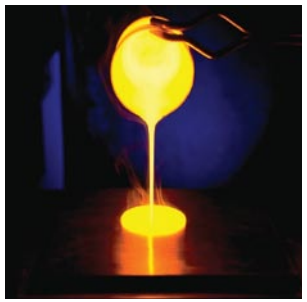
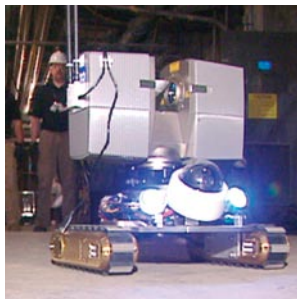
A Year of Successful Investments

Office of Engineering and Technology 2008 Annual Report




U.S. DEPARTMENT OF
ENERGY

OFFICE OF
ENVIRONMENTAL MANAGEMENT

Office of Engineering and Technology

The U.S. Department of Energy's (DOE) Office of Environmental Management (EM) was established in 1989 to achieve the safe and compliant disposition of legacy wastes and facilities from a variety of U.S. defense nuclear sites that performed nuclear energy research, uranium enrichment, isotope production, weapons production, and nuclear fuel processing. The sheer volume and types of wastes, as well as affected groundwater, soil, and facilities, make this one of the world's most complex environmental challenges. Over the last 20 years, new technologies and approaches had to be developed or reengineered before being successfully applied to meet EM's needs. To address this continuing need, EM established the Office of Engineering and Technology (OET) to identify vulnerabilities and reduce technical risks and uncertainties for EM projects.

The OET mission is to improve the performance of environmental cleanup projects over their entire lifecycle, through targeted investments that identify, advance, develop, and implement the best engineering concepts, technologies, and practices. A cadre of subject matter experts is utilized to

- Reduce planning, design, construction, and maintenance and operation costs;
- Provide innovative transition to state-of-the-art, beneficial research and technology development and deployment;
- Promote lessons learned across DOE sites; and
- Improve safety while enhancing operational efficiencies.

Message from the Director

Being affiliated with the EM Office of Engineering and Technology brings a special kind of satisfaction. At the end of the year, the accomplishments are tangible. You can see real improvements in DOE's work as a result of our efforts: how much less radiation exposure workers received, how many dollars were saved, how much faster projects were completed.

2008 is notable, not just for those measurable enhancements - of which there were plenty - but also for the groundwork that we established for continuing to support DOE's projects into the future. In March 2008, we published our Engineering and Technology Roadmap to guide our applied research and technology development/deployment efforts. This Roadmap identifies technology gaps and lays out a strategy for addressing them in a way that minimizes the risks and uncertainties that could stand between us and success.

From the Roadmap came specific Five-Year Plans for each of our program areas: waste processing, groundwater and soil, and deactivation and decommissioning/facility engineering. Together, these tools enable us to systematically address DOE's current and future environmental management needs.

Several key themes listed below illustrate how this office helps DOE sites across the country to achieve the kind of results that the American public expects for its investment.

- We are reducing technical risks and uncertainties
- We are establishing "best practices" to share at DOE sites
- We are collaborating with other technical experts across the globe
- We are improving safety and efficiency
- We are exchanging technical information and lessons learned
- We are bridging the gap between science and application
- We are saving money and accelerating schedule
- We are building a sustainable future.

I am pleased to present you this annual report, which demonstrates how our work is reflected in these key themes through brief examples from the past year. These few examples represent only a small portion of our 2008 successes. However, with these examples, I believe you will see why we are proud of the way that engineering and technology solutions are being used to address some of our most significant challenges - radionuclides in the groundwater, legacy radioactive waste, and removal of contaminated facilities. For more information on our 2008 successes, please visit our web page (www.em.doe.gov/EM20Pages/EM20HomePage.aspx), especially noting the issues of our quarterly newsletter (Highlights), as well as specific technical documents prepared during 2008.

The need for continued progress in DOE's cleanup program as greater challenges are faced means an increasing need for engineering and technology solutions to address them. There is much to be done, but the foundation of 2008 and previous years shows how we make progress meeting those needs, and our roadmap for the future points us in the right direction to keep us moving forward.

Mark Gilbertson
Deputy Assistant Secretary
Office of Engineering and Technology
Office of Environmental Management

Building upon Past Successes

DOE's EM cleanup program is the largest in the world, currently involving approximately two million acres in 14 states. A majority of the wastes and facilities to be cleaned up are unique to DOE, while some involve the same challenges that other industries are struggling to address. Many of the projects to treat these wastes have been "first-of-a-kind"; they are unprecedented in scope and complexity. The contaminated materials - including liquids, sludge, solids, facilities, and equipment - contain plutonium, uranium, and other radioactive elements, as well as hazardous chemicals.

Within DOE's sites, there are:

- **13 metric tons of plutonium**
- **108 metric tons of plutonium and uranium residues**
- **88 million gallons of radioactive liquid waste containing nearly 10 million curies of radioactivity**
- **2,400 metric tons heavy metal of spent nuclear fuel**
- **158,000 cubic meters of transuranic waste**
- **1.4 million cubic meters of low-level waste and mixed low-level waste**
- **450 nuclear facilities, 3,600 industrial facilities, and 900 radiological facilities**
- **10,000 areas needing groundwater and/or soil remediation.**

Although great progress has been made over the last 20 years, the time required to complete these cleanup activities continues to be measured in decades. Approximately $70 billion has been spent to date cleaning up this Cold War legacy. Cost estimates place the final cost at more than $200 billion. The remaining challenges require unique approaches utilizing new technologies and approaches developed by an effective combination of basic science and applied research and engineering. In 2008, OET continued to address these challenges by building upon successes of the past 20 years.

In recent years, EM has made great progress toward safely disposing of the Cold War legacies by completing remediation of more than 80% of their sites. One example of successful DOE site cleanup and closure is the Fernald Closure Project near Cincinnati, Ohio, completed in 2006. DOE and Fluor Fernald completed the project 13 years ahead of schedule, at a cost approximately $4.4 billion less than original projections. With the expertise and support of OET, the largest, most challenging project at Fernald, the Silos Project, was successfully completed on schedule. System designs based upon OET laboratory, pilot- and full-scale testing of waste retrieval, treatment, and process monitoring

DOE's inventory of high-level waste could fill the Louisiana Superdome.

technologies resulted in removal of 10,000 tons of uranium mill tailings waste from the Silos and processing into a stable grout-based material for off-site disposal. The Fernald site is now a nature preserve with a visitor center.

