



Energizing the Future: Research Thrusts at ORNL

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Energy Resources & Environment Committee
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U. S. DEPARTMENT OF ENERGY

Oak Ridge National Laboratory



East Campus of ORNL

- **\$1 billion budget**
- **DOE's largest multiprogram science laboratory**
- **Nation's largest energy R&D laboratory**
- **Nation's largest concentration of open source materials research**
- **Building the \$1.4 billion Spallation Neutron Source**
- **3700 employees**
- **18 user facilities**




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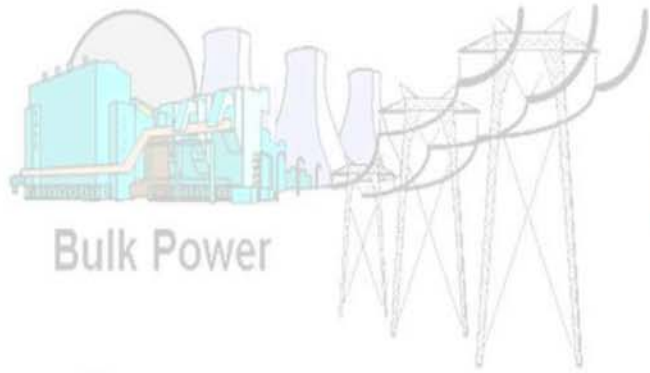


Oak Ridge National Laboratory

**Our Energy R&D Signature:
Integration of science, technology, and thought leadership**

Generation	Distribution	Consumption
<p>Fossil Fission Renewables Fusion</p> 	<p>Transmission technology Hydrogen Distributed Energy</p> 	<p>Buildings Industry Transportation</p> 
<p>Supporting DOE's strategic goals for energy security and independence</p>		

Distributed Energy



Bulk Power

Grid Ancillary Services



Power Quality and CHP



Remote Power and CHP



Energy Management, future CHP and Sell to Grid



Base-load, and Industrial Cooling, Heat and Power



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Distributed Energy

Mission: Improve the energy and environmental performance of the distributed technologies and increase the level of technology integration among on-site energy generation alternatives so the nation can achieve a more flexible, smarter energy system.

- **Major Activities and Facilities:**

- Technology Base
 - Turbines & Microturbines
 - Reciprocating engines
 - Materials
 - Thermally activated equipment
- Integrated Energy Systems
 - Systems integration modeling
 - Optimized, replicable CHP systems



UTC Power PureComfort 240
(microturbine/chiller system)

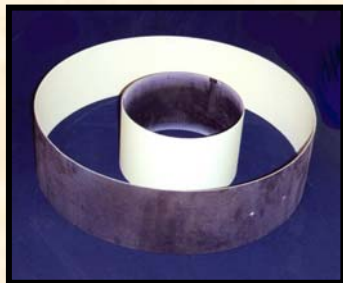
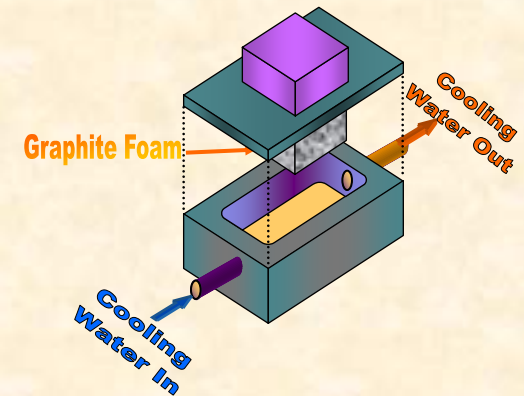
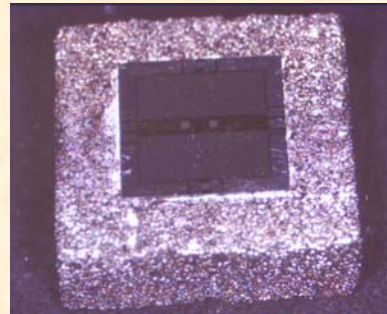
- **Recent Achievements:**

- Microturbine Test Facility: systems integration modeling and testing
- Control techniques to reduce combustion variability in reciprocating engines
- Supported the development of UTC PureComfort 240 & other systems

