High Performance Active Perimeter Building Systems

2015 Building Technologies Office Peer Review

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

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Project Summary

Timeline:

Start date: October 1, 2014 (new T2M project)

Planned end date: September 30, 2017

Key Milestones

1. Issue functional specification, May 2015
2. Field test of commercial products initiated, Sept 2015
3. Evaluate interoperability of dynamic façade and lighting components, FY16
4. Evaluate integrated systems performance of interoperable façade and lighting, FY17

Budget:

Total DOE $ to date: $300K

Total future DOE $: $400K FY15, $1M FY16, $1M FY17

Target Market/Audience:

Commercial and residential buildings; new or retrofit applications; manufacturers, owners, architects, engineers, regulators, utilities

Key Partners: (subset of 50 partners)

View Electrochromics	Ams
Sage Electrochromics	AllSeen/ AllJoyn
Draper/ Embedia	Open Interconnect
Enlighted	PNNL/ ORNL/ VT
Orama Lighting	PG&E, CEC EPIC

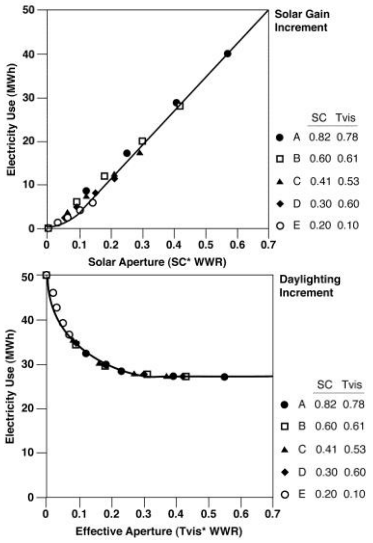
Project Goal:

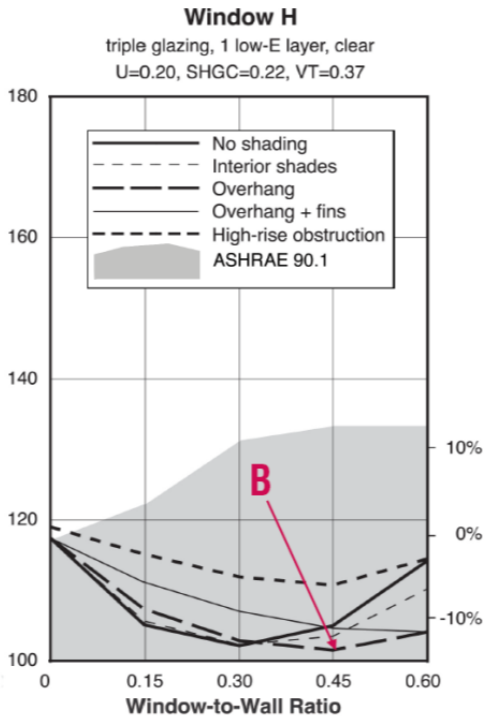
Define and challenge the market to produce integrated, interoperable dynamic shading, daylighting, and lighting systems that enable reliable, less complex, and cost-effective reductions in energy use and peak demand at the perimeter zone in commercial buildings.

Purpose and Objectives

Problem Statement

- Integrated envelope, shading, daylighting, and lighting systems have the technical potential to reduce perimeter zone energy use and peak demand by 30-50% compared to ASHRAE 90.1-2013 → 1-2 Quad potential
- Systematic failure to achieve savings in the real world despite evidence from simulations, lab studies, and demonstrations
- Low market penetration and savings due to cost and complexity of achieving optimum balance between heating, cooling, and lighting, glare, thermal comfort, & view
- **Achieving near net zero energy use goals will depend on more optimal, integrated control of envelope and lighting systems within the perimeter zone, building, and building-to-grid context.**





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Purpose and Objectives

Project Objective

- To challenge the market to produce integrated, interoperable fenestration and lighting systems that enable reliable, less complex, and cost-effective reductions in energy use and peak demand at the perimeter zone in buildings.
- To leverage the power of low-cost Internet of Things (IoT) microprocessors to realize more optimal, lower cost control and analytics over the life of the building

Target Market and Audience

- New and retrofit commercial and residential buildings
- Architects/ engineers/ contractors/ owners (AECOs), utilities, regulators, vendors

Impact of Project

- ***Near-term:*** Identify IOT technologies and infrastructure that can be the basis for successful open interoperable solutions
- ***Intermediate-term:*** Broad range of available IOT devices/ sensors/ systems that meet industry standards for plug and play and open data exchange
- ***Long-term:*** Leveraged use of the IOT platform to achieve more cost-effective, deeper, and reliable savings within the broader whole building and smart grid context

Approach

Context: Pilot Technology-to-Market (T2M) project → bridge the "valley of death" using both technical and commercial activities to drive emerging technologies from R&D to market readiness.

