Emerging Sensors and Controls Technologies

Steven Lanzisera

Lawrence Berkeley National Laboratory

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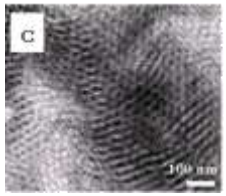
Lawrence Berkeley National Laboratory (LBNL)

Managed by the University of California for the United States Department of Energy

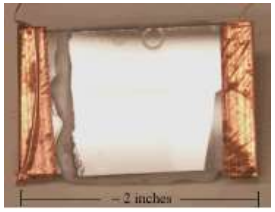
Lawrence Berkeley National Laboratory

- **Dedicated to solving the most pressing scientific problems facing humankind**
  - Basic science for a secure energy future
  - Science of living systems to improve the environment and energy supply
  - Understanding and control of matter and energy in the universe
  - Translation to applied energy programs
- **Build and safely operate world-class scientific facilities**
- **Train the next generation of scientists and engineers**

LBNL Research Spans Development Spectrum



"Dry" Li-ion Battery



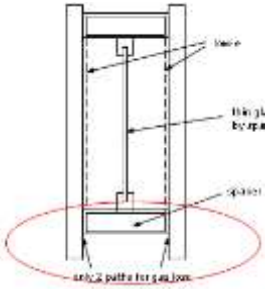
Switchable Mirrors

Cool Colored Shingles

Aerosol Duct Sealing

Gas-Filled Panel

Low-NOx Burner



High-R Window

Darfur Stove

Lighting Controls

openADR ALLIANCE

Automated Demand Response

Low-e Window Coatings

EnergyPlus

Energy Simulation

Consumer Web Tools

ENERGY STAR

NFRC
National Fenestration Rating Council

Window Ratings

Proof of Concept (1-3)	Validation (4-5)	Prototype Demo (6-7)	Demo (8)	Operation (9)	Market Adoption* (10)

Technology Readiness Level

Continual Feedback

*Not an official TRL level, but essential for impact in real world.

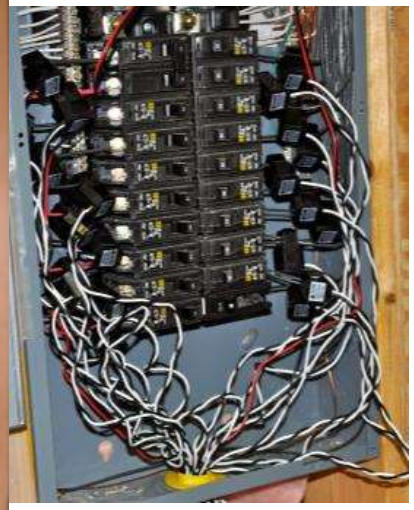
Overview

- Electricity metering
- Enabling fast DR
- Validating energy efficiency technologies

Overview

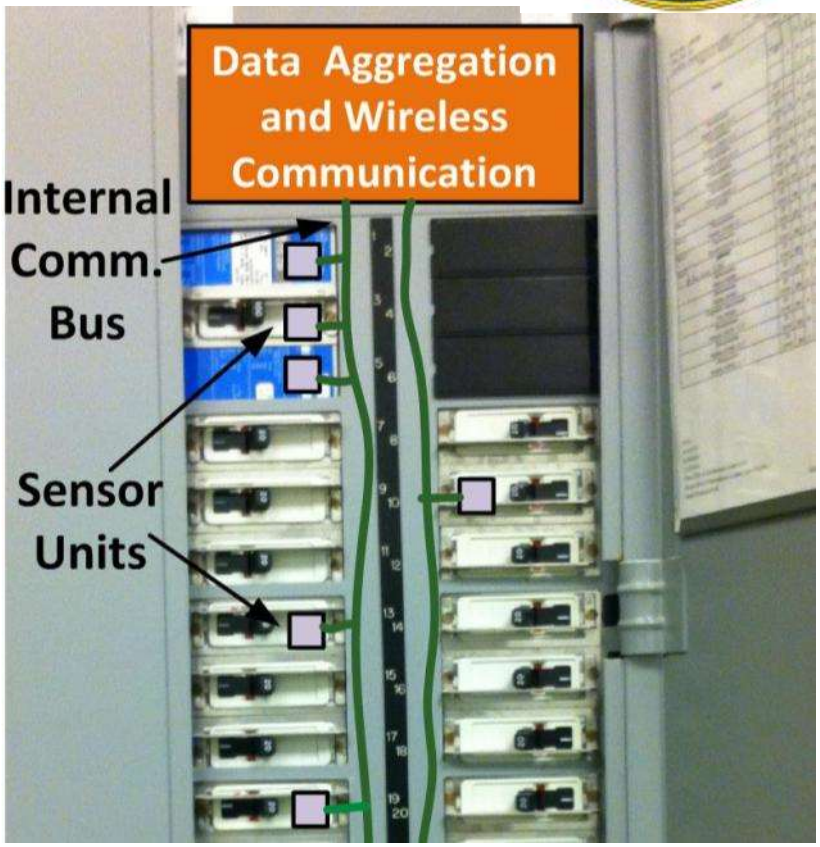
- Electricity metering
  - Sub-metering at the panel
  - Metering individual appliances
- Enabling fast DR
- Validating energy efficiency technologies

Submetering Today



Lots of conduit, wires
Need an electrician
15 min – 1 hour per breaker (CT, conduit, test).

