Integrated Energy Systems Research at ORNL

Presented by
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Oak Ridge, Tennessee
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ORNL is managed by UT-Battelle
for the US Department of Energy

OAK RIDGE National Laboratory

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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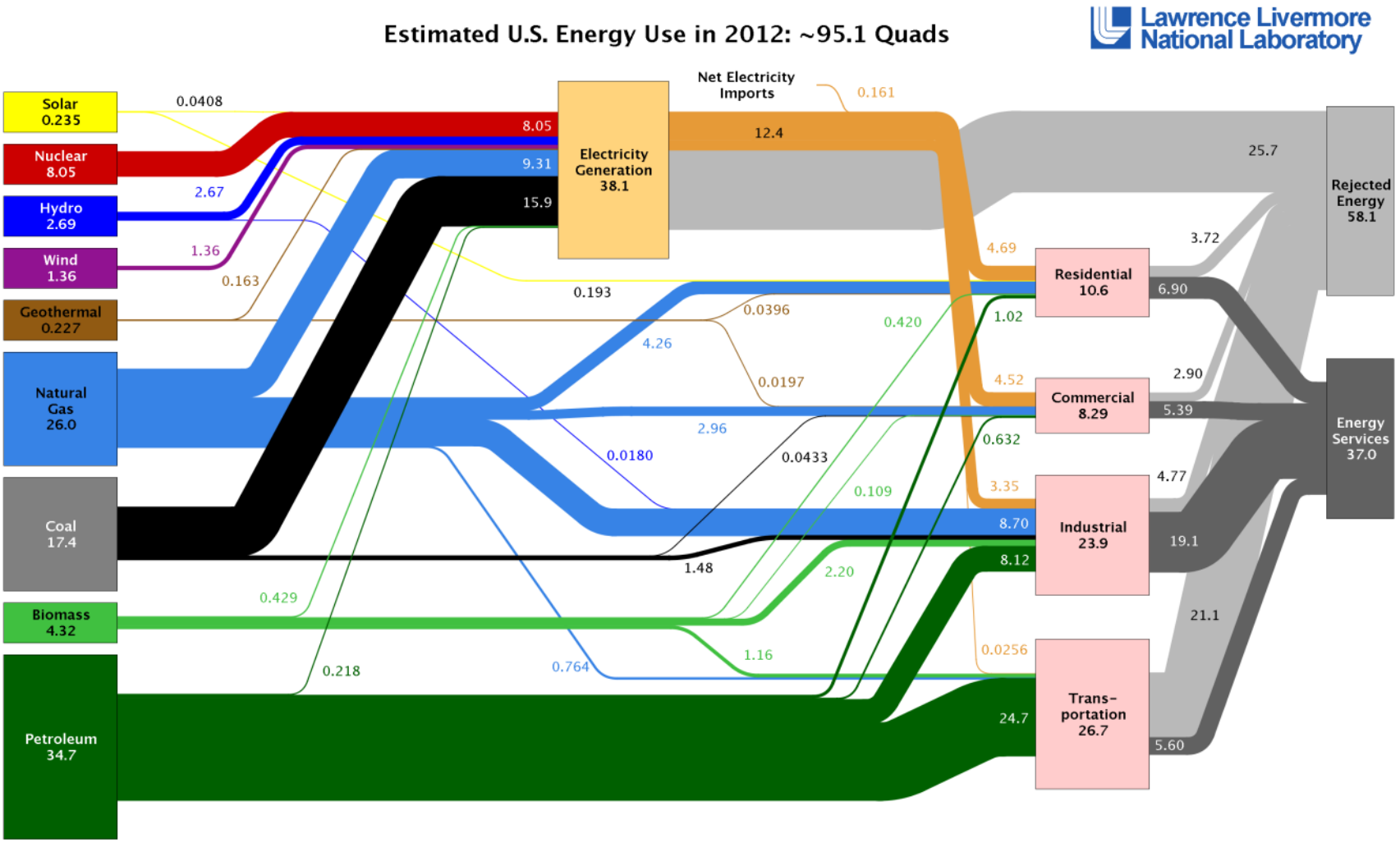
Over 60% of our energy is wasted — innovative science is needed to solve this problem



Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

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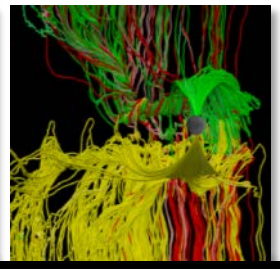
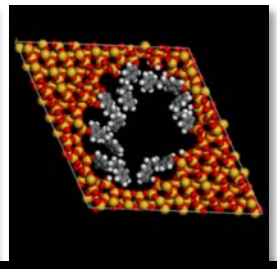
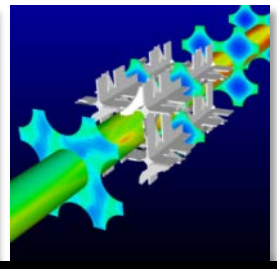
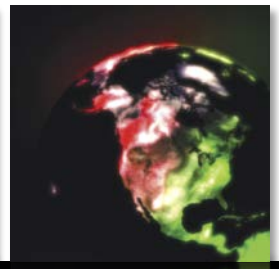
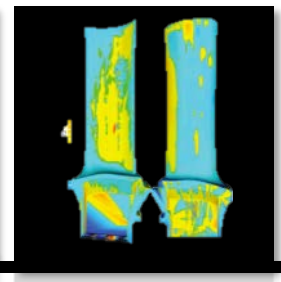
ORNL's science and technology initiatives


