Building Technologies Office (BTO) Sensors and Controls Technologies

Emerging Technologies R&D Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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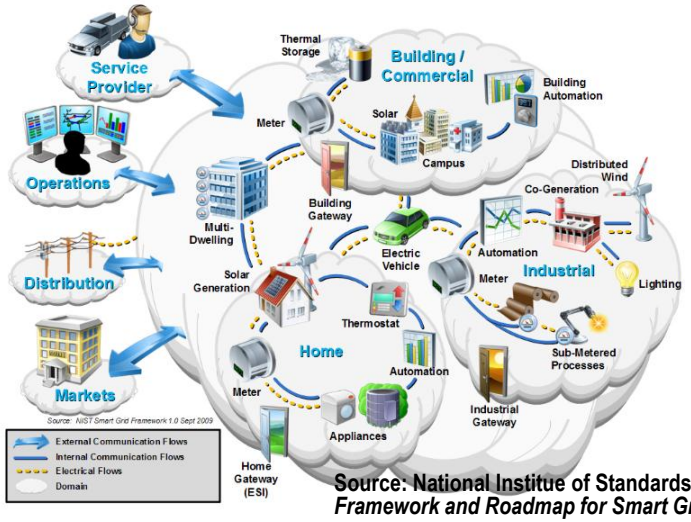
BTO Emerging Technologies R&D Goals

As a result of ET sponsored research, cost effective technologies will be introduced into the marketplace by 2020 that will be capable of reducing a building's energy use by 25% relative to 2010 cost effective technologies, and 35% by 2030.

Technology-specific targets relative to the 2030 primary energy consumption projected by the *2010 Annual Energy Outlook*:

2020		**2030**	
Lighting:	30%	Lighting:	65%
HVAC:	10%	HVAC:	25%
Water Heating:	20%	Water Heating:	35%
Appliances:	15%	Appliances:	30%
Windows/Envelope:	15%	Windows/Envelope:	35%
Sensors & Controls:	10%	Sensors & Controls:	20%



Source: National Institute of Standards and Technology. *NIST Framework and Roadmap for Smart Grid Interoperability Standards*

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Buildings Sensors & Controls Vision

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

BTO's Integrated Approach

Research & Development

- Develop technology roadmaps
- Prioritize opportunities
- Solicit and select innovative technology solutions
- Collaborate with researchers
- Solve technical barriers and test innovations to prove effectiveness
- Measure and validate energy savings

Market Stimulation

- Identify barriers to speed and scale adoption
- Collaborate with industry partners to improve market adoption
- Increase usage of products & services
- Work through policy, adoption, and financial barriers
- Communicate the importance and value of energy efficiency
- Provide technical assistance and training

Codes and Standards

- Establish minimum energy use in a transparent public process
- Protect consumer interests
- Reduce market confusion
- Enhance industry competitiveness & profitability
- Expand portfolio of EE appliances & equipment
- Raise the efficiency bar

BTO Sensors and Controls Program Goals and Areas

Develop a low-cost, self-powered wireless sensor platform and self-configuring, self-optimizing controls that:

- Can help integrate buildings with the rest of the electrical grid
- Enable automatic energy transactions with the grid

1. **Open-Source Sensors** (i.e. open-source reference designs for wireless, self-powered sensor packages)

2. **Foundational Control Theories** (i.e. control algorithms and the resulting application of the controls, including solutions for retro-commissioning)

3. **Transaction-based Controls** (i.e. open-architecture control platforms for buildings that are transactive and energy-ready)

FY15 BTO Sensors and Controls Projects

1. Core National Lab Efforts
   a) Unique and critical resources held by DOE National Labs to support industry and R&D community.
   b) Intellectual and physical assets with high start up and/or shut down costs.

