

ORNL's Energy Efficiency and Renewable Energy Program

Marilyn A. Brown, Ph.D., CEM

Director of the Energy Efficiency and Renewable Energy Program, Oak Ridge National Laboratory

www.ornl.gov/eere

"Energy Study Linkages" delegation from the University of Calgary, sponsored by the U.S. State Department

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Enhance national security

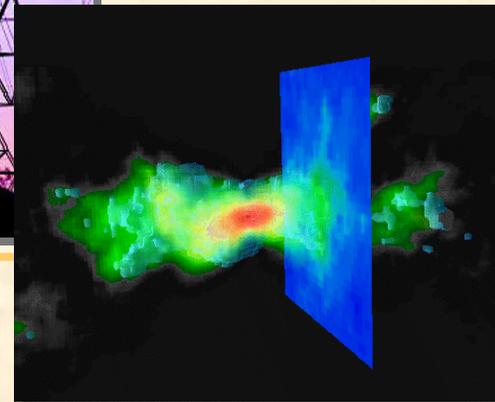


DOE has four important national missions and ORNL contributes to all of them

Provide energy security



Advance fundamental science



Clean up Cold War legacy



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U. S. DEPARTMENT OF ENERGY**

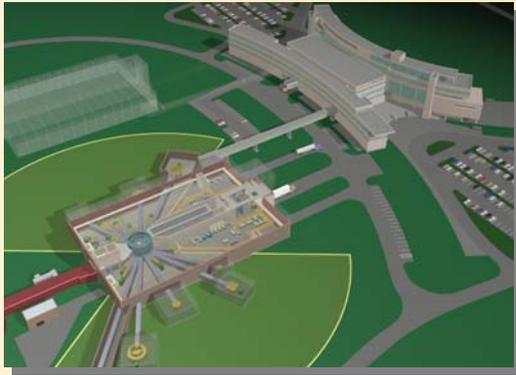
UT-BATTELLE

Oak Ridge National Laboratory



- **DOE's largest multipurpose science laboratory**
- **Nation's largest concentration of unclassified materials research**
- **Nation's largest energy R&D laboratory**
- **\$896 million budget; 90% from Department of Energy**
- **Sixteen research divisions – 1500 R&D staff**
- **3000 guest scientists and engineers annually**
- **17 user facilities**

Our Science & Technology Agenda



Become the world's foremost research center for neutron sciences



Provide leadership in open scientific computing



Become a center of excellence for understanding complex biological systems

Build meaningful partnerships



Provide the S&T for secure and reliable energy



Become a key resource for national security and public safety technologies



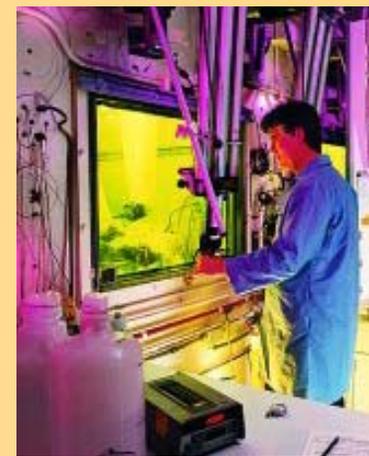
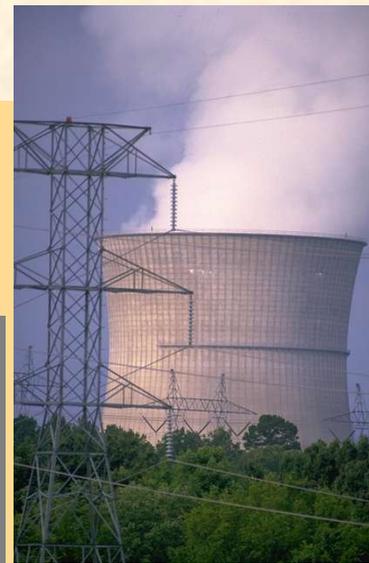
Continue as a leading materials research lab

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ORNL is DOE's premier energy laboratory

