NREL's energy research

is making an **impact**

NREL at a Glance

1,850

Employees,
plus more than
600
early-career researchers
and visiting scientists

World-class
facilities, renowned
technology experts,
campus that
operates as a living
laboratory

nearly 820

Partnerships
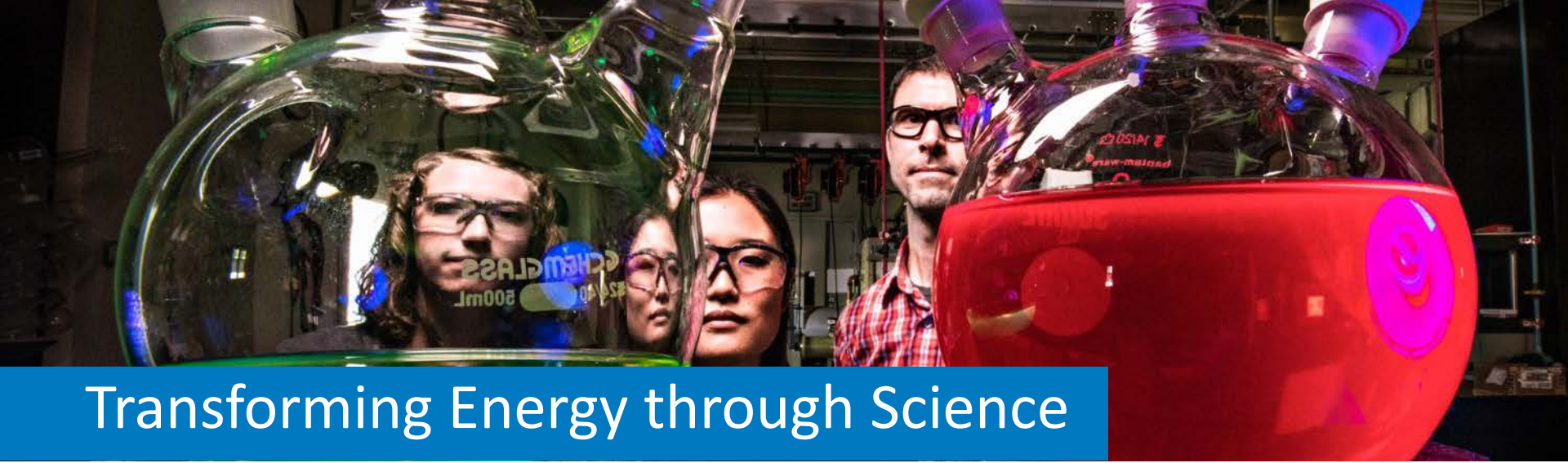with industry,
academia, and
government

708

Peer-Reviewed
journal articles in
FY18 and a 2018 field
weighted citation
index of
1.7

$1.1B
annually

National economic impact

Transforming Energy through Science

NREL advances the science and engineering of **energy efficiency**, **sustainable transportation**, and **renewable power technologies** and provides the knowledge to **integrate and optimize energy systems.**

