The Role of Transactive Energy in Grid Modernization: Leveraging Building Technologies

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NASEO Energy Outlook Conference

February 6, 2014

Grid Modernization – Driving Factors

Changing Supply Mix

- Requires additional transmission
- Requires more advanced communications and controls

Transforming Demand

- Digital Economy: demand growth and power quality needs
- Electrification of transport

Growing Complexity

- Expanding connectivity and data
- New market products and players
- Optimization across many goals

Increasing Vulnerability

- Electricity, communication, and control systems interdependent
- Requires resiliency to disruptions

Potential Benefits of a Modernized Grid

- Increased resilience to energy disruptions
- Reduced emissions from the electric utility sector
- Increased energy independence
- Sustained US technology leadership and increased international competitiveness
- Major increases in economic productivity with new products and services

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Vision of the Future Grid

Key Goal: Appropriate balance of several key attributes while recognizing situational differences

Cost-Effective and Reliable

Clean and Efficient

Empowered Consumers with Options

Accessible to New Technologies

Secure and Resilient

A seamless, cost-effective electricity system, from generation to end-use, capable of meeting all clean energy demands and capacity requirements, with:

- Significant scale-up of clean energy (renewables, natural gas, nuclear, and clean coal)
- Universal access to consumer participation and choice (including distributed generation, demand-side management, electrification of transportation, and energy efficiency)
- Holistically designed solutions (including regional diversity, AC-DC transmission and distribution solutions, microgrids, energy storage, and centralized-decentralized control)
- Two-way flow of energy and information
- Reliability, security (cyber and physical), and resiliency

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Framework – Grid Interdependencies

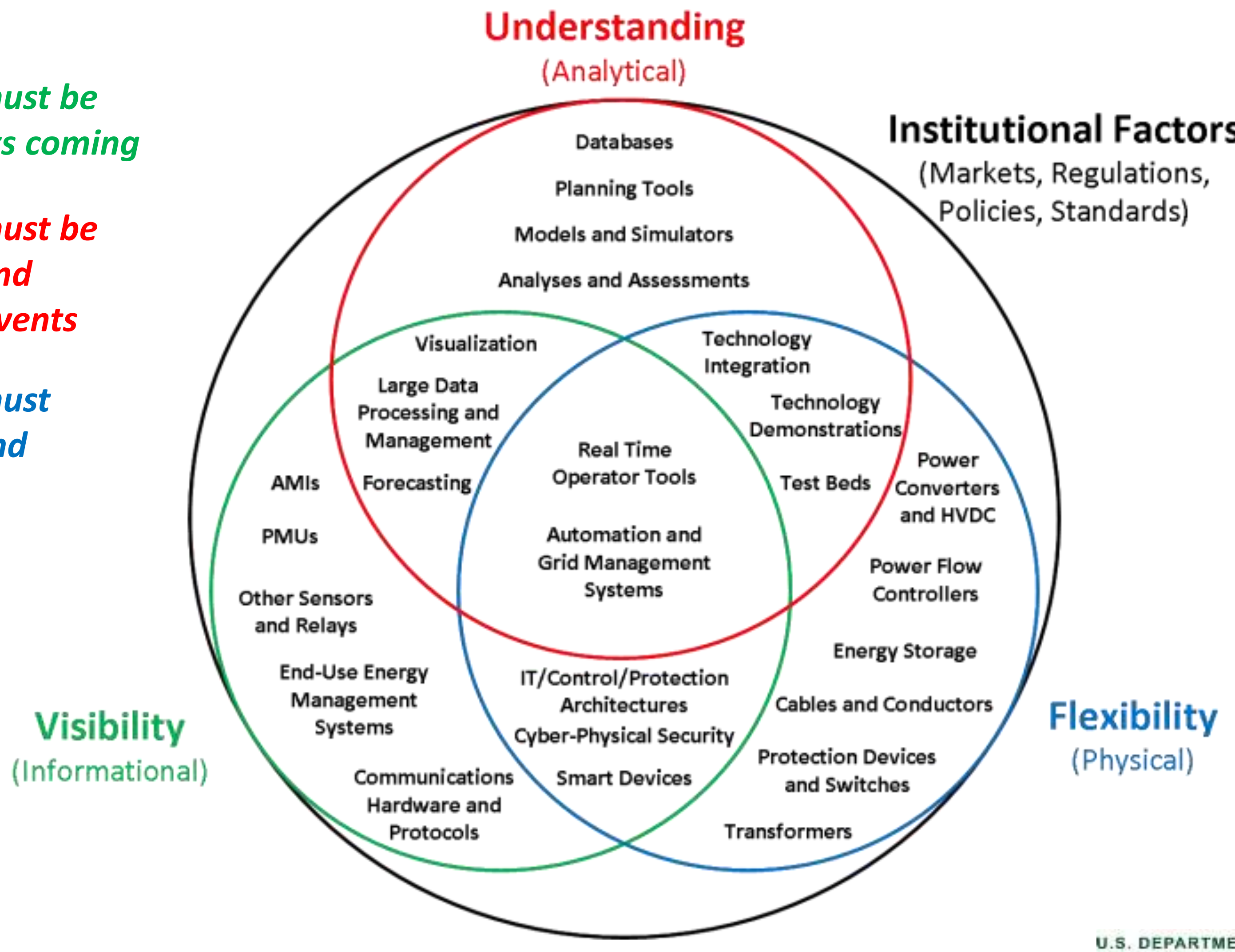
The future grid will be vastly more complex than the one we have today

