing Team she provided key technical support to several refineries and developed and evaluated alternative technologies for lowering the sulfur levels of gasoline. Dr. Regalbuto serves today as a member of the Standing Advisory Group on Nuclear Energy (SAGNE) at the IAEA which advises the Director General. She has authored multiple journal articles, reports, and presentation and hold six patents.

Gilles Rodriguez, Technical Director of the Generation IV International Forum

Gilles Rodriguez is from the French Atomic Energy Commission, where he is Senior Expert Engineer. He has been occupying the position of Deputy Head of the ASTRID Project team since 2016. He graduated from the University of Lyon in France in 1990 with an engineering degree in chemistry and he obtained a Master of Science in Process Engineering from the Polytechnic University of Toulouse in 1991. His areas of expertise are fast reactor technology, liquid metal processes, process engineering. From 2007 to 2013, he was project leader of the sodium technology and components within the CEA SFR project organization. Since 2013, he has joined the CEA project on Sodium Fast Reactor: ASTRID, for Advanced Sodium Technological Reactor for Industrial Demonstration, first as responsible for the ASTRID Nuclear Island.

Frédéric Serre, Chair of the Generation IV International Forum Sodium-cooled Fast Reactor (SFR) System Steering Committee

Frédéric Serre was elected Chair of the GIF SFR System Steering Committee for a 2-years period in October 2020. He joined the French Alternative Energies and Atomic Energy Commission (CEA) in 1985, and currently hold the position of Reactor Studies Department Representative for International Relations on Fast Reactors. He has worked in the field of thermal hydraulics and severe accidents modelling of LWRs, before heading the lab in charge of LWR and SFR Severe Accident programs in the CEA experimental reactors PHEBUS and CABRI. He was head of the department in charge of the operation of the CEA zero-power reactors EOLE, MINERVE and MASURCA devoted to LWR and Fast Reactor neutron physics programs, before becoming SFR Severe Accident Project Manager during the 10–years ASTRID Program (Advanced Sodium Technological Reactor for Industrial Demonstration). Frederic Serre holds engineering degrees from the Ecole Centrale de Lyon and from the French National Institute of Nuclear Sciences and Technologies.