Another example of our progress involves the Rocky Flats Closure Project in Colorado, where DOE and Kaiser-Hill successfully partnered in a 10-year effort to complete the largest, most complex environmental cleanup project at that time in U.S. history. With the help of OET, the project was completed nearly 50 years sooner and $30 billion below initial estimates. OET provided innovative solutions to the Rocky Flats team for a critical issue, deactivation and decommissioning (D&D) of approximately 1,000 gloveboxes and tanks contaminated with radioactivity. The innovations resulted in significantly less exposure to airborne radioactivity and other industrial hazards as workers packaged the gloveboxes and tanks for shipment off site. These innovations were key to enabling the schedule and cost reductions. The majority of the 6,200-acre site in Colorado was transferred to the Interior Department to become a national wildlife refuge in 2007.

While these and other past accomplishments provide a guide for future success, the unique nature of many of the remaining challenges will require continuation of a strong and responsive applied research and engineering program. OET, which is entering its 20th year in 2009, looks forward to continuing its tradition of support to advance the success of DOE's crucial cleanup activities.

OET's innovative technologies helped Rocky Flats close 50 years ahead of schedule with $30 billion saved. In 2007, it became a national wildlife refuge.

We are Reducing Technical Risks and Uncertainties

OET is reducing technical risk and uncertainty for all types of EM projects, including waste management, groundwater and soil cleanup, and deactivation and decommissioning of facilities. One of OET's highly successful initiatives addresses uncertainties involving the use of natural processes for cleaning up contaminated groundwater.

Technical Risks: **Known technical issues that could prevent the success of a cleanup project**

Uncertainties: **Indefinite or unpredictable technical aspects of a project**

At many DOE sites, the volumes of contaminated groundwater associated with a waste disposal site or spill are very large. Remediation of this contaminated groundwater is under way, but many uncertainties related to meeting final cleanup goals remain. Because of the variability in the geology and the distribution of contaminants, each site requires multiple approaches to groundwater cleanup. In areas near the source of the contamination, active and aggressive treatments have been conducted or are planned. In locations farther from the original contaminant source, where concentrations of contaminants are lower, natural processes, requiring little human involvement and minimal energy, may be highly effective. What has been missing, however, is adequate understanding of how to know when these natural processes will be effective.

Savannah River National Laboratory scientists and engineers are working with OET, in partnership with experts from other national laboratories, universities and industry, to study nature's ability to clean solvents from the groundwater.

Through 14 innovative research projects, we:

- developed new tools to measure the progress of natural attenuation;
- prepared guidance on how to demonstrate whether natural attenuation is effective at a particular site or whether it can be enhanced; and
- collaborated with the Interstate Technology and Regulatory Council, a coalition of regulators from 50 states whose charter involves advancing the application of innovative technologies and approaches to produce a guidance document and subsequent training programs. DOE's support has resulted in broad dissemination of "best practices" information across the United States.

The results of this multiyear program are expected to accelerate cleanup by a minimum of 10 years for DOE sites with solvent-contaminated groundwater.

National laboratory scientists injected edible oil into the subsurface at the Savannah River Site to naturally treat solvent-contaminated groundwater.

Natural attenuation processes include a variety of physical, chemical, and biological processes that act, without human intervention, to reduce the mobility, concentration, or toxicity of contaminants in the groundwater.

Enhanced attenuation involves human intervention to assist a site to reach a state where natural attenuation can complete the cleanup.

Savannah River National Laboratory is now working with OET to extend this scientific understanding of natural attenuation to metals and radionuclides in groundwater. Metals and radionuclides are different from organic solvents; while they cannot be destroyed, they can be geochemically changed to reduce mobility and reactivity. This project's goal is to improve understanding of natural attenuation for metals and radionuclides by better predicting how geochemical conditions change over time and location and what influences these changes.

The project team is developing a guidance document that builds upon recent Environmental Protection Agency natural attenuation guidance for metals and radionuclides to help DOE project managers implement natural attenuation at their sites.

These projects are helping predict long-term effectiveness of attenuation-based strategies for groundwater cleanup, while also reducing costs and increasing the efficiency of site closure.

National laboratory scientists prepare soil samples to study how well the subsurface can naturally attenuate contaminated groundwater.

We are Establishing "Best Practices" to Share across DOE Sites

One way of meeting OET's goal of reducing risks and uncertainties in the EM cleanup program is the development and promotion of "best practices." Following are some examples of OET "best practices" implemented in 2008. For more information, visit www.em.doe.gov/EM20Pages/EM20ReferencePage.aspx#independent.

Technology Readiness Assessments, based upon a model successfully implemented at the Department of Defense, provide a snapshot in time of the maturity of a technology considered for a cleanup project. The results assist EM in decision-making, and, if the technology is not ready for implementation, also help with planning of further technology development. During 2008, Technology Readiness Assessments were conducted for the Hanford K Basins Sludge Treatment Project and the Oak Ridge ^{233}Uranium Downblending and Disposition Project. By ensuring that technologies in these sophisticated treatment systems were at the appropriate level of maturity, final designs were optimized, reducing risks associated with construction and operation.

External Technical Reviews provide independent assessments of project risks and uncertainties by convening subject-matter experts from EM, the national laboratories, academia, and industry. These reviews produce recommended strategies for reducing identified risks and provide information that supports critical project decisions. During 2008, External Technical Reviews were conducted for the following projects:

- Oak Ridge Y-12 Mercury Contamination;
- Hanford Columbia River Projects;
- Supplemental Treatment of Low Activity Waste at Hanford;
- Integrated Facility Disposition Project at Oak Ridge; and,
- Landfills at Idaho, Oak Ridge, Portsmouth, Nevada, Savannah River, and Paducah sites.

The six landfill reviews enabled exchange of technical information from site to site, so that lessons learned could be shared, while also considering unique aspects of each of the sites.

Technical Risk Ratings provide a structured methodology to evaluate technology maturity, risk urgency, handling difficulty, and resolution path using a stoplight-themed visual graphic to enhance communication between Federal Project Directors and EM management. These ratings incorporate existing

An External Technical Review at Oak Ridge recommended innovative methods to reduce mercury contamination in fish in East Fork Poplar Creek; one approach reduced mercury in the creek by 37.5%.

information from a variety of sources and promote excellence in risk management, ensuring that technical risk impacts are fully understood and effectively managed. During 2008, Technical Risk Ratings were developed for all EM projects.