Grid operators must be able to see events coming

Grid operators must be able to understand implications of events

Grid operators must be able to respond appropriately to events

Institutional factors guide actors' behavior



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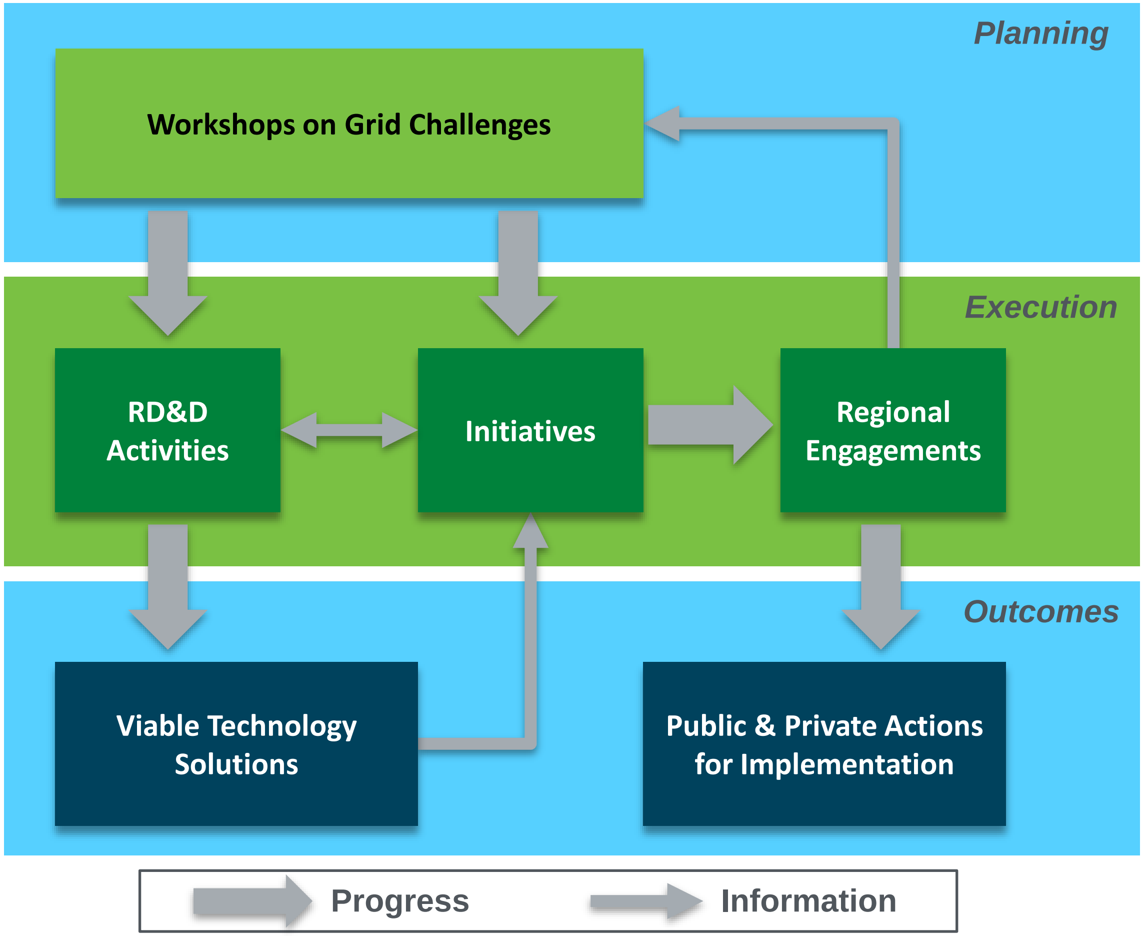
Grid Modernization - Strategy

DOE has several strategic roles: convener, provider of technical capabilities and expertise, and disseminator of data and information



Key Elements of Strategy

- **RD&D activities** to *overcome mid- to long-term technical issues* identified during workshops and discussions on grid modernization challenges
- **Initiatives** to *address institutional barriers and near-term technical issues* that represent obstacles to the broad deployment and commercialization of technology solutions
- **Regional engagements** to *incorporate regional differences and sensitivities associated with executing initiatives* at regional, state, and local levels

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Grid Modernization Challenges

Improving Control of Power Flows

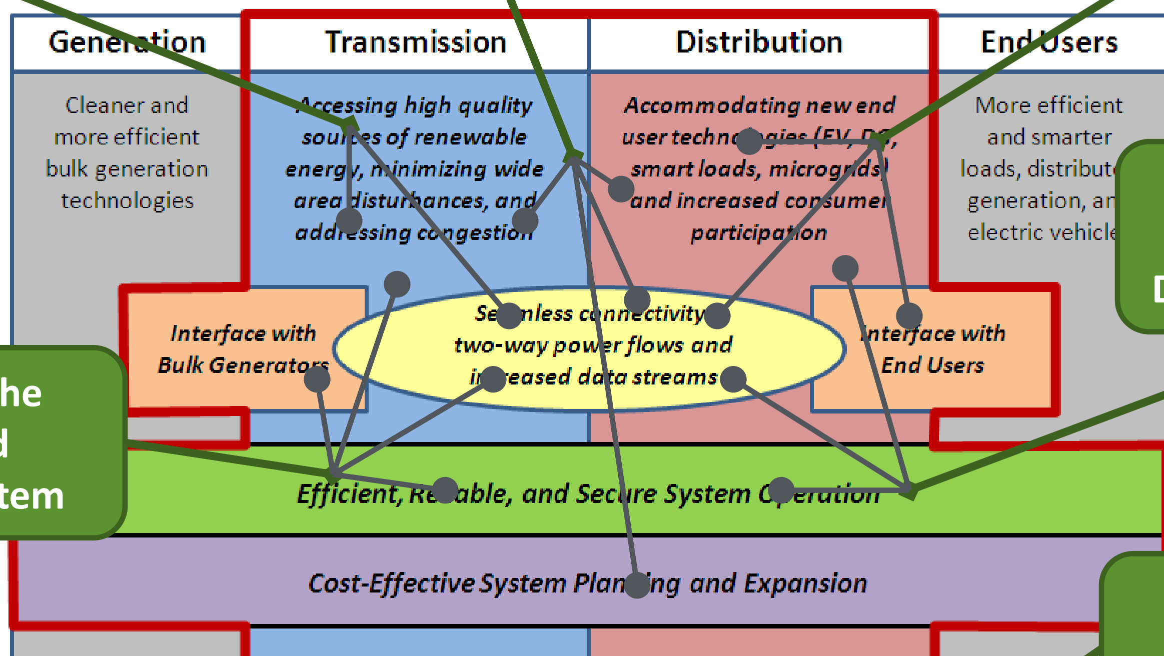
- Congestion
- Asset utilization
- Reliability

Designing and Planning the Future Grid

- Costs
- Innovation
- Security
- Access

Integrating Multiple Systems and Technologies

- Access
- Empower consumers
- Aggregation



Creating Smarter, More Resilient Distribution Systems

- Manage assets
- Reliable
- Efficient
- Resilient

Developing the Future Grid Operating System

- Clean energy
- Reliable
- Efficient
- Resilient

Engaging and Assisting Grid Stakeholders

- Empower stakeholders
- Lower barriers

- **Evolving utility business models**
- **Access to capital for investment**
- **Regulatory changes**
- **Consumer behaviors**