The Future Is

Grid-interactive Efficient Buildings

Generation
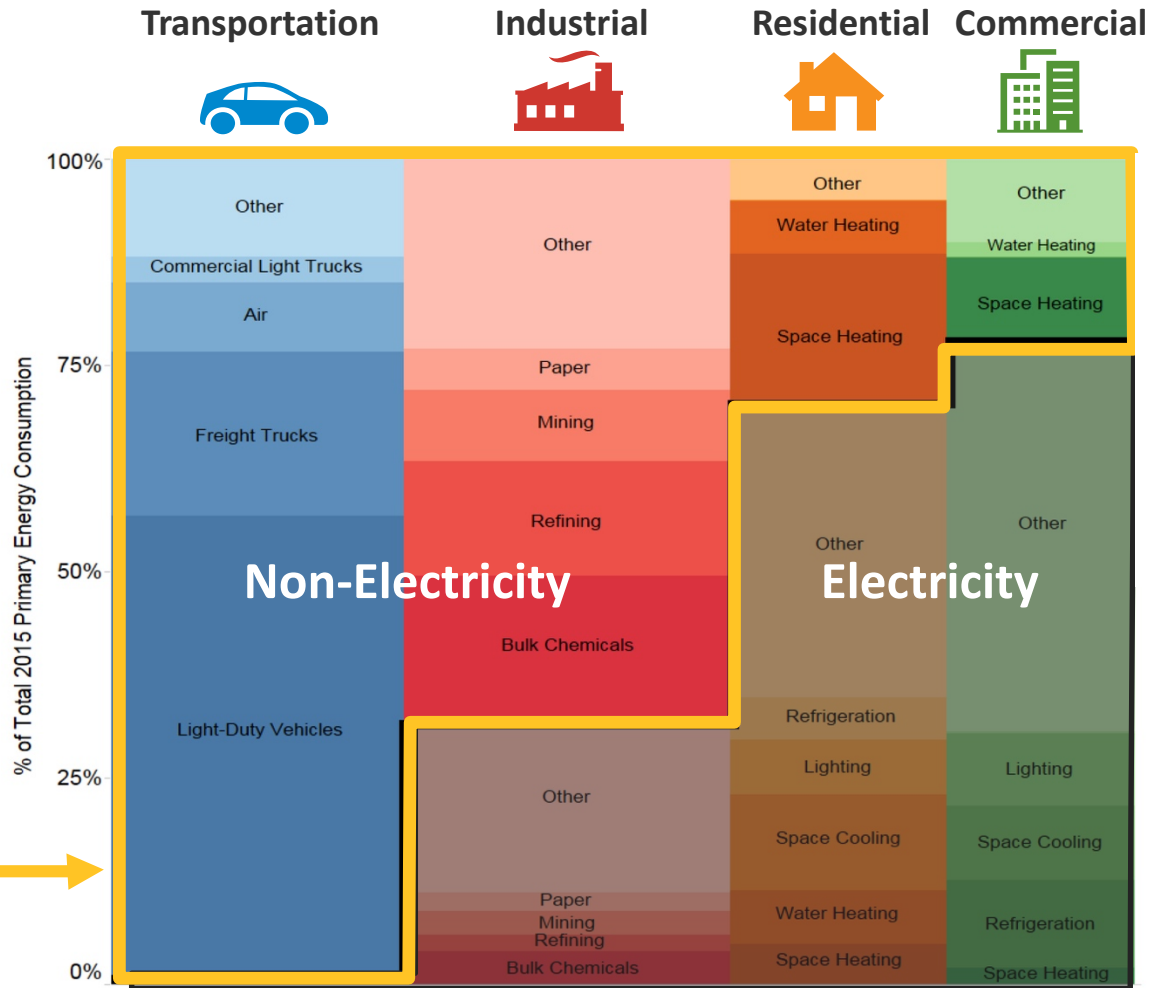
Transmission/
Distribution & Storage

Loads & Storage
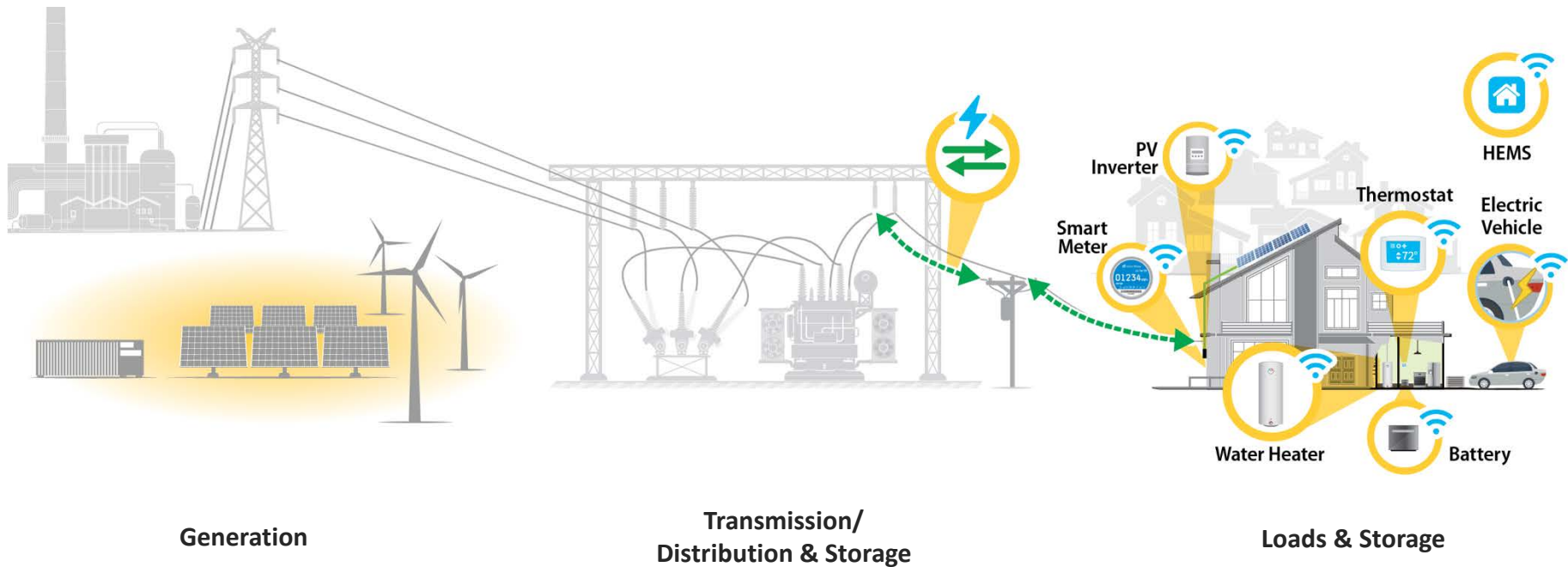
The grid is changing, largely at the edge

