Technology Development and Deployment for U.S. DOE: University, Research Institution and Industry Partnerships

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INTRODUCTION

The Institute for Central and Eastern European Cooperative Environmental Research (ICEECER) at Florida State University was formed in 1990 soon after the end of the Cold War. The ICEECER consists of a number of joint centers which link Florida State University, and U.S. as well as international funding agencies, to academic and research institutions in Hungary, Poland, the Czech Republic, Russia, other countries in Central and Eastern Europe and the Newly Independent States (NIS).

There are three compelling reasons to work cooperatively with scientists from Central and Eastern Europe to demonstrate and deploy more effective and less costly technologies for assisting the U.S. DOE with its clean-up program. These reasons are expertise, cost and "ease of entry". The countries of Hungary, Poland and the Czech Republic have scientists with excellent academic training in the areas of chemistry, nuclear chemistry, physics, biology, engineering and other technical disciplines which are at parity with expertise found in the United States and western Europe. CEE scientists have been working for many years with colleagues in western Europe, the United States, Japan, China and Russia on technical solutions for problems that can be directly transferred to environmental applications. During the Cold War, the Soviets relied heavily on the technical skills of scientists from the Soviet satellite countries. The second reason is cost. The cost of a highly trained scientist from Hungary, Poland or the Czech Republic is about 1/4 or less the cost (including all overhead costs and fringe benefits) of similarly trained and skilled scientists from the United States. The last reason, "ease of entry" relates to the prevailing ability to demonstrate and validate innovative technologies rapidly and with relatively few regulatory hurdles. This allows for the rapid acquisition of data on technologies which can result in accelerated site remediation progress at DOE sites.

This paper will summarize the mission, structure and administration of the ICEECER and will provide updated information on the activities conducted through this international, university-based partnership program at Florida State University. While an emphasis of this DOE-sponsored conference is on evaluating and forming industry partnerships to deploy environmental technology, the activities of the ICEECER in Central and Eastern Europe extend heavily into environmental technology development, demonstration using laboratory experimentation, field demonstrations, and other approaches for addressing environmental restoration and waste management needs worldwide.

Contract Information

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Funding sources for the ICEECER include the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Defense - USAF, NATO, DuPont Company, the Australian Government, the Swiss Federal Institute for Environmental Science and Technology, the Hungarian Ministry for the Environment and other international agencies and organizations. Examples of funded projects include advanced radio-chemistry research in conjunction with the Czech Technical University in Prague; sensor and remote-sensing equipment development with the Technical University of Budapest; development of remediation technologies and technology demonstrations in Poland with the DOE and the Institute for Ecology of Industrial Areas; containment technology demonstrations with the DOE, EPA, DuPont Company and the USAF; risk assessment and toxicology training in Hungary and Poland; and topical issues for NATO (development of remediation strategies for environmental contamination problems at former Soviet military bases in Central and Eastern Europe, Expert Panel Workshop on In-Situ Bioremediation of TCE). In addition, the ICEECER conducts numerous international conferences, symposia and high-level meetings which have as principal objectives: the exchange of technical information, technology demonstration and exhibition, facilitating interactions among U.S. and non-U.S. environmental technology developers, and the formation of technical international partnerships for technology development and application.

OBJECTIVES

Florida State University utilizes its experience and knowledge base derived from on-going activities to expand its program of international environmental technology identification, development, demonstration and associated research that will support the nation’s, and specifically DOE's, environmental clean-up efforts by increasing the quantity and quality of technical information which can be used for cleaning-up contaminated sites. The ICEECER not only utilizes the academic resources of Florida State University, but also those of other appropriate academic institutions, the national laboratories, and nationally-renown and internationally-renown experts as needed to conduct the activities for this cooperative agreement. Work activities focus on the investigation of environmental technologies under development to determine applicability to various public environmental clean-up situations in the context of whether these technologies are more effective, safer to use, and/or less-costly than existing technologies in-use at DOE and other contaminated sites. Site characterization technologies, containment technologies, monitoring technologies and restoration technologies are also investigated to determine effective approaches for site clean-up.

The technologies investigated by the ICEECER include not only those in the U.S. but also technologies being developed abroad for site restoration and waste management (e.g., in the Czech Republic, Hungary, Poland, Italy and Russia). The focus of these investigations are on enhancing the technology transfer, both import and export, of innovative and emerging technologies dealing with site characterization, containment, site remediation, monitoring and waste management.

