

The US DOE-EM International Program – 14606

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INTRODUCTION

The Department of Energy's (DOE) Office of Environmental Management (EM) International Program supports the EM Mission Units by identifying opportunities to collaborate with international partners in the areas of radioactive waste processing, groundwater and soil remediation, deactivation and decommissioning (D&D), and nuclear materials disposition. The EM International Program seeks opportunities to leverage advances in science and engineering occurring on a global basis into the EM clean-up mission. Collaboration with governmental, academic, and industrial organizations in other countries expands the technical depth of the EM program.

MISSION

The mission of the EM International Program is to foster international cooperation as defined by the EM Mission Units in addressing environmental and waste management issues leading to the reduction of technical, financial, and programmatic risks for the EM Program.

INTERNATIONAL PROGRAM OBJECTIVES

The EM International Program has two primary objectives. The first objective is to directly contribute to the advancement and deployment of technologies that are supportive of and integrated with the EM Mission Units, and the EM Technology Development Program, complementing the technology development and testing activities such that the program assists in addressing identified environmental remediation and waste management needs through continued communication, collaboration, and integration with international entities. The second objective is to support EM in developing effective international D&D and waste management strategies, including identifying appropriate technologies and best practices that protect and help clean-up the environment.

STRATEGIC APPROACH

The EM International Program seeks to utilize the following existing mechanisms to increase EM engagement in international technology development activities:

- Multinational forums and agencies
- Collaborative international agreements
- International visitors at EM and foreign sites
- International conferences
- Interaction with other US agencies and programs
- Interaction with other DOE program offices
- Funding of technical projects.

EM will seek to engage with multilateral international organizations in order to tap into best science being used in the field. The EM International Program will use existing international agreements in order not to duplicate efforts and, where none exist, establish new agreements, that assist in developing effective international D&D and waste management strategies and formalize undertakings with international partner countries.

EM will also strive to work with other U.S. agencies involved in energy, waste management, and other nuclear-related programs. By working closely with other government agencies, EM can remain up to date on the latest policy and technological developments that have the potential to be leveraged to address the time and high-cost of the clean-up mission. To avoid duplication of effort and enhance return on investment, EM will strive to increase coordination between Departmental offices engaged in missions that interface with EM's remediation and waste management activities in order to complement existing international programs and avoid duplication of efforts, and enhance return on investment.

Engage with Multinational Forums/Agencies

The United States along with 68 other nations are signatories pledged to support the objectives of the **Joint Convention** on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention). Opened for signature in September 1997 and entered into force in June 2001, the Joint Convention is the first legal instrument to directly address those issues on a global scale. The United States actively promotes and participates in the Joint Convention implementation process since inception. DOE/EM provides leadership to the US government-wide, inter-agency effort. The Assistant Secretary for EM, and the Assistant Secretary for NE, both served as U.S. representatives leading the U.S. delegation at the Fourth Review Meeting of the Parties in May 2009. In addition, EM management and staff served as Joint Convention officials at all four review meetings held to date, and at two of the review meetings EM provided vice presidents, presiding over the Open-Ended Working Group sessions. EM is charged with leading the Working Group that prepares the U.S. National Report for international peer review, reviews all other Contracting Party national reports, responds to questions on the U.S. National Report, and provides technical expertise at the Review Meeting

country review sessions. The Working group is currently preparing the Fifth U.S. National Report which will be shared with all Contracting Parties in October 2014. The Fifth Review Meeting of the parties is scheduled for May 2015.

An avenue where EM can show case its expertise and provide benefit is through participation in the **International Atomic Energy Agency (IAEA)** “Network of Networks” established in September 2007 by the General Conference, the highest policymaking body of the IAEA composed of representatives of all Member States. Two established networks of interest to EM are the International Decommissioning Network and the ENVIRONET for remediation of radiologically contaminated sites and remediation of soil and groundwater.