Concept



Stick sensors on the outside of breakers

Calibration is automatically handled without reference loads or meters

<5min per breaker

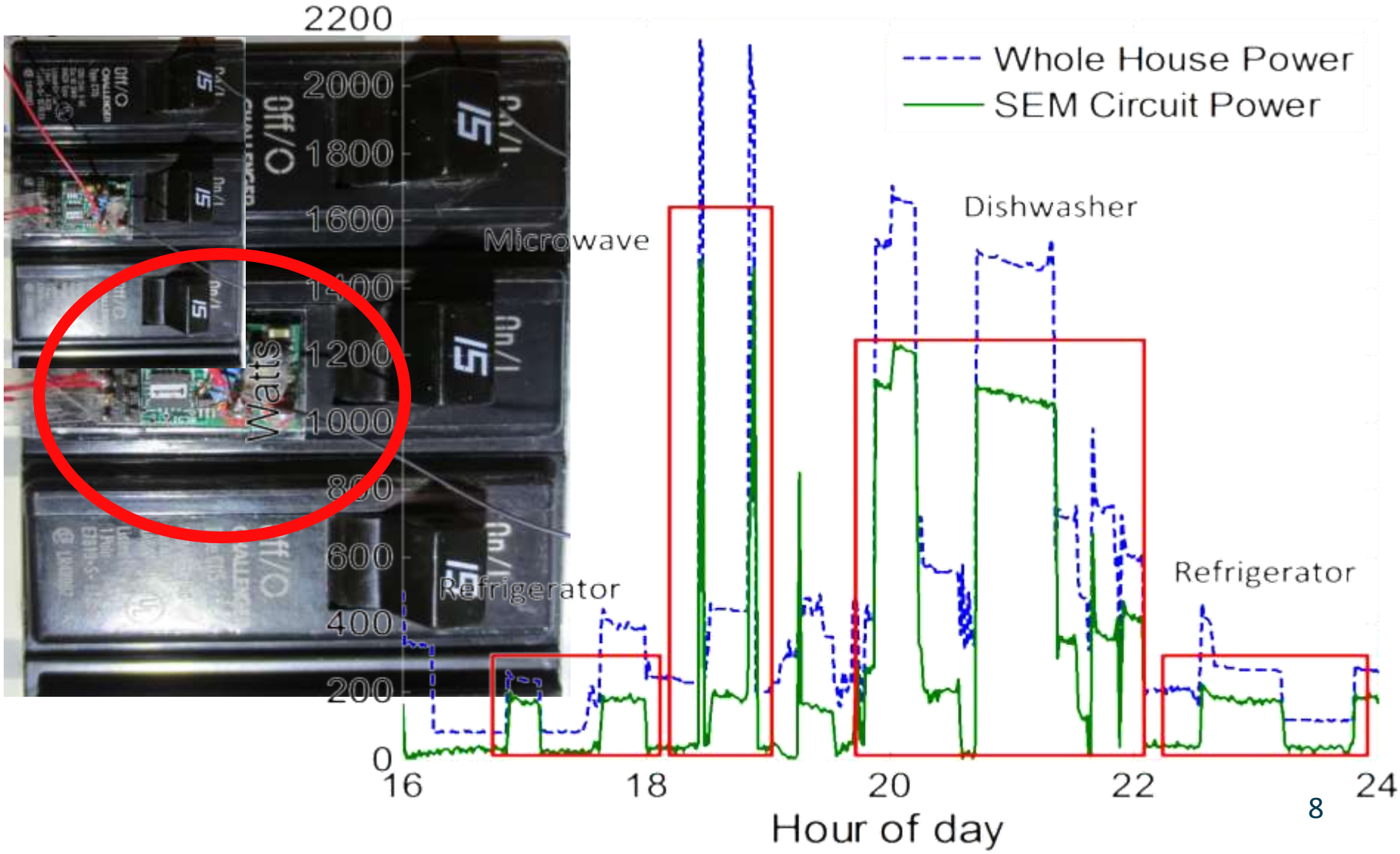
6

Scope

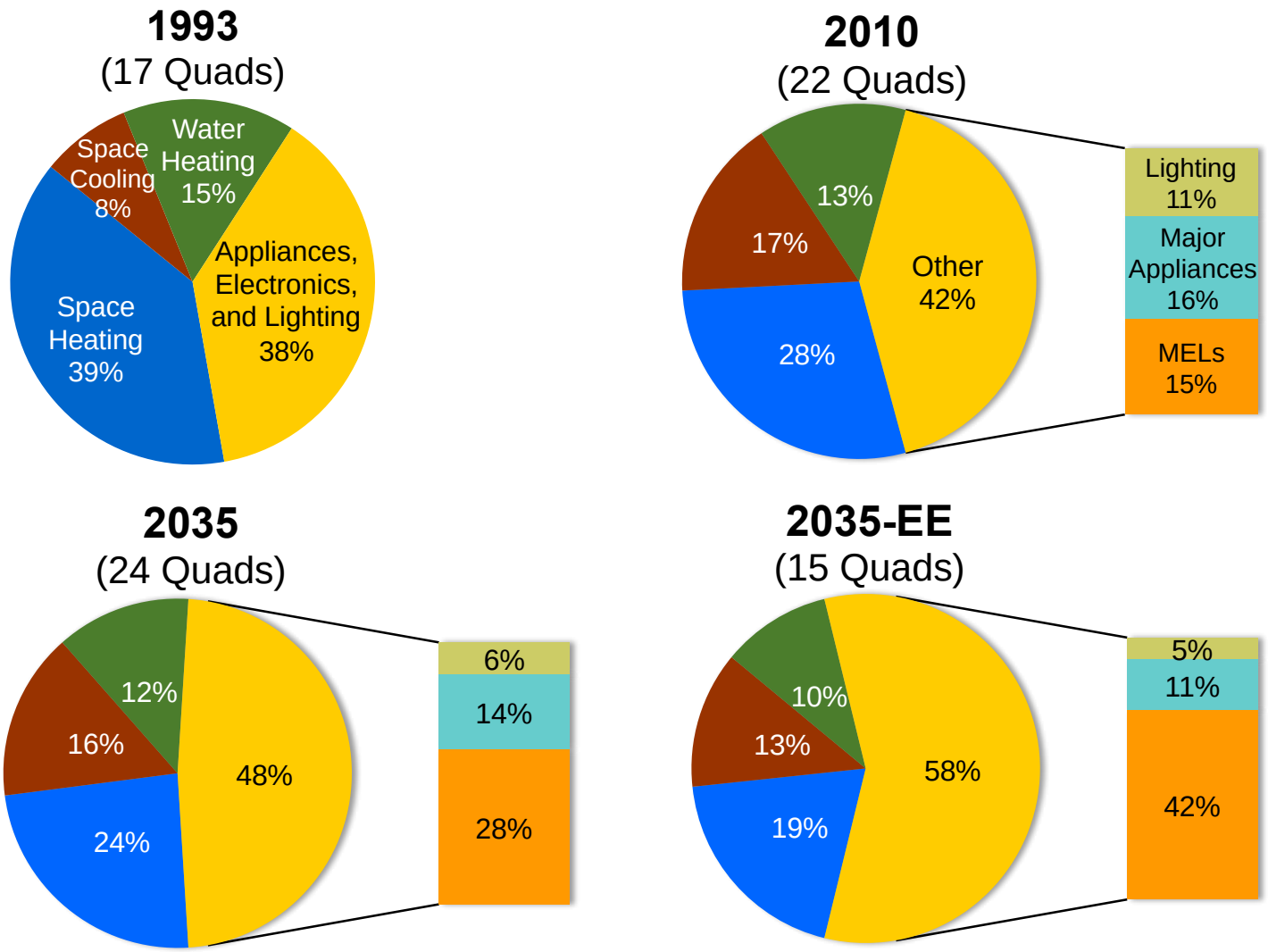
- Demonstrate system with clear path to 80% cost reduction of installed metering system.
  - Eliminate CTs and voltage connections
  - Simple installation, commissioning
- Develop stick-on current and voltage sensors
  - State of the art sensor arrays
  - Self-calibration algorithms for easy system commissioning
- Provide proof-of-concept level demonstrations
- Timeline:
  - Residential: Winter 2013
  - Commercial: Fall 2014