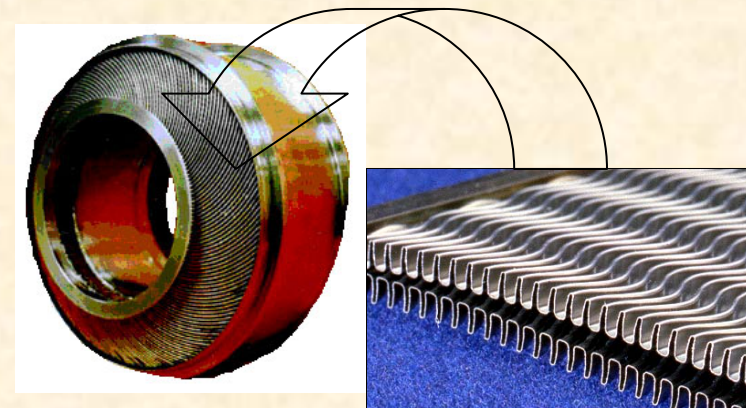
Technology Base

Increase technology efficiency, reduce emissions, reduce costs and increase reliability and durability

- **Ceramics**
- **Coatings**
- **Advanced Metals**
- **Thermal Management**
- **Power Electronics/Sensors**



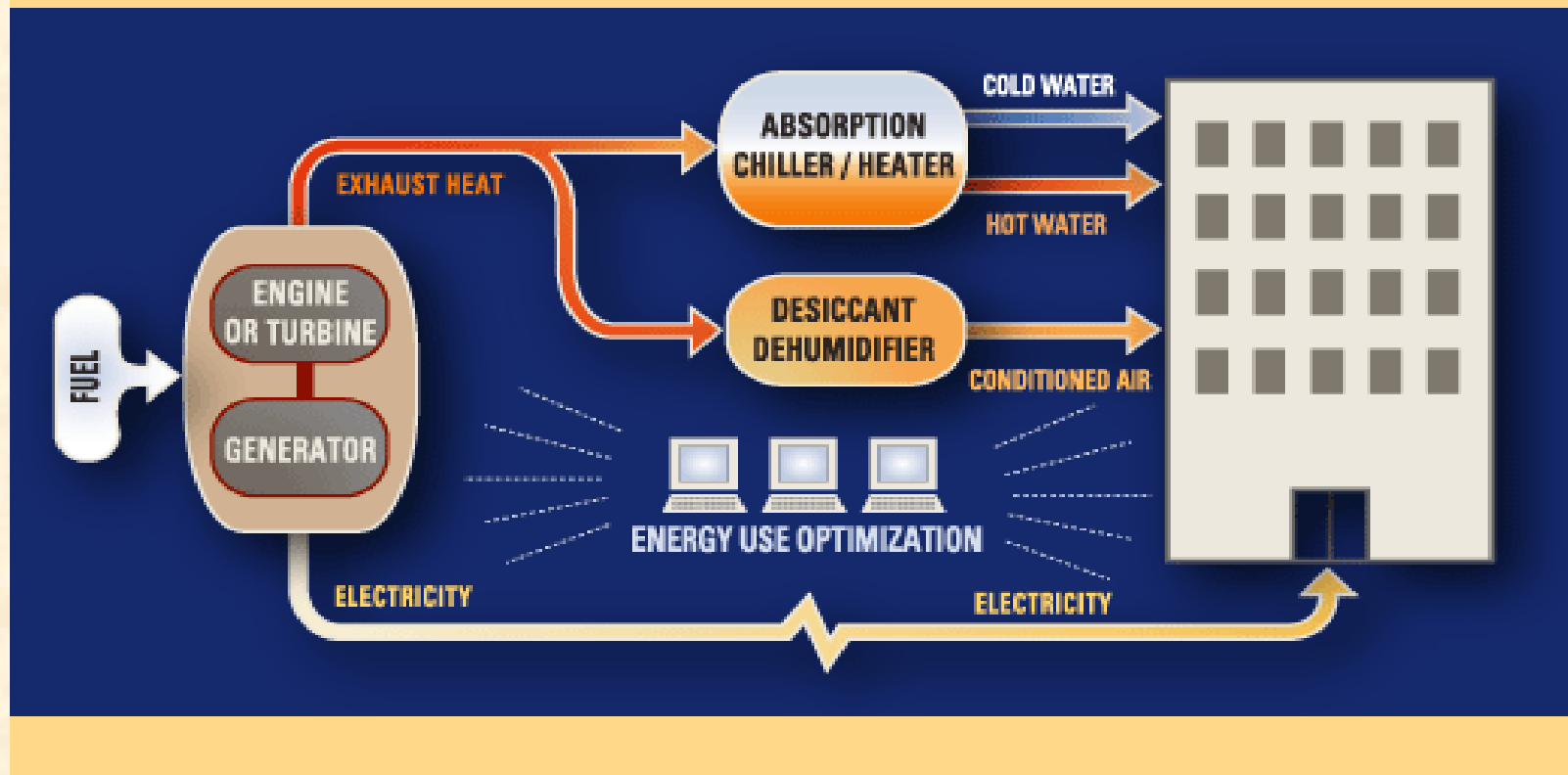
Continuous fiber ceramic components with EBC on gas-path surfaces