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

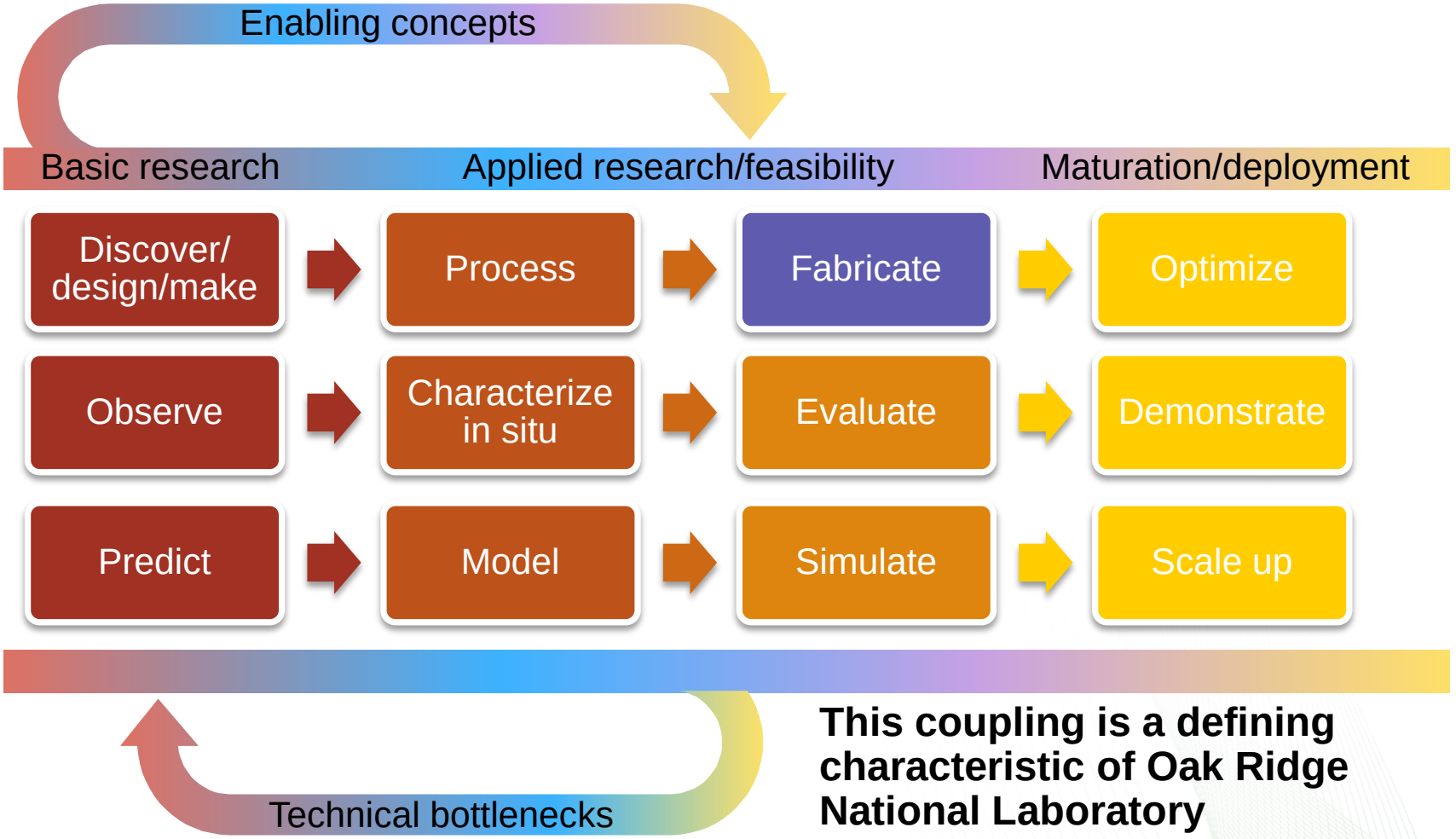
Enhance building energy efficiency, sustainable transportation, and advanced manufacturing

Solve the nation's most compelling global security challenges

Maximize ORNL's impact

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

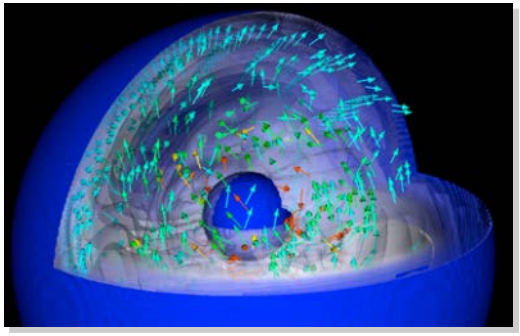
Close coupling of basic and applied R&D can accelerate new energy technologies



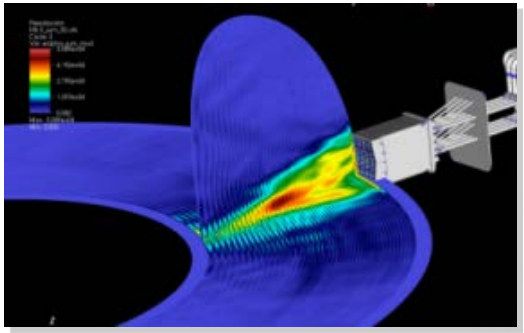
This coupling is a defining characteristic of Oak Ridge National Laboratory

High Performance Scientific Computing

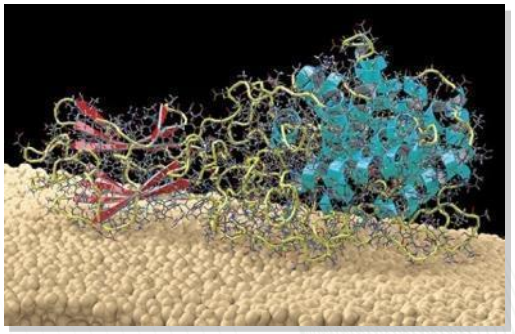
- Titan is the world-leading scientific computing facility
- Operating at 20 petaflops (fastest non-classified system in world)
- Focus on computationally intensive projects of large scale and high scientific impact
- Enabling scientific discovery



Astrophysics



Fusion



Biology

Energy and Environmental Sciences: Solving problems at the nexus of energy, climate, and security

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The Energy and Transportation Science Division provides solutions to pressing energy challenges

Sustainable transportation

Energy efficiency in buildings

Advanced manufacturing

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

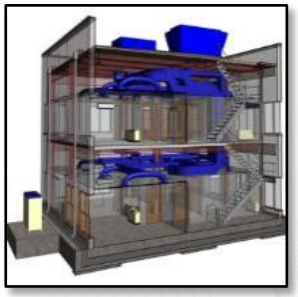
Equipment: Develop component technologies that deliver the same amenities while using significantly less energy than existing technologies

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








We Stand at a Key Point In Time

- Buildings are more efficient than ever

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Maximizing Energy Efficiency in Homes

The Houses

- **A public/private partnership to maximize cost effective energy efficient practices and technologies needed for zero energy buildings**

- Four houses that demonstrate different strategies to achieving 50 to 60% energy savings relative to traditional new construction

- The four houses are unoccupied for the duration of a two-year field study. Occupancy for an average 3 bedroom home is simulated in the homes.