7

First Proof of Concept



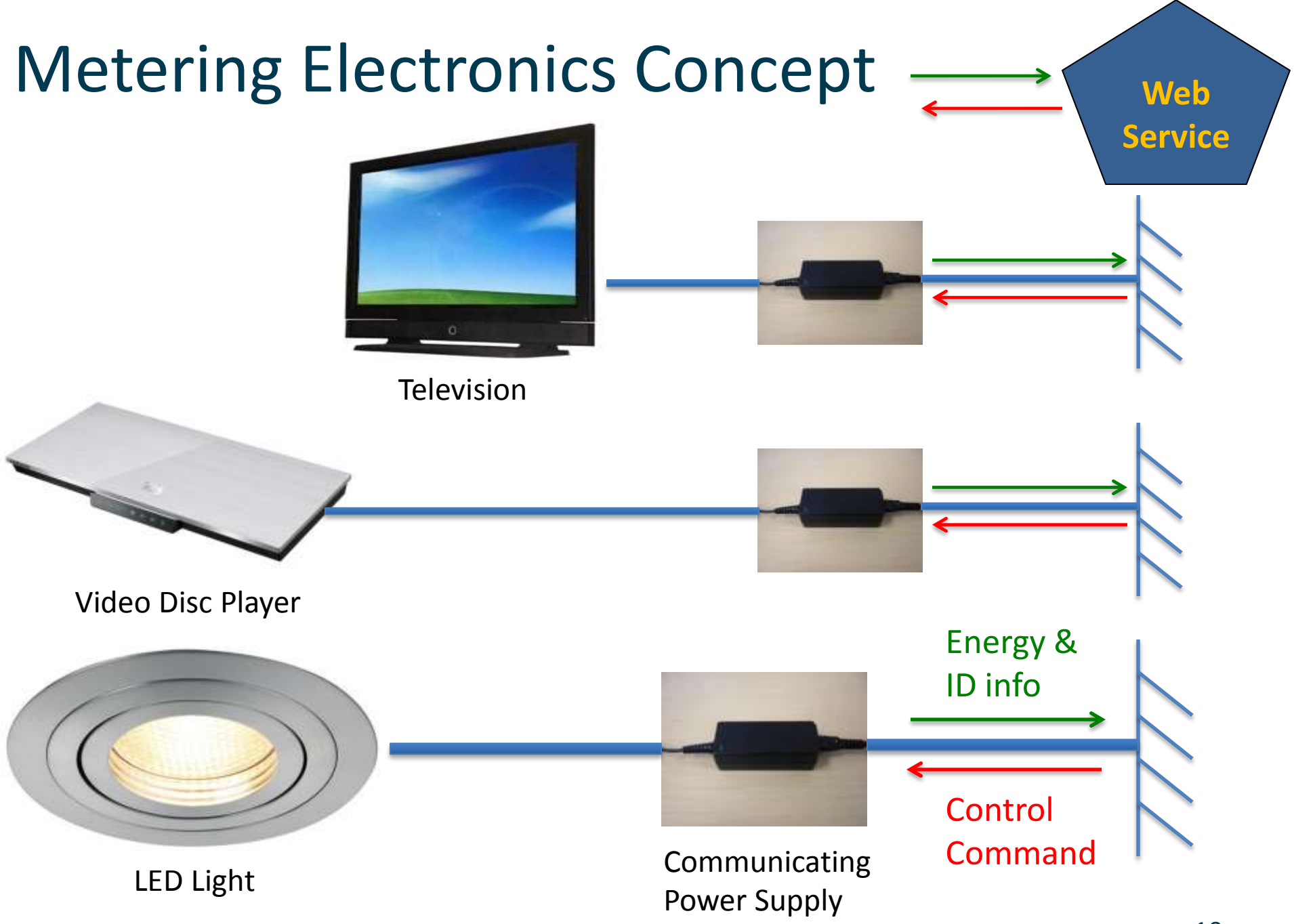
What About Individual Appliances?



- Appliances, Electronics, and Lighting expected to grow to half of residential primary energy
- 2035-EE Scenario: 10% savings in MELs, 50% in everything else; only about 1/3 overall savings

Sources: 1993 RECS, 2011 Building Energy Data Book (AEO 2012)