1) **Define the strategic vision and value proposition** for architects, engineers, contractors and owners to create market demand; define use cases, market demand and barriers with input from industry
2) **Develop functional specifications for open interoperable systems** with input from AECOs, IOT vendors, manufacturers, then issue an RFI to solicit products for testing and evaluation
3) **Evaluate performance** of commercial systems in full-scale outdoor testbeds (FLEXLAB, Advanced Windows Testbed)
4) **Develop consensus standards** for data exchange in collaboration with industry
5) **Promote successful systems** through DOE's Better Building Alliance, GSA, market leaders, utilities, and other stakeholders

Approach

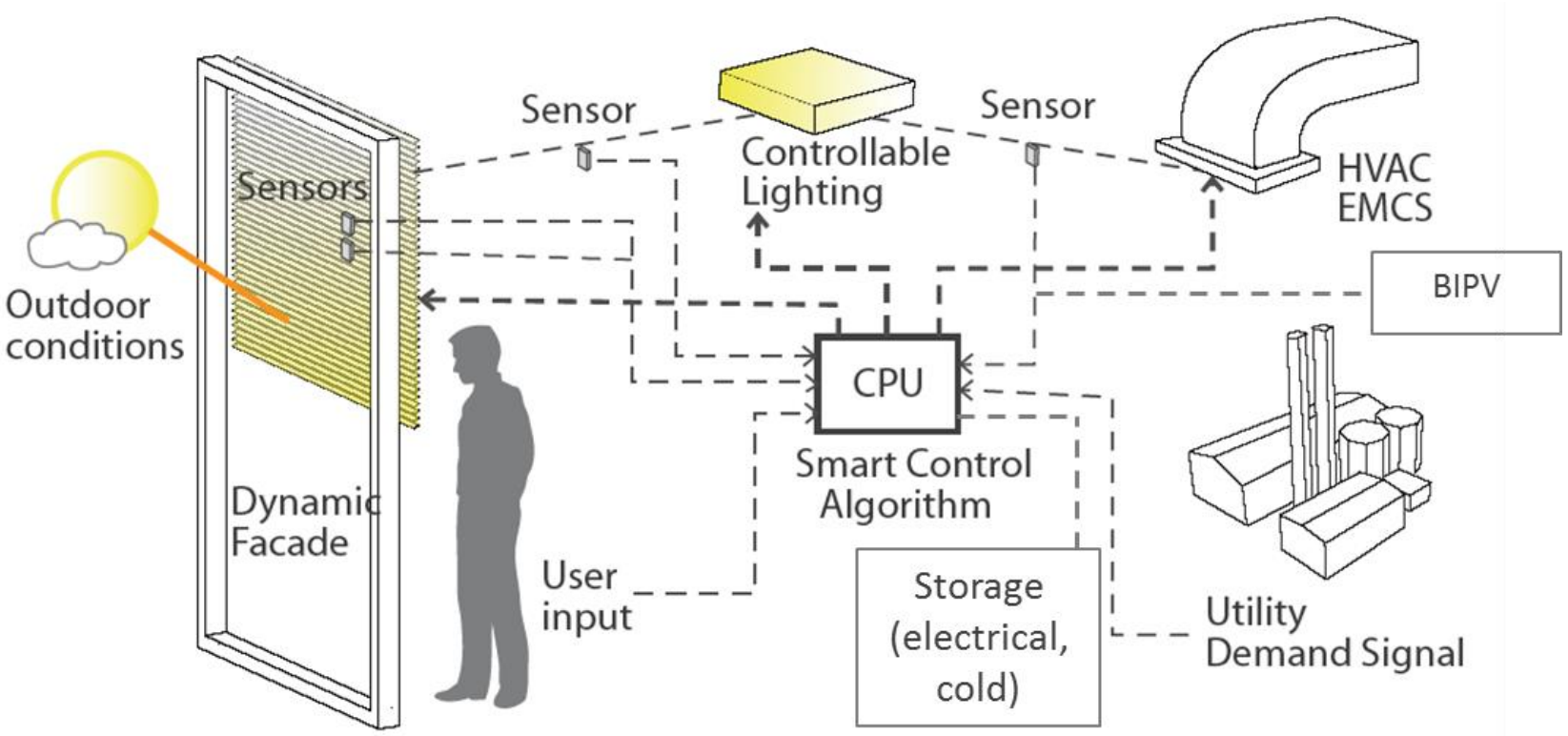
Key Issues

- Ride the Internet of Things (IoT) wave – a powerful new capability supported by industry leaders and $$B of investment
- Assume a targeted government role: encourage product development and market uptake that supports DOE BTO's broader long-term vision

Distinctive Characteristics

- Focus on vetting commercial IoT solution(s) within the energy-efficiency context in collaboration with the buildings industry
- Use a tiered, iterative approach for evaluation as product offerings mature over the 3-year term of the project
- Encompasses devices, networks, IP connectivity, data integration, applications, services

LED/Fixtures/Controls/Shading/Daylight → Integrated systems for very low energy use, comfort and increased amenity