The **Nuclear Energy Agency (NEA)** is a specialized agency within the Organization for Economic Co-operation and Development, an intergovernmental organization of industrialized countries based in Paris, France. EM participates in the NEA’s Radioactive Waste Management Committee and the Working Party on Decommissioning and Dismantling. This relationship benefits the EM mission through:

- Fostering a shared and broad-based understanding of the state of the art and emerging issues;
- Facilitating the elaboration of waste management and D&D strategies that respect societal requirements;
- Helping to provide common bases to the national regulatory frameworks;
- Enabling the management of radioactive waste, materials and D&D to benefit from advances in scientific and technical knowledge, e.g., through joint projects and specialist meetings;
- Contributing to knowledge consolidation and transfer, e.g., through the publication of technical reports, consensus statements and short flyers; and
- Helping to advance best practice, e.g., by supporting international peer reviews.

Establish Collaborative International Agreements

The EM International Program will foster existing partnerships and establish new ones with countries that embrace a mission-completion philosophy based on remediation and reducing risk in conjunction with the Mission Units. For example, the United Kingdom (UK) is already one of EM’s primary international partners. Current collaboration takes place under the DOE-EM and UK Nuclear Decommissioning Authority Statement of Intent for Exchange of Information Concerning Management of Radioactive Waste. With the formation of the UK Department of Energy and Climate Change, EM has the opportunity to solidify this bilateral relationship at a government level and establish a mechanism in which to establish future work and an ability to grow the areas of cooperation under one overarching agreement. In the beginning of 2013, EM signed an agreement with Atomic Energy of Canada Limited in the field of used fuel and radioactive waste management, decommissioning and environmental restoration. The first meeting under this agreement was held December 2013 via televideo to discuss potential future areas of cooperation. Additionally, EM signed an agreement with the Public Agency for Radioactive Waste Management (PURAM) of the Republic of Hungary for Information

Exchange Relating to Operation of Modular Vault Systems for Storage of Spent Nuclear Fuel. The first meeting under this agreement was held May 18, 2010, at Fort St. Vrain, Colorado. Plans are to conduct the next meeting between PURAM and EM at the Paks Modular Vault Dry Store facility in Hungary. In late FY 2012, DOE also signed an agreement with France's Commission for Atomic and Alternative Energies (CEA) for Cooperation in Low Carbon Energy Technologies. This agreement has allowed EM to explore potential collaboration with CEA to further EM's mission.

On September 27, 2012, the Secretary of Energy signed a Statement of Intent with Rosatom concerning collaboration in innovative technologies for environmental restoration and radioactive waste management. This agreement further enhances our relationship with Russian organizations and promotes joint future collaboration. Almost one year later, on September 10, 2013, the Secretary of Energy and the Director General of Rosatom signed an Agreement on *Cooperation in Nuclear and Energy-Related Scientific Research and Development*. This Agreement provides a legal framework for collaborative projects between EM and Rosatom in common areas related to energy and non-proliferation, including radioactive waste management technologies.

A Memorandum of Understanding was also signed in FY2012 between DOE and France's National Radioactive Waste Management Agency which will allow cooperation and sharing of information on geological repository issues. Future agreements will enhance international cooperation in order to strategically promote research and development in EM.

Engage with International Visitors at EM and Foreign Sites

Visits by our international colleagues to DOE sites and facilities offer a unique opportunity to facilitate information exchange and collaboration. These visits can be formal (e.g., in conjunction with workshops or meetings) involving numerous participants or relatively informal visits by one or two individuals. Irrespective of potential language barriers, concepts and issues can be readily communicated through visual observations of sites, facilities and systems.

In the EM arena, the DOE sites that may have significant interest to international colleagues include-- the Waste Isolation Pilot Plant, Idaho National Laboratory (INL), West Valley Demonstration Project, Savannah River Site, and the Hanford Site.