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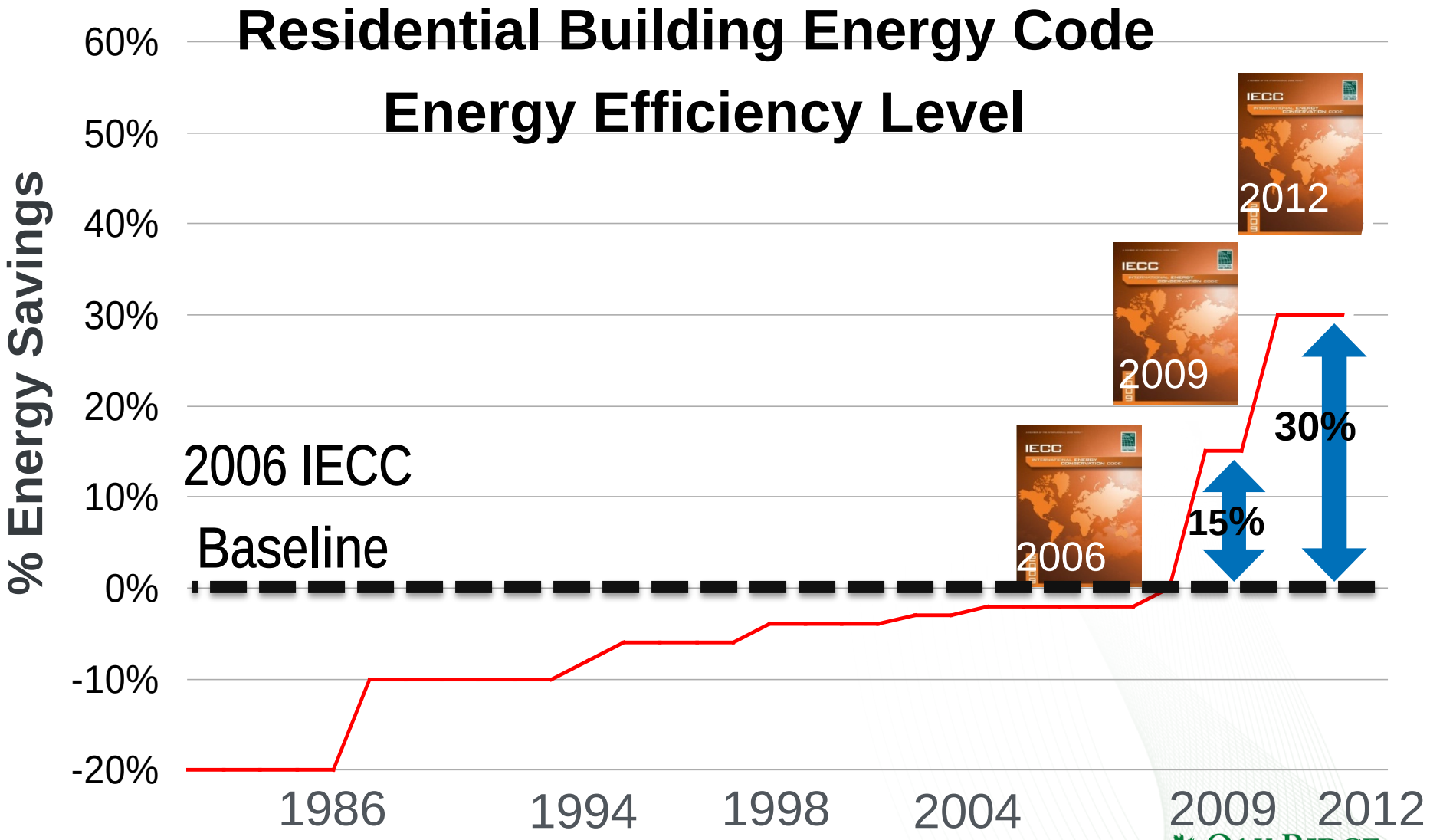

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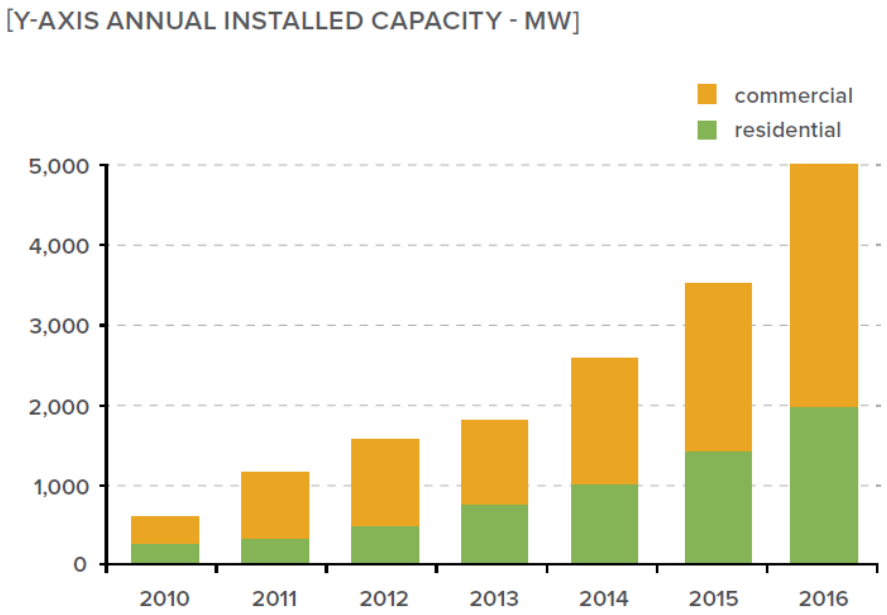
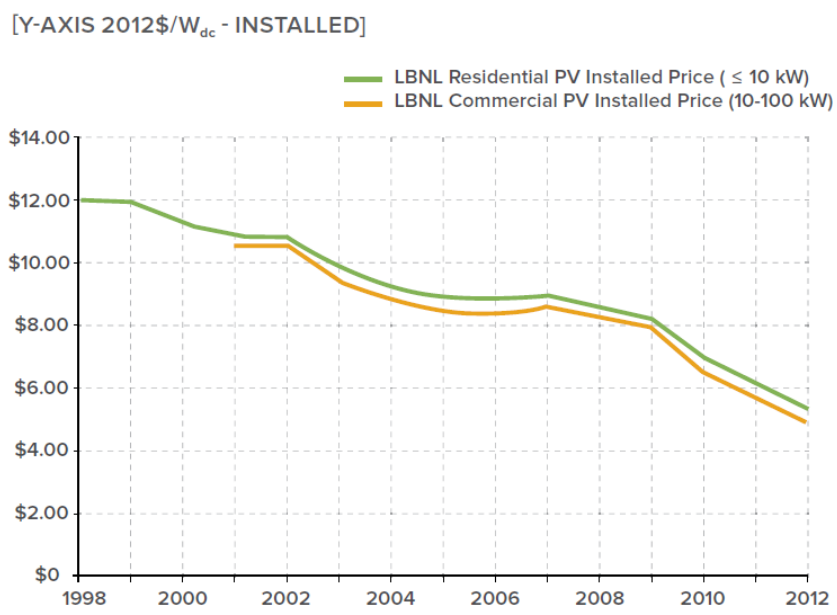
We Stand at a Key Point In Time

- Buildings are more efficient than ever
- Cost of distributed generation is lower than ever

U.S. Distributed PV Installations (Actual and Projected)



Historical PV Prices



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We Stand at a Key Point In Time

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ZERO non-renewable energy buildings could be a near term reality

Envision a Future...

where communities have full access to sustainable power where they need it, when they need it.