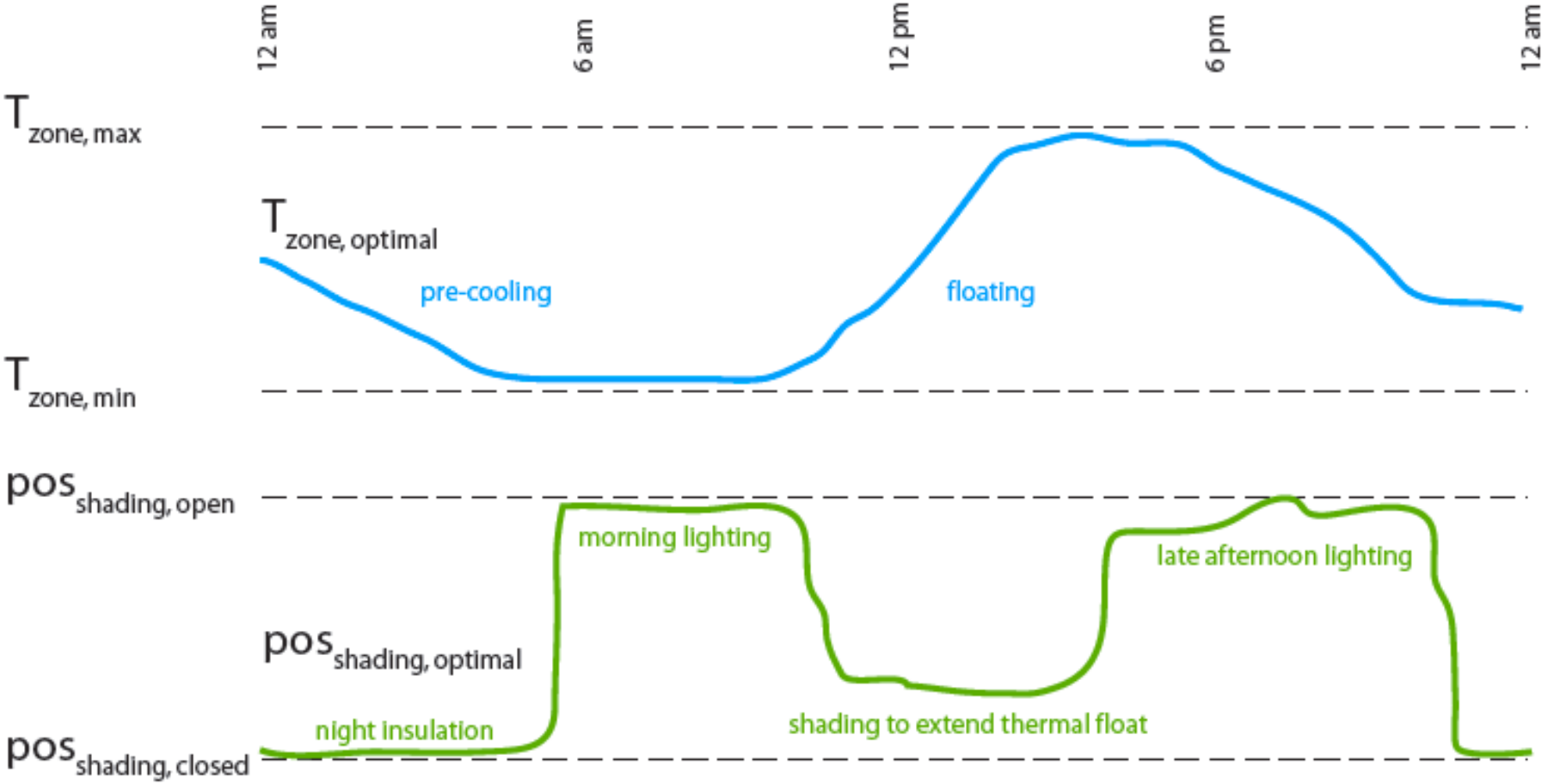


Facade
Solar intensity
Daylight, glare
Shade position

Lighting
Occupancy
Illuminance level
Energy use

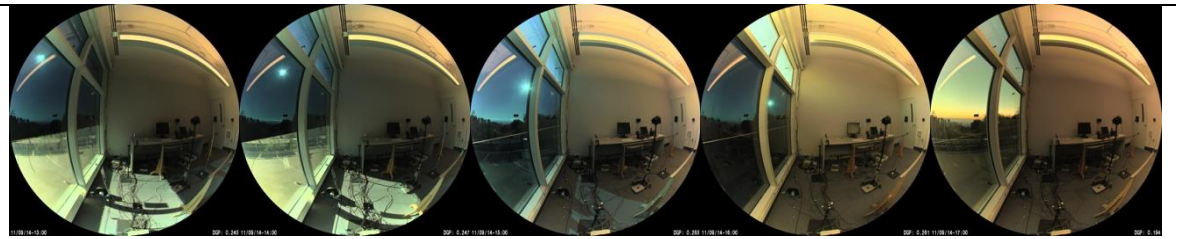
HVAC
Outdoor and indoor temp
Heat/ cool/ econ mode
COP

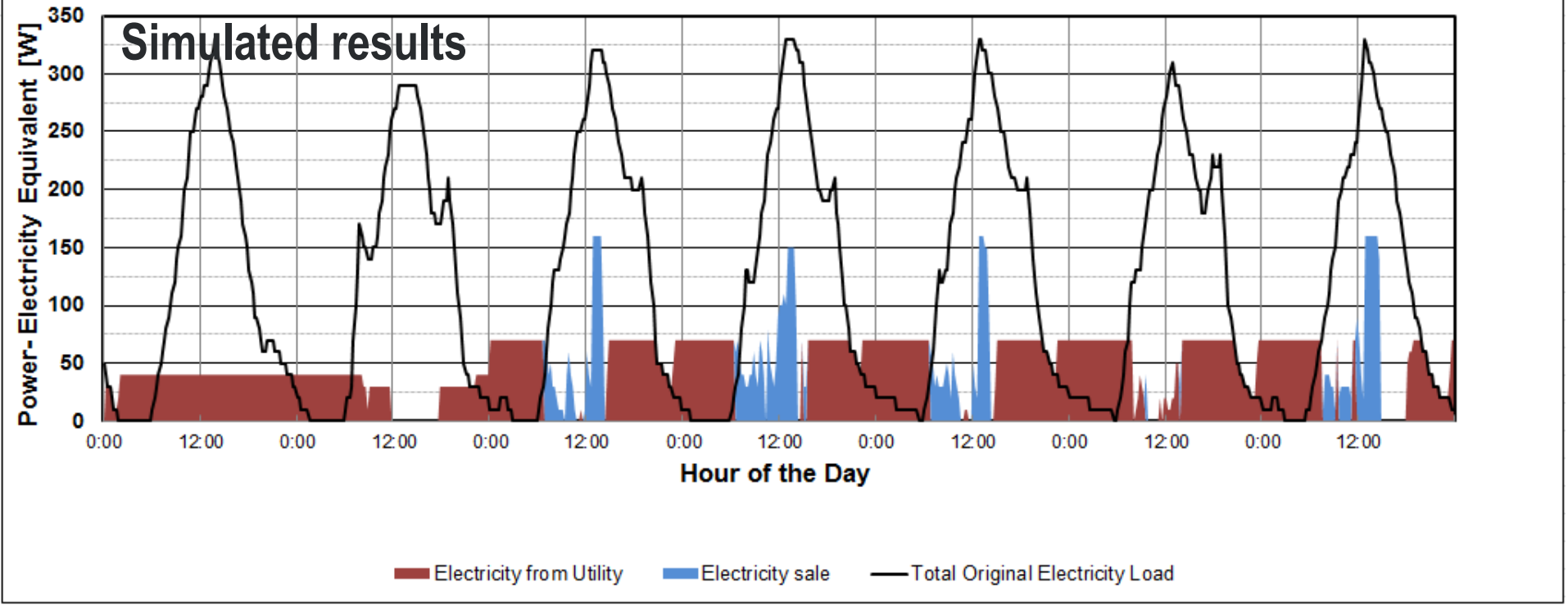
Example #1 of integrated façade-lighting-HVAC control