OET "best practices" for D&D of facilities are disseminated by the Hanford ALARA (As Low As Reasonably Achievable) Center so that the work can be accomplished more efficiently with lower worker exposure to radiation. "Best practices" information is disseminated on the ALARA web site, by the ALARA real-time D&D Hotline, via emails, and training classes. For more information , visit www.hanford.gov/rl/?page=973&parent=0.

In February 2008, the Office of Deactivation & Decommissioning/Facility Engineering sponsored an External Technical Review for the Experimental Breeder Reactor-II (EBR-II) at Idaho National Laboratory to address the Idaho Department of Environmental Quality permit requirements for removal of all regulated materials by 2022. Seven technical experts in sodium-cooled reactor cleanup and decommissioning from the United States and the United Kingdom. were convened to:

- review past sodium removal efforts and current closure plans for the reactor;
- evaluate alternative cleanup methods and recommend a best path forward.

After evaluation of six alternative methods, the experts recommended an approach that leaves all major components in place, but breaches a number of locations to allow circulation of steam and wash water throughout. Compared to the original plan, this alternative reduced 1) the volume of waste to be generated (more than 30,000 gallons), 2) personnel radiation exposure, 3) schedule (by two years), and 4) cost (saving more than $7 million).

OET's Office of Waste Processing sponsored a high-level waste slurry handling workshop in 2008. Approximately 70 experts from DOE's national laboratories, academia, and commercial slurry processing companies shared new information and lessons learned on waste retrieval, transport, mixing, and processing of these complex mixtures. Three sets of "best practices" guidelines were developed,

The Hanford ALARA (As Low As Reasonably Achievable) Center provides training to D&D workers in proper use of TriTool clamshell cutters to improve cutting effectiveness and increase equipment life.

We are Collaborating with Technical Experts across the Globe

OET is collaborating with the best technical experts from around the world to solve EM problems by reducing risk and accelerating cleanup with new technologies and methodologies. These collaborations span the globe from Russia and the Ukraine to South Korea and the United Kingdom. In 2008, DOE continued:

- working with scientists in the United Kingdom to evaluate and transfer successful technologies and methodologies into the U.S. DOE cleanup program;
- working with Russian and Ukrainian scientists and engineers to conduct research and technology development that address DOE cleanup challenges.

Collaborative projects in 2008 focused on the following projects:

- Application of the Cold Crucible Induction-heated Melter (CCIM) to DOE high-level radioactive wastes;
- CCIM demonstration with simulated Savannah River Site waste;
- Improved solubility and retention of troublesome components in Savannah River Site and Hanford waste glasses;
- Long-term impacts from radiation contamination within the Chernobyl Exclusion Zone; and,
- Sampling and retrieval of tank waste using power fluidics.

Two of the projects are advancing a new melter technology, the CCIM, which produces glass from high-level waste for long-term storage. The main benefit of this new melter is that its glass can accept a higher waste load (60% waste) when compared to the waste loaded at the Savannah River Site vitrification facility, the Defense Waste Processing Facility, which produces glass containing 39% waste. The CCIM also has the potential to operate with a higher waste throughput, a higher melt rate, and a longer service life. If implemented at the Savannah River Site, the CCIM could reduce the

- number of high-level waste canisters produced;
- cost of production, storage, and disposal of waste by billions of dollars; and
- schedule for project completion.

An engineering assessment of the CCIM is under way to determine the feasibility of retrofitting the CCIM into the Defense Waste Processing Facility. In addition, the CCIM is being tested for various waste feed compositions and conditions to demonstrate its long-term performance.

OET and national laboratory staff collaborate with world-renowned experts through joint projects and by attending conferences and site visits to share new approaches and lessons learned for treating high-level waste.

The United Kingdom projects rely heavily on NuVision Engineering's extensive experience with power fluidics technology to solve challenging new problems with tank waste retrieval, mixing, and sampling. More than 400 power fluidic pump, mixing, and sampling systems have been successfully used in nuclear installations in Europe. The devices have no moving parts in contact with the contaminated medium and thus require no maintenance on contaminated equipment. Because the DOE and the United Kingdom have collaborated to solve unique DOE problems for several years, many solutions have already been developed using this innovative technology and new problems are currently being investigated.

Another way of collaborating involves exchange of information on technical advances at international conferences. In 2008, OET shared information on processing high-level radioactive waste through papers, presentations and discussions at such meetings as the:

- International Symposium on Radiation Safety Management, Daejeon, South Korea;
- AtomEco-2007, Moscow, Russia;
- Waste Management '08, Phoenix, Arizona, United States;
- American Ceramic Society Glass and Optical Materials Division Meeting, Tucson, Arizona, United States;
- American Chemical Society Annual Meeting, Philadelphia, Pennsylvania, United States; and,
- Materials Science and Technology Annual Conference, Pittsburgh, Pennsylvania, United States.

These and other international collaborations have resulted in significant benefits to the EM cleanup program, and potential exists for even greater impacts in the years to come.

OET collaborations are advancing technologies for turning high-level waste into a stable glass form. One example is the Cold Crucible Induction Melter (CCIM) being considered as an alternative that may significantly reduce the cleanup schedule at Hanford and Savannah River Site.

We are Improving Safety and Efficiency

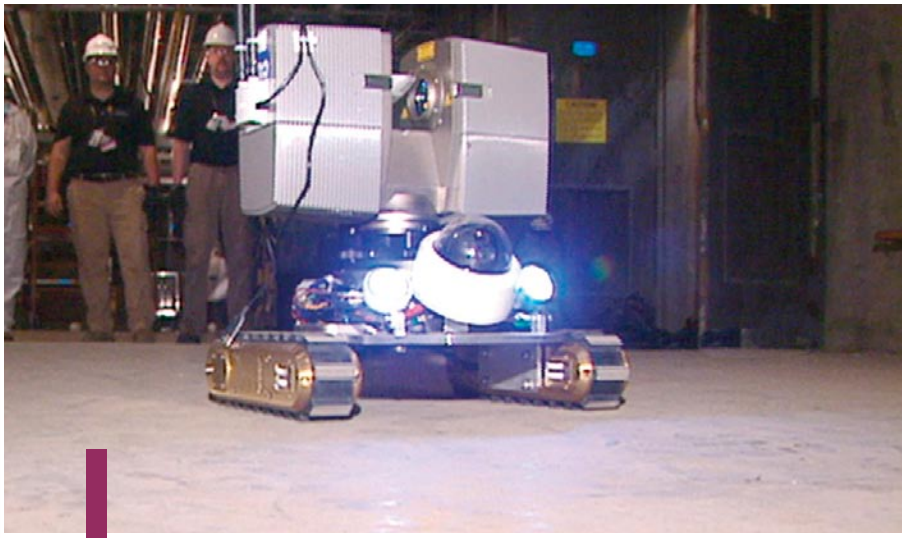
OET is improving safety and efficiency in the EM cleanup program through development of improved technologies and approaches. EM is fully committed to doing work safely for all of its projects. As problems arise when EM begins planning for new activities that have never before been accomplished, they reach out to OET to bring solutions that meet or exceed EM safety standards. New technologies and approaches often go much farther than simply meeting EM's safety standards. OET's contribution often introduces a new technology or approach that enables work to be conducted more efficiently or effectively.