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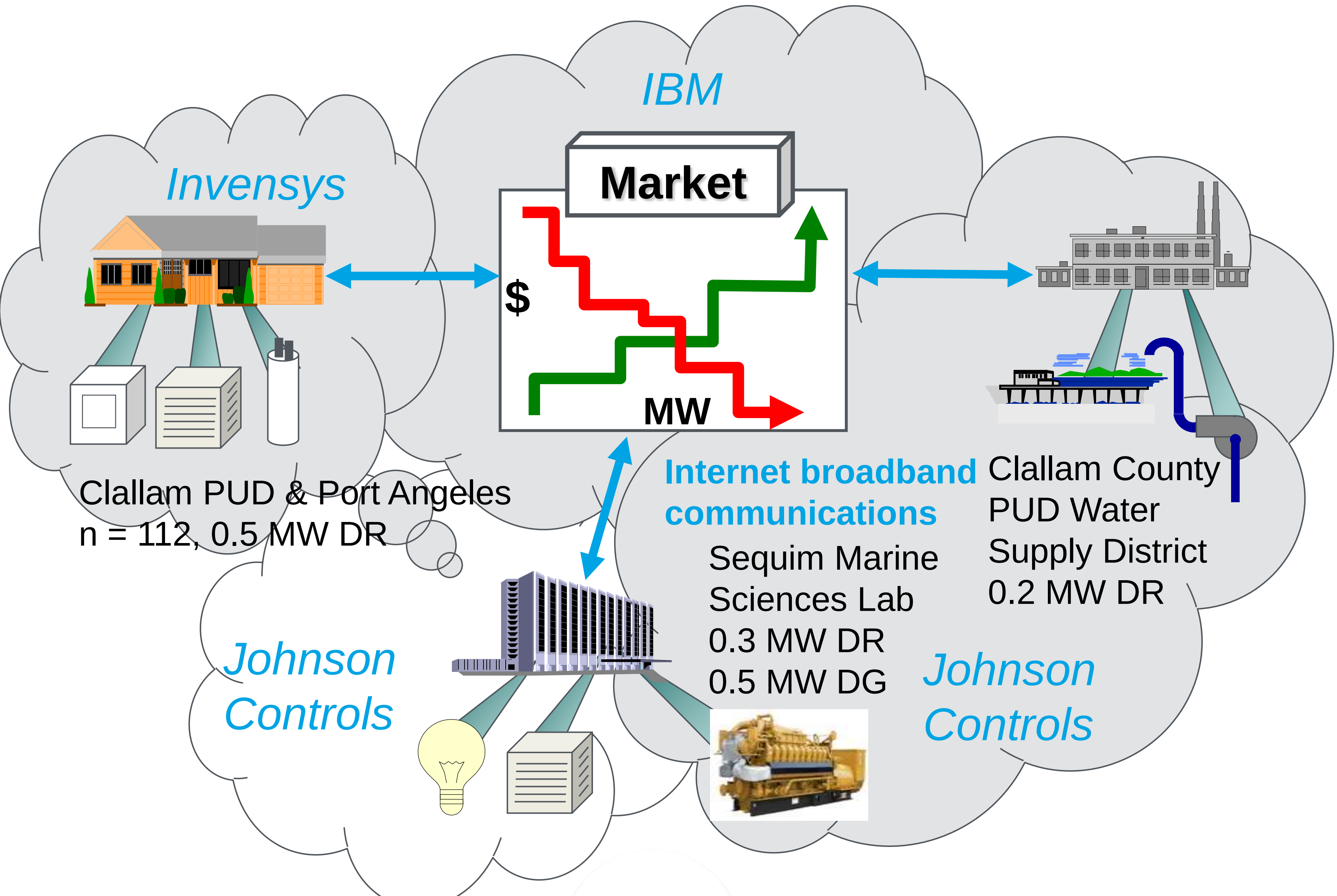
GridWise™ Demonstration Project (2006-2007)

- **Pioneering "smart grid" experiment to test grid-friendly appliances and address constrained transmission**
  - Explored consumer response to real-time prices via a two-way market with cash incentives
  - Buildings engaged: 112 residential, 1 commercial, 2 municipal

- **Clear response to wholesale prices**
  - 15% reduction of peak load
  - Up to 50% reduction in total load for several days when needed
  - Managed line capacity for a full year
  - Average customer savings of ~10%
  - Clear customer acceptance

GridWise Demonstration: First Instantiation of Transactive Control in Real-World Buildings



Pacific Northwest Demonstration Project

What:

