

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

**Opportunities and Approaches for Supplying
Molybdenum-99 and Associated Medical Isotopes to
Global Markets: A Symposium**

July 17-19, 2017

**International Atomic Energy Agency
Vienna International Centre
PO Box 100, 1400 Vienna, Austria**



The symposium is co-hosted by the National Academies of Sciences, Engineering, and Medicine and the Russian Academy of Sciences and is held in cooperation with the International Atomic Energy Agency. It is sponsored by the Department of Energy-National Nuclear Security Administration.

Agenda

Symposium Day 1: Monday, July 17, 2017

Board Room A
M Building

9:00

Opening Session

Welcome

- ⊙ Meera Venkatesh, International Atomic Energy Agency (5')
- ⊙ Christophe Xerri, International Atomic Energy Agency (5')

Statement from the US and Russian Academies

Stepan Kalmykov, *co-chair*, Russian Academy of Sciences (on behalf of the symposium organizing committees) (10')

9:20

Plenary Session

Moderator: Alexander Bychkov, Permanent Mission of the Russian Federation to the International Organizations in Vienna

Mo-99 production: past, present, and future

Hedvig Hricak, *co-chair*, U.S. National Academies (on behalf of the symposium organizing committees) (10')

Russia's role in global molybdenum-99 supply

Alexey Vakulenko, JSC V/O IZOTOP, Russian Federation (20')

Establishing and expanding nuclear medicine programs

- ⊙ Rodolfo Nunez-Miller, International Atomic Energy Agency (10')
- ⊙ Wolfgang Weber, Memorial Sloan Kettering, United States (10')

Plenary session discussion (15')

10:30

BREAK

10:50

Molybdenum-99 Supply Reliability: Session 1

Moderator: Jack Coffey, Enigma Biomedical Group

Organisation for Economic Co-operation and Development-Nuclear Energy Agency's principles to address molybdenum-99 supply reliability and the organization's global market demand and production capacity projections

Kath Smith, High-level Group on the Security of Supply of Medical Radioisotopes (15')

The European Commission's efforts to evaluate the supply of medical radioisotopes

Margarida Goulart, European Commission (15')

Reactor schedule coordination for molybdenum-99 supply reliability

Bernard Ponsard, AIPES Reactors & Isotopes Working Group (15')

Investments in AREVA's target production facility to improve long term sustainable security of molybdenum-99 supply

Yann Guinard, AREVA, France (15')

Session 1 discussion (20')

12:10

Molybdenum-99 Supply: Session 2 (part 1)

Moderator: Rania Kostj, U.S. National Academies

Existing global suppliers: current production and future plans

- ⊙ Roy Brown, Curium (10')
- ⊙ Michael Druce, ANSTO, Australia (10')
- ⊙ Gavin Ball, NTP, South Africa (10')
- ⊙ Jean-Michel Vanderhofstadt, IRE, Belgium (10')

12:50

LUNCH

Molybdenum-99 Supply: Session 2 (part 2)

Moderator: Rania Kosti, U.S. National Academies

14:30

New projects for regional or global molybdenum-99 supply

- ⊙ James Harvey, NorthStar, United States (10')
- ⊙ Katrina Pitas, SHINE, United States (10')
- ⊙ Carolyn Haass, Northwest Medical Isotopes, LLC, United States (10')
- ⊙ Carmen Bigles, Coquí Radio Pharmaceuticals, United States (10')
- ⊙ Matthew Lish, Flibe Energy, United States (10')
- ⊙ Hermen van der Lugt, PALLAS Reactor, Netherlands (10')
- ⊙ Oleg Kononov, Karpov Scientific Research Institute of Physics and Chemistry, Russian Federation (10')
- ⊙ Ken Buckley, TRIUMF, Canada (10')
- ⊙ Kennedy Mang'era, Canadian Isotope Innovations Corp. (10')
- ⊙ Jin Du, China Isotope & Radiation Corporation (10')
- ⊙ Anupam Mathur, Department of Atomic Energy, India (10')
- ⊙ Ul-Jae Park, Korea Atomic Energy Research Institute (10')
- ⊙ Pablo Cristini, National Atomic Energy Commission, Argentina (10')
- ⊙ Mostafa Abd Elaal, Egyptian Atomic Energy Authority (10')

Session 2 discussion (30')

17:30

Late afternoon break and closing remarks
(Participants move to MO2 Foyer)

19:30

Adjourn symposium day 1

Symposium Day 2: Tuesday, July 18, 2017

Board Room A
M Building

9:00

Welcome

Stepan Kalmykov, *co-chair*, Russian Academy of Sciences committee (on behalf of the two Academies) (5')

9:05

Technical Considerations : Session 3

Moderator: Boris Zhuikov, Russian Academy of Sciences

Conversion to low enriched uranium-based molybdenum-99 production

- ⊙ Jean-Michel Vanderhofstadt, IRE, Belgium (10')
- ⊙ Roy Brown, Curium (10')
- ⊙ Gavin Ball, NTP, South Africa (10')
- ⊙ Vladimir Risovaniy, Rosatom, Russian Federation (10')

Production expansion

Michael Druce, ANSTO, Australia (10')