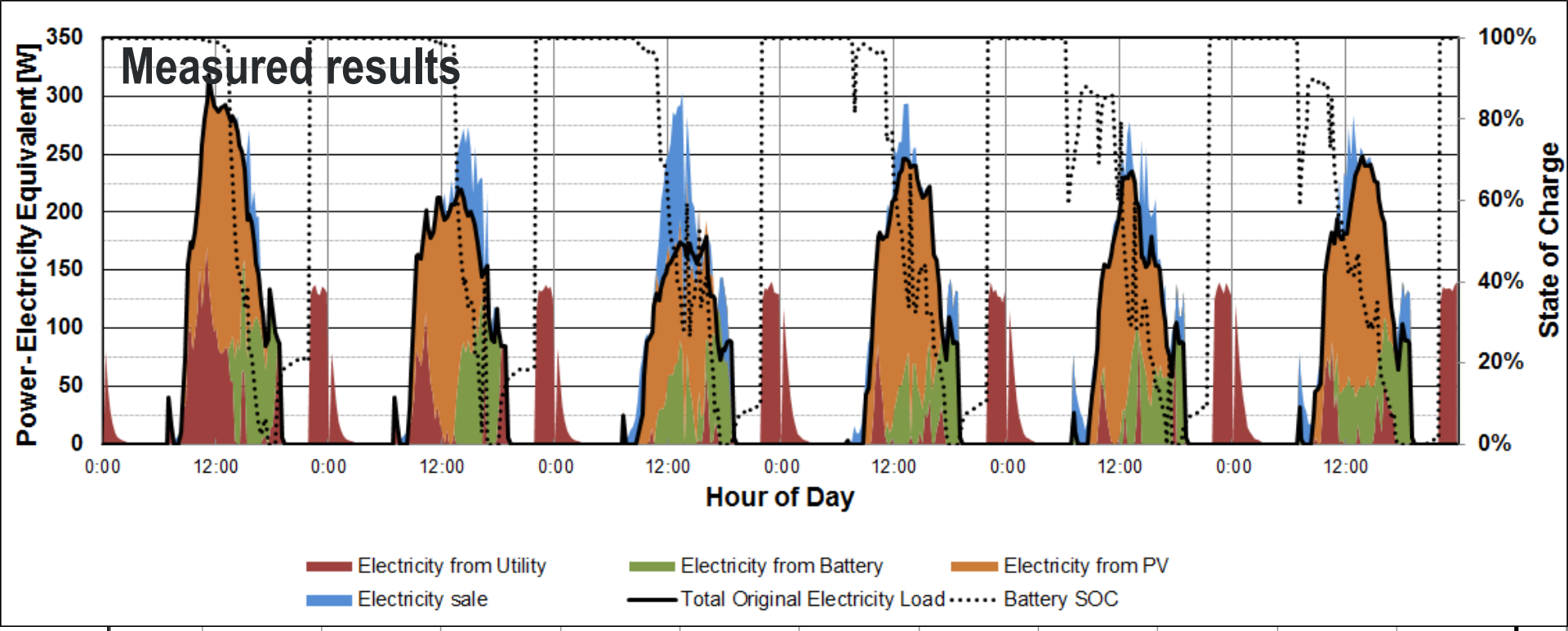


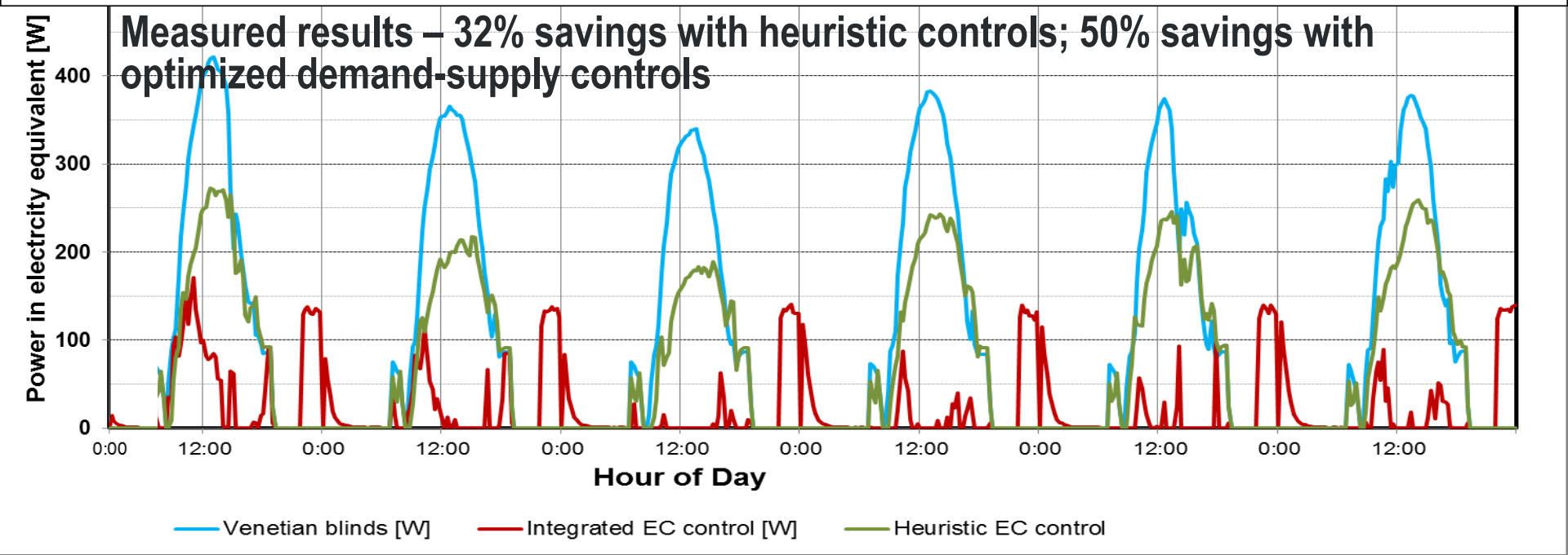
Challenge: Determine shading position and radiant cooling level to minimize energy consumption for lighting and cooling over a 24-h period, subject to zone temperature constraints and given weather forecast. Overlay TOU rates and on-site BIPV/ storage source availability for energy cost minimization.

Example #2: Electrochromic windows, dimmable LED lighting, 200 Wp PV, 540 kWh storage, dc µG (prior R&D)





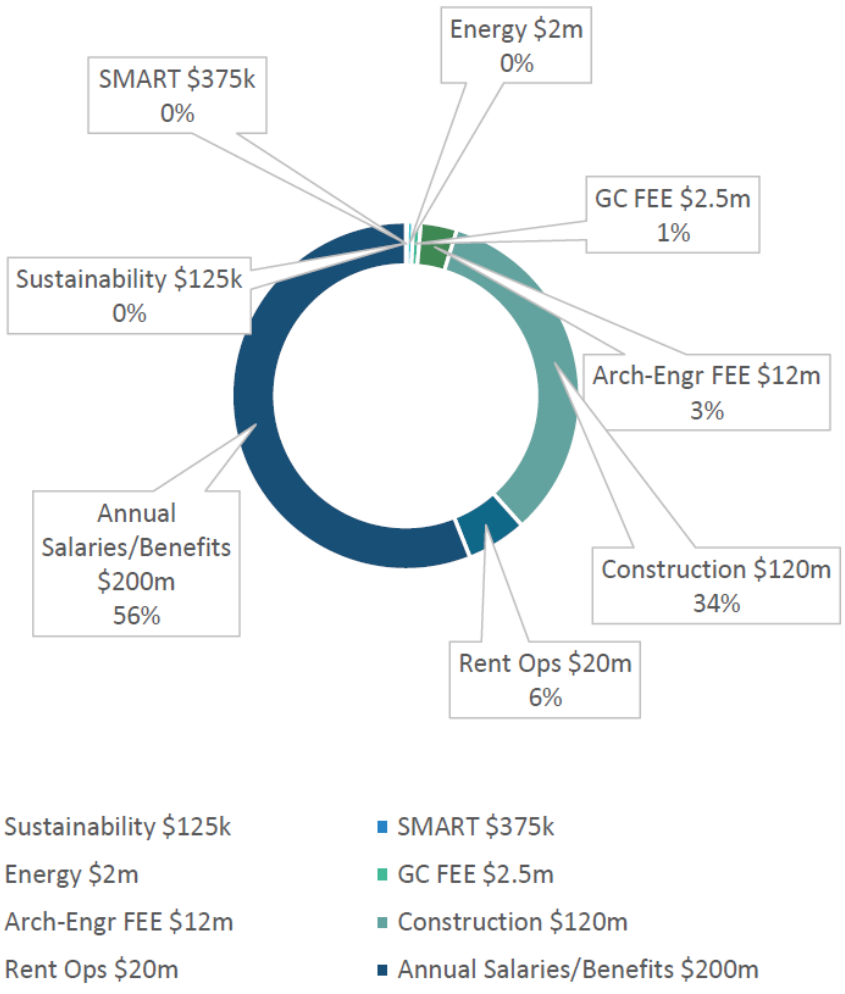

Measured results
Power-Electricity Equivalent [W]
350
300
250
200
150
100
50
0
100%
80%
60%
40%
20%
0%
State of Charge
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
Hour of Day
Electricity from Utility
Electricity from Battery
Electricity from PV
Electricity sale
Total Original Electricity Load
Battery SOC


Measured results – 32% savings with heuristic controls; 50% savings with optimized demand-supply controls
Power in electrcity equivalent [W]
400
300
200
100
0
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
Hour of Day
Venetian blinds [W]
Integrated EC control [W]
Heuristic EC control

