

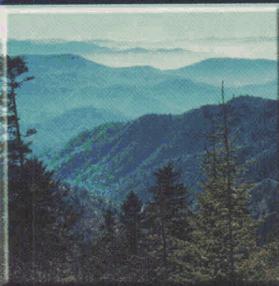
# ENERGY DIVISION PROGRESS REPORT

Fiscal Years 1996–1998



Buildings  
Technology

Energy &  
Environmental  
Analysis



Transportation  
Analysis

Emergency  
Management



*Cover photos:* Winchester Greens, developed by the Richmond, Virginia, Better Housing Coalition, photo courtesy of M. P. Ternes, Energy Division, ORNL; the Great Smoky Mountains, East Tennessee, ORNL Photo 193393; freeway traffic, photo courtesy of NREL/PIX; firefighters in protective gear, photo courtesy of IMSI, San Rafael, Calif.

*Background:* Norris Dam, one of the Tennessee Valley Authority dams in East Tennessee, ORNL Photo 3387-84.

**Note on Telephone Numbers in This Publication:**

The Oak Ridge area code shown with the many telephone and fax numbers in this report—area code 423—will change to area code 865 as of February 2000.



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ORNL-6951

# **ENERGY DIVISION PROGRESS REPORT**

## **Fiscal Years 1996 –1998**



**Robert B. Shelton, Director**

**June 1999**

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# CONTENTS

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✦ From the Director	v
✦ The Energy Division — An Overview	1
✦ The Energy Division Centers of Excellence	7
✦ Research Accomplishments — Addressing Today's Issues	11
✦ Ongoing R&D — The Search for Answers	27
✦ Research Facilities	43
✦ Collaborations and Outreach	48
✦ Celebrating Achievement	51
✦ Budget and Partners	55
✦ Selected Publications	58

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*“Energy plays a critical role in the workings of modern society, in our standard of living, and in our security. It is entwined with world economic growth, environmental quality, and geopolitics. Technological advances emerging out of R&D will be critical to meeting future energy and environmental needs.”*

**Secretary of Energy Advisory Board**

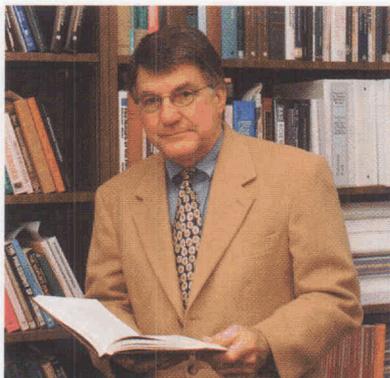
*“With the application of cost-effective new technologies and practices, new homes and commercial buildings can achieve 50% savings in energy consumption over current practices. In addition, renovation of existing homes and buildings can achieve 20% in energy savings. If this theoretical potential were achieved in all buildings by 2010, the U.S. would save 10 quads each year. Ten quads of annual energy savings would reduce building energy consumption by one-third and save \$60 billion in energy costs.”*

**U.S. Department of Energy  
Buildings for the 21st Century: A Strategic  
Plan for the Office of Building Technology**

*“That the transportation sector is a major and growing source of greenhouse gas emission is certain. What impacts those emissions will have on the global environment, how urgently we must act to curb them, and how effectively and efficiently we can do so are all highly uncertain and controversial questions.”*

**David Greene and Danilo J. Santini  
Transportation and Global Climate Change**

## FROM THE DIRECTOR



*Robert B. Shelton*

The past three years have been exciting and challenging for the Energy Division. Our continuing research successes have provided innovative solutions to energy and related issues of national and global importance. Challenges include maintaining our existing programs in a changing funding environment and developing new research areas that can take advantage of our unique multidisciplinary capabilities.

Our research and development focuses on four main areas: buildings technology, energy and environmental analysis, transportation analysis, and emergency management. In each of our programs, we continue to emphasize collaborations with universities, other national laboratories, and the private sector.

This report gives a synopsis of our division's recent and current research and development activities. We hope that the information contained in the report will give readers a snapshot of our capabilities and accomplishments in addressing some of our most important energy and related issues. We also hope this report will inspire new partnerships with other organizations.

Those of you familiar with the Energy Division will note our new organizational structure. Our new organization places greater emphasis on program development and encourages teaming across the entire division. I am happy to report that the new structure is working. New and exciting programs have been developed, funding has increased, and we continue to address issues of national and global importance.

We encourage you to learn more about the Energy Division by exploring our web site ([www.ornl.gov/divisions/energy/energy.html](http://www.ornl.gov/divisions/energy/energy.html)). Our home page provides links to more detailed information about our Centers of Excellence and the exciting research being done in our division.

Robert B. Shelton



# THE ENERGY DIVISION — AN OVERVIEW



## Who We Are

### Our Mission

To provide innovative solutions to energy and related issues of national and global importance through interdisciplinary research, development, and deployment.

### Our Vision

The Energy Division strives to

- be one of the world's foremost centers of excellence in conducting research at the energy-environmental-economic interface;
- become the preeminent institution in the United States in mobilizing teams that combine perspectives from the natural, social, and engineering sciences to solve energy and other problems of national and global importance;
- provide a working environment that promotes creativity, encourages staff interaction, and fosters collaboration with other institutions.

### Our History

The Energy Division is one of 15 research divisions at Oak Ridge National Laboratory (ORNL). The division was established in 1974 to consolidate work on environmental, technological, and regional assessments related to energy development and to conduct research on improving the efficiency of energy use and conversion.

### Our Focus

We focus on technology and human systems. While much of our work emphasizes energy and environmental issues, we also address other pressing concerns on the national agenda, reflecting the division's problem-driven nature.

### Our Centers

The division's work has four principal thrusts:

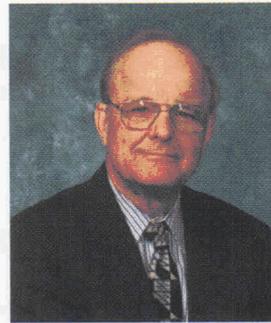
1. performing research and development (R&D) to improve the efficiency of *building energy use and delivery technologies*;
2. performing environmental, technological, regional, and policy *analysis and assessments* related to energy production and use;
3. conducting research on improving the efficiency of *transportation systems*; and
4. conducting applied R&D for *emergency planning capabilities*.

In line with these focus areas, the division is structured around four programmatic centers—the Buildings Technology Center (BTC), the Center for Energy and Environmental Analysis (CEEA), the Center for Transportation Analysis (CTA), and the Emergency Management Center (EMC).

## OVERVIEW

### Our Organizational Structure

The Energy Division underwent a significant organizational change in 1997, moving away from a traditional organization in which all staff members were assigned to one of four sections constituting both line management and programmatic responsibilities. Under our new organization, we have created four centers of excellence in which all programmatic responsibilities, marketing, and program oversight, reside. All staff members now report to one of two division resource managers—George Courville and Randy Curlee—in a line sense. This new organizational structure was adopted to place greater emphasis on program development, to promote additional teamwork across programmatic and disciplinary lines, and to provide greater flexibility in utilizing our staff capabilities across the entire division.

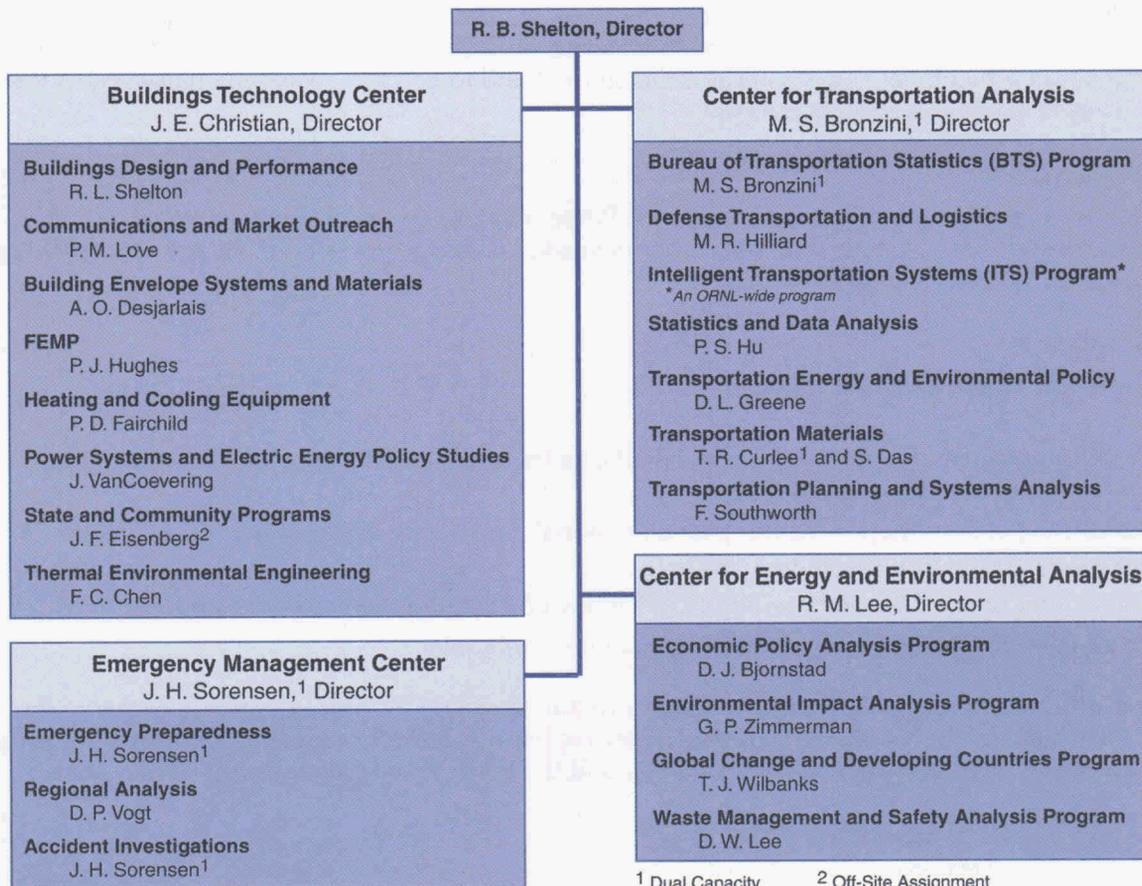


George Courville

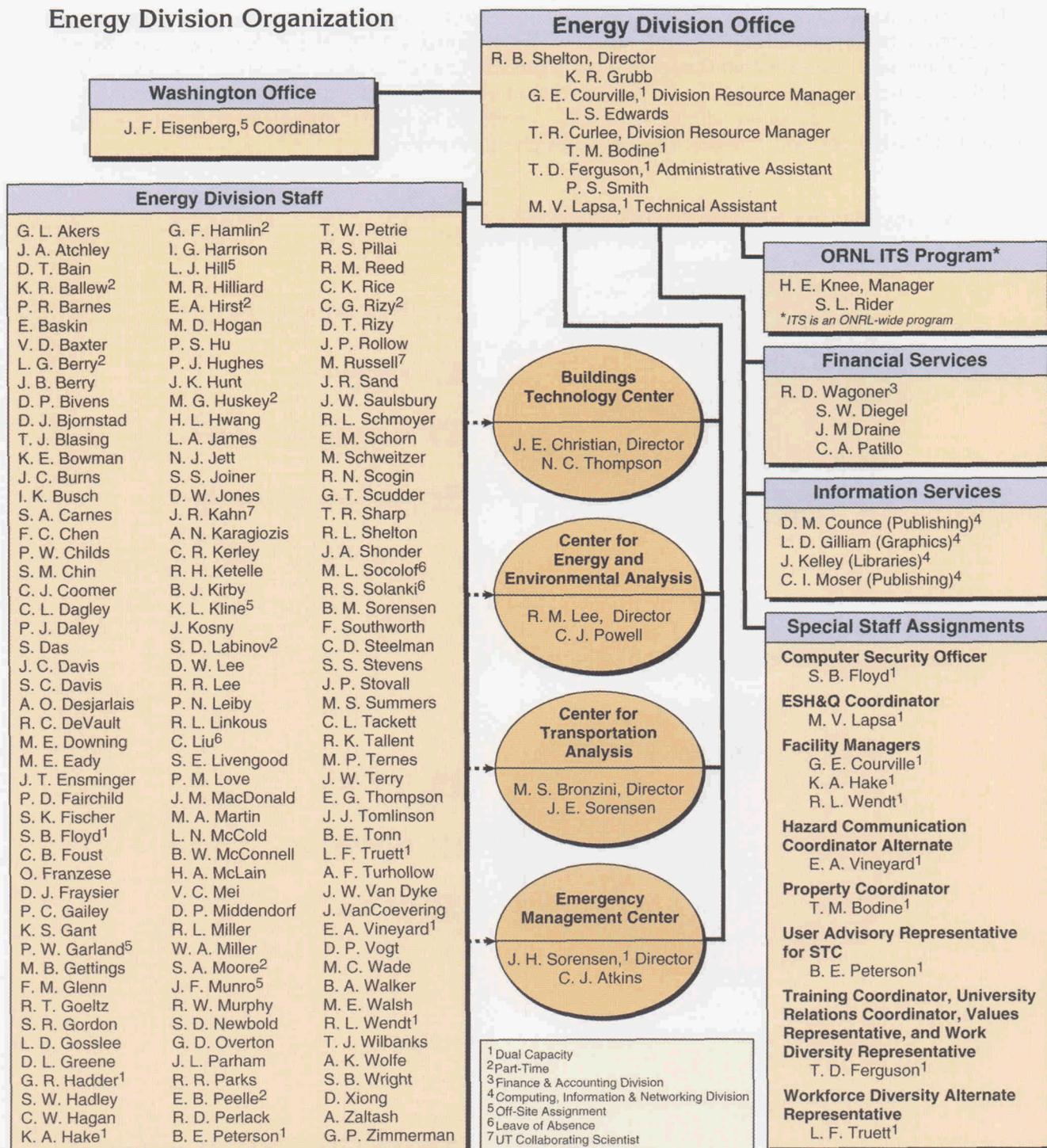


Randy Curlee

#### Energy Division Program Organization



Energy Division Organization

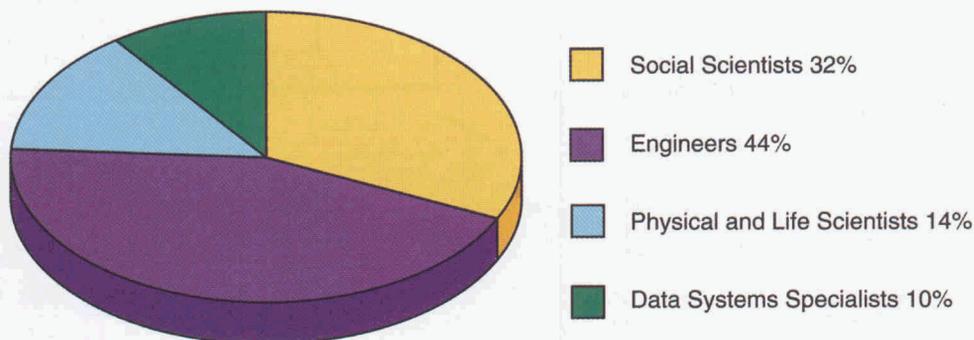


## OVERVIEW

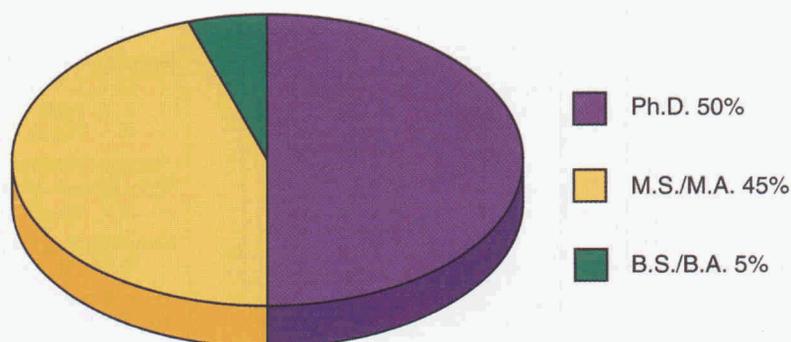
### Our Staff

The Energy Division is one of ORNL's most diverse research divisions in terms of its partnerships, research activities, and range of staff expertise. As of January 1999, the division was composed of 158 full-time equivalent staff and 54 on-site guests. The full-time-equivalent staff consists of 108 scientific and technical, 32 administrative, and 18 technical support personnel. Energy Division staff work in eight buildings at ORNL, in addition to several off-site locations, including ORNL's Washington, D.C., office; Hawaii; and Central America.

Energy Division Technical Staff by Discipline



Energy Division Technical Staff by Degree



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## Our Strategic Goals

The Energy Division brings its unique interdisciplinary skills to bear on a variety of energy and environmental issues of national and global importance. Our strategic goals focus on four key areas.



### Buildings technology

*Goal:* To identify, develop, and deploy sustainable and energy-efficient building system technologies by forming partnerships between the public sector and private industry for analysis, well-characterized experiments, technology development, and market outreach.



### Energy and environmental analysis

*Goal:* To perform applied, interdisciplinary research on energy and environmental issues of local, regional, national, and global importance to provide decision makers with information on which to base major policy, program, and project decisions.



### Transportation analysis

*Goal:* To conduct innovative, high-quality, cost-effective R&D on transportation energy and environmental issues, national transportation planning and policy, military transportation and logistics, and transportation systems engineering.



### Emergency management

*Goal:* To conduct applied social science, engineering, and interdisciplinary research on emergency management, including mitigation, preparedness, response, and recovery, and to transfer that knowledge into practical use through the development of guidance, tools, and training.

## OVERVIEW

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### Our Capabilities and Strengths

Our greatest strength is derived from our disciplinary diversity and our ability to combine perspectives from among the natural, social, and engineering sciences to address complex issues of national and global importance. We also offer unique research facilities and mechanisms to work with other researchers in the public and private sectors. Our research capabilities and strengths can be grouped according to our four strategic goals.



#### Buildings technology

- Building equipment R&D
- R&D on energy-efficient building envelopes and systems
- Outreach programs to encourage use of energy-efficient technologies
- Research on electric power systems, especially transmission and distribution capacity
- Research on low-frequency electric and magnetic fields and human health effects



#### Energy and environmental analysis

- Social and economic assessment of new energy and environmental technologies
- Technical/policy analyses related to radioactive/hazardous chemical waste management
- Environmental impact analysis and assessment
- Energy and environmental planning in developing countries
- Global climate change research and assessment
- Contaminant transport modeling
- Institutional mechanisms for managing complex technologies



#### Transportation analysis

- Defense transportation and logistics systems modeling
- Intelligent transportation systems analysis, evaluation, and simulation modeling
- Statistical analysis of large transportation databases
- Transportation energy and environment modeling and analysis
- Transportation materials modeling and evaluation
- Transportation planning methods for improved policy analysis



#### Emergency management

- Modeling and simulation
- Information systems
- Survey research
- Demographics
- Multimedia development
- Impact assessment
- Evaluation research
- Accident analysis

# THE ENERGY DIVISION CENTERS OF EXCELLENCE



## The Buildings Technology Center

Contact: Jeff Christian, Center Director (e-mail: christianje@ornl.gov)

The Buildings Technology Center (BTC) at ORNL is the premier U.S. research facility devoted to the development of technologies that improve the energy efficiency and environmental compatibility of residential and commercial buildings. The BTC is housed in a cluster of six buildings offering 20,000 square feet of space and state-of-the-art experimental facilities valued at more than \$6 million. A permanent staff of 50, continually supplemented by 10 to 20 guest researchers, operate the center. Annual program expenditures are about \$18 million.

The center's major areas of expertise focus on eight program themes:

- heating and cooling equipment (vapor compression, absorption, and desiccants);
- thermal environmental engineering;
- envelope systems and materials (roofs, walls, foundations, insulation, and fenestration);
- building design and performance (Rebuild America, residential and commercial buildings research, and industrialized housing);
- state and community programs;
- the Federal Energy Management Program;
- communications and market outreach; and
- power systems and energy policy studies.

Established by the U.S. Department of Energy's (DOE's) Office of Building Technologies, the BTC is a designated National User Facility whose facilities are available to manufacturers, universities, and other organizations for proprietary and nonproprietary R&D. Access to these unique facilities and capabilities is obtained through user agreements, Work for Others arrangements, and cooperative research and development agreements (CRADAs).

Further information is available on the center's web site at [www.ornl.gov/BTC](http://www.ornl.gov/BTC).



Jeff Christian



The BTC transfers its R&D on energy-efficient buildings and equipment to the real world in many ways, including helping Habitat for Humanity improve the energy efficiency of its new homes.



## CENTERS

# The Center for Energy and Environmental Analysis

Contact: Russ Lee, Center Director (e-mail: leerm@ornl.gov)



Russ Lee

The Center for Energy and Environmental Analysis (CEEA) conducts research and prepares analyses on global, regional, and local issues associated with energy and the environment. Most of the center's work is performed by multidisciplinary teams led by center staff. The center supports a diversity of sponsors and provides technical analyses and assessments in

- economic policy,
- environmental impacts,
- global climate change and developing country programs, and
- hazardous and radioactive waste management.