Work is focused on assisting in the identification and evaluation of innovative technologies which are being developed by foreign scientists. The Florida State University both conducts and participates in symposia, conferences, workshops and other high-level meetings (e.g., NATO, IAEA) which serve as vehicles for identifying and evaluating these innovative environmental technologies. One of the critical objectives of this program is to address problems at federal (DOE) and other publicly-owned facilities where contamination of the environment is of concern. The focused effort at Florida State University and associated project results will be integrated into remediation efforts at other sites which have comparable environmental problems. Through this process, research on these technologies can support remediation and waste management clean-up activities throughout

the United States. Such feedback can be effectively utilized in the development of new technologies, prioritization of restoration efforts, communication with the public, and acceleration of contaminated site clean-up to protect human health and the environment. in the context specifically of DOE sites

APPROACH

The approach taken to attain the objectives of this joint DOE-FETC/Florida State University initiative is to utilize a combination of projects to address the needs of international environmental technology identification, development, demonstration and associated research for the DOE. These projects involve laboratory research, field investigations, technology demonstrations, technical exchanges of scientists from Central and Eastern Europe, Russia, other countries and from the United States. This approach is described in the context of the projects for this cooperative agreement. Selected major projects are described in the following section (Project Descriptions).

PROJECT DESCRIPTIONS

Environmental Research in Russia

The technical/experimental international activities of the ICEECER will be presented as examples of projects conducted typically in conjunction with partnership institutions in Central and Eastern Europe and Russia. The program in Russia is one that has been in operation for approximately four years through the DOE-OST and FETC. Dr. Thomas Albert (Thomas E. Albert and Associates, Inc.) is chiefly responsible for coordinating the research activities of this program under sub-contract to Florida State University. As examples of activities under the Russian Program, a total of 17 FY97 projects were authorized for funding at Russian institutions in early February of 1997. These 17 new projects, conducted by Russian research institutions, are the following:

- Experimental Research Program on Self Cleaning of the Mishelak River ($60K research budget)
- Experimental Research Program on Multi-Packer Well Tests ($100 budget)
- Experimental Research Program on Mayak Contaminant Transport Modeling ($40K research budget)
- Experimental Research Program on Tomsk Contaminant Transport Modeling ($20K research budget)
- Biotechnological Decontamination of Open Ponds Contaminated with LLW ($10K research budget)
- Use of Supercritical Fluid Extraction for Transplutonium Element Decontamination of Solid Materials ($10K research budget)
- Cryogenic Technology and Development Equipment for Production of Granulated Materials ($10K research budget)
- Applicability of the Russian Separations Technology to Processing of US Radioactive Wastes ($200K research budget)
- Recovery of 137 Cs from Actual INEL High Level Waste by Sorption Technique with Copper Ferrocyanide ($15K research budget)

- Investigation on Removal of TRU from Alkaline Solutions on Carriers Obtained by the Method of Appearing Reagents ($30K research budget)

- Investigation on Disproportion of Plutonium(V) in Alkaline Media of Various Composition in Liquids and Model Sludges ($30K research budget)

- Investigation on Isolation of Technetium from Alkaline Solutions ($30K research budget)

- Investigation on Application of Homogeneous and Heterogeneous Catalysis from Alkaline Treatment ($30K research budget)

- Evaluation of Russian Liquid-Liquid Extraction Technologies Using Crown Ethers (CE) for Decontamination of Low and High Level Radioactive Wastes from Long-Lived Radionuclides and Toxic Metals ($50K research budget)

- Assessment of Russian Waste Treatment Technologies and Applicability to US DOE Mixed Waste Focus Area Needs ($20K research budget)

- Experimental Investigation of Radionuclide Partitioning in a High frequency Induction Melter ($50K research budget)

- Pilot-Scale Apparatus for Treatment of Solid Mixed Radioactive Wastes: Plasmatron with Induction Cold Crucible Melter (PICCM) ($71K research budget)

The total budget for all 17 FY97 Russian projects is $771,000 to be conducted throughout fiscal year 1996.