Visits which took place in 2013 include a delegation from Rosatom that visited the INL to participate in the Separations Workshop to discuss waste form performance. Subject Matter Experts from other National Laboratories also participated. Additionally the UK National Nuclear Laboratory (NNL) visited DOE Headquarters to discuss potential cooperation with EM in the areas of waste management, nuclear materials disposition, soil and groundwater remediation, and D&D. Most recently, in January 2014, Japan's Ministry of Economy, Trade and Industry visited the Hanford site to better understand the experiences of the Hanford area in clean-up, but also in revitalization and economic sustainability in diversifying away from clean-up missions.

Alternatively, visits by U.S. personnel to foreign facilities are equally important in providing insight into waste management practices employed outside the United States. In 2013, U.S. representatives travelled to Berlin, Germany to attend the 4th U.S.-German Workshop to participate in technical exchanges related to salt repository R&D and to conduct technical visits of salt disposal sites in Germany. EM has also participated in tours of the Sellafield Site near Manchester, England to participate in Plutonium Technical Exchanges, with specific focus on stress corrosion cracking R&D activities and related plutonium management issues.

Finally, EM continues to be engaged with Japan in helping to address some of the cleanup issues relate to the Fukushima accident. Several U.S. agencies, including EM, sponsored the 3rd Workshop for Fukushima Daiichi Cleanup at the Hanford site this past year. Participants included representatives from Japanese agencies (Ministry of Environment, Ministries of Economic Trade and Industry, and the National Institute for Environmental Studies), as well as EM, U.S. Environmental Protection Agency (EPA), and several national laboratories. Early in 2013, Savannah River National Laboratory (SRNL) and Pacific Northwest National Laboratory (PNNL) produced a feasibility study in order to identify what support SRNL and PNNL could provide for the challenges towards decommissioning Fukushima Daiichi Nuclear Power Station. The feasibility study identified several potential areas for further cooperation, such as prevention of groundwater contamination, water sealing technology, waste processing & disposal, fuel debris removal & storage, and contaminated water treatment. A contract was concluded between Tokyo Electric Power Company and DOE's National Laboratories on September 23, 2013. The U.S.-Japan Bi-Lateral Commission on Civil Nuclear Cooperation, Decommissioning and Environmental Management Working Group meeting, was recently held in Washington, DC. The primary objectives were to discuss U.S. and Japan climate change policies, off-site environmental remediation around the Fukushima nuclear site, and potential bilateral cooperation related to climate change, and clean energy. EM representatives will also participate in Japan-U.S. Decommissioning and Remediation Fukushima Recovery Forum in Tokyo, Japan.

Participate in International Conferences

International conferences provide the opportunity for EM to promote the EM program to an international audience, including at a programmatic and technology level. Most importantly it allows for the EM program to stay abreast of science and technology developments of other countries that may benefit the overall EM mission. International conferences allow the opportunity to obtain current technical information related to treatment of radioactive waste in other countries, and to facilitate contact with potential subject matter experts that could assist EM in future technical reviews of environmental treatment technologies. EM has been a supporter of various conferences at which EM management has been able to engage with international counterparts that have allowed the pursuit of research and development (R&D) collaboration. Important conferences that EM supports are the Waste Management Conference held annually in Phoenix, Arizona, the International Conference on Environmental Management and Radioactive Waste Management in Reims, France; and various topical meetings organized by the American Nuclear Society. The EM International Program in conjunction with the Mission Units will continue to identify key conferences focused on environmental remediation and radioactive waste management that allow EM to engage the technical skills and knowledge

of foreign governments, industries, and universities to help identify transformational solutions to that have the potential to assist with EM's clean-up mission.

Coordinate with Other U.S. Agencies and Programs

In recent years, the U.S. State Department (DOS) has increased its activities in technical cooperation under the Joint Standing Committee on Nuclear Energy Cooperation (JSCNEC) and Joint Coordinating Meetings (JCM) on Science and Technology. The JSCNEC meeting includes a review of several joint projects between the United States and foreign nuclear research institutions. The JCM's focus is more on basic and applied scientific research. At these annual meetings the Department of Energy has been responsible for coordination among the DOS, U.S. national laboratories, program offices, and other DOE participants and private entities, collecting updates on ongoing projects and identifying any new areas of collaboration. DOE's Offices of Nuclear Energy and Defense Nuclear Non-Proliferation also participate in DOS's JSCNEC and JCM meetings held annually.

