Highlights of Battelle's International Energy,

ETE Updates

Transportation, and Environmental Leadership

SUMMER 2006

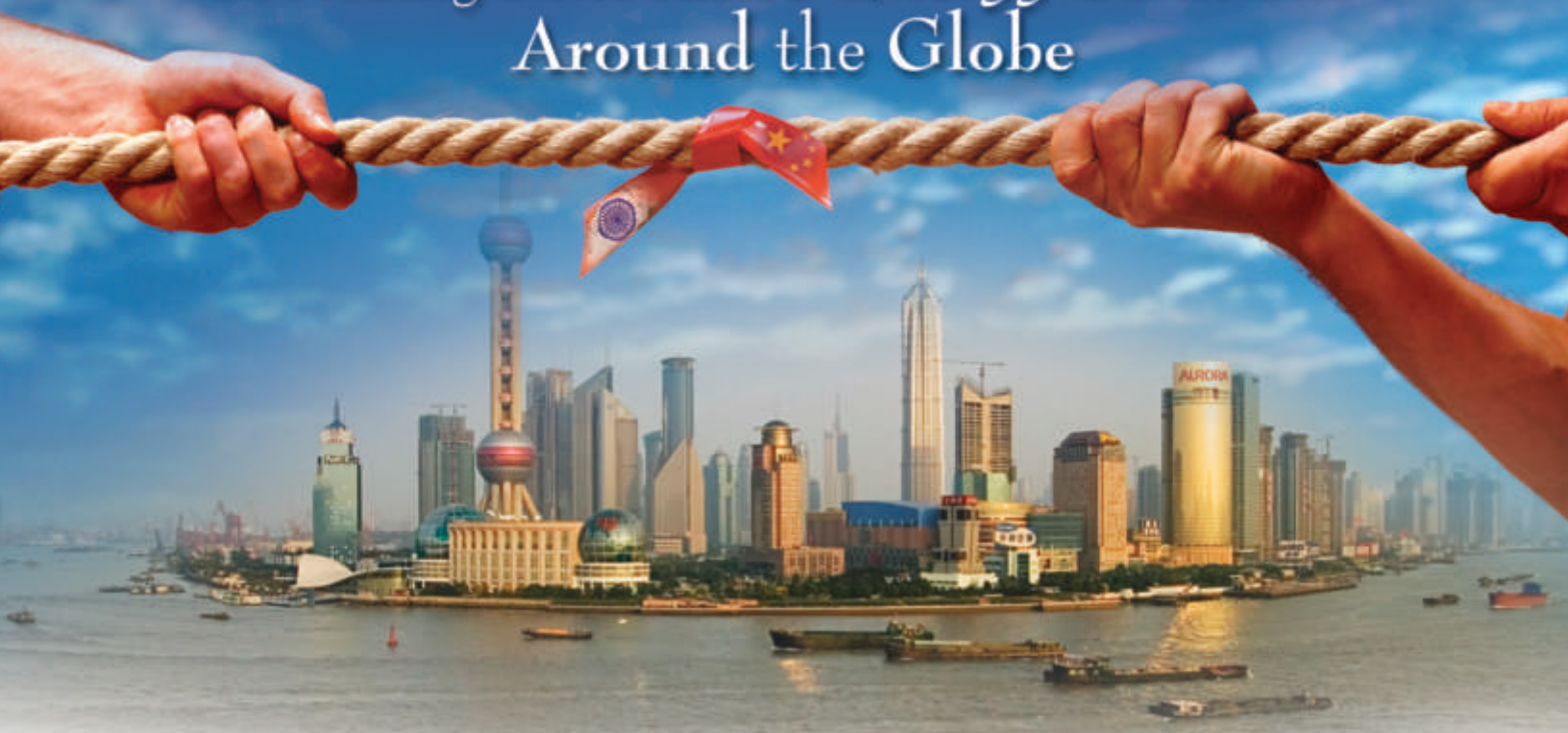
ENERGY *SOLUTIONS*







Providing *Innovative Energy Solutions* Around the Globe



International competition for energy resources, resulting in rising energy costs for consumers, tops daily news reports. Oil prices are at an all-time high. Historically, the cost and availability of various forms of energy have been cyclical. Many of us can remember waiting in long lines for gasoline and paying astronomical heating bills during the 1970 energy shortages.