Prospects for the use of activation of molybdenum for the production of technetium-99m generators

Victor Skuridin, Tomsk Polytechnic University, Russian Federation (15')

High-density low enriched uranium targets production

- ⊙ Bertrand Stepnik, AREVA, France (15')
- ⊙ Kinam Kim, Korea Atomic Energy Research Institute (15')

Session 3 discussion (20')

11:40

BREAK

12:00

Regulatory Considerations: Session 4

Moderator: Joao Alberto Osso Junior, International Atomic Energy Agency

European Medicines Agency's regulatory considerations

Brendan Cuddy, European Medicines Agency (20', pre-recorded)

Perspectives from Tc-99m generator manufacturers

- ⊙ Ira Goldman, Lantheus Medical Imaging, United States (10')
- ⊙ Roy Brown, Curium, Netherlands (10')

Perspectives from a nuclear pharmacy

David Pellicciarini, Cardinal Health, United States (15')

Session 4 discussion (15')

13:15

LUNCH

14:30

Economic Considerations: Session 5

Moderator: Charles Ferguson, Federation of American Scientists

Molybdenum-99 supply economics

Jan Willem Velthuisen, PwC Europe (20')

Low enriched uranium-based molybdenum-99 production

- ⊙ Gavin Ball, NTP (5')
- ⊙ Michael Druce, ANSTO (5')

Session 5 discussion (25')

15:30

BREAK

Chemical Processing and Waste Management: Session 6

Moderator: Sergey Yudintsev, Russian Academy of Sciences

Chemical processing and waste management following neutron activation

Engeniy Nesterov, Tomsk Polytechnic University, Russian Federation (10')

Development of a novel dry chemical uranium molybdenum separation: Research for a future efficient Mo-99 extraction process

Riane Stene, FRM-II, Germany (10')

Waste management in HEU versus LEU-based molybdenum-99 production

Jean-Michel Vanderhofstadt, IRE, Belgium (15')

Synroc Technology for the Management of molybdenum-99 Waste

Bruce Begg, ANSTO, Australia (10')

Recycling processed LEU for reuse as target material

Carolyn Haass, Northwest Medical Isotopes, LLC, United States (10')

Session 6 discussion (30')

15:50

17:20

Closing remarks

Stepan Kalmykov, *co-chair*, Russian Academy of Sciences

17:30

Adjourn symposium

Invited Briefing and Tour: Wednesday, July 19, 2017

MOE03*

*Room capacity is 25; please indicate your interest to participate to the organizers

11:30 – 12:30

IAEA activities in nuclear energy and applications

Meera Venkatesh, International Atomic Energy Agency
Christophe Xerri, International Atomic Energy Agency

12:30 – 12:55

LUNCH

Tour participants should consider picking up their lunch “to-go”

13:00

Meet for departure to the IAEA laboratories in Seibersdorf Depart for laboratories

Meeting location for departure UN is at the side street of Wagramer Strasse where the airport buses and “big” buses stop.
Arrive on time to avoid missing the bus.

14:00 – 16:00

Tour of the IAEA laboratories in Seibersdorf

16:45

Return to VIC

Statement of Task

The U.S. National Academies of Sciences, Engineering, and Medicine (the National Academies) and the Russian Academy of Sciences will organize a joint symposium to discuss opportunities and approaches for supplying molybdenum-99 (Mo-99) and associated medical isotopes (iodine-131 and xenon-133) to global markets. The symposium will address the following topics:

- Trends in global demand and supply for Mo-99 and associated medical isotopes.
- Prospects and approaches for developing new global supplies of Mo-99 and associated medical isotopes.
- Technical, regulatory, economic, and policy considerations for producing Mo-99 and associated medical isotopes for global markets using uranium-fission and other processes.

The symposium presentations and discussions will be summarized in a National Academies proceedings that will be issued in English and Russian.

If you wish to be added on the project's distribution list and receive a notification about the release of the symposium proceedings and other activities email us at MO99@nas.edu.

Symposium Organizing Committee

NASEM Committee

Hedvig Hricak, *Chair*
Memorial Sloan-Kettering Cancer Center

Jack L. Coffey
Lachman Consulting Services

Eugene J. Peterson
Los Alamos National Laboratory

Consultant

Charles Ferguson
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Rita Guenther, senior program officer

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RAS Committee

Stepan Kalmykov, *Chair*
Moscow State University

Sergey Vladimirovich Yudintsev
Institute of Geology of Ore Deposits,
Petrography, Mineralogy, and Geochemistry,
Russian Academy of Sciences

Boris L. Zhuikov
Institute for Nuclear Research
Russian Academy of Sciences

Consultants

Boris Myasoedov
Russian Academy of Sciences

Yuri Shiyan
Russian Academy of Sciences

Biographical Information

COMMITTEE MEMBERS, PRESENTERS, AND MODERATORS

Mostafa Abdelaal is a molybdenum-99 production operator at the Radioisotope Production Factory at Egyptian Atomic Energy Authority (EAEA). He was born in Egypt in 1982 and was graduated from faculty of science chemistry department with excellent degree. He worked at EAEA in 2007 then he obtained a master degree in 2012 and then a doctorate degree in radiochemistry in 2016. Beside molybdenum-99 and iodine-131 production he works as a researcher in the field of radioisotopes production and labeling.