Both the JSCNEC and JCM provide an important opportunity for the EM International Program to continue to broaden its understanding of environmental remediation and energy efforts in the international context. The meetings also enable senior EM personnel to share information and to gain lessons learned from environmental programs that are highly developed and assist in establishing EM as a world leader in remediation and environmental management. A number of countries with developed energy and environmental programs use the JSCNEC and JCM as the formal bilateral cooperation channel between them and the United States through which nuclear and science policy consultations, exchange of technical information, joint R&D activities, etc., transpire.

As deemed necessary by the EM mission and the EM Mission Units the EM International Program may also engage and coordinate with other U.S. agencies through U.S. Department of Commerce trade delegations and the Nuclear Regulatory Commission Committee Sessions on Environmental Management. Both of these agencies can help to meet EM's and DOE's goals in advancing scientific and technological innovation, energy security, and environmental remediation of the national nuclear weapons complex.

The Bilateral Commission on Civil Nuclear Cooperation, established by the President and Japanese Prime Minister Noda, was formed to build on the close U.S.-Japan cooperation following Japan's March 2011 nuclear accident in Fukushima, and to further strengthen joint work in this field, while fostering comprehensive strategic dialogue and joint activities related to the safe and secure implementation of civil nuclear energy. Jointly with the EPA, EM leads the Bilateral Commission's Environmental Management and Decommissioning Working Group. This Working Group focuses on bilateral cooperation to address long-term the consequences of the Fukushima accident, including lessons learned, facility decommissioning, site remediation and clean-up, and possibly managing the longer term consequences of an incident, such as monitoring contaminated areas. As mentioned earlier, EM has been very active in these workshops and technical exchanges.

Engage with Other DOE Program Offices

The EM International Program will engage with the DOE Office of Science, National Nuclear Security Administration, Office of Policy and International Affairs, and the Office of Nuclear Energy on international programs that support and enhance the EM International Program goals and objectives.

The Office of Science (SC) is the single largest supporter of basic research in the physical sciences in the United States, providing more than 40 percent of total funding for this vital area of national importance. It oversees – and is the principal federal funding agency of – the Nation’s research programs in high-energy physics, nuclear physics, and fusion energy sciences. It also manages 10 world-class laboratories, which often are called the “crown jewels” of our national research infrastructure. The national laboratory system, created over a half-century ago, is the most comprehensive research system of its kind in the world.

SC oversees the construction and operation of some of the Nation’s most advanced R&D user facilities, located at national laboratories and universities. These include particle and nuclear physics accelerators, synchrotron light sources, neutron scattering facilities, supercomputers and high-speed computer networks.

By tapping into these resources EM can leverage the ongoing work and the results to its technology innovation program. A good example for leveraging is working with SC to develop EM’s Advanced Simulation Capability for Environmental Management (ASCEM). ASCEM is an integrated, modular, open-source toolset for advanced modeling and simulation that reduces uncertainties and risks associated with environmental remediation and closure programs. Another example would be the coordination with SC on studies supporting transformational waste processing technologies.

The Office of International Affairs (IA) has primary responsibility for the DOE's international energy activities including international emergency management, national security, and international cooperation in science and technology. IA's role is to deliver unbiased advice to the Department of Energy's leadership on existing and prospective energy-related policies, based on integrated and well-founded data and analysis.