However, today additional pressures on energy supply could mean high energy costs are here to stay. We're living through a period of unprecedented global economic growth. Developing nations such as China and India are rapidly becoming world economic powers. Simply put, the demand for energy is growing rapidly and outpacing supply.

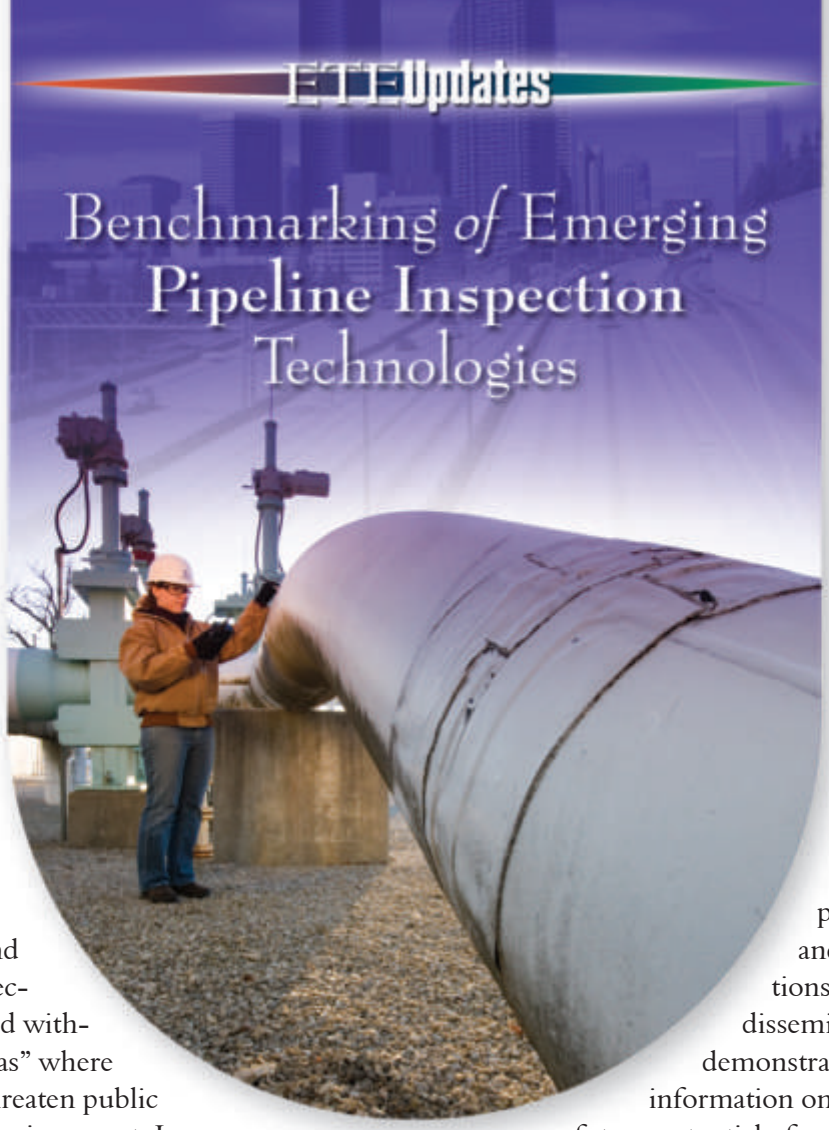
As energy prices continue to rise and other factors come into play affecting optimal choices for energy supply and use, facility operators are faced with the task of reevaluating their energy infrastructure. In addition to high energy prices, factors such as reliability in the face of electric grid instability, fuel disruption, environmental regulations, conservation incentives, and physical threats such as terrorism must also be taken into account.