The cost of electricity generation is declining and new sectors are electrifying at an unprecedented pace, most notably transportation.

Scenarios of Electrification of the U.S. Economy

Several **energy system transformation scenarios** assume a great degree of future electrification, especially for transportation.

Further *exploration* **is needed in energy pathways.**
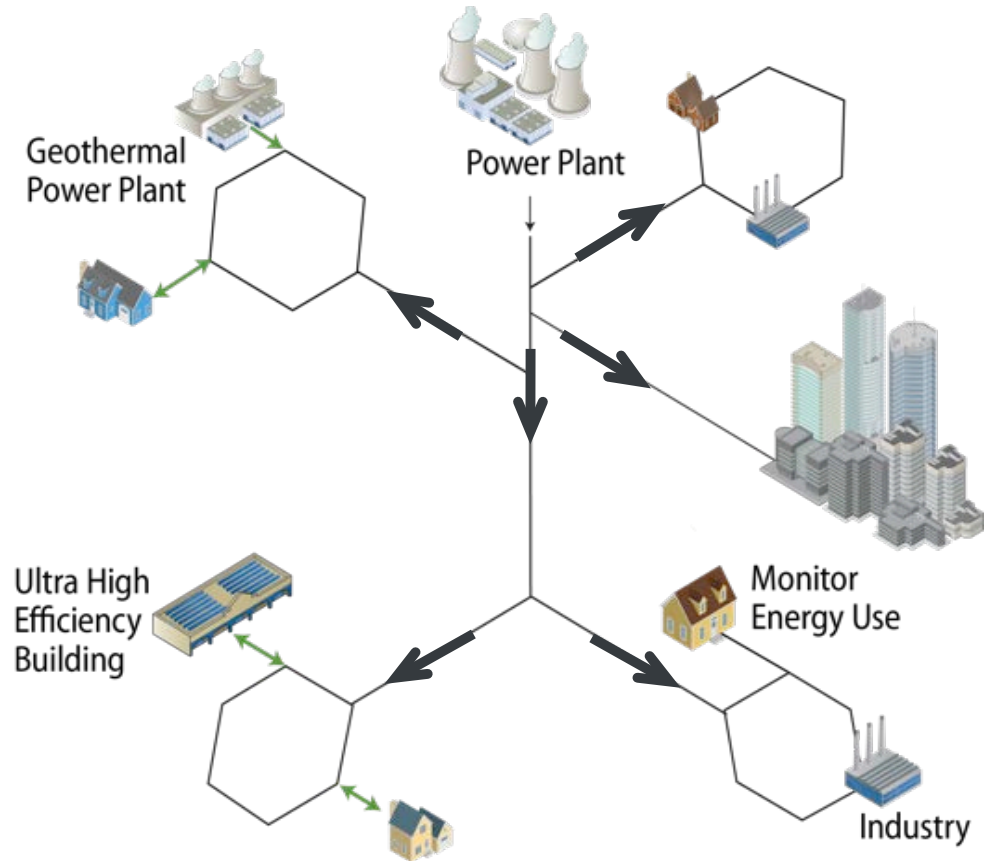
Source: *https://www.nrel.gov/analysis/electrification-futures.html*