Through its Energy Policy Dialogue discussions, IA works closely with DOE program Assistant Secretaries and other DOE Secretarial officers to maintain a knowledge of the activities, issues, and policies of the Department, other Federal departments and agencies (including the National Security Council, Office of Management and Budget, and other White House offices), members of Congress and Congressional Committees, and energy producers and consumers. By engaging in the Energy Policy Dialogue discussions and being an active participant, EM can contribute to the optimization of the national environmental management system. Additionally, in its leadership role the U.S. will continue to assist other countries to adopt high-level waste management and disposal practices that enhance international security, safety, and environmental management.

The EM International Program will work closely with IA as it establishes international agreements to ensure that a mechanism is in place to pursue international collaborative undertakings in environmental management. In addition, the EM International Program will keep abreast of the latest policy issues affecting bilateral consultations in environmental management and radioactive waste management.

The Office of Nuclear Energy mission is to promote nuclear power as a resource capable of meeting the Nation's energy, environmental and national security needs. There are two programs relevant to EM's mission, currently the International Framework for Nuclear Energy Cooperation (IFNEC)¹ and the Generation IV International Forum (GIF). IFNEC was established to promote cooperation among States that share the common vision of the need to expand nuclear energy production worldwide in a safe and secure manner. It aims to accelerate development and deployment of advanced fuel cycle technologies to encourage clean development and prosperity worldwide, improve the environment, and reduce the risk of nuclear proliferation. To date the partnership consists of 31 partners, three permanent international nongovernmental observers and a number of observer countries. The partners are: Armenia, Australia, Bulgaria, Canada, China, Estonia, France, Ghana, Hungary, Italy, Japan, Jordan, Kazakhstan, Republic of Korea, Lithuania, Morocco, Oman, Poland, Romania, Russia, Senegal, Slovenia, Ukraine, United Kingdom, Argentina, Germany, Kenya, Kuwait, Netherlands, UAE, and the United States. The three permanent international nongovernmental observers are: the International Atomic Energy Agency, the Generation IV International Forum and EURATOM.

IFNEC has two working groups—the Infrastructure Development Working Group (IDWG) and the Reliable Nuclear Fuel Services Working Group. Of special interest to EM is the IDWG. One of the subgroups of the IDWG is the Waste Management Group whose goal is to address radioactive waste management issues. EM has the unique opportunity to identify specific activities in the area of radioactive waste management. Some proposed activities are human capital development, exchanging information on calculations and costing methodology, identifying and addressing research and development gaps and providing lessons learned. The partners have suggested that each country identify an expert to participate in the subgroup. Through the International Program, EM can have an important role in the establishment of an IFNEC sub-Working Group to explore possible strategies for the long term management of radioactive wastes arising at nuclear power stations and from associated fuel cycle activities.

The mission of GIF is to develop the next generation nuclear energy systems to meet the world's future energy needs. This unique international effort allows unprecedented coordination among the national research organizations of the various partners in the GIF, which include Canada, China, Euratom, France, Japan, Republic of Korea, Republic of South Africa, Russia, Switzerland, the United Kingdom, and the United States [Argentina and Brazil are inactive]. Senior representatives from GIF member countries participate in committees that coordinate the research activities required to develop up to six next generation nuclear energy systems. The U.S. is actively participating in joint R&D with various GIF members; EM can leverage these research and development activities to assist in identifying environmental technologies.

¹ The IFNEC was formerly known as the Global Nuclear Energy Partnership.

EM is working with NE in a joint international Study of Glass Behavior over Geologic Time Scales. Last year, 22 representatives from five nations (Belgium, France, Japan, United Kingdom, and the United States, including three DOE offices and four national labs) simultaneously connected to a webinar/teleconference meeting to discuss progress and opportunities for collaboration in the field of Long-term Glass Corrosion. This webinar was a follow-up to a three-day workshop in Seattle in October 2009 at which a similar group of scientists and administrators met to establish the current state of understanding, to discuss and develop a comprehensive research plan, and to come to a consensus on required future research.

