U.S. DEPARTMENT OF ENERGY

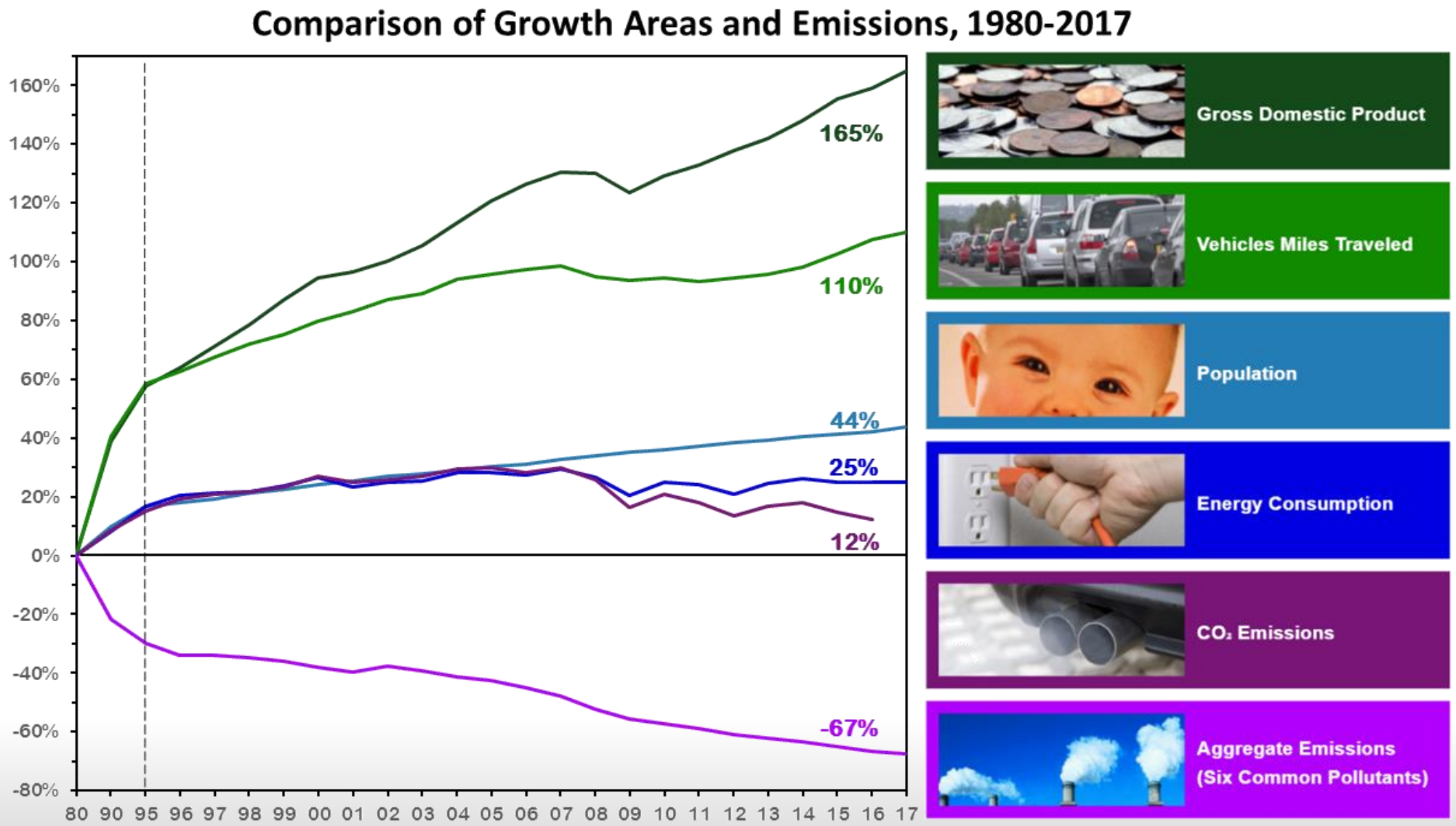
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2019 Buildings Technologies Office Peer Review

Steven G. Chalk, Acting Deputy Assistant Secretary for Renewable Power and Energy Efficiency

April 15, 2019

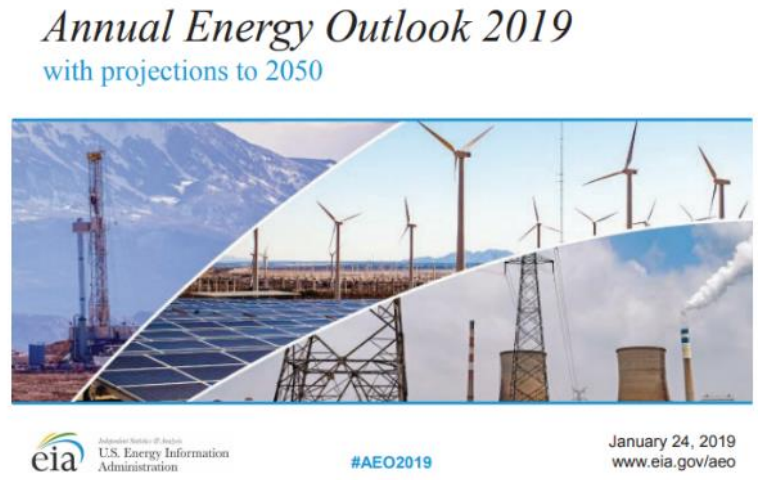
U.S. Productivity and the Environment



Source: EPA

EIA 2019 Energy Outlook: Key Takeaways from Reference Case

- The U.S. becomes a net energy exporter in 2020 and remains so throughout the projection period as a result of large increases in crude oil, natural gas, and natural gas plant liquids (NGPL) production coupled with slow growth in U.S. energy consumption.
- Of the fossil fuels, natural gas and NGPLs have the highest production growth, and NGPLs account for almost one-third of cumulative U.S. liquids production during the projection period.
- Natural gas prices remain comparatively low during the projection period compared with historical prices, leading to increased use of this fuel across end-use sectors and increased liquefied natural gas exports.
- The power sector experiences a notable shift in fuels used to generate electricity, driven in part by historically low natural gas prices. Increased natural gas-fired electricity generation; larger shares of intermittent renewables; and additional retirements of less economic existing coal and nuclear plants occur during the projection period.



Increasing energy efficiency across end-use sectors keeps U.S. energy consumption relatively flat, even as the U.S. economy continues to expand…

Source: EIA

EIA 2019 Energy Outlook: Key Takeaways (Continued)

...but growing floorspace and expanding information technology needs drive an overall increase in electricity consumption.

- Commercial floorspace grows by an average 1% per year in the Reference Case through the projection period, reflecting rising economic output. Some of the fastest-growing building types, including health care and lodging, are also among the most energy-intensive.

- Commercial electricity intensity, defined as electricity consumption per square foot of commercial floorspace, declines at an average 0.4% per year from 2018 to 2050. Lighting accounts for the steepest intensity decline among the major end uses, as falling costs and energy efficiency incentives lead efficient light-emitting diodes to displace linear fluorescent lighting as the dominant commercial lighting technology by 2030.

- Improved appliance efficiency and a population shift to warmer regions of the U.S. cause commercial electricity consumption for space heating, water heating, and ventilation to decline by 29% from 2018 to 2050. This population shift causes space cooling intensity to decrease less rapidly, and commercial space cooling electricity consumption remains flat during the projection period.

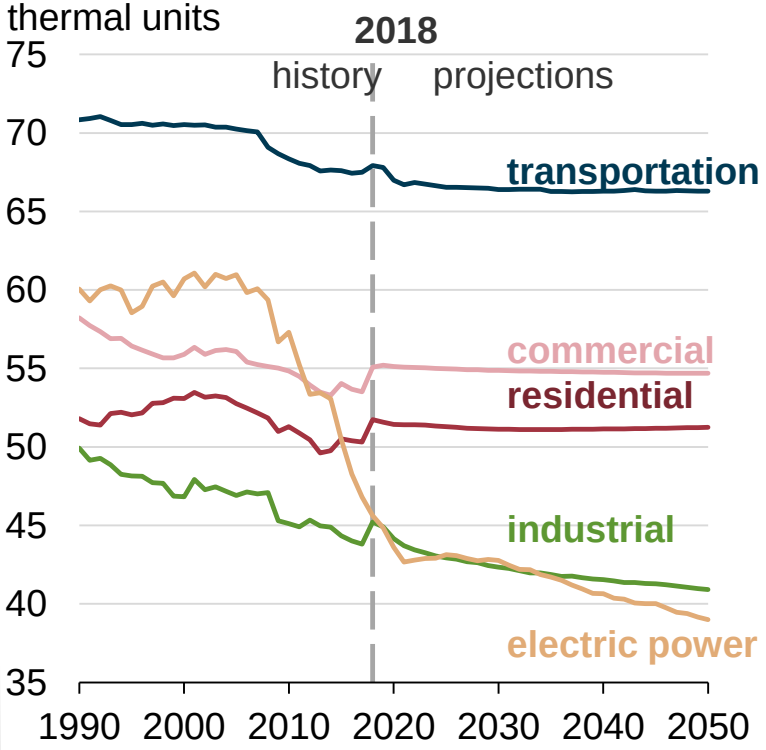
- Although the U.S. has no federal building energy code, state- and local-level building codes also reduce energy used for heating and cooling in commercial buildings.