- Energy infrastructure assurance
- Energy-efficient technologies
- Hydrogen and fuel cells
- Nuclear technology and safety
- Fusion energy prototypes
- Fossil fuels
- Distributed generation
- Biomass
- Carbon sequestration
- Environmental consequences of energy production



ORNL Energy Efficiency and Renewable Energy Program

Mission

Collaborative research, development, and analysis of energy-efficient and renewable energy technologies to strengthen America's energy security, environmental quality, and economic vitality

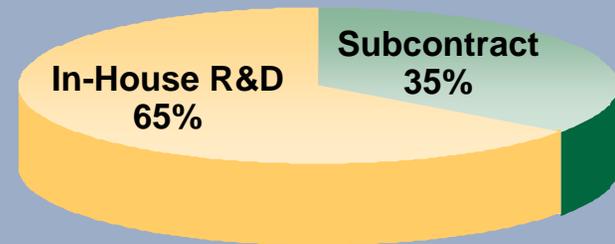
Sponsor, Customers, and Approach

- DOE is the sponsor
- Industry and the public are our customers
- States and universities are key partners

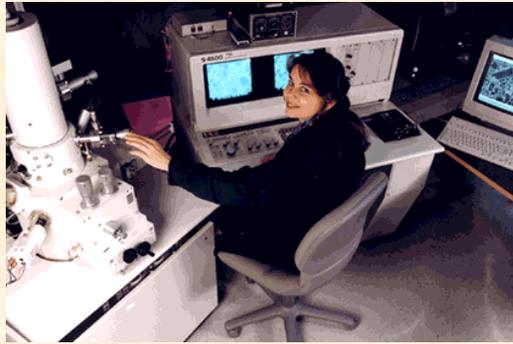


Scope

- All energy use sectors
- FY2003: ~\$130M,
~250 R&D FTEs (~400 FTEs total)



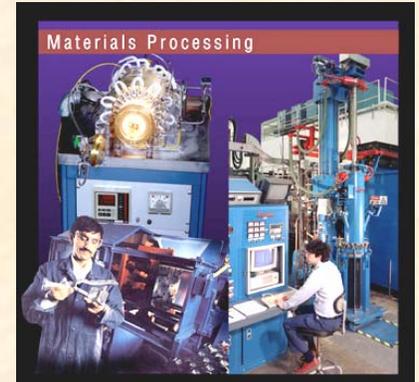
Six EERE National User Centers offer Unique Equipment and Capabilities



High Temperature Materials Laboratory (HTML)



Cooling, Heating and Power Integration Laboratory



Metals Processing Laboratory User Center (MPLUS)



Bioprocessing R&D Center (BRDC)



Buildings Technology Center (BTC)



National Transportation Research Center (NTRC)

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ORNL's EERE User Facilities are a Catalyst for Scientific Discovery and Partnerships

- **FY 2002 User Statistics for ORNL's EERE User Facilities:**
 - Organizations: 374
 - Experimenters: 3,524
 - User Days: 7,551
- **In addition, ORNL hosts 10,000+ visitors each year.**

Buildings

“Drop-in” residential heat pump water heater



- New design
 - Same footprint, electrical, and plumbing requirements as conventional
- Energy Factor
 - 2.4 compared to 0.95
 - ECR International Beta unit improved from 1.0 to 2.5 in BTC Lab
- 3 manufacturers currently
- DOE-sponsored field tests with utility partners across 10 states
 - 50% energy savings
 - Two-year payback potential

Frostless heat pump

Key innovation

Addition of heat to the accumulator to warm the refrigerant in the outdoor coil

- Eliminates cold air blowing indoors
- Retards frost formation
- Increases heating capacity