By integrating “scientific discoveries and technical breakthroughs” in energy systems through key ORNL strengths, we have the opportunity to improve the lives of people all over the globe for generations.

- Buildings
- Sustainable Electricity
- Energy Storage and Generation
- Computational and Data Science
- Vehicles
- Cyber-Physical Systems
- Advanced Manufacturing
- Control Systems
- Power Electronics

Buildings with Sustainable Power: Where They Need It, When They Need It

Cost effective, energy efficient buildings are required

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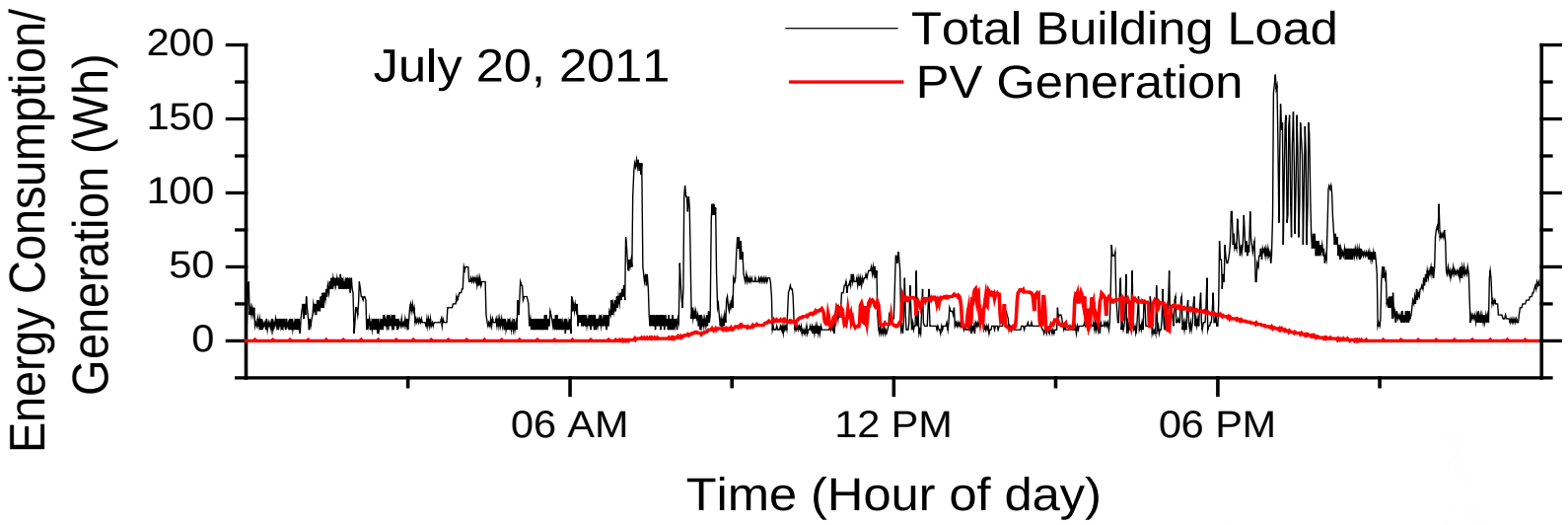
Matching load to generation is a primary science and engineering challenge



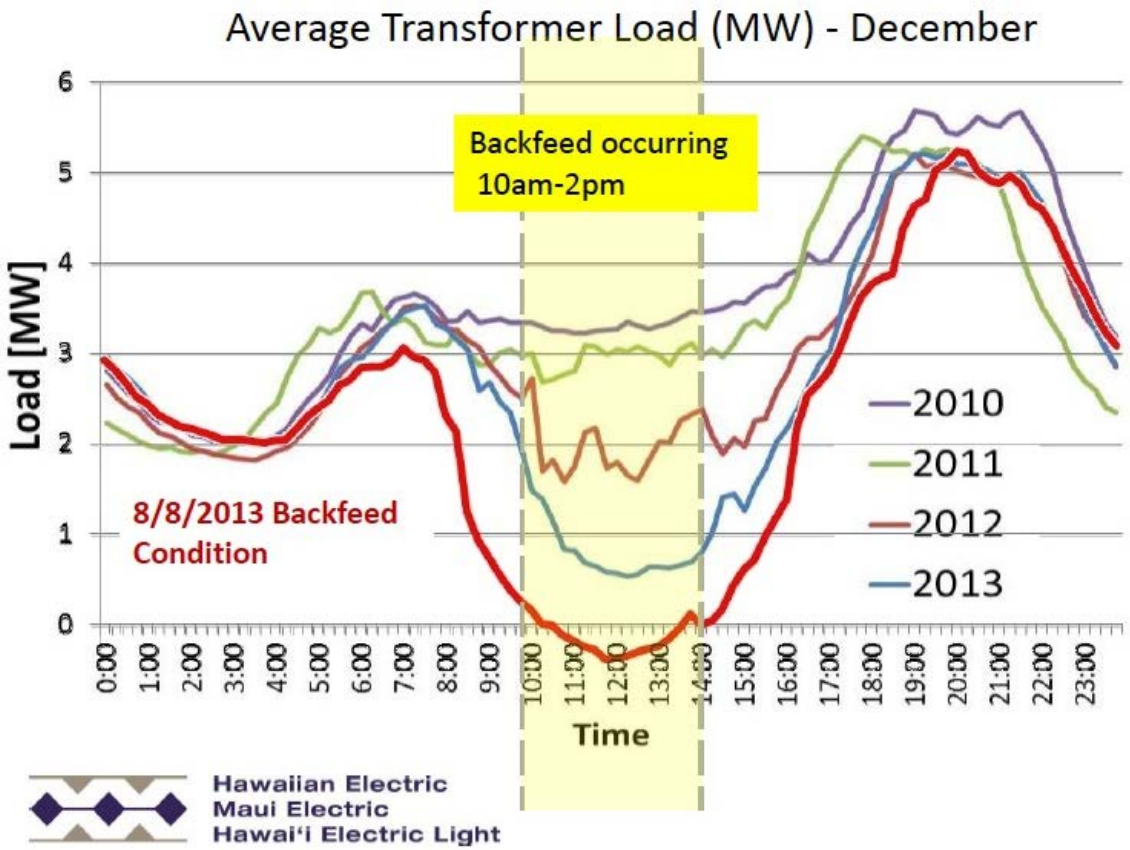
<15% of energy consumption occurs during peak PV generation