Recuperator air cell made from 347 stainless steel foil

Integrated Energy Systems Is a Key to Cost-Effective On-Site Power

- **\$500 / KW**
- **80%+ system efficiencies**



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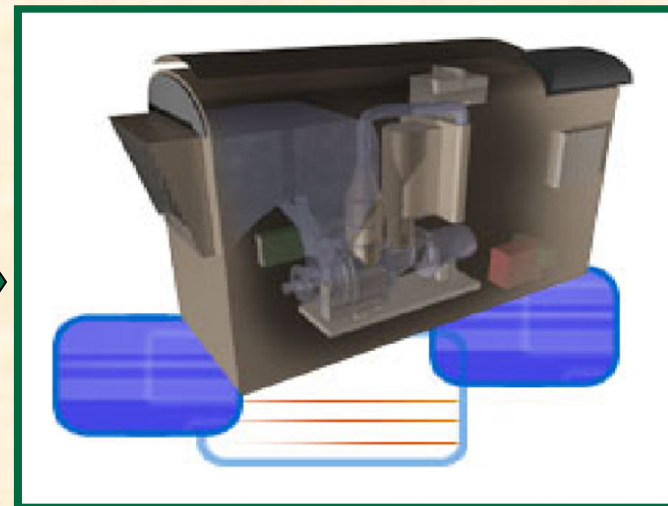
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Vision: Packaged System Integration

2004: Individually optimized products combined on-site



2010: Single optimized package from manufacturer



- **Integrated or modular packages**
- **More cost-effective**
- **Little onsite engineering**
- **Higher overall efficiency**

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Burns & McDonnell Project

- Austin Energy's solution to provide clean energy in NO_x non-attainment zone
- Installation of 5MW turbine & waste heat-fired 2,500-ton absorption chiller



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Electric Transmission & Distribution

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Advanced Composite Conductors

Three companies are developing conductors:

3M Innovation

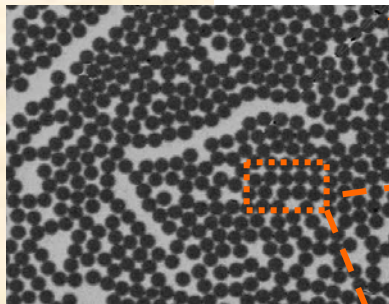
CTC



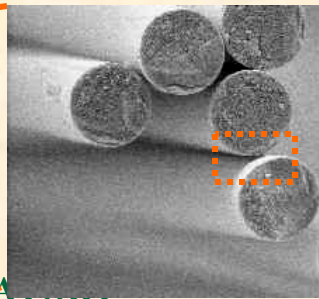
ORNL is researching alternatives materials

High Temp Al Strands
(Al-Zr Strands)

Aluminum Composite Wire

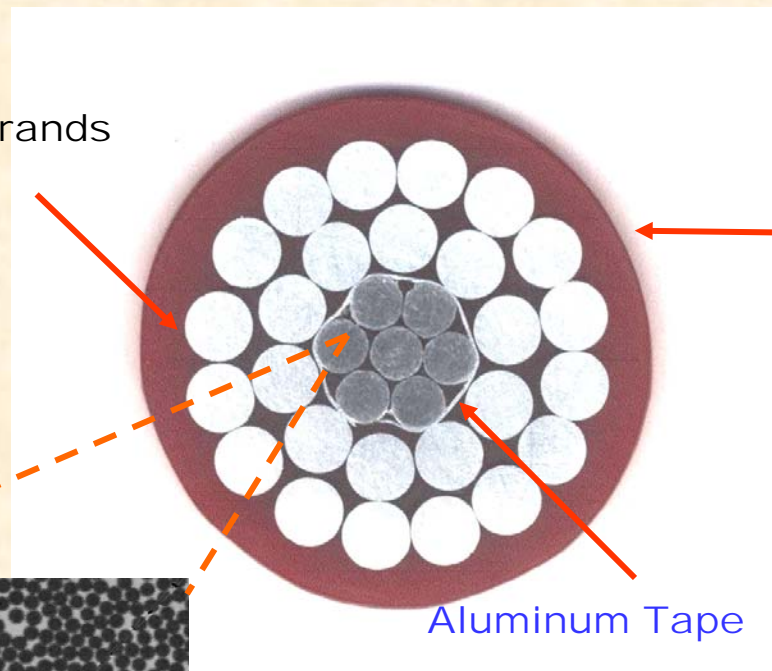


Aluminum Wire
Reinforced with
Carbon Nanotubes



Aluminum Tape

Sol-Gel (Aluminum Dioxide)