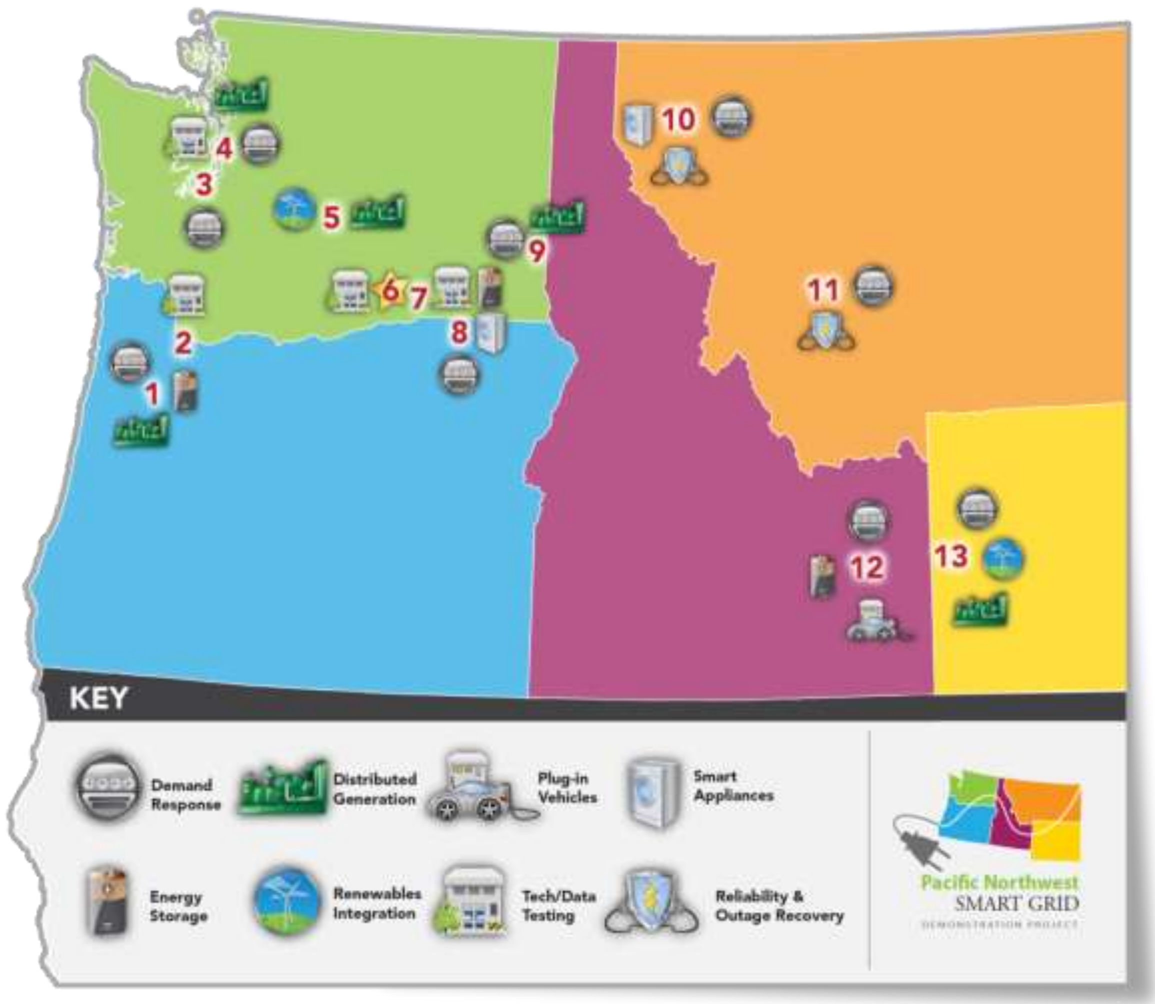
- $178M, ARRA-funded, 5-year demonstration
- 60,000 metered customers in 5 states

Why:

- Quantify costs and benefits
- Develop communications protocol
- Develop standards
- Facilitate integration of wind and other renewables

Who:

Led by Battelle and partners including BPA, 11 utilities, 2 universities, and 5 vendors



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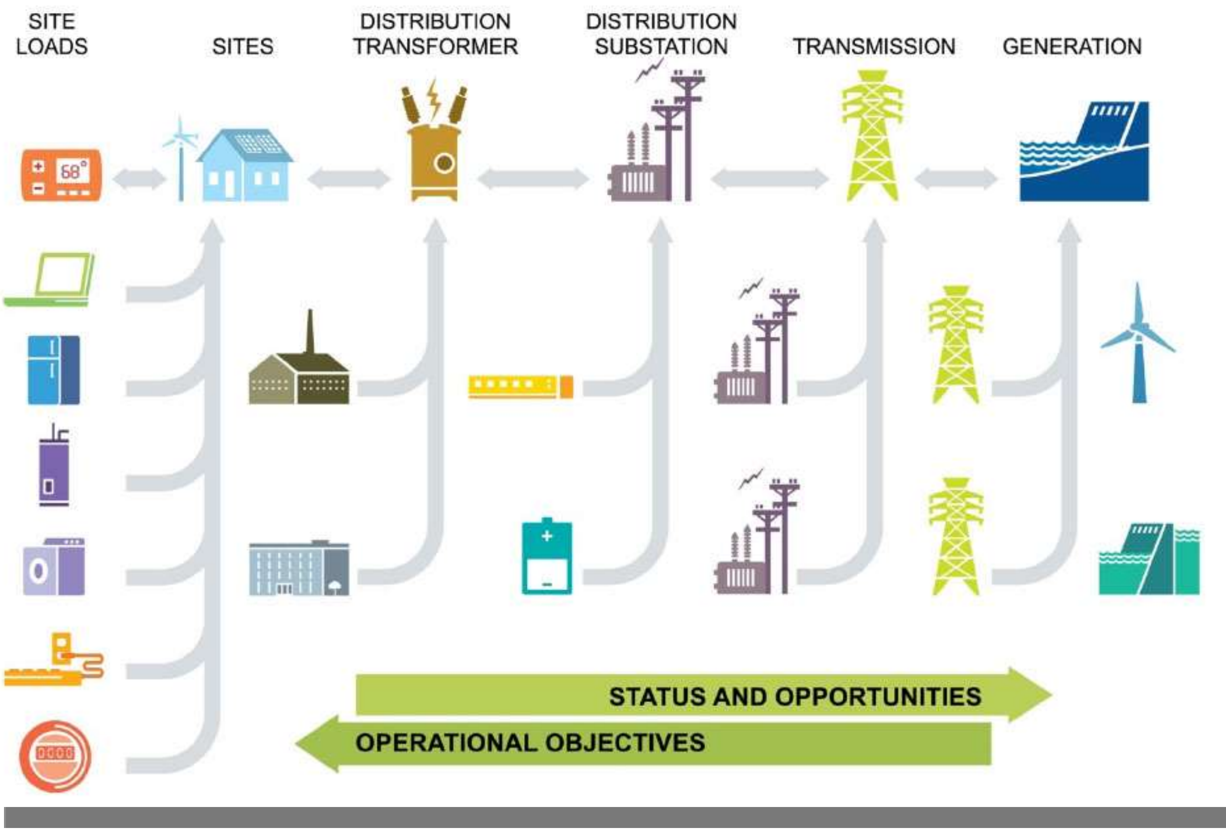
Project Basics