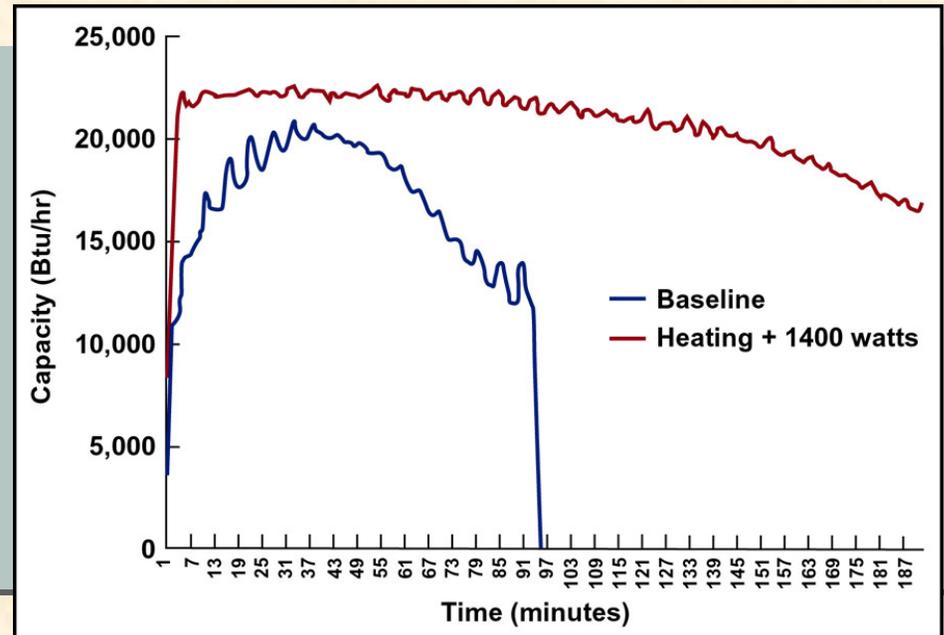


Two units in TVA employee homes being monitored



25+ units to be field tested this winter (2003-2004)

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Heating capacity comparison
at 35° F / 75% RH-12 SEER unit

Sponsors: TVA, DOE/EERE



ORNL and Partners Building Village of “Zero Energy” Houses

- The “Zero Energy” goal is for houses to produce as much energy as they use
- Advanced energy technologies being researched with Habitat for Humanity
 - HPWH
 - High velocity ducts
 - Photovoltaics
 - Structural insulated panels
- Up to 90% more efficient than typical Habitat for Humanity (HFH) homes



Solar panels on the roof will generate electrical power for the home.

Sponsor: Building Technologies

Partners: Habitat for Humanity, Tennessee Valley Authority, building materials manufacturers

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Hybrid Lighting: one part of a zero-energy building

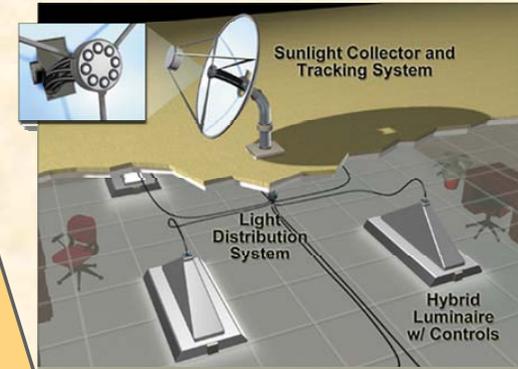
Hybrid Lighting Uses

- Full solar energy spectrum
- Natural and electric light sources
- Networks of optical fibers
- Hybrid luminaires and control systems

•Projected Benefits

- Payback estimated at 2–5 years after R&D
- Student/worker productivity shown to be much higher under natural lighting
- Significant public interest

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Hybrid
Lighting
Design
Concept



Prototype Hybrid Luminaire

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Spinning reserves from thermostat controls

Smart thermostats in hospitality industry and homes can

- **Save energy and reduce electric demand**
- **Shift electric loads during peak periods for short time intervals**
- **Improve electric system reliability by providing spinning reserve (fully responsive in 10 minutes – able to operate for hours)**

Controllers and thermostats

- **Developed by Digi-Log and CARRIER**
- **Able to operate by RF and satellite**
 - Signal from utility or ISO
- **Spinning reserves for \$50 vs \$500/KW**