Source: EIA

EIA 2019 Energy Outlook: Key Takeaways (Continued)

Across end-use sectors, carbon dioxide intensity declines with changes in the fuel mix, despite overall increases in energy consumption

Carbon dioxide intensity by end-use sector (Reference case)
metric tons of carbon dioxide per billion British thermal units



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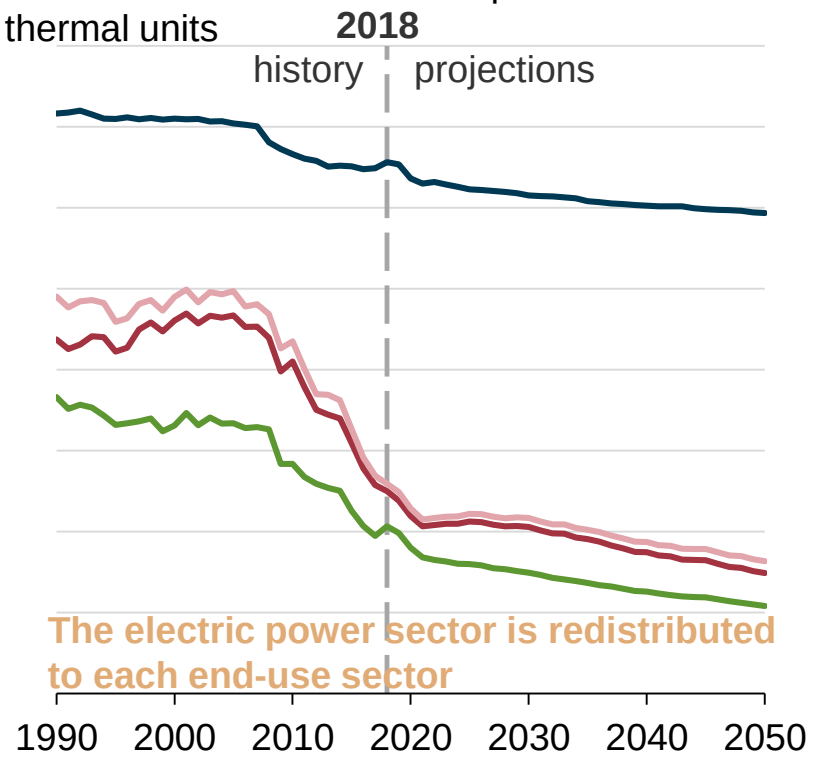


Note: Carbon dioxide intensities are calculated as carbon dioxide emissions per unit energy output (in British thermal units).

Source: EIA

EERE Priorities

- EERE promotes affordable and reliable energy to enhance America's economic growth and energy security.

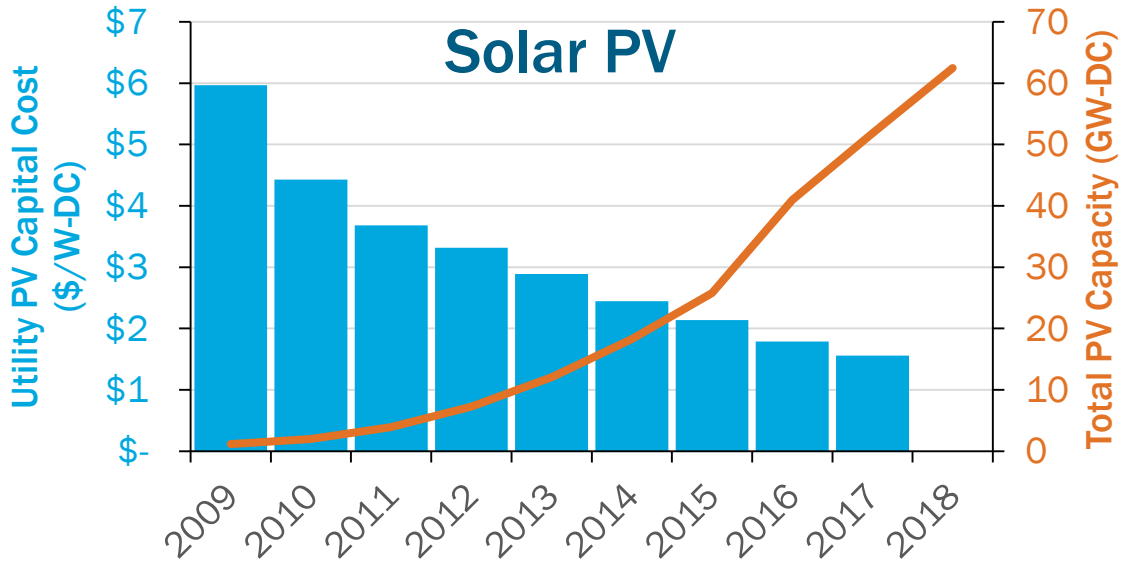
- Priority focus areas include:

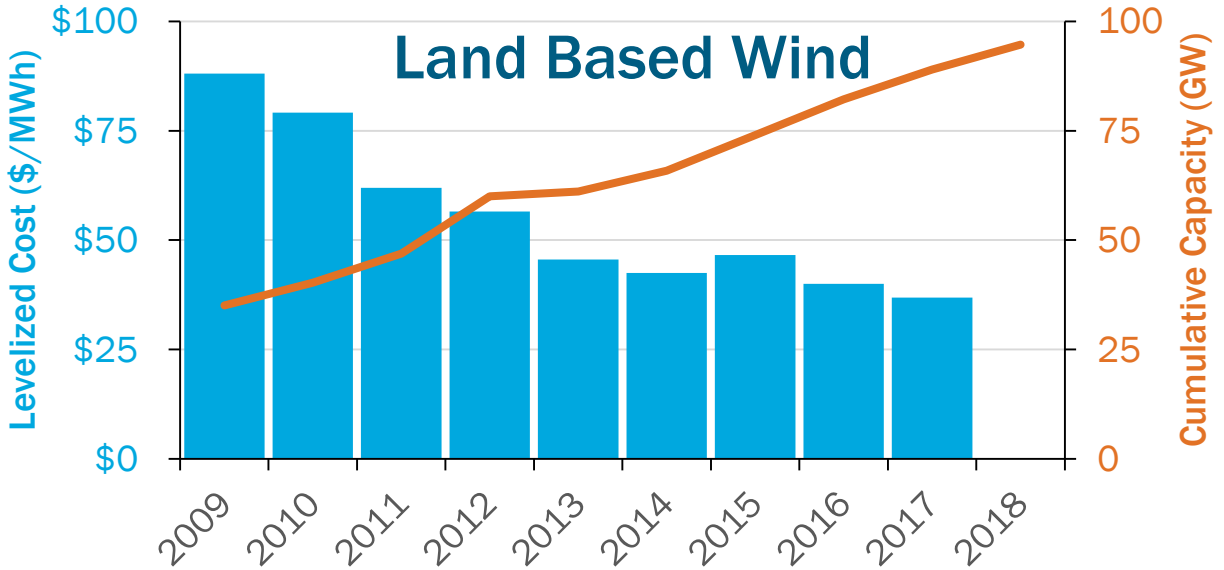
  ✓ **Energy Affordability** – continue to drive down costs of the energy technologies in our portfolio.