Gavin Ball serves as Group Executive: Operations of NTP Radioisotopes where he is responsible for safe, efficient and sustainable production operations of the company's radioisotope production plants in South Africa. He has been involved in the nuclear industry for 30 years and has over 20 years' experience in isotope production. During this period he has specifically been involved in key leadership roles in the HEU to LEU conversion projects.

Bruce Begg is an Executive Manager within Nuclear Business at ANSTO, with responsibility for identifying and developing strategic commercial opportunities for ANSTO. He has over twenty years' experience with ANSTO's synroc technology, from initially leading its technical development to now overseeing its commercialisation.

Carmen Bigles is President and CEO of Coquí RadioPharmaceuticals, Corp. (Coquí Pharma), a company founded in 2009 with the goal of establishing a medical radioisotope production facility in the United States. Prior to founding Coquí Pharma, Bigles co-founded and served as Chief Financial Officer of Caribbean Radiation Oncology Center in Puerto Rico. Bigles was born in San Juan, Puerto Rico, and received her education in Florida and Puerto Rico. In 1997, she earned a bachelor's degree in mathematics from Interamerican University in San Juan and subsequently master's degrees in architecture and suburban and town planning from the University of Miami in 2000.

Roy Brown is currently the Vice President of Government Affairs & Strategic Alliances for Curium. His principle responsibility is engaging with state and federal legislators, regulatory agencies and trade associations to educate and advocate on behalf of Curium. He is also engaged in the long term strategy for radionuclide supply. He has more than 30 years of experience in the nuclear medicine industry. He holds a B.S. in Radiation Biophysics from the University of Kansas and a M.A. in Business Administration from Webster University.

Ken Buckley has a Bachelor's of Science degree in Physics from McMaster University. He has over 30 years' experience in the production and use of medical radioisotopes, particularly in the field of positron emission tomography. His experience includes accelerator operation and maintenance, targetry development, automated radiochemistry development, and PET camera characterisation. Since 2011 he has been the project manager for the TRIUMF-led collaboration of five institutions establishing cyclotron based direct-production of Tc-99m. In 2015 the

collaboration won the Natural Sciences and Engineering Research Council *Brockhouse Canada Prize* for Interdisciplinary Research in Science and Engineering.

Alexander Bychkov is the Representative of ROSATOM in Vienna and has a post of Senior Counsellor of Russian Permanent Mission for International Organizations in Vienna. He is out-of-staff adviser of Director General of ROSATOM, and Visiting Professor of National Nuclear Research University - MEPhI. Before that he was a Deputy Director General of IAEA until February 2015 and a Director General of Research Institute of Atomic Reactors in Dimitrovgrad, Russia, until 2011. He graduated in chemistry from Moscow State University in 1982. His main areas of activity cover the nuclear full cycle subjects, including nuclear fuel, fast reactors and high level waste, radionuclide technologies and research reactors applications. Dr. Bychkov is a co-author of more than 160 scientific work.

Jack L. Coffey serves as a consultant with Enigma Biomedical Group and Cerveau Technologies Inc. focusing on radiopharmaceutical development with primary emphasis on supplier and manufacturing site qualification, Food and Drug Administration compliance, and manufacturing process improvements. His experience at Cardinal Health Nuclear Pharmacy Services (2003-2012) and Syncor International Corporation (1984-2003) has included regulatory compliance auditing, quality and regulatory affairs management, as well as serving as an officer of a publicly held corporation. As a scientist at Oak Ridge Associated Universities (1974-1984). Mr. Coffey chaired the Council on Radionuclides and Radiopharmaceuticals (CORAR) from 2011-2012. He received a BS in chemistry and biology from the University of the Cumberland and an MS in radiation biology at the University of Tennessee.

Pablo Cristini, born in 1958, is an Argentine radiochemist, graduated at the University of Buenos Aires in 1985. In 1979 entered in the National Commission of Atomic Energy of Argentina (CNEA), participating in the "Fission Mo-99 Production Project". In 1991 he became the head of CNEA fission Mo-99 production plant and since 2005 is the Manager of Radioisotope Production responsible for the conversion of Mo-99 production from HEU to LEU. He has published over 30 scientific papers and publications as author and co-author. He was technical responsible for the transference of technology of Mo-99 production with LEU to ANSTO (Australia), AEA (Egypt), CRND (Algeria) and BRIT (India).

Brendan Cuddy joined the European Medicines Agency as a Scientific Administrator in October 2002. Brendan is currently Head of Manufacturing and Quality Compliance Service and he is Chairman of the Good Manufacturing and Distribution Practice Inspectors Working Group (GMDP IWG). The Service plays a key role in collaborating and communicating with international partners on setting and recognizing GMP standards, making better use of inspectional resources and exchanging information on availability of already authorized medicines. Brendan obtained his degree in Chemistry from University of Dublin, Trinity College in Ireland. He holds a Master's degree from the National University of Ireland in Quality and Operations Management and a postgraduate diploma in Pharmaceutical Manufacturing Technology from University of Dublin, Trinity College which satisfies the educational requirements for Qualified Person.

