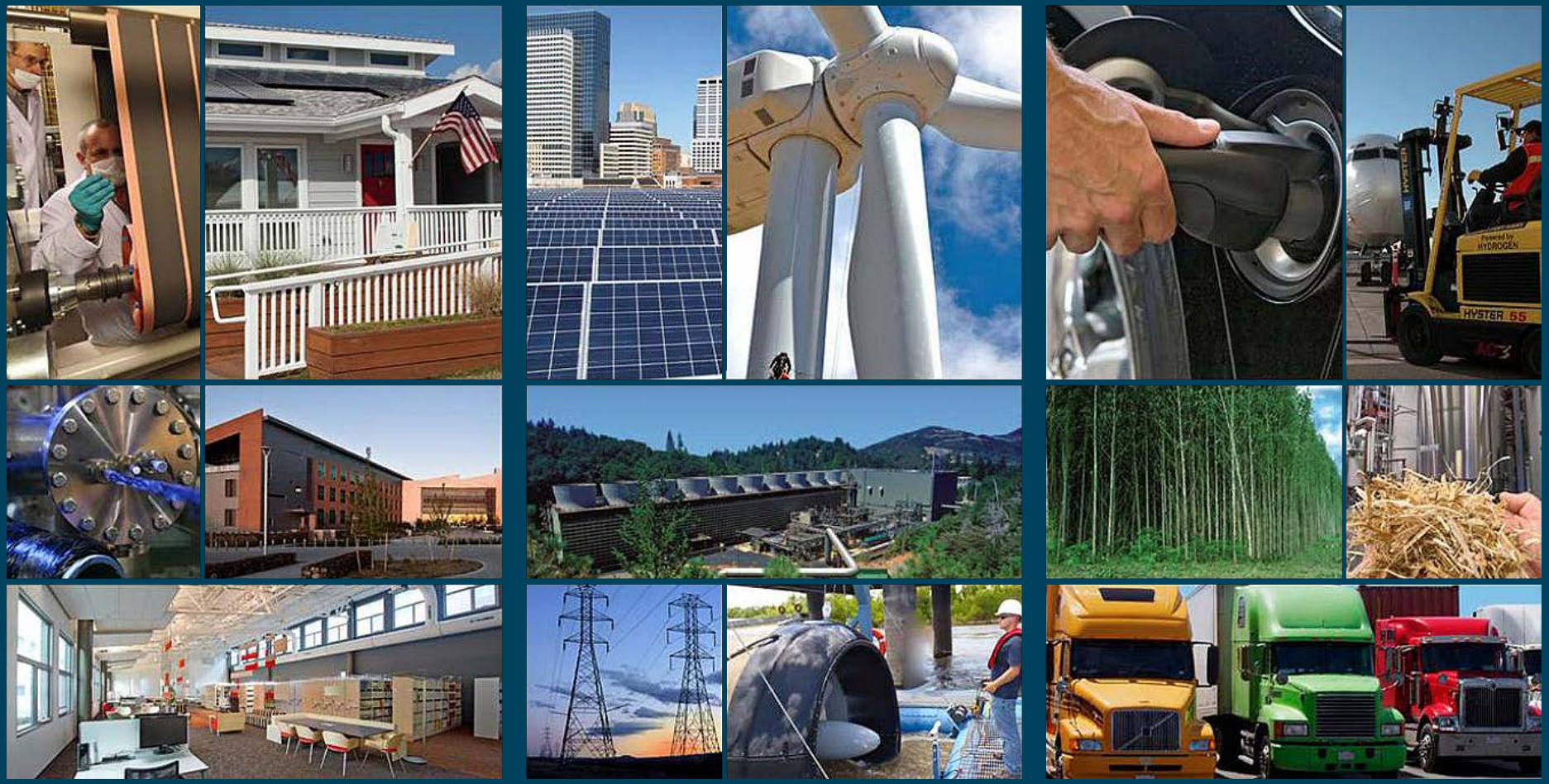
Transactive Controls R&D (Tx-R&D)

Holistic Thinking with Control of Sources to Loads…



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Joseph Hagerman
Building Technologies Office

Building to Grid (B2G) is one facet of Tx-R&D

Transactive Controls R&D funding represents an opportunity for BTO's B2G program to…

- Fully **realize** whole buildings & Connected Equipment are assets that can benefit the grid but that will scale at different rates and through different drivers (and to contribute to GMLC where applicable);
- **Extend** applicable outcomes from a comprehensive Building Sensors & Controls Roadmap, AOP funding, & merit review
- **Focus** on grid & energy service apps.

BTO Tx-R&D projects must...