Operational objectives

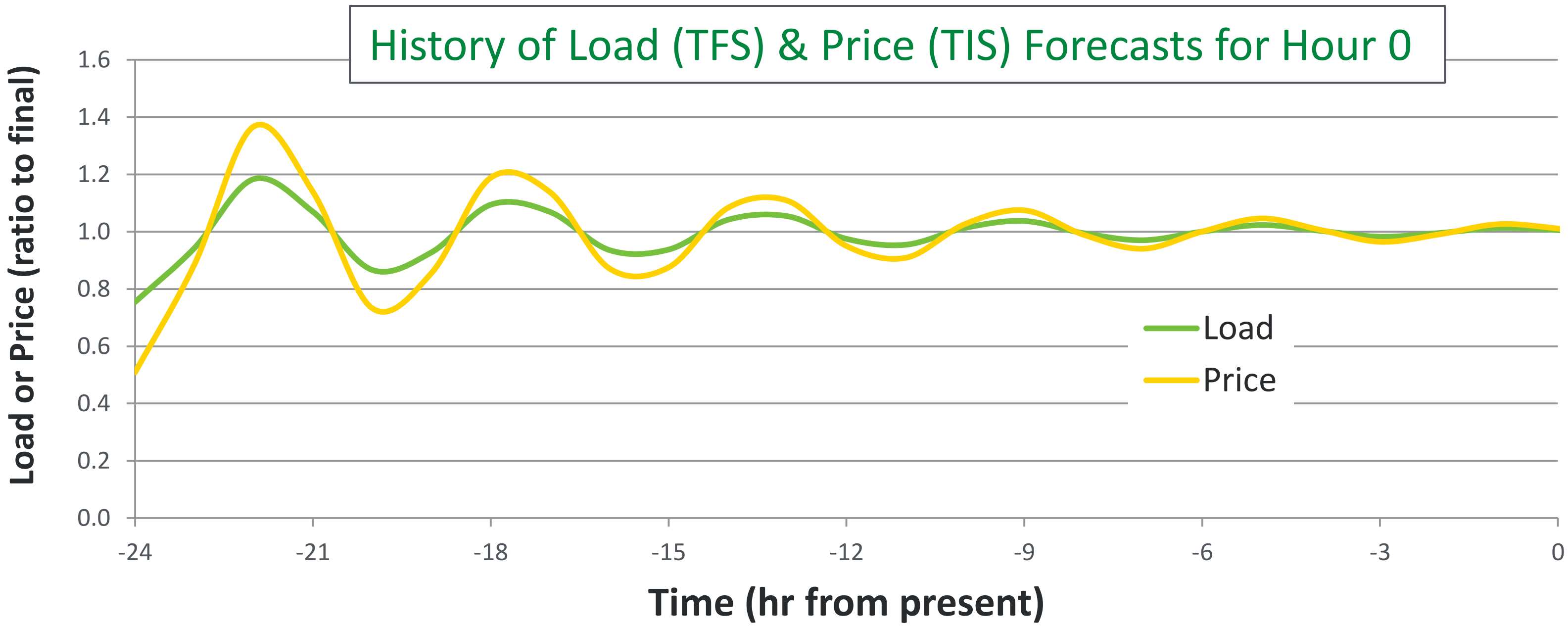
- Manage peak demand
- Facilitate renewable resources
- Address constrained resources
- Improve system reliability and efficiency
- Select economical resources (optimize the system)



Aggregation of power and signals occurs through a hierarchy of interfaces

Transactive Control Feedback Loop

- New incentive signals and feedback signals are generated on an event-driven basis
- The most recently available information is used
- Each signal responds to changes in the other, and the values converge



AEP's GridSmart™ ARRA-Funded Demonstration Project

- $150M, 100,000 AMI meters, volt-VAR control, various DR experiments, storage, small renewables, electric vehicles, etc.
- ~1,000 residential customers will be recruited for TC2 demo (RTP Double-Auction is AEP's name for TC2)
- Technical performance & customer engagement to be compared with other DR program types (DLC, TOU, CPP, etc.)
- RTP double-auction rate design (tariff) approved by Ohio PUC
- Software engine for market operation, HEM-based thermostat bidding, & billing under construction

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Pecan Street Project Energy Internet Demonstration

ARRA : $10,403,570   Total: $24,656,485

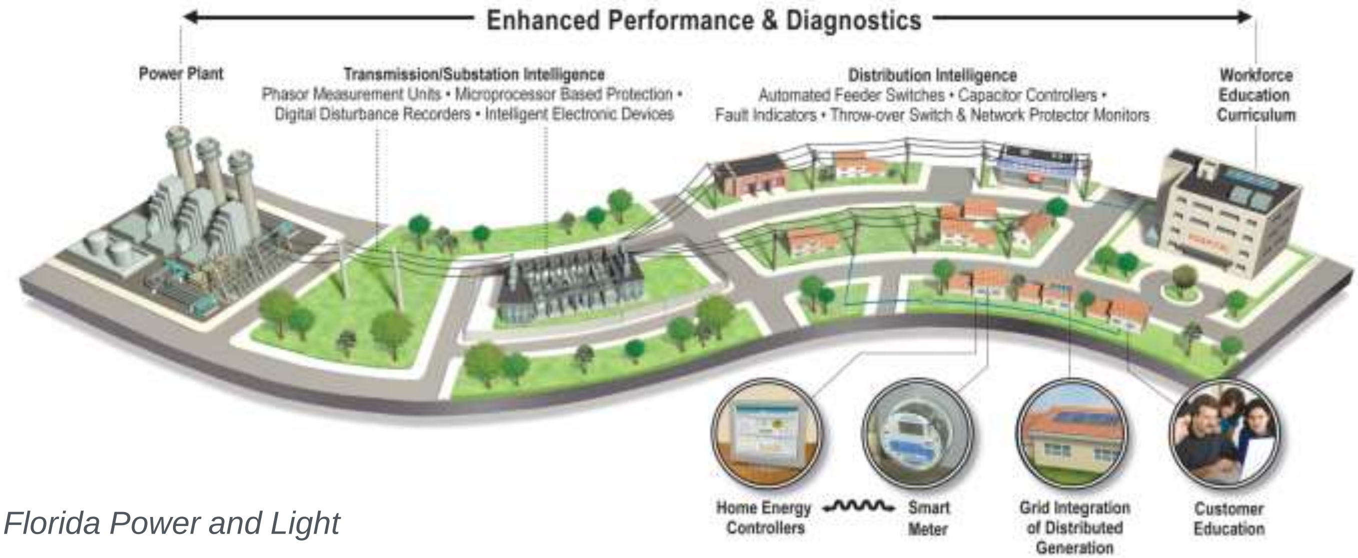
- **Project Location:** Austin, TX

- **Key Attributes:**
  - Located on Mueller infill (brownfield) development – 711 acres (previously abandoned airport) of mixed used development
  - Collect data and analyze the results against control groups and distribution feeder systems in other locations in the Austin Energy service area
  - Integrates water management solutions as well as SG software, V-2-G, PHEVs, and green building initiatives (LEED or "Austin's Green")
  - Links 1000 residential meters, 75 commercial meters and PHEV charging sites