Michael Druce is Nuclear Business's Chief Technology Officer and Manager of Client Office activities for the new ANM Plant. He provides technical support for Nuclear Business Projects and Operations. Michael has extensive experience in the development and manufacture of radioisotopes for both medical and industrial applications. He provides technical advice on ANSTO projects and consulting services to other organizations. He is the technical director for the new ANM Mo-99 Plant and responsible for preparing the plant for operations. Michael holds

a Bachelor of Applied Science (Chemistry) and a Master of Business Administration. He has also graduated from the Australian School of Nuclear Technology and is a Graduate of the Australian Institute of Company Directors. He has over 30 years of experience with both reactor and cyclotron based radioisotopes. He is based at ANSTO's Lucas Heights campus.

Jin Du is the Chief Technology Officer at China Isotope & Radiation Corporation. Dr. Du received his BS (1986) in Chemical Engineering from Wuhan Institute of Chemical Technology, and PhD (2001) in Chemistry from University of Jyvaskyla, Finland. He started as a research fellow in medical radioisotopes and radiopharmaceuticals fields at China Institute of Atomic Energy since 1986, and then moved to Japan Atomic Energy Research Institute (1996), MAP Medical Technologies Oy, Finland (1997), and Peking University Health Research Center (2002). He accepted a senior research position in China Isotope & Radiation Corporation (2006) and then promoted to Chief Technology Officer in 2016. His main responsibility was in charge of R&D of new medical radioisotopes and radiopharmaceuticals.

Charles Ferguson has been the president of the Federation of American Scientists since January 1, 2010. From February 1998 to August 2000, Dr. Ferguson worked for FAS on nuclear proliferation and arms control issues as a senior research analyst. Previously, from 2002 to 2004, Dr. Ferguson had been with the Monterey Institute's Center for Nonproliferation Studies (CNS) as its scientist-in-residence. Dr. Ferguson also has consulted with the Oak Ridge National Laboratory, Sandia National Laboratories, and the National Nuclear Security Administration. From 2000 to 2002, he served as a physical scientist in the Office of the Senior Coordinator for Nuclear Safety at the U.S. Department of State, where he helped develop U.S. government policies on nuclear safety and security issues. After graduating with distinction from the United States Naval Academy, he served as an officer on a fleet ballistic missile submarine and studied nuclear engineering at the Naval Nuclear Power School. Dr. Ferguson received his undergraduate degree in physics from the United States Naval Academy in Annapolis, Maryland, and his M.A. and Ph.D. degrees, also in physics, from Boston University in Boston, Massachusetts. Dr. Ferguson is the incoming director of the National Academies' Nuclear and Radiation Studies Board.

Ira Goldman is Director, Strategic Supply and Government Relations, Lantheus Medical Imaging (LMI). He is Co-Chair of the Isotope Supply Committee, Council on Radioisotopes and Radiopharmaceuticals (CORAR); and Vice-Chair of the Reactor and Isotopes Working Group, Association of Imaging Producers and Equipment Suppliers (European Industrial Association for Nuclear Medicine and Molecular Imaging). Mr. Goldman is responsible for development, implementation, and monitoring of corporate strategy and actions for acquisition of a globally diversified and reliable supply of Mo-99, including strategic planning for Mo-99 and Tc-99m, analysis of global Mo-99 supply options; establishing and expanding relationships with global suppliers for reliable and high quality supply of Mo-99 and materials; project management for technical evaluation of various Mo-99 and Tc-99m production technologies. He is also responsible legislative and government relations and assists with new business development for medical radioisotopes.

Margarida Goulart has a Pharmaceutical Sciences degree, a Medical degree, and a PhD in Genetic Toxicology, and worked as a researcher and university professor for several years, in toxicology of organic and inorganic compounds and radioactive elements, in Portugal (National Institute of Nuclear Technology) and in the United States (Brown University, UNC). She is currently a permanent staff of the EC as a Research Programme Officer in the Joint Research Centre - Euratom Coordination Unit, responsible mainly for the coordination of nuclear security and nuclear science applications activities, including the cooperation between the EC and the

IAEA (Seibersdorf and Monaco labs) and the JRC contribution to EC actions towards the security of supply of medical radioisotopes.

Yann Guinard is the Managing Director of CERCA™ at AREVA NP. He joined AREVA in 2009, and was previously the Vice-president in charge of Strategy of AREVA's Fuel Business Unit. Prior to that, he has had several management positions in various industries, with a focus on Aerospace. He holds a Master in Public Affairs, and a MBA.

Carolyn Haass is the Chief Operating Officer of Northwest Medical Isotopes. She has over 30 years of experience in multi-disciplinary complex nuclear, chemical, hazardous, and mixed waste engineering, procurement, construction, and project management projects in both the government and private industry. She was regulator with the U.S. Department of Energy for more than 10 years and has extensive communication experience in the nuclear and environmental industry including day-to-day interface with regulators, safety boards, congress, stakeholders, tribal nations, public, media, community leaders, and decision makers. Ms. Haass earned a Bachelor of Science in Chemistry and Metallurgical Engineering from Colorado School of Mines.