Uncertainty increases complexity

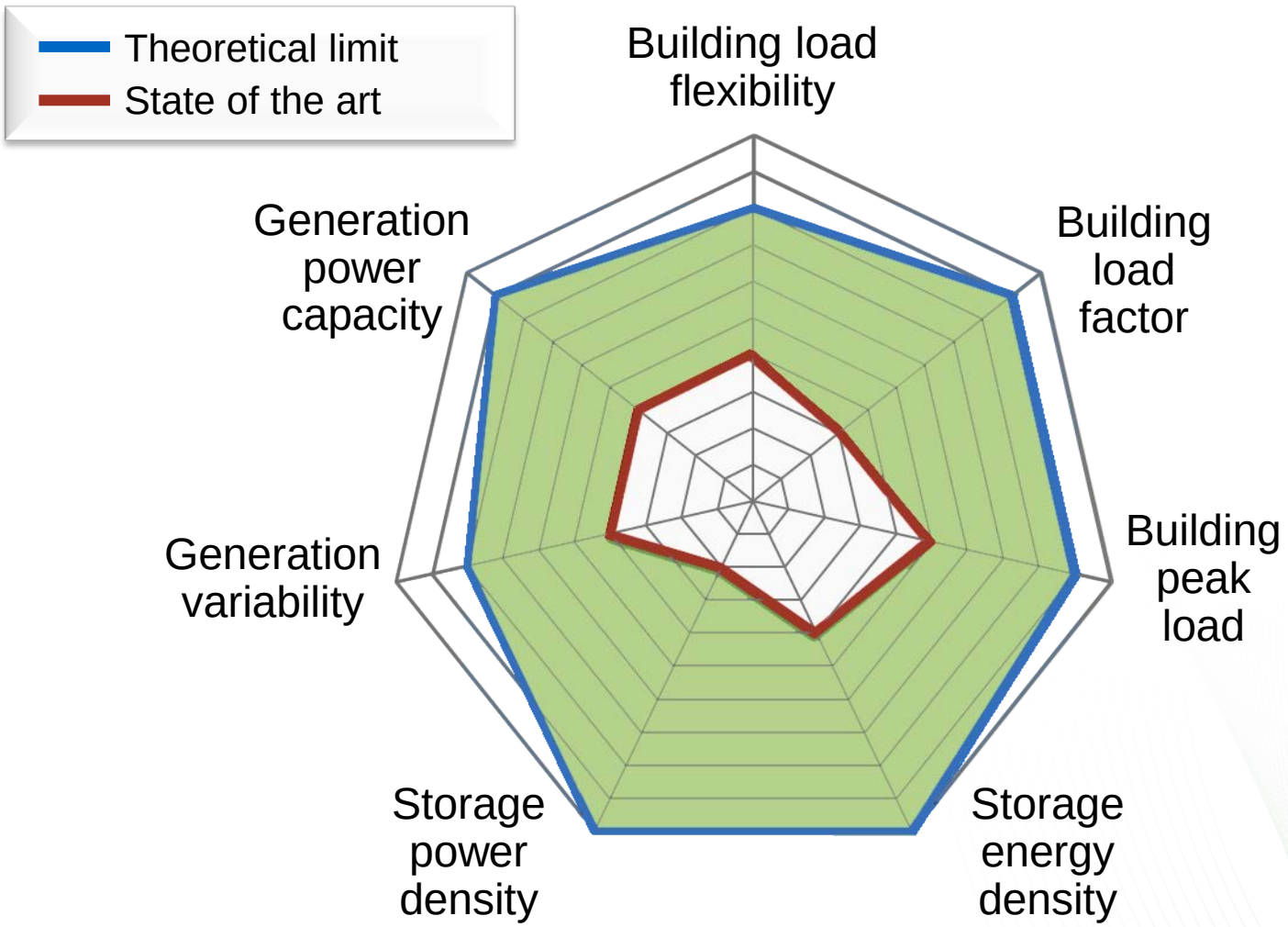
Weather and occupancy patterns

Additional generation, storage, and building energy management solutions are needed