EM's safety record meets or exceeds the records of the best industrial firms in the U.S. EM continually strives to:

- **improve this safety record, looking for new ways to raise individual awareness of the importance of safety, knowledge, and competence through training;**
- **motivate through leadership and sustained, demonstrated interest in safety performance; and**
- **improve independent assessment and self assessment of safety issues.**

One recent example of OET's contribution to improving safety and efficiency comes through development of innovative robotic tools to support D&D of facilities and equipment. OET has supported development and application of these types of tools for more than 15 years as part of its D&D Program. In 2008, the Robotic High-Resolution Laser Imaging System was successfully deployed at the Savannah River Site P Reactor Closure Project for safe and efficient facility characterization.

D&D projects typically require significant planning based upon characterization of complex facilities to reduce potential personnel hazards, while enabling efficient operation of D&D equipment. Planners must know the condition of the facilities, i.e., structural integrity, radiological or chemical hazards, to allow job sequencing, hazard mitigation, and estimation of waste types and volumes.



A simple robotic platform was integrated with an innovative laser-imaging surveying system to remotely map piping and equipment in the purification room of the Savannah River Site P Reactor to support planning for D&D. This innovative approach was far more efficient and significantly reduced worker exposure to radiation.

Much of the data needed for D&D project planning can often be collected using robotically deployed configurations of available sensor systems. However, these unique configurations often require some ingenuity and testing.

OET matched a simple robotic platform with a commercially available laser-imaging system to generate as-built configurations of complex piping and equipment in the purification room of the P Reactor at the Savannah River Site. The robotic laser surveying system surveyed the entire room during a 5-hour period to obtain optimal line-of-sight images to produce a high-resolution representation of the room and all of its features.

This technology allowed detailed characterization of visible structural components in the facility without incurring risk to personnel from hazardous levels of radiation, chemicals, or structural deterioration. Thus, the work was accomplished safely, with minimal dose to workers, while also efficiently conducted. The efficient planning enabled productive operations during the D&D, further protecting worker health and accelerating project schedule. This is but one example of how robotic tools have been developed to meet unique DOE needs for D&D of radioactively contaminated facilities, present at most DOE sites. These innovative tools improve safety and efficiency, while minimizing impacts to worker health.

- **The EM program maintains the highest safety standards in all that it does, for its employees' protection, for the safety and security of its physical assets, and for the citizens and stakeholders in the communities where DOE facilities are located.**

- **DOE has more than 4,500 deteriorating buildings and facilities that are contaminated with radionuclides. Many of these facilities require D&D, but these activities pose significant hazards to workers, because of the levels of radioactivity and the structural condition of the ancient facilities. As such, innovative approaches to do the work more safely and efficiently are needed. Because of the unique nature of many of the facilities, special expertise in D&D innovations is needed.**

The Surveillance and Measurement System, a handheld radionuclide detector, has been widely used at DOE facilities undergoing D&D, as it can provide data on specific isotopes, providing results in real time and eliminating the need to send samples for more costly laboratory analysis.

We are Exchanging Technical Information and Lessons Learned

OET provides a critical role for sharing technical information and lessons learned across the DOE sites. Although each DOE site is unique, there are many similarities in terms of challenges to its cleanup programs that can benefit from technical exchanges. OET fills that key role by promoting communication from site to site via conference calls, email broadcasts, web-hosted information, and technical workshops. For more information, visit www.em.doe.gov/EM20Pages/EM20ReferencePage.aspx#independent. Each of OET's three offices actively pursues technical information exchange using a variety of methods. A few examples follow.

OET conducted a number of workshops on radioactive tank waste and other technical issues in 2008. Through these efforts, new technical information was shared among cleanup managers at Hanford, Savannah River, and Idaho and scientists and engineers at DOE national laboratories, academia, and industry.

- The Office of Waste Processing holds technical workshops several times a year, each focused on key issues, such as tank integrity and waste retrieval. Typically, these workshops are attended by staff from DOE's national laboratories and sites with high-level waste, as well as scientists and engineers from academia and industry with specific expertise in the topic of interest. More than 100 attendees usually convene for several days to share lessons learned and report on the latest developments. Each workshop is documented with a technical report that disseminates technical guidance, "best practices," and lessons learned.

- The Office of Deactivation and Decommissioning/Facility Engineering, in collaboration with Florida International University, has developed a D&D Knowledge Management Information Tool to enhance communications and exchange technical information and ideas collected at the Hanford ALARA Center. The tool, which currently contains more than 100 D&D problem/solutions, is being tested and is available at http://dndkm.arc.fiu.edu.

- The Office of Groundwater and Soil Cleanup promotes sharing of technical information and experience through its active technical assistance program. When a DOE site has a specific technical issue that requires outside expertise, they ask

the Office of Groundwater and Soil Cleanup to convene a team of technical experts at their site. After briefings about the specific problems, the team of experts makes an assessment and prepares a report of recommendations.

In 2008, a workshop was held at Oak Ridge National Laboratory to address mercury issues at the Y-12 Plant, which is a significant challenge due to the enormity and complexity of the problem, as well as the fact that mercury, which impacts multiple media in the environment, has been transported beyond the boundary of the Oak Ridge Reservation. At the workshop, the internationally recognized experts:

- identified key uncertainties;
- developed a site conceptual model;
- made recommendations for remedial technologies and strategies; and
- identified needs for further research.

As a result of this workshop, OET is supporting a mercury stabilization project that builds upon the recommendations of the experts to support the enormous challenges faced by the Oak Ridge EM cleanup contractor.