Today's Grid

Buildings comprise

74%

of the total load

Geothermal Power Plant

Power Plant

Ultra High Efficiency Building

Monitor Energy Use

Industry

Tomorrow's Grid

Buildings comprise **??%** of the total load

Geothermal Power Plant

Power Plant

Solar Arrays

Rooftop PV

Wind Farm

Ultra High Efficiency Building

Energy Storage

Plug-in Car

Monitor Energy Use

Gas
Heat
Water

Industry
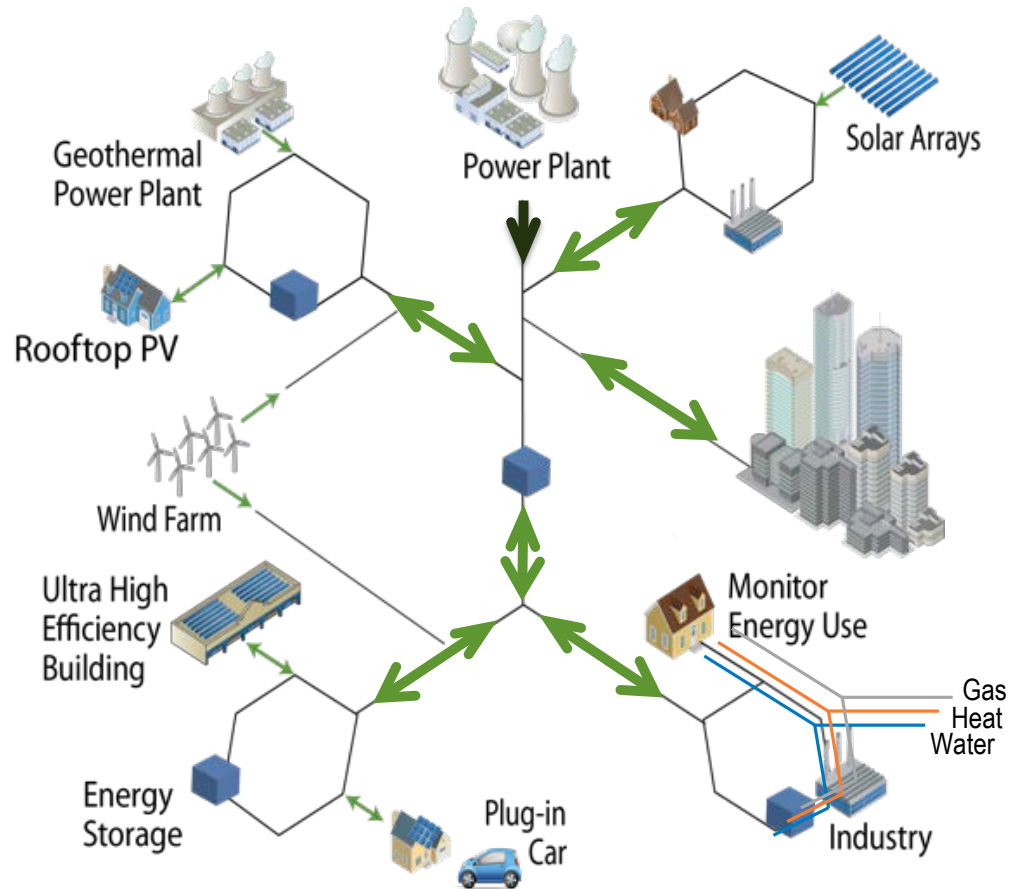
Moving Toward the Grid of the Future

TODAY: ONE-WAY POWER SYSTEM
Central, One-Way Power Systems

POWER PLANT

TRANSMISSION & DISTRIBUTION

RESIDENTIAL

COMMERCIAL

INDUSTRIAL
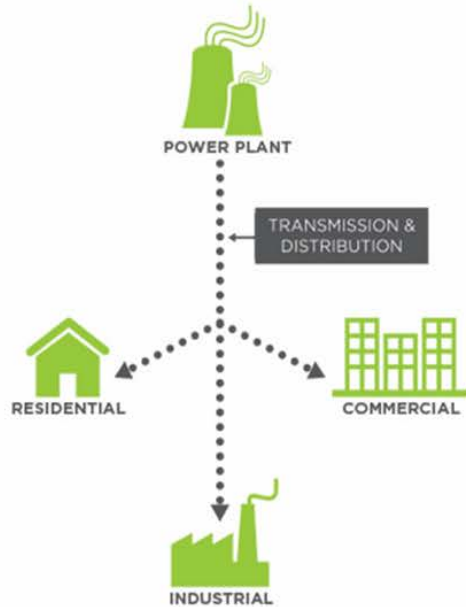
EMERGING: THE ENERGY CLOUD
Distributed, Two-Way Power Flows

