ORNL Energy and Transportation Science Division

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Hosted by Tennessee Valley Authority

Presented by:

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ORNL is managed by UT-Battelle
for the US Department of Energy

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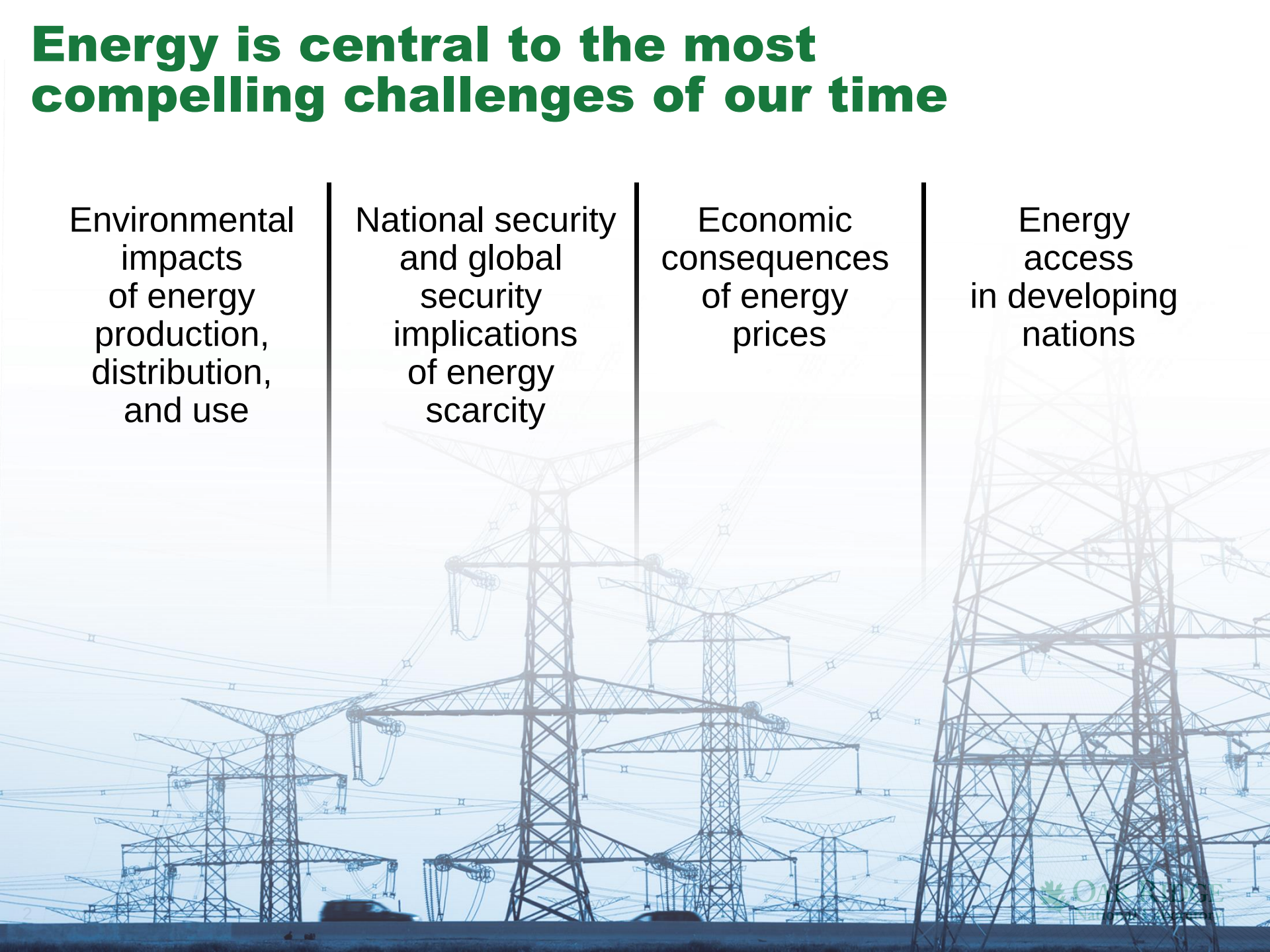
Energy is central to the most compelling challenges of our time

Environmental impacts of energy production, distribution, and use	National security and global security implications of energy scarcity	Economic consequences of energy prices	Energy access in developing nations



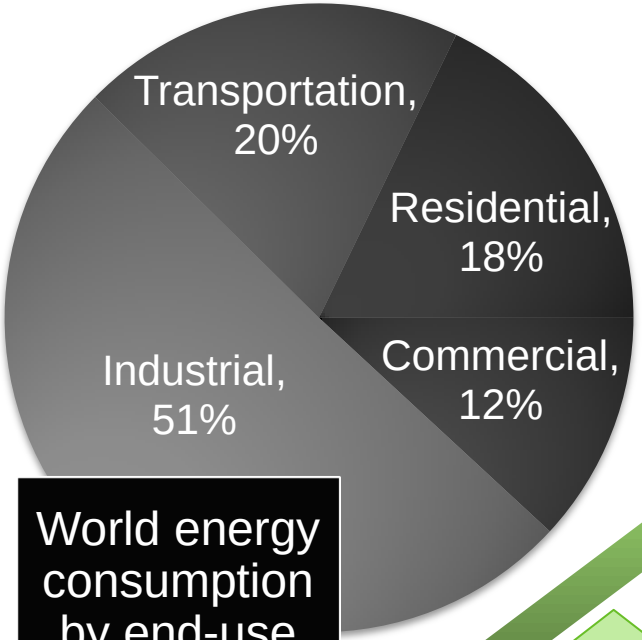
Transformation of the global energy system is required