James Harvey holds a PhD degree in Nuclear Chemistry. He has forty-four (44) years of experience in nuclear research, development and commercial applications of radioactive materials in both federal and private positions. He has held Principal Investigator roles on a number of grants and Cooperative Agreements and Grants with various federal agencies. He has extensive experience working within and with various Department of Energy programs including environmental clean-up and radioisotope production applications. He has served as the Chief Science Officer of NorthStar Medical Technologies, LLC the last 12 years.

Hedvig Hricak is Chair of the Department of Radiology at Memorial Sloan-Kettering Cancer Center. As a member of the IOM/NAM, her contributions have included chairing the Committee on the State of the Science of Nuclear Medicine (2006-7) and the Committee on Research Directions in Human Biological Effects of Low Level Ionizing Radiation (2012), and serving as Vice Chair of the Committee on Tracking Radiation Doses from Medical Diagnostic Procedures (2012). She served on the Nuclear and Radiation Studies Board of the National Academy of Sciences from 2008 to 2014.

Stepan Kalmykov is the head scientist at the laboratory of radioecological and radiation problems of Institute of Physical Chemistry of Moscow State University and the head of the division of nuclear and radiation medicine of National Research Center Kurchatov Institute. His research focus on actinide speciation, colloid facilitated radionuclide migration, surface complexation modeling, determination of low level activities, and nuclear medicine and radiopharmaceutical chemistry. He is a member of the scientific council on radiochemistry (a partnership between Russian Academy of Sciences and ROSATOM), the International Nuclear Chemistry Society, the Scientific Secretary of National Committee of Russian Chemists, and the American Chemical Society.

Kinam Kim is a Senior Researcher at Korea Atomic Energy Research Institute (KAERI). He received his Ph.D. degree in Material Science and Engineering from Hanyang University, Korea in 2013. He began his career at KAERI in 2013 as a researcher working on producing, and studying research reactor fuels. Since April 2017, He has worked as a project manager developing Atomized Powder-based High Density LEU Dispersion Targets.

Matthew Lish is a graduate of the University of North Carolina at Chapel Hill with a bachelor of science in chemistry, and the University of Tennessee at Knoxville with a doctorate in nuclear engineering, concentrating in system dynamics, instrumentation, and control. Dr. Lish currently works as a reactor dynamicist at Flibe Energy in Hunstville, Alabama where he is developing a closed fuel cycle thorium nuclear reactor known as the liquid fluoride thorium reactor, or "lifter" (LFTR). His areas of interest include reactor dynamics and simulation, inorganic separations chemistry, chemical process engineering, reactor dynamics, and radiation hardened electronics for signal processing.

Hermen van der Lugt is director of PALLAS. PALLAS is responsible for all required preparations for the construction of the PALLAS-reactor in Petten, the Netherlands. The PALLAS-reactor will take over the current role of the HFR reactor in the supply chain of isotopes. Activities include requirements specification, reactor design, nuclear and conventional licensing. The PALLAS organisation develops a business case for PALLAS that enables private investors to fund the construction and operation.

Kemmedy Mangera is Chief Operating Officer at Canadian Isotope Innovations Corp (CIIC), based in Saskatoon, Canada. Dr. Mangera was previously Director of the Radiopharmacy for Winnipeg Health, a Technical/Scientific Leader for the Prairie Isotope Production Enterprise, and Head of the Radiopharmaceuticals Research Group. In these roles, he led critical research initiatives into isotope production technologies; prior to joining the commercialization private company CIIC as a founder and COO. Dr. Mangera is an adjunct professor at the University of Winnipeg, and is past president of the Canadian Association of Radiopharmaceutical Scientists.

Anupam Mathur is a scientist working in the Radiopharmaceuticals Program of Board of Radiation and Isotope Technology (BRIT), Department of Atomic Energy, India. He has joined the department after completing one year training in Radiochemistry from Bhabha Atomic Research Centre, India. Currently, he is involved in bulk production of few regular ready to use injectable radiopharmaceuticals based on radioisotopes such as ^{131}I / ^{32}P / ^{153}Sm / ^{177}Lu supplied by BRIT for clinical end use. His research interests include designing of novel ^{68}Ga / $^{99\text{m}}\text{Tc}$ / ^{188}Re / ^{177}Lu labeled molecules for varied diagnostic and therapeutic applications.

Boris Myasoedov is deputy secretary general for science of the Russian Academy of Sciences (RAS), head of laboratories at both the RAS Vernadsky Institute of Geochemistry and Analytical Chemistry and the RAS Frumkin Institute of Physical Chemistry and Electrochemistry. His scientific activity covers such fields as the fundamental chemistry of actinides, fuel reprocessing, partitioning of radioactive waste, and environmental protection. Academician Myasoedov graduated from D.I. Mendeleev Chemical-Technology Institute in Moscow in 1954, and earned a PhD in radiochemistry from the Vernadsky Institute in 1965 and his full doctorate in 1975 from the same institute. He was elected to the Russian Academy of Sciences in 1994 and has been awarded two State Prizes for his research on the chemistry of transplutonium elements (1986 and 2001), the Khlopin Prize for his studies of the chemistry of protactinium (1974), and the Ipatiev Prize of the RAS Presidium in 2003.