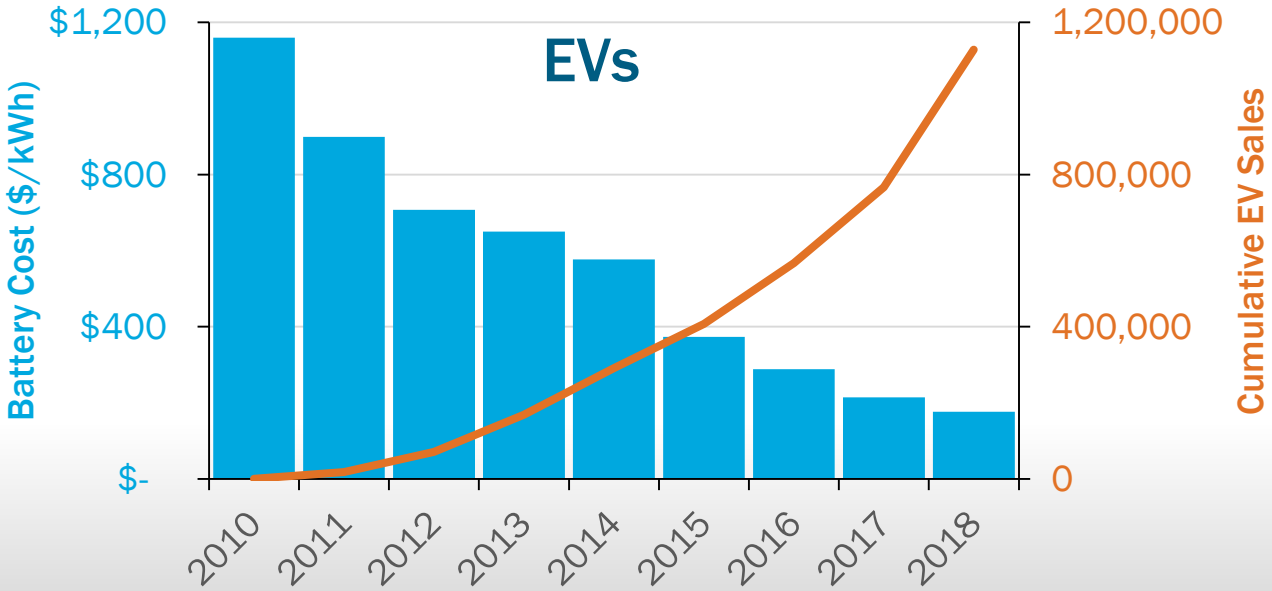
  ✓ **Energy Integration** – facilitate the integration of new sources of generation and consider opportunities from greater flexibility in energy consumption.

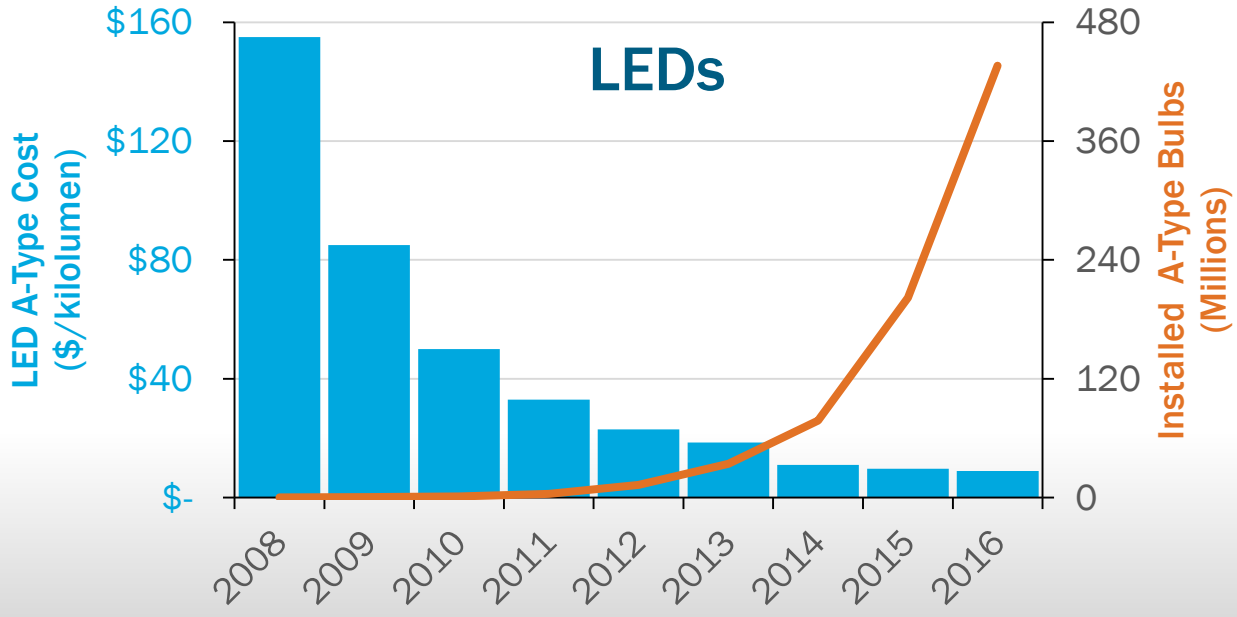
  ✓ **Energy Storage** – technological advances to provide more flexible generation and more flexible load through a comprehensive approach to energy storage with smart buildings, pumped hydro, hydrogen storage, and batteries.

EERE R&D Catalyzes Greater Energy Affordability







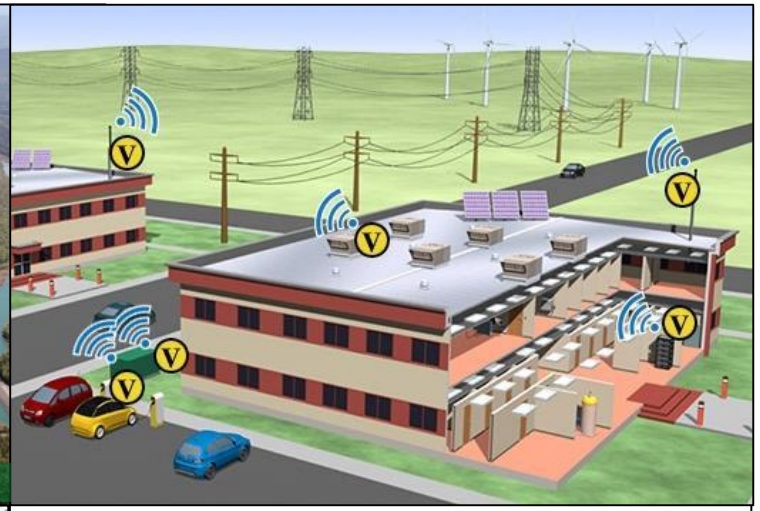


Energy Integration

With today's electric grid and the grid of the future, greater flexibility of both supply and load enables a wider array of technologies to contribute to the electric grid.

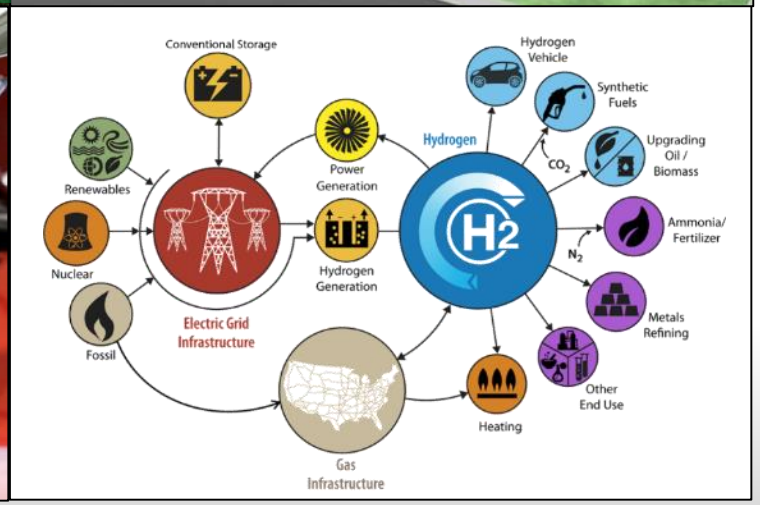
Pumped Storage Hydropower

Credit: Southern Company and Georgia Power.