- Major improvements in energy efficiency: Transportation, buildings, industry, electric grid
- Electrification of transportation
- Renewable energy: Solar, wind, geothermal
- Biofuels and bioproducts
- Advanced liquid fuels from fossil resources
- Carbon management
- Next-generation nuclear power: Fission and fusion

Major advances in basic science and supporting technology are needed to ensure success

Improving energy efficiency

Our most readily available source of energy



World energy consumption by end-use sector

High-efficiency equipment/ appliances

Distributed generation/ smart grid technologies

High-efficiency vehicles

Green building standards for new construction

Energy-saving retrofits for existing buildings

Improvements in industrial processes and manufacturing

ORNL is DOE's largest science and energy laboratory

- $1.65B budget
- 4,400 employees
- 3,000 research guests annually
- $500 million invested in modernization
- 179 R&D 100 Awards

- Nation's largest concentration of open source materials research
- World's most intense pulsed neutron source and a world-class research reactor

- World's most powerful open scientific computing facility
- Nation's most diverse energy portfolio
- Managing the billion-dollar U.S. ITER project

ORNL's mission

Deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in clean energy and global security, and in doing so create economic opportunity for the nation

Signature strengths

- Energy and environmental sciences
- Computational science and engineering
- Materials science and engineering
- Neutron science and technology
- Nuclear science and technology

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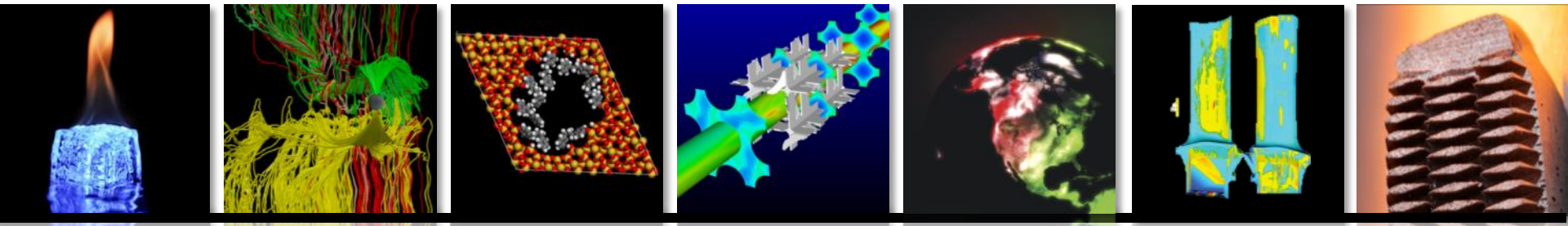
ORNL's science and technology initiatives



Deliver science using neutrons

Scale computing, data infrastructure, and analytics for science

Discover and demonstrate advanced materials for energy

Advance scientific basis for new nuclear technologies and systems

Advance understanding in biological, environmental systems, and climate change impacts science

Enhance building energy efficiency, sustainable transportation, and advanced manufacturing

Solve the nation's most compelling global security challenges

Maximize ORNL's impact

- Enhance technology transfer
- Invigorate science through graduate research and education

ORNL's vision for a sustainable community

Green Intelligent Buildings

- Commercial and residential integration
- Envelopes
- Appliances
- Cool roofs

Industrial

- High efficient processes
- Advanced manufacturing

Smart Grid

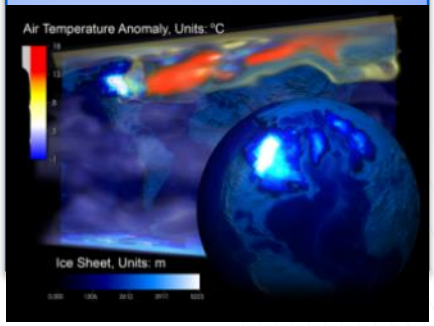
- Situational awareness
- Advanced communications and controls
- Energy storage

Renewables

- Bioenergy
- Solar
- Geothermal systems
- Wind

Climate and Sustainability

- Large scale environmental experiments
- Climate modeling



Intelligent Transportation Systems

- Integrated land use planning
- Public transit friendly
- Alternate mobility choices (incl. freight)
- Clean fuels
- Intelligent vehicles and infrastructure