Next Steps

- **NERC application for spinning reserves**



Industry

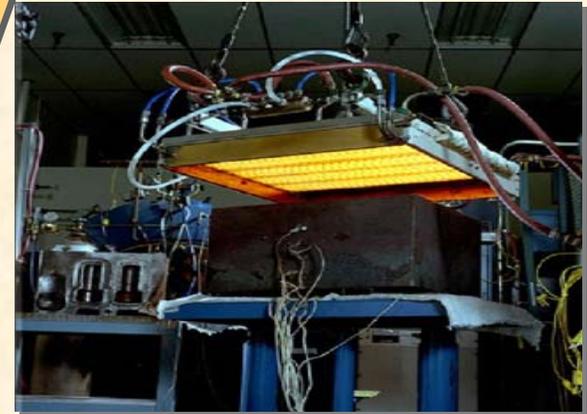
Advanced materials are cutting energy use in energy-intensive industries

- **Nickel aluminide alloys improve energy efficiency in steel, heat treating industries**
 - Energy efficiency improvements range from 5–25%
- **New crack-resistant alloys for Kraft recovery boiler tubes**
 - Five percent improvement in energy efficiency of boiler operations



Advanced High Flux Infra Red heating technologies are being developed

- High Flux IR tungsten systems
- Rapid heating
- Minimizes process heating losses
- Improves materials properties by limiting grain growth
- Being evaluated in steel, aluminum, heat treating, mining, and forging industries
- Steel strip preheating



Motor systems, steam, and compressed air “Best Practices” pay back quickly

ORNL plays key roles in developing software tools & guides:

- Motor assessment tool
- Pump system assessment tool
- Plant-wide profile tool
- Steam System Survey Guide
- Low-Emission Boiler
- Combustion Equipment Selection

In 25 recent plant-wide energy assessments:

- Annual cost savings of \$138 million
- Average payback of <2 years

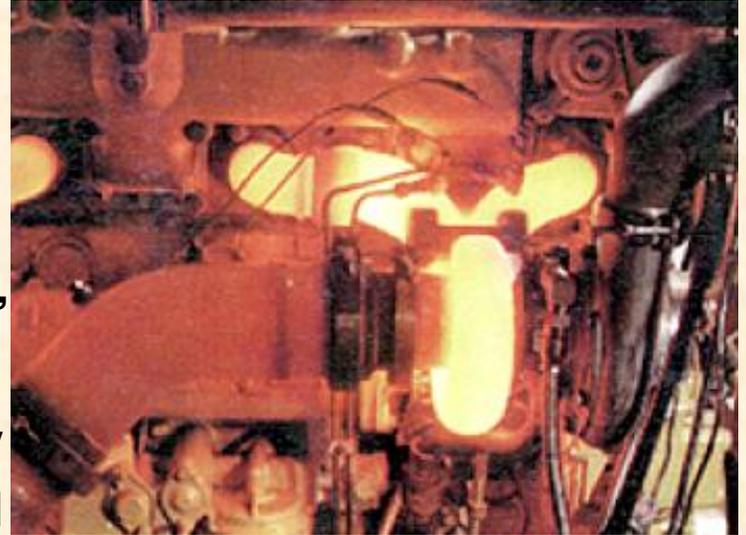


ORNL researchers developed a motor assessment tool that accurately estimates operating efficiency and load without disrupting shop floor operations

Transportation, Hydrogen and Fuel Cells

CF8C-Plus: A New Cast Stainless Steel for High-Temperature Performance

- Engineered microstructure enables CF8C-Plus to be used up to 850°C
- Operating at higher temperatures allows engines to run at greater efficiency with fewer emissions
- Has denser dispersions of “near nanoscale” niobium carbides inside the grains
- Results in high strength and higher ductility
- Same cost per pound as cast stainless steel
- Potential applications: exhaust manifolds and turbocharger housings in large diesel engines; industrial gas turbines