LBNL Industry Workshop, January 21, 2015

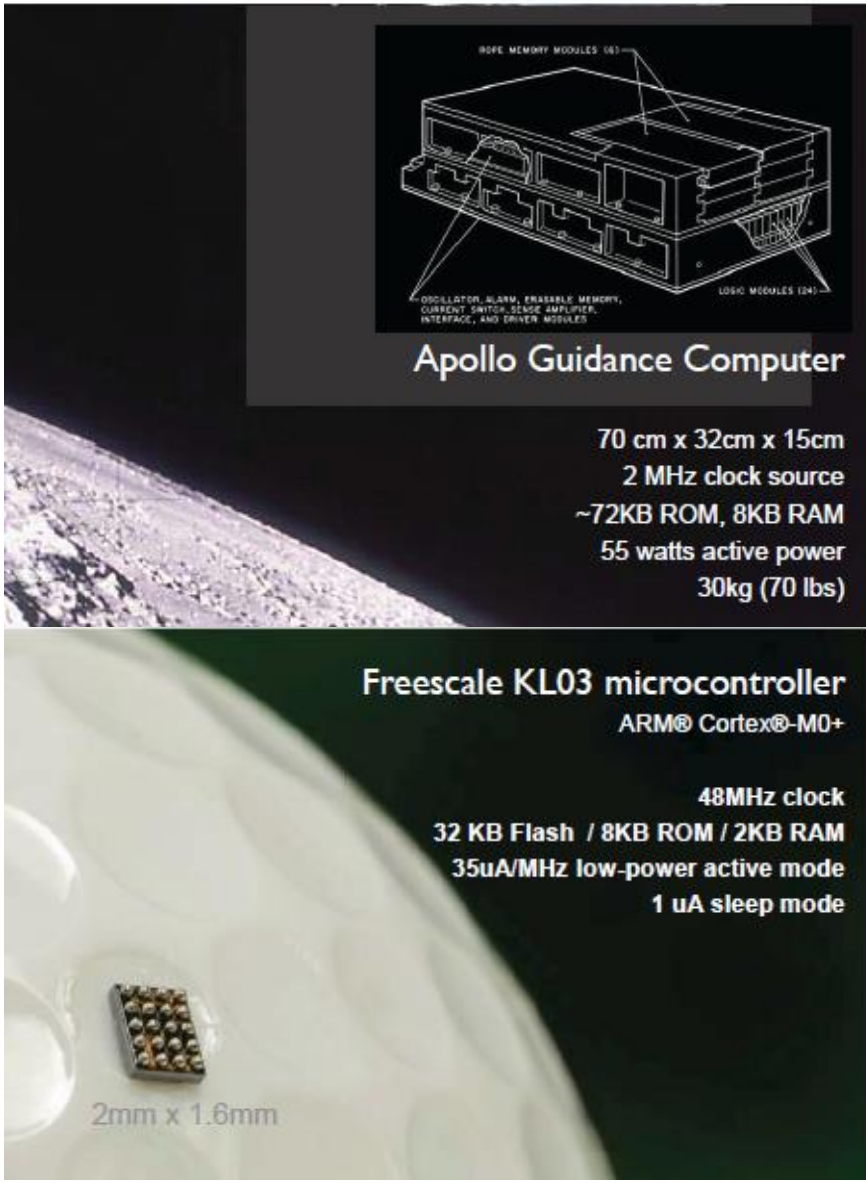
36 Participants from AECO and manufacturers community; 50+ interested in continued participation on focus groups

- **Use cases and value proposition**
  - Focus the value proposition on people; <1% of cost of business is for energy
  - **Enabling comfort + amenity are key**
  - Integrated control solutions seen as more complex: solutions must make things easier
  - Concern over rapid changes based on IT industry; security, privacy, warranty/ liability, future-proofing
- **Coordinating with other projects** – e.g., PNNL Buildings Interoperability Vision Meeting, March 11-12, 2015



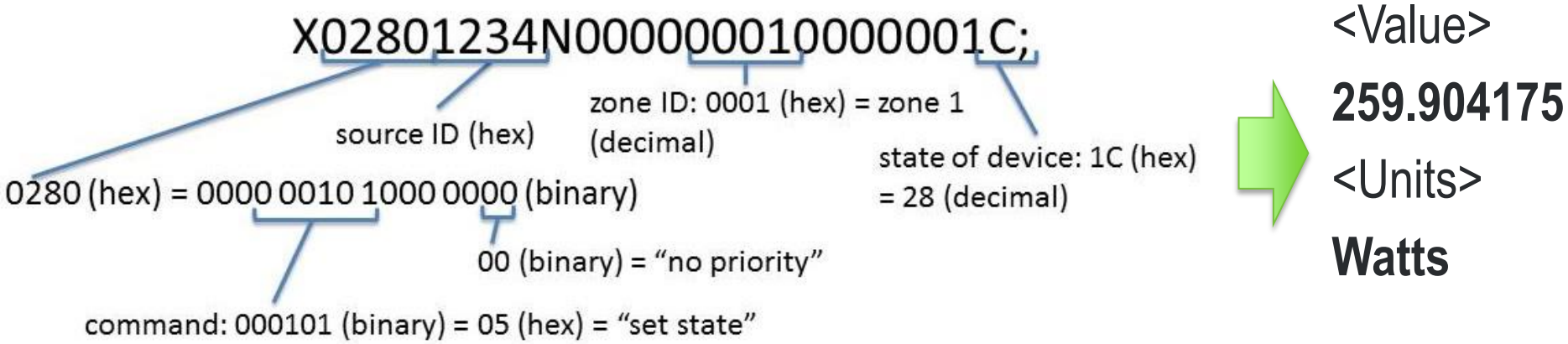
RFI and functional specifications

- **Open RFI**: Inclusionary approach
- **Spec:** Tiered approach for façade and lighting devices
  - Tier 1: limited bandwidth (1.2 kB/s), low-resolution data exchange with IP-based gateway
  - Tier 2: IP-based (1 Gbps), high-res control per device



