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

June 2 and 7, 2021
Virtual Meeting
(Please note non-consecutive dates.)

PUBLIC AGENDA
Draft: June 2, 2021

Day 1: Wednesday, June 2, 2021 (All times are US Eastern.)

PUBLIC SESSION 1

WEBEX connection details for June 2:

Join from the meeting link
https://nas-sec.webex.com/nas-sec/j.php?MTID=m5160716d3c4ceeb4aa54e47031a094f9

Join by meeting number
Meeting number (access code): 199 991 8583
Meeting password: JaTkpVgk366 (52857845 from phones and video systems)

Tap to join from a mobile device (attendees only)
+1-415-527-5035,,1999918583#52857845# US Toll
+1-929-251-9612,,1999918583#52857845# USA Toll 2
Some mobile devices may ask attendees to enter a numeric password.

Need help? Go to http://help.webex.com

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
	Theme: Front-End and Back-End of the Nuclear Fuel Cycle
11:05 am – 11:30 am	**Status and Prospects of HALEU Production in the United States** Daniel B. Poneman, President and Chief Executive Officer, and Larry Cutlip, Senior Vice President, Field Operations, Centrus Energy Corporation (*confirmed*)
11:30 am – 12:00 pm	**Q&A for Academies committee and staff**
12:00 pm – 12:40 pm	**Break**
12:40 pm – 1:10 pm	**The Rationale for Reprocessing and Recycling** Andrew Worrall, Section Head, Integrated Fuel Cycle, Oak Ridge National Laboratory; Deputy Director, GAIN (Gateway for Accelerated Innovation

in Nuclear); and UK Country Coordinator, DOE Office of Nuclear Energy *(confirmed)*

1:10 pm – 1:40 pm	**Q&A for Academies committee and staff**
1:40 pm – 1:50 pm	**Brief Break**
1:50 pm – 2:20 pm	**Impacts of Nuclear Fuel Cycle Choices on Permanent Disposal of High-Activity Radioactive Waste** Peter N. Swift, Ph.D., Sandia National Laboratories (retired) (*confirmed*)
2:20 pm – 2:50 pm	**Q&A for Academies committee and staff**
2:50 pm – 3:00 pm	**Public Comment Period**
3:00 pm	**Adjourn PUBLIC SESSION – Day 1**

Day 2: Monday, June 7, 2021 (All times are US Eastern.)

PUBLIC SESSION 2

WEBEX connection details for June 7:

Same connection info for BOTH days.

11:00 am – 11:05 am	**Call Open PUBLIC SESSION 2 to Order and Welcome** Janice Dunn Lee, Committee Chair, and Charles Ferguson, Study Director **Theme: Front-End and Back-End of the Nuclear Fuel Cycle**
11:05 am – 11:30 am	**Radioactive Waste Management Issues to be Considered when Evaluating Different Nuclear Fuel Cycle Options** Piet Zuidema, Ph.D., Chief Scientific Officer, European Joint Programme on Radioactive Waste Management (EURAD) *(confirmed)*
11:30 am – 12:00 pm	**Q&A for Academies committee and staff**
12:00 pm – 12:25 pm	**Some Impacts of Advanced Fuel Cycle Options on Waste Management and Long Term Disposal Risks** Bernd Grambow, Ph.D., Professor of Excellence and Chair of Nuclear Waste Management, IMT Atlantique, École des Mines Télécom Atlantique, Nantes, France *(confirmed)*
12:25 pm – 12:55 pm	**Q&A for Academies committee and staff**
12:55 pm – 1:35 pm	**Break**
1:35 pm – 2:05 pm	**Economic and Environmental Costs and Benefits of Reprocessing**

Frank N. von Hippel, D.Phil., Senior Research Physicist and Professor of Public and International Affairs, Emeritus, Princeton University *(confirmed)*

2:05 pm – 2:35 pm	**Q&A for Academies committee and staff**
2:35 pm – 3:05 pm	**The Economics of Reprocessing and Recycling Versus Direct Disposal of Spent Nuclear Fuel** Matthew Bunn, Ph.D., Co-Principal Investigator, Managing the Atom Project, Belfer Center, Harvard University *(confirmed)*
3:05 pm – 3:30 pm	**Q&A for Academies committee and staff**
3:30 pm – 3:55 pm	**Westinghouse eVinci™ Micro-Reactor** Vefa N. Kucukboyaci *(confirmed)*
3:55 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 2**

Reading Materials

Matthew Bunn, Steve Fetter, John P. Holdren, and Bob van der Zwaan. 12/2003. The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel, pp. 117. Cambridge, MA: Project on Managing the Atom, Harvard University.