Glass is the waste form of choice for immobilizing high level waste (HLW) in the U.S. and internationally; however, there is uncertainty due to different repository environments and a lack of consensus on glass corrosion behavior between nations vitrifying HLW. This activity aims to develop the data and understanding necessary for an international consensus on the behavior of glass waste form corrosion over geologic time scales in a variety of disposal environments. This long-term research program was initiated in 2009 with participation from the U.S. (Joint EM-NE-RW), France (CEA, Nantes, AREVA), Belgium (SCK-CEN), UK (NNL, Sheffield), and Japan (Kyushu and JAEA) [Note: additional members, such as Russia, have joined since, and others will be added on an as needed basis]. This international collaboration will not only help these scientific advances be realized more quickly, but an international consensus on corrosion rate will lessen the complications inherent in the qualification of waste forms and will open the possibility of disposing of HLW glasses in a variety of potential environments.

The National Nuclear Security Administration (NNSA) holds high-level meetings and discussions on non-proliferation issues that have the potential to influence the EM mission. NNSA holds meetings with countries with whom EM may be interested in working or expanding collaborations. Just recently, NNSA held discussions with Russia, India, and China in support of the Peaceful Uses of Nuclear Technology Agreement. Even if some of these countries are not actively engaged with EM, there are collaborative opportunities that can be attained with research centers and institutions. As part of the NNSA Global Threat Reduction Initiative, EM can develop close relations with foreign countries possessing U.S.-origin foreign research reactor spent fuel (i.e., Japan, Turkey, Israel, and Chile) that can lead to innovative technology development and increased scientific discovery.

TECHNICAL FOCUS AND INTERNATIONAL PARTNERS

The EM International Program coordinates with the EM Mission Units organizations. Specifically, the Office of Site Restoration includes the Soil and Groundwater Remediation and D&D technology areas. Similarly, the Office of Tank Waste and Nuclear Material includes Tank Waste Management, and Spent Nuclear Fuel (SNF) and Nuclear Materials Disposition technology areas. Also, the Office of Waste Management includes Disposal Operations, Disposition Planning and Policy, and Packaging and Transportation. Within each of these areas, several technical topics have been identified that represent identified needs that 1) have been collaborated on in the past, 2) have ongoing collaborations, or 3) offer potential areas of future international collaboration. These topics are summarized below:

Waste Processing

- Next generation melter development
- Advanced waste form development
- Waste form chemistry and behavior (crystallization, melting rate)
- Long-term performance of waste forms
- Tank retrieval
- Waste pretreatment
- Waste tank integrity
- Repository issues

Soil & Groundwater Remediation

- Radionuclide distribution and migration
- Biogeochemical gradients and permeable reactive barriers
- Site characterization
- Performance assessments and modeling
- Predicting, contaminant fate and transport in the vadose zone
- Monitoring, access, control and delivery of remedial action in the deep vadose zone
- Transformational remediation technologies
- Natural attenuation and enhanced remediation technology development
- Green and sustainable remediation
- Long-term monitoring and data management
- Advanced modeling and simulation

SNF and Nuclear Materials Disposition

- Spent nuclear fuel receipts, storage transportation, and disposition
- Plutonium storage and disposition
- Corrosion and materials integrity (storage containers, spent fuel, etc.)
- Materials characterization

Deactivation & Decommissioning

- Decontamination technologies
- Remote inspection
- Characterization technologies
- In-situ immobilization and closure.

International Partners

Based on these areas of identified needs, and through the existing agreements, technical exchanges, and collaborative relationships, the following technology areas of mutual interest and potential partnering have been identified with various International participants.