Buildings-to-Grid Integration

EV Charging Stations



Hydrogen @ Scale

Advanced Energy Storage Initiative

An DOE-wide initiative to develop **new technologies and analytical tools** that provide **increased flexibility and grid services from renewable generation, load, and alternative storage technologies.**

Flexibility: *the ability to shift the timing of generation or consumption of electricity to when most valuable to the grid*

Grid services: *in addition to flexibility, the ability to improve the grid's ability to respond to rapid changes in generation or load (e.g. ramping, reserves) or electrical disturbances (e.g. frequency response, voltage support)*

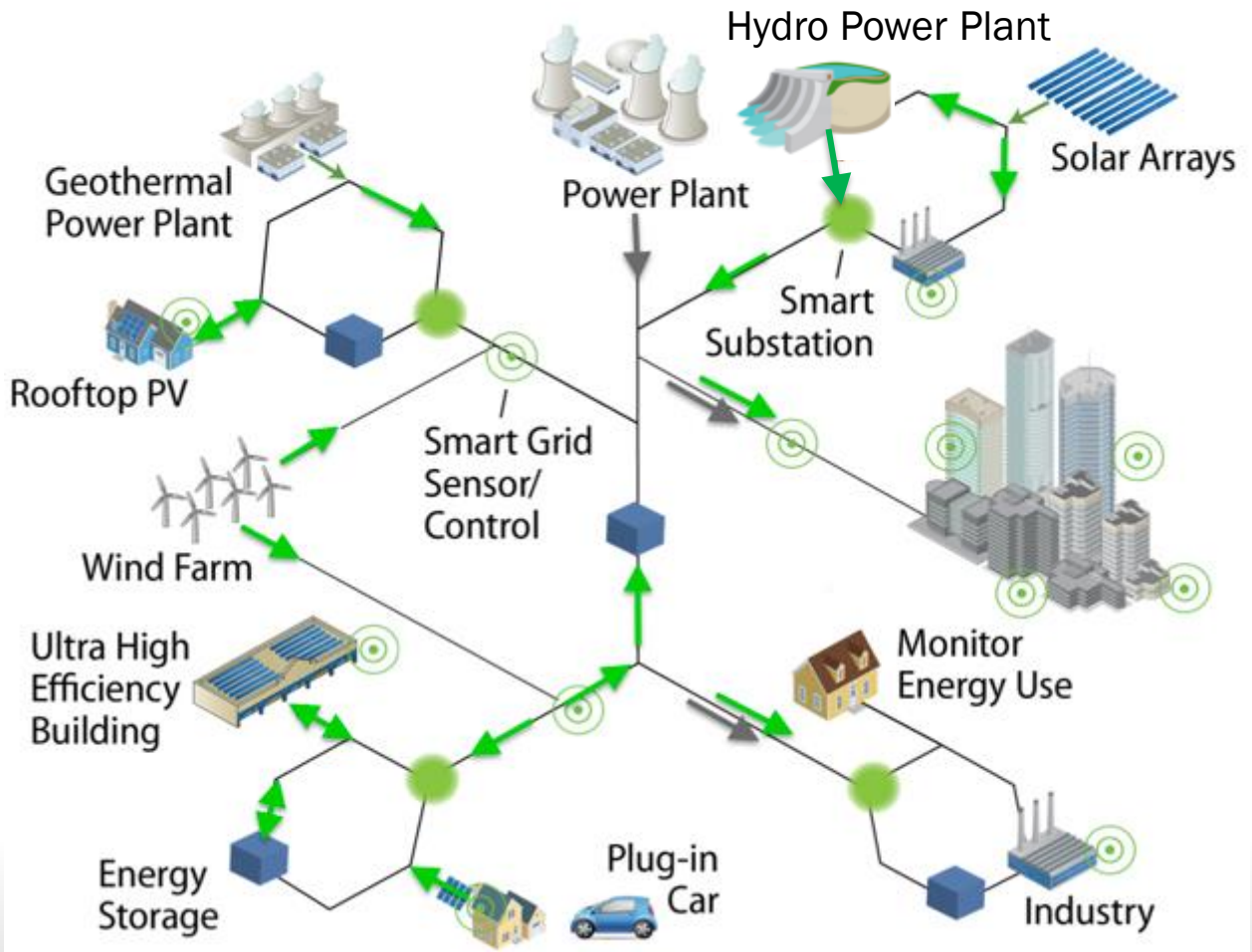
Generation

Storage

Behind-the-meter

Moving Toward the Future Energy System

Future Energy System



- DOE has been successful in driving down the costs of technologies, but LCOE will not result in the success of the past.

- The future energy system:
  - Will be more complex, distributed, and interdependent, integrating all types of energy systems.
  - If done correctly, can be more efficient, resilient, and affordable.
  - Maintain customer choice and catalyze greater participation around preferences/options for energy services.

Source: NREL

Future Energy System: More Power Electronics-Based Resources

Generation

- PV, wind, fuel cells, microturbines use power electronic interfaces to the grid
- Over 50% of PE generation by 2050
- Other bulk source should work synergistically

Storage

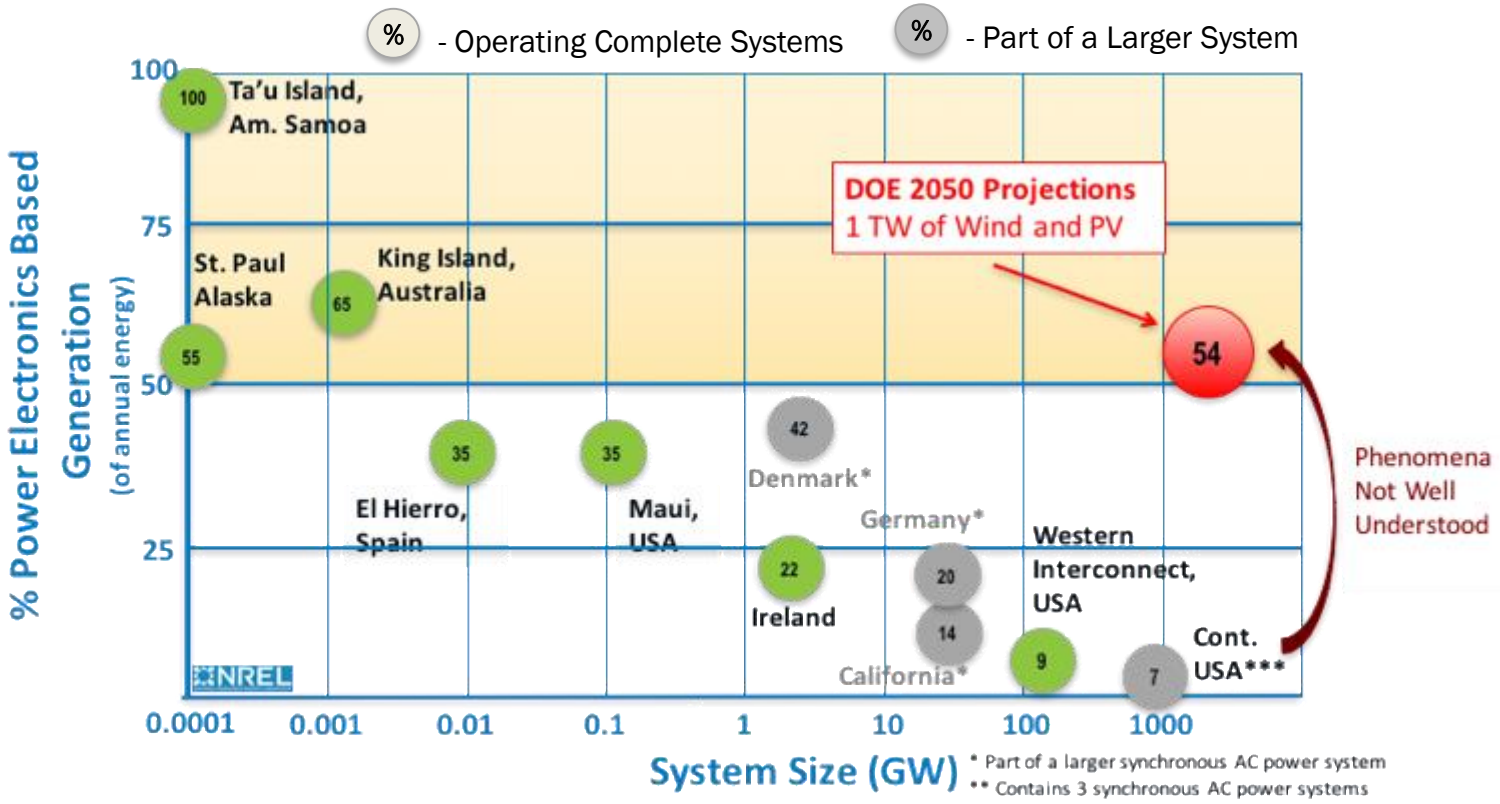
- Batteries use power electronic interfaces to connect to the grid
- Pumped hydro can add power electronics to increase controllability and provide grid services