Because of OET's ability to work across DOE sites to promote sharing of information and lessons learned, OET fills a critical need that can significantly accelerate the overall EM cleanup schedule, while reducing costs and offering better protection of human health and the environment.

The results of OET's successful field demonstrations are shared through site visits, such as this one at the Savannah River Site.

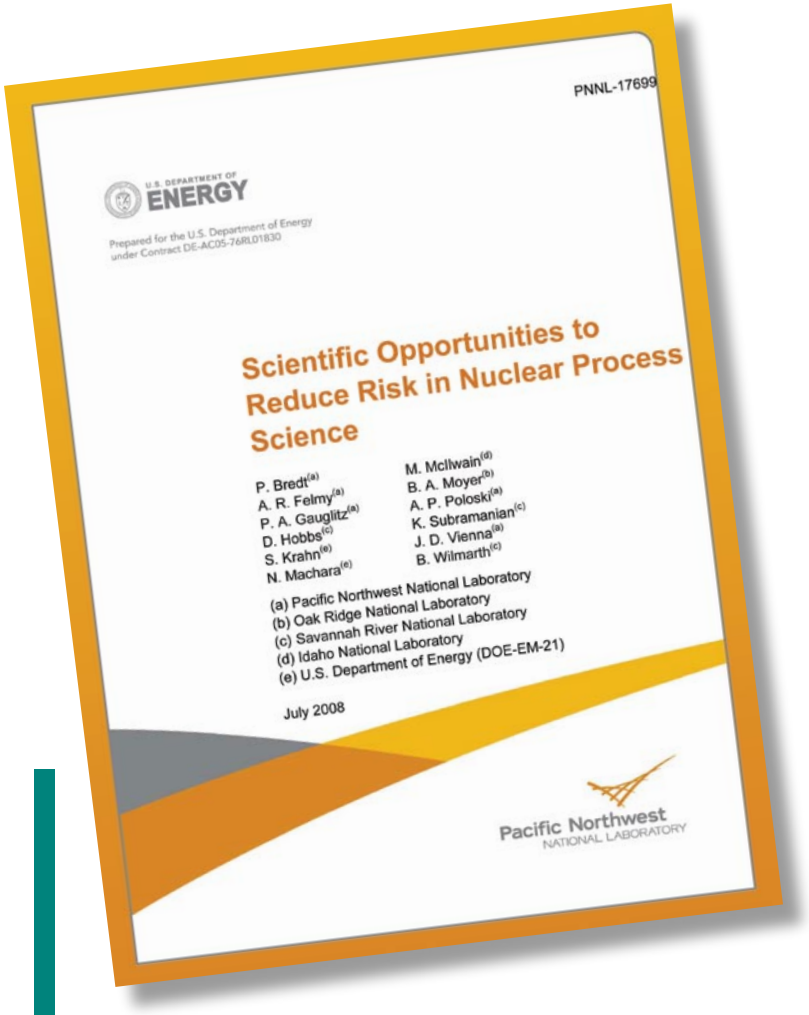
We are Bridging the Gap between Science and Application

Because advances in science can produce great strides in addressing cleanup needs, OET is bridging the gap between science and application in a variety of ways. Because many of EM's remaining cleanup problems are unique, highly complex, and technologically challenging, OET convened national laboratory scientists to work with them to investigate how basic fundamental scientific research can help to reduce risks and uncertainties in the current cleanup program. The scientific team concluded that basic research could provide:

- insight into fundamental mechanisms for current waste processing and disposal options;
- a path to develop alternative technologies should primary options fail;
- confidence that current models predicting long-term performance of different options are based upon best available science; and,
- fundamental science discovery to enable transformational solutions to revolutionize current processes.

Four science theme areas, linked to major risks identified within the OET Roadmap, were proposed for study. To foster a dialogue on how this type of research could assist DOE in executing its cleanup and environmental management mission, the team prepared a report of recommendations, which has served the important function of catalyzing discussions between various DOE Offices (the Office of Science, specifically Basic Energy Sciences, the Office of Nuclear Energy, and OET) and the university community. These discussions center around identifying critical areas for future research and development work that may enable breakthrough approaches to be developed for treatment and final disposal of DOE's high-level waste inventory.

OET is also working closely with DOE's Office of Science, in particular the Office of Biological and Environmental Research, which directs a research



OET serves to bridge the gap bringing state-of-the-art scientific knowledge from the Office of Science and the Office of Nuclear Energy to practical application in the EM cleanup program.

program that is directly applicable to EM cleanup problems. Working together, the two DOE organizations are applying the latest research knowledge to technology demonstration projects at DOE sites. These collaborative projects are demonstrating new approaches to cleaning up DOE's contaminated groundwater, an extremely large problem that involves more than 100 square miles of contaminated groundwater at various DOE sites.

One example of this collaborative approach involves Lawrence Berkeley National Laboratory scientists working with Savannah River National Laboratory scientists to further understanding of natural processes for cleanup of metals and radionuclides in groundwater. Lawrence Berkeley National Laboratory is conducting basic science research of natural cleanup mechanisms in the subsurface, while Savannah River National Laboratory will field test and verify the knowledge and tools developed by Lawrence Berkeley and others to develop a technical framework for applying natural cleanup strategies. This project will provide both scientific and policy support to facilitate implementation of appropriate natural cleanup strategies, potentially saving millions of dollars at DOE sites.

These collaborations are two examples of the many activities bringing new scientific knowledge to EM cleanup project managers to enable them to make decisions that can more efficiently clean contaminated sites. Without these joint research and development efforts, some of DOE's most intractable, unique problems may not be solved, or the solution may require more money or time, or may create higher risks to workers, the public, and the environment.

The key to the smooth transition from basic scientific understanding to full-scale application in the field is an effective engineering and technology program that reaches out to both the national laboratory researchers and to the field engineers implementing the cleanup program for DOE.

Lawrence Berkeley National Laboratory scientists are collaborating with Savannah River National Laboratory scientists to bring new understanding regarding natural attenuation and new technologies like directional drilling to cleanup managers to address contaminated groundwater at the F Area Applied Research Site. This is made possible through shared support from OET, Office of Science, and EM.

We are Saving Money and Accelerating Schedule

OET is helping the EM program save money and accelerate schedules by providing innovative technologies and approaches that reduce risks and uncertainties. OET's technical support to all aspects of the EM program - including waste processing, groundwater and soil cleanup, and D&D of existing facilities - has positively impacted EM project schedules and budgets.