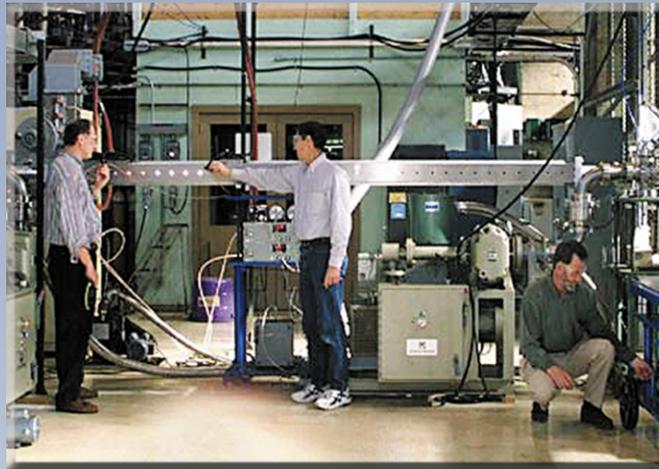
Hot cast iron exhaust manifold and turbo charger on a diesel engine being tested at Caterpillar

**Partners: Caterpillar,
Bradley University, Solar
Turbines**



Rapid developments in low-cost carbon fiber

ORNL research has reduced the cost of manufacturing carbon fiber from \$8 to < \$6/lb. The goal to be competitive with metal is \$3/lb



Microwave-assisted carbon fiber production unit at ORNL



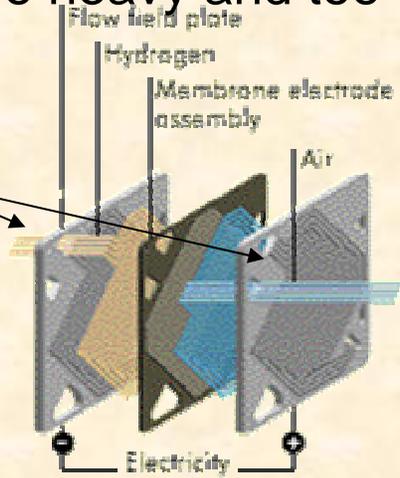
Developed lignin-based precursors

Partners: North Carolina State University, Westvaco

Bipolar Plate Development

Challenge: Current technology for bipolar plates for PEM fuel cells (machined graphite) is too heavy and too costly.

- Bipolar Plate is**
- Cell electrode
 - Sealing surface
 - Flow field for gas

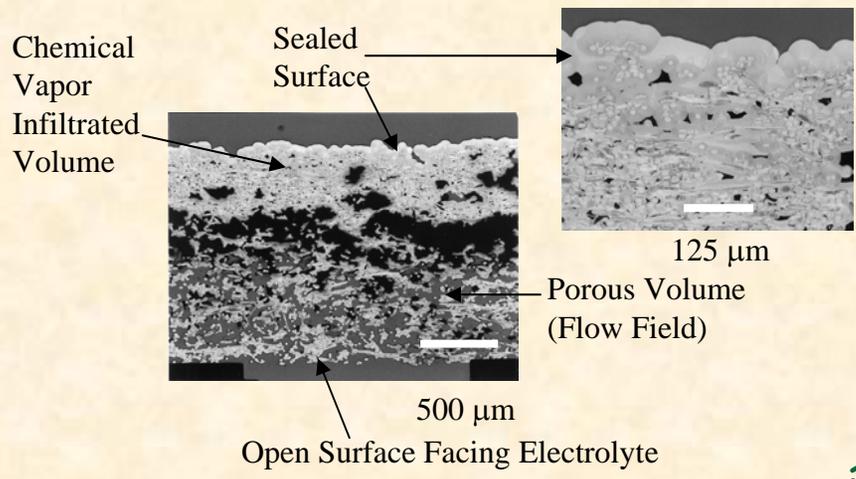


- Bipolar Plates Must**
- Be low cost
 - Not corrode
 - Have high electrical conductivity
 - Have sufficient strength
 - Prevent gas leakage

PEM Fuel Cell

Answer: Carbon fiber material, sealed with chemical vapor infiltrated carbon.