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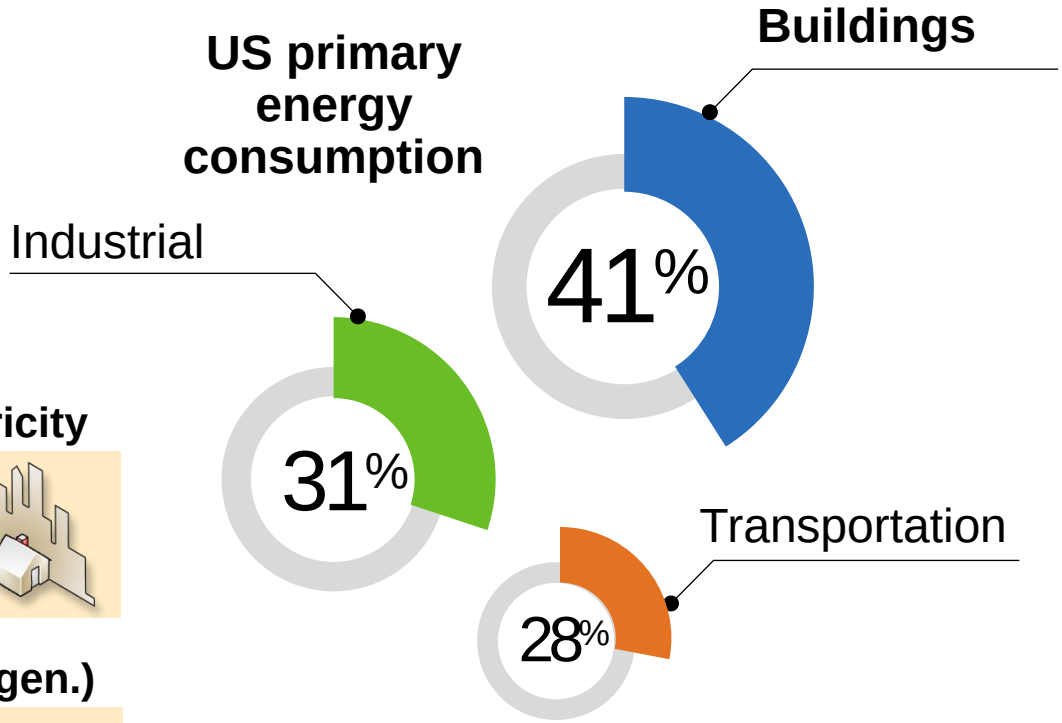
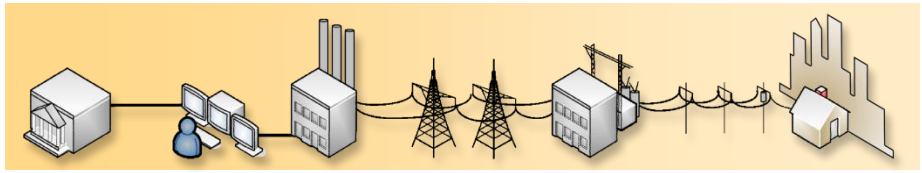
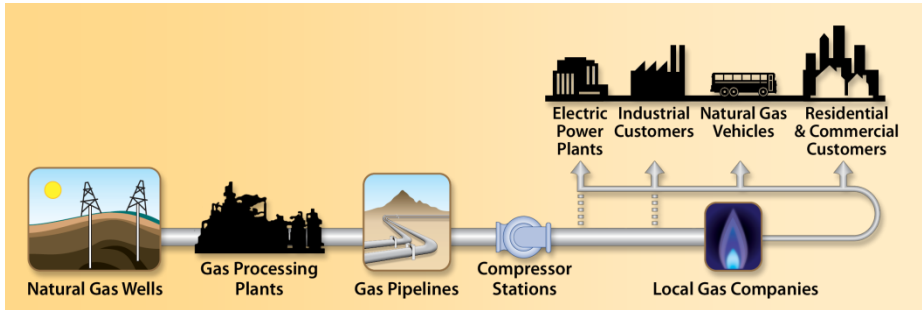
Buildings: U.S. energy footprint



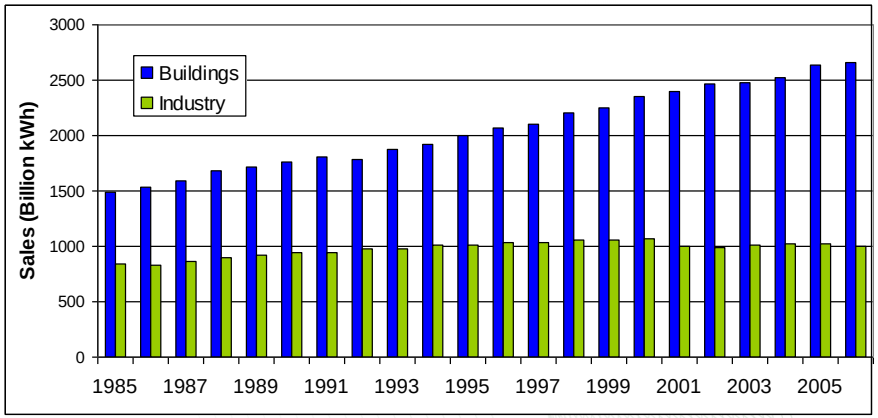
Buildings consume 73% of U.S. electricity



34% of natural gas directly (55% incl. gen.)