Advanced Chemical Separations (Ion-Exchange) Research in the Czech Republic

Dr. Ferdinand Sebesta (et al.) of the Faculty of Nuclear Sciences and Physical Engineering at the Czech Technical University in Prague has completed experiments on the chemical and radiation stability of the specialized ion-exchange polymer materials developed at the CTU. In FY96/FY97, a project “Evaluation of Polyacrylonitrile (PAN) as a Binding Polymer for Absorbers Used to Treat Liquid Radioactive Wastes” was conducted at the Czech Technical University in Prague as a project supported by the Efficient Separations and Processing Crosscutting Program (ESP) of the U.S. Department of Energy’s EM-50. The main and most important result of this project is that polyacrylonitrile (PAN) is being shown to be a versatile polymer capable of forming porous composite absorbers with small particles of a large number of primary absorbers. The composite absorbers are proving to be capable of withstanding harsh acidic and alkaline conditions and significant radiation doses that may be encountered in the treatment of DOE liquid radioactive wastes.

In acidic solutions, the results of the study of the chemical stability of PAN in the form of macroporous beads (B-PAN) similar to the beads of composite absorbers revealed their excellent chemical stability for a period of one month of contact with 1M HNO 3 + 1M NaNO 3 . Chemical stability of AMP-PAN composite absorber (ammonium phosphomolybdate active component in PAN binder) was found to be as good as that of B-PAN beads. In highly alkaline solutions (concentration of NaOH 1 mole.L -1) and in the presence of NaNO 3 the stability of the tested type of polyacrylonitrile polymer was sufficient for applications of composite absorber not exceeding 10 days. The experimental results achieved proved that the hydrolysis of PAN is accelerated by the presence of sodium nitrate. The study of influence of concentration of sodium hydroxide on the

chemical stability of the binder revealed that in 0.1M NaOH + 1M NaNO 3 , PAN is stable for the tested period of 1 month. Because of the high sorption rate achievable with these absorbers, the stability found for most applications in the U.S. will be sufficient. Radiation stability of the PAN binder was found to be satisfactory up to radiation doses of 10 6 Gy (10 8 Rad) for all the media tested (distilled water, 1M HNO 3 + 1M NaNO 3 , 1M NaOH, and 1M NaOH + 1M NaNO 3).

In alkaline simulant solutions, clear positive influence of g-radiation on the stability of PAN in alkaline media could be seen. This effect, that was ascribed to PAN polymer cross-linking during irradiation, enables additional prolongation of the period of applicability of PAN-based composite absorbers. Further, improving the chemical stability of the binding polymer was suggested to be achievable by selecting another type of polymer from the broad family of polyacrylonitrile polymers. Results of the FY96 experiments are reported in "Evaluation of PAN-Based Inorganic-Organic Composite Absorbers for Chemical Separations Applications at DOE Sites" (Ferdinand Sebesta, Jan John, Alois Motl - June 1996).

These experimental results and potential application within the U.S. have resulted in a technology demonstration at INEL (FY97) using actual DOE waste that was co-directed by Dr. Sebesta (CTU) and Dr. Terry Todd (INEL). This demonstration involved the use of columns through which radioactive waters that were pumped to determine the effectiveness and selectivity of the PAN-based ion exchange materials using actual waste.

Containment Technology Research

A containment technology demonstration project, jointly sponsored as a public/private partnership project, was implemented at the National Groundwater Remediation Field Laboratory (GRFL) at Dover Air Force Base (Dover, Delaware) during FY97. This project is supporting the Subsurface Contaminants Focus Area within DOE-OST. This project will evaluate the effectiveness of high pressure, thin-walled diaphragm containment walls and "cofferdam" configured containment systems. Co-sponsors of this project include the DOE, EPA, DuPont Company and the USAF. This project will be conducted principally during FY 97. This is a two-phase project involving a test panel phase (Phase I) which will include emplacement of the panels, verification monitoring, coring of the walls to evaluate emplacement effectiveness and lab testing of the wall cores. Phase II activities ("cofferdam phase"), which began in September of 1997, involved the emplacement of a cofferdam box configuration to test the effectiveness of a thin-walled, diaphragm containment system based on the results of Phase I activities. Additional Phases of activities are planned for FY98 for this on-going project.