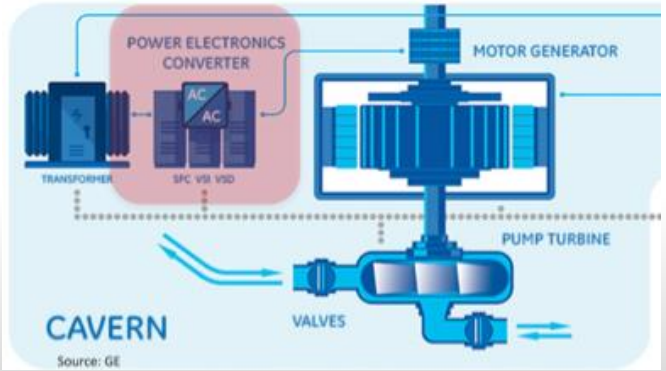
Building Loads

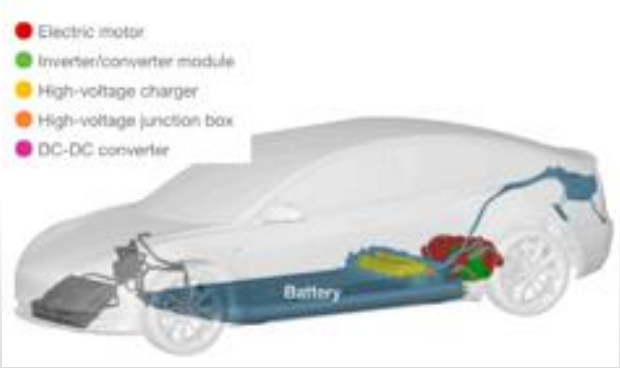
- Over 60% of major home appliances, PE based by 2021
- Lighting switching to LEDs
- Variable speed drives for motors

Mobility

- EVs – 7 million by 2025
- MD/HD – Electrifying







Source: NREL

Getting Too Complex to Control?

