



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Buildings to Grid Integration & Interoperability

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EERE: Office of Energy Efficiency and Renewable Energy

BTO: Building Technologies Office (Portfolio – RD&D, Deployment, Regulatory)

The Office of Energy Efficiency and Renewable Energy's mission is to:

- **Enhance energy efficiency** and productivity;
- **Bring clean, reliable and affordable energy technologies** to the marketplace; and
- **Make a difference in the everyday lives** of Americans by enhancing their energy choices and their quality of life.

EERE spent \$16.8 billion in ARRA funds to stimulate jobs and help create a clean-energy economy in the US.

Office of Energy Efficiency and Renewable Energy

Program Priorities	
Biomass	Investing over \$1.4 billion to achieve cost competitiveness and commercialization of cellulosic and other advanced biomass feedstocks and biofuels through applied research, next generation pilot scale development, commercial scale biorefinery demonstrations and targeted infrastructure activities.
Buildings	Implementing a systems approach in deploying technologies for “net-zero” energy buildings that produce as much energy as they consume. Builder’s Challenge, the Commercial Buildings Initiative, and accelerated building codes and appliance standards implement this new approach.
FEMP	Doubled energy efficiency investment in Federal building through \$1 billion of private-party performance contracting. New ESPC contracts will support up to \$80 billion in energy savings at federal facilities and increase individual contract ceilings to \$5 billion over the life of the contract.
Geothermal	Program renaissance emerged on foundation of Enhanced Geothermal Systems (EGS) that allows geothermal energy to be harnessed nationwide providing up to 10% of our Nation’s future electricity.
Fuel Cells	Added focus on near-term stationary and early market applications to create economies of scale, accelerate learning-by-doing, and reduce cost of technology for transportation market.
Industrial	Concentrating on the Save Energy Now program, which through energy assessments has resulted in savings of over \$100 million and 75 trillion Btus of natural gas.
Solar	Achieve grid parity with PV and other solar technologies by 2015 through advanced R&D over the entire supply chain. Re-invigorate Concentrated Solar Power program through launch of energy storage research and demonstration.
Vehicles	Focusing on fuel flexible Plug-in Hybrid Electric Vehicles through greatly enhanced battery research activities and new utility partnerships.
Weatherization/SEP	Developed stronger ties with States and utilities by providing technical assistance and by developing “best practices” and model policies for faster and larger scale adoption of efficiency and renewable energy.
Wind & Water Power	Assessed feasibility for wind energy to provide 20% of our Nation’s electricity which led to new industry vision. Launched new program in wave, tidal and current energy.

Building Technologies Office (BTO)

Delivering Energy-Efficient Solutions

Emerging Technologies

- High-impact building technologies
- ~Five years to market-ready

Residential Building Integration

- Cost-effective technologies, tools, solutions
- Peak energy performance in new & existing homes

Commercial Building Integration

- Cost-effective technologies, tools, solutions
- Peak energy performance in new & existing commercial buildings