Buildings drive electricity load growth



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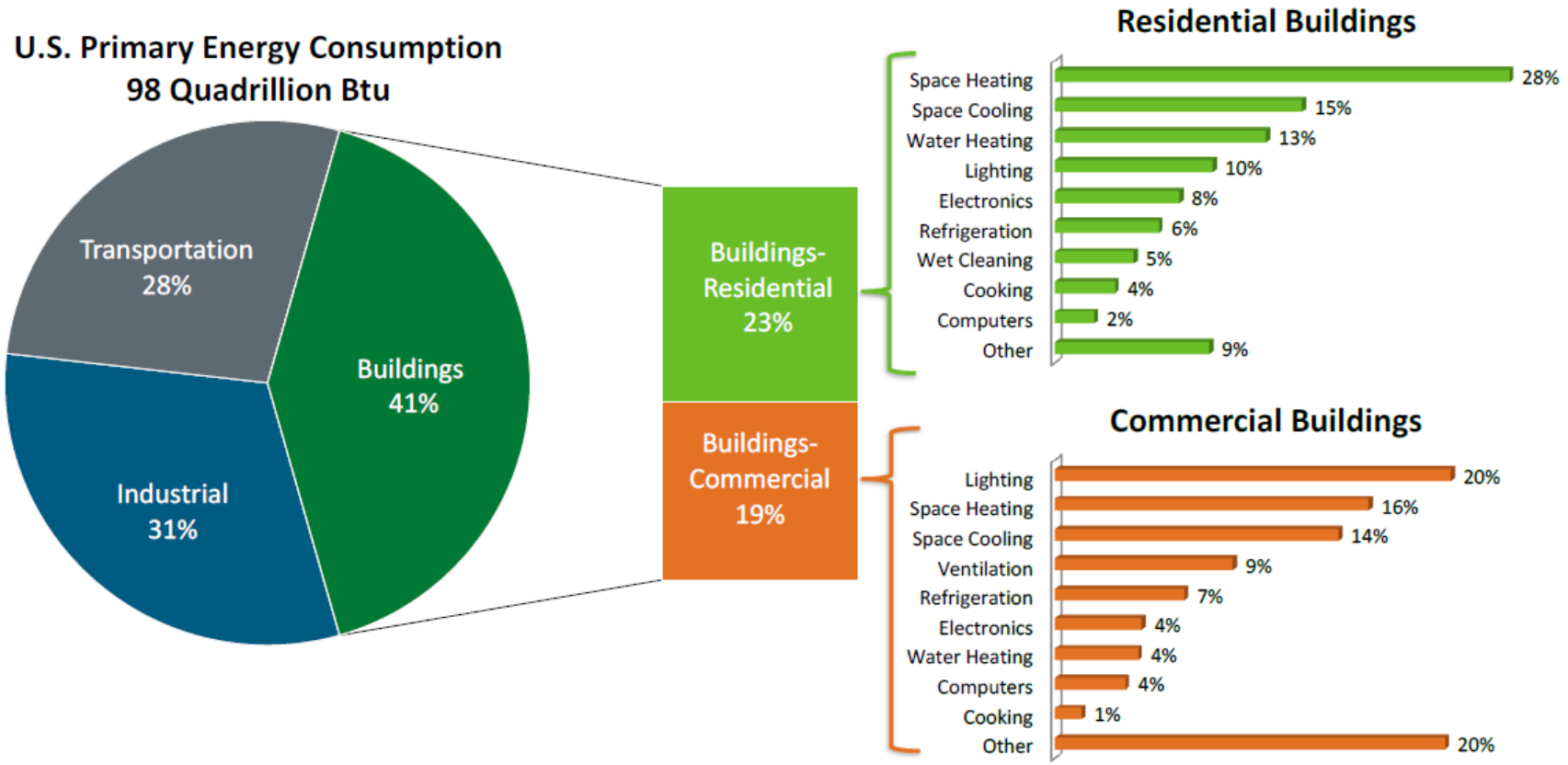
Buildings have many energy consuming systems within them (no silver bullet)



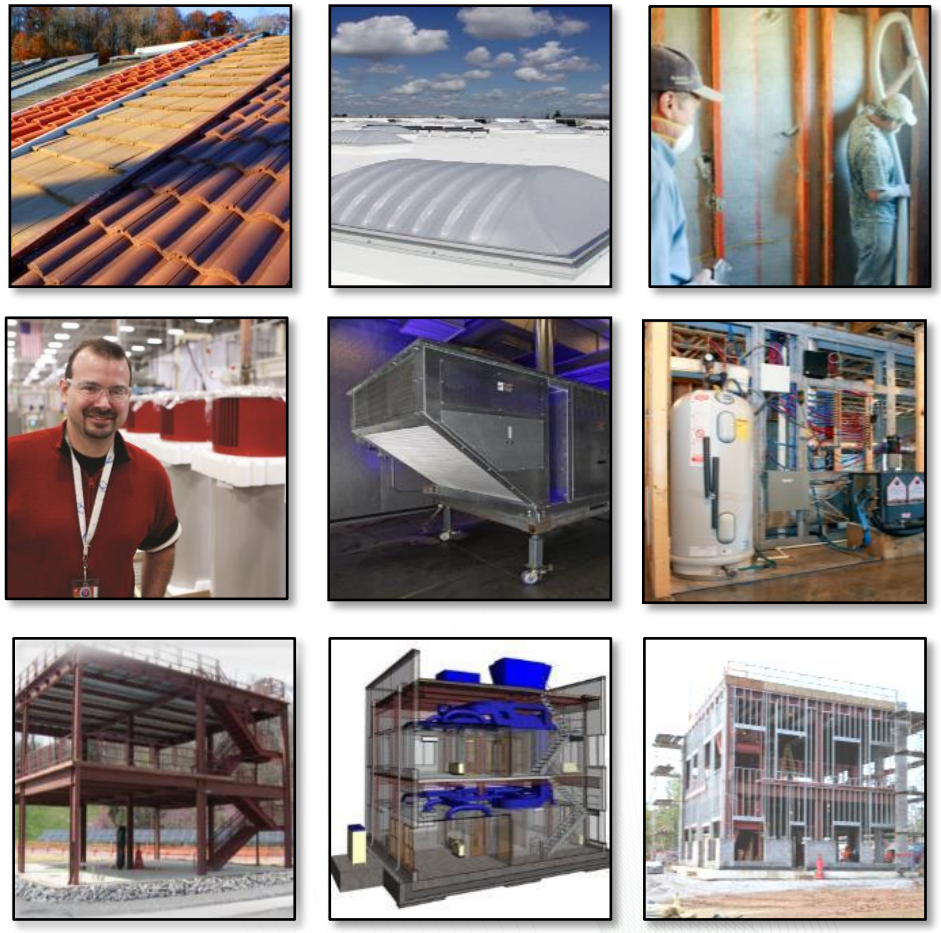
Building Technologies Research and Integration