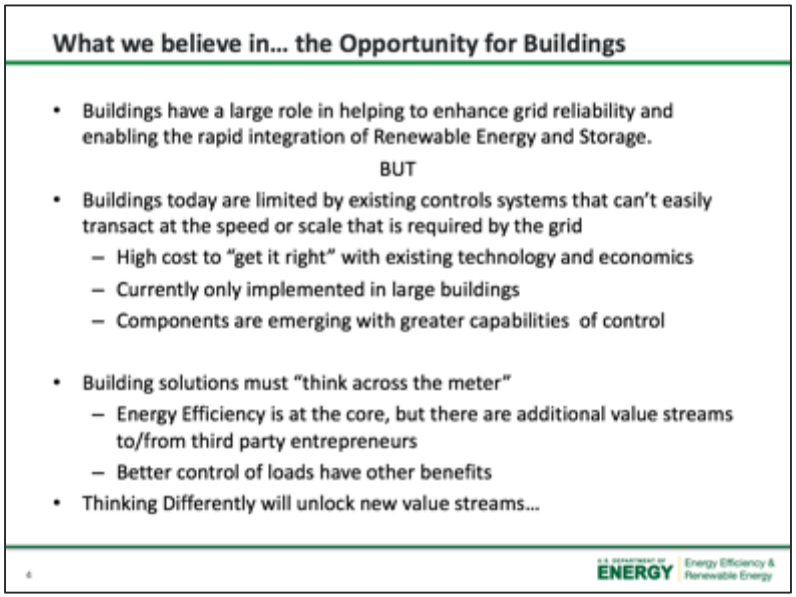
- Understand, evaluate, & unlock the characteristics of whole buildings & Connected Equipment that provide all services/benefits/functionalities.
- Balance these B2G characteristics with other EE & RE technologies.
- Always be mindful that Connected Equipment can impact ongoing regulatory issues.

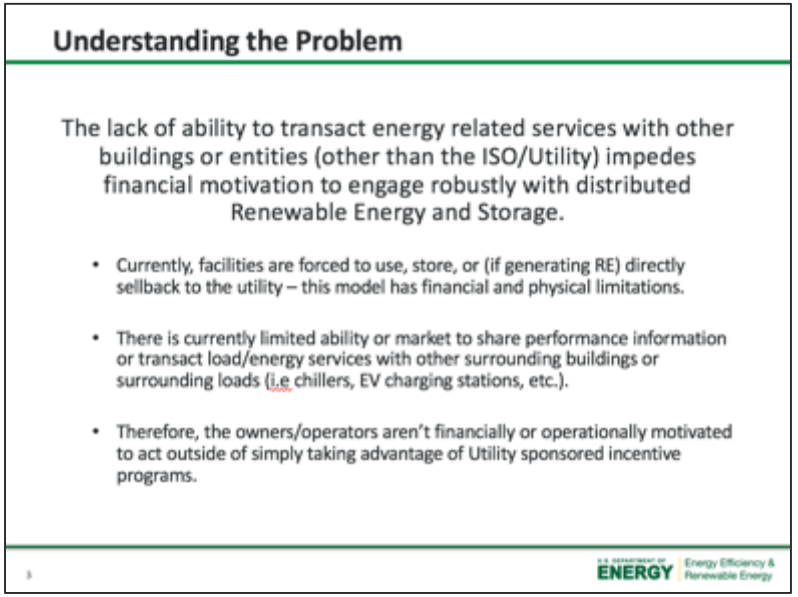
B2G Definitions

These B2G terms have been established in BTO's public meetings & reference documents (through review and comment):

- **Transaction** – The negotiated exchange of products, services, and rights within a structured or unstructured market that enables allocation of value among all parties involved (known as settlement). Transaction require the exchange of the …
  - Physical (in our case, Energy + Information)
  - Logical (in our case, controls or control systems that act on information)
  - Financial (in our case, a price to determine value to users)

"Value" is allocated & can be based on non-energy criteria expressed as price (i.e. "green-ness" of the power, asset valuation, comfort, etc).