Current Grid

Central Control
10^4 Bulk Generators

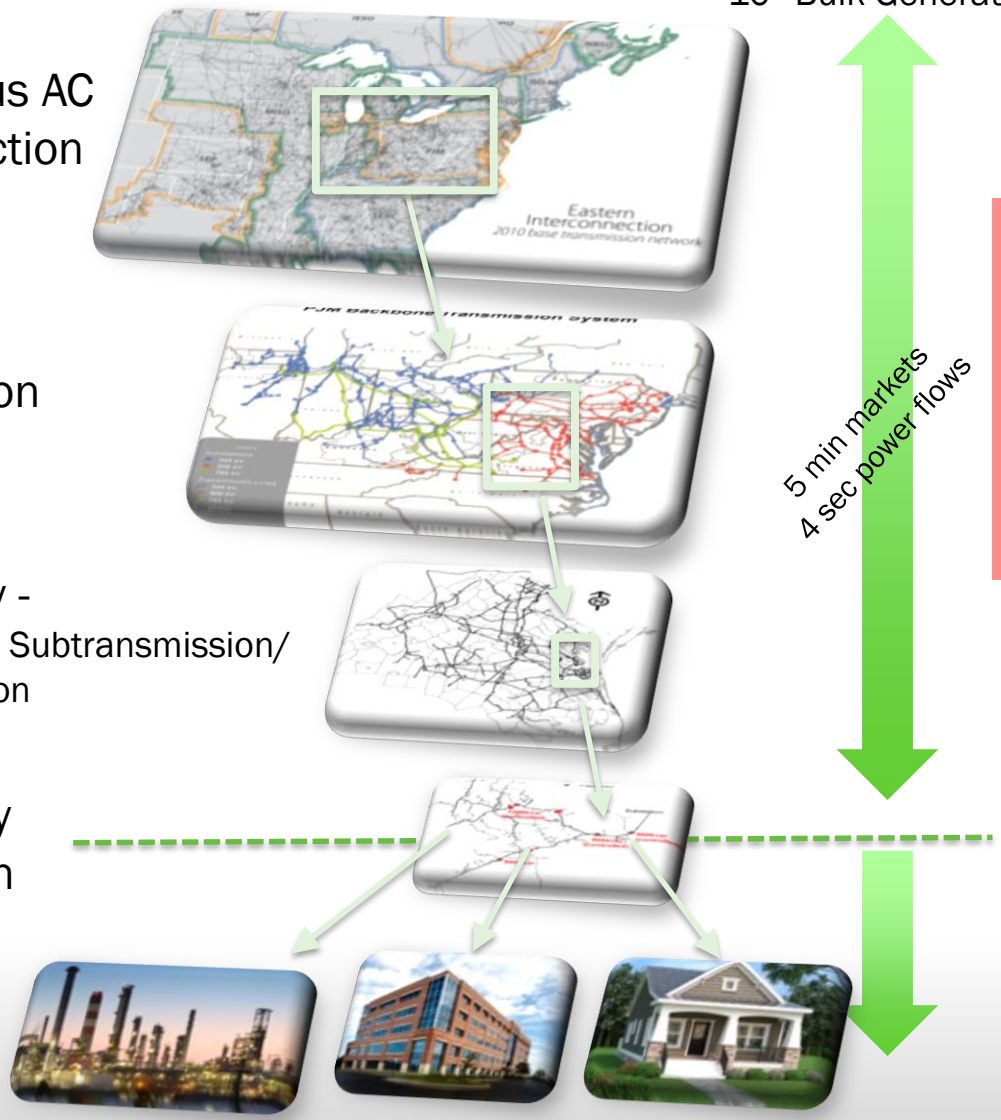
Synchronous AC Interconnection

Regional Transmission Operator

Local Utility -
Transmission/ Subtransmission/
Bulk Generation

Local Utility Distribution

Industry/
Commercial/
Residential



5 min markets
4 sec power flows

Central Control
?
10^4 Bulk Generators and Storage
+
10^8 DER

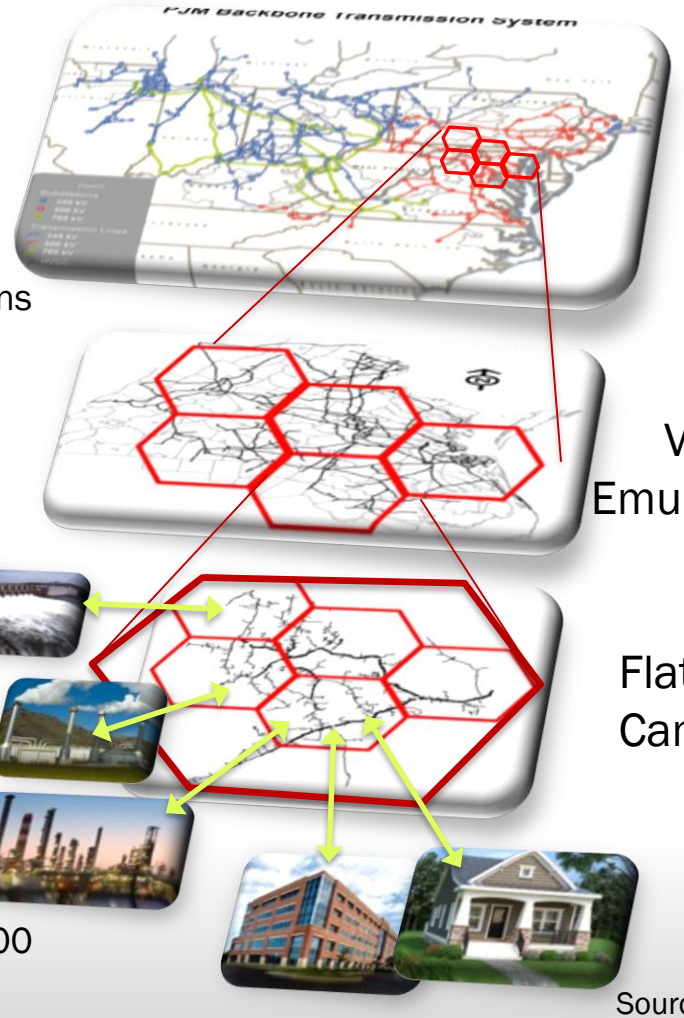
Distributed, Hierarchical Control

10^8 Generators, Storage, Active Loads
1 sec optimizations at each level

Millions

1000s

1-100



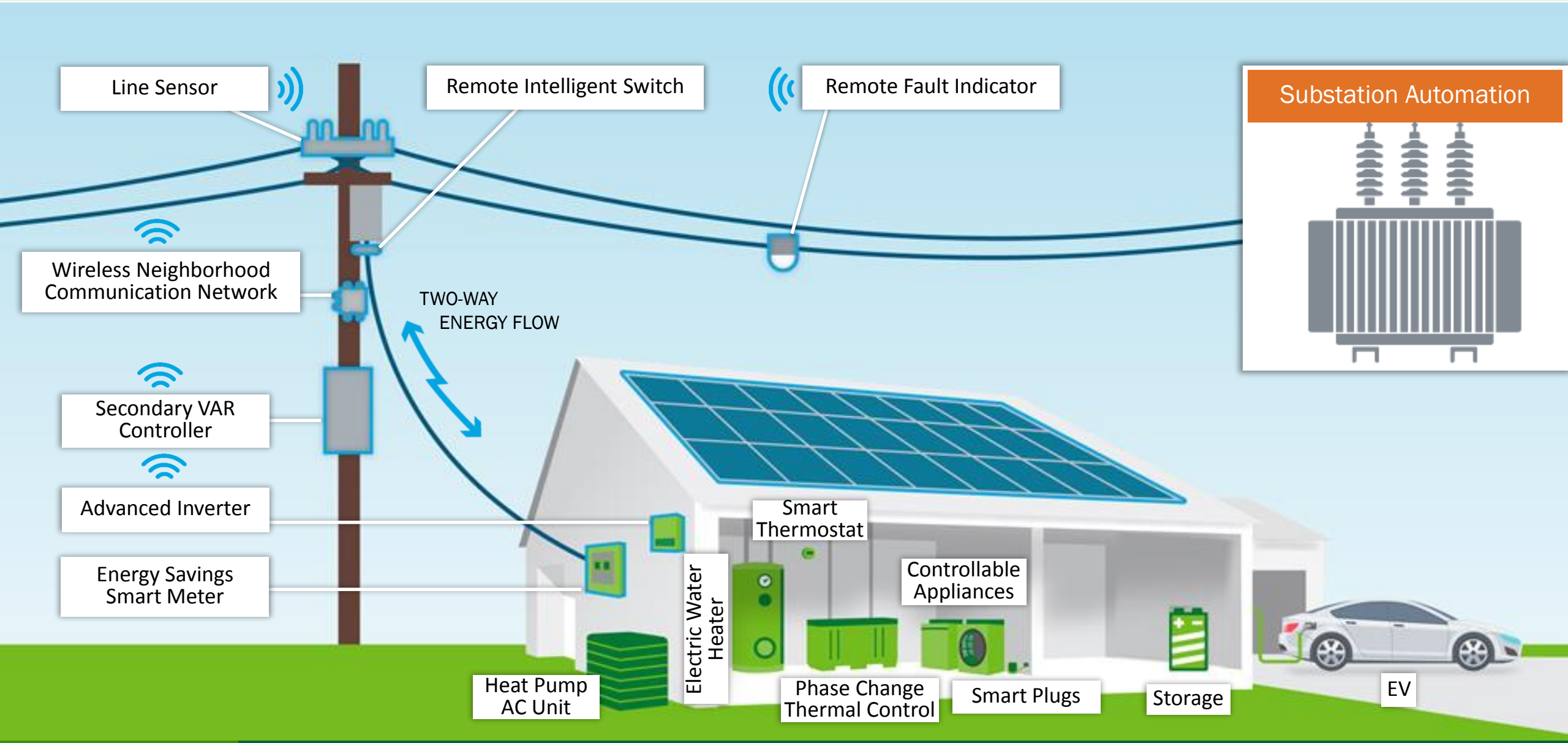
Virtual Emulation

Flatirons Campus

ESIF

Source: NREL

Situational Awareness and Energy Efficiency: Sensors and Controls



BPA/Bosch Advanced HEMS and Battery

Description

- Develop cyber-secure Home Battery System (HBS) controls that deliver high-reliability demand response while avoiding negative homeowner impacts.

Technologies

- Connected home appliances, rooftop solar, grid, energy storage.
- Designed for future integration of other technologies: EVs, wind, fuel cells, etc.

Final Deliverable

- Methodology for selecting and sizing smart home equipment, including batteries, with plan to formalize it into a design process. Aggregation study showing local grid impacts of home controls which deliver local and bulk grid services.

Project Impact

- Enables design approaches for connected home energy systems that is applicable to developers, appliance manufacturers, regulators and utilities nationwide as home automation is adopted.

Partners

BONNEVILLE POWER ADMINISTRATION

BOSCH

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Colorado State University

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

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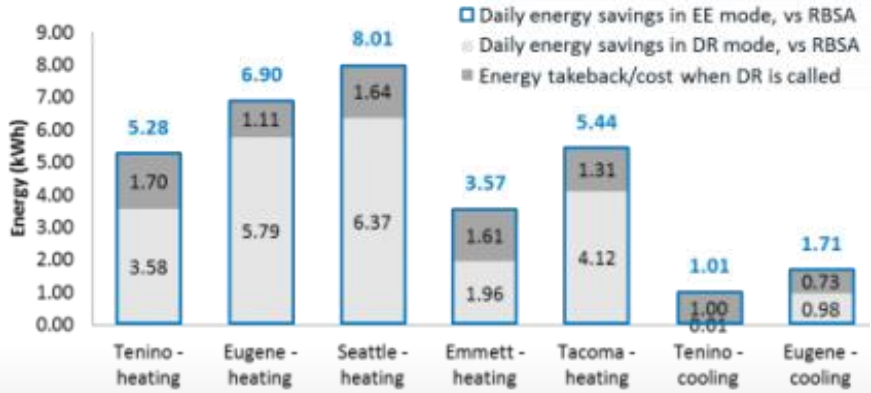
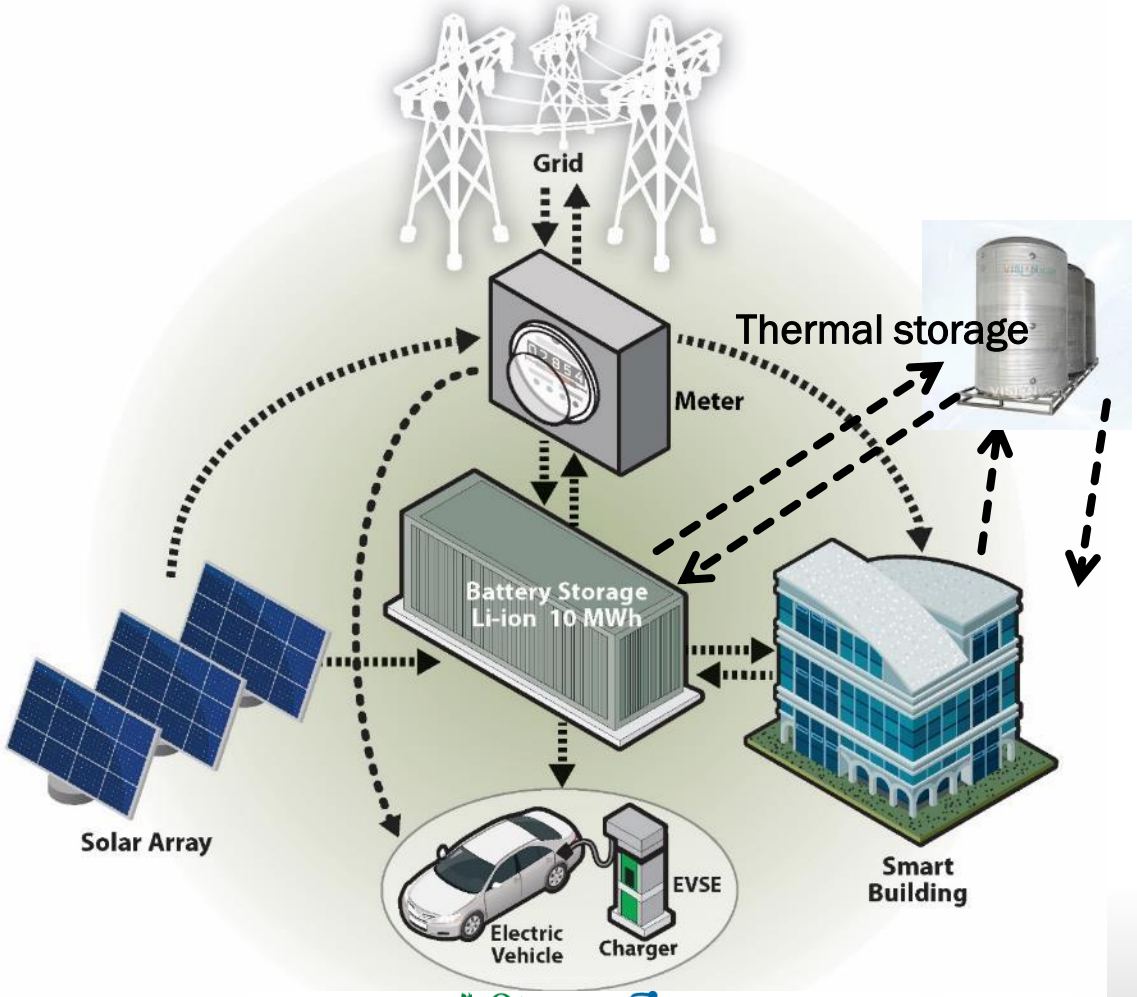
Daily Energy Savings in EE & DR modes



Behind-The-Meter Storage (BTMS)

A partnership with the Vehicles, Buildings, and Solar Offices



NREL NATIONAL RENEWABLE ENERGY LABORATORY · OAK RIDGE National Laboratory · INL Idaho National Laboratory · Sandia National Laboratories

Fundamental research based upon a systems understanding.