Matching load to generation is a primary science and engineering challenge

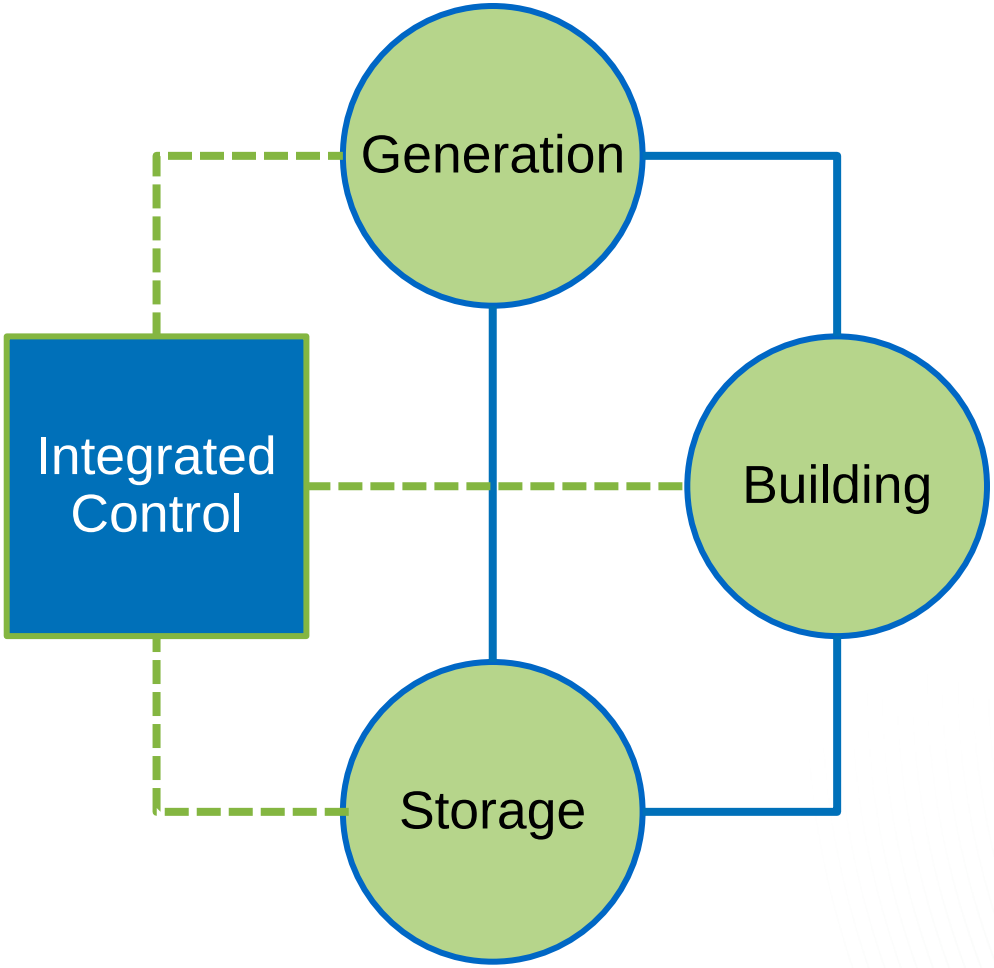


Science and engineering advances: Many opportunities exist

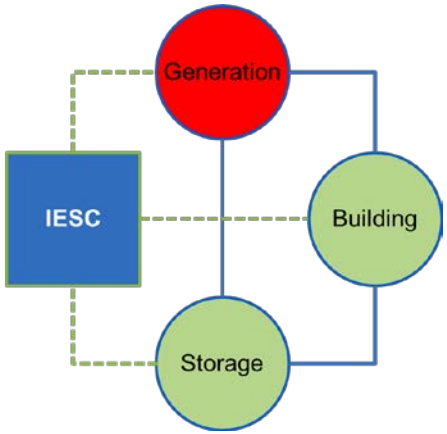


For illustration only

System optimization is required for cost-effective integrated energy systems



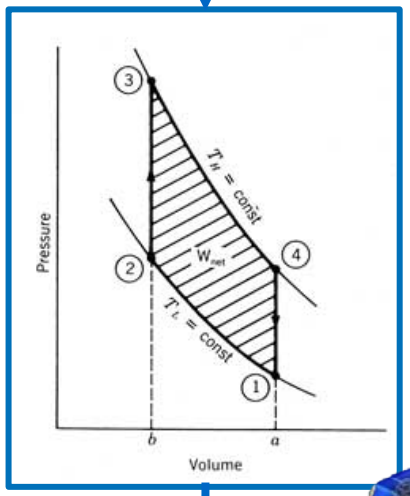
Task 1: Advanced Heat Engine Generators

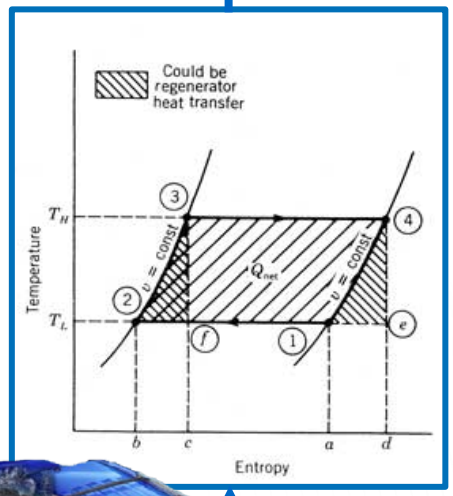


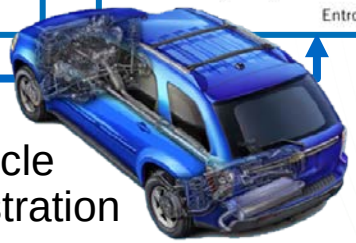
Demonstrate the potential of advanced heat engine generator (HEG) systems to generate power for vehicles and buildings