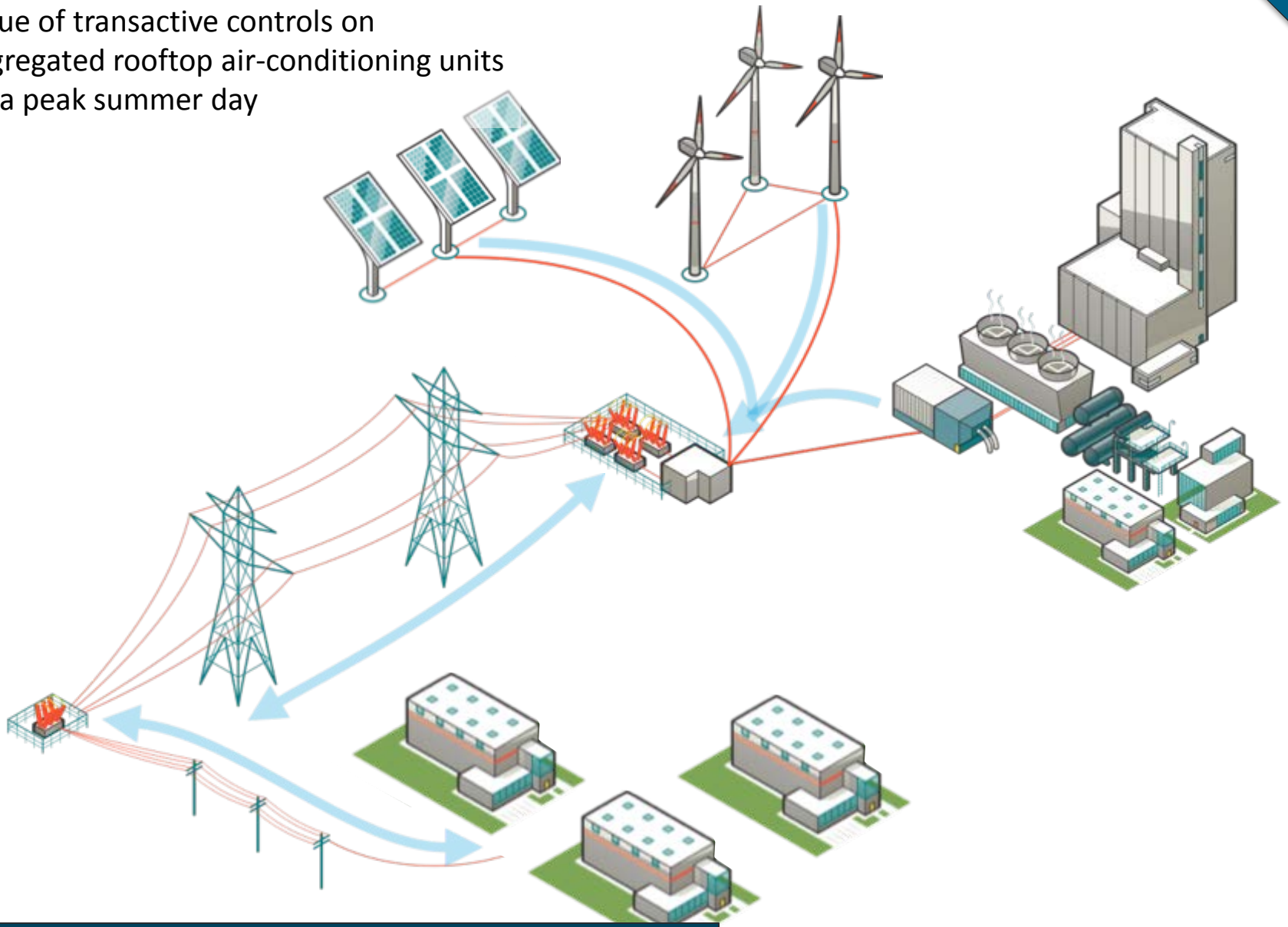


Fundamentally, to enable transactions we must commingle energy + information and assign value.

illustrative

Example Opportunity:

- Value of transactive controls on aggregated rooftop air-conditioning units on a peak summer day



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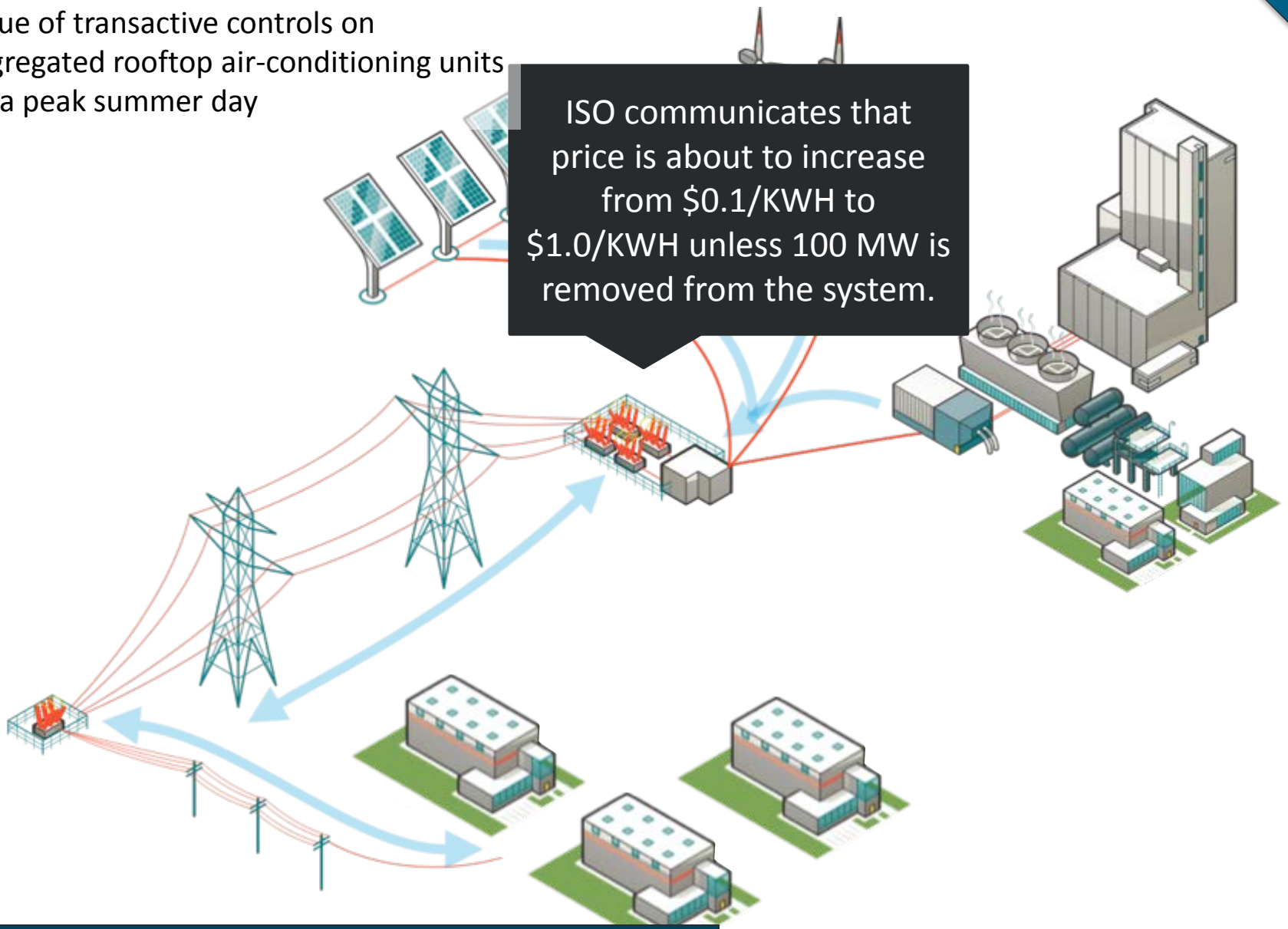