Partners: Austin Energy, City of Austin, Environmental Defense Fund, Cattelus Austin LLC, University of Texas

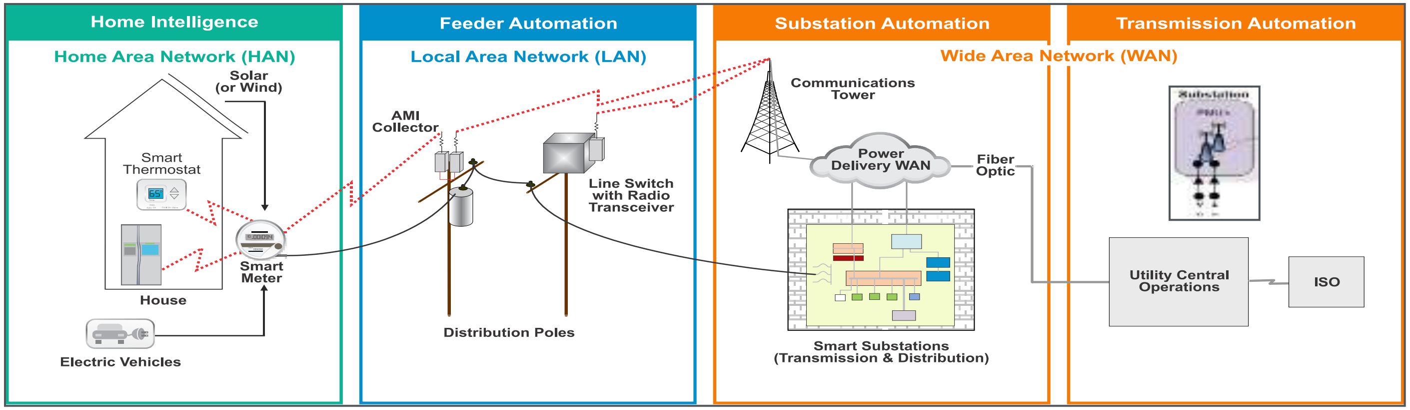
Smart Grid Communications Landscape

Smart Grid requires seamless, SECURE communications across multiple interconnected domains and platforms



Courtesy of Florida Power and Light

Generic Smart Grid Communications Architectures



Interoperability

- Smart Grid Interoperability Panel
  - Technical committee
  - **Represented on Cyber Security Working Group**
  - **National Lab support**
- Standards & Interoperability Coordination with NIST Smart Grid Team and FERC
- Previous funding of key standards development work (e.g. P2030 and 1547) and participant in several others through direct and laboratory resources
- Foundational architecture work provided by OE-funded GridWise Architecture Council

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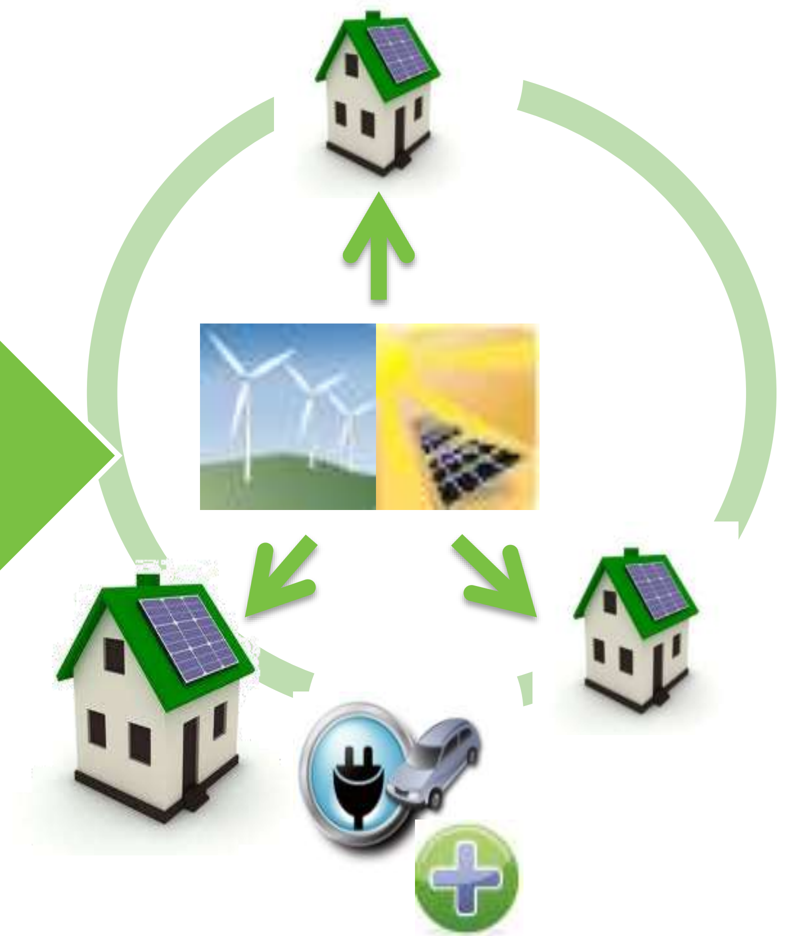
DOE Building Technologies Office (BTO) Vision

Transaction Based Control's enables more efficient buildings and Distributed Energy Resources (DER)

Buildings will be self-configuring, self-commissioning, and self-learning such that they optimize operation, maximize all cost effective energy savings and are enabled to participate in transactions within the building, between buildings, and with the grid



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BTO Vision Supports a Larger DOE Goal

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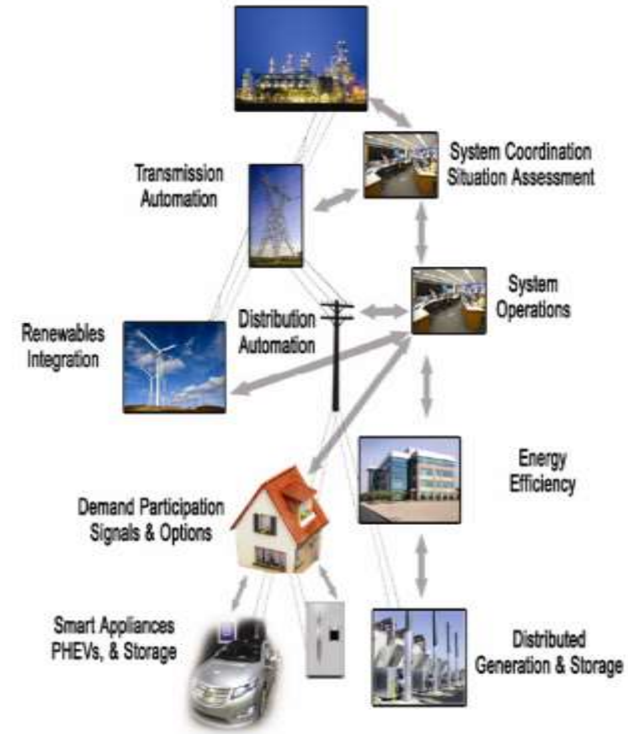