- Advantages of Approach**
- Continuous or semi-batch process
 - Carbon does not corrode
 - Low cost (less than \$1/plate)
 - High conductivity
 - Impermeable
 - Thin (2 mm)/lightweight
 - Built in flow field



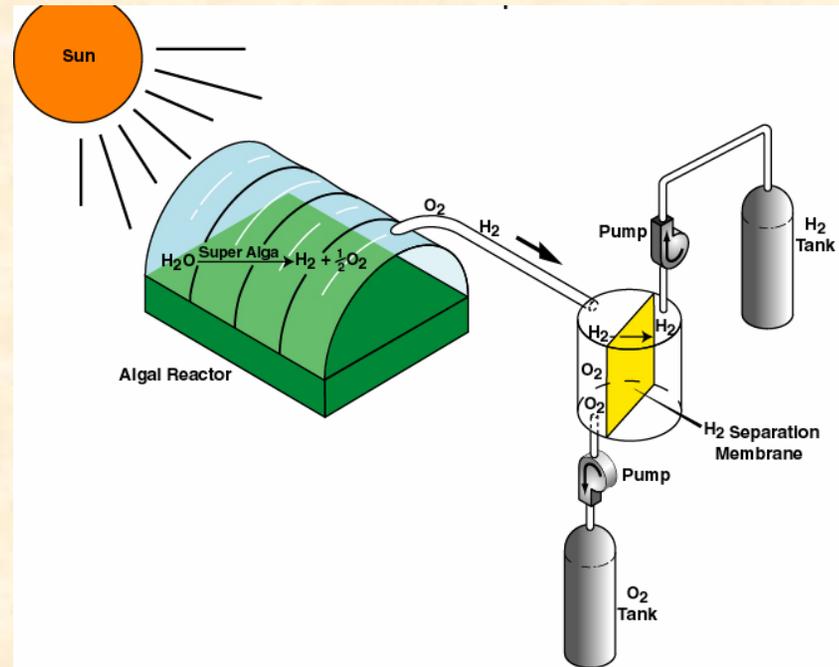
Cross-Section of Bipolar Plate

Hydrogen production from photosynthetic water splitting by designer alga

- This research involves the creation of:
- Designer alga by genetic insertion of hydrogenase promoter-programmed polypeptide proton channels in photosynthetic thylakoid membrane
- Smaller chlorophyll antenna
- O₂-tolerant hydrogenase

This project aims to deliver a H₂-production technology that can meet the DOE goal of \$10/MMBtu

Partners: NREL and UC Berkeley



Vision of H₂ production from designer alga

Power

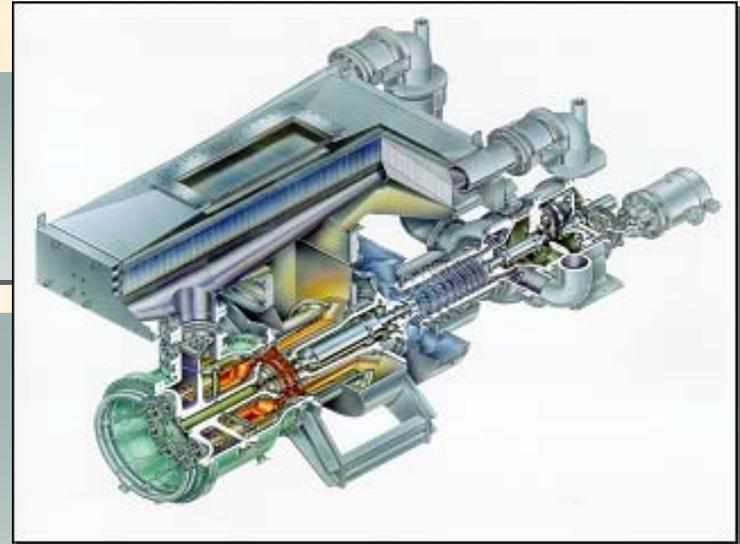
Improved industrial gas turbine technologies have advanced combined heat and power