CEEA's work includes environmental impact assessments of hydropower and other energy projects.



In its economic policy analysis programs, the center engages in strategic planning for public policy, with emphasis on strategic options for DOE's waste cleanup and environmental remediation activities. The center pursues initiatives in understanding the social acceptability of controversial technologies, such as the use of natural and genetically

engineered microorganisms for waste cleanup; the use and effectiveness of stakeholder involvement programs; hazardous and mixed waste cleanup decision making; and environmental justice and risk communication. Staff economists also work with the Bioenergy Feedstock Development Program to better understand biomass marketing and procurement systems and to model the economic potential and impact of bioenergy crops.

Through environmental impact analysis the center has supported a number of government agencies in complying with the National Environmental Policy Act (NEPA). Activities

have focused on complex programmatic federal actions that require state-of-the-art assessment tools and interdisciplinary teams. Recent efforts include assessing the impacts of new technologies for

the disposal of chemical weapons, analyzing the impacts of decommissioning sites with radioactive contamination, evaluating environmental issues associated with clean coal technologies, and assessing the environmental effects of licensing actions for hydropower projects.

Analyses of global climate change issues include studies

of vulnerabilities to climate change impacts and strategies for mitigation. Center staff support the U.S. Agency for International Development (USAID) by formulating strategies to address global change issues. CEEA also assists developing countries and emerging economies in drafting climate change action plans and assessing the potential of different technologies to reduce greenhouse gas emissions. Developing country initiatives apply CEEA's experience with energy strategy development and environmental impact analysis to help countries move toward sustainable paths for development and strengthen institutions for implementing those paths.

The center also analyzes hazardous material and radioactive waste management issues. Recent activities include preparing the DOE Order, Guidance, and implementation strategy for radioactive waste management; analyzing the long-term performance of radioactive waste disposal facilities; preparing information for DOE Safety Analysis Reports on the consequences of possible accidents at DOE facilities that involve hazardous materials; and analyzing the environmental restoration of contaminated sites on the Oak Ridge Reservation.

Further information is available on the center's web site at [www.ornl.gov/ceea/home.html](http://www.ornl.gov/ceea/home.html).



## The Center for Transportation Analysis

Contact: Mike Bronzini, Center Director (e-mail: [bronzinims@ornl.gov](mailto:bronzinims@ornl.gov))

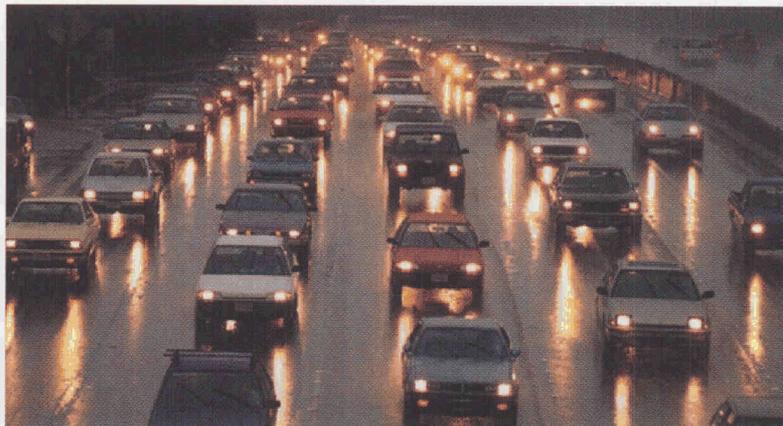
The Center for Transportation Analysis (CTA) develops and applies advanced computational techniques, analytical methods, and the latest information resources to understand and improve the economic and energy efficiency, environmental quality, mobility, national security, and public safety of the nation's multimodal transportation system.

A mixture of technical and scientific backgrounds and diverse project sponsorship strengthens CTA's interdisciplinary approach to problem solving. Staff expertise includes transportation engineering, transportation geography, transportation economics, operations research, computation, computer science, statistics, and other physical and social sciences. The center's major areas of emphasis are

- transportation energy and environment studies,
- transportation data and statistics,
- transportation planning and policy analysis,
- intelligent transportation systems,
- military transportation logistics, and
- transportation materials.

CTA's work in these areas is wide-ranging. Staff conduct analytic modeling of the energy and environmental trends and implications of transportation systems, including the relation-

ships between travel demands and fuel costs, the implications of alternative transportation fuels pricing, and the market potential for adoption of such fuels. The center plays a significant role in the processing and subsequent analysis of a number of the federal government's national passenger and freight transportation surveys and databases. A third area of considerable activity is the analysis of real-time telecommunications, sensor, and



satellite-based "intelligent transportation" technologies—how such technologies work, how travelers respond to them, and how the information they provide can be put to best use. The analysis of military transportation and logistics systems focuses on the multimodal (air, sea, land) supply of transportation assets during mobilizations, from small-scale training exercises to large-scale military deployments at home and abroad. CTA staff have also been involved for a number of

years in the construction and enhancement of a set of multimodal national and international transportation network databases. These networks are used for a variety of traffic routing studies, and for estimating national patterns of passenger and goods movements. They also support economic assessments of the needs for and costs of large transportation infrastructure projects. The desire to display the



Mike Bronzini

CTA's work includes development and testing of traffic monitoring and control systems that alert drivers to traffic conditions through devices such as variable messages mounted above freeways and in-vehicle information systems.

patterns of such flows over networks has encouraged innovative use of geographic information systems (GIS) technology within national and regional transportation planning studies. CTA also conducts research into the use of lightweight materials in the manufacture of fuel-efficient vehicles and the benefits and costs of getting such vehicles onto the market.

Further information is available on the center's web site at [www-cta.ornl.gov](http://www-cta.ornl.gov).



## CENTERS

# The Emergency Management Center

Contact: John Sorensen, Center Director (e-mail: [sorensenj@ornl.gov](mailto:sorensenj@ornl.gov))



John Sorensen

Research and development in the Emergency Management Center (EMC) is aimed at advancing the science and practice of emergency management, including preparedness, mitigation, response, and recovery. The center conducts applied social science, engineering, and interdisciplinary research in emergency management and transfers that knowledge into practical use. The center creates computer-based tools for planners and responders, including simulation models and training materials. The staff also provide analytical assistance to sponsors with respect to technical and policy issues. One strength of the center is demographic analysis as it relates to risk management. In addition,

the center conducts research to better understand human behavior in emergencies, including human response to warnings.

Currently, the center has three major thrusts:

- emergency preparedness,
- accident investigation, and
- regional analysis.

Emergency preparedness encompasses planning, training, risk communication, and exercises. Work has focused on developing state-of-the-art planning guidance, plan review tools, training CD-ROMs, web sites, exercise plans, decision support tools, and information management systems. Accident investigations include field

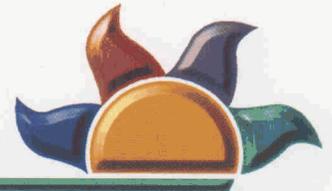
studies of primarily chemical accidents and R&D to support the accident investigation process. Investigations involve the study of emergency response or the review of the causes of accidents. Accident investigation support includes research on accident processes and development of databases and information tools. Regional analysis involves the application of demographic and economic analysis to help understand population change in both temporal and spatial contexts. Models have been developed to predict change using a geographical information systems framework.

Further information is available at the center's web site at <http://emc.ornl.gov>.

The Chemical Stockpile Emergency Preparedness Program (CSEPP) is being implemented to protect communities near chemical weapons storage and disposal facilities. The Desert Chemical Agent Disposal Facility is at one of eight sites where such weapons are located.



# RESEARCH ACCOMPLISHMENTS — ADDRESSING TODAY'S ISSUES



## The Buildings Technology Center

### Helping Habitat for Humanity Build Energy-Efficient Homes

Habitat for Humanity International is one of the 20 largest builders of houses in the United States and the largest nonprofit home builder. With assistance from staff in the BTC, the energy efficiency and indoor living conditions of new Habitat-built homes are being improved.

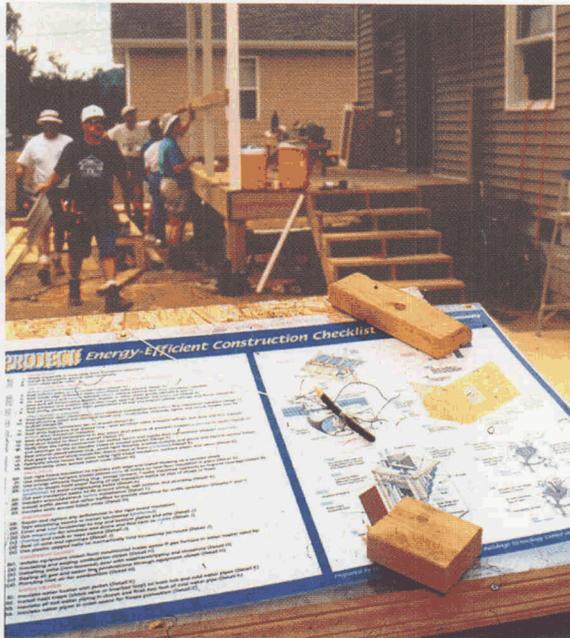
The incorporation of energy-efficiency practices into the building process was demonstrated during Habitat's 1997 and 1998 Jimmy Carter Work Projects. During the June 1997 work project in Appalachia, BTC staff reviewed a construction manual, developed an energy-efficiency checklist to be used by volunteers, ensured properly sized HVAC equipment, prepared installation instructions for heating and cooling equipment and air distribution systems, and provided technical advice on-site. These houses are estimated to use 32% less energy for heating and cooling than a house featuring standard construction, meeting the 1995 Model Energy Code, and using minimum efficiency equipment.

The energy-efficiency construction checklist developed for the 1997 Jimmy Carter Work Project has proved to be one of the most useful areas of assistance. The checklist, which now includes 76 items, describes first steps in a whole-house approach to energy efficiency and guides Habitat

affiliates through energy features such as insulated sheathing and low-e windows that should be considered during the design process. At the work site, the checklist guides volunteers through construction tasks such as sealing air leaks and properly installing windows and insulation.

The BTC's technical fact sheets and other materials provide details on the checklist items.

In a recent project in April 1998, the BTC provided technical assistance for a 5-day "blitz build" of 20 homes in Sumter County, Georgia, by Habitat volunteers. These houses are twice as airtight as the typical Habitat house and exceed efficiency standards set by the 1995 Model Energy Code. Contrary to accepted wisdom, energy efficiency does not add unacceptable expense to affordable housing. Habitat projects are demonstrating that even volunteers on a 5-day blitz can build efficient homes that will save families hundreds of dollars each year.



The energy-efficiency checklist developed by BTC staff is used on-site during Habitat for Humanity work projects.

**References:** M. P. Ternes, M. K. Barcik, and D. B. Creech, "Achieving Sustainable Construction in Affordable Housing," *Thermal Performance of the Exterior Envelopes of Buildings VII: Conference Proceedings*, Clearwater, Fla., December 6–10, 1998.

M. P. Ternes, S. E. Livengood, D. B. Creech, and M.K. Barcik, "Incorporating Energy Efficiency into Affordable Housing Construction Practice," *Proceedings of the 1997 Excellence in Building Conference*, November 5–8, 1997, Energy Efficiency Building Association, Denver, Colo.

**Sponsor:** DOE Office of Building Technology, State and Community Programs

**For more information:**  
[www.habitat.org](http://www.habitat.org); <http://eber.ed.ornl.gov>; [www.eren.doe.gov/buildings/residential](http://www.eren.doe.gov/buildings/residential)

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# ACCOMPLISHMENTS

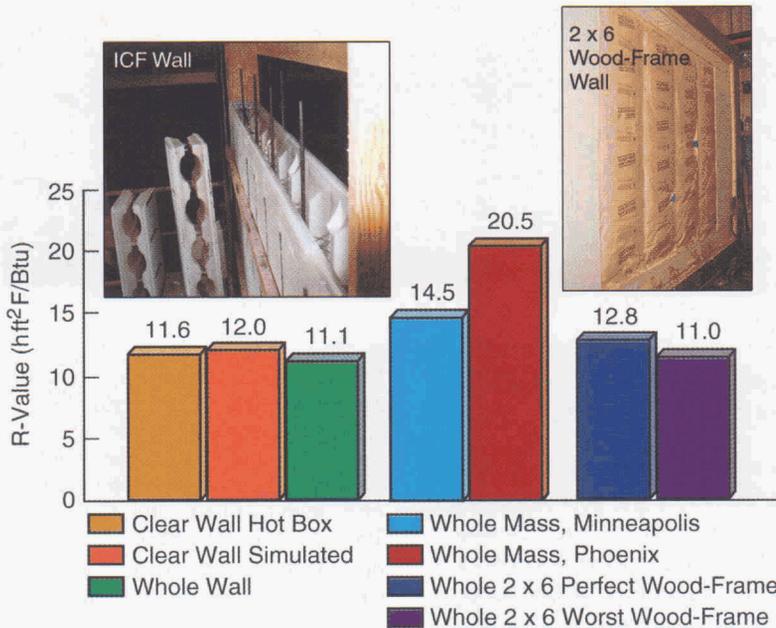
## A Whole-Wall Thermal Performance Calculator on the Net

As a part of the building “envelope,” a building’s wall helps provide a thermal barrier between the indoor and outdoor environment and is one of the key determinants of the building’s energy requirement. Researchers at the BTC have now developed a method of estimating the whole-wall

To assist in choosing a wall system, line and rendered drawings of structural details are available. This interactive calculation tool can accept custom building plans. Once a wall system is selected and options are chosen, the calculator supplies the whole-wall R-value. The total time

whole-wall R-values. The database for the calculator is growing, with other wall systems being added to the calculator periodically as more systems undergo testing and analysis. The completed whole-wall rating procedure will eventually provide a means to compare wall systems with respect to five elements: thermal shorts, exterior envelope thermal mass benefit, air-tightness, moisture control, and sustainability.

One of the Whole-Wall Thermal Performance Calculator’s comparisons of R-values. The R-values for an insulated concrete form (ICF) wall as tested in a guarded hotbox and as calculated are comparable to a whole-wall R-value of 14.5 in a cold climate (Minneapolis) and 20.5 in a hot climate (Phoenix) and to more conventional wood-frame systems.



thermal performance that can be used by anyone and have posted it as an interactive calculator on the World Wide Web.

The Whole-Wall Thermal Performance Calculator allows users to select a structural wall system type and then choose various options (e.g., interior finish, exterior sheathing) specific to that wall type.

needed to input the building description into the calculator and receive the results is less than 10 minutes per wall system. The tool can be found at [www.ornl.gov/roofs+walls/whole\\_wall/wallsys.html](http://www.ornl.gov/roofs+walls/whole_wall/wallsys.html).

For the development of this tool, more than 15 wall system manufacturers submitted over 40 different wall systems for generation of

**References:** J. E. Christian, J. Kosny, and A. O. Desjarlais, “The Whole Wall Thermal Performance Calculator—On the Net,” in *Proceedings of the Seventh Conference on Thermal Performance of Exterior Envelopes*, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), December 1998.

J. Kosny, J. E. Christian, A. O. Desjarlais, et al., “The Performance Check between Whole Building Thermal Performance Criteria and Exterior-Wall-Measured Clear Wall R-Value, Thermal Bridging, Thermal Mass, and Airtightness,” in *ASHRAE Transactions* 104, pt. 2, 1998.

**Sponsor:** DOE Office of Building Technology, State and Community Programs

**For more information:** [www.ornl.gov/roofs+walls/whole\\_wall/wallsys.html](http://www.ornl.gov/roofs+walls/whole_wall/wallsys.html)

**Contact:** André Desjarlais  
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## Development of a Residential Gas Absorption Heat Pump

The generator-absorber heat exchanger (GAX) concept was originally described in 1913 by Altenkirch, who showed a generator and an absorber operating with overlapping temperatures. Although the GAX is a simple thermodynamic concept, it is difficult to achieve in compact hardware. Therefore, the GAX concept was not put into practice until the early 1980s, when Phillips Engineering, sponsored by DOE under an ORNL-directed subcontract, developed the basic GAX technology and the first working prototypes.

An absorption heat pump does not use a compressor or environmentally damaging refrigerants. Instead, refrigerant vapor is absorbed in a solution, which is then pumped to a high-pressure generator chamber where it is heated and the refrigerant boils off as a high-pressure vapor. A natural gas burner supplies the heat to the generator. The heat-exchange loop between the generator and absorber increases the cooling efficiency of the GAX by recycling the heat released in the absorber when the refrigerant mixes with water.

A major environmental advantage of the GAX cycle is its use of ammonia and water rather than long-lived, environmentally damaging refrigerants. GAX units also consume less power, thus substantially reducing carbon emissions from the burning of fossil fuels in power plants and seasonal

peak demands on the electricity system. For consumers, the energy efficiency of the GAX cycle translates into lower energy bills.

ORNL's prototype GAX heat pump, consisting of the Phillips prototype GAX heat pump outdoor assembly coupled to a standard off-the-shelf indoor fan coil unit, began full operation at ORNL in early 1998. The measured heating efficiency of the unit is 33% better than that of the best existing gas condensing furnace.

DOE is now working with HVAC equipment manufacturers and the natural gas industry to move GAX heat pump products successfully into residential and light commercial markets. In two separate projects currently being funded by ORNL, a manufacturer of lower-efficiency single-effect absorption chillers is introducing chillers based on GAX

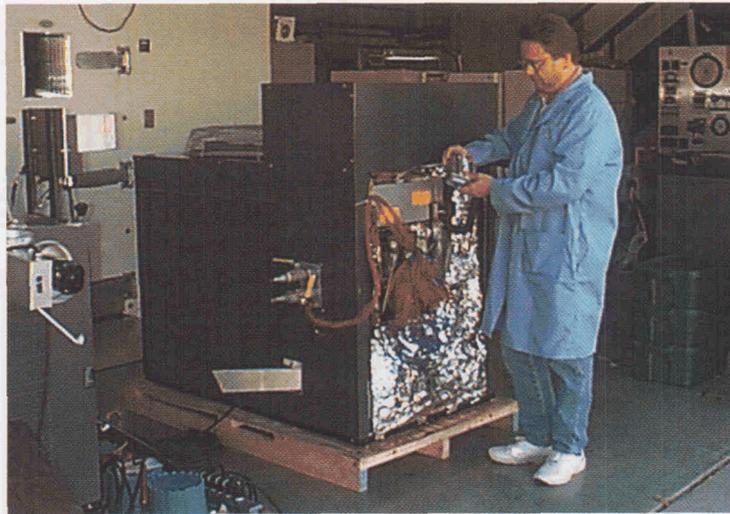
technology and completing pre-production prototypes of a GAX heat pump; and a consortium of gas utilities is partnering with HVAC manufacturers to bring GAX heat pumps to the market in high volume. The generator-absorber heat exchanger heat pump fueled by natural gas is expected to increase the efficiency of new gas heating and cooling units by 40% over existing technology.

**Reference:** B. A. Phillips, *Development of a High-Efficiency, Gas-Fired Absorption Heat Pump for Residential and Small-Commercial Applications, Phase I Final Report: Analysis of Advanced Cycles and Selection of the Preferred Cycle*, ORNL/Sub/86-24610/1, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1990.

**Sponsor:** DOE Office of Building Technology

**For more information:**  
[www.ornl.gov/BTC/resabhp.html](http://www.ornl.gov/BTC/resabhp.html)

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The prototype GAX heat pump tested at ORNL had a heating efficiency 33% better than the best gas condensing furnace.



# ACCOMPLISHMENTS

## The “Fridge of the Future”

To meet the government’s new energy standard for refrigerators—a 30% reduction for units manufactured after July 2001—BTC researchers have designed and demonstrated a “fridge of the future” that uses half as much energy as today’s refrigerator-freezers (RFs) and one-fifth as much as 1972 models: the 1 kilowatt-hour per day refrigerator.

In a CRADA with the Appliance Research Consortium (ARC), a subsidiary of the Association of Home Appliance Manufacturers, researchers adapted a standard 1996 baseline 20-ft<sup>3</sup> RF cabinet by adding various features that would improve energy efficiency, including vacuum insulation panels around the freezer section, polyurethane foam in the doors, replacement of AC motors with more efficient DC motors, and replacement of the automatic defrost control with

Refrigerator/freezer	Energy consumption (kWh/d)	Run time* (%)	Manufacturer cost increase (\$)	Simple payback time (yr)
<b>A</b> Baseline unit	1.68	44.2	—	—
<b>B</b> Unit A with 2-in.-thick doors, high-efficiency compressor, low-wattage condenser fan, and adaptive defrost scheme	1.16	47.6	53.38	6.6
<b>C</b> Unit B with vacuum insulation around freezer section and larger evaporator	0.93	36.5	134.33	11.4

\*Percentage of time compressor runs each hour.

an adaptive defrost that operates only when needed.