Technical innovations in the EM tank waste program have the potential to enable the greatest cost savings and schedule acceleration, because treatment of this waste at the Hanford, Savannah River, Idaho National Laboratory, and West Valley sites represents the largest EM projects with the longest schedules (as much as 35 years of treatment) and the largest budgets, as well as being most challening from a technical and safety perspective. Current plans call for converting these wastes into glass and disposing them in an off-site repository. If the number of canisters of glass can be reduced (e.g., by hundreds), millions of dollars can be saved, and project schedules can be greatly shortened.

OET provides engineering and technology support for all tank radioactive waste project components, from waste storage and retrieval to pretreatment and treatment to tank closure. These project components vary from DOE site to site, because of the unique characteristics of the waste at each site. However, there are also opportunities for new technologies and approaches to be used at multiple sites, because of certain commonalities.

As an example, OET supports eight technology development projects to develop next-generation pretreatment solutions for tank waste. Pretreatment involves separation of low radioactivity, chemical components from the waste feed, so that the volume of highly radioactive waste requiring treatment and disposal can be significantly reduced. In addition, troublesome components are

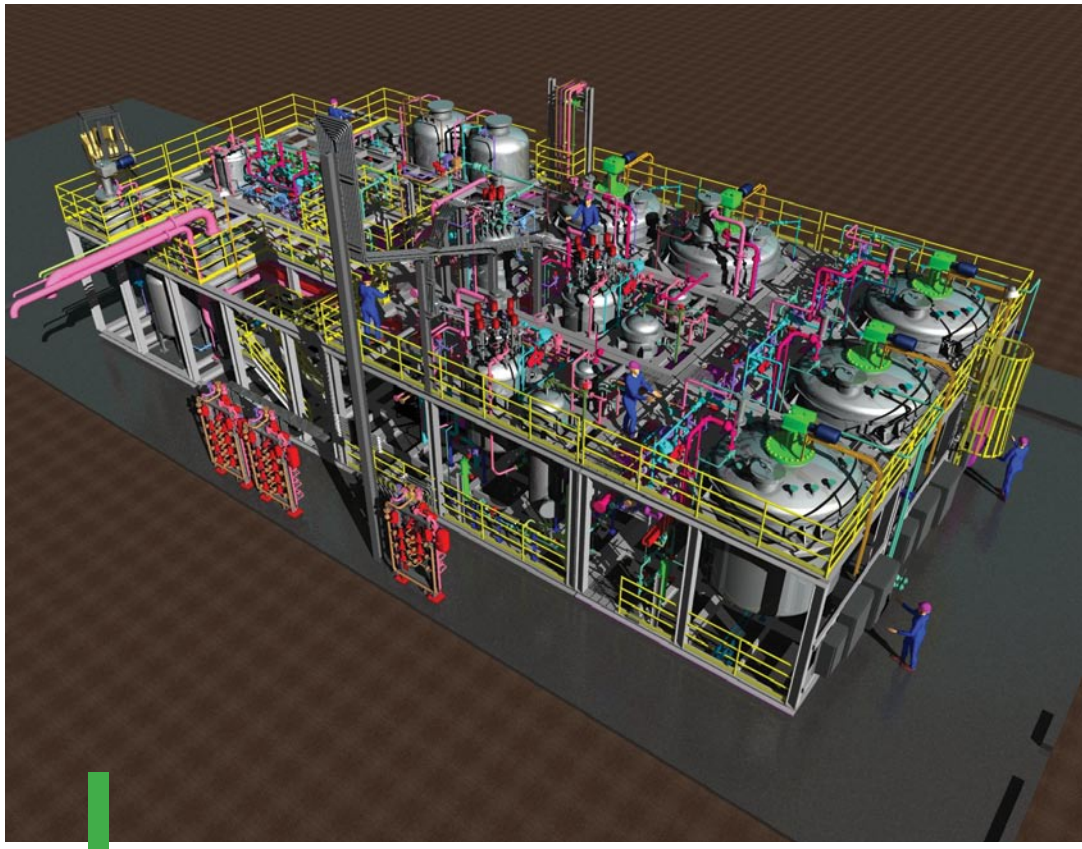
Fractional crystallization technology was pilot tested at the Savannah River National Laboratory through successful collaboration with Hanford staff to demonstrate a pretreatment technology that could significantly reduce the volume of tank waste required to be turned into glass at the Hanford site.

removed from the high-level waste feed, so that a more stable glass product can be produced. With successful pretreatment, the high-level waste glass product will be disposed in the off-site national repository, while the lower radioactivity product will be disposed on site (e.g., Hanford or Savannah River Site). If this can be accomplished, fewer high-level waste canisters will be required, reducing treatment and disposal costs.

Pretreatment begins by separation of tank waste liquids and solids. Pretreatment projects that OET supported in 2008 involved:

- removal of nonradioactive chemical constituents (e.g., aluminum and sodium) from the liquid waste stream to significantly reduce the volume of radioactive waste
- removal of radionuclides (e.g., cesium) present in the liquid waste stream so that it can be reclassified as low-activity waste
- removal or destruction of organics
- improved separation of solids and liquids, and
- dissolution of solid sludge in tank bottoms.

One of OET's recent projects demonstrated a pretreatment technology called fractional crystallization, which is well proven for industrial applications. Fractional crystallization uses an evaporation and crystallization process - a process similar to that used to purify table salt - to separate some of the radionuclides from the salts that have formed in the tank waste. If these radionuclides can be removed from the salts, the volume of high-level waste to be turned into glass can be reduced, also reducing the number of waste canisters to be disposed, possibly accelerating the schedule by 20-30 years and saving more than $1 billion. In 2008, fractional crystallization was successfully pilot tested at Savannah River National Laboratory using Hanford waste.



The Pretreatment Engineering Platform was designed and constructed at the Hanford site to enable pilot testing at one-quarter scale for a variety of pretreatment technologies for Hanford tank waste. Pacific Northwest National Laboratory scientists will be performing the testing of various pretreatment technologies.

The Pretreatment Engineering Platform was designed and construction was completed in 2008 at the Hanford site to enable one-quarter scale testing of pretreatment technologies for tank waste. Pacific Northwest National Laboratory scientists will conduct the tests to support final selection and design of preferred pretreatment technologies for Hanford's Waste Treatment and Immobilization Plant.

