Efficiency is key to meeting U.S. climate, energy goals

Our Homes and Buildings Use More Energy than Any Other Sector

- Residential & Commercial: 40%
- Industrial: 32%
- Transportation: 28%
Potential Opportunities of **Residential Building Energy Efficiency**

**Residential Energy (Single Family, All Regions)**

*Energy Savings %*

- HVAC shows LARGE potential for efficiency improvement
- “Other” dominates in the future: Small electric devices, heating elements, outdoor grills, exterior lights, pool/spa heaters, etc.
- Best available does not consider cost
- ET 2020 includes cost effectiveness

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**Energy Efficiency Scenario**

- Primary EUI (kBtu/sq. ft.)
- End Use:
  - Heating
  - Secondary Heating
  - Cooling
  - Lighting
  - Water Heating
  - Refrigeration
  - Drying
  - Drying
  - Other

- Stock Energy Star Best Avail. ET 2020 Thermo. Limit

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U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
Potential Opportunities of **Commercial** Building Energy Efficiency

“Other” dominates in the future: Small electric devices, heating elements, outdoor grills, exterior lights, pool/spa heaters, etc.

Best available does not consider cost
ET 2020 includes cost effectiveness

Lighting shows LARGE potential for efficiency improvement

*Energy Savings %

“Other” dominates in the future: Small electric devices, heating elements, outdoor grills, exterior lights, pool/spa heaters, etc.

Best available does not consider cost
ET 2020 includes cost effectiveness
An Ecosystem for Locking In Energy Savings

**Scale** energy savings through building codes and appliance standards

**Develop** cost-effective, energy efficient technologies

**Research and Development**

**BTO ECOSYSTEM**

**Market Stimulation**

**Speed** adoption of energy-saving technologies and practices
The vision of DOE’s Grid Modernization Initiative (GMI) is:

- A future grid that will solve the challenges of seamlessly integrating conventional and renewable sources, storage, and central and distributed generation.
- The future grid as a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy.
- A future grid that will deliver resilient, reliable, flexible, secure, sustainable, and affordable electricity to consumers where they want it, when they want it, how they want it.
B2G & V2G are Key to EE, Grid Mod. & Renewables in the increasingly dynamic electricity system

One-Way Power Flows

- POWER PLANT
- TRANSMISSION & DISTRIBUTION
- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL

Two-Way Power and Information Exchange

- Wind Farm with Energy Storage
- Power Plants
- Utility/Community Solar
- Commercial Offices with Rooftop Solar
- Factory with Natural Gas Combined Heat and Power
- Electric Vehicles
- Homes with Solar PV and Storage
- Hospital Campus with Microgrid

- Distributed energy resources
- Multiple inputs and users, supporting two-way energy flows
- Digitalization of the electric-mechanical infrastructure: smart grid and behind the meter energy management systems
- Flexible, dynamic, and resilient
- Complex market structures and transactions
- Regulation changing rapidly around renewables, distributed generation (solar, micro-grid, storage), net metering etc.

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Connected Buildings: What are they? How can we benefit?

Buildings will be self-configuring, self-commissioning and self-learning such that they optimize operation, maximize energy savings cost effectively and can participate in transactions within the building, between buildings and with the grid.
How We Can Scale Connected Buildings

<table>
<thead>
<tr>
<th>Technology today</th>
<th>Needs</th>
<th>Technology at scale</th>
</tr>
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<tr>
<td>High Integrated System Cost</td>
<td>Interoperability lowers cost across vendors</td>
<td>Higher energy savings</td>
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<tr>
<td>Internet of Things</td>
<td>Cybersecurity lowers risk</td>
<td>Non-energy benefits</td>
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<tr>
<td>No Consistent B2G Value Proposition</td>
<td>Characterize Equipment for valuation</td>
<td>Secure, resilient, modern grid</td>
</tr>
</tbody>
</table>
Vehicle Technologies Office & Grid Modernization

State Engagement

Working to support states' transportation electrification efforts

Grid Modernization

Utility engagement with DOE’s Grid Modernization Laboratory Consortium on transportation electrification

Research & Development

Optimization of vehicle architecture to allow for more cost-effective and competitive solutions

EV Everywhere UP

Collaborating with utilities through partnership with EEI to expand EV market

Electrification Benefits Awareness

Drawing attention to the value of transportation electrification through outreach, studies and more on digital platform

Workplace Charging Challenge

Initiative to increase EV charging infrastructure deployment at the workplace
VTO Grid Modernization Projects

• VTO seeks to research, develop, and demonstrate plug-in electric vehicle (PEV) technologies that enable efficient grid integration.