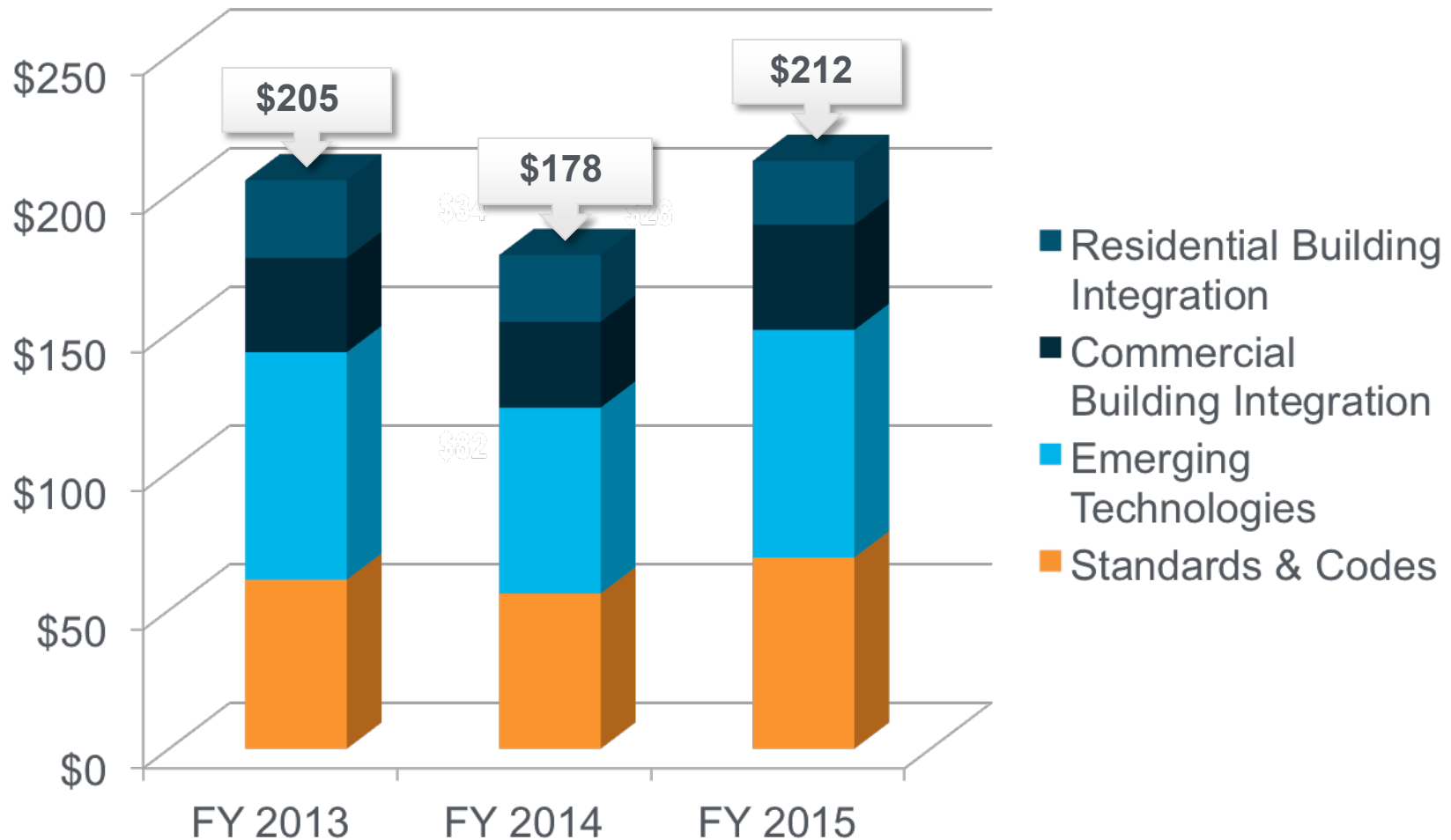
Codes & Standards

- Building energy code language with adoption/compliance strategy
- National appliance & equipment standards