These improvements cut power consumption to 0.93 kWh/day, a performance that exceeds the 2001 energy standard and that would save \$6.5 billion annually if all the 125 million RFs in the United States operated as

efficiently. Researchers also tested a less expensive modified unit without the vacuum insulation. This modified unit consumed 1.16 kWh/day, a performance that would be about 44% more efficient than the 1993 standard and would save \$4.5 billion annually in the United States.

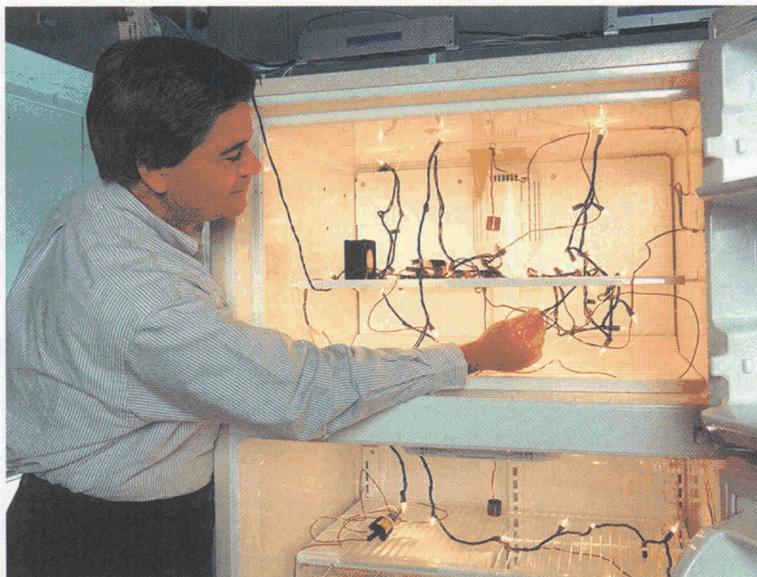
This achievement has been widely reported in the news media, including spots on Paul Harvey’s “News and Comments” and in *Popular Science* magazine.

**Reference:** E. A. Vineyard and J. R. Sand, “Experimental and Cost Analyses of a One Kilowatt-Hour/Day Domestic Refrigerator-Freezer,” *ASHRAE Transactions* 103, pt. 2 (1997).

**Sponsor:** DOE Office of Building Technology, State and Community Programs

**For more information:** [www.ornl.gov/BTC/adv-rf-tech.htm](http://www.ornl.gov/BTC/adv-rf-tech.htm)

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A BTC researcher checks the test instrumentation in the highly efficient refrigerator developed at ORNL.

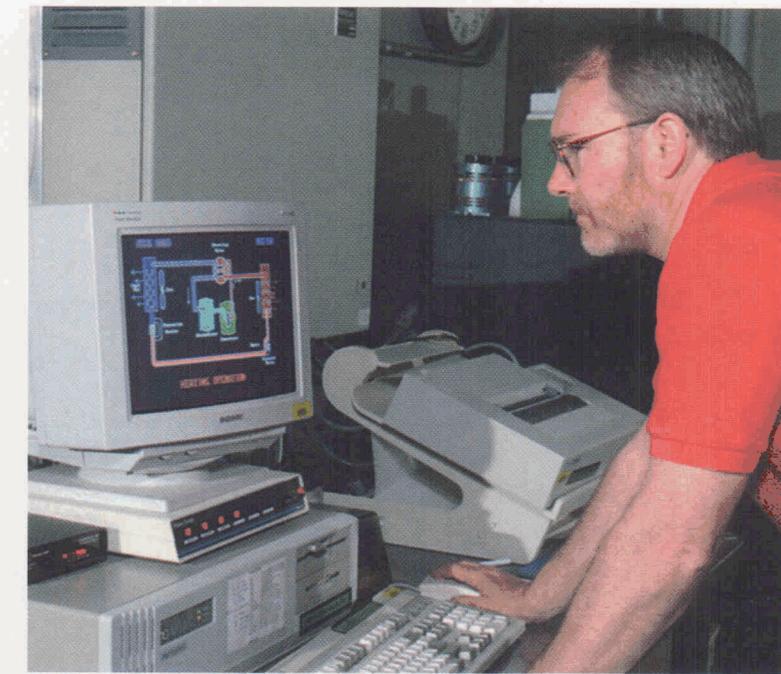


## DOE/BTC Heat Pump Design Model Is a Hit on the Web

The DOE/BTC Heat Pump Design Model (HPDM) is one of the most widely used products of the BTC Heating and Cooling Program. Over 300 copies of the model have been distributed to users worldwide, and it is actively used by companies representing about 30% of the U.S. unitary equipment market.

The HPDM is a hardware-based steady-state performance simulation and design tool for air-to-air heat pumps. Single- and variable-speed versions are available; the latest version includes the leading near-azeotropic HFC alternatives. The program runs extremely quickly (less than 1 second on a 90-MHz Pentium) for a single design point simulation and has versatile input options allowing simultaneous two-parameter studies of many system design variables. The HPDM also has off-design charge inventory balancing capability for assessing heat pump performance over a wide range of heating and cooling ambients with a variety of flow control devices. This model has been widely distributed to industry, university, and research groups.

The latest release of the model, Mark V, is able to simulate air-to-air heat pumps using the leading HFC alternatives to R-22, such as R-410A, R-404A, R-507, and the natural refrigerant propane. AlliedSignal used the HPDM to optimize heat pump systems using R-410A



ORNL's Heat Pump Design Model, available on the Web, is being widely used by industry and other groups.

and was able to show an improvement in efficiency over R-22. The company further concluded that higher-efficiency systems derive even larger benefits from R-410A. Purdue University selected the HPDM over two other public domain models (one from the National Institute of Standards and Technology and one from Purdue) for use in simulating heat pump performance at extreme ambient conditions under an ASHRAE-funded research project. The model was used by a utility consultant who designed and tested a unit for improved operation at peak cooling conditions. An interactive version of the Mark V model is available on the World Wide Web at [www.ornl.gov/~wlj/hpdm/doehpdm.html](http://www.ornl.gov/~wlj/hpdm/doehpdm.html).

**References:** C. K. Rice, "DOE/ORNL Heat Pump Design Model: Overview and Application to R-22 Alternatives," pp. 43-66 in *3rd International Conference on Heat Pumps in Cold Climates*, August 11-12, 1997, Caneta Research, Mississauga, Ontario, 1997.

J. Zheng, et al., "Optimization Strategies for Unitary Air Conditioners Using R-410A," pp. 69-74 in *Proceedings of the 1998 International Refrigeration Conference at Purdue*, Purdue University, July 14-17, 1998.

**Sponsor:** DOE Office of Building Equipment

**For more information:**  
[www.ornl.gov/BTC/h\\_and\\_c.htm](http://www.ornl.gov/BTC/h_and_c.htm)

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# ACCOMPLISHMENTS

## A Frostless Heat Pump for Residential Use

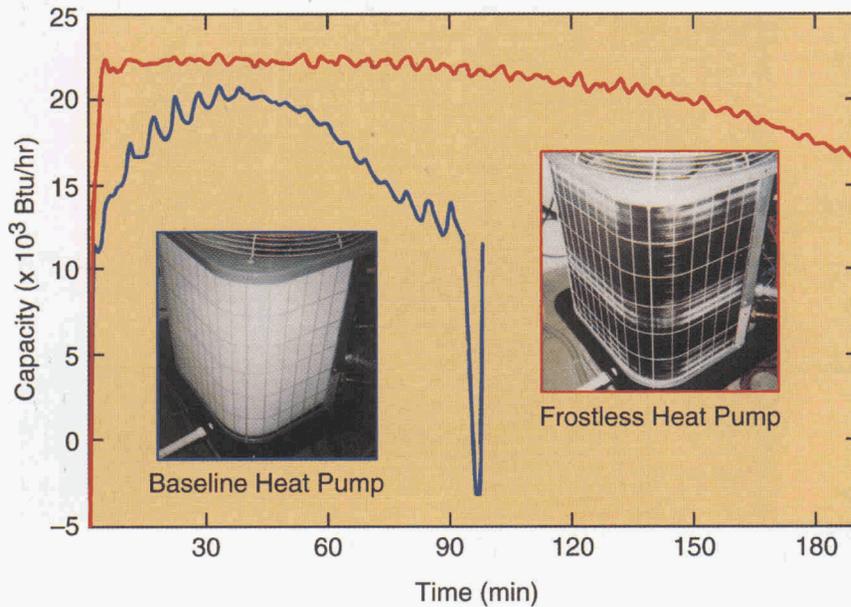
Heat pumps, used as primary residential space conditioning systems in many temperate climates, have inherent

pump outdoor coil frosting to ambient temperatures as low as 33°F and that it eliminates the need for reverse-cycle

ORNL new technology was virtually frost-free. In addition, the ORNL frostless heat pump maintained a constant supply air temperature of around 92°F over the entire test period, while the corresponding supply air temperature of the baseline unit dropped to 82°F.

This ORNL innovation could prove beneficial to further advancing energy-efficient heat pump technology for space conditioning, as well as reducing the national energy demand from buildings and therefore carbon emissions that lead to global warming.

At 39°F and 75% relative humidity, the ORNL frostless heat pump performed much better than the standard baseline unit, which was covered with frost after 90 minutes.



requirements for defrosting of the outdoor evaporator coil during the winter heating season when frost forms.

Researchers at the BTC have developed a new concept that minimizes the formation of frost on heat pump outdoor coils and have received a U.S. patent for this process. In this process, the strategic addition of controlled heat to the liquid stored in an accumulator increases the outdoor coil temperature, thereby retarding frost formation.

In the past year, test results of the new technology have shown that it reduces heat

defrosting under many conditions. The new ORNL frostless heat pump technology improves not only equipment defrosting but also the thermal comfort characteristics of the system. The laboratory test results compared the time-dependent frosting behavior and supply air temperatures of a baseline (off-the-shelf) heat pump and the ORNL frostless heat pump at 39°F air temperature and 75% relative humidity ambient conditions. The outdoor coil of the baseline unit was covered with frost after 90 minutes of continuous operation, while the heat pump unit using the

**Reference:** R. E. Domitrovic et al., "Study of a Frostless Heat Pump," in *Proceedings of the Conference on Renewable and Advanced Energy Systems for the 21st Century*, American Society of Mechanical Engineers, Maui, Hawaii, April 11-15, 1999.

**Sponsor:** Tennessee Valley Authority

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### The Largest Demonstration of the Energy Savings of Geothermal Heat Pumps

The BTC has played a very active role in DOE's efforts to promote the use of geothermal heat pumps (GHPs). One of the center's most significant accomplishments in this area was an independent evaluation of the largest GHP application in the world (the army base at Fort Polk, Louisiana), in which GHPs were installed to replace inadequate and aging heating and cooling systems.

The final reports on the Fort Polk evaluation were published March 1998 and have been broadly distributed. This project provided irrefutable documentation of the energy and maintenance savings from use of the GHPs and developed a number of models and techniques both for effective installation of GHPs and for estimating savings in GHP projects.

ORNL's Fort Polk evaluation results have already dramatically increased the comfort level of federal customers considering GHP mega-projects, and the following summary makes it easy to see why. In a typical year the energy savings of the project are 33% of pre-retrofit electric consumption and 100% of the gas consumption for heating and hot water. Summer peak demand for electricity decreased 43%.

In addition to energy and demand savings, the Army is avoiding the costs of replacing

aging equipment upon failure and the ongoing costs of a previous maintenance subcontractor (estimated at 24¢/ft<sup>2</sup> of building floor area per year) by hiring the energy service company (ESCO) that installed the project to perform those duties for 18¢, for a net savings of 6¢/ft<sup>2</sup>/year.

As a result of the performance contract, the Army incurred no initial costs, got all new equipment, and will save \$345,000 per year on energy and maintenance costs during the 20-year project. Occupant comfort is also greatly increased, a "quality-of-life" plus for the Army.

Other BTC accomplishments in DOE's GHP program have included

- a leading role in efforts to broaden deployment of GHPs in the federal sector via energy savings performance contracts (ESPCs);
- development of the first validated capability to represent residential and large commercial-scale GHP projects in engineering models to analyze building energy use and estimate energy and demand savings;



ORNL conducted a definitive evaluation of the installation of geothermal heat pumps in 4,003 family housing units at the Fort Polk, Louisiana, army base.

- a leading role in efforts to broaden use of GHPs in K-12 schools through DOE's Rebuild America and Energy Smart Schools programs; and
- development of a fast, statistically valid procedure for estimating soil/rock formation and borehole thermal properties from test data on vertical borehole ground heat exchangers.

**References:** P. J. Hughes and J. A. Shonder, *The Evaluation of a 4000-Home Geothermal Heat Pump Retrofit at Fort Polk, Louisiana: Final Report*, ORNL/CON-460, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1998.

P. J. Hughes et al., *Methodology for the Evaluation of a 4000-Home Geothermal Heat Pump Retrofit at Fort Polk, Louisiana*, ORNL/CON-462, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1998.

**Sponsor:** DOE Office of Utility Technologies

**For more information:**  
[www.eren.doe.gov/femp/financing/ghptools.html](http://www.eren.doe.gov/femp/financing/ghptools.html)

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## ACCOMPLISHMENTS

### The Center for Energy and Environmental Analysis

#### ORNL Aids Guatemala in Pursuing Environmental and Economic Sustainability in Rio Dulce Region

Sustainable development can be most difficult to achieve in developing countries, especially in areas where scenic and biodiversity resources need protection. Here, the need to weigh job creation against biosphere protection, economic growth against ecosystem valuation, local priorities against global priorities, can be both dramatic and painful.

One case of this confrontation of values is the Rio Dulce National Park (RDNP) in eastern Guatemala, a unique and beautiful tropical river ecology extending from Lake

long-term environmental management, and sustainable resource use—this area will have lost its special character forever.

In a collaborative effort between the Guatemalan government, the U.S. Agency for International Development, and ORNL's Developing Countries Program, Energy Division staff have been assisting in meeting this challenge over the past two years. First, an environmental impact assessment of a proposed project involving commercial use of the river was carried out to inform stakeholders and decision-makers. In the

Guatemala is now using the recommendations that resulted from the strategic assessment to prepare a new master plan for the RDNP, including regulations to control river uses and financial mechanisms for revenue generation to support the RDNP. As part of the master plan, 35 park guards are being trained to manage the park, establishing for the first time a permanent presence in the park, and demonstrating the government's determination to reverse the environmental deterioration of the region.

These positive developments in the Rio Dulce are considered especially important in Guatemala and Central America because they represent a model for other areas. They demonstrate not only a move toward more effective environmental management of biospheres of special importance, but also how sound information-gathering, analysis, and assessment can help such management planning to be more appropriate and more successful.

**Reference:** J. T. Ensminger, R. D. Perlack, and J. Ranney, *The Transport of Gmelina Logs on the Rio Dulce: Final Environmental Impact Assessment*, ORNL-M 6691, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1999.

**Sponsor:** U.S. Agency for International Development

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The new master plan for the Rio Dulce area will allow Guatemala to minimize commercial development, such as this marina, in the national park.



Izabal to the Caribbean Sea. The Guatemalan government's objective for the area has been to protect biological diversity and at the same time create jobs and incomes through ecotourism. Current land and river use trends, however, pose serious threats to these potentials. Unless effective action is taken very soon—including policies, laws, and institutions for environmental restoration,

process, a new standard for environmental impact assessment in Guatemala was established. Second, ORNL and Guatemalan partners conducted a strategic environmental assessment of policy and management options for the RDNP. Public consultation regarding the results of this effort is under way. This represents another innovation in environmental policymaking in this country.

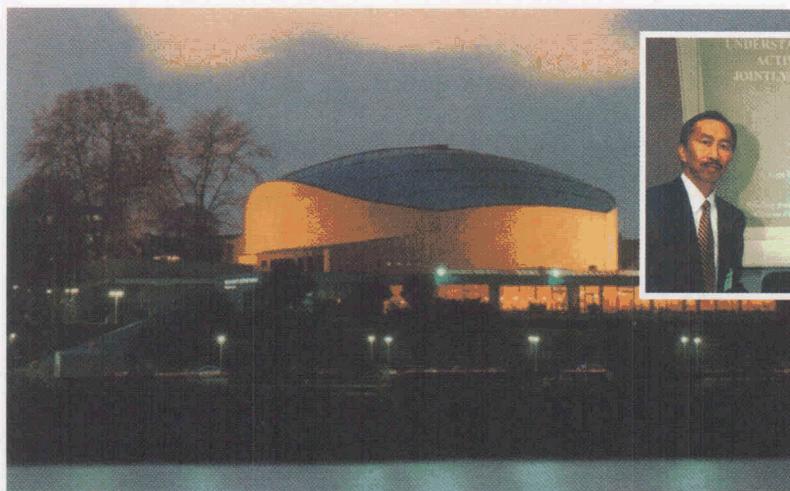


### JIEE and ORNL Participate in Meetings of the U.N. Framework Convention on Climate Change

In December 1997 in Kyoto, Japan, at the meetings of the United Nations Framework Convention on Climate Change (UNFCCC), the world reached a major milestone in its efforts to address the problem of climate change from greenhouse gas emissions. The Kyoto Protocol calls on the industrialized countries to reduce their emissions by the year 2012 to levels about 7% below their emissions in the year 1990.

Among the key features of the Protocol are the so-called flexibility mechanisms, Joint Implementation (JI) and the Clean Development Mechanism (CDM). These provisions allow countries to meet their emissions-reduction commitments, in part, by engaging in projects in other countries whose effects are to reduce greenhouse gas emissions. The concept behind these mechanisms is beguilingly simple and attractive: use the lowest-cost opportunities to reduce greenhouse gas emissions, wherever they exist. The costs of doing so would be borne by those obligated to reduce their emissions as a result of the Protocol.

What has enthusiastic support in some countries has aroused substantial opposition in others, especially some developing countries. Working under the Joint Institute for Energy and



An ORNL staff member and a DOE official discuss climate change policy at the UNFCCC meetings, which took place in Bonn's Beethovenhalle (background photo).

Environment (JIEE)—a collaborative organization established by ORNL, the Tennessee Valley Authority, and the University of Tennessee (UT) to perform research on critical topics related to energy and the environment—six ORNL and UT researchers, including the Energy Division's Russ Lee and Tom Wilbanks, issued a report just before the Kyoto meetings entitled *Understanding Concerns about Joint Implementation*. This study analyzes the main objections raised against JI and CDM and outlines ways in which the obvious potential for global gain can be realized. Russ Lee presented the results of the report at UNFCCC meetings in Bonn, where preliminary negotiations were held prior to Kyoto.

To the surprise of many, an agreement was reached in the negotiations in Kyoto. In addi-

tion to the commitments to reduce greenhouse gas emissions, central to the Protocol, the most important elements of the agreement were the sanctioning of emissions permit trading and the CDM. The CDM bears a striking resemblance to many of the ideas in the JIEE report.

**Reference:** R. Lee, J. R. Kahn, G. Marland, M. Russell, K. Shallcross, and T. J. Wilbanks, *Understanding Concerns about Joint Implementation*, JIEE Occasional Paper 97-6, Joint Institute for Energy and Environment, October 1997, available online at [www.jiee.org/jpubs.htm](http://www.jiee.org/jpubs.htm).

**Sponsor:** DOE Office of Policy and International Affairs

**For more information:** *The United Nations Framework Convention on Climate Change and the Kyoto Protocol*, accessed: February 23, 1999, available online at [www.unfccc.de/fccc/conv/file01.htm](http://www.unfccc.de/fccc/conv/file01.htm).

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## ACCOMPLISHMENTS

### Strategic Options for DOE's Cleanup Program

DOE's Office of Environmental Management (EM) is responsible for ensuring the safety of lands and facilities contaminated by years of weapons production and related research throughout the DOE Complex. This activity is scheduled to continue for 70 years at a cost of about \$6 billion per year.

To ensure that the public is well served by such large, long-term expenditures, DOE-EM invests in analyses to scrutinize current practices and suggest new ones. As part of this scrutiny, the Energy Division's Economic Policy Analysis Program, working through the Joint Institute for Energy and Environment, conducts an ongoing program entitled Strategic Options for DOE's Cleanup.

It uses cost-benefit and risk analysis to develop strategic options for EM to work more efficiently, effectively, and responsively. The target of the analysis is Headquarters guidance for broad program initiatives, not individual projects or purely technical issues.

Strategic Options for DOE's Cleanup has developed option papers on wide-ranging topics:

- overall program strategy,
- divorcing the goals of risk management from desires to provide economic support to local communities,
- an outcome-oriented risk planning program to guide the setting of cleanup priorities,

- implementing outcome-oriented risk planning,
- managing technology development for environmental management,
- privatization through contract reform, and
- legal implications of programs that seek flexibility in cleanup.

Among studies currently under way are DOE cleanup and the national environmental agenda, issues in local economic sustainability, and stewardship of residual lands.

The program draws on the talents of an interdisciplinary research team with expertise in economic policy analysis, applied microeconomics, numerical analysis, engineering, and environmental law. Publications and papers are available through the link to the Economic Policy Analysis Program on the CEEA Web site noted below.