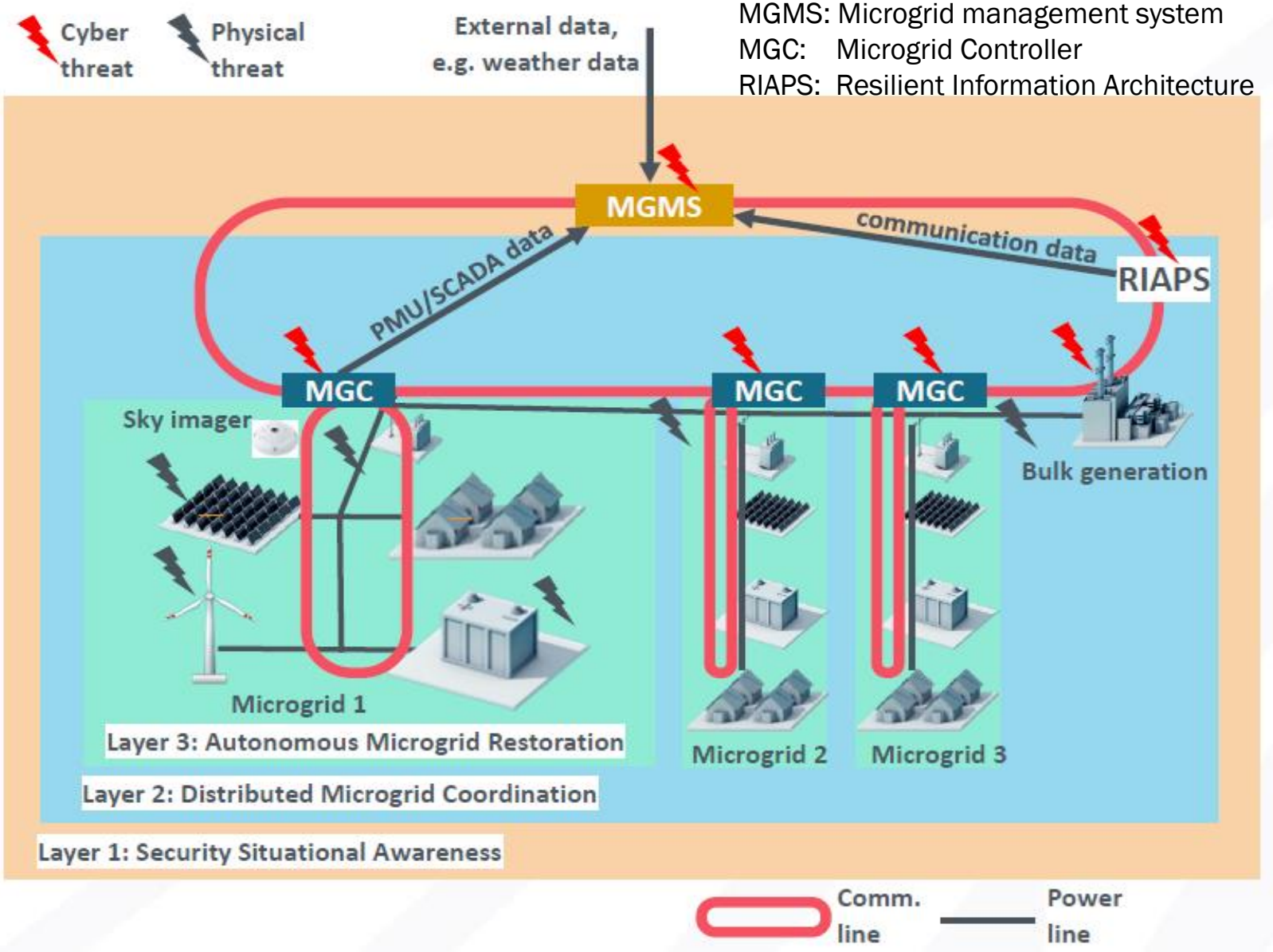
- Integration of PV.
- Buildings are the largest electrical users.
- EVs will be charged at buildings.
- Avoid high demand charges.
- Grid impacts minimized.

- Store both electrons and heat.
- New battery chemistries and new thermal storage materials may be needed depending on application.

Siemens Corp: Grid Industry Partner with Buildings and Solar

Resilient and Autonomous Microgrids

- Peer to Peer microgrid management for power continuity
- Inverter-based “Black Start” for islanded recovery
- Autonomous reconfiguration for restoration after faults



Looking Ahead Across EERE in FY 2019

- **Advanced Manufacturing**
  - Cybersecurity Institute – up to $70M; Call for Concept papers due May 15.
  - Medium-voltage power conditioning systems to enable grid-dispatchable facilities
- **Hydrogen and Fuel Cells**
  - Reversible fuel cells
- **Geothermal**
  - Machine learning for resource development
- **Solar**
  - Grid services from BTM solar, PV inverter controls, cybersecurity
  - Distributed PV integration: curtailment, reliability, enhanced flexibility
  - CSP flexibility, pumped thermal storage, CSP for industrial process heat
- **Water**
  - Improved grid services from hydropower and PSH, valuation
- **Wind**
  - Off-Shore and Tall Wind
  - Reliability services from wind plants, integration with multiple other technologies
- **Vehicles**
  - Extreme fast charging interoperability, grid impacts, cybersecurity, smart charging
  - Behind-the-meter storage and integration

Opportunity Space: Buildings

Buildings consume 74% electricity produced in the U.S.

(CBECS 2009)

Buildings have the potential to reduce their consumption by 20-30% through advanced sensors and controls

(TIAX 2005, PNNL 2017, BTO MYPP)