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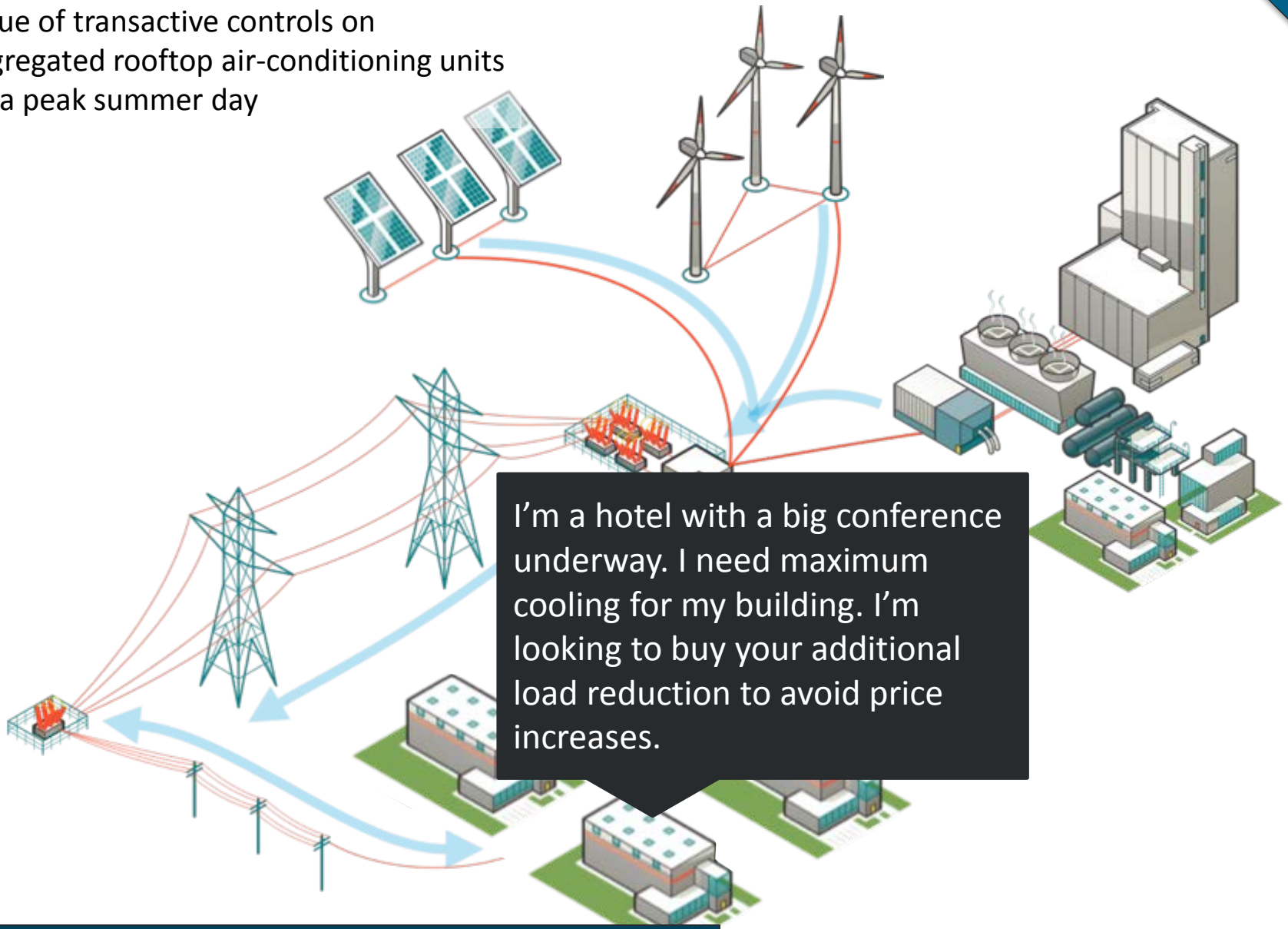