(Frank von Hippel recommendation) Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World (IPFM, 2015), http://fissilematerials.org/library/rr14.pdf, Summary and chapter 1.

Swift, P.N., & Sassani, D.C. (2020). Impacts of nuclear fuel cycle choices on permanent disposal of high-activity radioactive wastes. International Atomic Energy Agency (IAEA): IAEA. (https://inis.iaea.org/search/search.aspx?orig_q=RN:51081645; re-directed to link with zip file download https://www.iaea.org/publications/14680/management-of-spent-fuel-from-nuclear-power-reactors?supplementary=82942 and access PDF of proceedings paper, ID185_PETER N. SWIFT.pdf.)

Andrew Worrall, "Utilization of Used Nuclear Fuel in a Potential Future U.S. Fuel Cycle Scenario," WM2013 Conference, February 2013, Phoenix, Arizona.

Presenter Biographies

Matthew Bunn, Ph.D., James R. Schlesinger Professor of the Practice of Energy, National Security, and Foreign Policy, and Co-Principal Investigator, Managing the Atom Project, Belfer Center, Harvard University

Professor Bunn's research interests include nuclear theft and terrorism; nuclear proliferation and measures to control it; the future of nuclear energy and its fuel cycle; and policies to promote innovation in energy technologies. Before joining the Kennedy School in January 1997, he

served for three years as an adviser to the Office of Science and Technology Policy, where he played a major role in U.S. policies related to the control and disposition of weapons-usable nuclear materials in the United States and the former Soviet Union, and directed a secret study for President Clinton on security for nuclear materials in Russia. Previously, Bunn was at the National Academy of Sciences, where he directed the two-volume study Management and Disposition of Excess Weapons Plutonium. He is the winner of the American Physical Society's Joseph A. Burton Forum Award for "outstanding contributions in helping to formulate policies to decrease the risks of theft of nuclear weapons and nuclear materials," and the Federation of American Scientists' Hans Bethe Award for "science in service to a more secure world," and is an elected Fellow of the American Association for the Advancement of Science. He is a member of the Department of Energy's Nuclear Energy Advisory Committee and a consultant to Pacific Northwest and Oak Ridge National Laboratories. He is a member of the Board of Directors of the Arms Control Association. Dr. Bunn holds a doctorate in technology, management, and policy from the Massachusetts Institute of Technology.

Larry Cutlip, Senior Vice President, Field Operations, Centrus Energy Corporation

Larry B. Cutlip is senior vice president, field operations, for Centrus Energy Corp. In this role, Mr. Cutlip leads Centrus' activities at its Tennessee, Ohio, and Kentucky sites. Mr. Cutlip also serves as president of the Company's wholly owned subsidiary American Centrifuge Manufacturing, LLC. Mr. Cutlip has more than 35 years of nuclear experience and has served in several senior operations, engineering and plant management positions at Centrus' facilities. Most recently, he was deputy director of the American Centrifuge Project, where he oversaw the teams charged with meeting the requirements of the United States Centrifuge Technology Advancement contract with Oak Ridge National Laboratory. Mr. Cutlip has a long history of successfully leading critical programs for the company, including establishing the manufacturing base for the American Centrifuge program, executing major contract work for the Department of Energy at the Portsmouth Gaseous Diffusion Plant site, and establishing Centrus' transfer and shipping capabilities at the Paducah Gaseous Diffusion Plant. He has received numerous corporate awards for his accomplishments. Mr. Cutlip holds a Bachelor of Science degree in physics and mathematics from Muskingum College. He completed Advanced Management Training School as well as numerous other technical and management training programs.