1992

- 28% Efficiency
- Double digit ppm NO_x

2000

- 40% Efficiency
- Greater than 80% Efficiency (CHP)
- Single Digit ppm NO_x
- 3.5 cents/kWh (8000hrs/yr)



Solar Turbines' Mercury 50

▶ Advanced designs

▶ Lower cost operations

Similar improvements are envisioned for microturbines

2000

First generation microturbines:

- 22-23% efficient
- \$1000 / kW



2010

Advanced microturbines:

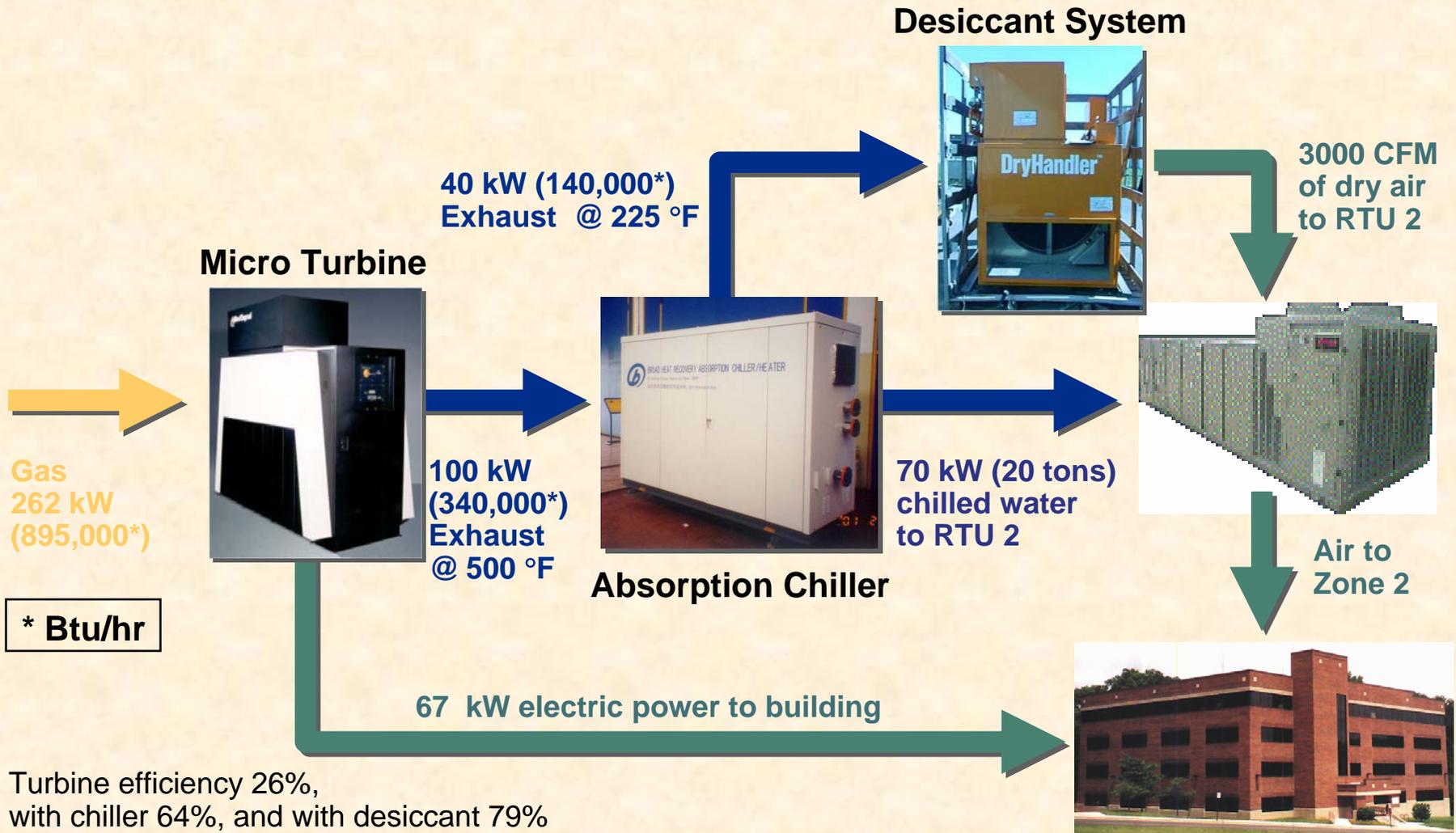
- 30-40% efficient
- Greater than 80% efficient (combined with chillers and desiccant systems)
- \$500 / kW