2. Awarded by Funding Opportunity Announcements to industry, academia or national labs
   a) ET-CBI Open Lab Call
   b) US-China CERC, US-China CBERD, Penn State CBEI
   c) FY13 Turn-Key and FY14 BENEFIT

Pathway to commercialization of low-cost wireless sensors

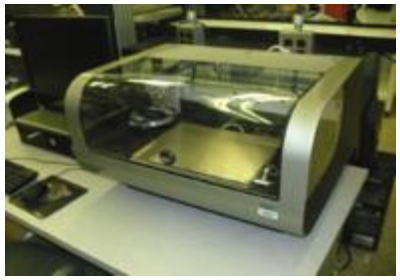
Project Goal:

Develop and deploy low-cost wireless sensors for building monitoring to realize energy savings through optimal control of building subsystems.

- Reduce cost to manufacture and commission ($1-$10/node)
- Low-power wireless communication driven by energy harvesting techniques
- Retrofit-friendly devices with minimal maintenance
- Multi-sensor platform tailored for building monitoring needs
- Leverage additive, roll-to-roll manufacturing techniques to enable rapid adoption

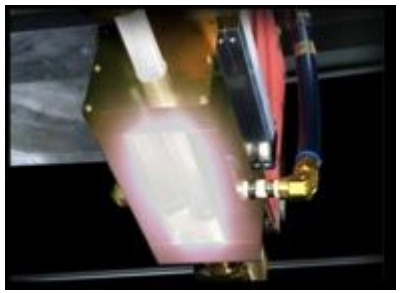
Recent Accomplishments:

Cooperative Research and Development Agreement (CRADA) recently established with commercial manufacturer, Molex to reduce cost through manufacturing improvements.



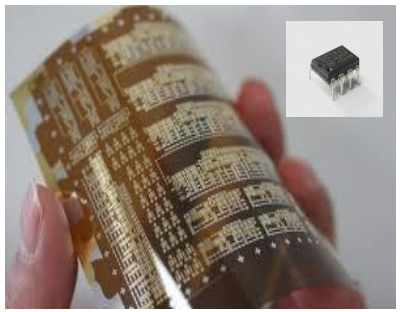
Print components on flexible substrates:

- 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

molex
one company › a world of innovation

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Low-Cost, Self-Powering Wireless Sensors & Sensor Networks (FY14 BENEFIT FOA)

Opportunity:

Low cost, maintenance-free wireless sensors will enable enhanced building controls for energy efficient operation

Problem:

Existing wireless sensors require battery or AC power, leading to high maintenance labor and cost, especially for large, distributed sensor networks

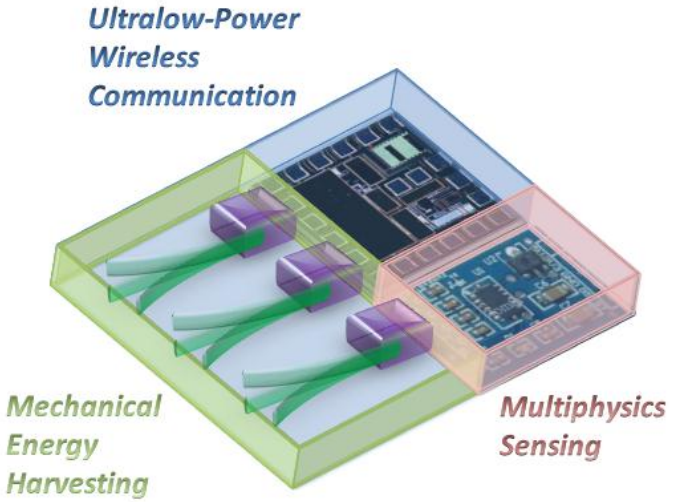
Solution:

Self-powering low cost wireless sensors ~***$15***/node (compared to *$25-$225* for existing products), and annual maintenance cost of ***$0*** (vs. *$160k-270k*/year for existing products) for a small town.