Images: Charlene Marini, ARM

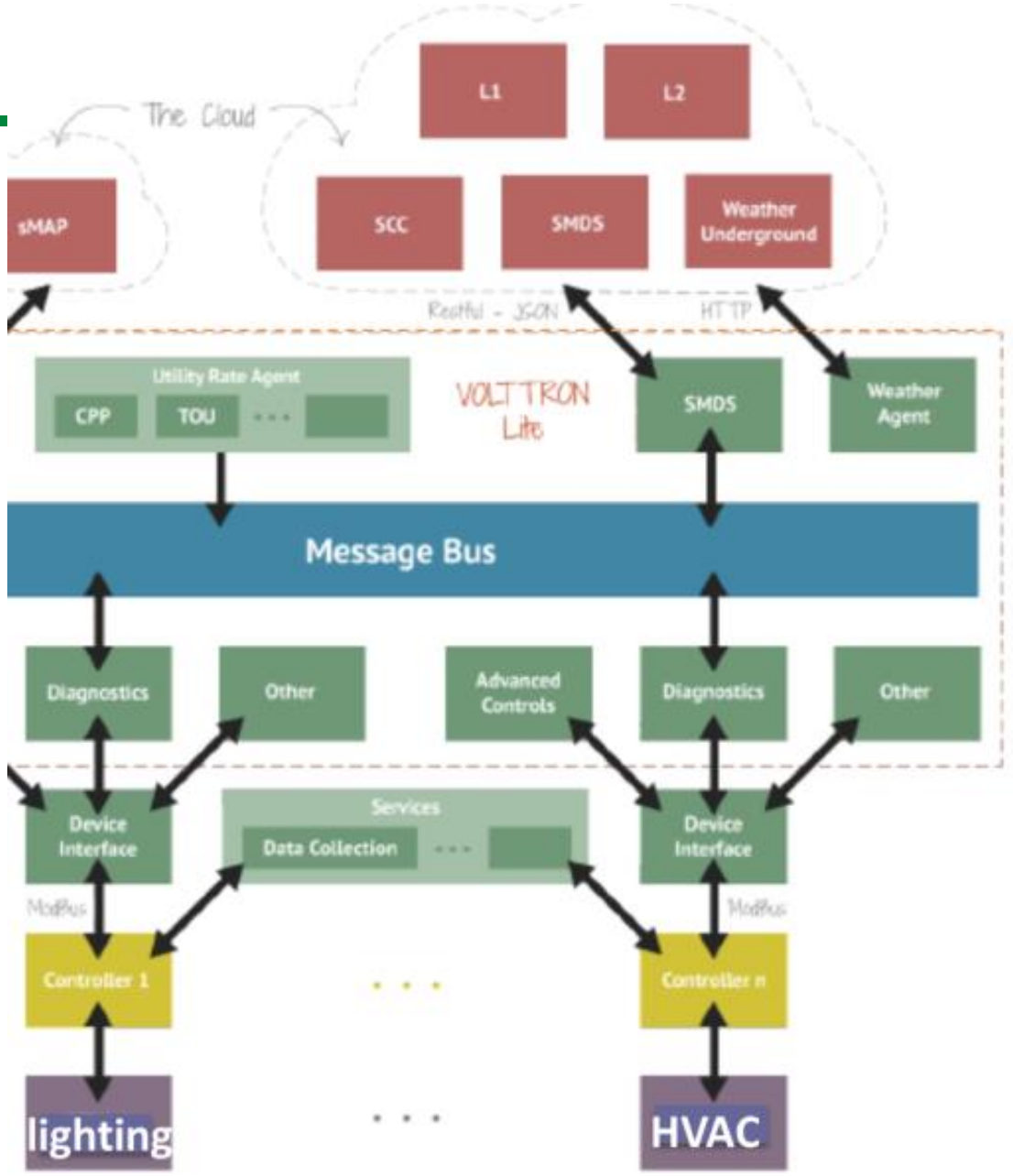
Data exchange



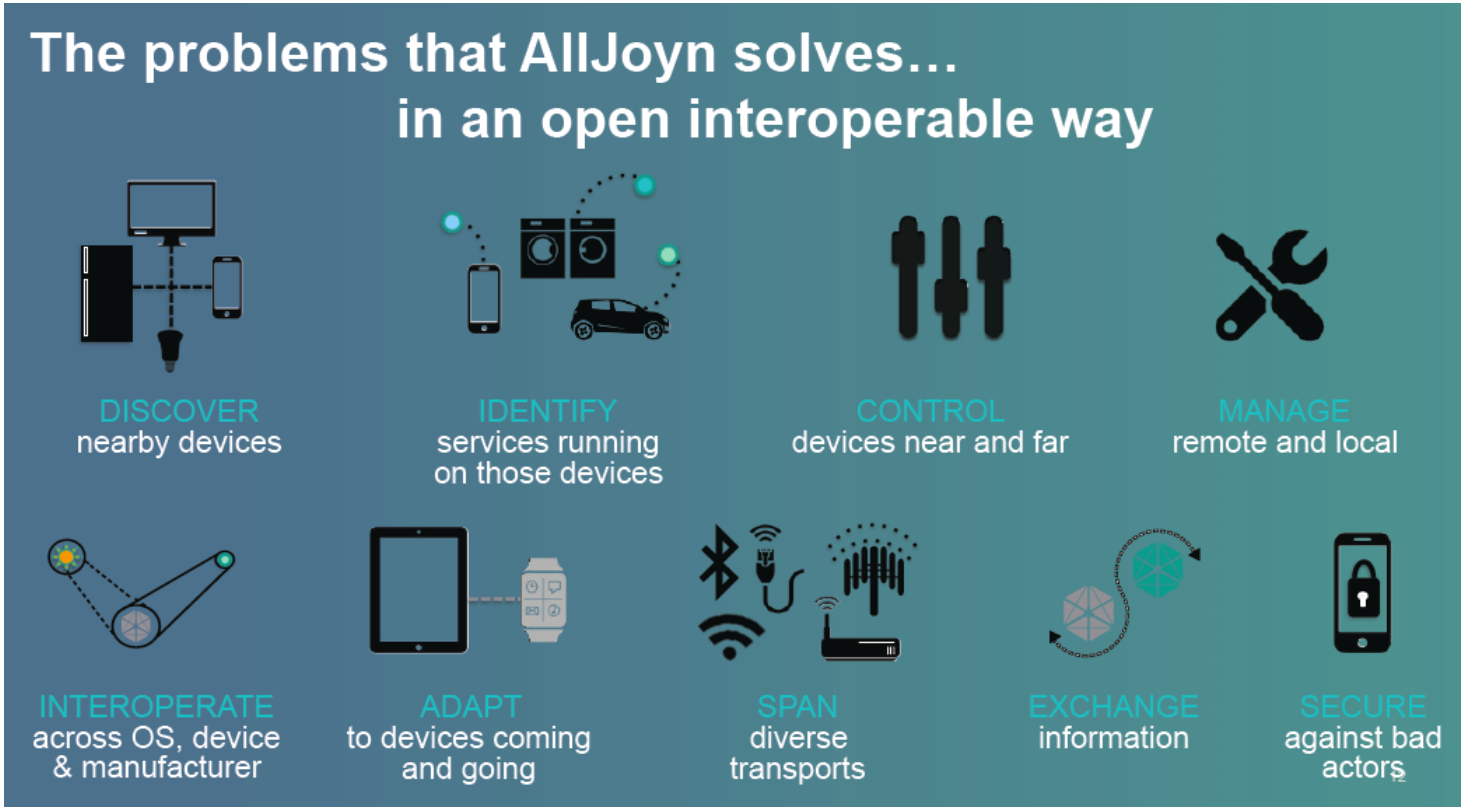
- **Open API**: documentation or software for open bidirectional communications; move to semantically rich metadata
- **Evolving consensus-based standards for data exchange**: Review of data requirements and current data offered by legacy products → map to what's needed, what's possible, then engage industry to define standards

IOT ecosystem

- **RFI and functional specifications**
- **System architecture**: Segue from heterogeneous IP/ legacy systems to seamless IP-based systems; implement use cases
  - Tier 1: open non-commercial middleware + device drivers → test device level interoperability (discovery DHCP/ configuration SNMP)



IOT ecosystem



– Tier 2: Commercial IOT ecosystems (beta releases at CES Jan 2015): AllSeen/ AllJoyn (Connected Lighting WG), OIC → test integrated systems at the supervisory level; evaluate features needed for building controls

Project Integration and Collaboration

Project Integration

- Stakeholder Focus Groups → A: define control scenarios, B: review functional specifications, C: develop data exchange standards
- Tech-to-market approach: Challenge the market, test product offerings
- Coordinate with other DOE BTO activities, industry organizations, standards groups, industry consortia

Partners, Subcontractors, and Collaborators

RFI-identified industry partners (in-kind); AECO & CBI BBA community; PG&E cost-share for FLEXLAB field testing; synergistic to CEC EPIC Program; VOLTTRON middleware (PNNL, ORNL)