Wind Farm with Energy Storage

Power Plants

Utility/Community Solar

Energy Efficient Commercial Offices with Rooftop Solar

Wind Farm with Cogeneration

Factory with Natural Gas Combined Heat and Power

Electric Vehicles

Energy Efficient Homes with Solar PV and Storage

Energy Efficient Hospital Campus with Microgrid

(Source: Navigant)
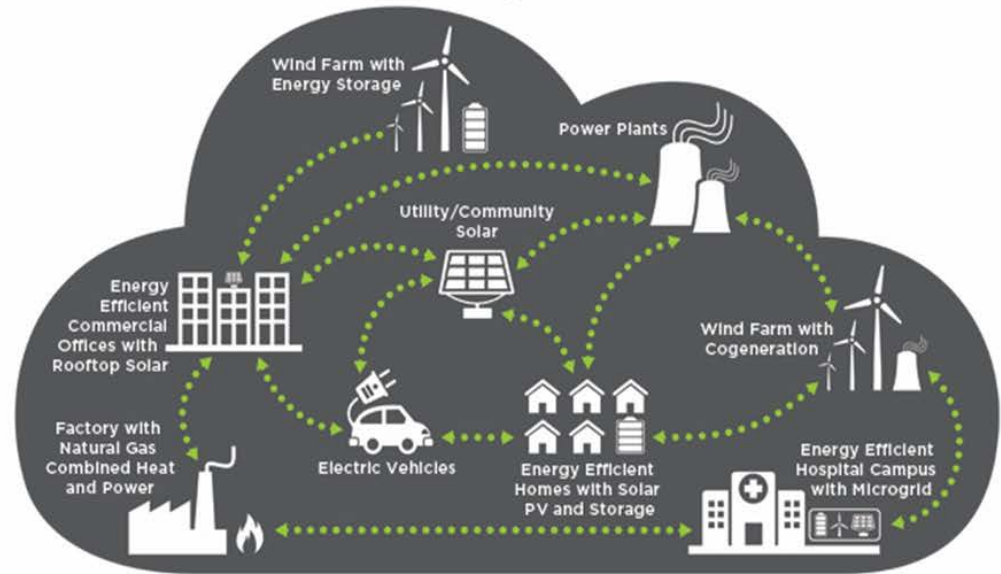
Flexible Building Loads

Provide options to increase electricity system reliability and energy affordability
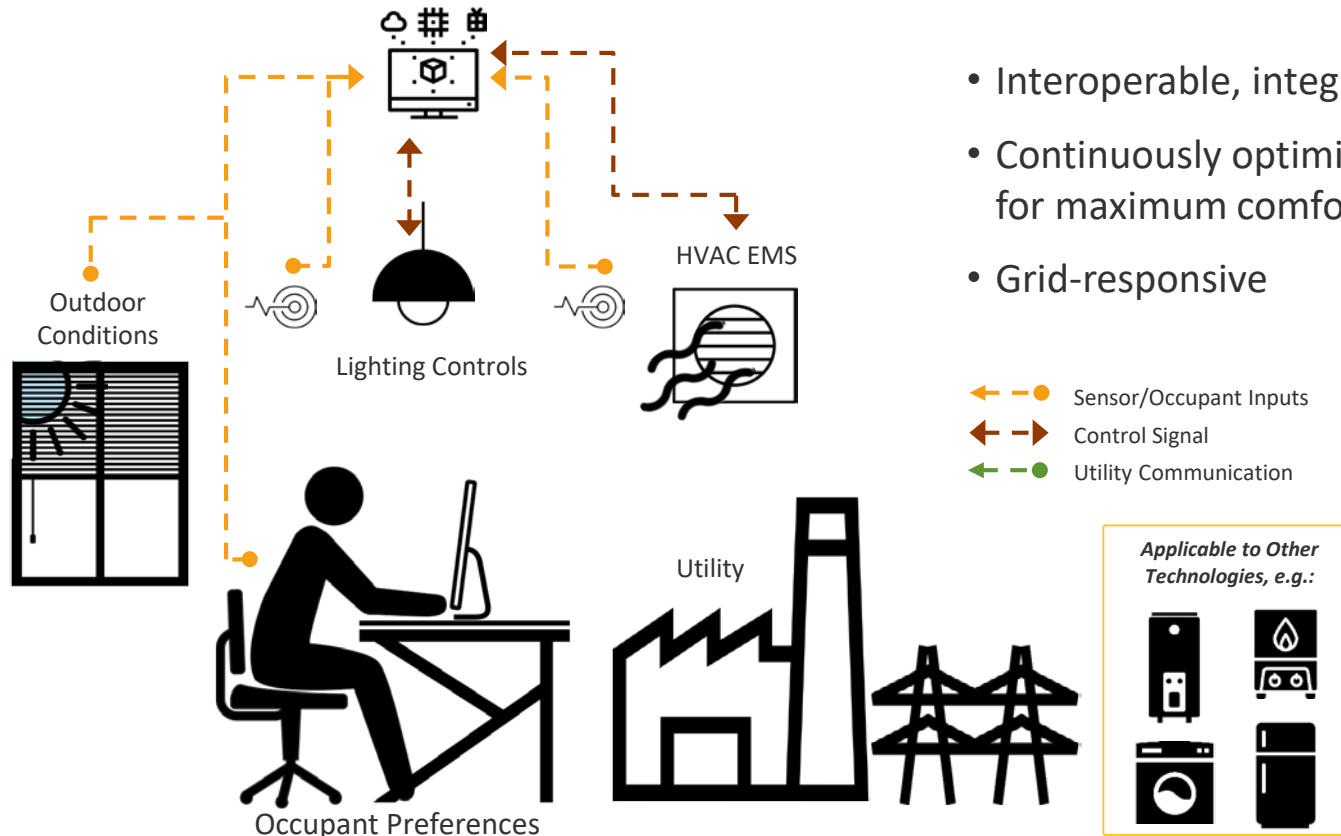