• VTO engages with utilities on transportation electrification through DOE’s Grid Modernization Initiative.

• Research areas of interest include:
  – Bi-Directional Power Flow
  – Load Control Using Vehicle-to-Grid Communication
  – Impact and Valuation of Grid Services on PEVs
  – Standardized and Interoperable Communication Protocols
  – Cybersecurity
Low-cost **Wireless Sensors** Improve Efficiency of Many Products

- Reduced cost to manufacture and commission ($10/node)
- Retrofit-friendly devices with minimal maintenance
- Multi-sensor platform tailored for building monitoring needs
- Leverage additive, roll-to-roll manufacturing techniques to reduce cost and enable rapid adoption

Print components on flexible substrates:
- Circuits
- Sensors
- Antenna
- Photovoltaics
- Battery

Low temperature photonic curing:
- Sinters ink for high electric conductivity
- Plastic substrate undamaged

Peel and stick flexible platform:
- Pick and place unprintable components
Transactive Controls, Building Controls & Smart Buildings

Smart Building Ecosystem  Comprehensive, interoperable integration of devices, buildings, and grid with Transactive Controls utilizes software applications to monitor, control, and aggregate building resources.

• Enables Smart Buildings to be aggregated dynamically and ‘transact’ with the electric utility (i.e., Buildings provide benefit to the consumer, the utility, and the environment);
• Leverages applications on a Cyber-secure Transactional Platform (VOLTTRON) that enhances seamless interoperability (i.e., doesn’t require new hardware or devices);
• Provides value from all aspects of the utility to the consumer domains (i.e., has capability to capture values from regulated and non-regulated markets).

Controls for Building Efficiency...
• Are defined by their inner building communication mechanisms (i.e., hardware and sensors for one building or system);
• Utilize Demand Side Management controls that optimize energy use for the consumer (i.e. measured by annual net consumption); and,
• Provide value to the owner or operator so they can recoup the investment.
An Open-Source Operating System for Transactive Controls
Example Opportunity:
- Value of transactive controls on aggregated rooftop air-conditioning units on a peak summer day

Fundamentally, to enable transactions we must commingle energy + information and assign value.
Example Opportunity:
- Value of transactive controls on aggregated rooftop air-conditioning units on a peak summer day

ISO communicates that price is about to increase from $0.1/KWH to $1.0/KWH unless 100 MW is removed from the system.

Fundamentally, to enable transactions we must commingle energy + information and assign value.
Example Opportunity:
- Value of transactive controls on aggregated rooftop air-conditioning units on a peak summer day

I’m a hotel with a big conference underway. I need maximum cooling for my building. I’m looking to buy your additional load reduction to avoid price increases.

Fundamentally, to enable transactions we must commingle energy + information and assign value.
Example Opportunity:
- Value of transactive controls on aggregated rooftop air-conditioning units on a peak summer day

I’m a big box store, with variable speed fans on my RTUs, and I can run those fans at somewhat lower speeds for 10 minutes and “sell” you the load reduction. It will make no noticeable difference to my customers, and I can make some money (part of the price increase the other customer is avoiding).

Fundamentally, to enable transactions we must commingle energy + information and assign value.
Example Opportunity:
- Value of transactive controls on aggregated rooftop air-conditioning units on a peak summer day

But to reach 100MW, negotiating and controlling across a few RTUs in a few buildings won’t realize an impact.

However, if all the RTUs in a service territory -- across the national accounts AND the independents -- could autonomously and automatically aggregate to deliver a solution for the utility, the system would be optimized and building owners/operators would realize energy and cost savings.

If only the controllers could systematically communicate, transact, and settle amongst themselves. These solutions are beyond simple Demand Response because they inherently understand, value, and can act for the owner’s operational needs while simultaneously optimizing to help the grid.

How can DOE enable this “transaction”-based ecosystem between end uses and utilities?
BTO and SEOs & NASEO

- Working together on Buildings to Grid
- Working together on other Buildings EE and clean energy issues incl.
  - Emerging technologies
  - Residential EE deployment, scoring, IAQ
  - Commercial EE deployment, often sub-sector specific
  - Building codes development, adoption, compliance
  - Appliance & equipment standards
  - Upcoming RFI (Misc. Elec. Loads released *today*, others)
  - Upcoming FOAs and other funding
- Don’t be strangers!

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