Metering Electronics Concept



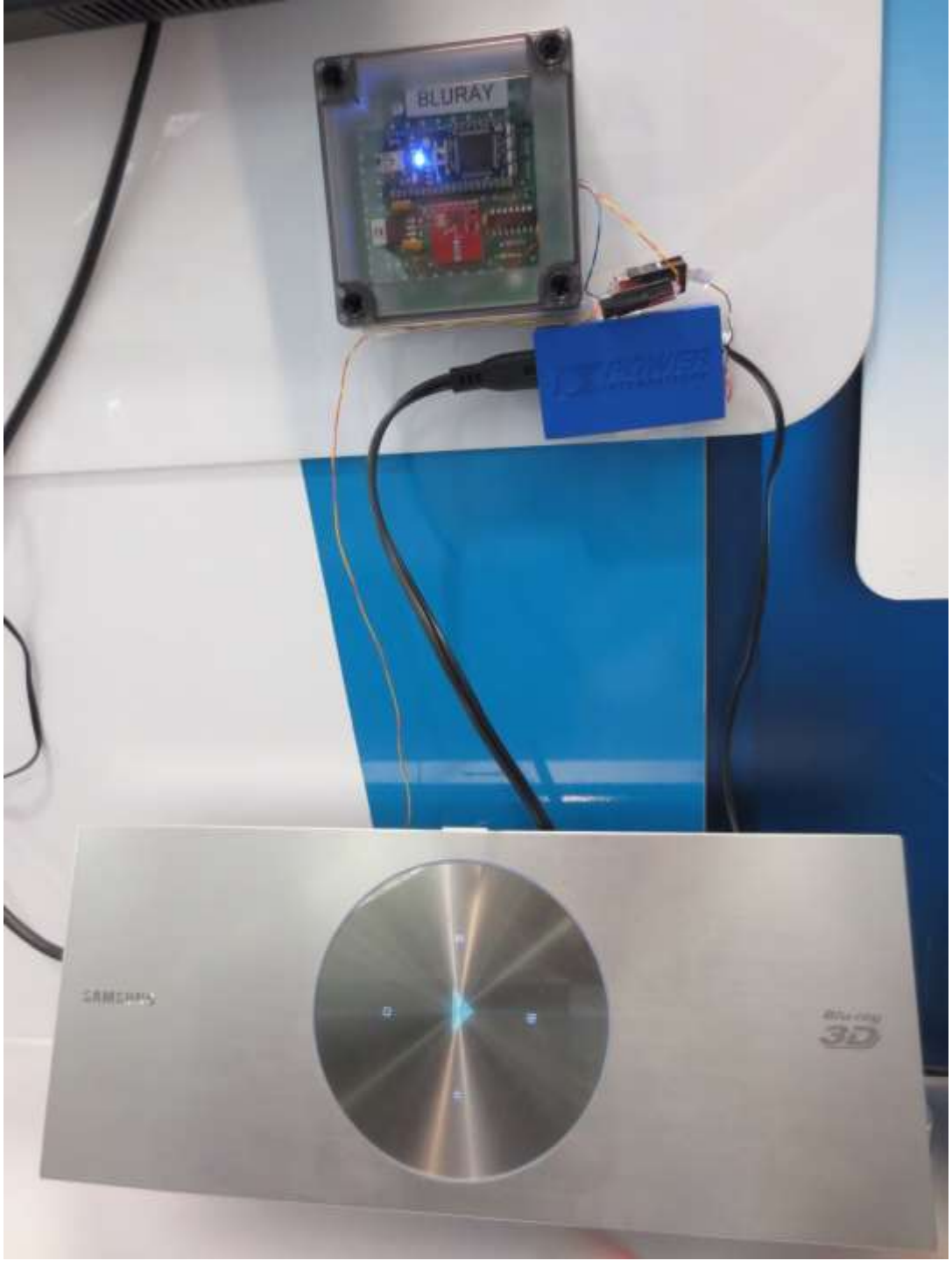
Design West 2013

- Metering <$0.10
- Add comms costs extra

STATE OF CALIFORNIA ENERGY COMMISSION

POWER INTEGRATIONS®

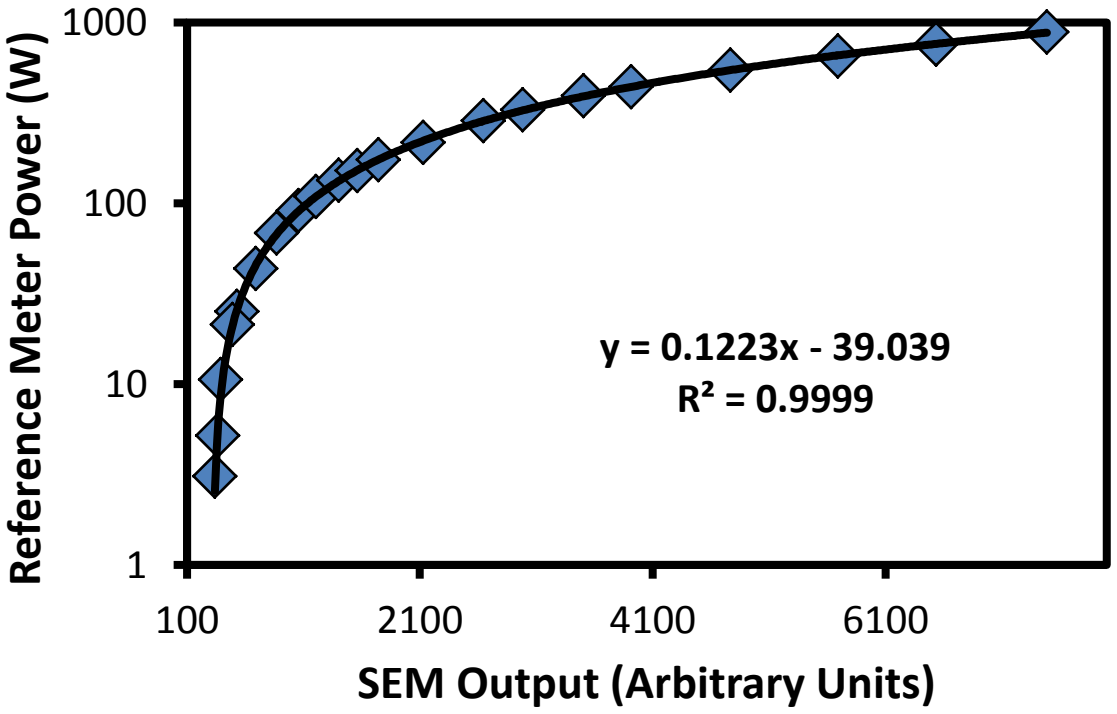
ARM


BLURAY
3D

ASUS
University of California Berkeley Power Usage Demo
BERKELEY LAB
Lawrence Berkeley
National Laboratory
POWER INTEGRATIONS
ARM
ON
Since 10:13 - 2.9 Whr
17.73W
ON
Since 10:13 - 3.4 Whr
19.41W
Since 10:13 - 2.6 Whr
18.51W
10:24

Devices That Use AC Directly

- Room AC, white goods
- Developing $1 power meter with <5% error
- Smart grid integration
- Improved data on energy use
- Energy management
- Timeline: Fall 2013



Overview

- Electricity metering
- Enabling fast DR
- Validating energy efficiency technologies

Fast DR and Ancillary Services

- Fast 5min or less to response
- Challenges
  - Telemetry
  - Programming new control sequences
- Enablement cost: $20k-$100k/building

AutoGrid

Focus on Smaller Buildings

Landscape

- 50% of buildings between 1,000 to 50,000 ft^2
- 90% do not use Building Automation System
- 10% of peak electrical demand under control