Support renewables and all generation options resulting from grid modernization

Optimize energy use based on customer preferences

Respond to innovations in the energy economy

Interactions with Building Occupants

- Interoperable, integrated systems

- Continuously optimized operation for maximum comfort and efficiency

- Grid-responsive

Outdoor Conditions

Lighting Controls

HVAC EMS

Occupant Preferences

Utility

Sensor/Occupant Inputs
Control Signal
Utility Communication

Applicable to Other Technologies, e.g.:

Grid-interactive Efficient Buildings

- Efficient equipment and building design reduce building load
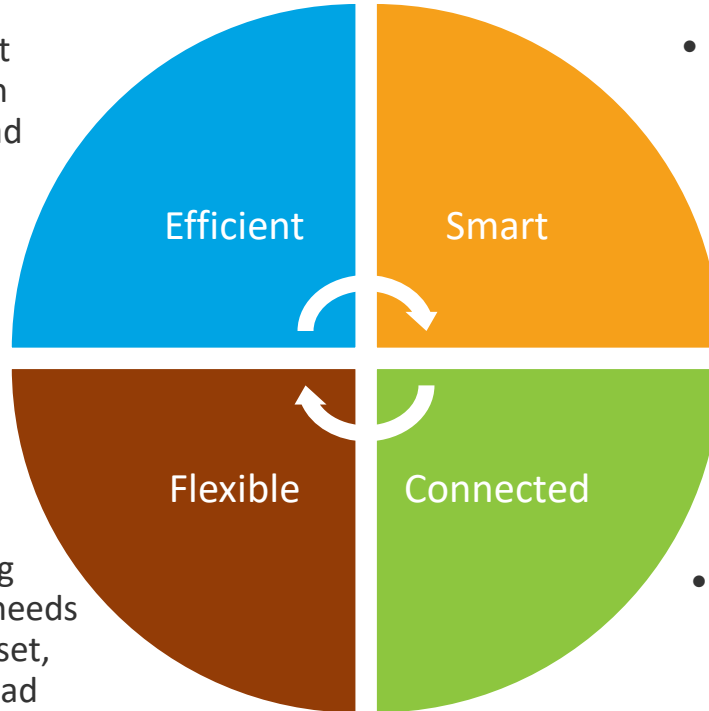
- Sensing, control, and analytics co-optimize efficiency, flexibility, and occupant needs

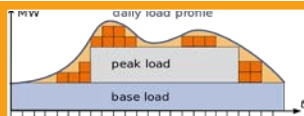Efficient

Smart

Flexible

Connected

- Ability to optimize building operations per occupant needs and DER availability to offset, shift, or flatten building load

- Two-way communication flow between building and external entities

Potential Benefits of Flexible Building Loads

 ✓ Energy Affordability

 ✓ Improved reliability

 ✓ Reduced grid congestion

 ✓ Enhanced services

 ✓ Environmental benefits

 ✓ Customer choice

Opportunities & Challenges

- Buildings can provide grid services such as reduced generation operation, generation capacity, transmission and distribution upgrades, and contingency reserves.

- Supply and demand diversity, which vary by climate, location, generation resource, market, and building type, drive spatial and temporal imbalances in the energy grid.

- "Behind the meter" solutions can be developed and optimized to provide grid services that reduce spatial and temporal energy imbalances; however, solutions must be integrated across diverse technologies, controls platforms, and systems.