R&D focus areas

Envelope: Develop component technologies that are more resistant to heat flow, airtight, and moisture-durable than existing technologies

Equipment: Develop component technologies that deliver the same amenities while using significantly less energy than existing technologies

System/building integration: Verify that advanced component technologies deliver what they promise and are durable and reliable in real buildings



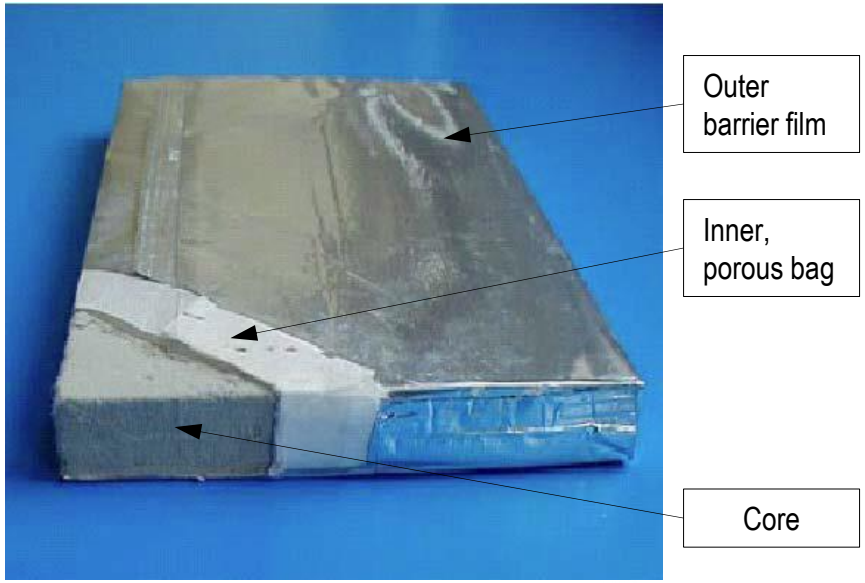
Significant increases in thermal resistance at half the cost

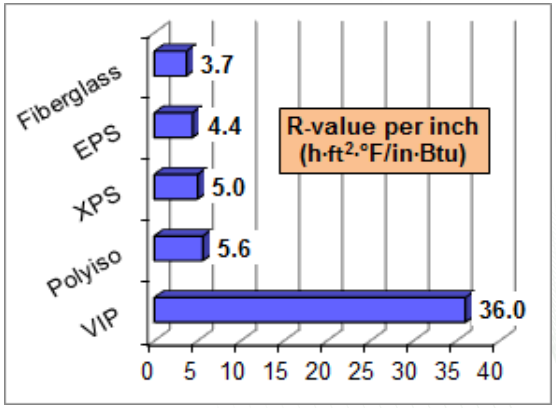
Description: Develop new high-performance modified atmosphere insulation (MAI), with NanoPore and Firestone Building Products, that doubles the performance of traditional building insulations per unit of thickness.

Approach: Insulation materials are developed for residential and commercial use; applicable to new construction and retrofits.

Impact:

- New MAI technology uses an alternative manufacturing process that could halve the cost of traditional vacuum insulation panel (VIP) technologies and simplify their application into building envelopes.
- ORNL-industry team will soon begin developing a composite board insulation (MAI in polyiso foam).





VIPs provide a significantly higher R-value (measure of thermal resistance) than current insulation materials.

Project sponsor: DOE-EERE Building Technologies Office

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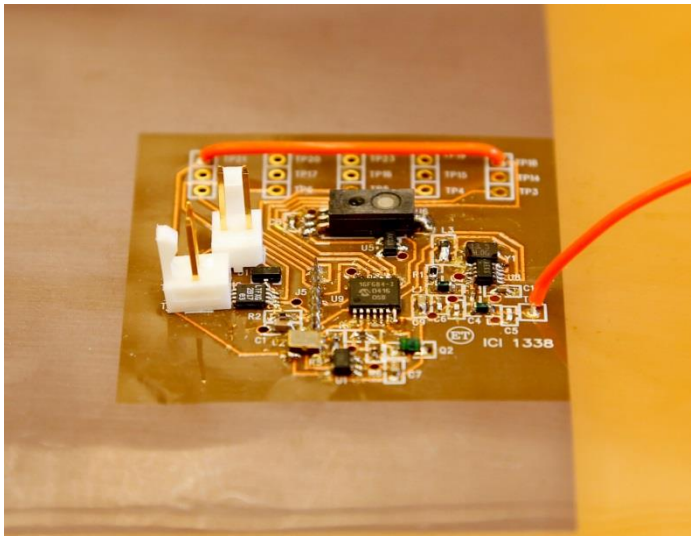
Low-cost wireless sensors monitor for better building efficiency in buildings

Description: ORNL researchers are developing a new generation of low-cost wireless sensors, leveraging additive, sheet-to-sheet or roll-to-roll manufacturing techniques; electronics integrated on flexible substrates; low temperature photonic curing; and advanced materials.