**References:** D. J. Bjornstad, C. Dümmer, and D. W. Jones, "DOE-EM Privatization and the 2006 Plan: Principles for Procurement Policies and Risk Management," *Technology: Journal of the Franklin Institute*, February 1998.

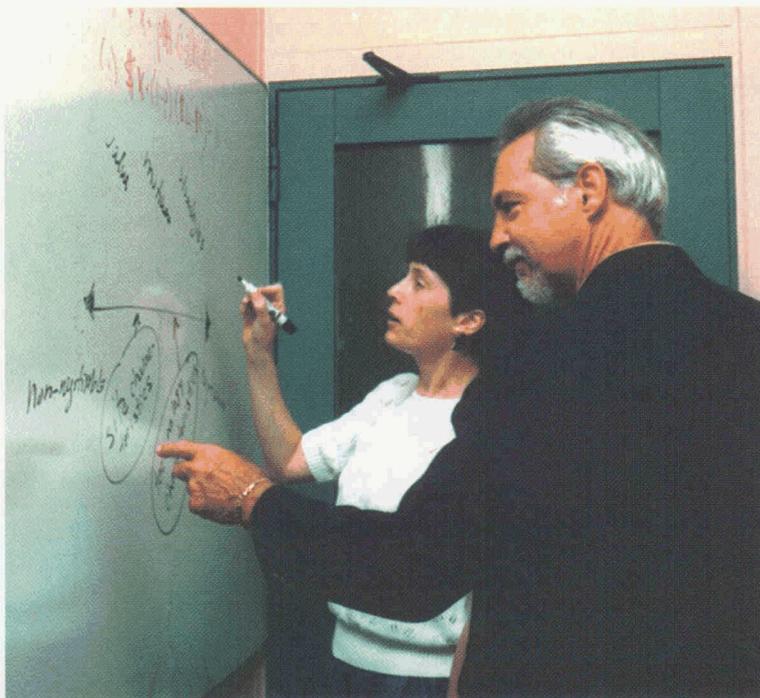
D. J. Bjornstad, R. C. Cummings, and L. Osborne, "A Learning Design for Reducing Hypothetical Bias in the Contingent Valuation Method," *Environmental and Resource Economics* 10 (1997).

**Sponsor:** DOE Office of Environmental Management

**For more information:**  
[www.ornl.gov/ceea/home.html](http://www.ornl.gov/ceea/home.html)

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An interdisciplinary team at ORNL is developing strategic options for cleanup throughout the DOE complex.



### Composite Analysis for Solid Waste Storage Area 6, Oak Ridge Reservation

As a result of a recommendation by the Defense Nuclear Facilities Safety Board that DOE evaluate all contributing sources of contamination as part of regulating the disposal of low-level radioactive waste (LLW), DOE has required a composite analysis (CA) for every LLW disposal facility. The CA and a performance assessment (PA) for a disposal facility form the technical basis for issuing a Disposal Authorization Statement by DOE Headquarters that permits the disposal of such wastes.

CEEA staff conducted such an analysis for Solid Waste Storage Area 6 (SWSA 6), a solid-waste disposal facility located about 2 miles south of ORNL on a 68-acre tract of land. About 30 acres of the site are suitable for disposal operations. The facility is projected to continue operations until the currently operating Interim Waste Management Facility (IWMF) disposal unit is filled to capacity: the IWMF is currently filled to 50% capacity. The CA was conducted to provide an estimate of the potential cumulative impacts to a hypothetical future member of the public from SWSA 6 disposal operations and from all other sources of radioactive material in the ground on the Oak Ridge Reservation (ORR) that might interact with contamination originating in SWSA 6.

Dose assessments were conducted for the first 1000 years

after disposal for comparison with the primary dose limit and the dose constraint. The data used in the analysis resulted in the definition of radioactive source inventories of important radionuclides in the White Oak Creek watershed in Melton and Bethel Valleys. Transport of radioactive materials in water



Aerial view of Solid Waste Storage Area 6, with the Interim Waste Management Facility at left. The composite analysis indicated that SWSA 6 poses no danger to public health under current land-use plans.

was the only release pathway considered in the CA because historical data on releases of radioactive material for the ORR and the findings of the PA have shown that releases by other pathways are insignificant compared with releases in water.

The results determined in the CA indicate that the potential dose from all contributing sources in the watershed is significantly less than the dose constraint (0.5 mrem/year), assuming the current ORR land use boundary. For a hypothetical case in which the land use boundary is changed to allow access to the shoreline of the Clinch River, however, the potential dose exceeds the

primary dose limit (500 mrem/year) at White Oak Dam. Thus, SWSA 6 meets the requirements for the CA for all existing sources of contamination that could contribute to the potential dose from LLW disposals, provided that the current system of land use controls is maintained on the

ORR. Changes in the land use plan for the ORR that would include the release of land along the shoreline of the Clinch River would require the implementation of alternatives to reduce potential exposures to individuals in the future. Current actions being considered by the CERCLA program are directed toward addressing this need.

**Reference:** *Composite Analysis for Solid Waste Storage Area 6*, ORNL-6929, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1997.

**Sponsor:** DOE

**For more information:** [www.ornl.gov/ceea/pubs/swsa6ca\\_xs.html](http://www.ornl.gov/ceea/pubs/swsa6ca_xs.html)

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## ACCOMPLISHMENTS

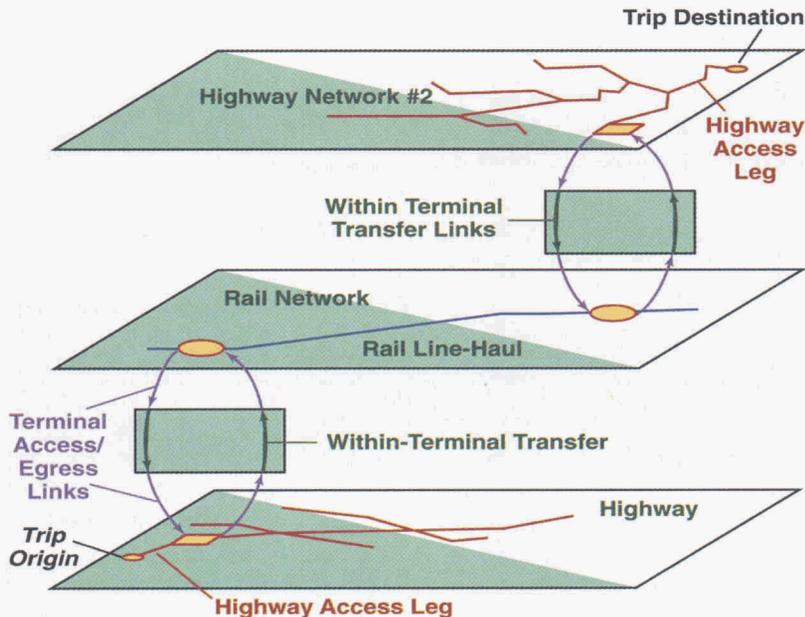
# The Center for Transportation Analysis

## Analytical Support for the Nation's Multimodal Travel Surveys

CTA staff have played an important role in helping government understand how, and how much, households and companies use the nation's transportation system. A key activity has been

mile statistics at the national level, for individual states, and for the nation's largest metropolitan areas. A unique feature of both ATS and CFS is their emphasis on the intermodal nature of travel,

U.S. zip code location, through specific U.S. airports and seaports, to foreign destinations. Intermodal trip-making required linking together the different modal components of a trip, as shown in the illustration. This work has also led to the creation of a multimodal, multiterminal, and multinational network database that allows routing between any two places in the United States by any mode sequence. For example, the highway-rail-waterways network used in CFS contains over 126,000 links, representing some 784,000 miles of road, rail, and waterways infrastructure.



A CFS modeling example: a truck-rail-truck routing through two intermodal terminals.

**References:** F. Southworth, D. Xiong, and D. P. Middendorf, "Development of Analytic Intermodal Freight Networks for Use within a GIS," pp. 201-18 in *Proceedings of the 1997-GIS-T, Geographic Information Systems for Transportation Symposium*, Greensboro, N.C., March 24, 1997.

F. Southworth, B. E. Peterson, and S. M. Chin, *Methodology for Estimating Freight Shipment Distances for the 1997 Commodity Flow Survey*, report prepared for the Bureau of Transportation Statistics, U.S. Department of Transportation, Washington D.C., 1998.

**Sponsor:** U.S. Department of Transportation, Bureau of Transportation Statistics

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the simulation of passenger and freight movements over the nation's air, highway, rail, water, and pipeline networks, based on data collected by the Bureau of the Census as part of the 1995 American Travel Survey (ATS) and 1997 Commodity Flow Survey (CFS).

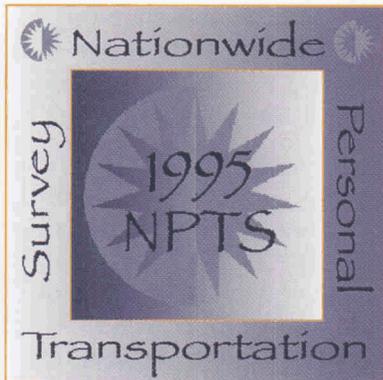
ATS is a nationwide survey of long-distance personal travel. CFS is a nationwide sample of freight shippers. Sample data from these two surveys are aggregated to provide passenger-mile, ton-mile, and dollar-

which they maintain by sampling complete door-to-door movements of people and goods, respectively, across a wide range of trip purposes (ATS) and commodities (CFS).

CTA simulated the routes taken by over one million person trips for the 1995 ATS and over 5.5 million shipments for the 1997 CFS. Movements for both surveys are simulated at the zip code area-to-area level, or from a



## Nationwide Personal Transportation Survey Data on the Web



Data on how much time and effort Americans put into driving, flying, cycling, walking, and using public transit—as well as why, when, and how far they are likely to travel—are collected every five years by the National Personal Transportation Survey (NPTS). The survey also collects data on how travel differs by, among other things, age, sex, income, and size of urbanized area. A great many cross-tabulations of data are possible with the survey data, although creating them was, in the past, an involved exercise in data acquisition and manipulation.

To support rapid access to this complex database, CTA staff were tasked by the Federal Highway Administration to develop an interactive, user-friendly, web-based data analysis tool. The resulting

web site has proved to be a great success. Unlike most online user-support software, this tool also serves as a “virtual analyst” that handles user-specified data queries in real time, with results usually transmitted back in under two minutes. In 1998 Department of Transportation Secretary Rodney Slater recognized the web site as a valuable tool for accessing transportation data.

The latest NPTS data (1995) can be accessed at [www.cta.ornl.gov](http://www.cta.ornl.gov).

[ornl.gov/npts/1995/Doc/index.shtml](http://www.cta.ornl.gov/npts/1995/Doc/index.shtml). The site is currently receiving more a thousand special-interest visits per month.

**Reference:** [www.cta.ornl.gov/npts/1995/Doc/publications.shtml](http://www.cta.ornl.gov/npts/1995/Doc/publications.shtml)

**Sponsor:** U.S. Department of Transportation, Federal Highway Administration, Office of Highway Information Management

**For more information:** [www.cta.ornl.gov/npts/1995/Doc/index.shtml](http://www.cta.ornl.gov/npts/1995/Doc/index.shtml)

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	Women		Men	
	1990 (Adj)	1995	1990 (Adj)	1995
Total	1,401 (100%)	1,558 (100%)	1,339 (100%)	1,579 (100%)
To or From Work	197 (14.1%)	229 (14.7%)	259 (19.3%)	327 (20.7%)
Work-Related Business	11 (0.8%)	23 (1.5%)	21 (1.6%)	60 (3.8%)
Family and Personal Business	693 (49.4%)	786 (50.5%)	549 (41.0%)	648 (41.1%)
School/Church	132 (9.4%)	141 (9.1%)	123 (9.2%)	134 (8.5%)
Social and Recreational	358 (25.6%)	375 (24.1%)	377 (28.2%)	406 (25.7%)
Other	9 (0.6%)	3 (0.2%)	9 (0.7%)	2 (0.1%)

The data generated by NPTS indicate how travel differs by various population subgroups. For instance, as this table indicates, women make more trips for family and personal business than do men. [From P. S. Hu and J. R. Young, *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey* (draft), ORNL, January 8, 1999.]



# ACCOMPLISHMENTS

## Dynamically Modeling the Transition to Alternative Fuels and Vehicles (TAFV)

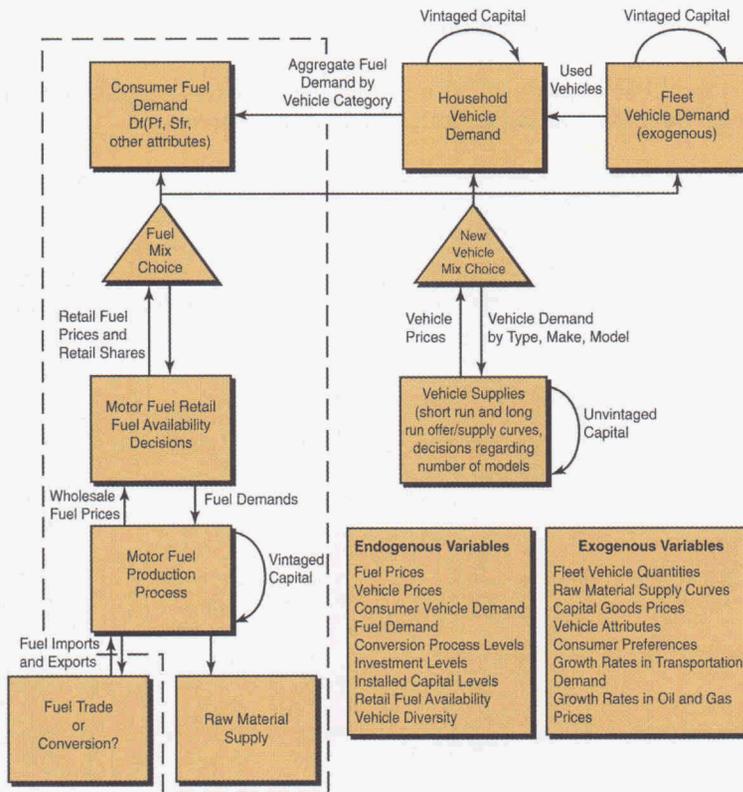
Lack of adequate infrastructure has long been recognized as a barrier to the market success of alternative fuel vehicles (AFVs). The problem is this: if no stations are offering a new fuel, people will not buy the vehicles that use it—and if no vehicles are using the fuel, no one will build the necessary production plants or distribution and retailing networks.

decision-making behavior of vehicle manufacturers, fuel producers and marketers, and consumers within a single model capable of analyzing policies designed to promote a transition to AFVs. The TAFV model boasts numerous technical innovations, including incorporation of multinomial discrete consumer choice theory into an integrated and theoretically

dedicated alcohol, natural gas, and electric vehicles as well as bi-fuel and flex-fuel gasoline and alcohol vehicles.

A recent report, *The Alternative Fuel Transition*, describes a series of recent evaluations using the TAFV model. The report covers the impacts of federal policies considered under the Energy Policy Act of 1992 to promote AFVs through federal, state, and private-sector fleet mandates. Using this unique analytical tool, the modelers were able to demonstrate that while requiring private fleets to purchase alternative fuel vehicles would significantly increase AFV sales, in the absence of other policies to subsidize or mandate fuel purchases, this action would result in little additional alternative fuel use by 2010.

The TAFV computer model created by ORNL analyzes policies that would promote a transition to alternative fuels and vehicles.



A multiyear research effort at ORNL has now produced a computer model that represents this complicated process of economic transition to a new technology. The research combines the dynamic

consistent dynamic programming framework. This breakthrough allowed modelers to incorporate the effects of fuel availability on consumers' choices among a wide range of fuels and vehicles, including

**References:** P. N. Leiby and J. Rubin, "The Transitional Alternative Fuels and Vehicles Model," *Transportation Research Record*, no. 1587 (1997): 10–18.

P. N. Leiby and J. Rubin, *The Alternative Fuel Transition: Draft Final Results from the TAFV Model of Alternative Fuel Use in Light-Duty Vehicles, 1996–2010*, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1998.

**Sponsor:** DOE Office of Policy and Office of Transportation Technologies.

**For more information:** <http://pzl1.ed.ornl.gov/altfuels.htm>

**Contact:** David Greene  
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## Emergency Management Center

### ORNL Investigates Chemical Accidents

Some 600,000 chemical incidents occurred in the United States between 1987 and 1996. U.S. chemical accidents kill about 256 persons each year. The causes of these accidents range from materials failures to human factors and human error—lack of training, use of unqualified personnel to do the work, or poor safety management.

To ensure the safety of workers and the public by preventing or minimizing the effects of industrial and commercial chemical incidents, the U.S. Chemical Safety and Hazard Investigation Board (CSB) was established in November 1997 as a scientific investigatory organization and independent federal agency. Modeled after the National Transportation Safety Board (which investigates aircraft and other transportation accidents to improve safety), CSB investigates the causes of chemical accidents and recommends ways to improve safety in the chemical industry.

To get its work done, CSB enlisted expert help from ORNL and DOE's Pacific Northwest Laboratories (PNL). The ORNL team—composed of Energy Division staff, staff from the Engineering Technology and Chemical Technology Divisions, and several University of Tennessee researchers—assisted in eight accident investigations for CSB in 1998. The accidents have included

explosions at a mining explosives plant in Nevada caused by operator error, a propane tank explosion at an Iowa turkey farm that was started when intoxicated teenagers collided with a tank pipe, and chemical process explosions in several states that were caused by pressure vessel failures.

Each of these events has posed unique challenges to the investigators attempting to determine the cause of the incident and develop recommendations to prevent a recurrence. Because chemical accidents are dominated by pressure vessel problems, for example, an ORNL team is systematically researching the causes of vessel failures. The team will also recommend methods for predicting and preventing such failures in chemical plants. In addition, the ORNL group has recommended better use of telecommunication technologies to obtain and transmit information more rapidly from the accident scene for analysis, so as to conduct chemical accident investigations more efficiently.

ORNL's future role in the CSB work will evolve from participation in the on-site accident



ORNL has assisted the Chemical Safety and Hazard Investigation Board in several on-site investigations of chemical accidents. [Photo provided by the Chemical Safety and Hazard Investigation Board.]

investigations to a more analytical role aimed at helping CSB analyze and understand information obtained from the accident scene and conducting research on how to avoid such accidents. ORNL researchers also plan to develop a database containing information on the causes of chemical incidents and recommended ways to prevent them.

**References:** Chemical Safety and Hazard Investigation Board, *Investigation Report: Explosives Manufacturing Incident, Sierra Chemical Company, Mustang, Nevada, January 7, 1998*, Report No. 98-001-I-NV, Washington, D.C., 1998. Online at [www.chemsafety.gov/1998/inv/98001nv.htm](http://www.chemsafety.gov/1998/inv/98001nv.htm).

Chemical Safety and Hazard Investigation Board, *Investigation Report: Union Carbide's Taft Facility Chemical Accident, Hahnville, Louisiana, March 27, 1998*, Report No. 98-005-I-LA, Washington, D.C., 1998.

**Sponsor:** U.S. Chemical Safety and Hazard Investigation Board

**For more information:** [www.chemsafety.gov](http://www.chemsafety.gov)

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e-mail: [sorensenhj@ornl.gov](mailto:sorensenhj@ornl.gov)



## ACCOMPLISHMENTS

### Chemical Stockpile Emergency Preparedness Program (CSEPP) Support

The United States is in the process of disposing of the nation's stockpile of chemical weapons. To help ensure the safety of this process, the Final Programmatic Environmental Impact Statement for the disposal program recommended a community-based emergency preparedness program. The Chemical Stockpile Emergency Preparedness Program (CSEPP), jointly managed by the Army and the Federal Emergency Management Agency (FEMA), was initiated as a result. CSEPP has the ambitious goal of achieving state-of-the-art plans with maximum public protection. It is being implemented in ten states surrounding U.S. chemical weapons storage facilities.

ORNL, through the Emergency Management Center, has provided the Department of Defense and FEMA with technical support for CSEPP since its inception in 1988. Applied research has been conducted to support planning, training, exercises, automation, public information, and reentry. Some of our significant contributions to CSEPP are

- a planning guide that defines state-of-the-art preparedness and response;
- a new approach for protective-action decision-making;
- a comprehensive training program addressing proper

response to chemical agents, including traditional and distance learning;

- a prototype of an advance emergency information system; and
- a new method for systematic review of emergency plans.

By combining research with application, CSEPP has become the most technically advanced emergency preparedness program in the country.

**References:** J. H. Sorensen, S. A. Carnes, and G. Rogers, "An Approach

for Deriving Emergency Planning Zones for Chemical Stockpile Emergencies," *Journal of Hazardous Materials* 30 (1992): 223-42.

G. Rogers, J. H. Sorensen, and A. Watson, "Protecting Civilian Populations during Chemical Agent Emergencies," pp. 357-86 in *Chemical Warfare Agents*, ed. S. Somani, Academic Press, London, 1992.