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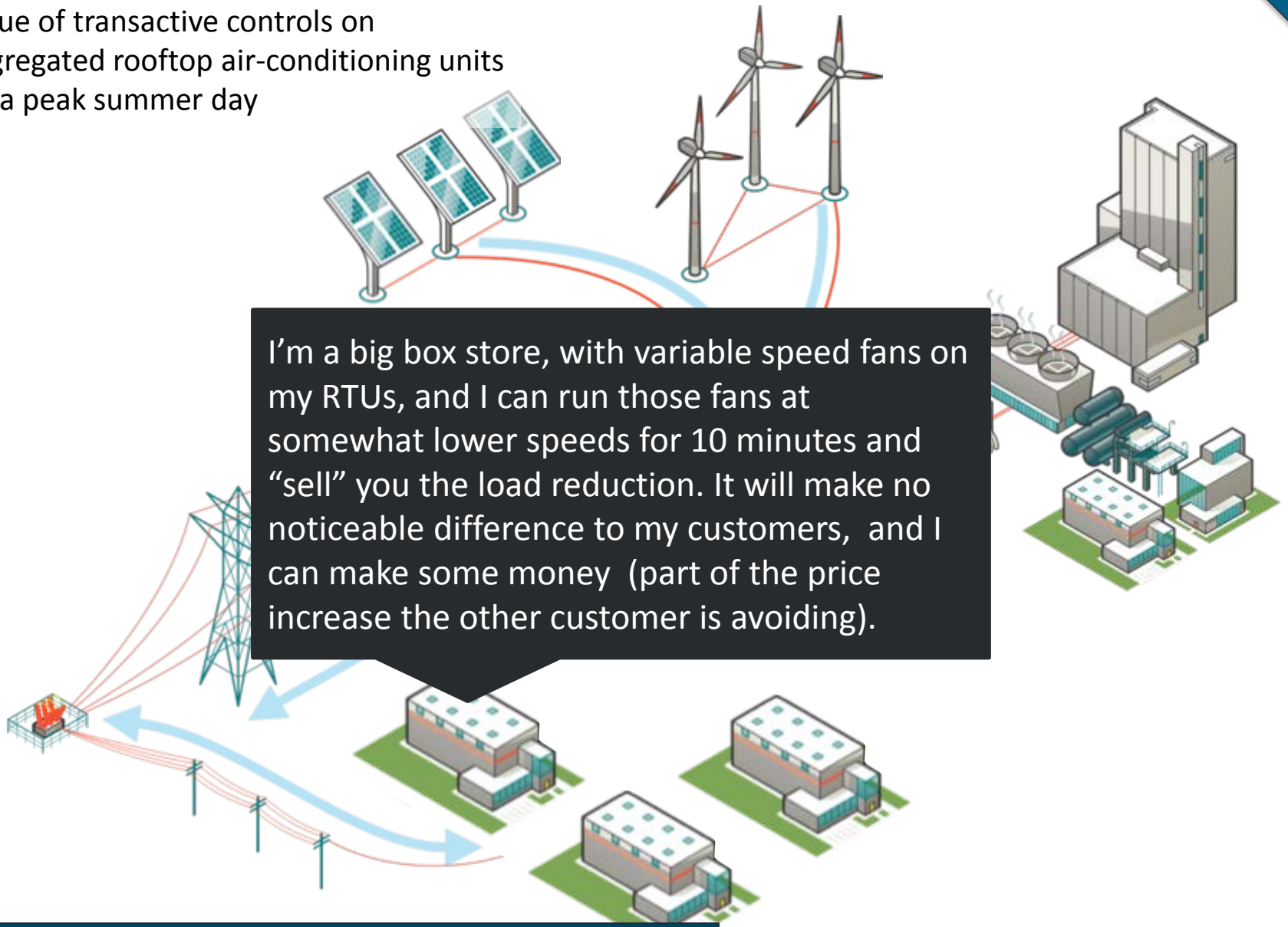

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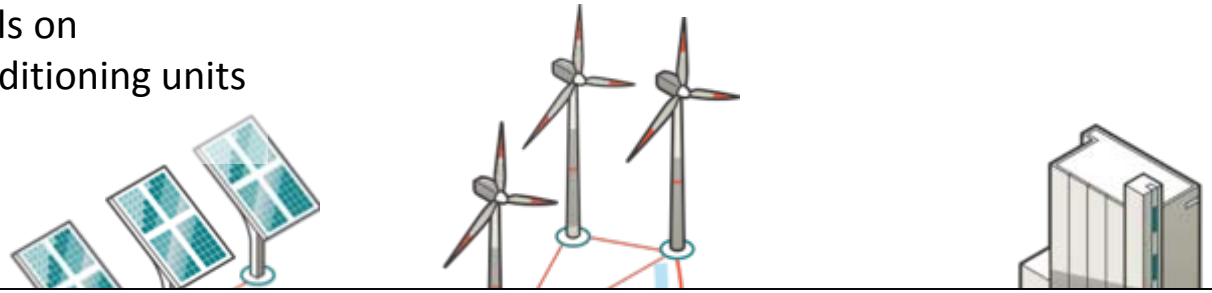


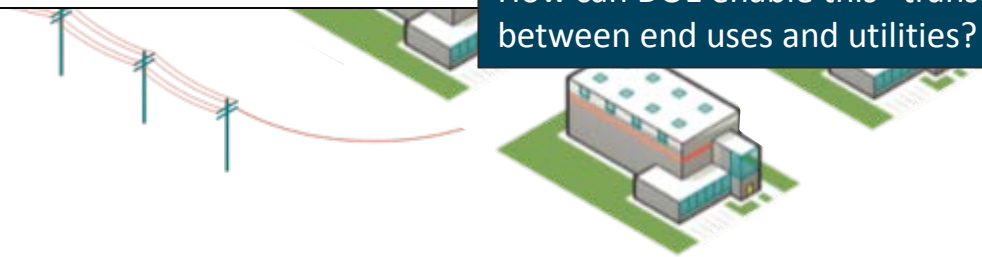
illustrative

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?