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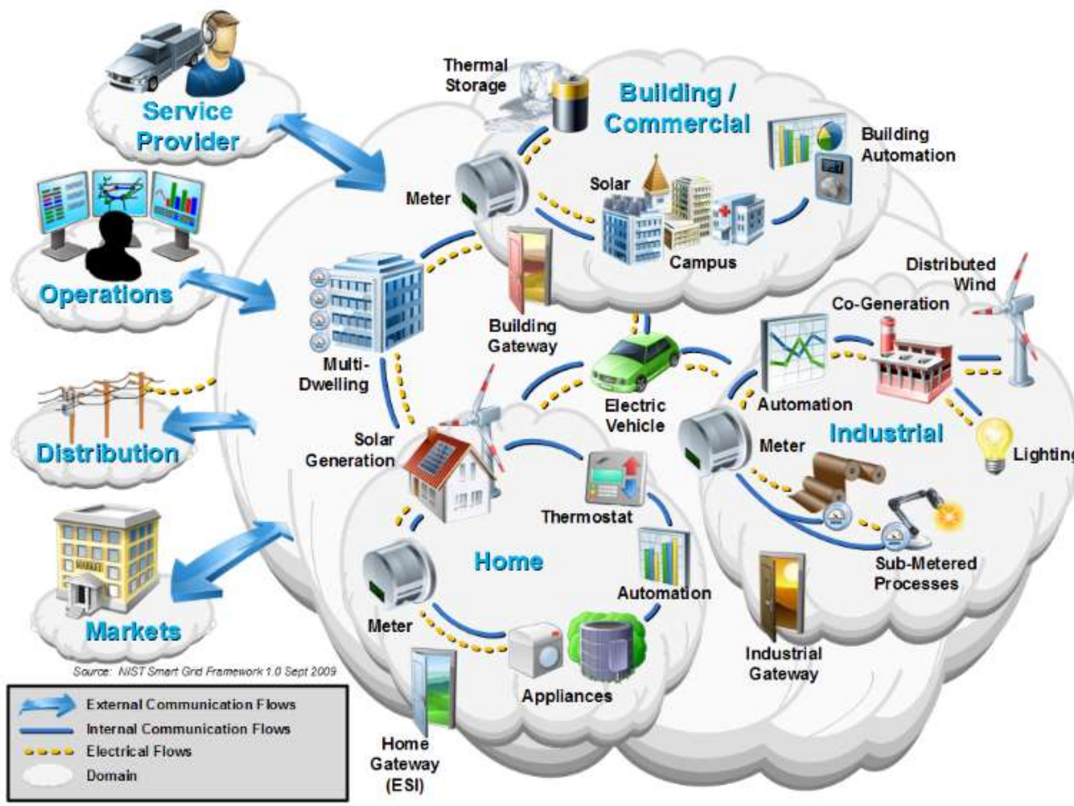
Dynamic Buildings Have an Important Role in this Future

- Significant building infrastructure exists today
- Buildings need to be dynamic to participate in transactions within the building, transact with other Buildings and with grid entities
- Requires a clear value proposition for customers, manufacturers, and utilities
- BTO projects are designed to improve building performance and incorporate the broader transaction capability.



Source: NIST Smart Grid Framework 1.0 Sept 2009

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What are the Challenges to this Future?

- Buildings have a role in helping to optimize grid interactions and enable the integration of Renewable Energy and Storage at a lower cost

BUT

- Today, Buildings are limited by existing controls systems
  - Currently implemented in large buildings with sophisticated systems
  - High cost to "make it work" with existing technologies
  - However, components are emerging with greater capabilities of control

- Building solutions must also "operate across the meter"
  - They need to transact at the speed or scale required by the grid
  - Better control of loads have other benefits and value streams
  - Scalable solutions require common, open protocols

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What is Needed for Scalability?

All of this is possible today, so what is the problem?

Interoperability – Equipment, systems, EVs, PV and buildings do not have a common data taxonomy or communications protocols

- Many companies make products that are either “smart” or enable some kind of transaction, most use their own proprietary protocols
- Many quasi standards are in place, but they are either not specific enough for complete interoperability or only cover a limited number of situations

Therefore, every interconnection requires a patchwork of different systems

Cost – Because each piece of equipment needs additional work to interoperate, there is added cost to the end user and to manufacturers

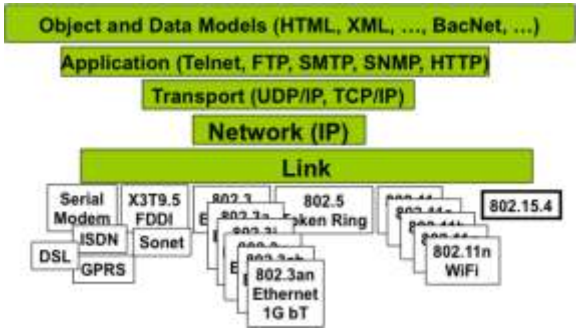
- An open communication protocol, that can transact with proprietary systems and is specific enough to enable these transactions, will lower costs and increase applicability
- Common data taxonomy (formats, etc.) will ensure that information is understood and used efficiently

Loads, energy storage, and distributed generation will be part of a dynamic future grid, lowering the future costs for reliable power, with clear value propositions for all participants.

What is an Energy Efficient and Network-Ready Device?