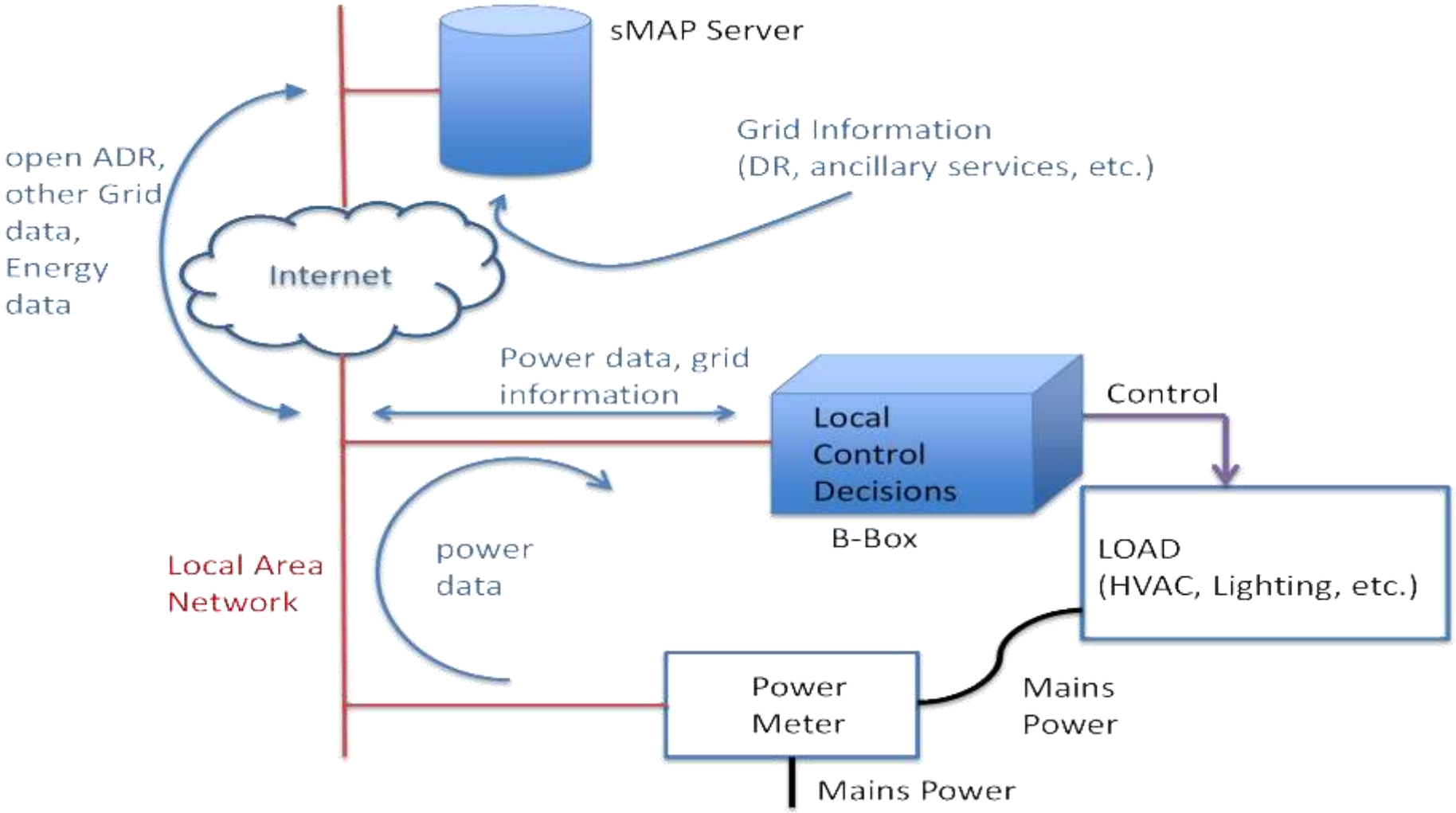
Scalable

- Requires no controls programming
- Productized
- Identical roll-out to residential solution

Cost Effective

- Current proof of concept $800 + labor
- Target: $200 retail cost, self install

How Does it Work?