▶ Advanced designs

▶ Lower cost operations

Integrating power with space conditioning is a key to cost-effectiveness



www.emme.umd.edu/ceee/bchp

**Chesapeake Building
University of Maryland**

First use of high temperature superconducting cable in industry (The Southwire Company)

**Cost-shared project:
HTS cable installed in
Carrollton, GA, in
February 2000**

- Twenty-five megawatt, real-world load equivalent to city of 25,000
- Cable powers two manufacturing plants and corporate headquarters for >13,000 hours at 100% load
- Unattended operation since June 2001
- 5x power through urban rights-of-way
- More efficient transmission and distribution
- Eliminates oil cooling in conventional underground cables



Companies are getting experience with 1st generation HTS wires while waiting for 2nd generation

Advanced Powerline Conductors Offer Greater Capacity, Efficiency and Security

- **Enhanced transmission reliability**
 - 3M Composite Conductor enables 2-3X power in same right-of-way, no tower modifications
- **ORNL is supporting a DOE CRADA with 3M**
 - Improvement in materials production
 - Thermal life cycle and utility field testing
- **Powerline Conductor Accelerated Test (PCAT) facility dedicated in March 2003**

- **Other composite conductors to be tested (i.e., CRAC, in collaboration with TVA)**
- **Evaluation of pre-commercial and commercial instrumentation**
- **Development of new instrumentation**
 - More information on conductor parameters
 - Better understanding of conductors stress performance



ORNL Research Staff: World-Class and Award-Winning

R&D 100 Winners



One of the Ten Outstanding Young Americans for 2000 - **Patricia Garland**



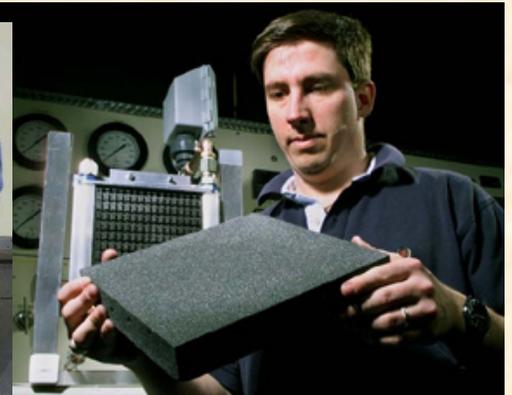
- CF8C-Plus Stainless Steel
- Graphite foam with high thermal conductivity
- Heat pump water heater



Fellow, American Ceramic Society - **Arvid Pasto**



IEEE Industry Applications Society 2001 Outstanding Young Member - **Leon Tolbert**



Since 1963 ORNL has been named on 115 R&D 100 Awards

ORNL's EERE Program is Sponsor-Oriented and Results-Driven

- Working with our partners, ORNL has produced numerous R&D breakthroughs and commercial successes
 - Highly conductive graphite foam
 - High performance carbon graphite bipolar plate
 - Low temperature, low emission diesel combustion regime
 - High-efficiency refrigerator
 - Insulation ratings corrected for convective loops
 - Nickel aluminide furnace fixtures and rolls
 - New kraft recovery boiler floor tubes
 - Suite of industrial assessment tools
 - Infrared curing process adopted by Ford
 - Wear resistant ceramic cutting tools
 - Improved materials for industrial gas turbines
 - World's first use of HTS cable in industry