HEG system design:
Sensitivity analysis

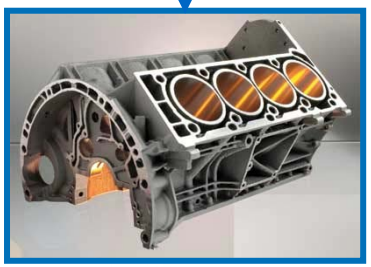
Building/transportation sized HEG





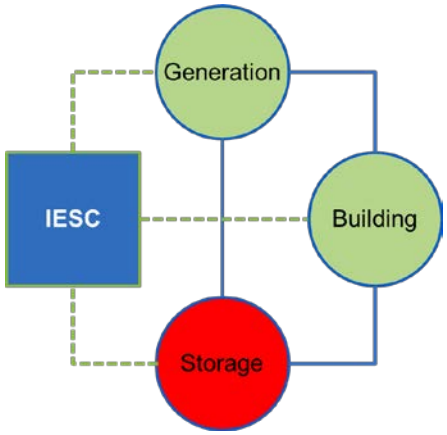


Vehicle demonstration

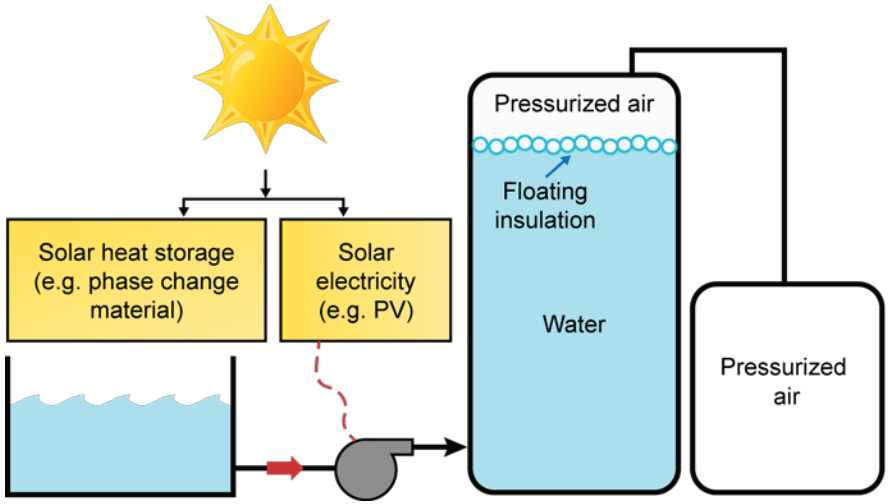


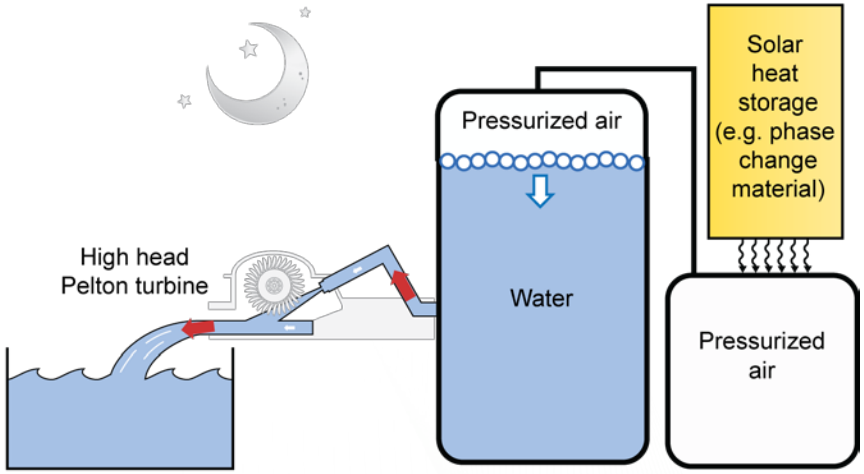
Additive manufacturing

Task 2: Ground-Level Integrated Diverse Energy Storage (GLIDES)



Develop a unique, low-cost, high round trip efficiency storage technology for building applications