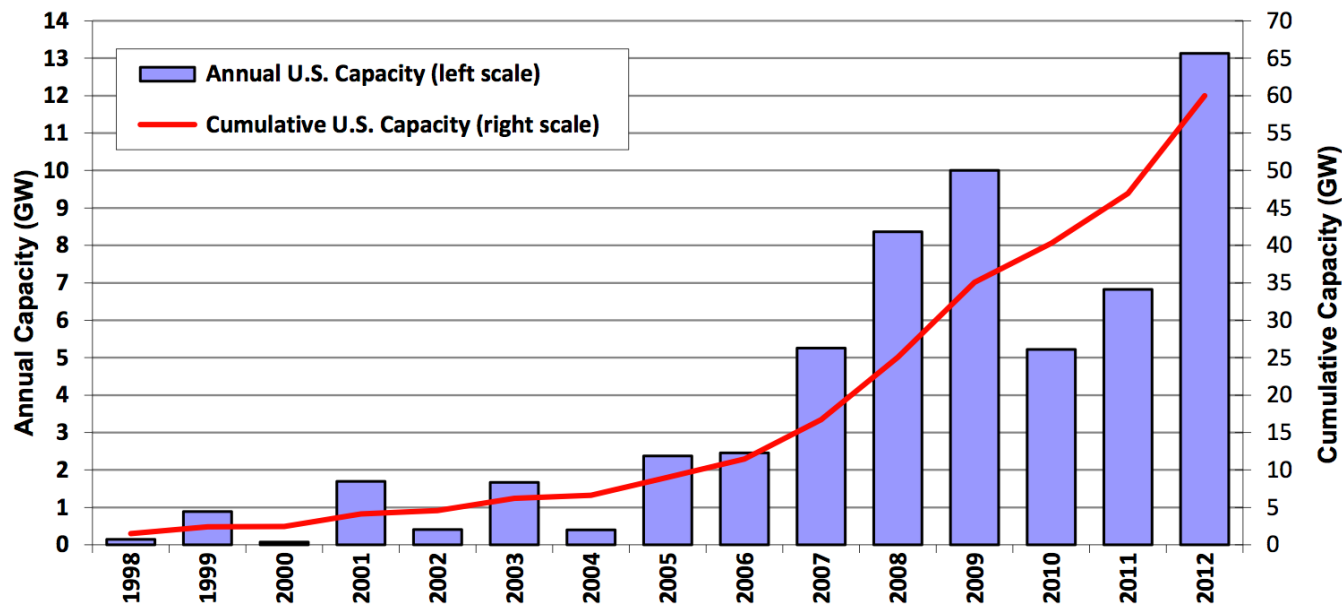
BTO Funding by Program

(in millions)



Grid Integration Initiative

- As EERE **drives down the cost** of emerging technologies, these technologies have started to proliferate into the energy system.
- The Grid Integration Initiative **addresses challenges** associated with the physical operation of the power system when these technologies are deployed at scale.



Source: AWEA project database

Figure 1. Annual and Cumulative Growth in U.S. Wind Power Capacity

Seamlessly integrating these technologies into the grid in a safe, reliable, and cost-effective manner is critical to enable deployment at scale.

One EERE: Our Shared Grid Integration Vision

Moving into the future, EERE has formed High Level Grid Integration Goals across EERE and DOE...

- Enable high penetration of clean energy and energy efficient technologies on distribution systems while maintaining reliability, safety, and affordability;
- Enable various clean energy and energy efficient technologies to interact with one another and the grid to optimize solutions across multiple objectives; and
- Leverage advances made from Recovery Act grid modernization investments and increase the value proposition of clean energy technologies.

Understanding the Problem

The lack of ability to transact energy related services with other buildings or entities (other than the ISO/Utility) impedes financial motivation to engage robustly with distributed Renewable Energy and Storage.

- Currently, facilities are forced to use, store, or (if generating RE) directly sellback to the utility – this model has financial and physical limitations.
- There is currently limited ability or market to share performance information or transact load/energy services with other surrounding buildings or surrounding loads (i.e chillers, EV charging stations, etc.).
- Therefore, the owners/operators aren't financially or operationally motivated to act outside of simply taking advantage of Utility sponsored incentive programs.

What we believe in... the Opportunity for Buildings

- Buildings have a large role in helping to enhance grid reliability and enabling the rapid integration of Renewable Energy and Storage.

BUT

- Buildings today are limited by existing controls systems that can't easily transact at the speed or scale that is required by the grid
 - High cost to “get it right” with existing technology and economics
 - Currently only implemented in large buildings
 - Components are emerging with greater capabilities of control
- Building solutions must “think across the meter”
 - Energy Efficiency is at the core, but there are additional value streams to/from third party entrepreneurs
 - Better control of loads have other benefits
- Thinking Differently will unlock new value streams...