FY16 goals (metrics):

Prototype sensor network, ready for production

- Self-powering sensor nodes, harvesting vibrational energy in indoor environments.
- Wireless connectivity through standard Zigbee network
- Technical Advantages:
  - Easy installation: no professional required
  - Self-sustaining: no battery needed
  - Cloud based: accessible and controllable from computer or mobile devices
  - Multiphysical measurement: temperature, humidity, illumination, pressure *etc*.
  - Fully adaptive: transmission rate self-adjustable and remote programmable



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Equipment Health Monitoring with Virtual Intelligent Sensing (FY14 BENEFIT FOA)

Technology/Approach Summary

- Today's commercial market does not offer building equipment health monitoring system capabilities.
- The industry needs a scalable, robust health monitoring platform consisting of sensing, computation, and visualization that is suitable for retrofit applications at an installed cost significantly below the common industry average today.

Technology/Approach Impact

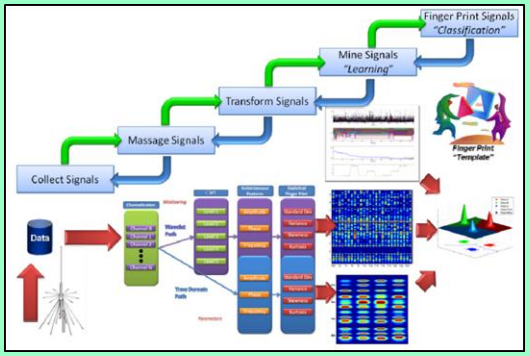
- Develop a comprehensive nonintrusive load monitoring system capable of identifying opportunities for energy efficiency within building subsystems.
- Identify equipment degradation and inefficiencies in energy delivery and improve the energy efficiency of the buildings by 15-25% while reducing the cost of deployment by 20-30% compared with the current sparse field diagnostics alternatives.

Proposed Goals

Metric	State of the Art	Proposed
Efficiency gain for small/medium commercial buildings by fault detection	~0%	15-25% energy efficiency gain 0.4 quad

Richman Surrey Power Measurement

ORNL Signal Processing



Project's Key Idea

This integrated system consists of:
(1) low-cost, nonintrusive power metering to augment existing sensor sources;
(2) an integrated power disaggregation fault identification system based on signal unmixing techniques; and
(3) a capability to deliver diagnosis information to building managers, including impact of fault on energy efficiency, for rapid response.

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Building Energy Management Open-Source Software Development (BEMOSS)

FY13 Turn-Key FOA, Phase II

Problem:

Lack of low cost, both equipment and installation, open-source building energy management (BEM) software that allow seamless integration with device controllers (HVAC, lighting and plug loads) from various manufacturers

Project Goal:

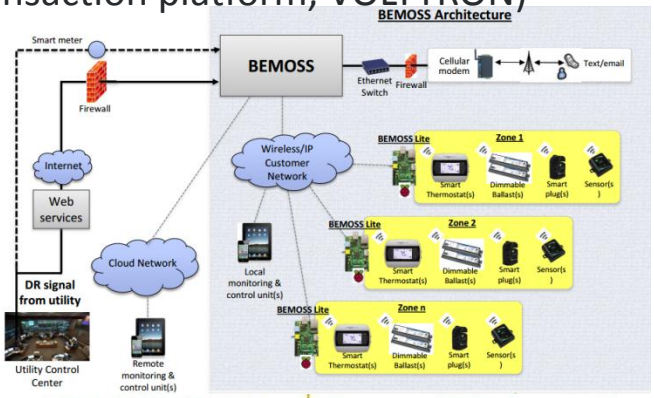
Develop a, plug and play open source open architecture control system that improves energy efficiency, optimizes electricity usage, and. improves the comfort for small and medium-sized buildings

Solution:

Development of cost-effective open architecture controls platform for small and medium-sized buildings.