Bernd Grambow, Ph.D., Professor of Excellence, IMT Atlantique, École des Mines Télécom Atlantique, Nantes, France

Dr. Grambow is a Professor of excellence at the IMT Atlantique in Nantes, France. He graduated at the Freie Universität Berlin, worked for one year at the Pacific Northwest National Laboratory (WA, USA) followed by research positions in Hahn Meitner Institute Berlin and Forschungszentrum Karlsruhe. He holds today the Chair on nuclear waste disposal in Nantes and was from 2011-2018 head of the Subatech laboratory in Nantes, France, a laboratory working on high energy nuclear physics, on nuclear medicine and radiochemistry. SUBATECH is a mixed research unit between the CNRS-IN2P3, the IMT Atlantique and the University of Nantes. Coordinator of various European projects and former director of the national CNRS-academic/industrial research network NEEDS "nuclear: environment, energy, waste, society," his areas of scientific expertise are radiochemistry, nuclear waste disposal science, geochemical modeling, radionuclide migration in the environment, chemical thermodynamics, and dynamics of solid/liquid interfaces. As to 2021, he published 180 peer reviewed research papers. In 2008 he received the Grand Prix Ivan Pechès of the French Academie of Science and in 2013 he became Chevalier of the Ordre des Palmes Académiques.

Vefa N. Kucukboyaci, Fellow Engineer, Westinghouse Electric Company

Dr. Vefa Kucukboyaci joined Westinghouse Electric Company in 2001. He is a fellow engineer within the Global Innovation organization, working on the eVinci micro-reactor development project. He is leading the efforts in using the TRISO fuel in the eVinci design and also has an instrumental role in core design and thermal analysis activities, developing models and methods for coupled, multi-physics tools. His research areas include reactor physics, multi-physics applications, safety analysis, thermal-hydraulics, criticality safety, and radiation transport. Dr. Kucukboyaci has a PhD in nuclear engineering from Penn State.

Daniel B. Poneman, President and Chief Executive Officer, Centrus Energy Corporation

Daniel B. Poneman is president and chief executive officer of Centrus Energy Corp. He also serves on the company's board of directors. From 2009 to 2014, Mr. Poneman was the Deputy Secretary of Energy, also serving as the chief operating officer of the U.S. Department of Energy. Between April 23, 2013, and May 21, 2013, Mr. Poneman served as Acting Secretary of Energy. Prior to assuming his responsibilities as Deputy Secretary, Mr. Poneman served as a principal of the Scowcroft Group for eight years, providing strategic advice to corporations in a variety of strategic industries. In addition, for eight years he practiced law as a partner at Hogan & Hartson and an associate at Covington & Burling, advising clients on regulatory and policy matters. In prior tours in government, Mr. Poneman served as a White House Fellow and as Director of Defense Policy and Arms Control for the National Security Council. From 1993 through 1996 he was Special Assistant to the President and Senior Director for Nonproliferation and Export Controls at the National Security Council. Mr. Poneman has published widely on national security issues and is the author of *Nuclear Power in the Developing World* and *Argentina: Democracy on Trial*. His third book, *Going Critical: The First North Korean Nuclear Crisis* (coauthored with Joel Wit and Robert Gallucci), received the 2005 Douglas Dillon Award for Distinguished Writing on American Diplomacy. Mr. Poneman is a Senior Fellow at the Belfer Center for Science and International Affairs at the Harvard Kennedy School, a Distinguished Fellow at the Paulson Institute, and a member of the Council on Foreign Relations. His fourth book, *Double Jeopardy: Combating Nuclear Terror and Climate Change*, was released by the MIT Press in May 2019. Mr. Poneman received A.B. and J.D. degrees with honors from Harvard University and an M.Litt. in Politics from Oxford University.

Peter N. Swift, Ph.D., Sandia National Laboratories (retired)

Dr. Swift was Senior Scientist (retired June 2020), Nuclear Energy Fuel Cycle Programs, Sandia National Laboratories in Albuquerque, New Mexico. He also had served as National Technical Director (retired June 2020), Spent Fuel and Waste Science and Technology/Used Fuel Disposition Campaign, U.S. Department of Energy Office of Nuclear Energy (2011-2020). Previously, he was Chief Scientist for the Department of Energy Office of Civilian Radioactive Waste Management's Lead Laboratory for Repository Systems, Las Vegas, Nevada (2006-2010). He has 31 years of experience in transuranic and high-level radioactive waste management and disposal programs. He holds degrees from University of Arizona, Tucson, Arizona, Ph.D., Geosciences, tectonics program, May 1987; University of Wyoming, Laramie, Wyoming, M.S., Geology, May 1982 and B.S. with honors, Geology, December, 1980; and Yale University, B.A., English, May 1974.