Largest unresolved issue is agreement for integrated, interoperability of equipment

- An enormous amount of physical information is available today as the cost of communication and instrumentation has fallen, yet that data is trapped.
 - information from and about equipment, equipment states, energy usage, potential reductions, etc --
- However, making use of that information is still challenging.
 - The information is frequently silo-ed into proprietary systems,
 - The information is frequently available only in batch, and
 - The information is fragmentary and disorganized.
- The lack of this information about the equipment causes the asset to be stranded
 - It cannot be pooled to the greater benefit of the system, and
 - It can run away, act sporadic, or exist randomly.

Why Interoperability?

Interoperability provides lower cost, scaled solutions for our evolving energy needs.

- Equipment manufacturers can sell higher performing equipment at a premium.
- End Users can optimize performance while getting compensation for offering incidental beneficial “use” of their equipment.
- Service providers can aggregate loads to create larger scale market solutions.
- Utilities can reduce consumer costs for the safe and effective integration of intermittent renewables or provision of ancillary services.

Scaling Transaction Based Controls

Vision

- Buildings operating at optimum energy efficiency over their lifetimes, interoperating effectively with the electric power grid.
- Buildings that are self-configuring, self-commissioning, self-learning, self-diagnosing, self-healing, and self-transacting to enable continuous optimal performance.
- Lower overall building operating costs and higher asset valuation.

<http://energy.gov/eere/buildings/downloads/buildings-grid-technical-opportunities-introduction-and-vision>

Mission

- Work with the market to develop and deploy cost effective solutions to building owners/operators, service providers, and manufacturers to manage energy consuming assets more easily and efficiently (38 quads of primary energy).
- Utilizing these solutions, enable optimum building energy efficiency and performance, renewable generation with reduced utility investments, and standardized financial transactions for across the meter opportunities

Research, Development and Deployment

Develop and commercialize advanced diagnostics and controls to create self-aware buildings that optimize performance.

Define, test, quantify and validate the value proposition, response and related services provided by Building Technologies

Enable buildings to interact (e.g. with the grid) to support transactive energy opportunities and deliver the value proposition

Scaling Transaction Based Controls

Research, Development and Deployment

Develop and commercialize advanced diagnostics and controls to create self-aware buildings that optimize performance.

- Fundamentals needed to enable buildings that are self-configuring, self-commissioning, self-learning, self-diagnosing, self-healing, and self-transacting to enable continuous optimal performance.

Define, test, quantify and validate the value proposition, response and related services provided by Building Technologies

- **Reference Guide to Transaction Based Building Controls** (FY14-FY15)
 - Fundamental work to define building related services (FY14) and the Minimum Requirements (FY15) to deliver those services.

Enable buildings to interact (e.g. with the grid) to support transactive energy opportunities and deliver the value proposition

- **Framework for Characterization of Connected Devices** (FY14-FY15)
 - Defined measurement process to characterize the response that “connected devices” can provide, including grid, operational and other services.
- **National Strategy for the Interoperability** (FY15)
 - Interoperability is the biggest requirement for a low cost and scalable smart grid, smart cities and smart buildings.

The Reference Guide = A Vision for Services

- **Grid Services**

- Traditional services the Grid needs -from DR to Ancillary Services
 - How can EERE technologies deliver these services at the lowest cost?
 - McKinsey report quantifies the value of these services but it does not match solutions to EERE technologies

- **End User Services**

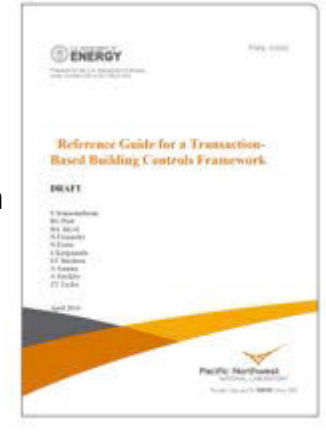
- Operations, Maintenance, and Energy Efficiency of behind the meter assets (example: EE, Continuous Commissioning)
 - EERE technologies have historically focused on these services. How can we best consolidate these value streams?