Approach: Self-powered "peel-and-stick" sensors provide information for optimal control of energy-consuming systems (HVAC, lighting); and fault detection and diagnostics

Impact: When commercialized, these low-cost sensors enable control system upgrades that could potentially reduce energy consumption of buildings by up to 20-30%; ORNL-developed sensor platform has potential to reduce cost from $150-300/node to $1-10/node while also reducing installation cost.*

Project sponsor: DOE-EERE Building Technologies Office



Low-cost wireless sensor prototype

In Fall 2014, ORNL's research team began evaluating the performance of low-cost wireless sensor prototype and developing commercialization relationships. ORNL recently signed an industry research agreement with global electronic components manufacturer, Molex.

**Price points may vary based on market conditions.*

Gas engine-driven heat pump reduces demand

Description: Develop a commercial gas engine-driven heat pump for the Southwest market

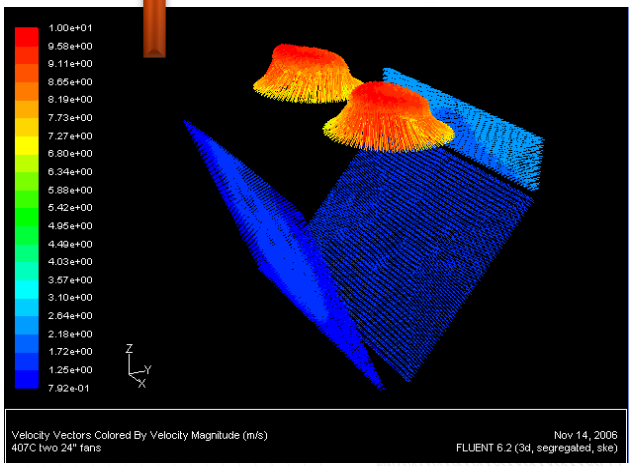
Approach:

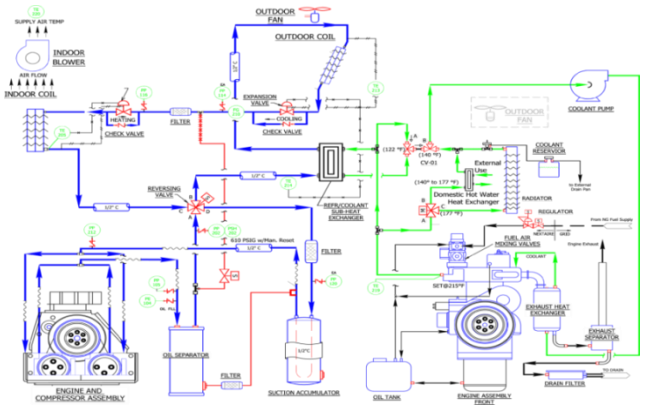
- Capacity: 120,000 btu/h @ 95°F; 150,000 btu/h @ 47°F
- COP: 1.2 @ 95°F; 1.5 @ 47°F
- Successful RTU project with Southwest Gas
- Market introduction April 2010

Impact:

- 2010 NSPE New Product Award
- 2011 R&D 100 Award
- 85% reduction in demand vs electric HP

NEXTAIRE PACKAGED GAS HEAT PUMP





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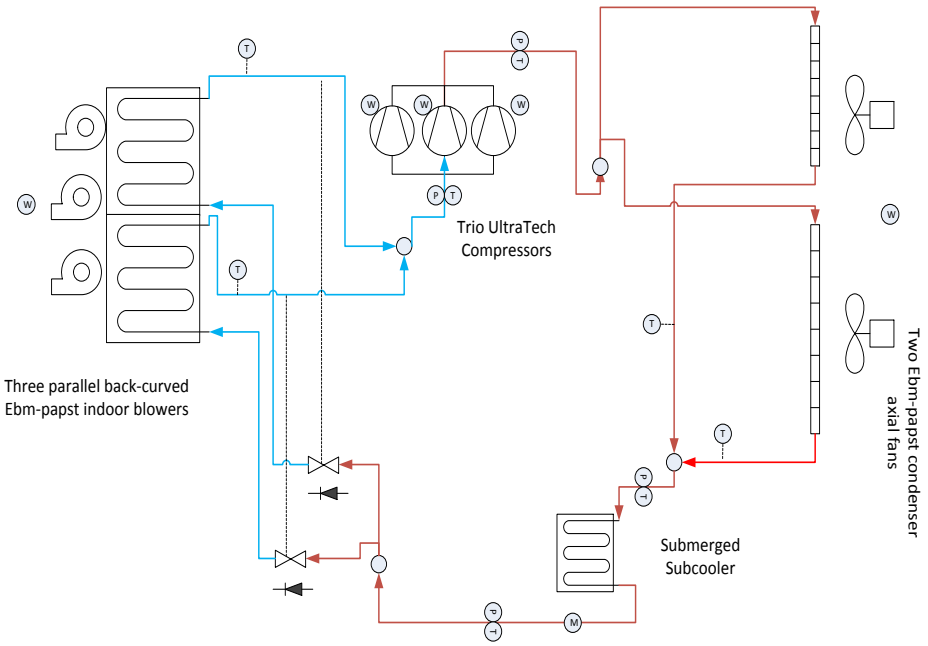
High IEER next generation rooftop unit

Description: Develop RTU with an IEER of 20.0 and 20-ton cooling capacity

Approach:

- Use Modelica modeling language linked to ORNL HPDM to evaluate multiple technical solutions
  - variable-speed compressors,
  - micro-channel HXs,
  - condenser evaporative pre-cooling,
  - desiccant and heat recovery wheels