Increasing Building Innovation Pace and Scale

Develop Emerging Technologies

Develop advanced building data and tools and conduct early-stage research

Support Innovation

Validate and help commercialize U.S. technologies

Create Economic Opportunities

Develop software to identify efficiency and integration at multiple scales

Strengthen Energy Security

Ensure grid reliability and stability through advanced sensors and controls

Grid-interactive Efficient Buildings Research

NREL's core R&D strengths are transforming energy by developing grid-interactive buildings that strengthen the **resiliency**, **efficiency**, and **affordability** of energy systems globally.
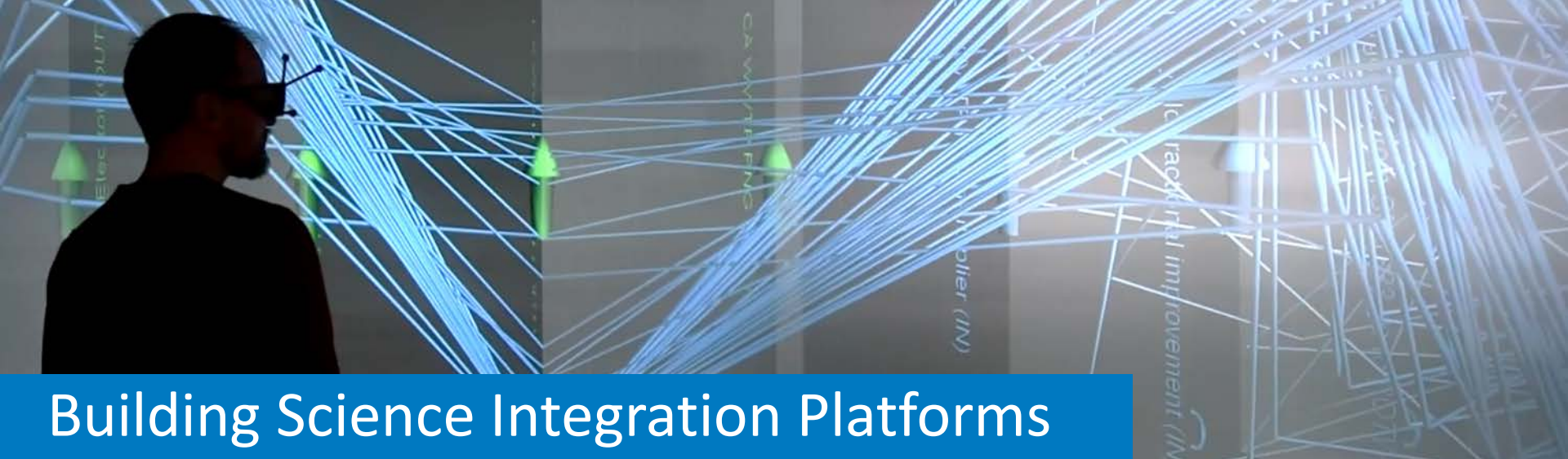
Building Science Integration Platforms

Research couples virtual and physical integration to prove the science and scale of building energy:
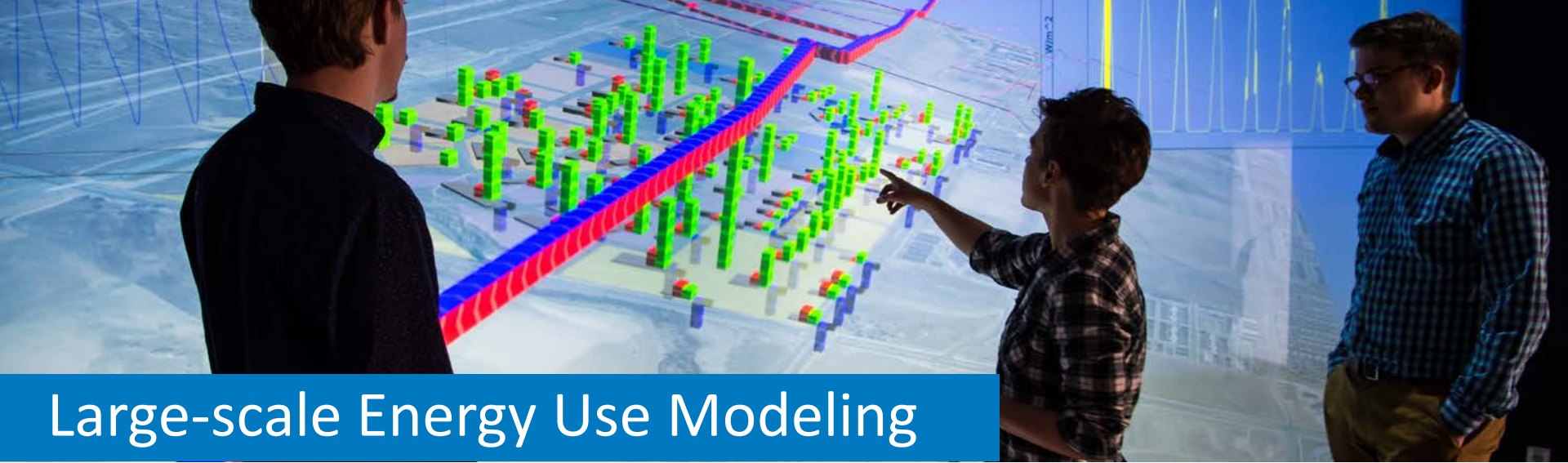
- Flexibility

