CONF-9510108--29

DOE/MC/31388-96/C0624

Environmental Management Technology Demonstration and Commercialization

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Energy and Environmental Research Center
15 North 23rd Street
Grand Forks, North Dakota 58203

Contract Number:

DE-FC21-94MC31388

Conference Title:

Environmental Technology Development Through Industry Partnership

Conference Location:

Morgantown, West Virginia

Conference Dates:

October 3-5, 1995

Conference Sponsor:

U.S. Department of Energy, Office of Environmental Management, Morgantown Energy Technology Center

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Introduction

The Energy & Environmental Research Center (EERC), a contract-supported organization focused on technology research, development, demonstration, and commercialization (RDD&C), is entering its second year of a Cooperative Agreement with the U.S. Department of Energy (DOE) Morgantown Energy Technology Center (METC) to facilitate the development, demonstration, and commercialization of innovative environmental management (EM) technologies in support of the activities of DOE's Office of Environmental Science and Technology (EM-50) under DOE's EM Program. This paper reviews the concept and approach of the program under the METC–EERC EM Cooperative Agreement and profiles the role the program is playing in the commercialization of five EM technologies.

Research sponsored by the U.S. Dept. Of Energy's Morgantown Energy Technology Center under Contract DE-FC21-94MC31388 with Energy & Environmental Research Center; 15 North 23rd Street; Grand Forks, ND 58203; telephone (701) 777-5000; fax (701) 777-5181.

Program Concept and Approach

Key components of commercialization activities in the EM program include knowledge of the marketplace, technical expertise, and the ability to forge partnerships with industry and government. In some cases, particularly for the small business technologist, commercialization prospects are hampered by limited technical expertise, testing and demonstration capabilities, capital and, specific to the EM program, knowledge of DOE and EM site needs. Alternatively, commercialization may hinge on the successful resolution of technical barriers. The program under the METC–EERC EM Cooperative Agreement is designed to facilitate the delivery of promising technologies to the marketplace through a dynamic process involving focused technical assistance, partnership brokering, and real-world demonstrations. With respect to resolving technical barriers, the EERC brings a wide range of technical expertise and state-of-the-art facilities for investigating chemical and physical processes. EERC facilities are capable of tests and demonstrations from laboratory to pilot scale and are suitable to conduct tests representing a wide range of physical conditions.

With respect to resolving investment and application barriers, the EERC acts as a broker between government and private sector interests in technology development and commercialization. Based on its long experience with government entities, including DOE, the Department of Defense, and the Environmental Protection Agency, the EERC is able to provide guidance in promoting contacts and fostering partnerships with appropriate government agencies and personnel. Alternatively, the EERC's experience in the private sector provides the basis for contacts and partnerships in that venue.

Because of legal and other regulatory constraints, gaining access to field test sites has become a formidable obstacle to the demonstration of promising EM technologies. The EERC's growing family of industrial partners provides the potential for access to a wide variety of technology demonstration sites. For example, the EERC has access to a remediation demonstration site in Alberta, Canada, through a relationship with the Canadian Association of Petroleum Producers, Gulf Canada, and the DOE Jointly Sponsored Research Program.

As a contract RDD&C facility, the EERC has a number of advanced analytical, monitoring, treatment, and processing methods in development, often in conjunction with private sector partners. The METC–EERC EM Cooperative Agreement provides an avenue to evaluate these technologies for EM applications and to work to bring deserving technologies into the EM marketplace.

Technology Commercialization Activities

FY1996 activities are focused on advancing five technologies to the commercialization stage. These technologies cover the gamut of EM Focus Areas and include private sector technologies, technologies already in place at DOE sites, and those under development in-house at the EERC. Most of the technologies are being developed with a commercial partner. FY1996 activities are focused on technical enhancements, the resolution of technical barriers, and field demonstration of prototypes.

Extraction and Analysis of Pollutant Organics from Contaminated Solids Using Off-Line Supercritical Fluid Extraction (SFE) and On-Line SFE/Infrared (IR) Spectroscopy

One of the remediation industry's greatest challenges is obtaining cost-effective, accurate, and precise analyses for organic contaminants. An inexpensive (<$20,000), simple-to-operate field instrument, consisting of SFE coupled with IR, intended for the extraction and analysis of organics at ppm to ppb detection levels is being developed in-house at the EERC. The method, based on SFE with CO_2, is highly accurate, rapid (<30 minutes), and nonpolluting. The unit has applications in several focus areas for characterization and sensing and is expected to be particularly useful as a screening tool.