- **Energy Market Services**

- New services where energy production and “use” can be exchanged between parties (potentially outside of regulated markets). Example: Provision of energy storage to avoid capacity charges
 - How do we explain and then help the market capture these values? We must identify potential energy market services that can be provided by these technologies.

- **Societal Services**

- Services that “society” needs or values (example: Staging of recovery)



Scaling Transaction Based Controls-Interoperability

Research, Development and Deployment

Develop and commercialize advanced diagnostics and controls to create self-aware buildings that optimize performance.

Define, test, quantify and validate value proposition, response and related services provided by Building Technologies

Enable buildings to interact (e.g. with the grid) to support transactive energy opportunities and deliver the value proposition

Vision is enabled by the development of a **Transactional Network (TN)**, Open Source Solution. This project is the first step in developing, demonstrating and deploying scalable, cost-effective and open solutions



Improve Operational Efficiency of Building Systems



Manage End-Use Loads



Help Integration of Renewables



Accommodate Millions of Electric Vehicles



Help to Maintain Reliability



Multi-Lab Coordinated and Cooperative Initiative

Feature Article

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

Jul 30, 2014

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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?

LATEST STORIES

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

[A grid management solution for today's grid >>](#)

How to keep your smart meters safe from attack (and not just cyber-attacks)

[Thwarting the dangers >>](#)

Smart grid technology roundup: What's new in metering, analytics and more

[New developments in smart grid tech >>](#)

HOT TOPICS

Now utilities can tell customers how much energy each appliance uses (just from the smart meter data)

[The next step for smart meters? >>](#)

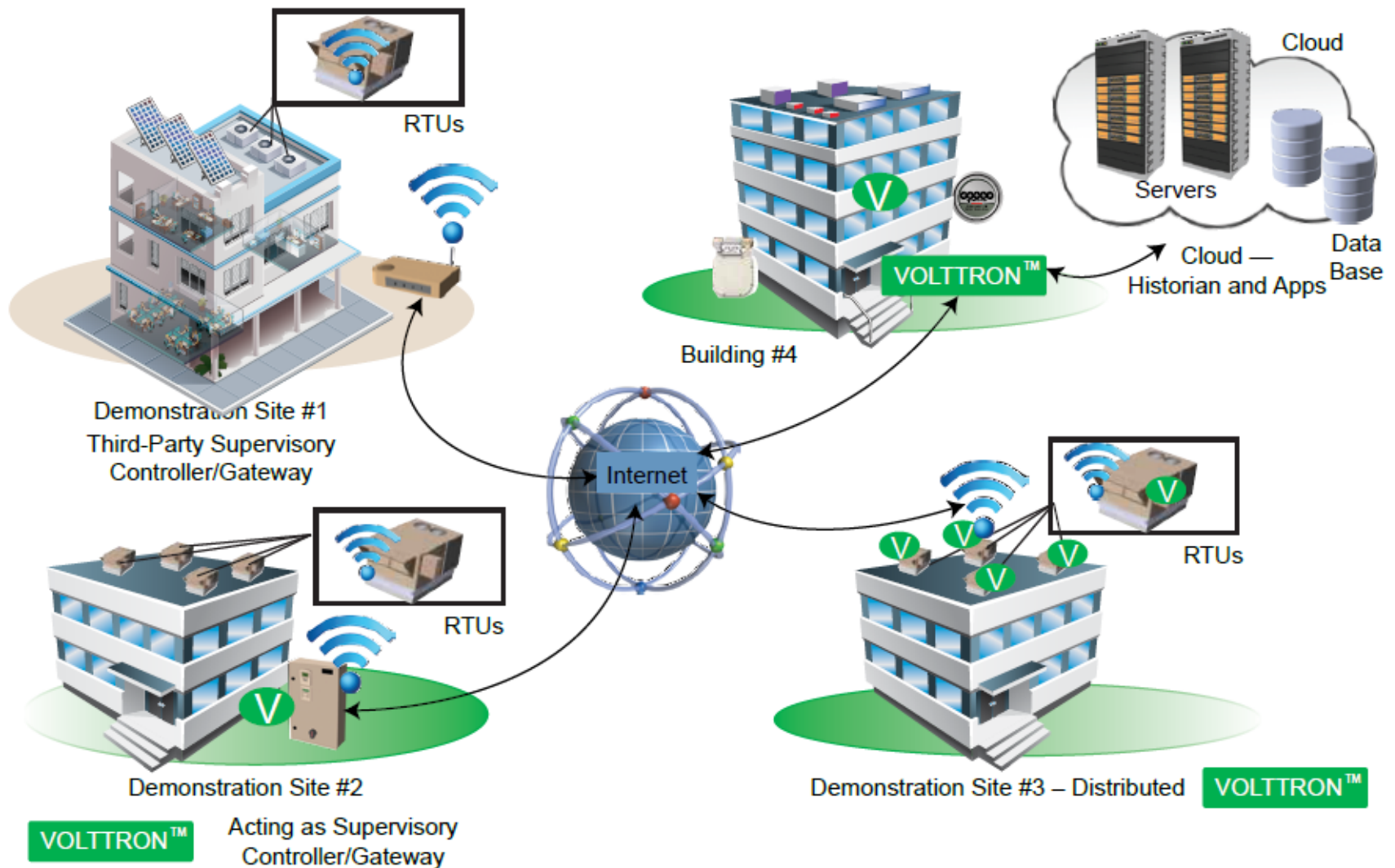
Utilities: If you think solar rooftops are a pain, wait until solar streets get here