Engeniy Nesterov is research scientist of Laboratory №31 at Nuclear Reactor, Institute of Physics and Technology, Tomsk Polytechnic University, PhD. Has 16 years of experience in field of R&D for medical isotopes production and application. Dr. Nesterov's Thesis was about production of Tc-99m generators based on aviation Mo-99. Has published more than 80 articles, co-author of 8 patents.

Rodolfo Núñez Miller, M.D. is a Board Certified Nuclear Medicine physician with more than 20 years' experience in the field of Nuclear Medicine and Molecular Imaging. His background training was in Internal Medicine. Currently, he works as Technical Officer at the headquarters of the International Atomic Energy Agency (IAEA) in Vienna, Austria.

Joao Osso, from Brazil holds the degrees of Ph.D. in Nuclear Chemistry from the University of Manchester, England, M.Sc. in Nuclear Engineering from the Federal University of Rio de Janeiro (UFRJ), Brazil and B.Sc in Chemistry from the University of Sao Paulo (USP), Brazil. He had more than 34 years of experience on the field of radioisotope and radiopharmaceutical production in Brazil before joining IAEA in February 2014. He is currently the Head of the Radioisotope Products and Radiation Technology Section from the Division of Physical and Chemical Sciences at the International Atomic Energy Agency (IAEA) in Vienna, Austria.

Ul Jae Park works for the RI Research Division at the Korea Atomic Energy Research Institute (KAERI).

David Pellicciarini is the Vice President, Pharmacy Safety, Practice and Technical Operations for Cardinal Health Nuclear Pharmacy Services (NPS). NPS operates 130 nuclear pharmacies, 30 positron emission tomography (PET) drug manufacturing facilities, and other radioactive drug manufacturing facilities. David has twenty five years of experience in the radiopharmaceutical industry, including nuclear pharmacy, SPECT drug manufacturing and PET drug manufacturing. David holds a B.S. in physics from the University of Nevada Reno and an MBA from UCLA. He is a Certified Health Physicist (by the American Board of Health Physics).

Eugene Peterson is executive advisor to Los Alamos National Laboratory's associate director for chemistry, life, and earth sciences and is leading the laboratory's strategic planning efforts for the Science of Signatures Science Pillar. Previously, he was the chemistry division leader at Los Alamos, where he was responsible for 350 chemical professionals and a budget of approximately \$150 million. Before his tenure as chemistry division leader, Dr. Peterson specialized in medical isotope production and applications research and development. Dr. Peterson served on the National Academies Committee on Medical Isotope Production without Highly Enriched Uranium (2007-2009) and the Committee on the State of Molybdenum-99 Production and utilization and Progress toward Eliminating Use of Highly Enriched Uranium (2014-2016). He received his B.S. degree from the Illinois Benedictine College and his Ph.D. degree in inorganic chemistry from Arizona State University.

Katrina Pitas is Vice President, Business Development of SHINE Medical Technologies, Inc. Before joining SHINE in 2011, Ms. Pitas did research and development work for Phoenix Nuclear Labs. In her capacity as VP of Business Development, she has played a key leadership role in implementing SHINE's strategic vision and driving SHINE's growth and development. Ms. Pitas was a key player in securing early funding for SHINE, and has also made important contributions to SHINE's regulatory efforts. Ms. Pitas received her undergraduate degree in physics from Carleton College and before joining Phoenix Nuclear Labs, she gained experience living in both China and Japan.

Bernard Ponsard (Master in Physics, Université Catholique de Louvain, UCL, Belgium, 1983; Master of Science "Nuclear Energy", Université Catholique de Louvain, UCL, Belgium, 1985) joined the 'Belgian Nuclear Research Centre' (SCK•CEN) in Mol in 1985 as reactor physicist at the BR2 High-Flux Material Testing Reactor. He is currently Head of Unit RSP, Radioisotopes and Silicon Production, at the BR2 reactor and in charge of the strategic development of new medical radioisotopes for nuclear medicine, new radioisotopes for industrial applications and

new products for the semiconductor industry within SCK's Institute for Nuclear Materials Science (NMS). Chairman of the "AIPES Reactors & Isotopes Working Group" from 2010 until 2017 for securing the global supply of medical radioisotopes as Mo-99/Tc-99m, he is currently Co-Chairman of the "AIPES Security of Supply Working Group", Chairman of the "Emergency Response Team" and Chairman of the "European Observatory Working Group for the European Supply of Medical Radioisotopes - Global Reactor Scheduling and Mo-99 Supply Monitoring".

Yuri Shiyon is the director of RAS CISAC and the head of the Office for Coordination of International Scientific Programs and Projects. He has worked in this capacity for more than 25 years, facilitating collaborative efforts and exchanges between international partners and Soviet/Russian scientists, engineers, and medical professionals. From 2004 through 2005, he served as an expert to the International Atomic Energy Agency Nuclear Fuel Subcommittee. For the past several years, Shiyon has served as coordinator of the RAS-NAS committees on counterterrorism and non-proliferation. Further, he has assisted several joint U.S.–Russian projects focusing on various aspects of the nuclear fuel cycle, including the storage of nuclear spent fuel.