Field trials using SFE for PAH (polycyclic aromatic hydrocarbon)- and PCB (polychlorinated biphenyl)-contaminated soils showed 1) complete extraction of PAHs and PCBs from field samples in 30 minutes (versus 14 to 18 hours with conventional extraction procedures), 2) SFE instruments performed well on a field generator unit, 3) total solvent use for field SFE was ca. 5 mL per sample, and 4) soil extractions were immediately ready for analysis without further cleanup or concentration.

On-line SFE has been coupled with Fourier transform IR (FT-IR) detection based on a fiber optic interface in a prototype unit. Results of field tests indicate 1) SFE/FT-IR gives good quantitative results for petroleum-contaminated soil in 20 minutes with no organic solvent (compared to a 4-hour lab extraction with 150 mL of Freon-113),
2) detection limits were in the ppm to ppb range for organics in soils, and 3) the interface is easily adaptable to most FT-IR and IR instruments.

An agreement has been reached with Suprex Corporation of Pittsburgh, a major SFE instrument company, to commercialize the fiber optic interface. Activities in the future will focus on the optimization of the interface to meet the conditions of sustained field use and field testing.

Thermal Decomposition of High-Organic-Content Radioactive Wastes

The diverse nature of mixed waste plastics has thwarted application of conventional methods for their reprocessing to yield recyclable chemical feedstocks or safely disposable materials. Because of their unique chemistry, polyethylene terephthalate (PET) and polyvinyl chloride (PVC) pose particular reprocessing challenges. A low-temperature process for thermal decomposition of mixed waste plastics, automotive shredder wastes, and chemical spill residuals has been developed by the EERC in partnership with the American Plastics Council, DOE, and other U.S. companies. This process, which utilizes fluidized-bed technology, will form the basis of a commercially viable recycling process able to accommodate a wide variety of plastics and other high organic-content materials from laboratory and production facilities that handle low-level nuclear materials.

Activities have consisted of pilot-scale testing using a variety of feedstocks and bed materials at temperatures between 480° and 600°C in the EERC 2-kg/hr continuous fluidized-bed reactor (CFBR). Feedstocks used in the tests consisted of postconsumer plastic wastes mixed with radionuclide surrogates selected to represent the following radioactive species: thorium, uranium, plutonium, neptunium, americium, cesium, strontium, ruthenium, rhenium, and iodine.

Results from the pilot-scale tests indicate that the EERC thermal decomposition process can 1) be successfully applied to a wide variety of plastics, including PET and PVC, 2) yield a condensate product with a chlorine content of less than 100 parts per million (ppm) from a feedstock mixture containing up to 10% PVC, 3) concentrate radionuclide surrogates in a dry, particulate solids product, and 4) yield a condensate product with radionuclide surrogate concentrations of less than 5 ppm (the analytical detection limit used in these tests) from a feedstock mixture containing surrogate concentrations of about 3000 ppm.

The EERC has entered into discussions with Los Alamos National Laboratory (LANL) for the performance of bench-scale process evaluation tests with actual radioactive wastes. Under the currently proposed program, LANL will validate EERC surrogate test findings in tests with mixed waste plastics spiked with known quantities of radionuclides and then perform process demonstration tests with actual radioactive waste. Following the LANL tests, pilot-scale surrogate tests at feed rates of up to 100 lb/hr will be performed at the EERC to provide scaleup data. For these tests, analytical detection limits will be lowered to below 100 parts per billion to provide a more definitive indication of process performance.

Fluid-Bed Calcination for Liquid Wastes

The EERC's extensive background and facilities for evaluating fuel properties in FBCs are being applied to bed-sintering problems experienced in the fluid-bed processing of EM liquid wastes at Idaho National Engineering Laboratory (INEL). INEL currently has large volumes (6900 m^3) of liquid wastes, mainly radioactive wastes from tanks, that cannot be processed in INEL's existing calciner because of bed sintering caused by sodium nitrates. The EERC will perform tests using its existing facilities to evaluate denitrification strategies for the Lockheed Martin Idaho Technologies Company (LMITCO) New Waste Calciner Facility. Optimizing the existing facilities at INEL will result in a substantial cost savings in waste processing. This technology would then find application at other sites under the EM tank waste focus area.