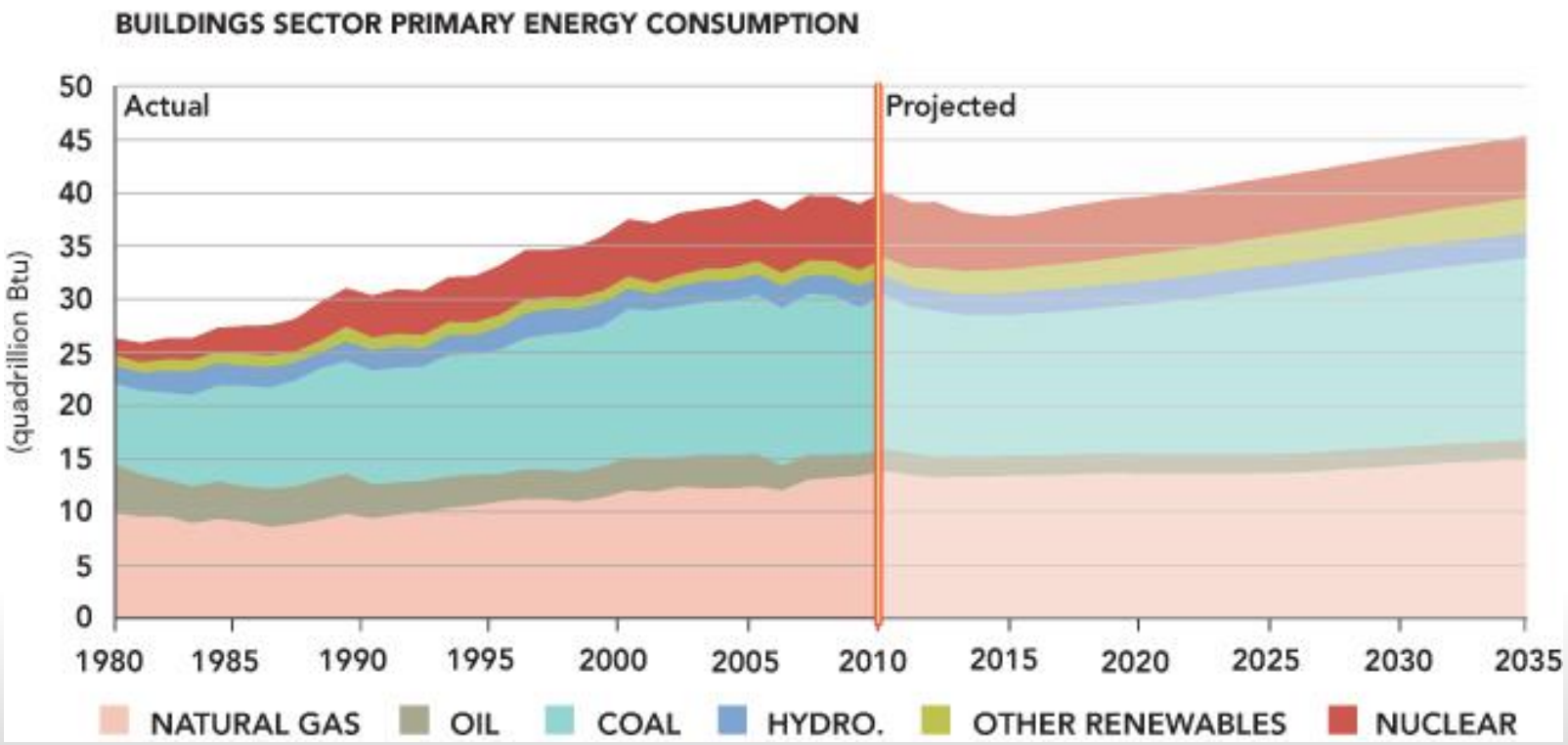
Potential nationwide value of demand dispatch could be several billion dollars yearly in reduced energy costs with 10% participation

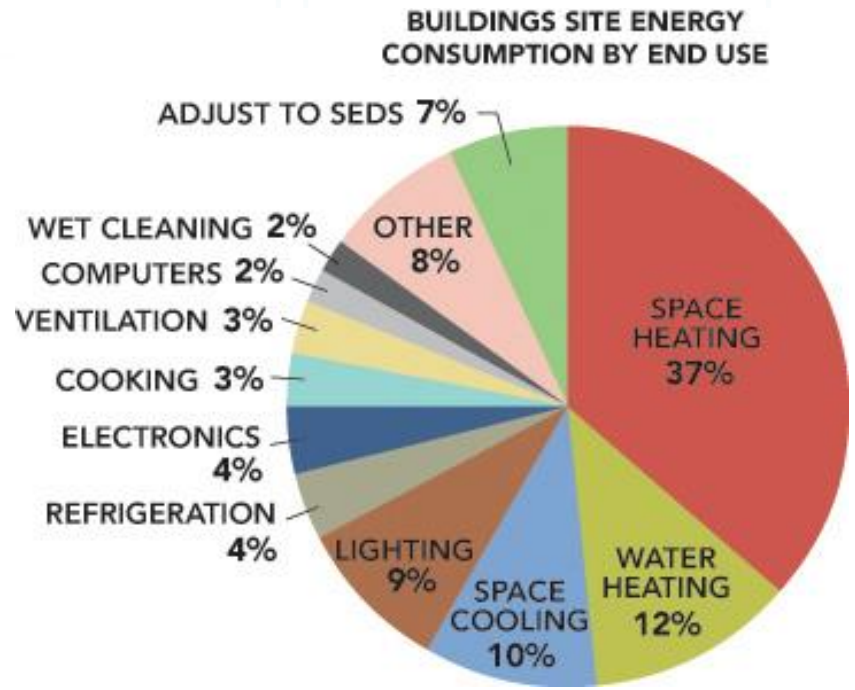
(NETL, Demand Dispatch – Intelligent Demand for a More Efficient Grid, August 2011)

One-fourth of the 713 GW of US electricity demand in 2010 could be dispatchable

90% of the commercial buildings are < 50,000 ft^2 and need aggregation

(PNNL - 22169)



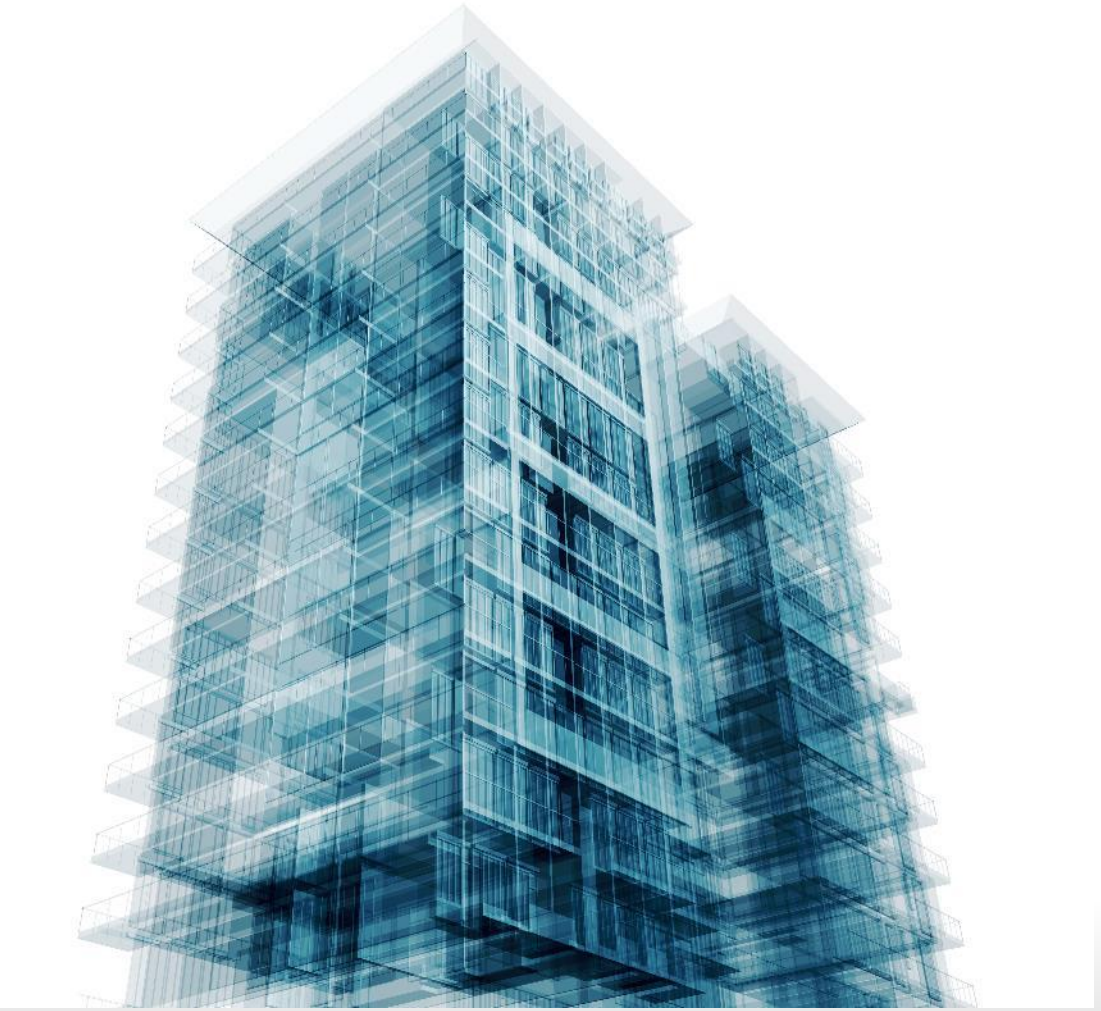


5.5 million commercial, 117 million residential, projected to be 80% of load growth through 2040

Source: ORNL

FY 2019 Look Ahead for Building Technologies Office

- **Grid-interactive and Flexible Building Technologies**
- **HVAC**
  - Non-vapor compression cycles
  - Natural gas equipment/appliance efficiency
- **Solid State Lighting**
- **Integrated Building Retrofits**
- **New Construction Techniques**
- **Advanced Technology Integration and Workforce Development**



DISCUSSION