Bioremediation and Phytoremediation Technology Demonstrations in Poland

The ICEECER, in conjunction with the U.S. DOE and the Institute for Ecology of Industrial Areas (Polish acronym: IETU) located in Katowice, Poland are conducting two technology demonstration/validation projects. The first project involves the use of bioremediation at an active oil refinery site near to Katowice, Poland. The second project involves evaluation and demonstration of an advanced phytoremediation technology for removal of heavy metals fro surficial soils. The Katowice region is part of the "Sulfur Triangle" which includes portions of the Czech Republic, (former) east Germany and southern Poland. This area is endowed with significant deposits of coal and non-ferrous metals, and as a result of these minerals, this region also is a major industrialized area. After nearly 4 decades of intense industrial activity (e.g., mining, smelting, heavy manufacturing, power generation), the area has become heavily contaminated both from atmospheric deposition as well as the more typical forms of environmental contamination, involving a variety of chemicals and heavy metals. In addition to heavy manufacturing and power generation, significant amounts of lead, zinc, cadmium and other metal smelting is

performed in this region of Poland resulting in atmospheric deposition of metals in soils and surface water. The IETU has historically been a major source of technical input to the Polish government on environmental and energy related matters and recently was designated as one of the foremost environmental research institutions in Central and Eastern Europe (CEE).

Given its significant environmental problems, its long history of environmental research and the technical capability of its senior scientific staff, the IETU was chosen as a Central European "partner" for this project. A three-phase project is being completed during FY98 to demonstrate the DOE's expedited site characterization (Phase I) methodology, risk assessment procedures for determining a site remediation approach (Phase II), and bioremediation technologies for site clean-up in southern Poland (Phase III). The ICEECER provides overall management and coordination for this project. Phase I and Phase II were completed (during FY96 and FY97) and Phase III was initiated during FY97 and will be completed during FY98.

Phase III activities consist of the implementation of the enhanced bioremediation phase of the project. The bioremediation system consists of "biopiles" placed over a network of pipes which are connected to a vacuum/pumping apparatus. The pipe network is used both for leachate collection and for the introduction of air/steam to accelerate the bioremediation of contaminants at the site. There are both structural and microbial aspects of this project which are new improvements on existing technology, and which will be used at DOE sites in the United States. At least one and perhaps two patent opportunities will result from this project.

The second project conducted in Katowice, Poland involves the evaluation and demonstration of an innovative phytoremediation technology to remove heavy metals from surficial soils. Three different plant species are being evaluated in conjunction with Phytotech, Inc., a New Jersey based firm. Phytotech utilizes special and proprietary soil amendments that mobilize the metals from the soil and increase significantly the accumulation of the metals by plants over a relatively short period of time. The test site is a number of acres in size, is located near to metal smelting operations and has been divided into test plots that control for irrigation and the amount of soil amendments used. In conjunction with the phytoremediation evaluation and demonstration, two laser-based technologies are also being demonstrated for evaluating plant stress in the context of monitoring the effectiveness of the phytoremediation process. One technology (developed for DOE by Specialized Technology Laboratory, Inc.) utilizes a remote-sensing approach for evaluating plant stress. The second technology (developed jointly by Central European Advanced Technologies and the Technical University of Budapest) utilizes the fluorescing of chlorophyll as a measure of plant "health".

Conferences, Symposia and High-Level Meetings to Facilitate International Technical Exchange

The ICEECER has conducted numerous large international conferences and symposia both in the U.S. as well as in Europe. Examples of these activities include the First, Second and Third International Symposia and Exhibitions on Environmental Contamination in Central and Eastern Europe (i.e., Budapest '92, Budapest '94 and Warsaw '96, respectively), the International Symposium and Trade Fair on the Clean-up of Manufactured Gas Plants (Prague, September of 1995) and the 1997 International Containment Technology Conference and Exhibition (St. Petersburg, Florida, February 9-12, 1997). These large international events have been sponsored by the DOE, the EPA and other public and private organizations. Each of these week-long international events has included participation by approximately 500 international environmental experts who have participated in 20+ technical sessions per event, poster sessions, workshops and special topical sessions (e.g., health effects from exposures to environmental contaminants in

Central and Eastern Europe, identifying sources of financing for environmental projects in Central and Eastern Europe), exhibitions and trade shows.

In addition, annual high-level meetings are facilitated by the ICEECER involving the NATO/CCMS Program as it relates to contaminated land and groundwater. The Council of the North Atlantic Treaty Organization (NATO) established the Committee on the Challenges of Modern Society (CCMS) in 1969. The CCMS was charged with developing meaningful environmental and social programs which complement other international programs with leadership in solving specific problems of the human environment within the NATO sphere of influence; as well as transferring solutions to other countries with similar challenges in environmental protection.