The EERC's effort is focused on constituent capture and immobilization and the development of data to determine optimum FBC capabilities to process wastes at INEL other EM sites. Specifically, the EERC will use surrogates to evaluate denitrification using sugar as a reducing agent and silica as a stabilizing agent to produce groutable or vitrifiable materials for disposal. Sodium- bearing liquid waste will be tested alone and in combination with material representing INEL's previously calcined waste to enhance its stability.

Based on the success in tests using surrogates at the EERC, INEL will demonstrate the process in its 12-inch calciner and grouting and vitrification facilities as appropriate.

Centrifugal Membrane Filtration

Large volumes of groundwater contaminated with heavy metals and radionuclides exist at DOE and Department of Defense sites. Conventional actions include the construction of in situ barriers or the use of ex situ treatment technologies such as chemical reduction followed by precipitation and ion exchange. In situ barriers contain the contamination but do not alter its character, and ex situ chemical and ion exchange require the use of hazardous chemicals and may result in secondary waste streams. SpinTek Systems, LP, has developed a uniquely configured centrifugal membrane filtration process to produce a clean, filtered water stream and a low-volume concentrate stream. The process can be applied to contaminated groundwater or to aqueous process or waste streams. Based on previous demonstrations of the SpinTek process, the unit has excellent potential for EM site applications, particularly under the contaminant plume focus area.

The centrifugal membrane filtration unit uses ultrafiltration techniques at pressures of up to 100 psig, in combination with centrifugal force, to remove suspended and dissolved solids to as low as 200 molecular weight. The main components of the unit include membrane filtration disks mounted on a hollow shaft and housed in a stationary pressure vessel. Feed water is introduced into the pressure vessel and flows across the membrane disks that are rotated at high speed.

In order to optimize the application of the technology to EM cleanup needs, the EERC is undertaking six tasks in support of the SpinTek commercialization effort: 1) a literature review; 2) a preliminary verification of process capability; 3) membrane optimization; 4) a process performance evaluation on EM surrogate waste; 5) extended testing on membrane cleaning cycle, scaling, fouling, and corrosion; and 6) preparation of a final assessment report. Testing and evaluation of a small pilot filtration unit is under way.

Laser Cleaning of Contaminated Painted Surfaces

Decontamination through the efficient removal of radionuclide-contaminated paint would greatly facilitate the economical decommissioning of structures and equipment at DOE weapons complex facilities. Conventional technologies, including sandblasting, create a secondary waste stream and erode substrates. Innovative surface abrasion technologies, including the use of CO_2 ice pellets, solve the issue of secondary waste generation but do not reduce the volume of primary waste.

A surface-cleaning technology developed by F2 Associates uses a CO_2 pulse laser with a 2.5-cm^2 area, in combination with robotics, resulting in a remote system that 1) removes contaminated paint from surfaces, 2) does not release hazardous constituents into the atmosphere, 3) reduces primary waste volume, 4) produces no secondary waste stream, and 5) does not erode substrates. The technology is scheduled for demonstration by year-end 1996.

EERC activities, focused on optimizing the technology and developing application parameters, include 1) incorporation of on-line analytical technologies, 2) design for enhanced decontamination, and 3) cost analysis. The incorporation of the on-line analytical capabilities will require researching small real-time radiation detectors and miniature spectrometers that will be used to characterize the emissions from the paint removal on-line instead of sampling after collection. The spectrometer would analyze for lead, chromium, and certain other heavy metals. To aid in defining the applications of these technologies, theoretical calculations will be performed, and existing experimental data related to the volatility and particle-size distribution of hazardous materials from related processes will be reviewed. Finally, a cost analysis algorithm, for use in developing economic profiles to allow a comparison of technology and process options, will be developed to factor in all of the aspects of paint removal under EM conditions, including surface characterization (before and after), cleaning costs, the cost of characterization of waste (if not done on-line), waste disposal costs, and salvage credits.

Summary

The METC–EERC EM Cooperative Agreement is a unique program involving a dynamic approach to bringing technologies into the marketplace. This "hands-on" approach features focused technical support, partnership brokering, and field demonstrations. The EERC provides a platform for the success of this program through its technical expertise, facilities, government and commercial partnerships, and access to field demonstration sites. The EERC, therefore, serves as an effective bridge between government and industry by becoming an active partner in the commercialization process. The search for additional candidate technologies and commercial partners is ongoing.

Acknowledgments

We wish to acknowledge Venkat Venkataraman, our METC Contracting Officer's Representative, and Madhav Ghate, Director of METC's Technology Base Projects Management Division.