Key Features of platform:

- Open Source (first application to be built on DOE-developed transaction platform, VOLTTRON)
- Open architecture (interoperable)
- Plug and Play
- Auto mapping
- Thermostat, lighting, plug load devices
- Grid ready
- Agent based applications



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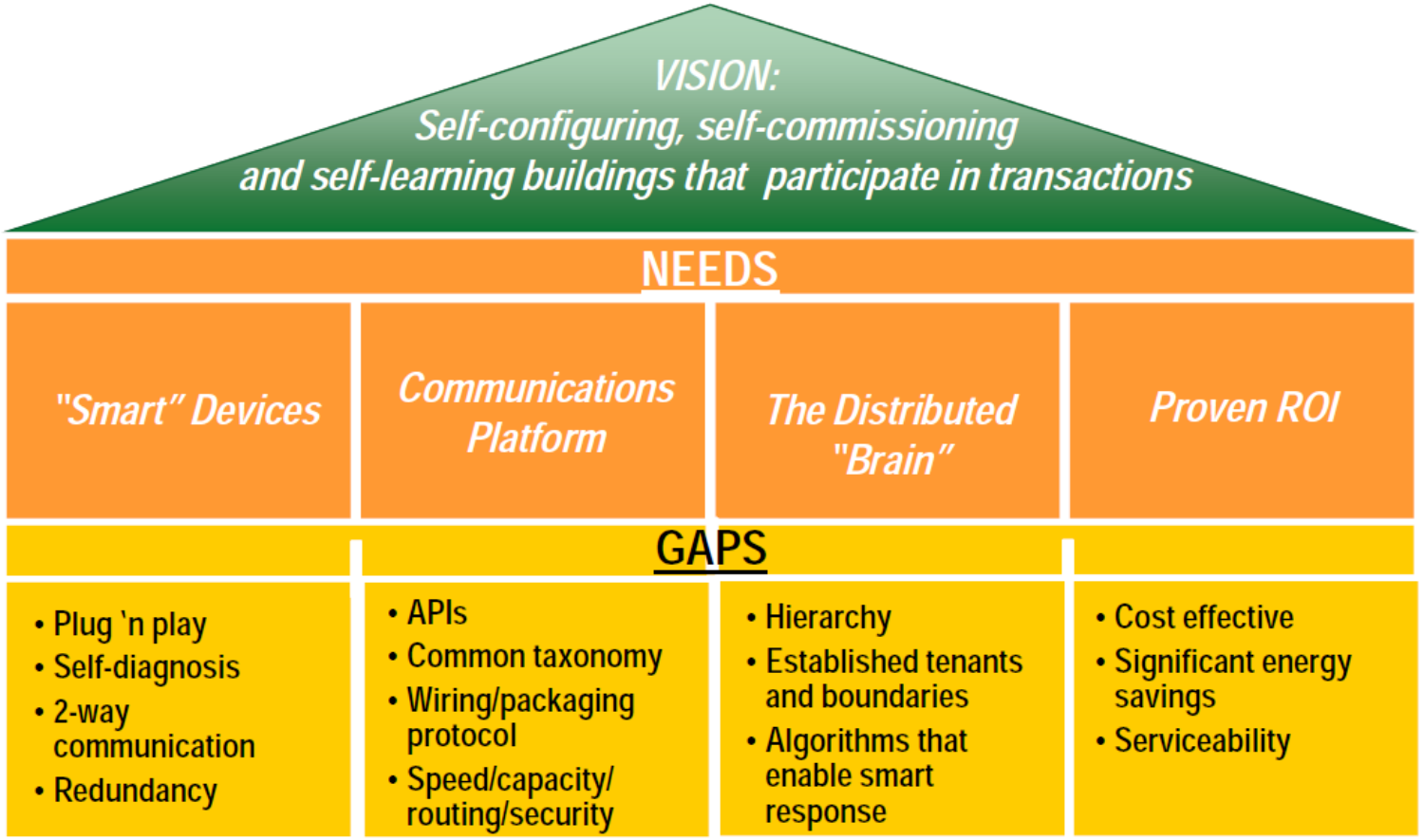
Defining the Pathway to Achieve our Future Vision