**Sponsor:** FEMA, Preparedness Directorate

**For more information:**  
<http://emc.ornl.gov>

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#### Examples of CSEPP Products and Publications Developed by ORNL's Energy Division

Computer models	<b>OREMS: Oak Ridge Evacuation Modeling System</b> <b>PADRE: Protective Action Dose Reduction Estimator Simulation</b> Simulation models developed for FEMA to estimate evacuation time in emergencies and to aid planners in developing protective action guides for chemical weapon accidents
CD-ROMs	B. Shumpert, <i>Emergency Planner's Companion: Command and Control</i> , 1996 B. M. Vogt and J. Sorensen, <i>Emergency Planner's Companion: Public Information and Education</i> , 1997
Databases	A. Smith, <b>CSEPP Planning Wizard</b>
Videos	B. M. Vogt and W. Clevenger, <i>Some Assembly Required: How Models Are Built and Used</i> , 1996
Publications	<i>Planning Guidance for the Chemical Stockpile Emergency Preparedness Program</i> , U.S. Department of the Army and FEMA, 1996. B. M. Vogt et al., <i>Compilation of Demographic Data for the Chemical Stockpile Emergency Preparedness Program</i> , ORNL/TM-13571, Oak Ridge National Laboratory, 1998.



# ONGOING R&D — THE SEARCH FOR ANSWERS



## The Buildings Technology Center

### Improving Building Energy Performance Benchmarks

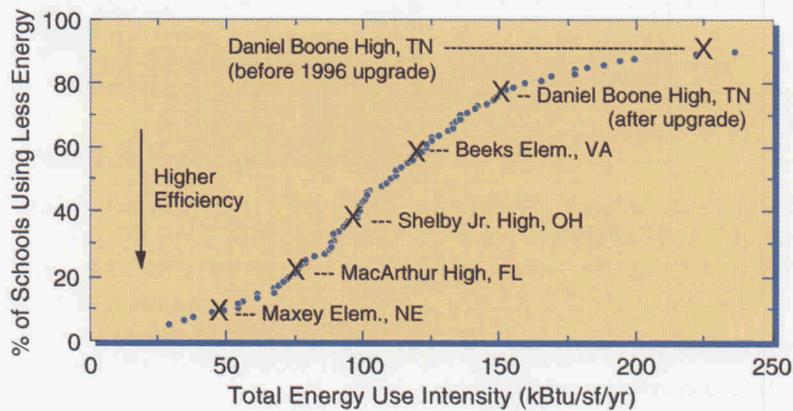
Building owners, managers, and energy service professionals interested in building efficiency upgrades regularly seek energy-use comparison benchmarks for their buildings to quickly gauge energy- and cost-savings potential. The average energy-use intensity (EUI) of a group of similar buildings (expressed in kBtu/ft<sup>2</sup>/year) is commonly used because averages are easy to develop and use. Recent research in the Buildings Technology Center (BTC), however, has shown averages to be poor energy performance benchmarks.

The BTC is developing new, distribution-based benchmarking spreadsheets to improve building energy performance comparisons with a similar emphasis on simplicity and ease of use. The tool will identify and quantify the impact of the major secondary influences—such as climate, people density, heating system types, and operating hours—on building energy use. These results will be used to normalize benchmarking distributions for secondary influences.

A cumulative distribution (or histogram) comprising the EUIs for individual buildings in a group is used. In the illustration, five schools are benchmarked against a distribution created from data on 449 schools across the United

efficiency, outperforming 90% of U.S. schools.

The BTC's spreadsheet-based benchmarking tools will be simple to understand and use. Almost instantly, a user with energy use and minimal



A cumulative distribution chart shows that energy efficiency in Daniel Boone High School could still be greatly improved, while Maxey Elementary is a model of energy efficiency.

States. The distribution indicates that 75% of U.S. schools have lower energy use intensities than Tennessee's Daniel Boone High, suggesting that sizable efficiency opportunities may exist even after a recent efficiency upgrade. By contrast, Nebraska's new Maxey Elementary School, with geothermal-based heating and cooling, is a model of energy

building characteristics data will be able to get an indicator of the hidden potential in a given building. Quick assessment tools such as this have broad application and benefit a wide range of users. Sponsor: DOE Office of Building Technology, State and Community Programs.

For more information, contact Terry Sharp, 423-574-3559 ([sharptr@ornl.gov](mailto:sharptr@ornl.gov)).

### Warming Impacts of HCFC Alternatives

As part of a CRADA with the Alternative Fluorocarbons Environmental Acceptability Study (AFEAS), a consortium of chemical manufacturers, BTC researchers evaluated the

total equivalent warming impact (TEWI) of alternatives to hydrochloro-fluorocarbon (HCFC) fluids.

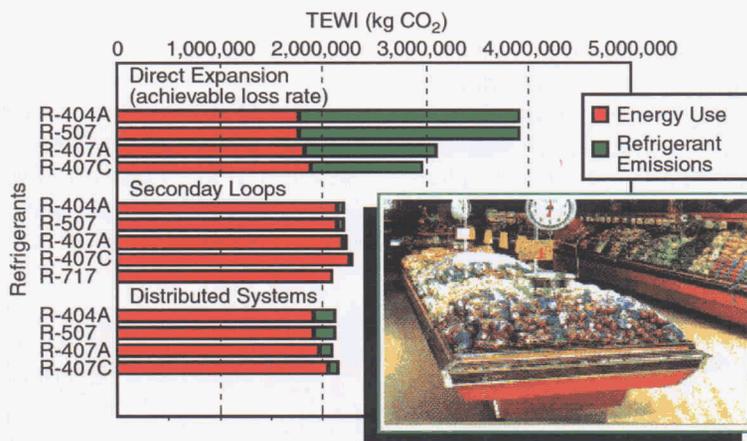
ORNL developed the TEWI index as a tool to combine the

global warming effects of direct refrigerant emissions with those of carbon dioxide emissions from energy use over the lifetime of a given heating, air-conditioning, or



## ONGOING R&D

The total equivalent warming impact (TEWI) index developed by ORNL indicates much higher emissions for conventional supermarket refrigeration systems (direct expansion) than for advanced (secondary loop and distributed) systems.



refrigeration system. TEWI has gained international acceptance as the preferred means to evaluate warming impacts.

The most recent TEWI project examined several alternatives as replacements for HCFC-based systems: hydrofluorocar-

bons (HFCs), near-zero-global-warming fluid alternatives (hydrocarbons, ammonia, and carbon dioxide), and emerging nontraditional or not-in-kind (NIK) technology options.

A summary of the Phase III study was published in a

headline article in the *ASHRAE Journal*. One of the principal conclusions of the study is that for systems with low refrigerant losses (e.g., refrigerator-freezers, heat pumps, and air-conditioning chillers), the best way to reduce TEWI is to increase system energy efficiency. For systems with high refrigerant loss rates (e.g., supermarket refrigeration and car air-conditioners), we must also find ways to reduce refrigerant emissions or to use alternative low-global-warming refrigerants or NIK technology alternatives. Sponsors: AFEAS and DOE Office of Building Equipment.

For more information, contact Van Baxter, 423-574-2104 ([baxtervd@ornl.gov](mailto:baxtervd@ornl.gov)).

## Developing Technologies for Practical Hydrogen Storage

If hydrogen is to become a dominant energy carrier for buildings, utility, and transportation applications, safe and cost-effective means for hydrogen production, use, and storage must be developed. For storage technologies, special considerations are energy efficiency, size, and weight. In particular, the absorption and desorption of hydrogen by storage materials require energy transfers to accommodate heats of hydrogenation and activation energies for the associated reactions. Both equilibrium amounts and rate aspects of the hydrogenation and dehydrogenation processes

can be limited by available temperatures and/or heat transfer capabilities. Therefore, the overall goal of an ongoing BTC project is to investigate thermal management technologies for hydrogen storage.

The near-term objective is to develop physical and heat transfer models to describe hydrogen absorption/desorption in fullerenes and related materials so as to characterize the behavior of the dynamic storage process. This family of giant cyclic alkene molecules (C<sub>60</sub>, C<sub>70</sub>, etc.) was selected because of its potential for high gravimetric and volumetric

hydrogen storage densities and because recent commercial production developments have led to rapidly declining prices. However, the large heats of hydrogenation attributed to most alkenes, and the high activation energies associated with the relevant absorption and desorption processes, indicated potential difficulties in the realization of such attractive storage performance in practical designs.

The approach adopted in the present project is to use the scientific and technical expertise of ORNL and its CRADA partner, a major manufacturer



of fullerenes and related materials, to (1) understand the mechanism of hydrogen storage in novel materials such as fullerenes, (2) optimize the hydrogen absorption/desorption properties of such materials, (3) develop the thermal management technol-

ogy needed to accomplish the associated processes for hydrogen storage in and removal from such media, and (4) construct and demonstrate an experimental hydrogen storage device based on the lessons learned. The methodology developed and the

experience gained for hydrogen storage in fullerenes and their derivatives can be applied to other options. Sponsor: DOE Office of Power Technologies.

For more information, contact Richard Murphy, 423-576-7772 (murphyrw@ornl.gov).

### Developing an Energy-Efficient Large Commercial Chiller

Researchers in the BTC are working in a cost-shared program with York International to improve U.S. economic competitiveness and energy efficiency by introducing a new gas chiller to the marketplace by the turn of the century. The objective of the DOE-sponsored work is to build a U.S.-developed triple-effect chiller that operates using LiBr/H<sub>2</sub>O fluids and has a coefficient of performance (COP) of 1.4, a 30% improvement over the best double-effect chillers currently on the market.

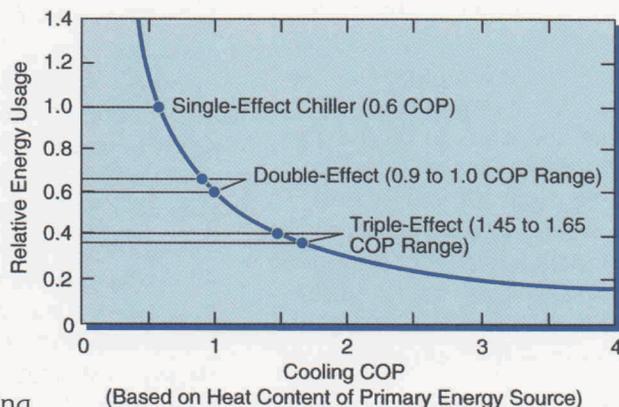
Currently, there are no triple-effect absorption chillers sold commercially. The predicted initial manufacturing cost of the triple-effect machine is somewhat higher than that of double-effect machines because of more expensive construction materials needed to reduce corrosion rates, larger heat exchanger surface areas, higher operating pressures, and more complicated control systems.

The objective of this project is to build fully functional hardware to demonstrate a practical triple-effect chiller for commercial air-conditioning applications. The design goal for the prototype is to achieve 450 tons of cooling capacity. The final goal is a U.S.-manufactured triple-effect absorption chiller.

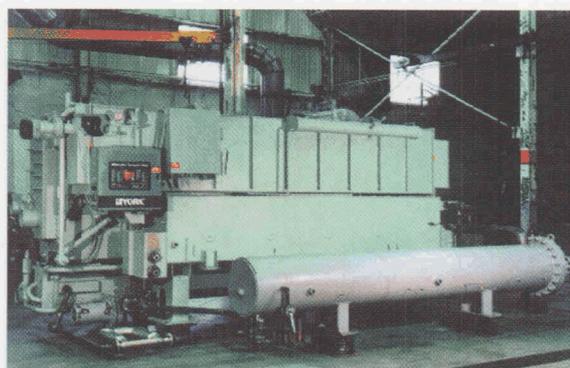
ORNL has reviewed several cycle possibilities for LiBr/H<sub>2</sub>O triple-effect chillers. One cycle in particular, the double condenser coupled (DCC) triple-effect cycle, has been patented by ORNL. This is

currently the base cycle being investigated by York International.

In 1997 and 1998, York successfully operated the 400-ton



Triple-effect chillers could reduce energy use and perform better than existing commercial chillers.



The York large commercial triple-effect chiller prototype, developed jointly with ORNL, is being tested.



laboratory prototype DCC triple-effect chiller and has proved that the DCC cycle performs as expected. In a field test, the 400-ton demon-

stration unit is to be installed at the Clark County Government Center in Las Vegas, Nevada, in late 1999 or early 2000. Sponsor: DOE Office of

Energy Efficiency and Renewable Energy.

*For more information, contact Patti Garland, 202-479-0292 (garlandpw@ornl.gov).*

### Liquid Over-Feeding Air Conditioners for Residential Use

Many air conditioners are designed in such a way that not all the evaporator coils are used. Liquid over-feeding (LOF) systems, which have 100% wet evaporator coils, have been used successfully in industrial refrigeration, but were too complicated for residential use in the past. The patented ORNL LOF technology simplifies the system design and makes the concept viable for residential units with only minor hardware changes by adding an accumulator heat exchanger.

There are several advantages to this arrangement: (1) the

entire evaporator is used, thus increasing system cooling and dehumidification capacity; (2) the compressor continually has saturated, or nearly saturated, vapor at the suction inlet, improving the compressor's volumetric efficiency and increasing the refrigerant mass flow rate; (3) the power consumption per unit of mass flow rate decreases because the compressor is more efficient; and (4) system cycling loss is reduced because LOF systems reach steady-state operation much faster than do ordinary systems.

LOF air-conditioning and refrigeration systems have been validated with laboratory experiments. In these tests, the LOF system improved the cooling capacity of off-the-shelf window air conditioners by 12% and the coefficient of performance (COP) by 7%; in addition, the COP of packaged terminal air conditioners improved by 10%, and the refrigeration energy consumption of vending machines was reduced by 12%. Sponsor: DOE Office of Building Technology, State and Community Programs.

*For more information, contact Vince Mei, 423-576-4945 (meivc@ornl.gov).*

### Smart Fuel Cells for Cogeneration

Power systems using fuel cell technology are highly energy-efficient and environmentally clean. Several fuel cell options—including phosphoric acid, molten carbonate, proton exchange membranes, and solid oxide types—are either currently available or under development. The complex balance of fuel cell and plant interfaces (auxiliary equipment—i.e., fuel reformer and dc-to-ac converter) poses many technical challenges to achieving proper system operation under steady-

state and transient conditions. Real-time predictive diagnostic computer systems based on advanced intelligent machine learning technologies are needed to detect, understand, and control the various plant operations so as to avoid system instabilities and failures that would lead to plant shutdown.

In a cooperative project with ERC, Inc., BTC researchers have been developing computer models for fuel cell power plant operation using intelligent

machine learning techniques (neural networks and control theories) and validating the models with available operating data. First-order intelligent machine learning models were constructed and tested for phosphoric acid fuel cell systems for building cogeneration applications. Then a neural network model for the fuel cell power systems was developed to simulate operating characteristics and performance. Finally, researchers developed a feed-forward intelligent control



system with a predictive neural network to control the physical and empirical model. The neural network controller performed

better than a traditional proportional controller; thus, it is a candidate for more sophisticated control strategies for advanced

fuel cell systems. Sponsor: DOE Office of Fossil Energy.

*For more information, contact Richard Murphy, 423-576-7772 (murphyrw@ornl.gov).*

### The Hi-Cool Heat Pump

ORNL's Hi-Cool research program is working to develop an absorption system with significantly higher energy efficiencies than current absorption technologies—30% or more in cooling coefficient of performance (COP), with potential increases in heating performance as well. This level of cooling COP can be achieved by using higher-efficiency cycles and fluids that can be operated to higher peak boiler temperatures. The target cooling gas COPs for Hi-Cool cycles are 1.5 or above for chillers and 0.9 or above for unitary/package heat pumps at the 95°F Air-Conditioning and Refrigeration Institute (ARI) rating condition.

Development of the Hi-Cool cycle technology is expected

to occur in four phases. The first phase, now completed, involved selection of absorption cycles with the best potential for achieving the objectives. BTC researchers are currently in the second phase of Hi-Cool cycle technology development. In this phase, critical components are being designed, fabricated, tested and developed. Two cost-sharing contracts are in place with research organizations to develop these next-generation heat pumps. The technologies being developed are (1) the vapor exchange GAX (VXGAX) concept using an ammonia-water working pair, which will result in an 8-ton light commercial size unit; and (2) the three-stage solid-vapor GAX

sorption cycle using complex-compound absorbents and ammonia refrigerants, with the goal of developing a 3-ton residential heat pump unit.

In phase 3, ORNL will oversee the design, fabrication, testing, and development of a laboratory Hi-Cool prototype heat pump to demonstrate the technical feasibility and thermal performance potential of the preferred cycle. Phase 4 will extend these steps to several packaged prototypes and will also involve a manufacturing cost study and market potential study. Sponsor: DOE Office of Building Technology, State and Community Programs.

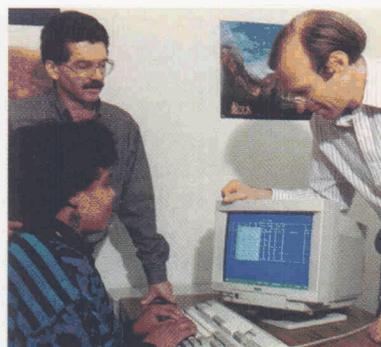
*For more information, contact Abdi Zaltash, 423-574-4571 (zaltasha@ornl.gov).*

### NEAT Savings of \$70 Million Each Year

The National Energy Audit Tool (NEAT) is easy-to-use but advanced computer audit software developed at ORNL for DOE's Weatherization Assistance Program. This computer program is designed to be used by state and local agencies and utilities to select the most cost-effective energy efficiency measures to install in the homes participating in the program. A new ver-

sion of NEAT was distributed in late 1997 and early 1998. This tool was combined with the Manufactured Home Energy Audit (MHEA), providing a package of tools for weatherizing both site-built and manufactured housing.

As of mid-1998, over 650 agencies had requested NEAT and MHEA. The tools are used by approximately 500 agencies



The NEAT software helps users select energy-efficient measures for homes.



## ONGOING R&D

in 31 states in weatherizing an estimated 80,000 low-income dwellings each year. Estimates based on field costs indicate that the use of these computerized tools saves an additional \$70 million in energy costs over the lifetime of the retrofits performed each year.

Work is currently under way to produce a full Windows version of the tool with added features such as a drawing tool for sketching the floor plan of the house. Additional information about NEAT can be obtained at [www.eren.doe.gov/buildings/](http://www.eren.doe.gov/buildings/)

[weatherization\\_assistance/audit\\_tools.html](#). Sponsor: DOE Office of Building Technology, State and Community Programs.

*For more information, contact Mike Gettings, 423-574-4506 ([gettingsmb@ornl.gov](mailto:gettingsmb@ornl.gov)).*

### High-Phase-Order Demonstration Line Operated in Utility Network

ORNL and its partners in the High-Phase-Order Demonstration Project have demonstrated that utilities can move more power over a given

limit. Transmission lines with more than three phases, called high-phase-order lines, can carry more power, use smaller towers, and produce lower electric and magnetic fields than conventional lines.

converted to six-phase operation for the tests. Line voltage was increased to the equivalent of 161 kV without changes in line conductors, towers, or insulators. This change alone increased the line's power-carrying capacity by over 40%. In addition, a portion of the 1.5-mile line was converted to a compact configuration that reduced by 50% the amount of space it occupied.

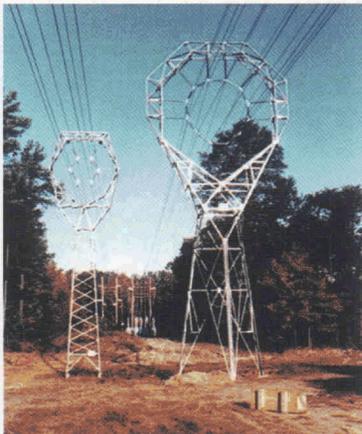
ORNL and the utility industry developed six- and twelve-phase lines over nearly 15 years to resolve issues such as insulation design and tower configurations and development of substation equipment. A key issue was determining how seamlessly a six-phase line could be integrated into a standard three-phase network.

Tests conducted during line operation measured audible and radio noise, electric and magnetic fields, and operation of the protection system. Substation equipment was adapted from three-phase designs and installed at the two terminals of the test line to connect it with the rest of the network. In all cases, the line functioned as designed, confirming that six-phase transmission can be incorporated into a utility grid with minimal disruption. Sponsor: DOE Office of Energy Efficiency and Renewable Energy.

*For more information, contact James VanCoevering, 423-574-4829 ([vancoeverinj@ornl.gov](mailto:vancoeverinj@ornl.gov)).*

right-of-way using high-phase-order transmission lines and that the lines can be incorporated into the existing power grid with minimal disruption.

Most electricity generated in the United States is transmitted by three-phase alternating current systems, which divide the current flow among three phases staggered in time by a third of a cycle. Theoretically, the number of phases has no



Converting an existing three-phase transmission line to high-phase order increases its capacity. [Photo courtesy of New York State Electric and Gas.]