[Now in second prototype stage >>](#)

[What the race to control the home means](#)

http://www.smartgridnews.com/artman/publish/Delivery_Grid_Optimization/Want-to-get-started-on-transactive-energy-and-nanogrids-Steal-this-government-software-6665.html#.U9lgCGRdXRc

Transactional Platform - Volttron



Interoperability is supported by a Transactional Network Platform

DOE's "connected controls" investments use an open source solution = Volttron

- Originally developed for utilities by National Labs and Office of Electricity
 - Cyber security is a core component.
 - Field tested by multiple utilities with many real customers and equipment
- Several control companies are now exploring this platform
 - Companies support an open platform if they open new markets and if they can develop value added proprietary applications;
 - All users benefit by not being locked into a single proprietary solution.
- DOE will continue to develop the platform and engage the market.
 - First Volttron user meeting September 2014.
 - Industry participants committed to taking on enhancements, validation and testing
 - Success requires further engaging the user community to achieve market uptake
 - Vendors are now selling Volttron based solutions.
 - Utilities are engaging DOE labs to discuss service territory deployments.
 - Control companies are testing Volttron based solutions in their labs.

Scalable Transaction Based Controls – Market Uptake

Research, Development and Deployment

- 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.
 - We need clear value proposition for consumers, manufacturers, utilities and service providers.
 - Current applications include...
 - ✓ Buildings as “virtual batteries” - balance 50kW PV with building loads (FY14)
 - ✓ M&V apps for utility programs also provides M&O support to building owners (FY14, FY15)
 - ✓ Electric Vehicle application to stage charging, deliver grid services, and push non-energy services to consumers (FY15)
 - We are now developing a Volttron application for home appliances (FY15)