Argentina

- Groundwater and Soil Remediation

Australia

- Waste processing technologies (i.e., Hot Isostatic Pressing (HIP))
- Long-term performance of waste forms
- Nuclear material management
- D&D

Canada

- Monitoring and retrieval of Spent Nuclear Fuel
Deactivation & decommissioning technologies

China

- Repository programs-- Developing a detailed knowledge of long-term corrosion behavior in a deep repository
- Spent fuel and fissile-materials management
- Peaceful Uses of Nuclear Technology (PUNT) --to share interest, experiences and potential topics for cooperation in the areas of environment and radioactive waste management

France

- Waste processing technologies-- melter technology, waste form chemistry
- Long-term performance of waste forms
- Deactivation & decommissioning technologies

Germany

- Safety case of a salt-based repository-- this cooperation may include exchange of experiences and results of theoretical, experimental and development projects

Hungary

- Operation of modular vault systems for storage of spent nuclear fuel

India

- Performance Assessment
- Waste form development and qualification
- Vitrification and glass technologies

Japan

- Waste processing technologies-- melter technology, waste form chemistry
- Waste retrieval technologies
- Long-term performance of waste forms
- Groundwater and Soil Remediation
- Deactivation & decommissioning technologies

Korea

- Waste processing technologies-- melter technology, waste form chemistry

- Molten salt extraction (electrochemical) processing of used nuclear fuel
- Long-term performance of waste forms

Russia

- Fundamental studies of contaminant transport processes to support modeling and simulation;
- Advanced Simulation Capability for Environmental Management (ASCEM)
- Waste processing technologies-- melter technology, waste form chemistry
- Mercury remediation technology

Sweden

- Fuel packaging technologies
- Long-term storage of Spent Nuclear Fuel

United Kingdom

- Plutonium storage
- Spent fuel storage
- Nuclear facility life management and materials degradation
- Waste form chemistry—crystallization, melting rate
- Tank retrieval technologies – Cryograb technology
- Deactivation & decommissioning technologies
- Advanced fogging technologies
- Glass chemistry – sulfur solubility model
- Safety, Security, and Quality Programs

Ukraine (Chernobyl)

- Performance Assessment
- Radionuclide distribution and migration in soils and groundwater
- Migration and fate of radionuclides in urban ecosystems.

In addition to the benefits from the technical knowledge of these international partners, EM has also realized significant benefit through use of existing infrastructure at various research institutions, national laboratories, and universities located in these countries. These capabilities will provide cost-effective methods to conduct key experimental work and testing.

RECENT AND ONGOING COLLABORATIONS

In FY 2013, the International Program awarded a number of international collaborative projects for work scope spanning waste processing, groundwater and soil remediation, D&D and nuclear materials disposition initiatives to various foreign organizations. Additionally, the International Program's scope and collaboration opportunities were expanded to include technical as well as non-technical areas. The following table provides examples of some of the awarded projects.

International Partner	Title	Scope/Status
Argentina	Predictive Modeling of Groundwater Flow and Transport in Saturated and Variably Saturated Zones	Argentina National Atomic Energy Commission, PNNL, and Lawrence Berkley National Laboratory have established a collaborative study to apply ASCEM to a site in the Argentine Republic. The project is applying the ASCEM toolsets to an evaluation of the Areco River Basin of Argentina. Initial efforts have focused on assembling data to describe groundwater flow and transport in the basin using the ASCEM platform known as Akuna.
United Kingdom	Advanced Fogging Technologies Demonstration – Misting	UK NNL and INL are collaborating on an advanced fogging technique for more effective coverage (i.e., larger area in less time, using less product) for fixing airborne and lose surface contamination in inaccessible areas, such as HVAC ducts and piping.
United Kingdom	Glass Chemistry and Processing Issues – Sulfur Solubility, Materials and Engineering Research Institute (MERI) Sheffield University	MERI, Hallam University, SRNL, and PNNL, are collaborating on development of a more comprehensive sulfur solubility model for glass chemistry related to HLW immobilization.
United Kingdom	Demonstration of a Reliable, Safe and Cost Effective Treatment Technology for Radioactive Organic Wastes	EM is collaborating with Arvia Technology through NuVision Engineering, and Perma-Fix, to evaluate the effectiveness of an innovative technology that combines adsorption using a patented material called "Nyex" with electrochemical oxidation for non-thermal destruction of radioactive organic waste streams.
Russia	Fundamental research of contaminant transport processes in geological media to support the development of the Advanced Simulation Capabilities for Environmental Management.	EM is collaborating with the Russian Academy of Science, Nuclear Safety Institute (IBRAE) to potentially impact the safety assessment of geological radioactive was disposal and polluted sites.
Sweden	Fuel packaging technologies and methods for long-term storage of SNF spent nuclear fuel	EM is collaborating with SKB to gain subject matter expertise on their KBS-3 SNF package and repository design, including package closure and emplacement.