Two types of conductor improvements are being developed and tested

#1 – Conductor Operating Temperature Limits Allowable Current

The aluminum used in ACSR is limited to a maximum operating temperature of 90°C to 125°C to avoiding annealing the aluminum

Aluminum (as all metals) will lose strength as temperature increases

The solution to increase the current carrying capability of the conductor is to process the aluminum to raise the annealing temperature and therefore the operating temperature

Fully anneal the aluminum – lower strength

Add small amount of zirconium to aluminum – retains strength

#2 – Conductor Sag Limits Allowable Current

The steel (as all metals) lengthens as temperature increases and controls how much the conductor sags

Coefficient of Thermal Expansion or CTE

The solution is to replace steel with a different material with a lower coefficient thermal expansion

PCAT – Powerline Conductor Accelerated Test Facility – established in 2003

**Structure #1,
Dead-end**

**Structure #2,
Suspension**

**Structure #3,
Dead-end**

**Structure #0,
Fiberglass
Pole**



Capabilities:

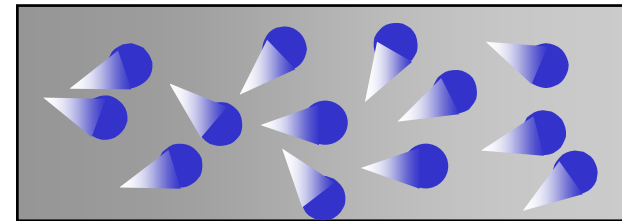
- Two 600 ft. spans with 2400 ft. of test conductor
- Four dead-end clamps
- Two suspension clamps
- Two splices
- Conductor clamps
- Jumpers and terminal pads
- Controlled current or temperature testing
- Up to 300°C
- Low voltage, 0 to 400 Vdc
- High current, up to 5,000 Adc

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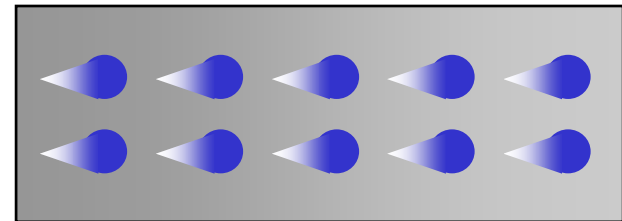


Superconductors: Electricity flows without loss of energy

DILBERT



Ordinary conductor: electrons moving at random lose energy in collisions, generating heat.



Superconductor: electrons moving in pairs don't collide, generating no heat and losing no energy!

Superconductivity partnerships with industry: Southwire Co. and ORNL

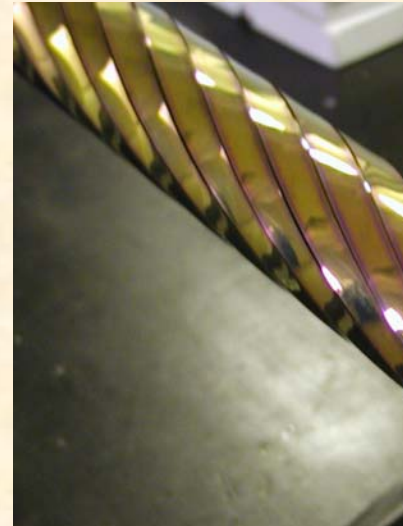
- **Cost-shared project - HTS 1G cable installed in Carrollton, GA in Feb. 2000:**
 - 25 megawatt, real-world load equivalent to city of 25,000
 - cable powers two manufacturing plants and corporate headquarters for >28,000 hours at 100% load, still running today
 - 5x power through urban rights-of-way