Energy efficient and smart equipment will have the following characteristics:

- Energy conservation standards if a DOE covered product (DOE to define smart)
- Capability to communicate with the grid or a building energy management system



- Standard, open protocol for communicating data/signals to and from the grid and/or the building energy management system
- Sensing and control capability to decrease or increase load in reaction to that data

- Provision for simple configuration and implementation of consumer's desired degree of flexibility in use of their appliances and equipment with respect to participating or acting upon system signals
- Responses to data/signals do not negatively impact device life-time

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Transaction Based Controls are a “No Regrets” Solution Today

The BTO prioritization tool indicates that various building controls measures have the potential to offer significant energy savings (> ~500 TBTUs in 2030) and are cost effective. These savings are derived from…

- Commercial building automation, particularly in small and medium buildings
- Advanced controllers in new refrigeration systems
- Demand control ventilation in commercial buildings
- Predictive thermostats in homes and commercial buildings
- Residential building automation (a sector of high market activity)

Next generation building sensors/controls can be low cost and offer significant energy savings for buildings and other technology sectors

Development and deployment of various cost effective transaction based control measures will contribute to 30% energy savings by 2030.

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What is DOE's Role Going Forward

For Grid Solutions, DOE will provide clear and consistent definitions for energy efficient and smart appliances, their characteristics or capabilities, and their value to consumers, utilities, and manufacturers.

- How will DOE do this:
  - Work with manufacturers through an open/transparent process to develop physical characterization procedures, leveraging existing efficiency testing protocols to the extent practical
  - Work with testing labs to develop the capability to conduct tests, leveraging the existing testing infrastructure to the extent practical
  - Work with market participants and stakeholders to define and communicate the value of "smartness," leveraging existing DOE, Energy Star, and FTC programs
  - Work with utilities to encourage deployment of energy efficient and networked equipment, leveraging existing utility efficiency programs after the benefits and values are clear

Planned Technical Meetings

Engaging manufacturers, utilities, and other stakeholders is critically important to the success of this effort.

- DOE will be developing these procedures and methods in an open and transparent process with public meetings and commenting periods

DOE is planning a series of technical meetings to collect feedback and provide input on the process…

- Phase 1: verify understanding of current state, refine value proposition, solicit input for metrics development, review equipment prioritization for testing schedule
- Phase 2: solicit comments on draft metrics and characterization procedures
- Phase 3: roll out characterization procedures and initial results from equipment tests

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The Future: Transactional Network Controls

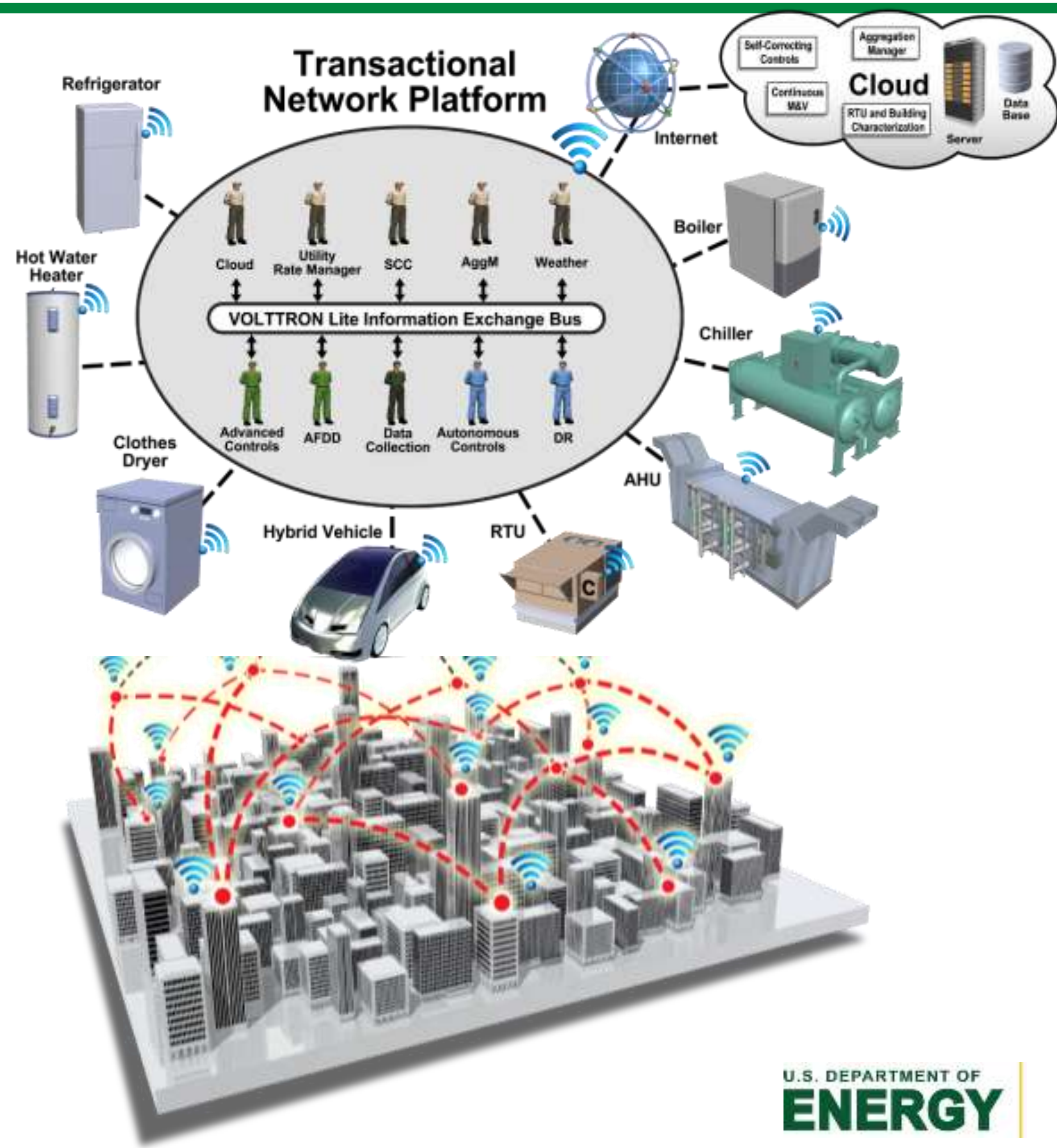
- Buildings need to be smarter to participate in transactions within the building, with other buildings, and with grid entities

- Sensors and controls are fundamental to optimize DER and the grid

- **An open source transactional network enables scalable energy saving retrofit solutions**

  AND

  The networked systems to transact with all grid connected devices (e.g. EV, storage) and with the grid to help mitigate DER related disturbances



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