Viktor Skuridin is a head of Laboratory №31 at Nuclear Reactor, Institute of Physics and Technology, Tomsk Polytechnic University, Dr. of Technical Sciences, professor. Has 50 years of experience in field of R&D for medical isotopes production and application. Leader of a research group of nuclear medicine at TPU. Co-author of more than 150 articles and 30 patents. Honorary worker of science and technics of Russian Federation, holder of various prizes.

Katherine (Kath) Smith is currently, the Counsellor Nuclear, at the Australian Embassy and Permanent Mission to the United Nations, in Vienna. In this role, she: develops briefs which underpin policy; participates in the Australian delegations to meetings convened by United Nations; manages relationships and facilitates interactions and dealings between Australian Departments and Agencies and the International Atomic Energy Agency (IAEA), the OCED Nuclear Energy Agency (in Paris) and other nations. She also contributes to research related to nuclear waste forms and related materials. This role is fully funded by Australian Nuclear Science and Technology Organisation (ANSTO).

Riane Stene grew up in the Southwestern United States and graduated from the University of Texas at El Paso with a bachelor's degree in chemistry. She then moved to the Pacific Northwest to pursue a master's degree in radiochemistry from Washington State University. Currently, she is working on her Ph.D. as a joint student between the Technical University of Munich and Philipps University Marburg. Her Ph.D. research focuses on the dry chemical separation of molybdenum from uranium. After her Ph.D. she would like to continue working in the field of molybdenum-99 production for medical use.

Bertrand Stepnik is working in AREVA. He is the head of the CERCA R&D department. He has an engineer degree and a Ph D. in Physics. He is AREVA expert in Uranium metallurgy.

Jean-Michel Vanderhofstadt serves as the chief executive officer of L'Institut National des Radioéléments (IRE), general manager of its subsidiary IRE-Environment and Lifescience Technology (IRE-ELiT SA) specializing in the production of medical radioisotopes for nuclear medicine, and president of TransRad, an IRE subsidiary company specializing in the transport of radioactive and nuclear material. Mr. Vanderhofstad also currently serves as the vice-president and treasurer of AIPES which represents many of the major pharmaceutical and imaging equipment companies in the field of nuclear medicine in Europe; is the board director of BioWin, a local government funded organization drawing together stakeholders (companies,

research centers and universities) involved in innovative R&D projects and/or skills development in the field of health biotechnology and medical technologies; and is an associate professor at the University of Liège, Belgium, where he lectures for an advanced masters in industrial pharmacy. Mr. Vanderhofstadt graduated from the University of Liège where he obtained a degree of industrial pharmacist and from the Free University of Brussels where he earned a post-degree in business management, respectively.

Jan Willem Velthuisen (1958) is Chief Economist at PwC Europe. At PwC Jan Willem is responsible for the Competition & Regulation team, which supports companies, governments and regulators on questions around market definition, competition, market entry, liberalisation of markets, privatisation and state aid. Jan Willem has worked in numerous industries, such as energy, financials, telecoms, transport & logistics and healthcare. Since three years Jan Willem is also responsible for the Thoughtleadership Programme of PwC Europe. Jan Willem holds a chair in economics at the University of Groningen and is visiting professor at the University of Oklahoma.

Meera Venkatesh is the Director of Division of Physical and Chemical Sciences in the Department of Nuclear Applications, at the International Atomic Energy Agency. She is responsible for the programs on radioisotope production & applications, radiation technology and nuclear sciences. Before joining the IAEA in 2011, Meera worked for 34 years at the Indian Department of Atomic Energy, beginning as a young researcher in the area of radioisotopes and radiopharmaceuticals and growing to lead the Radioisotope and Radiopharmaceuticals Program for which she received awards of excellence from the Indian Nuclear Society and from the Department of Atomic Energy, India. She has authored over 200 papers in International Journals, several book chapters and is an editor in 2 International Journals. She has guided 12 PhD students in areas of her expertise and is passionate about promoting peaceful applications of nuclear technologies.

Wolfgang Weber is a nuclear medicine physician with expertise in molecular imaging and targeted radionuclide therapy — particularly in the use of positron emission tomography (PET) in oncology. In addition to his role as Chief of the Molecular Imaging and Therapy Service, he also serves as Director of the Laurent and Alberta Gerschel Positron Emission Tomography Center at Memorial Sloan Kettering.

Christophe Xerri has 25 years of experience in nuclear fuel cycle and waste management. Before his appointment to the IAEA, he served from 2011 to 2015 as Counsellor for Nuclear Affairs to the French Embassy in Japan and in Mongolia. He joined COGEMA (now AREVA) in 1991, in the field of spent fuel and waste management. He then moved to uranium mining and enrichment technology. Later on he worked in non-proliferation and international relations, and then was assigned to the office of the President of AREVA. He moved to Japan in 2007 and became Vice President of Mitsubishi Nuclear Fuel in 2009, where he was also involved in handling the consequences of the earthquake and tsunami of March 2011.