Examples of Recent Accomplishments for International Program Collaborative Projects

The following are examples of recent accomplishments achieved through some of the EM International Program collaborative projects.

- The Sulfur Solubility Modeling effort has studied over 300 U.S. glass compositions and made significant advances in developing a correlation model for sulfate solubility in borosilicate glasses (i.e., waste loading impacts). A relatively simple model has been identified that shows strong correlation to actual waste glasses, as well as indicators of when it is applicable. Investigations have also identified and begun quantifying the effects of halides (i.e., chlorides and fluorides) on sulfate solubility. This data will be used to validate a model that can help maximize waste loadings for sulfate limited glasses, providing more cost-effective operations at both the Defense Waste Processing Facility at the Savannah River Site and the Waste Treatment and Immobilization Plant at the Hanford Site.
- The Advanced Fogging Technologies Demonstration project has recently completed integrated of a fogging solution (i.e., a “capture coating” developed at INL) and a misting technology (i.e., micron level atomization) technology developed at NNL) that can provide a rapid, complete, and cost effective decontamination technique for large and/or inaccessible spaces. Recent test results demonstrated the feasibility of this integrated system, with several key characteristics observed: 1) a dense fog was produced that lasted over 10 minutes, 2) the micron size particles coalesced providing binding capability for dry contamination on substrates, and 3) effective line of sight and non-line of sight coverage. Additional testing and development are planned to advance the technical maturity such that it is ready for a hot demonstration. Once validated, this technology will significantly reduce costs of decontamination of ducts, stacks, and other areas with large concentrations of airborne contamination.
- The Radioactive Organic Waste Destruction Technology project recently completed successful demonstration testing of an adsorption/electrochemical oxidation process (i.e., a non-thermal process that converts organics to water and carbon dioxide) to non-radioactive organic wastes that are simulants for those existing at DOE facilities, such as radioactively contaminated dioxins, furans, and polychlorinated biphenyl-laden oils. These streams are generally considered “orphan” wastes since currently a treatment technology is not available. Recent testing on both hydrophilic and hydrophobic compounds (representing the range of the types of organic wastes that DOE must disposition) provided valuable data in determining the optimal operating parameters for cost-effective processing and high destruction efficiencies for these diverse waste streams. Once the process has been further validated and optimized, a platform will be established in the U.S. and actual wastes currently stored at the Oak Ridge site will be treated as part of the technology maturation process. Once demonstrated, this technology will potentially provide a treatment strategy for a class of waste at several DOE sites that does not currently have a disposition path.

CONCLUSION

EM's International Program in conjunction with the EM Mission Units continues to focus on identifying and leveraging international expertise, infrastructure, and collaboration opportunities that can assist in reducing the cost and schedule of the environmental remediation mission; enhancing understanding of the processes related to environmental management; accelerating and increasing innovative technology applications; and helping to ensure that science-based approaches and solutions are implemented on an international level that provide safe, effective, and responsible environmental management approaches. This will be accomplished by enlisting international support and cooperation through participation in international organizations and developing and maintaining appropriate frameworks for bilateral and multilateral cooperation. Most importantly, EM's International Program will advise on international agreements which may involve EM organizations. The International Program with Mission Units will also be able to monitor and support international advances in technology that can potentially reduce cost and optimize the efficiency of site remediation and will be responsible for obtaining and exchanging information on the global status of technical progress and relevant policies in waste management.