## The Center for Energy and Environmental Analysis

### Assessment of Chemical Weapon Disposal Options at Aberdeen

An interdisciplinary team led by the Energy Division is preparing an environmental impact statement (EIS) on pilot-testing a technology for the destruction of mustard gas, a chemical warfare agent. The EIS team, which is supporting the U.S. Army's Program Manager for Chemical Demilitarization, is composed of staff from four ORNL divisions. This effort was a particular challenge to the ORNL team because of the Army's need to comply with National Environmental Policy Act requirements in a very short time.

The Army is proposing to demonstrate the feasibility of a neutralization process that uses water followed by biotreatment to destroy mustard agent now stored in bulk containers at Aberdeen Proving Ground, Maryland. The draft EIS (DEIS) assesses

the potential environmental impacts of the design, construction, and operation of a facility to test this process.

The DEIS addresses two alternatives: demonstration of the proposed pilot facility or continuing storage of the chemicals without conducting the pilot-testing (the no-action alternative). The ORNL assessment finds that the environmental impacts of facility construction would be similar to those resulting from construction of any medium-sized industrial facility. No appreciable adverse impacts to human health or the environment are expected during the 9-month pilot test. Preliminary risk analyses and accident



An ORNL EIS is helping the Army evaluate options for destroying mustard gas at Aberdeen Proving Ground.

assessments indicate that either alternative—operation of the proposed facility or continued storage of the chemicals—could involve similar accidents, with the maximum zone of impact extending 7.5 km from the point of the worst accident. No off-site fatalities would be expected from such an event under either alternative. Sponsor: U.S. Army Program Manager for Chemical Demilitarization.

For more information, contact Greg Zimmerman, 423-574-5815 ([zimmermangp@ornl.gov](mailto:zimmermangp@ornl.gov)).

### Evaluating the Public Acceptability of Controversial Technologies

Very often in the world of hazardous waste remediation and disposal, there are no ideal technological options. One possible technique is a relatively novel remediation technology—the use of genetically engineered microorganisms (GEMs) that break down certain hazardous wastes such as polycyclic aromatic hydrocarbons. The use of such technologies raises the issue

of public acceptability: Under what circumstances would the parties engaged in decision making seriously consider GEMs as a remediation option? Likewise, under what circumstances would the application of GEMs be viewed as so outlandish, so controversial, as to render it a non-option?

These two questions are at the heart of a project now being conducted by Energy Division

and University of Tennessee researchers. In this DOE-funded project, researchers have developed a conceptual model of the determinants of social acceptability of controversial technologies, focusing on the use of GEMs for remediation. They are now working to test, refine, and implement the model, called PACT, or Public Acceptability of Controversial Technologies.



## ONGOING R&D

PACT provides an encompassing framework within which to understand and, ultimately, predict the social acceptability of controversial technologies such as GEMs. The word “acceptability” (not “acceptance”) is used deliberately. In a decision-making context, acceptability gauges whether the technology or technological method at issue conforms with societal values and norms sufficiently well to be “placed on the table” as a viable alternative to other technologies. The research team’s

approach emphasizes the processes, not outcomes, of interactions among constituency groups engaged in the decision-making process. PACT highlights those features in the dialog “landscape” that serve to encourage a willingness to negotiate or that promote non-negotiable stances.

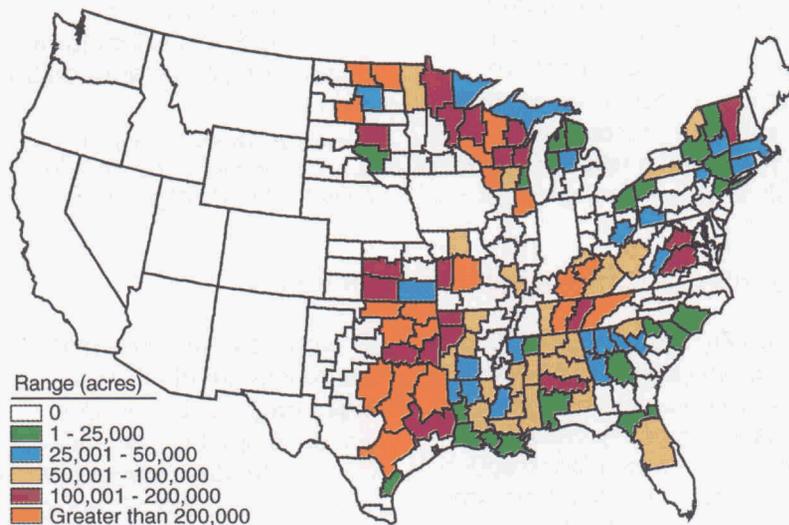
Current research activities focus on one particular formal venue for dialog among constituency groups, DOE’s federally chartered

site-specific advisory boards (SSABs). Analyzing SSAB meetings will enable the research team to gain information about the involved constituency groups, the issues of greatest concern to them, their goals and typical strategies, and their perspectives on other groups participating in the meeting and on the dialog process. Sponsor: DOE Natural and Accelerated Bioremediation Research Program.

*For more information, contact Amy Wolfe, 423-574-5944 (wolfeak@ornl.gov).*

## Economic Modeling of Biomass Energy Crops

Switchgrass-producing regions in the United States. ORNL is helping the USDA and DOE to evaluate the economic potential of such biomass energy crops.



Energy Division economists are leading the effort to evaluate the economic potential and possible economic impacts of biomass energy crop production on the

agricultural sector. Biomass energy crops (switchgrass, hybrid poplar, willows) are grown on agricultural land using practices similar to those used in traditional

agricultural crop production. When used to produce electricity, liquid fuels, and chemicals they can effectively mitigate carbon emissions. As new agricultural crops, they can be used to address other environmental issues (e.g., soil erosion, chemical runoff and leaching, wildlife habitat) and economic issues (farm net returns, rural development) in the agricultural sector. To explore the economic implications of wide-scale production of biomass energy crops, DOE and the U.S. Department of Agriculture (USDA), in collaboration with the University of Tennessee and ORNL, are modifying an agricultural sector model,



POLYSYS, to include biomass energy crops.

The model will be used to evaluate the number of acres and quantities of biomass produced by location (Agricultural Statistical District, or ASD) at any given price level. It will also identify the acres of traditional crops displaced by biomass energy crop production in each ASD and estimate the impact that this will have on the quantity and price of

the major crops (corn, wheat, soybeans, barley, oats, cotton, rice, sorghum). Finally, the model will estimate the effects of changing crop prices and quantities on net farm returns.

In a second project with the USDA Forest Service, the analysis will be used to evaluate the potential impacts that hybrid poplar production might have on fiber markets. Hybrid poplars are an excellent fiber source and can be

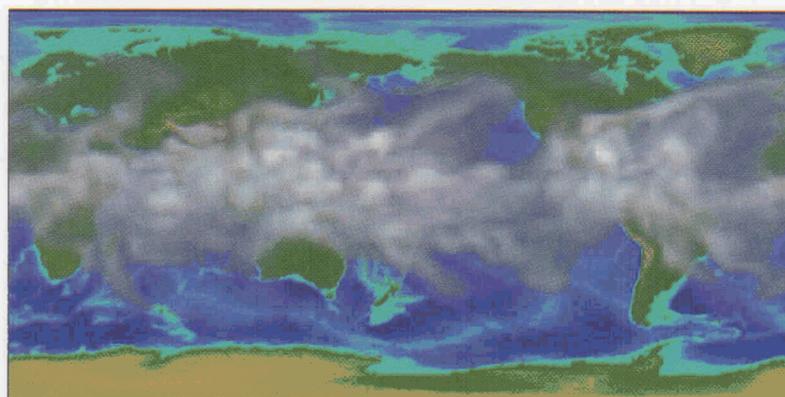
used to produce paper and pulp, oriented strandboards, and other products. The modified POLYSYS model will be linked to Forest Service fiber demand and supply models to evaluate the potential of hybrid poplars to become a major fiber source and to displace harvesting in public and private forests. Sponsors: DOE and USDA.

*For more information, contact Marie Walsh, 423-576-5607 (walshme@ornl.gov).*

## Assessing the Regional Implications of Climate Change for the United States

ORNL is playing a key role in the first U.S. National Assessment of Possible Vulnerabilities to Climate Variability and Change. It is the only national laboratory involved in the leadership team. The \$14 million effort, mandated by the Global Change Research Act of 1990, will report to Congress by the end of 1999. It builds on 19 regional and 6 sectoral assessments, each including broad stakeholder representation, and establishes a framework for developing and integrating climate change and socioeconomic scenarios.

ORNL staff members participated in several early regional workshops and in the first and second national workshops in 1997 and 1998; and ORNL co-organized and chaired the third national workshop in April



ORNL is a key player in a national assessment of the possible impacts of global climate change.

1999. The Energy Division's participation has focused on four needs:

- **Socioeconomic scenarios and impact assessments.** CEEA staff helped develop high and low scenarios of economic and demographic change in 2025 and 2050 in the United States, down to the county level, for use by regional assessment teams.

In addition, ORNL developed summaries of forecasts of technological change, institutional change, and land use change.

- **Good stakeholder participation.** Under the auspices of the National Center for Environmental Decision-making and Research, a team including CEEA staff prepared a



summary of the knowledge base on stakeholder participation, and a template for recording experiences, for use by assessment teams.

- **Coordination and representation of regional views and contributions.** CEEA's Tom Wilbanks is

coordinator of the Inter-Regional Forum, which will coordinate the regional assessment component of the national assessment.

- **Planning for a continuing assessment process.** The assessment is expected to be the first report from a long-term process of

analysis and assessment. ORNL is representing regional views in the effort to design the "post-2000" structure for the work.

Sponsor: DOE Office of Science.

*For more information, contact Tom Wilbanks, 423-574-5515 (wilbankstj@ornl.gov).*

### Evaluating the Public Health Cost of Exposure to Hazardous Substances

The Energy Division is developing an integrated economic assessment methodology to assess the public health cost of exposure to hazardous materials at waste sites nationwide. The multiyear research effort is being conducted in collaboration with the Joint Institute for Energy and Environment.

The project recently estimated the health costs in areas near Superfund sites for conditions associated with exposure to volatile organic compounds (VOCs) in drinking water. Published literature and data from the Agency for Toxic Substances and Disease Registry were used to identify health conditions that occur at excess rates in VOC-exposed

populations. They are some categories of birth defects, urinary tract disorders, diabetes, eczema and skin conditions, anemia, speech and hearing impairments in children under 10 years of age, and stroke. The excess rates were used to estimate the excess number of cases likely to occur among the total population living within a half mile of 258 Superfund sites that show evidence of completed human exposure pathways for VOCs in drinking water. For each type of medical condition, an individual's expected medical costs, long-term care costs, and lost work time due to illness or premature mortality were estimated. Those costs at the selected sites were calculated to be

approximately \$330 million per year in the absence of any remediation or public health intervention programs.

These results indicate the general magnitude of the economic burden associated with a limited number of contaminants at some Superfund sites, suggesting the burden would be greater if all contaminants at all Superfund sites were taken into account. A soon-to-be-completed study is estimating the economic burden of lead exposure on children. Sponsor: Agency for Toxic Substances and Disease Registry.

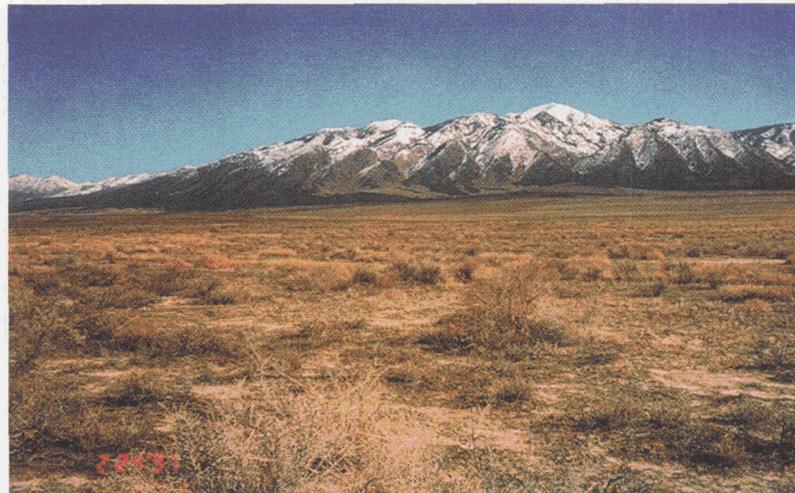
*For more information, contact Russell Lee, 423-576-6818 (leerm@ornl.gov).*



## Environmental Impact Statement for Spent Nuclear Fuel Storage

All energy technologies produce wastes. The most problematic waste from nuclear power plants, which provide about 20% of America's electricity, is spent nuclear fuel. DOE is attempting to develop a site for disposal of spent nuclear fuel, but meanwhile spent fuel is accumulating at nuclear power plants. Storing many years' worth of spent fuel on-site can be costly for nuclear power plant owners. To alleviate the storage costs, a private corporation proposes to build an interim spent fuel storage facility on the reservation of the Skull Valley Band of the Goshute Indians, about 50 miles west of Salt Lake City, Utah. The site is in a sparsely populated valley in which the principal economic activity is raising cattle.

An interdisciplinary team led by the Energy Division is performing technical analyses for and helping to prepare the environmental impact statement (EIS) for construction and operation of the proposed storage facility. In addition to



CEEAA is preparing an environmental impact statement for a proposed project at Skull Valley, Utah, for temporary storage of spent fuel from nuclear power plants.

public health and safety issues, the EIS will address social and economic impacts, aesthetic effects, transportation impacts, effects on ecological resources, transportation impacts, environmental justice concerns, air quality issues, and effects on cultural resources. The principal alternative to approving the facility is to disallow its construction and operation, but the EIS will also analyze an alternative site that had been considered by the proponent.

The principal approval for the facility would be a license from the Nuclear Regulatory Commission, but because two other federal agencies—the Bureau of Land Management and the Bureau of Indian Affairs—are responsible for approving parts of the proposal, the EIS will represent the views of all three agencies on the impacts of the proposed facility. Sponsor: U.S. Nuclear Regulatory Commission, Spent Fuel Project Office.

*For more information, contact Lance McCold, 423-574-5216 (mccoldln@ornl.gov).*



## The Center for Transportation Analysis

### ITS Deployment Analysis System

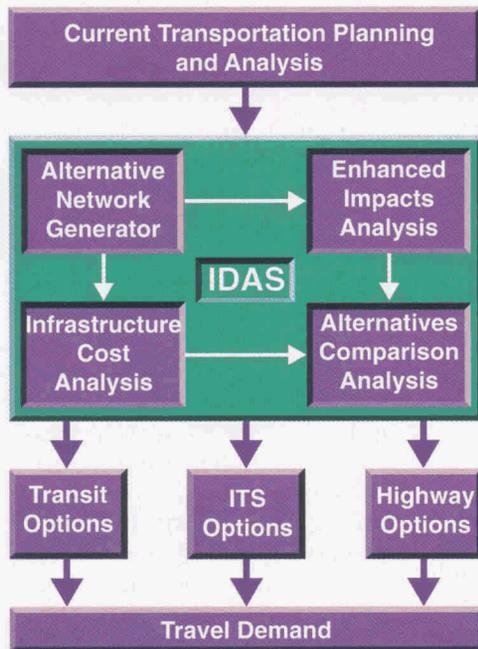
Many areas in the United States have intelligent transportation systems (ITS) in early deployment, and many are planning initial or additional deployments. For deployments to be efficient

projects such as road widening and new highway construction. CTA staff are heading a research team, for which Cambridge Systematics, Inc., is the prime contractor, to develop transportation planning software that allows such evaluations.

and other investments, including ITS, on specific links and nodes in transportation networks;

- work with the output of existing transportation planning models to analyze the impacts of transportation improvement alternatives;
- provide life-cycle cost estimates of alternative transportation projects; and
- compare the costs and benefits of alternative ITS deployment scenarios.

The IDAS modeling system will assist cities, states, and regions in assessing the benefits and costs of intelligent transportation systems (ITS) and other transportation options.



The software is the ITS Deployment Analysis System (IDAS). IDAS is envisioned as a modeling system that will provide quick-response and sketch planning capability for systematic and quantitative evaluation of the relative costs and benefits of intelligent transportation infrastructure investment options as alternatives to and/or enhancements of traditional highway and transit infrastructure investment options. IDAS will provide

Initial testing of an IDAS prototype on specific ITS planning options began in Tucson, Arizona, toward the end of 1998 and is continuing with the cooperation of metropolitan planning agencies in Chicago, Miami, and Oakland-San Francisco. Sponsor: U.S. Department of Transportation, Federal Highway Administration and the Joint Program Office.

and cost-effective, it is important to evaluate the costs and benefits of alternative transportation investment options—both ITS and conventional

metropolitan and regional transportation planning agencies with the capability to

- represent transportation infrastructure improvements

For more information, contact Russ Lee, 423-576-6818 (leerm@ornl.gov) or visit the IDAS web site at [www-cta.ornl.gov/cta/research/idas](http://www-cta.ornl.gov/cta/research/idas).

### Designing the Supercar: Materials Infrastructure Challenges

ORNL and the University of Tennessee are assessing the constraints associated with the increasing production and use of eight lightweight materials—aluminum, titanium, Lexan,

lithium, glass fibers, carbon fibers, composites, and magnesium—in advanced vehicles called 3XVs. Two prospective 3XVs are the focus of the research: the

aluminum-intensive Ford P2000 and the plastic-body Chrysler ESX2. Designed to be three times more fuel-efficient than conventional autos, both will use diesel fuel.



The project considers natural resource, capital investment, cost, and manufacturing-process constraints associated with manufacturing the vehicles. Energy requirements, environmental burdens, repair, use, market acceptability, and the economic viability of recycling 3XVs also are being considered. Some manufacturing constraints—raw material, financial, or process barriers to production

and use of the lightweight materials—appear to be minimal. In addition, lifetime energy consumption and emissions of greenhouse gases and carbon monoxide promise to be much lower than for conventional autos. However, the environmental impacts of producing some of the materials and the higher NO<sub>x</sub> and particulate emissions of conventional diesel engines are concerns; and repair and

insurance costs for 3XVs may also be higher, at least initially. Market acceptability of the vehicles is expected to hinge upon consumer reaction to the combination of sticker price, reliability, comfort and convenience, and operation and maintenance costs. Sponsor: DOE Office of Advanced Automotive Technologies.

*For more information, contact Sujit Das, 423-574-8884 (dass@ornl.gov).*

### The Electronic Driver's License as a Means of Discouraging Drunk Drivers

According to the National Highway Traffic Safety Administration (NHTSA), many people continue to operate their vehicles after their licenses have been revoked or suspended for drunken driving. Some 14% of drunk drivers involved in fatal crashes are driving with suspended licenses. These drivers are hard to catch unless they have an accident or are stopped for some other violation.

A potential solution for keeping these people off the road is being tested at ORNL. The "electronic driver's license" is a card with programmed information on the driver that acts as a key to start the car. If the driver's data check out, he or she is allowed to start up the vehicle and drive it. The card and equipment for using

it can also be retrofitted onto existing autos.

CTA staff are currently testing one such vehicle, on loan from the Swedish automaker Volvo and equipped with an electronic license card system known as "Kittelock." CTA staff are field-testing the card and looking for ways that it might, for example, be disabled under normal driving conditions. Such systems could also include a breath analyzer. At a jointly sponsored NHTSA/ORNL workshop in September 1998, a group of international attendees also considered other barriers to implementing this and similar devices in cars. Sponsors: U.S. Department of



An electronic card is required to start the Kittelock-equipped Volvo being tested at ORNL.

Transportation, National Highway Traffic Safety Administration; and Volvo.

*For more information, contact Pat Hu, 423-574-5284 (hups@ornl.gov).*



### Intelligent Traffic Routing Using Real-Time Dynamic Traffic Assignment Algorithms

CTA staff have been working for several years on a Federal Highway Administration project to develop and test real-time operational dynamic traffic assignment (DTA) software. Such software is a core element of any real-world regional traffic control system, in which tens of thousands of vehicles are monitored and fed the latest information on traffic conditions within a metropolitan area. DTA systems can estimate and predict traffic network states; provide route guidance to vehicles; offer departure time and mode choice (e.g., transit vs auto) advice to travelers; and interface with regional traffic control centers.

A key feature of an operational DTA traffic monitoring and control system is its

ability to collect and feed back information on traffic movements to regional traffic control centers, which then use this data to inform travelers of current and forecast conditions. The system allows electronic messages to be posted on large signs mounted above freeways and also feeds information to vendors who provide individual drivers with in-vehicle information. Rapid identification and notification of traffic accidents can save considerable travel time if DTA-inclusive traffic management systems can re-route traffic around such bottlenecks—now known to be a major cause of traffic congestion in our largest cities.

With the help of computer programs developed at the Massachusetts Institute of

Technology and at the University of Texas at Austin, this research is currently moving from initial algorithm design toward field-testing of prototype DTA algorithms along a busy urban traffic corridor. As the technical manager for the R&D effort, ORNL is evaluating alternative DTA approaches, integrating DTA components into an effective and testable traffic prediction system, and testing and evaluating the DTA algorithms themselves in a simulated and real world context. Sponsor: U.S. Department of Transportation, Federal Highway Administration.