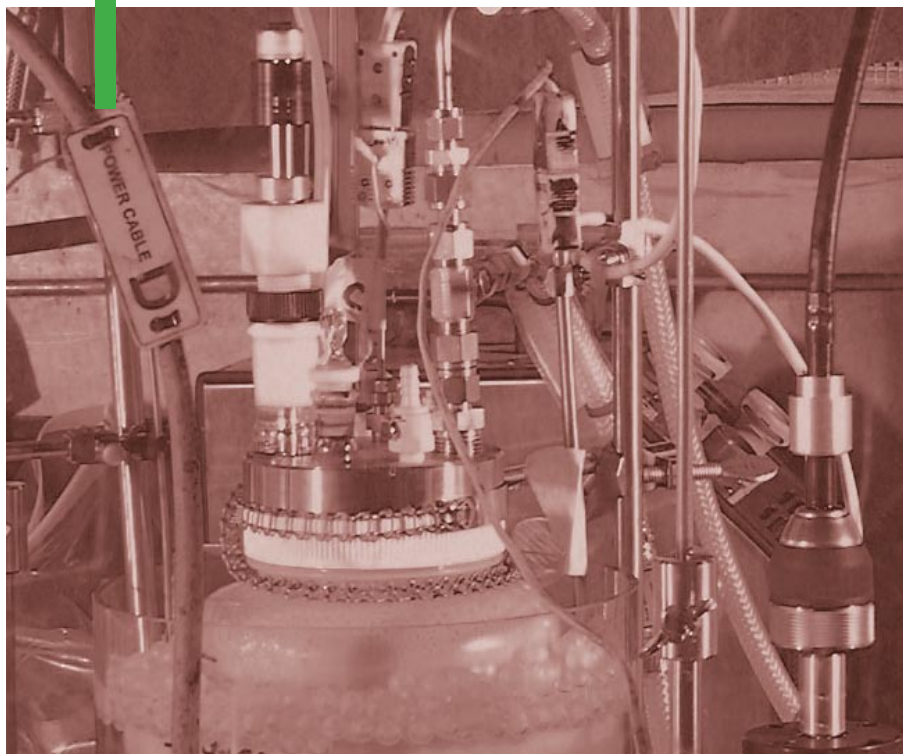
As part of the pretreatment program, OET supports several projects to investigate various alternatives for removal of nonradioactive chemicals, such as aluminum and sodium, which comprise very large volumes of the tank waste. If these high-volume components can be removed before the high-level waste reaches the vitrification plant, the volume of high-level waste to be turned into glass will be significantly reduced.

At Savannah River Site, the majority of the aluminum is located in a small number of tanks, and waste is staged in batches to the glassification plant, the Defense Waste Processing Facility. As such, an in-tank pretreatment approach is preferable. At the Hanford site, aluminum is widely distributed among the tanks, calling for a removal technology in the pretreatment section of the glassification plant, the Hanford Waste Treatment and Immobilization Plant.

To address site-specific needs, an in-tank caustic leaching technology was demonstrated at the Savannah River Site, first in the laboratory and then full-scale in an actual waste tank, to remove significant quantities of aluminum present in the tank waste sludge. The innovative approach involved addition of caustic material (sodium hydroxide) at low temperature directly into the tanks. After thoroughly mixing the caustic-treated sludge, aluminum dissolved into a liquid layer, which was removed from the tank and sent to the Salt Waste Processing Facility where the low-level liquid waste is treated by incorporating it into a solid grout. The solid low-level waste form is disposed in above-ground vaults at the Savannah River Site.

During the full-scale demonstration in Tank 51, 65% of the aluminum in the sludge was removed after 80 days, resulting in savings of $40 million by reducing the number of canisters required by 100. If this process were to be used in

Successful laboratory-scale caustic leaching tests at Savannah River National Laboratory led to a full-scale demonstration in Savannah River Site's Tank 51, which saved $40 million.

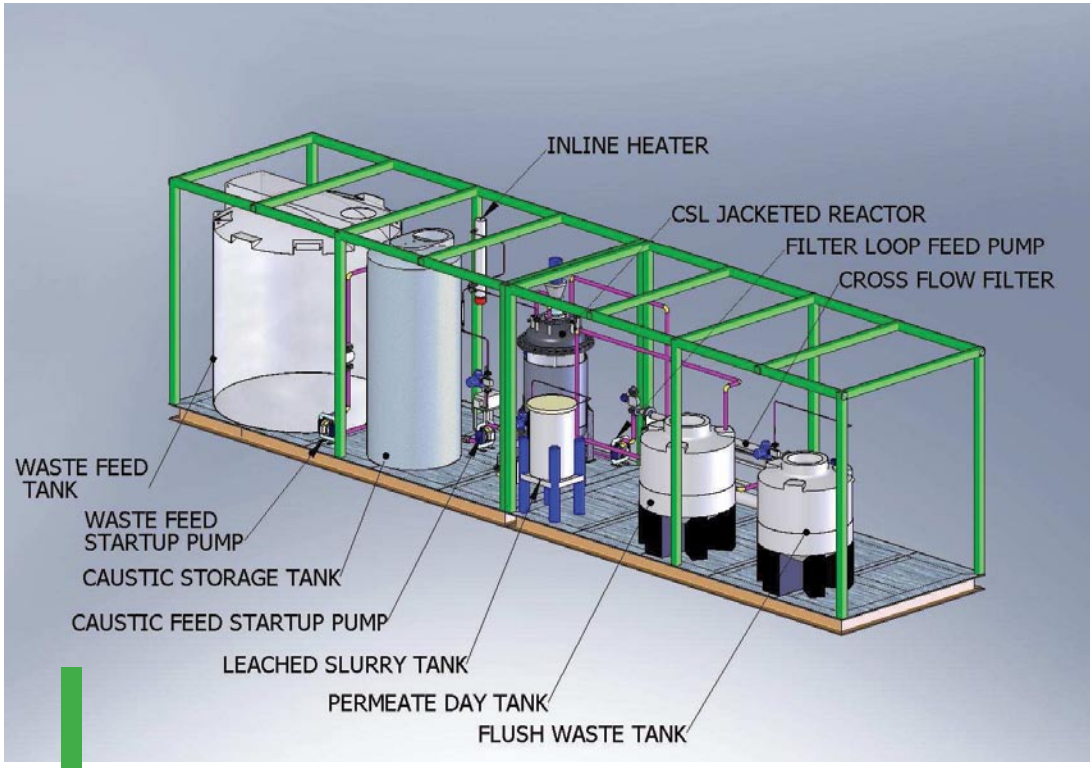


other waste tanks, the volume of sludge requiring high-level waste treatment would be reduced by 900 canisters, resulting in even greater life-cycle cost savings. Current estimate of the mass of sludge in the Savannah River Site tanks requiring conversion to glass is ~7,900 canisters. The new technology is easy to implement, and has a key advantage in that it can be performed in the tank farm rather than requiring construction of a new facility.