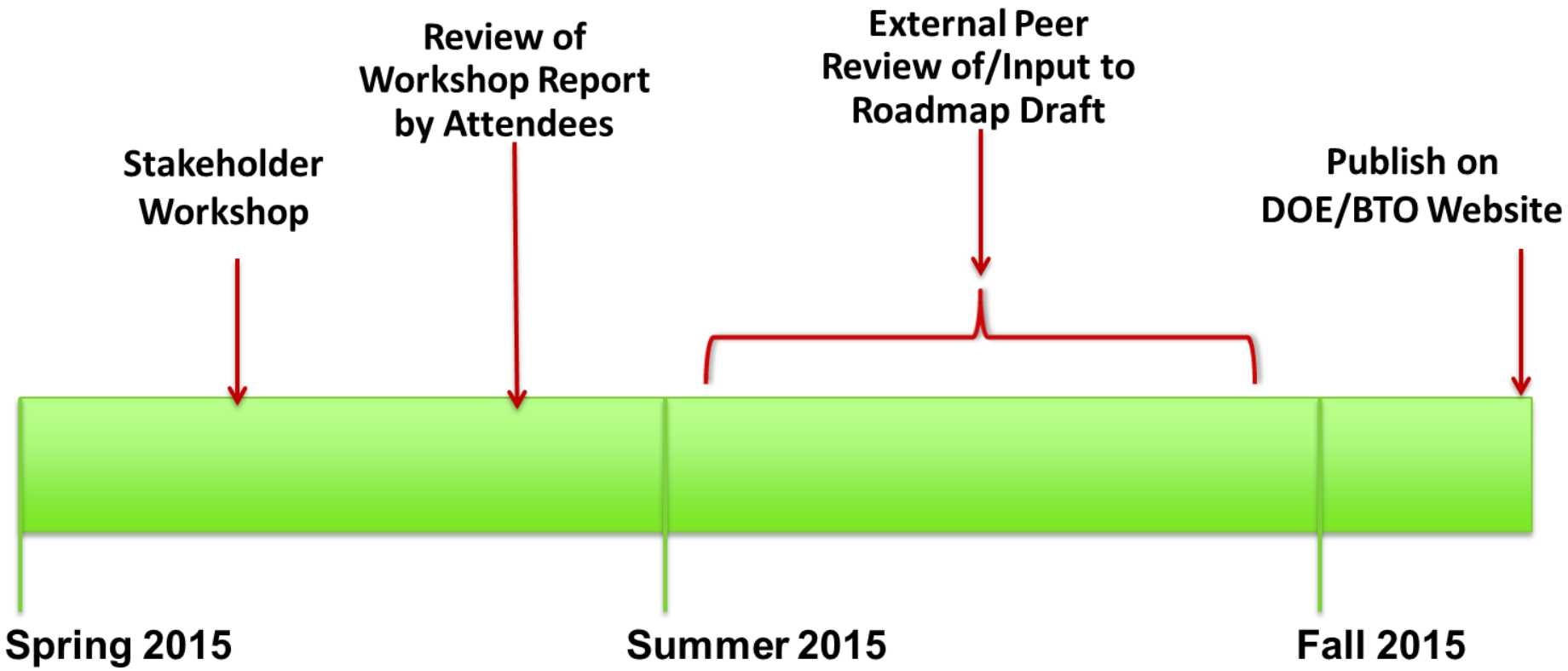


Buildings Sensors and Controls R&D Technology Roadmap

Purpose of Roadmap:

- Identify priority R&D areas of interest
- Identify cost and performance metrics and targets for each key R&D area, and timeline to achieve these targets
- Describe technical and market challenges to be overcome, R&D activities and milestones, key stakeholders, and potential energy savings that could result if cost and performance targets are met
- Identify methods for improving technology performance and specific strategies for reducing costs and mitigating any other market barriers, which would increase the likelihood of mass-market technology adoption
- Resource for public and private decision makers evaluating and pursuing high-impact R&D focused on advancing buildings sensors and controls technologies

Roadmap Development Timeline



Interested in providing input to the Roadmap as a Contributor and/or Reviewer?

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