*For more information, contact Michael Summers, 423-576-4488 ([summersms@ornl.gov](mailto:summersms@ornl.gov)) or visit ORNL's DTA web site at [www.cta.ornl.gov/cta/research/dta](http://www.cta.ornl.gov/cta/research/dta).*

### Standardization of Spatial Data for Interoperable Intelligent Transportation Systems

For maximum effectiveness, regional intelligent transportation systems (ITS) must be able to share large volumes of spatially referenced data. Among other projects related to ITS interoperability, ORNL is developing a Geographic Information Systems (GIS) Features and Attributes Catalog for the Federal Highway Administration. Using the Geographic Data Files, or GDF, standard as a backbone, Energy Division staff are

creating a database with all of the features and attributes required to represent and pass spatial data effectively between the many different ITS technologies, including Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Public Transit Systems (APTS), and Advanced Commercial Vehicle Operations (CVO) technologies. These features and attributes, common to all systems, will

serve as the ITS GIS data core, and once standardized, will allow for the transfer and sharing of spatial data among all of these systems by both public agencies and private vendors involved in ITS deployments. Sponsor: U.S. Department of Transportation, Federal Highway Administration.

*For more information, contact Steve Gordon, 423-576-8626 ([gordonsr@ornl.gov](mailto:gordonsr@ornl.gov)) or visit the ORNL ITS web site at [www.cta.ornl.gov/research/its](http://www.cta.ornl.gov/research/its).*



## Emergency Management Center

### Simulating the Effectiveness of Evacuation and Sheltering Indoors

ORNL researchers have developed several models to help planners draw up protective action plans for chemical weapons accidents. The Oak Ridge Evacuation Modeling System (OREMS) is a Windows-based software that addresses problems encountered in conducting evacuation time estimation studies using available commercial and public-domain software. OREMS helps planners estimate the time it takes to evacuate an area, identify bottlenecks in the road system, and assess the effectiveness of traffic control strategies.

PADRE, or the Protective Action Dosage Reduction Estimator, is an interactive software program that simulates an emergency response

to airborne releases of chemical agents for the Federal Emergency Management Agency. PADRE helps emergency planners evaluate protective actions for chemical emergencies, including evacuation and sheltering in place. The program asks the user about accident parameters, the emergency response, and the protective actions employed. PADRE then graphically presents the results of the analysis, showing the accumulated dosage received by someone with no protection versus someone implementing the chosen protective action (i.e., evacuation or sheltering).

Technical Planning and Evaluation is a computer-based training course designed to teach planners how to use

models such as OREMS and PADRE in protective-action decision making. The course identifies the properties of chemical agents; describes the potential human health effects of these agents; defines the concepts of exposure, dose, and risk; and describes specific planning tools developed within the Chemical Stockpile Emergency Preparedness Program (CSEPP) for protective action planning.

Work planned for the future will integrate PADRE and OREMS and develop more sophisticated model algorithms. Sponsor: Federal Emergency Management Agency.

For more information, contact John Sorensen 423-576-2716 ([sorensenjh@ornl.gov](mailto:sorensenjh@ornl.gov)).

### Research into Public Compliance with Protective Action Warnings

The most common emergency response to on-site chemical accidents that release toxic fumes into adjacent communities is an official evacuation of the affected areas. Some communities are now suggesting, however, that sheltering in place is a practical alternative to evacuation. Under certain conditions, sheltering in place in one's residence may offer a safer option, especially if a toxic plume is very fast moving.

In a study of a chemical release in West Helena, Arkansas,

advisories to evacuate or shelter in place were extended to different segments of the community, depending on the distance of the residence from the accident site. Residents within a 2-mile radius of the accident site were told to evacuate, while those out to a 3-mile radius were told to shelter in place. The resulting actions presented an opportunity to study whether those told to evacuate left their residences as told, sheltered, or took some other action, and whether those told to shelter



EMC staff are studying public response to emergency warnings.



## ONGOING R&D

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actually sheltered, evacuated instead, or took another action. This is the first study to investigate a situation where geographically defined groups were given different protective action recommendations.

A mail survey was conducted with a census sample of local residents who were told to evacuate and those who were

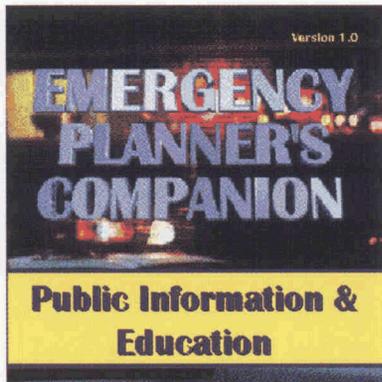
told to shelter. The questionnaires were designed to gather information on when and how people received warnings, what environmental clues were present, how long it took them to respond, where they went, what they did with their pets, how long they stayed away or sheltered, and what actions they took after the event was over. The findings

indicate a high degree of compliance with the evacuation order but a fairly low degree of compliance with the sheltering order, with people evacuating instead. Additional studies on this topic are planned in the future. Sponsor: Federal Emergency Management Agency.

*For more information, contact Barbara Vogt Sorensen, 423-574-5886 (sorensenbm@ornl.gov).*

### Emergency Planner's Companion

The *Emergency Planner's Companion* is a series of CD-ROMs being developed to familiarize planners with



critical areas of the emergency planning process. They are based on the operational concepts in the CSEPP Planning Guidance document, a 400-page-plus volume. Extracting information from that document posed a formi-

dable task to many; hence, it was decided to develop interactive and self-paced training.

These computer-based courses cover the state-of-the-art practices developed for CSEPP as well as the underlying rationale for those practices. They do not tell planners how to write a plan or provide a cookbook approach to planning. Instead, they provide knowledge which can be used within the existing planning context of a state or community.

The CDs in this series, when completed, will cover the topics of Command and Control, Public Information and Education, Protective Action Decision-making and Implementation, Emergency Support Opera-

tions, and Communications. The first two titles have been released to date.

Each CD contains a comprehensive track and an executive overview track. These are divided into units and topics that can be accessed in a linear manner or from a map. Interactive review questions and exercises are provided at the end of each unit. The CD concludes with a test that can be used to assess the planner's competency or as part of a performance assessment process. Each CD contains a searchable version of the Planning Guidance as well as other reference materials. Sponsor: Federal Emergency Management Agency.

*For more information, contact Barbara Vogt Sorensen, 423-574-5886 (sorensenbm@ornl.gov).*



# RESEARCH FACILITIES

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The Energy Division's unique facilities are essential to our research and our outreach to other researchers in the public and private sectors. The Buildings Technology Center, designated as a National User Facility, is recognized internationally for its unique building equipment and envelope testing facilities and extensive modeling capabilities. We also maintain state-of-the-art computing laboratories in the areas of transportation, emergency planning, and regional assessment. These computing facilities house unique data and computer models that complement our interdisciplinary strengths.

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## The Buildings Technology Center

The Buildings Technology Center (BTC) is a designated National User Center whose facilities are available to manufacturers, universities, and other organizations for proprietary and nonproprietary R&D. Users between 1997 and 1999 have included 27 roofing companies that delivered and installed 60 different reflective roof assemblies. These were used in a 3-year field exposure study to help develop a realistic performance database to establish Energy Star and Cool Roof ratings. Eighteen other users participated in conducting whole-wall ratings on 63 different wall assemblies.

The center's research facilities are housed in a cluster of six buildings with over 20,000 ft<sup>2</sup> of space. Within this complex are seven major experimental apparatuses that are used for building envelope and HVAC research.

## Large-Scale Climate Simulator

The large-scale climate simulator provides controlled conditions of temperature, pressure, and humidity above and below test sections as big as 12.5 × 12.5 × 6 ft high. Test assemblies can weigh as much as 10 tons, and have ranged from attic and low-slope roof sections and models of skylight systems for shopping malls to a heat pump installed in a hybrid electric automobile. The simulator allows testing under steady-state temperatures from 150°F to -40°F and a wide range of relative humidities. Infrared lamps can heat surface temperatures to 200°F. Once a test specimen is in place with all instrumentation installed and checked out, an automated data acquisition and control system maintains desired conditions above and below it and records the responses of thermocouples and resistance temperature devices, heat-flux transducers, relative humidity sensors, mass flow-rate meters, load cells, current

shunts or any transducer that produces a voltage output.

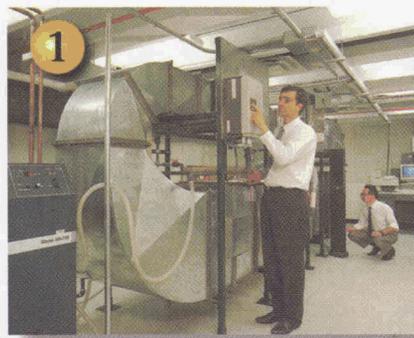
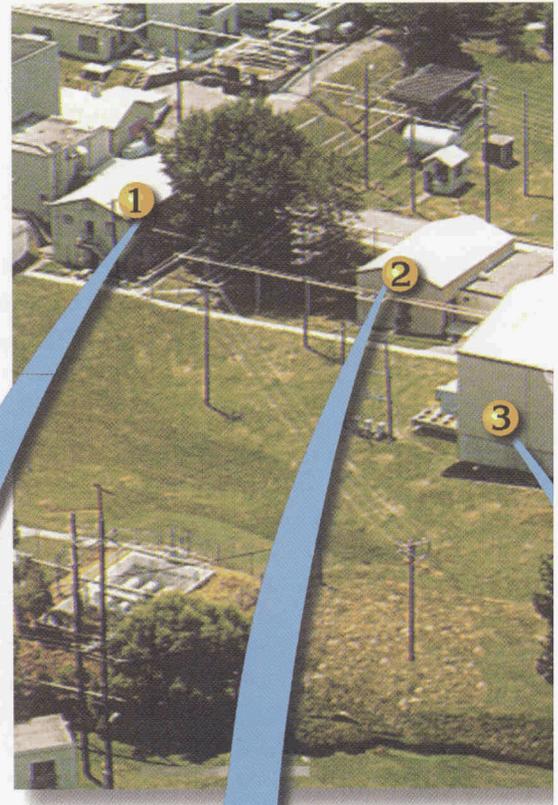
## Rotatable Guarded Hot Box

Researchers use the rotatable guarded hot box to test full-size wall, fenestration, roof, and floor systems. An advanced thermal testing facility designed in accordance with ASTM C236, the rotatable guarded hot box has a metering chamber approximately 8 × 8 ft and accepts test specimens up to 13 × 10 ft in cross section. The apparatus can accommodate projecting or extremely thick envelope assemblies. Because the test walls can be rotated, researchers can measure thermal performance at any angle from 0 to 180°. Other unique features are the ability to conduct dynamic guarded hot box tests on massive wall systems and simultaneous measurement of conduction and convective heat transfer by controlling pressure difference across the test specimen. Both the climate chamber and the metering chamber temperatures and air velocities

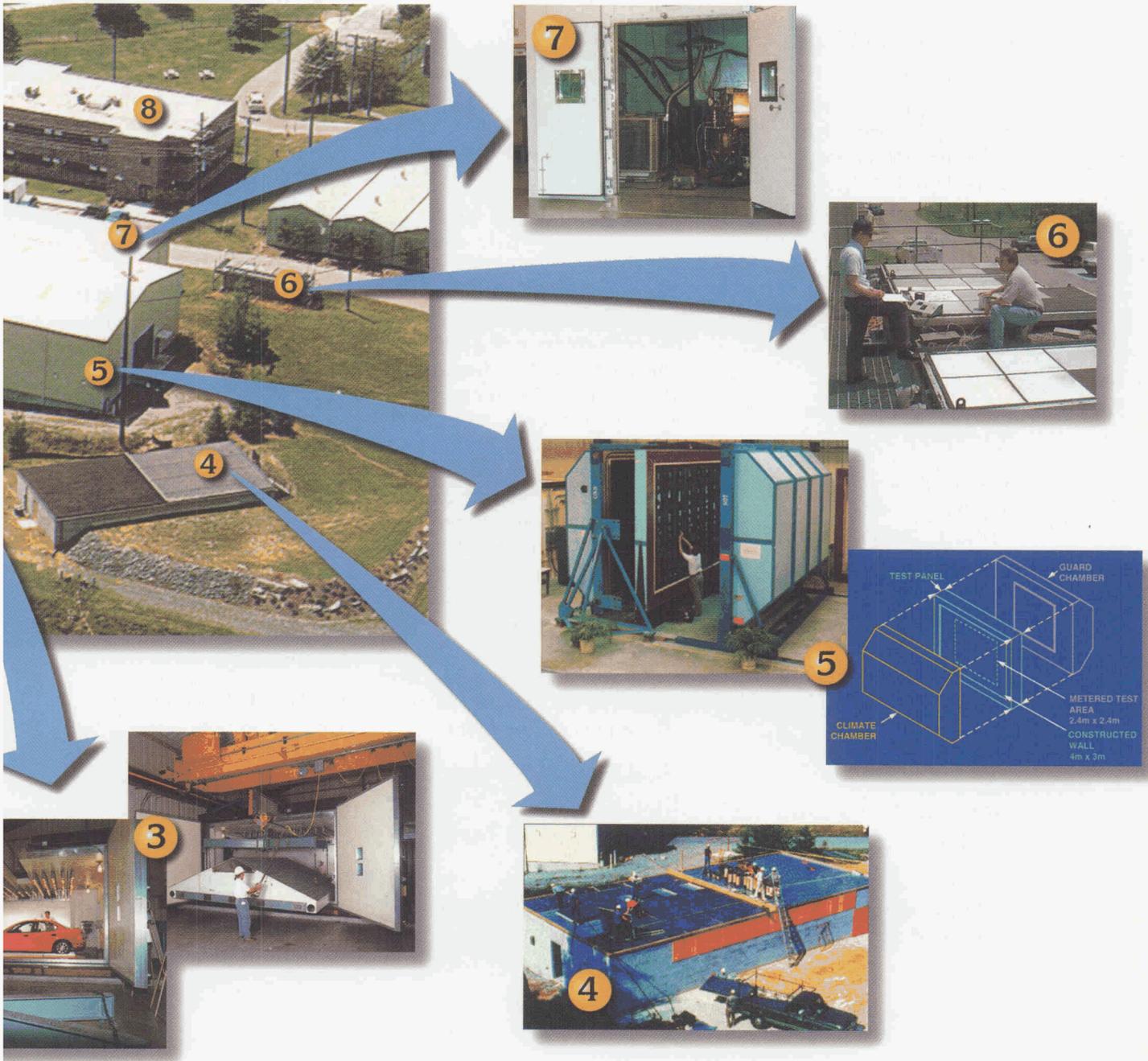
# FACILITIES

## Buildings Technology Center Facilities

- 1 Heat Exchanger Test Facility
- 2 Desiccant Systems Test Facility
- 3 Large-Scale Climate Simulator
- 4 Envelope Systems Research Apparatus
- 5 Rotatable Guarded Hot Box
- 6 Roof Thermal Research Apparatus
- 7 Heating and Cooling Equipment Test Chambers
- 8 Office



# FACILITIES



## FACILITIES

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can be controlled over a wide range of parameters.

### Roof Thermal Research Apparatus

The roof thermal research apparatus currently has 32 different roof assemblies under simultaneous thermal monitoring, four replaceable wall panels, and a controlled interior. Two calibrated slab-foundation edges measure thermal performance of slab-on-grade insulation systems.

### Envelope Systems Research Apparatus

The envelope systems research apparatus is a 30 × 70-ft structure designed to field-test commercial low-slope roofs and walls as well as residential above- and below-grade walls. It is used to study energy and moisture flow through envelope test sections. The interior space is used for thermal and moisture material property measurements.

### Desiccant Systems Test Facility

The desiccant systems test facility is designed to rapidly evaluate the performance of an

active desiccant air-conditioning system under a variety of operating conditions. The facility supports certification procedure efforts and can be used to develop next-generation systems with enhanced energy savings and expanded market opportunities.

### Heat Exchanger Test Facility

The heat exchanger test facility is designed to enhance the performance of air-to-refrigerant heat exchangers. The equipment can operate without lubricants, a capability that permits rapid transition from one working fluid to the next without contamination from the previous experiments. With the global transition from HCFCs to more environmentally acceptable fluids, including new refrigerant blends (zeotropes), heat exchangers become a key component in equipment system efficiency improvements.

### Heating and Cooling Equipment Environmental Test Chambers

The BTC has two environmental chambers with a common

wall for simulating indoor and outdoor conditions for steady-state and dynamic testing of heating and cooling equipment such as absorption chillers, integrated heat pump and water heaters, and vending machines. Some of the patents held by BTC staff could produce energy savings of up to 20% in a typical vending machine.

More information about BTC research facilities is available at [www.ornl.gov/roofs+walls/tour/index.html](http://www.ornl.gov/roofs+walls/tour/index.html) and at [www.ornl.gov/ORNL/BTC/h\\_and\\_c.htm](http://www.ornl.gov/ORNL/BTC/h_and_c.htm).

## Other Research Facilities

### Bureau of Transportation Statistics (BTS) Laboratory

The BTS Laboratory is a secure computing laboratory where Title 13 sensitive data are received, processed, and returned to the Bureau of the Census on a regular basis. The laboratory was established to allow ORNL to process the more than 6.5 million data records associ-

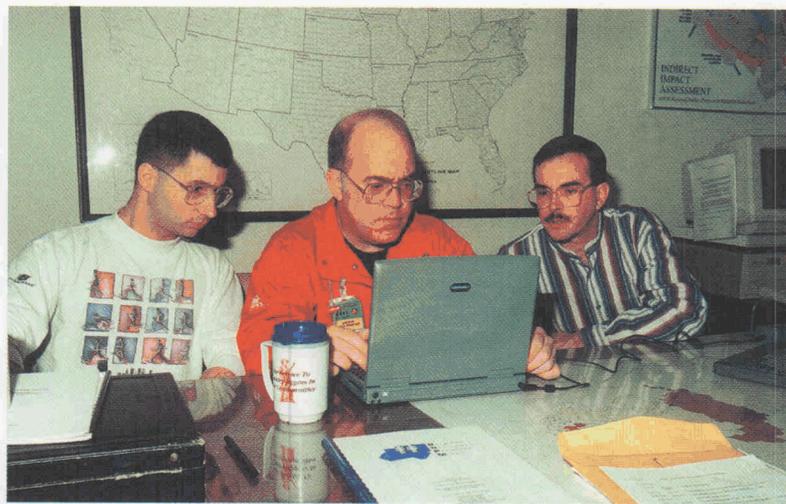
ated with the 1995 American Travel Survey and 1997 Commodity Flow Survey. The laboratory contains a number of personal computers, workstations, and other data storage and encryption devices that operate on their own local area network.

### Dynamic Traffic Assignment Laboratory

The Dynamic Traffic Assignment Laboratory contains computer hardware and software for testing alternative real-time dynamic traffic assignment algorithms that have been developed by various universities and contractors. High-speed computations are required for simulating traffic movements in faster-than-real-time and for animated displays of traffic flows that simulate the temporal as well as the spatial buildup of traffic congestion on highway networks.

### Emergency Management Center Multimedia Laboratory

The Emergency Management Center has developed a computer laboratory to support the development of



The Regional Studies Laboratory developed a demographics software called the Regional Recruitment Potential Model (RRPM) to assist Army National Guard recruiters like those shown here in identifying regional economic and demographic trends that affect local recruitment.

planning and training tools. These include reference CD-ROMs, interactive CD-ROMs, Internet web sites, and hybrid tools. The laboratory contains workstations for audio and video capture, scanning, and authoring and mastering CD-ROMs. Computers are set up to run a variety of operating systems to test products and meet sponsors' requirements.

### Regional Studies Laboratory

The Regional Studies Laboratory contains a large collection of regional economic and demographic information covering the entire United States, by state, county, and

zip code. Data sources include both paper reference volumes and public/proprietary computer databases. The laboratory contains several networked personal computers equipped with tools for database management, statistical analysis, and geographical mapping. These resources have been used in a wide variety of energy/economic impact assessments and analyses. The laboratory resources also provide an ideal environment for the design and testing of user-oriented decision support systems, such as the Regional Recruiting Potential Model developed for the Army National Guard.

# COLLABORATIONS AND OUTREACH



As part of a national laboratory, the Energy Division has a responsibility for outreach to all educational levels, elementary school through college. We also have a responsibility to communicate with the general public about the work being done within our division. Our collaborations and outreach programs bring a unique perspective to our R&D activities.

These programs also promote diversity and train and motivate the scientists and leaders of tomorrow. The Energy Division maintains its strong support for these programs, and we are proud of our accomplishments in this area.

Energy Division collaborations and outreach also involve collaborations with DOE and other federal agencies, as well as efforts to support diversity in the workplace.

## University Collaborations

The Buildings Technology Center (BTC) has participated in DOE's Historic Black Colleges and Universities

Tennessee State University students and professors collected data on heat pump performance before visiting the Buildings Technology Center to present the results of their research.