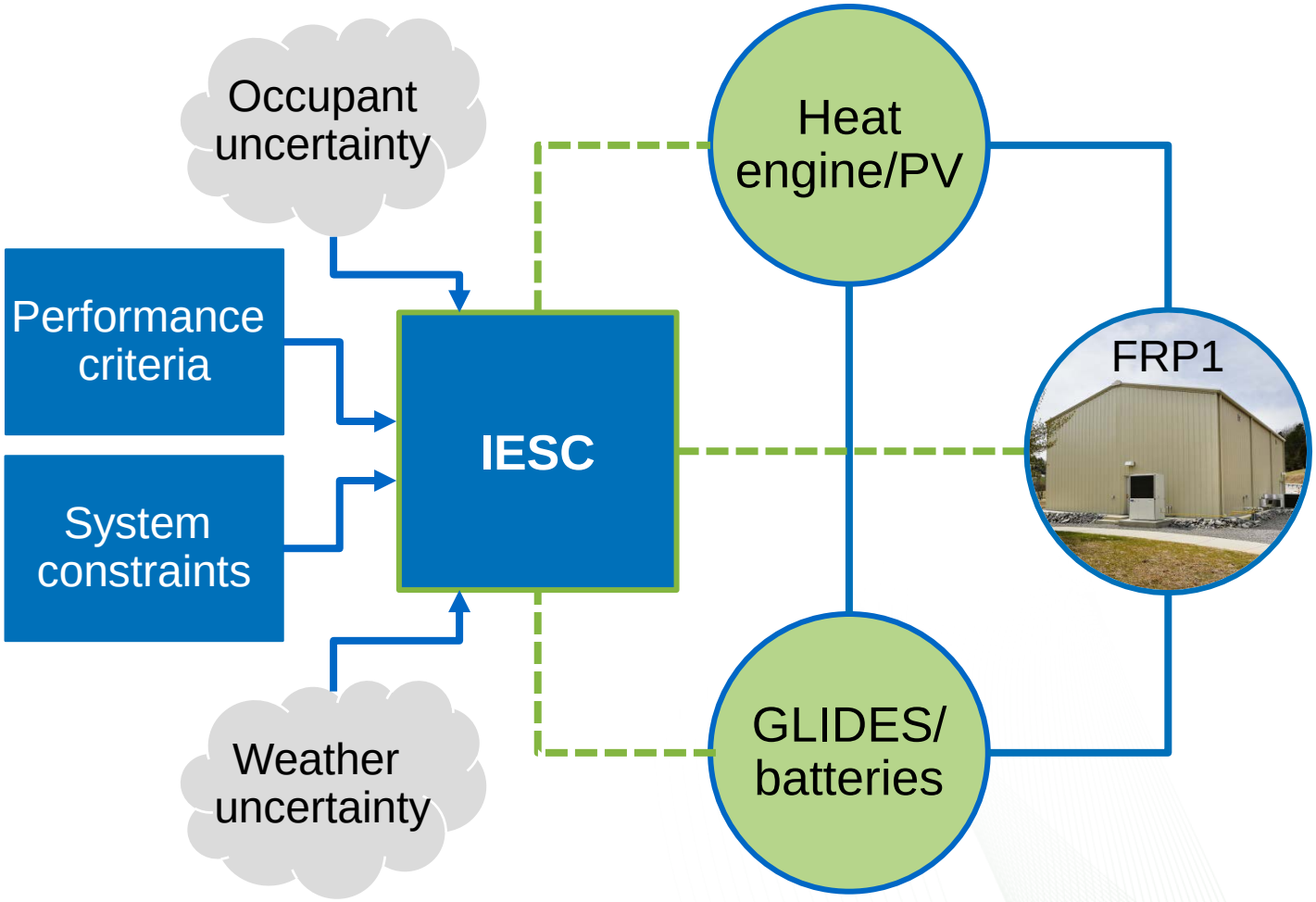




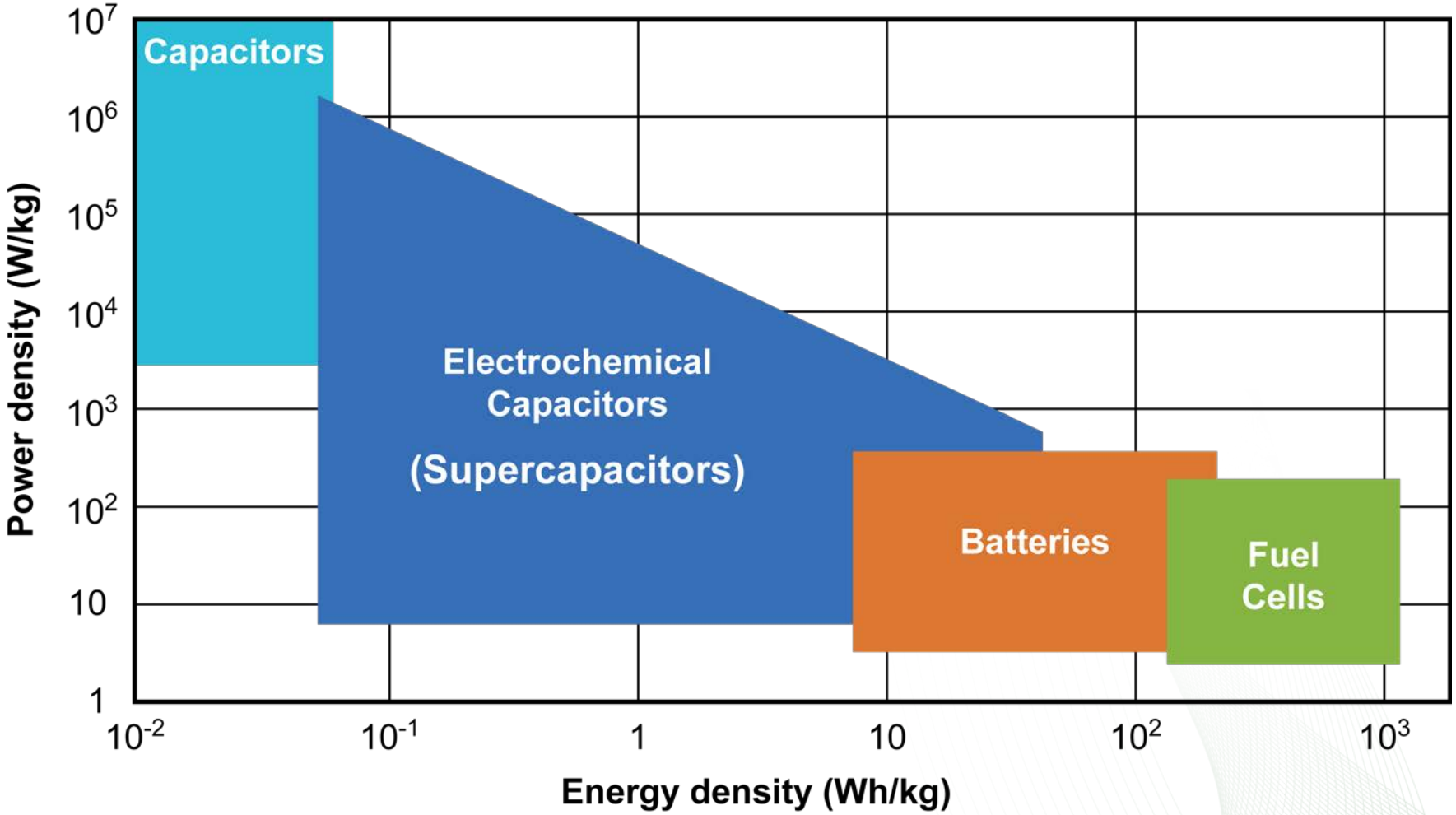
Key advantages	
Simple, low cost (<$80/kWh-e)	Dispatchable
Accepts different energy sources	Scalable
Round-trip efficiency: 82% (modeled)	Quick or slow charge/discharge time

Task 3: Flexible and Scalable Integrated Energy Systems Control (IESC)

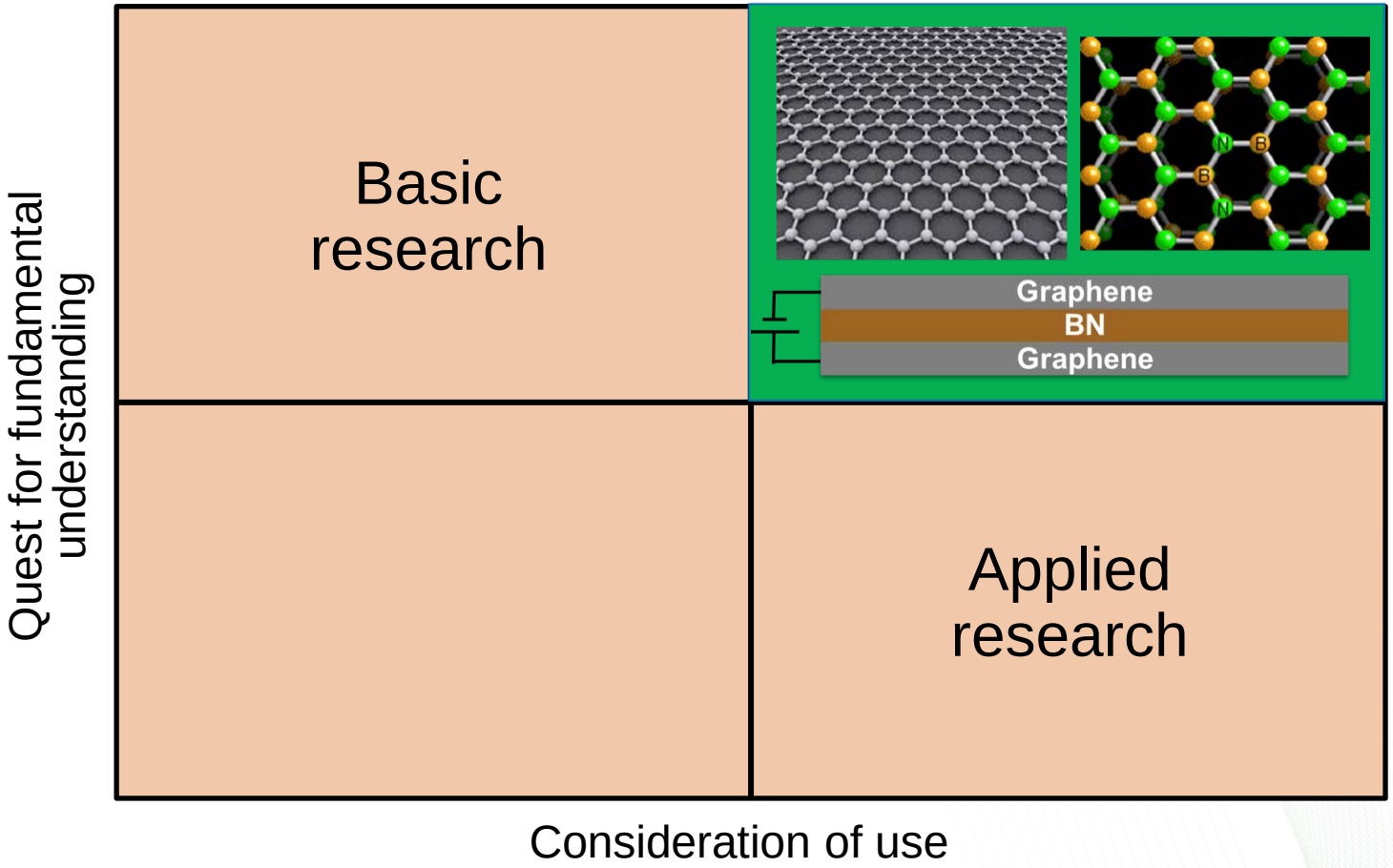
Demonstrate integrated energy systems control of Flexible Research Platform (FRP1), HEG, and GLIDES



Task 4: Demonstration of Use-Inspired Basic Research



Demonstration of Use-Inspired Research: 2D Capacitors



Let's Talk

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