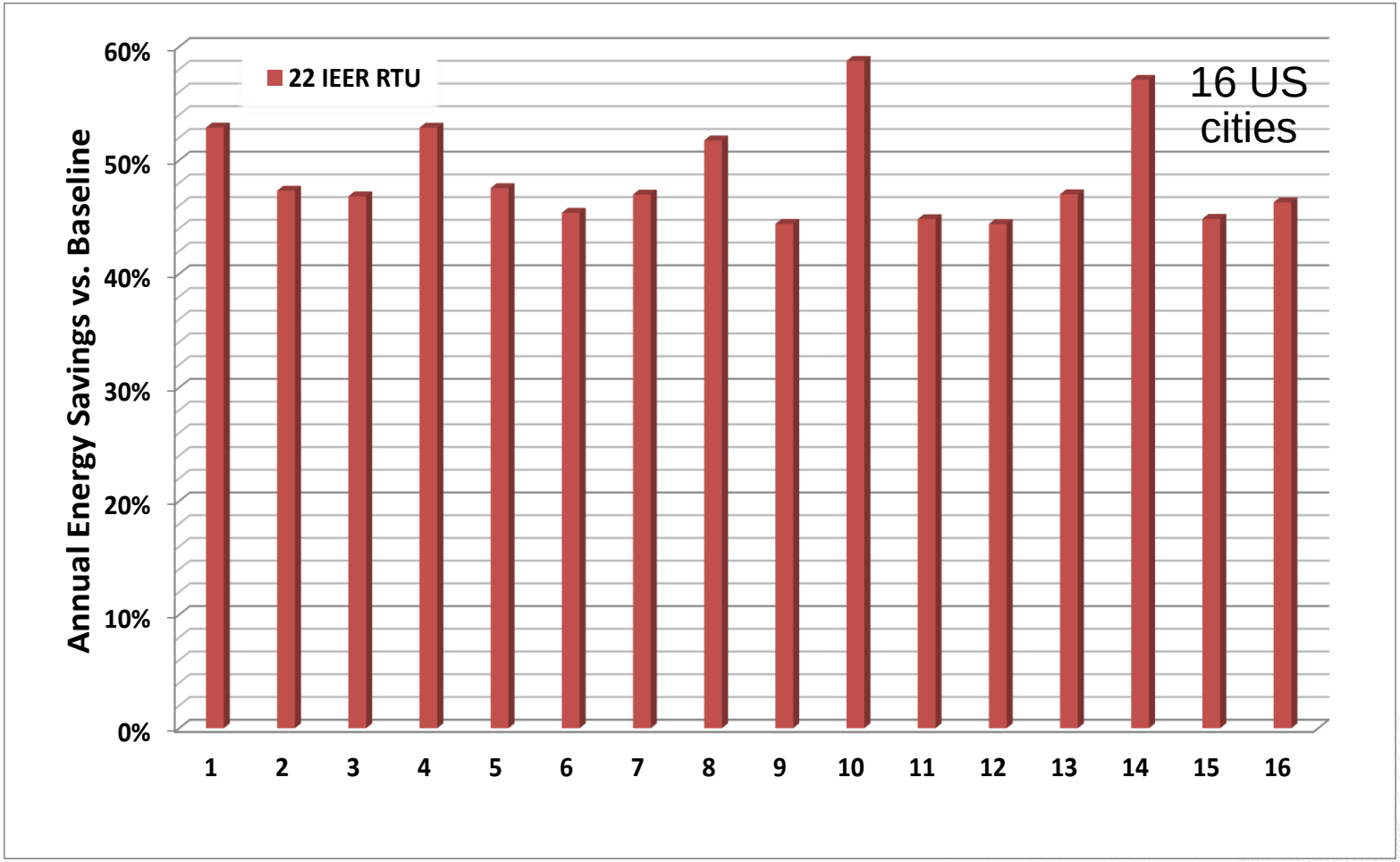
Highest efficiency RTU (22 IEER) developed by Trane, ORNL



Field evaluation in ORNL's flexible research platform in 2015

Significant building energy savings nationwide

- Baseline single-speed RTU, IEER of 11.2, in commercial, small office buildings
- Energy savings predicted by simulations using EnergyPlus



Supporting deployment of environmentally friendly technologies

Hillphoenix
Advansor System

First HFC-free CO_2 transcritical refrigeration system to be UL listed in North America

12 US applications to date

Honeywell
N40 (ASHRAE designation: R-448A)

~67% global warming potential (GWP) reduction compared to R-404A

Improves system efficiency by 10%

Commercialized in Jan 2015

By leveraging CO_2 refrigerant systems and new refrigerant molecules, ORNL researchers mediate and minimize conventional refrigeration's environmental footprint

Hillphoenix
A DOVER COMPANY

Honeywell

Lab → Market

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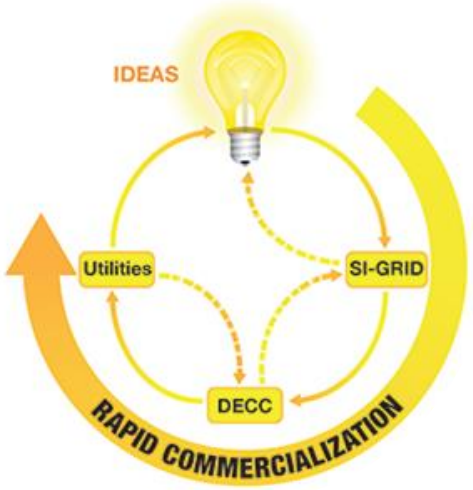
Accelerating microgrids of the future

Rapid Pace from Concept to Commercialization

- Modeling and simulation
- Software-defined Intelligent Grid Research Integration and Development (SI-GRID) platform
- Distributed Energy Communications and Controls (DECC) facility
- Quick deployment of new technologies by utility companies
- Accelerated process for commercialization in half the time