B2G Definitions (2)

These B2G terms have been established in BTO's public meetings & reference documents (through review and comment):

- **Transaction** – an exchange or interaction between entities.
- **Transaction Based Controls** – controls that exchange, negotiate, & respond to information through information and communication technologies (ICT).
  - Most common signal is economics based: "price."
  - Needs advancements in fundamental sensors & controls – like plug-n-play, FDD, auto-mapping, etc.
- **Transactional Platform** – a software platform (e.g. ICT & related physical hardware) that allow applications to be programmed and negotiate/act on the exchange of information.
  - VOLTTRON is fully supported throughout DOE (OE, EERE, others) & is open source.
- **Transactive Energy** - techniques for managing the generation, consumption or flow of electric power within an electric power system through the use of economic (or market-based) constructs while considering grid reliability constraints. (GWAC)
  - The term "transactive" comes from considering that decisions are made based on a value to the parties involved. The decisions may be analogous to (or literally) economic transactions.
- **Transactive Devices** or **Connected Equipment** – consumer products with ICT that enable them to be exercised through transactions – without boundaries.
  - Available technologies are typically proprietary (e.g. vendor specific ICT)

Fundamental concepts – typically bound within buildings to take advantage of the closed ecosystem. "No Regrets to EE."

Core Controls platform that supports whole buildings, appliances & devices. Can be applied anywhere.

Fundamentally supports grid & energy market service benefits. May opt out of "No Regrets to EE" to benefit "System Efficiency."

“Smart Buildings” Are Transactive Buildings

Within S. 1046, the Smart Building Acceleration Act, these concepts translate into SMART BUILDINGs. The term “smart building” means a building with an energy system that:

- is flexible and automated *[that leverages building capabilities to provide services to other entities];*
- has extensive operational monitoring and communication connectivity, allowing remote monitoring and analysis of all building functions *[has the ICT capabilities of a software platform];*
- takes a systems-based approach in integrated with the overall building operations for control of energy generation, consumption, and storage *[connects building components and a tie to the larger electricity system];* and
- communicates with utilities and other third party commercial entities if appropriate *[has capabilities to tie to electricity markets to transact].*
- *is cyber-secure [has a plan and implementation to secure and recover from cyber threats].*

Research, Development & Deployment

Scaling Transaction-Based Controls
through Apps to enable Smart Buildings

Apps, apps, and more apps!!!
Applications (using the VOLTTRON platform) help both large and small companies develop new solutions smart building solutions, or improve existing ones, and reduce the time to market.

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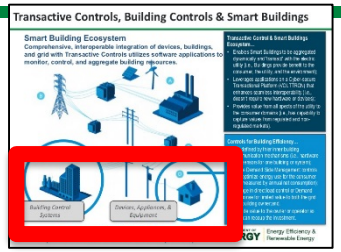
The Software Revolution can also benefit Building Controls