Battelle has a history of assisting facility operators and planners in providing comprehensive and objective technology-based support for making such evaluations. In addition, Battelle scientists have been directly involved in the development and evaluation of advanced energy technologies such as innovative cogeneration systems; fuel cells; renewable energy systems; and energy-conserving, end-use devices.

In the past, Battelle has conducted energy master planning studies for a number of major campus-like facilities including the Sewells Point Naval Complex, various Air Force Logistic Command Bases, the University of Cincinnati, the U.S. Environmental Protection Agency's A.W. Breidenbach Research Center in Cincinnati, Ohio, and others. Energy master planning studies involve comprehensive reviews of facility energy flows, usage cycles, technologies used, and costs. Opportunities for reductions in energy use, efficiency improvements, and cost savings are identified from the results and recommended for implementation. Battelle has also developed and deployed the Decision Support for Operations and Management (DSOM) suite of technologies (see http://www.pnl.gov/dsom/), which has helped various facility operators improve energy efficiency, increase reliability, and reduce cost.

For additional information on Battelle's Innovative Energy Solutions, please contact Dr. Steve Ricci at (614) 424-4359, ricci@battelle.org, or Mr. Dave Ball at (614) 424-4901, balld@battelle.org.

Benchmarking of Emerging Pipeline Inspection Technologies



Pipeline infrastructure is a critical element in the energy delivery system across the United States. Its failure can affect both public health and safety directly and indirectly through impacts on the energy supply.

With passage of the Pipeline Safety Improvement Act (PSIA) in 2002, industry is now required to invest significantly more capital to inspect and maintain their systems. The PSIA requires enhanced maintenance programs and continuing integrity inspection of all pipelines located within "high consequence areas" where a pipeline failure could threaten public safety, property, and the environment. Inspection of the pipeline from the inside, commonly referred to as "pigging," is a reliable and economical method to meet this requirement. However, a large percentage of these pipes cannot be inspected using typical pigs due to diameter restrictions, pipe bends, and valves. In other pipe infrastructure, pressure differentials and flow are too low to move a pig forward.

To enhance safety for unpiggable pipelines, research programs have been initiated to develop advanced in-line inspection (ILI) technologies capable of maneuvering around the various pipeline restrictions/limitations to detect mechanical damage, corrosion, and other threats to pipeline integrity. Through these efforts, several projects have matured to a stage where practical demonstration of their detection capability is necessary.

With funding from the Pipeline & Hazardous Materials Safety Administration (PHMSA), Pipeline Safety R&D Program, and the Department of Energy National Energy Technology Laboratory (NETL) Gas Delivery Reliability Program, Battelle developed and conducted live technology demonstrations for several of these innovative pipeline inspection technologies.

Battelle was instrumental in developing the demonstration protocol, collecting field pipe samples with corrosion and stress corrosion cracking anomalies, manufacturing pipe samples with corrosion and mechanical damage anomalies, providing facilities to conduct the demonstration, and supplying documentation of the pipe samples and inspection results.

While research reports, review meetings, and conference presentations are commonly used to disseminate information, live demonstrations provide additional information on the current state and future potential of each development. Demonstrations are challenging to technology developers because newly developed technologies must be sufficiently reliable to obtain results in a fixed time frame. While the pressure to demonstrate the best capability of their technology advances is enormous, the developers understand these events are needed to bolster support for continued development.

With the ultimate goal of ensuring the safe, reliable, and environmentally sound operation of the nation's pipeline transportation system, in-field technology demonstrations are necessary to facilitate technology transfer from government-funded R&D programs and to strengthen communication and coordination with industry stakeholders. Through these efforts, it is anticipated that prototype systems can be built to traverse all pipes (including unpiggable lines) of various diameters while providing continuous, real-time detection of pipe anomalies or defects.