Frank N. von Hippel, D.Phil., Senior Research Physicist and Professor of Public and International Affairs, Emeritus, Princeton University

Dr. Frank von Hippel is one of the United States' most prominent scientists in the nuclear policy arena. He co-founded Princeton University's Program on Science and Global Security and the International Panel on Fissile Materials, and is a member of the *Bulletin*'s Board of Sponsors. A former assistant director for national security in the White House Office of Science and Technology, during the Clinton administration, von Hippel's policy research currently focuses on reducing global stocks of weapon-usable fissile materials and the number of locations where they can be found.

Andrew Worrall, Section Head, Integrated Fuel Cycle, Oak Ridge National Laboratory; Deputy Director, GAIN (Gateway for Accelerated Innovation in Nuclear); and UK Country Coordinator, DOE Office of Nuclear Energy

Andrew is Section Head, Integrated Fuel Cycle, Oak Ridge National Laboratory; Deputy Director, GAIN (Gateway for Accelerated Innovation in Nuclear); and UK Country Co-ordinator, DOE Office of Nuclear Energy. He has has 27 years of professional experience in the United Kingdom and the United States working and leading in the fields of reactor physics, fuel and core design, plutonium disposition, fuel development and fuel cycle analysis (technical, economics, and safeguards). Andrew is the senior leader responsible for providing technical leadership, coordination and integration for the numerous and diverse nuclear energy related fuel cycle R&D activities within the division consistent with existing programmatic missions and emerging opportunities. His fuel cycle R&D leadership areas of responsibility include nuclear fuel cycle systems analyses for open, limited recycle (such as MOX fuel cycles) and closed fuel cycles, actinide transmutation in thermal and fast reactors and externally driven systems, evaluation of uranium, plutonium and thorium fuel cycles, fuel resources, fuel manufacturing, materials recovery, materials safeguards and security, used fuel management and disposition, and waste forms. He is a Chartered Physicist (CPhys), a Fellow of the Institute of Physics (FInstP), and formerly a Royal Academy of Engineering Professor of Nuclear Engineering in the UK. In December 2014 the US Department of Energy appointed Andrew as the Laboratory Lead Coordinator for nuclear energy research programs between the US and the UK. In January 2021 Andrew, as part a multi-laboratory project, was awarded the U.S. Secretary of Energy's Achievement Award for addressing a grand challenge in the safeguarding of nuclear material is characterizing commercial spent fuel assemblies. He holds a MSc from Birmingham University in Physics and Technology of Nuclear Reactors and a BSc from Lancaster University in Applied Physics.

Piet Zuidema, Ph.D., Chief Scientific Officer, European Joint Programme on Radioactive Waste Management (EURAD)

Dr. Piet Zuidema has worked for more than 30 years at Nagra, the Swiss National Cooperative for the Disposal of Radioactive Waste. For about 20 years he was director 'Science and Technology.' In that position he had the responsibility for the whole Science and Technology programme at Nagra. This included the responsibility for Nagra's RD+D programme, the work on the inventory of radioactive wastes, the design of the repositories, the geoscience programme (including field work) and safety analyses for both the operational phase and post-closure phase. Piet Zuidema was in charge of several major repository projects within the Swiss deep geological repository programme. He was also responsible for Nagra's scientific-technical work within the 1st and 2nd phase of the Swiss site selection process. Furthermore, he had the responsibility for the periodic updates of the cost estimates for the whole disposal programme. By the end of 2017, Piet Zuidema retired from Nagra. Since then, he has his own advisory company (Zuidema Consult GmbH) and acts as an independent advisor to several organisations and companies, including Nagra. He currently also acts as the Chief Scientific

Officer for EURAD, the European Joint Programme on Radioactive Waste Management. He was a member of several international committees (e.g. NEA / OECD) where he also served as chairperson. He participated in several expert advisory groups and committees in other waste management programs in broad range of different countries. He has a degree in civil and environmental engineering from ETH Zürich, Switzerland. He also received his PhD from ETH Zürich.