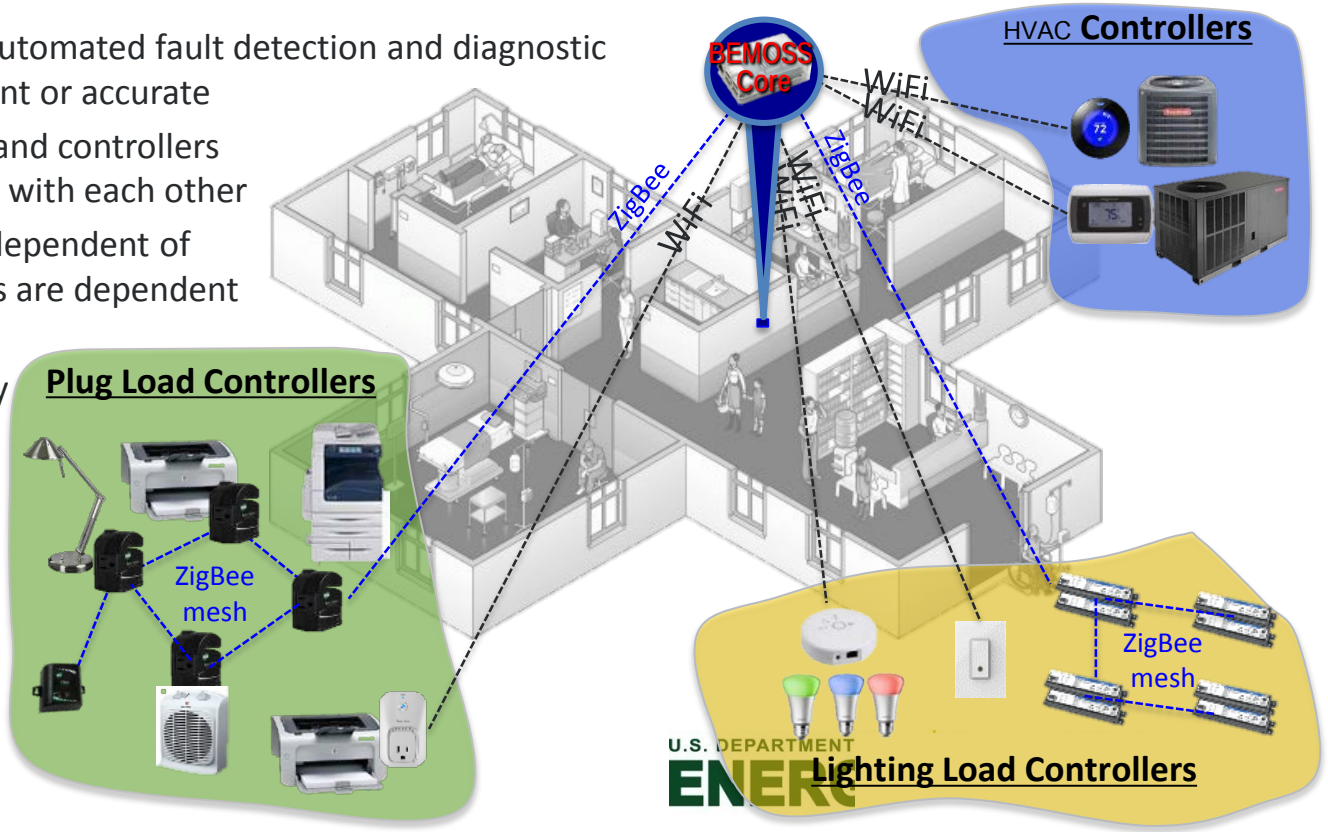


The DOE Open Execution Platform (i.e. Volttron) can also be utilized inside buildings

Examples:

- Existing systems do not automatically configure resulting in increased labor and maintenance costs due to manual optimization
- Advanced sensor/control systems are too expensive to encourage wide adoption
- Thermostats are typically deployed across too large a space to properly condition the building for comfort
- The performance of existing automated fault detection and diagnostic systems is not always consistent or accurate
- Building devices, equipment, and controllers typically cannot communicate with each other
- Lighting control is typically independent of thermal control yet the effects are dependent
- Occupancy sensors are expensive to deploy yet rarely operate effectively

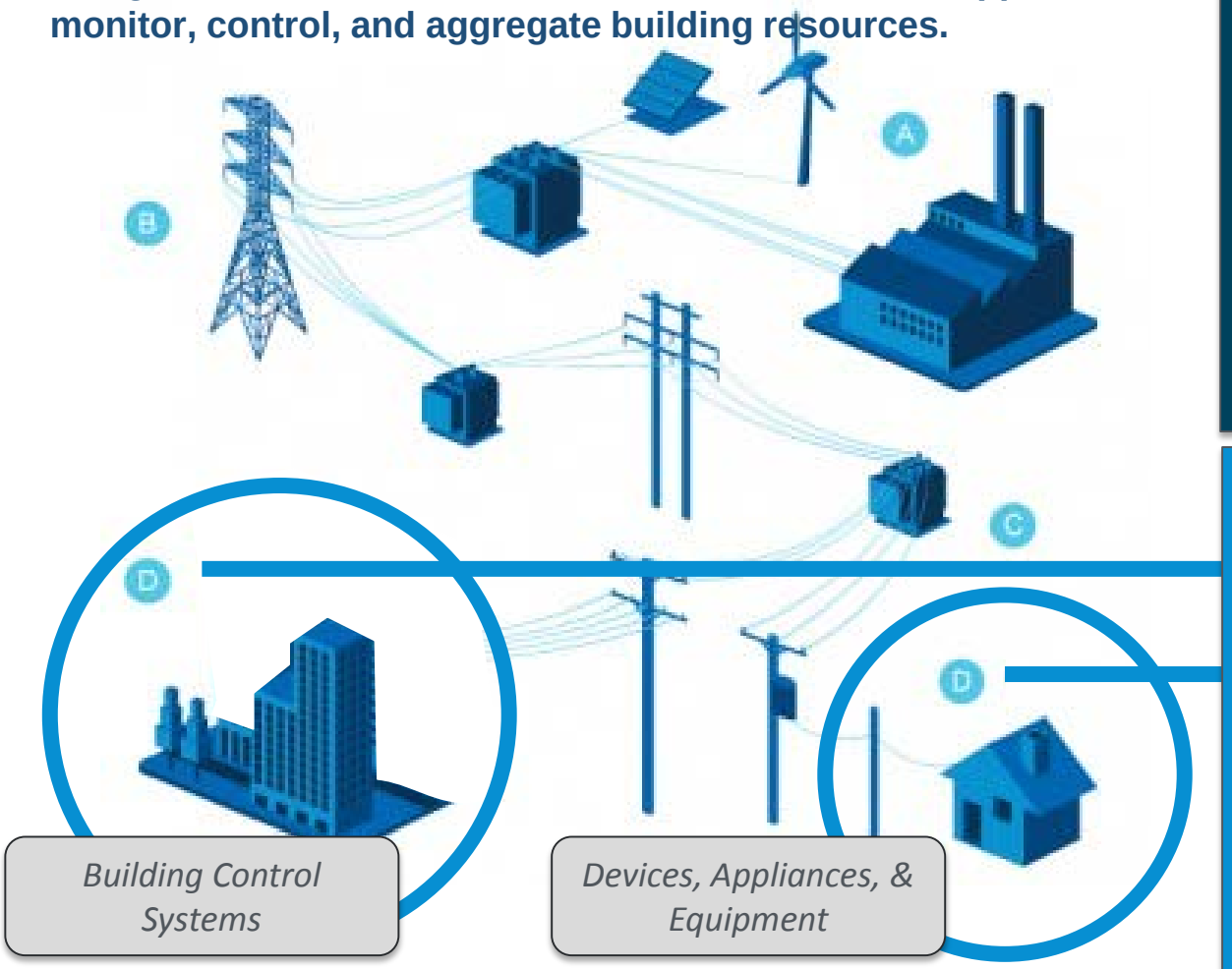
Smart buildings start with smart sensors and controls that can transact energy and information.