For additional information on Battelle's pipeline safety and security capabilities, contact Dr. Bruce Nestleroth at (614) 424-3181, nestlero@battelle.org.

Battelle's Continuing Role *in* Carbon Sequestration Research

Carbon sequestration is part of an energy strategy aimed at mitigating carbon dioxide (CO_2) emissions and reducing the potential impact of those emissions on climate change. It includes both terrestrial and geologic sequestration. Terrestrial sequestration removes CO_2 already in the atmosphere and stores it in plants and soils. Geologic sequestration captures CO_2 from power plants and other industrial facilities and injects it into carefully chosen geologic formations where it is permanently stored deep underground.

The Midwest Regional Carbon Sequestration Partnership (MRCSP) is one of several programs led by Battelle in the carbon sequestration area. It was formed in 2003 as a part of a national effort sponsored by the U.S. Department of Energy's National Energy Technology Laboratory to address the increasing amount of CO_2 in the atmosphere. Today the MRCSP includes over 30 partners representing the public, private, and research sectors of Indiana, Kentucky, Ohio, Maryland, Michigan, Pennsylvania, and West Virginia (see www.mrcsp.org).

In Phase I of the program, the MRCSP identified the sources of CO_2 emissions in its region and opportunities for both terrestrial and geologic sequestration. During this phase, the MRCSP also studied potential options for transporting CO_2 and regulatory frameworks and began a major effort to inform and engage stakeholders in its region about sequestration and the MRCSP project. As a result of Phase I research, the MRCSP concluded that the region has substantial terrestrial and geologic storage resources.

The MRCSP's four-year, Phase II research program commenced in the fall of 2005. It is building on the Phase I effort by conducting a series of field validation tests in a variety of land and geology types to determine how the region's sequestration potential can be used to advance economic growth while protecting the environment. Specifically, the MRCSP will:

- conduct three small-scale CO_2 injection field tests in the region's deep geologic reservoirs to demonstrate the safety and effectiveness of geologic sequestration systems. Detailed studies will determine whether these sites are geologically suitable before injection tests begin;
- conduct three small-scale field validation tests of terrestrial sequestration to show how the stored carbon can be measured and monitored;
- implement an innovative "piggyback drilling" program pioneered by Battelle that will allow the Partnership to leverage the ongoing and extensive investments made by local oil and gas drilling companies to gather "real-world" sequestration-related data, such as core samples from deep geologic formations;
- continue crucial work initiated in Phase I to further map and define the sequestration potential of the region;
- continue to develop an understanding of key regulatory issues; and
- launch the first systematic attempt to engage and inform stakeholders in the region about this important class of technologies.

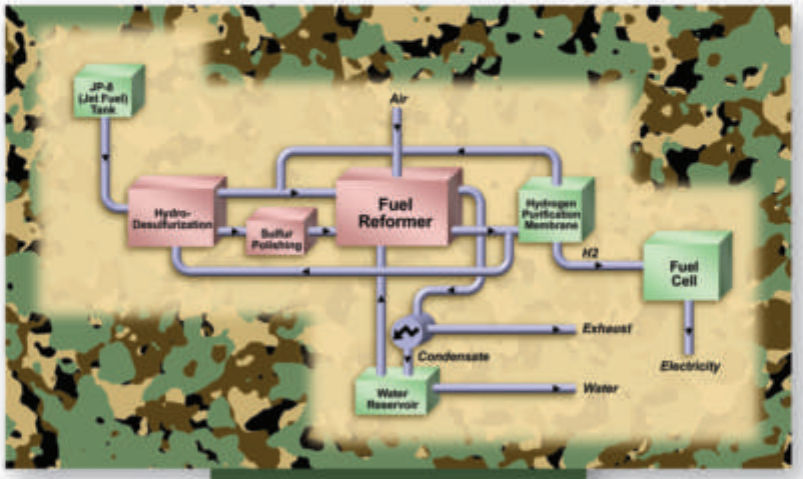
Vibroseis trucks—also called thumper trucks—are used to generate vibrations in the ground.