For Hanford applications, OET is supporting investigation of other options for aluminum removal, such as Continuous Sludge Leaching, as well as investigations as to how to increase the loading of aluminum in the glass to be produced, while maintaining adequate physical and chemical characteristics to make it acceptable for disposal in an offsite high-level waste repository.

To address an even broader set of issues with aluminum in tank waste, OET convened an external technical review of options for aluminum removal. The experts recommended further development, including engineering-scale testing of three options, which included caustic recycle, modified Bayer process, and nitrate/nitrite destruction, as well as further development of improved glass loading and caustic optimization methods. In September 2008, OET also convened a workshop on the broad topic of aluminum handling in tank waste. Representatives from national laboratories and site operations contractors discussed operations and potential process improvements at the Savannah River Site Defense Waste Processing Facility and Hanford's Waste Treatment and Immobilization Plant, including options for aluminum dissolution as a pretreatment step and impacts of high aluminum concentrations on vitrification processes.

These few examples show potential cost and schedule impacts that can be realized in just one problem area: pretreatment of tank waste. Current efforts in all aspects of tank waste treatment and disposal are showing potential for similar improvements that could save significant amounts of money and accelerate schedules. However, much work remains to be done.



Continuous Sludge Leaching is being tested as an option to remove aluminum from tank waste to reduce the volume of waste feed to the Hanford Waste Treatment and Immobilization Plant.

We Are Building A Sustainable Future

As EM pursues cleanup of DOE's sites and facilities, it strives for more than environmentally safe property; EM is also dedicated to using these facilities to build a sustainable future. This will be accomplished through a combination of steps, including:

- Achieving ambitious energy management goals;
- Using cleanup techniques that require minimal energy and/or make use of self-sustaining natural cleanup mechanisms; and,
- Making unneeded DOE facilities available for energy or commercial use.

OET has responsibility for numerous facilities (some 5,000 buildings and other structures) through its Facility Engineering and Real Property Asset Management Program. Many of these facilities require D&D. As cleanup progress is made, the footprint of the EM facilities is significantly reduced, transforming many of these properties into community reuse sites through property transfer, or supporting construction of new facilities for new DOE missions.

One recent example of DOE's property transfer program involves the reindustrialization of the Oak Ridge Reservation's former K-25 Gaseous Diffusion Plant as the East Tennessee Technology Park Heritage Center, a private industrial center. As a result of this property transfer, DOE has avoided $12.1 million in demolition costs and up to $100 million in lifecycle costs. To date, six facilities and four vacant land parcels have been transferred to the Community Reuse Organization of East Tennessee since 2005. Additional transfers are under development or are available for transfer.

TEAM Goals:

- **Reduce energy efficiency by 30% in 2015**
- **Purchase, generate, or use 7.5% of our electricity from renewable energy sources by 2013**
- **Meet all annual federal fleet fuel reduction and alternative fuel goals**
- **Ensure that at least 15% of EM applicable footprint meets federal sustainability goals**
- **Reduce water efficiency by16% by 2015**
- **Support sustainable environmental practices in all federal acquisitions**
- **Align the Environmental Management Systems with requirements for toxic and hazardous material use, diversion of solid waste to recovery, and increased recycling**
- **Incorporate electronics stewardship activities for purchase, use, and disposal of electronic equipment**

Through its Energy Management Program (EMP), OET is also responsible for implementing EM's participation in the Transformational Energy Action Management (TEAM) Initiative, which is designed to meet or exceed the goals outlined in the Energy Policy Act of 2005 and Executive Order 13423. Under the TEAM Initiative, there are eight goals to transform the way DOE manages its energy, environmental, and transportation programs in a more efficient and conservative manner.

In 2008, significant progress toward these goals was made:

- Achieved green performance indicators on all milestones for Energy Savings Performance Contracts;
- Demonstrated a LEED tool and conducted LEED webinar training; and,
- Issued guidance on EM fuel utilization and management.

One major OET achievement in 2008 was the start up of a new Biomass Steam Plant at the Savannah River Site. The project, which helped EM achieve its FY2008 energy efficiency and renewable energy goals, was funded using an

innovative third-party Energy Savings Performance Contract. The contractor-guaranteed savings in energy and operational costs were used to fund the project under a financed mortgage. The arrangement does not increase the Savannah River Site budget or annual cost of operating the facilities. When the mortgage is paid off, all savings accrue to the federal government.

The innovative biomass steam plant project involved replacing a 1950's vintage coal-fired steam plant that had outlived its usefulness with two new energy-efficient 30,000 pounds-per-hour boilers. The new boiler systems use less energy, have reduced operating and maintenance costs, and comply with Clean Air Act Standards.

As the Savannah River Site mission evolved over the years and old facilities were torn down, the A-Area coal-fired steam plant was providing steam to fewer facilities, leaving it oversized and inefficient, while also incurring high maintenance and repair costs. One of the new boilers, which is a wood-fired unit that utilizes local biomass (~27,000 tons annually), a renewable energy source, as the feed. The second boiler is a standby, fuel-oil fired boiler, which operates during maintenance periods for the wood-fired boiler and during peak steam demand times.

Annual air quality benefits of the Savannah River Site Biomass Steam Plant project include:

- **Particulate matter reduction of 400 tons**
- **Sulfur dioxide gas reduction of 1,742 tons**
- **Nitrous oxide gas reduction of 218 tons**
- **Carbon monoxide gas reduction of 10 tons.**

DOE is actively investigating other approaches toward a sustainable future, including passive or natural remediation approaches, greater efficiencies to meet DOE's long-term monitoring requirements, and conversion of facilities to energy parks to promote U.S. energy independence. DOE is fully committed to building a sustainable future and will dedicate more and more resources to this goal each year.

The Savannah River Biomass Steam Plant is a significant achievement to help DOE meet its federal enegy management goals.

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