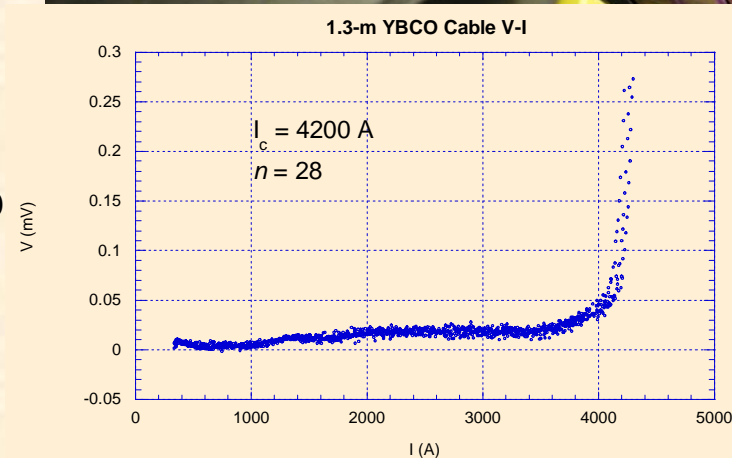
- **more efficient transmission and distribution**
- **eliminates oil cooling in some conventional underground cables**
- **Low impedance → increase flow control, longer underground lines**

Promising Status of High-Temperature Superconductivity

- Consistent progress in increasing critical current of long-length coated conductors in U.S.
- New materials and methods are being researched at the national labs and industry.
- Five processes for deposition of buffer layers and YBCO on alloy tapes are being developed.
- Opportunities for enhanced J_c versus thickness and in magnetic fields have been demonstrated.
- 4 U.S. companies hope to scale-up coated conductors to 10-100 meters by 2006.



First 2G
Demonstration Cable
(made by Ultera) uses
American
Superconductor 2G
wire tested by ORNL





Sensors and Controls

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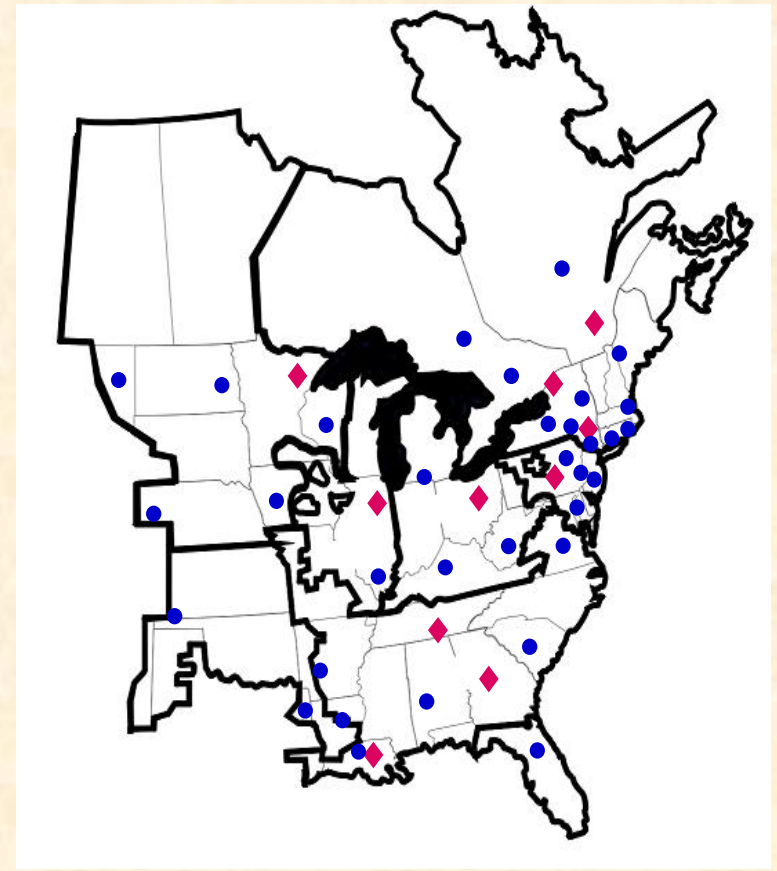
Eastern Interconnection Phasor Demonstration

Status:

- Demonstration initiated in FY03
- ~50 phasor measurement units & other devices sampling voltage and current waveforms
- All major corridors covered
- Data available to research community

Projected Benefits:

1. More comprehensive wide-area view of system
2. Rapid assessment of system conditions
3. Improved system models for steady-state and dynamic analysis



Spinning Reserves from Large Pumps

- This demonstration with the CA Department of Water Resources consists of controlling water utility pumps so that they respond to frequency deviations and system operator commands for contingency events
- CDWR managers are enthusiastic & have supplied proprietary pumping data
- Soft starts from the installation of variable speed drives are only needed on the largest pumps
- Initial review of the data shows that there are key pumping “strings” that could provide significant payback
- Waivers for rule changes and approvals from FERC, NERC, WECC and the CAISO are being sought



For ORNL's research to help "energize the future," partnerships are essential

Let's stay in touch:

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www.ornl.gov/eere

www.ornl.gov/sci/oetd/index.htm