Once the vibroseis data are gathered, they are processed using a computer to produce a representation of the rock layers in the survey area. The representation is then interpreted by the geologic team to make a preliminary evaluation of the potential capabilities of the subsurface formations for CO_2 storage. The next step would be to gather local, detailed information by drilling through the formations of interest.

For more information about MRCSP or Battelle's role in other carbon sequestration programs, contact Mr. David Ball at (614) 424-4901, balld@battelle.org, or Dr. Neeraj Gupta at (614) 424-3820, gupta@battelle.org.

Battelle *Powers the Military* with a Cleaner and More Efficiently Used Fuel

Running a noisy, hot generator in a war zone can give away your position. Not running it can leave you without power for communications, air-conditioning, heat, and other critical systems. Researchers at Battelle Pacific Northwest Division are developing methods to enable use of existing military fuel for fuel cells, which operate silently and at increased efficiency. The reduced acoustic and thermal signature is a distinct benefit in military environments.



Through the Tank Automotive Research, Development and Engineer Center (TARDEC), Battelle is developing a single system to convert military fuel (JP-8) into sufficient hydrogen to generate 10 kW of electrical power, which is enough energy to run critical air-conditioning or communications systems for hours inside an armored vehicle.

Poisonous sulfur

The military has long used logistics fuels. However, these fuels, such as jet fuel or diesel, contain sulfur that is poisonous to fuel cells.

"Because the sulfur content of logistics fuels is damaging to both the fuel reforming catalyst and the fuel cell itself, one of the key technical challenges for fuel cell systems is the requirement to remove sulfur from the fuel prior to reforming to prevent system degradation," says Dale King, TARDEC project manager.

Battelle's fuel cell power system operates by significantly reducing the level of sulfur in the fuel, then converting it to hydrogen in a Battelle-developed microchannel steam reformer. Reformation of battlefield fuels to hydrogen allows use of the fuel cell to generate electricity.

This project leverages previous efforts internally funded by Battelle for microchannel steam reforming of synthetic jet fuel, and by TARDEC for desulfurization technology research.

Prototype fuel cell auxiliary power unit demonstrated

Battelle previously demonstrated the conversion of sulfur-free diesel for fuel cell power generation on an armored vehicle. Engineers at Battelle integrated and installed a fuel reformation and hydrogen purification system in a prototype fuel cell auxiliary power unit and operated the unit on sulfur-free synthetic jet fuel.

Aside from military vehicles, this technology can be applied in many areas where generation of electrical power is needed and small size and high performance are important.

For additional information, please contact Mr. Dale King at (509) 376-6282, dale.king@pnl.gov.

What is a Fuel Cell?

A fuel cell combines hydrogen and oxygen to produce electricity, with water and heat as by-products. As long as fuel is supplied and conversion to hydrogen is provided, the fuel cell will continue to generate electrical energy.

Because the conversion of the fuel to power takes place via an electrochemical process, not combustion, the process is clean, quiet, and highly efficient — up to three times as efficient as conventional internal combustion engines.

No other energy generation technology offers the combination of benefits that fuel cell systems do. In addition to increased efficiency, benefits include reduced emissions, increased reliability, multi-fuel capability, durability, and ease of maintenance.

In addition, waste heat from a fuel cell can be used to provide hot water or space heating, or to drive other heat-actuated systems.

Battelle Provides Global Capital Project Support

Since the initial discovery of oil within Nigeria during the 1950s, the country has grown to be the eighth largest exporter of oil in the world, and the fifth largest source of imported oil for the United States. Most of Nigeria's oil and gas reserves are located in the Niger River Delta and adjacent offshore region where significant environmental challenges exist. The development of major projects aimed at ending gas flaring (combustion of surplus gas produced in association with oil production) by 2008 has been one of the highlights of the past three years in the Nigerian energy sector.