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.



Transactive Control & Smart Buildings Ecosystem...

- 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 apects 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 thier 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);
- Engage in direct load control or Demand Response for limited value to both the grid and building owner;and,
- Provide value to the owner or operator so they can recoup the investment.

Controls for Building Efficiency

(behind the meter - within the customer premises)

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Feature Article

Want to get started on transactive energy and nanogrids? Steal this government software

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Quick Take: *We've been talking for years about the need to move sensing, intelligence and control to the edges of the grid. A centralized approach simply can't achieve the visibility and response time needed in a world where everything is connected.*

More recently, we've been talking about ***transactive energy as a solution****. Essentially, transactive energy lets devices publish their power needs and prioritization. Fine in theory, but how do you put that into practice?*

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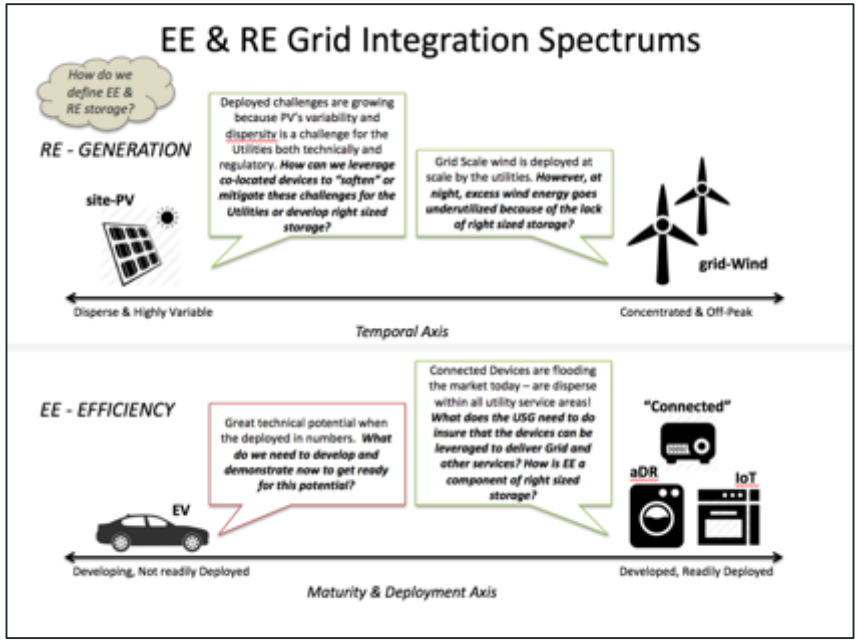
Scalable Transaction Based Controls

Research, Development and Deployment

Connected Equipment performs **primary functions** as we holistically think "from sources to loads:"

- **SUPPLY (+)** - generate power to avoid, minimize, or shift larger system distortions → FC, PV, Wind, etc.
- **CONSUME (-)** – change, or alternate operation to optimize or reduce large system distortions → End use loads
- **REGULATE (rate)** - transfers loads between two or more devices to optimize the larger electricity system → Transformers, economic dispatch, dynamic management of loads and generation, etc.
- **STORE (time)** – applications of those functions necessary to store or stage energy → Batteries, Virtual Batteries, and thermal storage.

Note: Fundamentally this coordination is beyond one building, and per building implementation will be custom without fundamental Sensor & Control (S&C) solution development (e.g. plug-n-play, auto-mapping, auto-tuning, auto-Cx, auto-etc).



Apps, apps, and more apps!!!

Applications using the VOLTTRON platform help both large and small companies to develop new solutions, or improve existing ones, and drive them into the market.

Buildings as an Energy System Asset: Foundational Items

- BTO must integrate the Connected Equipment cross cut initiatives into the GMLC so that the BTO defined methods can be scaled across all EE & RE technologies – as well as be better recognized by OE & their stakeholders.
  - **Interoperability** – EERE should roll up their activities in terms of defining a roadmap & action plan.
    - DOE must collaborate with utilities, other agencies (e.g. NIST, ANSI), and manufacturers to define a unified plan that can realize results.
  - **Characterization** – from defining frameworks to writing protocols this work must be scaled across the diversity of EE & RE technologies and with the representative stakeholders.
    - DOE must also understand that each technology is at a different stage with different stakeholder structures – this diversity must be mapped across DOE.
    - DOE must also consider its role in terms of working with utilities to define unified models that align with the characterization results.
  - **Cyber Security** – buildings and end-uses must be incorporated into OE's cyber activities.