Over the past thirteen years, this issue, the treatment of contaminated land and groundwater, has been addressed by three NATO/CCMS Pilot Studies. This third Pilot Study, initiated in 1992, focuses on evaluation of demonstrated and emerging technologies for the treatment of contaminated land and groundwater (both chemical and radioactive contaminants as well as mixed waste). Through these Pilot Studies, critical technical information has been made available to participating and other countries. The EPA and the DOE have been active participants in this NATO Pilot Study entitled, “Evaluation of Demonstrated and Emerging Technologies for the Treatment of Contaminated Land and Groundwater”. All of the NATO countries and many non-NATO participating countries participate in the Pilot Study activities which serve to effectively disseminate information on technologies in-use worldwide related to contaminated land and groundwater.

Because of the relevance of this NATO activity to the mission of the ICEECER, this Pilot Study has been planned and organized by Florida State University as an adjunct activity to its funded activities at the ICEECER. Florida State University has assisted with the organization of these international meetings for the last five years and will continue to do so throughout the year 2002. This Pilot Study is particularly important to the activities of the ICEECER as it provides ready access to a network of high-ranking agency officials (and associated support contractors) throughout most of Europe and many other parts of the world. Many of the Pilot Study members participate in the other non-NATO related activities of the ICEECER and are also very effective in disseminating information about the work of the institute within their respective countries.

RESULTS AND BENEFITS

The purpose of this paper is to demonstrate, through the use of examples, the effectiveness of international environmental technology development and demonstration through international university and research institution-based initiatives. The ICEECER provides an effective conduit for accessing technical environmental expertise in a region of the world heretofore almost inaccessible prior to the end of the Cold War. During the last five years the ICEECER has moved quickly, using a variety of activities to facilitate the establishment of technical relationships and commercial linkages between western countries and the countries of Central and Eastern Europe. Through direct research and development programs in Hungary, Poland, Czech Republic and Russia, the ICEECER has been able to provide multi-lateral benefits to U.S. funding agencies, research institutions in Central and Eastern Europe and other interests worldwide. The ICEECER at Florida State University intends to build upon these opportunities through expanded research programs and through the implementation of broad-based activities which address environmental problems in Central and Eastern Europe - problems which are also common to the rest of the developed world.

The opportunities in this region of the world for environmental technology development and demonstration are significant. Research scientists from this region of the world are highly training and skillful individuals having technical, laboratory skills on a

parity with the rest of the world. In addition, many scientists in the region have had relatively more extensive experience with specific problems as compared to U.S. scientists. The cost of highly-skilled labor for conducting research projects in Central and Eastern Europe is typically much less (i.e., as little as 25% of the cost for equivalent services in the U.S.) than if the same projects were conducted in the United States or Western Europe and, for this reason, the incentive to utilize scientists from Central or Eastern European countries as well as from Russia can be significant, especially in the areas where these scientists have a relative advantage, scientifically.

Certain industrial areas of Central and Easter Europe have extreme forms of environmental degradation (e.g., the "black triangle" area of southern Poland, northern Czech Republic and former east Germany) have very severe environmental problems. These problems exist because of the abundance of high-sulfur brown coal and associated concentration of industry over the last 40-50 years and, finally, the near absence of environmental protection during Soviet occupation. This region of Central and Eastern Europe, for example, represents an unusual setting that does not generally exist in the United States or Western Europe with regard to human exposure to contaminants, soil and groundwater concentrations of certain environmental contaminants, and a willingness to have environmental technologies demonstrated at sites with these extreme environmental conditions.

CONCLUSIONS

Based on the experiences gained over the last five years with the activities of the ICEECER, it is concluded that significant multi-lateral benefits can be obtained by the U.S. DOE and participating universities and research institutions in Central and Eastern Europe and Russia related to environmental needs. These benefits result in the form of access to advanced scientific knowledge related to certain environmental problems, lower costs for conducting critical research, technology and expertise exchange (both direct and indirect through the rapid transfer of technology throughout the region), and access to unique environmental conditions in order to rapidly demonstrate/validate technologies for shared environmental problems. Beyond the relative cost advantages associated with conducting environmental research, technology development and demonstration in the Central and Eastern European region using highly skilled scientists, there is also the benefit of accessing unique scientific skills and information for certain targeted projects as well as accessing technology demonstration sites to rapidly evaluate new environmental technologies. These initial investigations (e.g., involving the enhanced bioremediation and phytoremediation technologies) rapidly provide important data to the U.S. DOE for application at sites within the DOE complex. This rapid acquisition of data and experience translates into technology availability for specific DOE problem units in a relatively short period of time.

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