- Efficiency

- Interoperability with the grid

Innovative Thermal Storage

Optimizes integration of advanced building-scale thermal energy storage technologies with other forms of:

- Energy storage

- Renewable energy

- Loads

Large-scale Energy Use Modeling

State-of-the-art facilities and world-class researchers leverage high-performance computing to model integration of high-efficiency, sustainable energy technologies at multiple scales for:

- Buildings
- Communities
- Districts

Beyond Buildings:
District Energy Design

Multibuilding Energy Simulation and Optimization

ResStock is helping states, municipalities, utilities, and manufacturers identify which home improvements save the most energy and money

Analytics Targeting Commercial Energy, Cost Savings

ComStock produces data-driven, physics-based simulation of the U.S. commercial building stock to achieve **unprecedented granularity in modeling** building energy use and demand

Urban Energy Modeling

NREL's **URBANopt platform** and its underlying **physics-based analytics engine** support the design and optimization of urban districts and help plan the integration of high-efficiency, sustainable energy technologies community-wide
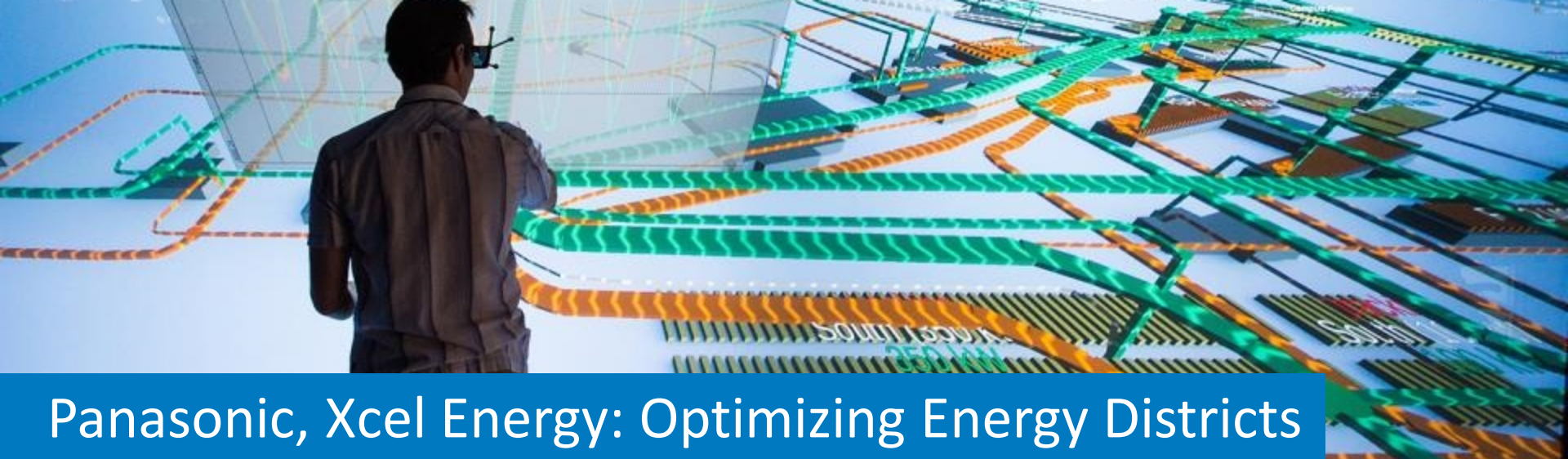
Panasonic, Xcel Energy: Optimizing Energy Districts

NREL is demonstrating its URBANopt software to analyze the projected dynamic energy consumption of corporate office space, retail space, multifamily dwellings, a hotel, parking, and street lighting within the planned development.

Peña Station NEXT

What are the quantifiable benefits of optimizing energy efficient, dynamic/responsive buildings in conjunction with the electric distribution system?

Systems Performance Laboratory

End-to-End Energy Ecosystem

- Residential loads hub that contains two residential electrical systems with associated smart home appliance suites
- Small commercial loads hub that includes building electrical infrastructure with common outlets and mounting infrastructure for appliances and distributed energy resources
- Power-hardware-in-the-loop test bays for multi-inverters, small-scale commercial equipment, and cyber security networks
- Demonstration and testing of commercial PV inverters

foresee™ Home Energy Management Software

Automating connected appliances and systems in a choreographed way saves energy, reduces strain on the grid, and could save homeowners up to $9 billion on their energy bills.

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Thank you

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NREL
NATIONAL RENEWABLE ENERGY LABORATORY