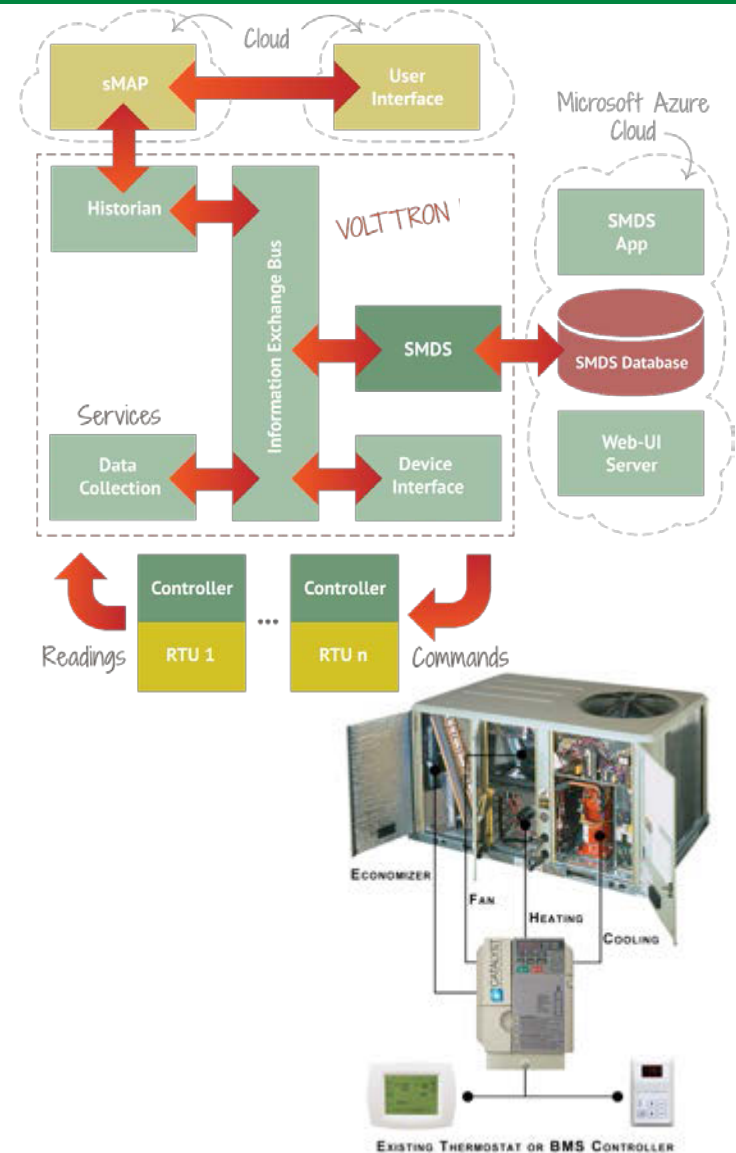
PNNL -Transactional Network Applications (2014)

Embedded Advanced RTU Controls: Improve operational efficiency of RTUs through use of advanced controls - leading to energy and carbon emission reductions over 50%

Demand Response Agent: Make RTUs more grid responsive - leading to a more reliable electric power grid and to mitigate impacts of intermittent renewable generation

Automated Fault Detection and Diagnostics:

- Detect economizer and ventilation failures as they occur and notify building operator to correct them
- Identify refrigerant-side performance degradation (or improvement)
- Quantify the energy and cost impacts of the degradation (or improvement)
- Identify operation schedule changes
- Identify selected operation faults, such as compressor short cycling, 24/7 operation, system never on, and inadequate ventilation



ORNL- Transactional Network Applications (2014)

Wireless Interoperability Seamless integration of wireless sensors into the transaction network platform

Renewable Integration Build autonomous controller to temporally match RTU energy consumption and peak PV generation using forecasting tools

Autonomous Control Build control formulation to manage multiple RTUs in a single building for a grid service (e.g. peak reduction, renewable integration) and energy efficiency applications (occupancy, weather forecast).

Super-Market Refrigeration Develop refrigeration system applications (with Emerson) to improve their performance and to provide energy services to the grid.