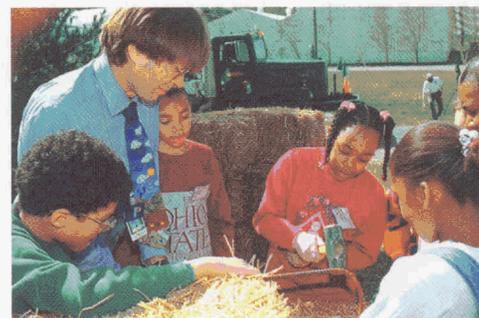
(HBCUs) Program for about a decade, providing technical support and project management. The goals of the program are to foster the development of minority students in the area of building energy efficiency, to strengthen the HBCUs' ability to teach and accomplish research in building energy efficiency, and to identify promising minority candidates for possible future employment in the buildings industry. BTC work has included establishing research on refrigerants and a perma-

nent heat pump test facility at Tennessee State University, as well as projects with Morgan State University in Baltimore, Maryland, and Southern University and A&M College in Baton Rouge, Louisiana, to study and test high-performance, energy-efficient retrofits to residences in those cities. These programs involve both graduate and undergraduate students performing directed studies.

## Schoolchildren Test the Efficiency of Straw Bale Walls

In the spring of 1998 the BTC was turned into an online, virtual classroom in which students around the world were able to watch the construction of a full-scale wall made from ordinary straw bales and to participate in the energy efficiency testing of this wall. Straw bale walls have experienced a renaiss-

ance because they can be constructed quickly and are purported to offer better insulation than conventional walls. The purpose of the student project was to test the insulation value (R-value) of the wall while at the same time giving schoolchildren hands-on experience with the scientific method. Fourth-through sixth-grade classes from Green Magnet School in Knoxville and International Relations Lyceum 51 in Kiev, Ukraine, as well as classes anywhere on the Internet, analyzed the wall's thermal performance and wrote a report. From the convenience of their classrooms, they interacted via a specially



designed web site that included live video feed during wall construction and a chat room for questions. Students from the Knoxville school actually participated in some of the construction work.

### Appalachian Regional Commission Program

Every summer the BTC opens up its laboratory and works with up to 30 science teachers from the Appalachian states for a two-week period. The purpose of the program is to provide science teachers an opportunity to work alongside building researchers on real-life problems. Projects have included optimizing the controls for an active desiccant dehumidifier, building and testing straw bale walls, constructing an energy-efficient concession stand, and measuring the reflectivity of 24 different gray and white coatings applied to a black roof surface on top of one of the BTC outdoor test facilities on a 95°F day.

### BTC Support for DOE's Rebuild America Program

DOE's Rebuild America program is designed to accelerate the adoption of energy-efficient technologies and



practices in existing commercial and multifamily buildings through building retrofits. The BTC is actively involved in Rebuild America's efforts to improve local buildings, thus reducing energy consumption and pollution, through community partnerships with local governments, institutions, and businesses. BTC staff share expertise in buildings and energy efficiency and provide guidance to partnerships during renovation projects. BTC staff are currently spearheading Rebuild America's efforts to improve financial services to partners. The program's more than 200 partnerships—with public housing authorities, colleges and universities, K-12 school districts, local and state governments, and private commercial building owners—are helping the nation work toward the goal of reducing energy use in existing building stock by 20%. More information on partnerships is available at the program's web site ([www.eren.doe.gov/buildings/rebuild](http://www.eren.doe.gov/buildings/rebuild)).

### High School and College Interns and Summer Guests

The Energy Division puts enormous effort into its support of summer intern programs, particularly the Southeastern Consortium for Minorities in Engineering



SECME interns work in the Regional Studies Lab and elsewhere in the division.

(SECME) program. In the SECME program, high school juniors and seniors from local high schools spend their summer vacation working at ORNL. Over the past four years the Energy Division has hosted a total of 22 students (five in 1995, six in 1996, five in 1997, and six in 1998). The interns provide technical support to a variety of projects in the division by conducting literature searches, gathering data from the Internet, developing and manipulating databases, and writing summaries. At the end of the summer, the students make oral presentations summarizing the events of their summer research. The division's SECME coordinator, Marty Schweitzer, was recognized at the 1997 Annual Diversity Awards and Recognition Breakfast, sponsored by the ORNL Workforce Diversity Office, for his outstanding efforts in promoting diversity in the workplace and for coordinating the SECME program.

In addition to its work in the SECME program, the division

## COLLABORATIONS

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hosts several guest researchers through summer programs offered by the Oak Ridge Institute for Science and Education (ORISE). During the past two years, the division has had a total of 15 guests in disciplines ranging from engineering (electrical, civil, and mechanical) to political science, communications, and architecture.

### Connie Dagley Rides the Technology Truck

Through staff member Connie Dagley, the division has been lending support to a high-visibility effort of the Federal Highway Administration (FHWA). For almost a year, the FHWA's "Technology Truck" has been traveling the nation's highways, stopping at preselected sites, and demonstrating new technologies for Intelligent Transportation Systems (ITS) and commercial vehicle operations. Dagley has been one of the facilitators who guide visitors through product demonstrations and computer, video,



and interactive displays. ORNL has been involved in the Technology Truck since its inception, taking the lead in working with private industry partners in the truck's concept, design, construction, and equipment installation, as well as maintaining the project's Web page ([www.ornl.gov/dp111/index.htm](http://www.ornl.gov/dp111/index.htm)). One value of the demonstration is to provide potential users with information that takes them beyond the initial concern with cost. In recognition of the impact of this on-the-road demonstration, the Intelligent Transportation Society of America has given the project its award for Outstanding Achievement in ITS Awareness Campaign by a Public Agency.

### Energy Division Caucuses

The Energy Division strongly supports formal and informal organizations within the division to highlight and address issues of special interest to the staff as a whole or to subgroups within the division. In 1997 and 1998, the division formed two caucuses for nonexempt staff members and for exempt women in the division.

The Nonexempt Caucus was formed in April 1997. The focus of the Nonexempt Caucus is to facilitate communication among nonexempt

staff and between nonexempt staff and other division staff and managers. The caucus meets every six to eight weeks to address topics of concern to caucus members and to hear invited speakers discuss matters of interest to the group. Meeting topics have ranged from discussions of organizational changes to exchanges of information about software programs used by members to an explanation of the promotion process.

The division's Exempt Women's Caucus was formed in February 1998, in recognition of the unique needs of professional women in the workplace. The caucus works to increase the visibility of women, enhance opportunities for promotion for women, and identify and communicate workforce and workplace issues that are important to the women in the division. Since its formation, the caucus has had a number of successes. The caucus has encouraged its membership to actively seek recognition through awards, both internal and external. As a result, two of the caucus members were finalists for the 1998 YWCA Women of the Year award. A staff mentoring pilot program was initiated with caucus support. The caucus provides regular input to management on issues especially as they relate to women within the division.



**David L. Greene**  
*Corporate Fellow*

In March 1999, David Greene was named an ORNL Corporate Fellow in recognition of his outstanding research career. Of 1500 research scientists and engineers at ORNL, only 23 are Corporate Fellows.



David holds a B.A. from Columbia University and an M.A. from the University of Oregon, both in geography. He received his Ph.D. in geography and environmental engineering from Johns Hopkins University. His concentration is on quantitative work in engineering, statistics, and the social sciences directed toward informing public policy on transportation energy use and environmental impacts. However, his greatest contributions have resulted from interdisciplinary efforts that meet the theoretical rigor of each discipline and combine different theoretical foundations in unique ways to bring new insights to each of the disciplines and to real-world decision makers. David's research has had a significant impact on national transportation energy and environmental policy, especially in assessing the effectiveness of regulatory standards for automotive fuel efficiency, measuring the economic impacts of past oil embargoes, assessing the viability of alternative automotive fuels and the optimal transition to those fuels, and evaluating transportation greenhouse gas emissions and global warming.

David has published widely in leading technical journals, and he is often invited to address major technical and professional society meetings on his work. He is the author or co-author of 60 refereed journal articles, 88 other technical publications and invited presentations, and a book, *Transportation and Energy*, that brings together most of the basic information and policy-related science in this area. He is a recipient of the prestigious Pyke Johnson Award of the Transportation Research Board, which is given annually for the best research paper on transportation system economics, management, and administration. He is the editor-in-chief of the *Journal of Transportation Statistics*.

David joins two other Energy Division Corporate Fellows, Eric Hirst and Tom Wilbanks.

## ACHIEVEMENT



**Sherry B. Wright**  
*1998 Trophy for National GREENTIE Liaison Office*

Sherry Wright was awarded the 1998 trophy for the Greenhouse Gas Technology Information Exchange, or GREENTIE, national liaison office of the year, the second such award in three years. The trophy was awarded by the International Energy Agency's Energy and Environmental Technologies Information Centers. GREENTIE is an Internet-accessible database of products and services that can reduce emissions of greenhouse gases. Sherry operates GREENTIE's U.S. liaison office.

Forty countries participate in GREENTIE. The database contains about 8,000 entries in 105 technology categories. The U.S. Liaison Office maintains and upgrades the U.S. part of the GREENTIE directory, provides information about GREENTIE to potential users of the directory, and offers the international program office advice about how to improve GREENTIE. Over the past two years, the office has increased total U.S. listings in the directory from 2203 to 3152, has notably increased the quality of the U.S. listings, and has begun surveying the most frequently "hit" entries to learn more about who is using the database and what benefits U.S. participants are getting.

**Elizabeth B. Peelle**  
*1998 YWCA Tribute to Women—Community Service Award*

In November 1998, Elizabeth Peelle was given the Community Service Award in the annual Knoxville-area YWCA Tribute to Women. Individuals who receive the YWCA awards have "shown qualities of leadership, demonstrated significant professional growth, shown a high level of achievement, and made a significant contribution/impact." Liz is well-known throughout the Oak Ridge area for her significant and long-standing volunteer efforts on desegregation issues, with Planned Parenthood, and on the Oak Ridge Committee for Higher Education, and in pro-choice advocacy. Her community efforts demonstrate the vision, organizational skills, perseverance, and personal qualities essential to achieving progress and action on difficult and controversial issues. Liz holds a B.S. in physical chemistry, an M.S. in sociology, and an honorary doctorate from Miami University. Her work in the Energy Division concentrates on stakeholder and community concerns vis-à-vis waste storage projects.



### Other Awards and Achievements

Energy Division staff received numerous professional, corporate, and organizational awards and honors. Among these are the following.

#### **Bjornstad, David**

Appointment to Editorial Council of the *Journal of Environmental Economics and Management (JEEM)*, 1996.

#### **Bronzini, Mike**

Appointment to a 3-year term as chairman of the Group 1 Council and member of the Division A Council of the Transportation Research Board, National Research Council; reappointment to three Transportation Research Board committees.

#### **Chen, Fang**

Elected fellow of the American Society of Mechanical Engineers (ASME), 1996.

#### **Desjarlais, André**

Award from SPRI, a trade association in the single-ply roofing industry, for exceptional contributions of time and effort to the organization, 1997.

#### **Downing, Mark**

1995 Outstanding Project Award, WesMin Resource Conservation and Development Council (Alexandria,

Minn.), Minnesota Wood Energy Scale-up Project, for work demonstrating the technical feasibility of agricultural plantings of tree crops for energy, 1996.

#### **Ferguson, Teresa**

Awards from the East Tennessee Chapter of the Society for Technical Communication for *The Energy Insider: The Newsletter of ORNL's Energy Division* (Excellence, 1996; Achievement, 1998).

#### **Garland, Patti**

Award for Distinguished Science Management and Policy Implementation, East Tennessee Chapter, Association for Women in Science, 1997.

#### **Goeltz, Rick**

"Find the Good and Praise It" award from the Secretary of Transportation, U.S. Department of Transportation, for work on the Nationwide Personal Transportation Survey interactive web site.

#### **Greene, David**

Appointment as editor-in-chief of the *Journal of Transportation and Statistics*, the only scholarly research journal of the U.S. Department of Transportation, 1998.

#### **Hirst, Eric**

Appointment to the editorial advisory board of the *Electricity Journal*, 1996.

#### **Hu, Pat**

Appointment to three committees on the Transportation Research Board of the National Research Council—the Urban Transportation Data and Information Systems Committee, the Committee on Statistical Methodology and Statistical Computer Software in Transportation Research, and the Committee on Traffic Records and Accident Analysis, 1996; Distinguished Technical Achiever Award, East Tennessee Chapter, Association for Women in Science, 1997; Award of Merit, East Tennessee Chapter of the Society for Technical Communication for the *1990 Nationwide Personal Transportation Survey Data Book*, Volume 2, 1996.

#### **Jones, Don**

Appointment to the editorial board of the *Asian and Pacific Journal of Energy*, 1995.

#### **Lee, Don**

Election as a Diplomat of the American Academy of Environmental Engineers; specialty certification as a sponsor nominee of the American Society of Civil Engineers in the category of radiation protection, 1996.

#### **Lee, Russ**

Appointment to the Committee on Transportation Economics of the Transportation Research Board, National Research Council.

## ACHIEVEMENT

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### *Miller, Bob*

Appointment to the American Meteorological Society's Committee on Meteorological Aspects of Air Pollution, 1996.

### *Moser, Carolyn*

Awards from the East Tennessee Chapter of the Society for Technical Communication for *The Energy Insider: The Newsletter of ORNL's Energy Division* (Excellence, 1996; Achievement, 1998) and *DOE Partnerships for Affordable Housing* (Achievement, 1998); Award of Excellence, Atlanta Chapter of the Society for Technical Communication, Online Communications Competition, for the DOE Weatherization Assistance Program Web Site, 1998.

### *Schweitzer, Marty*

Special event award, ORNL Annual Diversity Awards, for coordination of the SECME program, June 1997.

### *Shelton, Ron*

Award of Excellence from the Atlanta Chapter of the Society for Technical Communication, Online Communications Competition, for the DOE Weatherization Assistance Program web site, 1998.

### *Southworth, Frank*

Appointment to two boards of directors of the Association of American Geographers, the Mathematical and Quantitative Methods Specialty Group and the Energy and Environment Specialty Group, 1996; appointment to the Committee on International Trade and Transportation of the National Research Council's Transportation Research Board, 1999.

### *Vogt, Dave*

Award from the Army National Guard Bureau (NGB) for support to the NGB in conducting demographic studies, 1996.

### *Wilbanks, Tom*

Chair of the National Research Council's (NRC's) Committee on Rediscovering Geography (1993–97) and the U.S. National Committee for the International Geographical Union (1993–97); appointment to the NRC Committee on Human Dimensions of Global Change, 1998; member of the editorial boards for *Social Science Quarterly*, *Forum for Applied Research and Public Policy*, and *Asian Journal of Environmental Management*.

### *Wolfe, Amy*

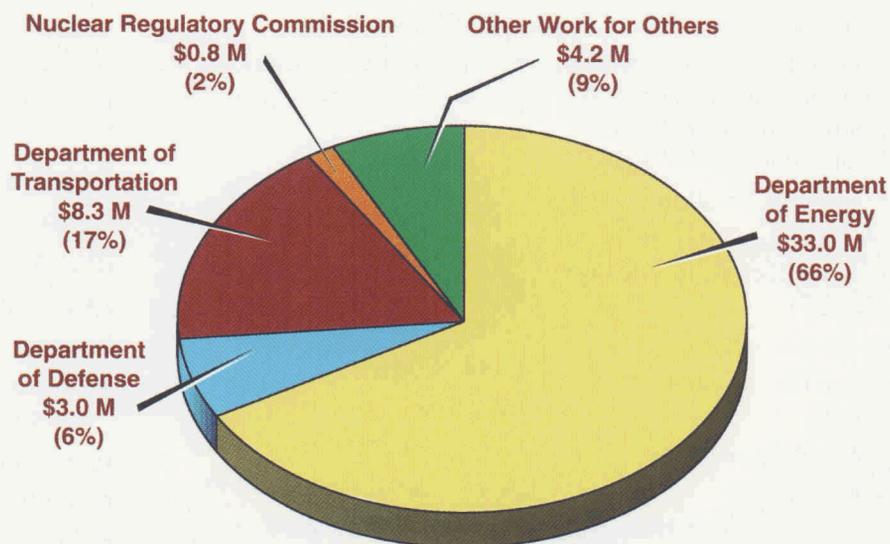
Distinguished Scientific Achievement award for individuals with careers of less than 10 years, East Tennessee Chapter, Association for Women in Science, for work in environmental justice, public environmental decision making, and the social dimensions of biotechnology, 1996.

# BUDGET AND PARTNERS



## Budget

Total FY 1998 research funding: \$49.3 million



- U.S. Department of Energy (66%)
- U.S. Department of Transportation (17%)
- Work for Others (17%)

## BUDGET/PARTNERS

### Research Partners

ABF Building Systems, Inc.	Composite Technology	Illinois Department of Housing
Agriboard	D&R International	Imperbel
Alliance to Save Energy	Design Harmony	Institute of Gas Technology
AlliedSignal	Dow Chemical Co.	International Energy Agency
Alternative Fluorocarbons	E. I. DuPont de Nemours & Co.	(IEA)
Environmental Acceptability Study (a consortium of CFC producers) (AFEAS)	Electricite de France (EDF)	Iowa Energy Center
Aluminum Association	EERS International	Johns Manville Corp.
American Council for an Energy-Efficient Economy (ACEEE)	Energy Efficient Building Association	JPS Elastomerics
American Gas Cooling	Enermodel	Karnak Corp.
American Gas Cooling Institute	Federal Emergency Management Agency	KLD Associates
American Iron and Steel Institute (AISI)	Fields Corp.	Lennox Industries
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	Firestone	Logicon
Argonne National Laboratory	Florida A&M University	Massachusetts Institute of Technology (MIT)
Arthur D. Little, Inc.	Florida Solar Energy Center	Mega Industries
Association of Higher Education	Foster Miller Associates	Metal Roof
Athena Sustainable Material	Frigidaire	Mississippi State University
Auburn University	General Motors	Monsey Bakor
Carlisle Co.	Georgia Institute of Technology	Morgan State University
Carrier Corp.	Georgia State University	National Association of State Energy Organizations (NASEO)
Caviler	Global Green USA	National Aeronautics and Space Administration (NASA)
Cellulose Insulation Manufacturers Association (CIMA)	Green Building Alliance	National Association of Energy Service Companies (NAESCO)
Certainteed	Green Building Challenge	National Association of Home Builders (NAHB)
Chemical Safety and Hazard Investigation Board	Green Clips	National Conference of State Legislators
CH2M Hill	Greening America	National Institute of Building Sciences/ Building Environment and Thermal Envelope Council (NIBS/ BETEC)
Climate Institute	Grundy Industries	
Coca Cola	Habitat for Humanity International	
	Hebel USA	
	Henry Co.	
	Home Energy Magazine	
	Honeywell, Inc.	
	IBICOS Truestone	
	Icynene	

## BUDGET/PARTNERS

National Institute of Standards and Technology (NIST)	Roof Coating Manufacturers Association	United Technologies Corp.
National Rural Electric Cooperative Association (NRECA)	Sarnafil	University of Hawaii
New York State Energy Research and Development Administration (NYSERDA)	Science Applications International Corporation (SAIC)	University of Alabama
Netherlands Agency for Energy and the Environment (NOVEM)	SEMCO, Inc.	University of Central Florida
North Carolina State University	Structural Insulated Panel Association (SIPA)	University of Colorado
Oak Ridge Institute for Science and Education (ORISE)	Siplast, Inc.	University of Illinois—Chicago
Ohio Department of Development	Southern University	University of Leuven
Oklahoma State University	Southface Energy Institute	University of Minnesota
Pacific Northwest National Laboratory	Society of the Plastics Industry (SPI)	University of North Carolina
Passive Solar Industries	SPM Thermoshield	University of Tennessee
Pennsylvania State University	Spray Polyurethane Foam Division of SPI	University of Texas
Phillips Engineering Co.	Single-Ply Roofing Industry (SPRI)	University of Wisconsin
PIMA	State of Iowa	U.S. Air Force
Polysteel Forms	Steven Winters Associates	U.S. Army
Portland Energy Conservation, Inc.	Structural Insulated Panel Association	U.S. Army Corps of Engineers
RASRTA of the Americans	Sustainable Design Group	U.S. Army Research Institute for Infectious Disease
Roof Consultants Institute (RCI)	Synertech Systems Inc.	U.S. Conference of Mayors
Roofing Industry Committee on Wind Issues (RICOWI)	Teledyne Brown	U.S. Department of Education
Robur Corp.	Tennessee State University	U.S. Department of Housing and Urban Development (HUD)
Rocky Research	Tennessee Valley Authority (TVA)	U.S. Environmental Protection Agency (EPA)
Rocky Mountain Institute	Texas A&M University	U.S. Naval Academy
Romine Roofing	Thermal Energy Systems	U.S. Navy
	Trane Co.	Vanderbilt University
	Tucson Institute for Sustainable Communities	Virginia Housing and Environment Network
	Tuskegee University	Volpe National Transportation Systems Center, U.S. DOT
	United Technologies Research Center	Westinghouse Electric Corp.
		Whirlpool
		York International Corp.

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