Communications

Greenbuild Nov 2014, ASHRAE Winter Jan 2015, R+T Stuttgart Feb 2015, Green Buildings, Beijing Mar 2015, LightFair May 2015

Next Steps and Future Plans

- **Year 2 – pre-commercial interoperable solutions**
  - Continue to test device-level interoperability
  - Evaluate systems-level performance in full-scale testbed (71T, FLEXLAB) of simple use case(s) using open source IOT ecosystem
  - Level I consensus standards for data exchange drafted in collaboration with industry – work out proprietary concerns, methods for verification, accuracy requirements
  - Re-issue RFI with revised functional specification for new Tier 2 systems and use cases
- **Year 3 – early commercial integrated systems**
  - Focus activities on field tests that measure/ evaluate/ demonstrate the value proposition of IoT systems to potential early adopters through a variety of use cases
  - Issue a qualified list of interoperable devices and systems and plan for deployment through the CBI BBA and other programs

REFERENCE SLIDES

Project Budget (new project)

Project Budget: FY15: $300K funds available, $700K total expected
Variances: None.
Cost to Date: $200K spent
Additional Funding: PG&E WFO cost-share on FLEXLAB user fee FY15; synergistic funding from CEC EPIC (prototype dynamic envelope technologies)

Budget History					
FY2014 (past)		FY2015 (current)		FY2016 – FY2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
		$700K	$150K	$1000K	$500K

Project Plan and Schedule