Networked Microgrids for Sustainable Energy:

- Overhead conductors and split-phase system for microgrid interconnection
- Two main DECC lab buildings
- 1-story and 2-story flexible research platforms
- Photovoltaic (solar) array
- Microturbine
- Load bank
- Energy storage

EPB partnership creates smart electric grid research opportunities

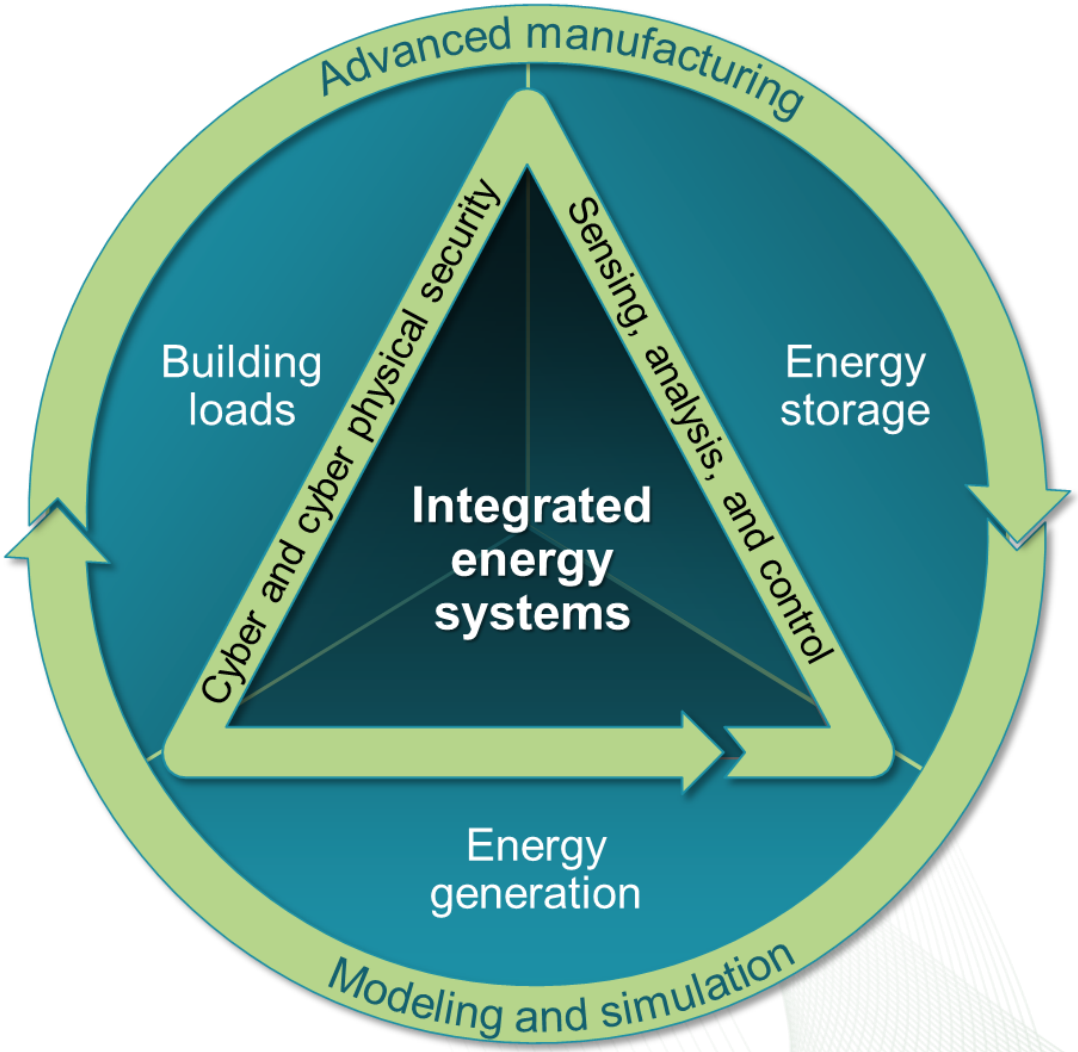
- MOU with ORNL, EPB, and DOE to develop engineering scholars program
- Lead to further research areas
  - Data management
  - Cybersecurity
  - Advanced controls
- Prime opportunity for ORNL to demonstrate energy technologies and gain real-world understanding of performance and ideal environments for emerging applications.

EPB brief

- Formerly the Electric Power Board of Chattanooga (TN)
- 170,000 residential and business customers; 600-square-mile service area
- 1 gigabit Internet offering to both residential and business customers; fastest in the U.S.
- Tennessee Valley Authority distributor

Leveraging ORNL assets with industry is key to vision for sustainable communities

- Vision: Sustainable communities with full access to energy, where they need it, when they need it
- Integrated energy systems project introduced to lay framework for an energy systems institute
- Leveraging expertise in building technologies, advanced manufacturing, sustainable transportation, power electronics, electric grid, modeling and simulation
- Collaborating with industry and EERE (BTO, AMO, VTO)
  - Demo Project: Connecting vehicle, building, manufacturing, and grid technologies to provide innovative, reliable energy solutions



3D printed all-electric Shelby Cobra

Plug-and-play “lab on wheels”

- Big area additive manufacturing
- Carbon fiber composites
- Integrated power electronics, battery, and electric motor
- Wireless power transfer
- Vehicle simulation based component sizing and controls development

Discussion

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