Sergey Yudin is a head of Laboratory of radiogeology and radiogeoeology at the Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry Russian Academy of Sciences (IGEM RAS). He is a specialist in field of management of radioactive waste derived in the closed nuclear fuel cycle. He was graduated from the Moscow State University (1981, geochemistry) and received his Ph.D. (1989) and Dr.Sc. (2009) degrees from the IGEM RAS. He was elected as a corresponding member of the Russian Academy of Sciences in 2011. Now he has been involved in research on geochemical-mineralogical aspects of safe radioactive waste disposal, including searching for new matrices for isolation of long-lived actinides and

fission products. Dr. Yudinsev has published more than 250 papers in Russian and international journals and presented these results at a number of international conferences. He participated in the meetings of the Russian and American experts (Global Nuclear Energy Partnership and Advanced Fuel Cycle Initiative workshops).

Boris L. Zhuikov, Ph.D., is the head of the Laboratory of Radioisotope Complex of the Institute for Nuclear Research (INR) of the Russian Academy of Sciences in Moscow. He is responsible for the radioisotope investigation and production program at INR, including medical isotope investigation and production. He has been the project leader in a number of successful mutual USA-Russia GIPP projects for development of medical isotope production. Dr. Zhuikov has been at INR since 1987. Prior to his employment at INR he was a research scientist at the Joint Institute for Nuclear Research, an international research center for nuclear sciences located at Dubna, Moscow Oblast. Dr. Zhuikov is the author and co-author of more than 200 scientific and popular-science publications including a review of medical isotope production in Russia. He is a member of the Scientific Council of Institute for Nuclear Research of the Russian Academy of Sciences; the Russian Society of Nuclear Medicine; the American Nuclear Society, and; the International Society of Nuclear Chemistry. He holds a BSc in chemistry and a PhD in radiochemistry from Moscow State University.

STAFF

Ourania (Rania) Kosti, joined the staff of the Nuclear and Radiation Studies Board (NRSB) of the National Academies of Sciences, Engineering, and Medicine in January 2011. Prior to her current appointment, she was a postdoctoral fellow at the Lombardi Comprehensive Cancer Center at Georgetown University Hospital in Washington, DC, where she conducted research on biomarker development for early cancer detection using case-control epidemiologic study designs. She focused primarily on prostate, breast, and liver cancers and trying to identify those individuals who are at high risk of developing malignancies. Dr. Kosti also trained at the National Cancer Institute (NCI) (2005-2007). She received a B.Sc. in biochemistry from the University of Surrey, UK, an M.Sc. in molecular medicine from University College London, and a Ph.D. in molecular endocrinology from St. Bartholomew's Hospital in London, UK. Dr. Kosti's interests within the NRSB focus on radiation health effects.

Rita Guenther, senior program officer for the National Academy of Sciences' Committee on International Security and Arms Control (CISAC), is the responsible staff officer for this project. Recipient of a Fulbright-Hays--Doctoral Dissertation Research Fellowship, Dr. Guenther manages CISAC's Russia Dialogue. She has worked on or led several cooperative U.S.-Russian and Indo-U.S. projects, including a joint U.S.-Russian workshop on the future of the nuclear security environment in 2015, a study on indigenization of Russian nuclear material protection, control and accounting programs, and Indo-U.S. workshops on science and technology for nuclear material security and on science and technology to counter terrorism. The Office of Science and Technology Policy and the Office of the Science and Technology Advisor to the Secretary of State has consulted her concerning reforms in Russian science. Dr. Guenther received the National Academies distinguished service award in 2007. She speaks Russian fluently and holds a M.A. degree in Russian Studies and a Ph.D. in History from Georgetown University.

Frances Marshall has been the project manager for the Research Reactor Fuel Cycle project in the Research Reactor Section at IAEA, responsible to support Member States with research

reactor fuel cycle issues since 2014. Prior to coming to IAEA, Frances was the manager of the Advanced Test Reactor (ATR) National Scientific User Facility (NSUF) Program at Idaho National Laboratory (INL) in the USA. Frances co-led the team to establish the ATR NSUF. At INL, Frances supported and led projects in the areas of irradiation experiments, nuclear power plant engineering, nuclear power plant probabilistic risk analysis, and regulatory assessment. Frances earned a bachelor's degree in nuclear engineering from the University of Virginia (UVA), a master's degree in chemical engineering from the University of Idaho, and is a registered Professional Engineer. She held a reactor operator license on the UVA Reactor and worked in the commercial nuclear power industry as a startup engineer, plant system engineer, and reactor for nine years prior to working at INL.

Tom Hanlon is a nuclear engineer in the Research Reactor Section at the International Atomic Energy Agency, responsible for project activities related to the LEU conversions of Miniature Neutron Source Reactors (MNSRs) and production of Mo-99 without the use of HEU. Prior to joining the IAEA Mr. Hanlon served as a Technical Advisor to the National Nuclear Security Administration's (NNSA) Mo-99 Program. He has also served as a Project and Program Manager at the Y-12 National Security Complex and as an Accelerator Specialist at the Oak Ridge National Laboratory's Spallation Neutron Source. Mr. Hanlon holds a Master of Business Administration from The College of William & Mary, a Master of Science in Applied Physics from The University of Tennessee, and a Bachelor of Arts in both Physics and Music from Ripon College.

Internet Access

Public access WiFi is available throughout the IAEA buildings. Select access point **wlan-guest** and the connection will be automatic; there is no password.

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