Working in conjunction with a local Nigerian consultant and its multinational oil and gas client, Battelle helped perform an Environmental Impact Assessment (EIA) for a proposed natural gas liquids (NGL) project. The project will make beneficial commercial use of offshore gas reserves by recovering, processing, and exporting the propane and heavier NGL components of the gas stream that would otherwise be re-injected back into the underground oil reservoir.

The EIA study was conducted in conformance with Federal Ministry of Environment and Department of Petroleum Resources requirements. Baseline surveys were conducted during the dry and wet seasons at more than 80 stations, including offshore, nearshore, and onshore locations. Sampled media included sediment, soil, water, and air (including noise). Socioeconomic surveys of potentially affected communities were also undertaken.

The results of the EIA and review of existing operations provided evidence that adding the proposed NGL facility would have minimal incremental and cumulative impacts on the environment. The EIA also demonstrated that the development could be safely constructed and operated in compliance with applicable regulatory requirements. The project will result in substantial environmental and economic benefit for Nigeria including:

- recovery of high-value NGL that, in the absence of the project, would be lost;
- generation of additional revenues;
- environmental conservation through replacement of existing pollution control measures and improvements to process systems' reliability;
- provision of employment and skill acquisition opportunities for Nigerians;
- maximization of Nigerian content for new facility components;
- improved economic viability for future development of satellite fields; and
- sustainable development of economic resources for future generations.

For more information, contact Mr. Alan Tilstone at (781) 869-1407, tilstonea@battelle.org, or Dr. Bernhard Metzger at (781) 869-1409, metzgerb@battelle.org.

Managing Contaminated Sediments *in* Brazil

Battelle staff members were recently approached by a client from a Brazilian energy company, who stated, "We know of Battelle's reputation in contaminated sediment remediation and we need your technical support." The energy company had operated a prototype oil shale processing plant since 1972. During the first six years of its operation, the spent shale was discharged to a man-made reservoir that had been built for the discharge. An environmental survey of the reservoir revealed an accumulation of arsenic. Although a risk assessment had indicated a very low level of health risk to the public, the company was sensitive to public concerns about possible exposure and agreed to address the sediment problem. Subsequently, the company entered into an agreement with the state environmental regulatory agency to implement a remedy. After a review of the alternatives, company decision makers concluded that removing the impacted sediments would create a more serious environmental and public health risk than leaving them in place; a sediment cap was determined as the only feasible alternative.

"We know of Battelle's reputation in contaminated sediment remediation and we need your technical support."

Sediment capping is a containment technology accepted by the U.S. Environmental Protection Agency (U.S. EPA), in which the sediment is isolated from the aquatic environment by depositing a layer of material on the sediment surface. The specific material is selected according to characteristics of the site and remediation goals, but could include sand, clay, or a more reactive material. Multilayer caps composed of different materials are also used.

Adding to the unique challenges of sediment-capping projects, this is the first use of sediment-capping technology in Brazil. Battelle remediation specialists have taken on the assignment to guide the company and its subcontractors through the process of characterizing the site, verifying the effectiveness of a sediment cap in this application, designing the cap, observing installation, and overseeing the performance monitoring. A key element of the design will be the cap materials, thickness, and placement method.

A subordinate, but equally important role is to convince the regulators and, by extension, the public, that a sediment cap is the right technology for the job. This is being done through a series of briefings and information-sharing sessions with the regulators, coupled with U.S. EPA and sediment-capping site visits in the United States to acquire first-hand assurance that sediment-capping is indeed an accepted remediation option. The project is currently in the design phase.

For more information, please contact Mr. Don Salmond at (781) 869-1408, salmondd@battelle.org.

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