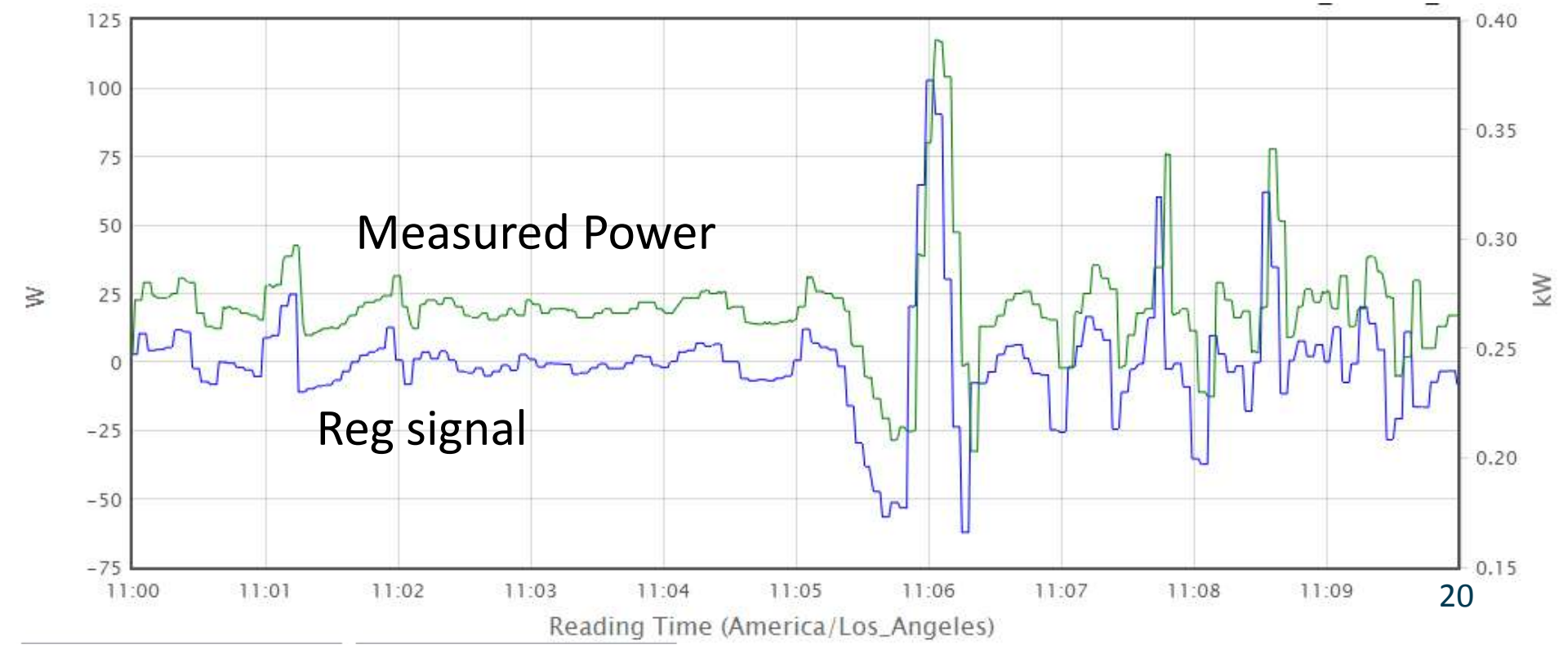


AutoGrid Systems, Inc. - Confidential

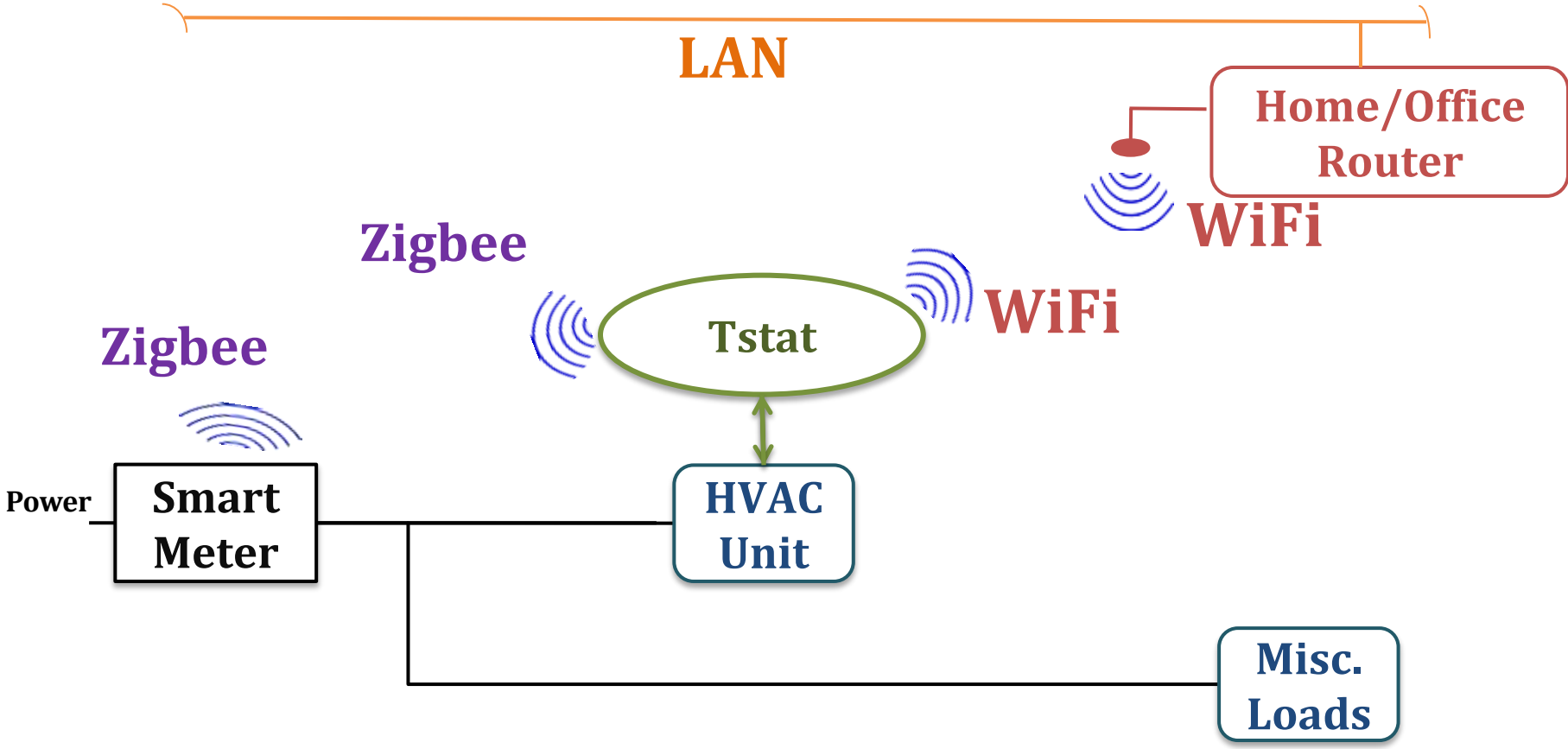
DENT

2 Second Regulation Demo

- Proof of concept
- Hardware no more capable than a Nest thermostat



Vision for scalability



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What is FLEXLAB?

Exterior Testbeds
- Focus on Integrated Systems & retrofit
- Opens January 2014

Lighting & Plug Load Testbed
- Controls, Visual Comfort & Behavior
- Completed

Virtual Design/Visualization
- Virtual Design & Modeling
- Opens Summer 2013

Controls Hardware Testbed
- Interoperability, Sensors
- Demand Response
- Pending - Opens Fall 2013

Capabilities

Comparative A-B testing

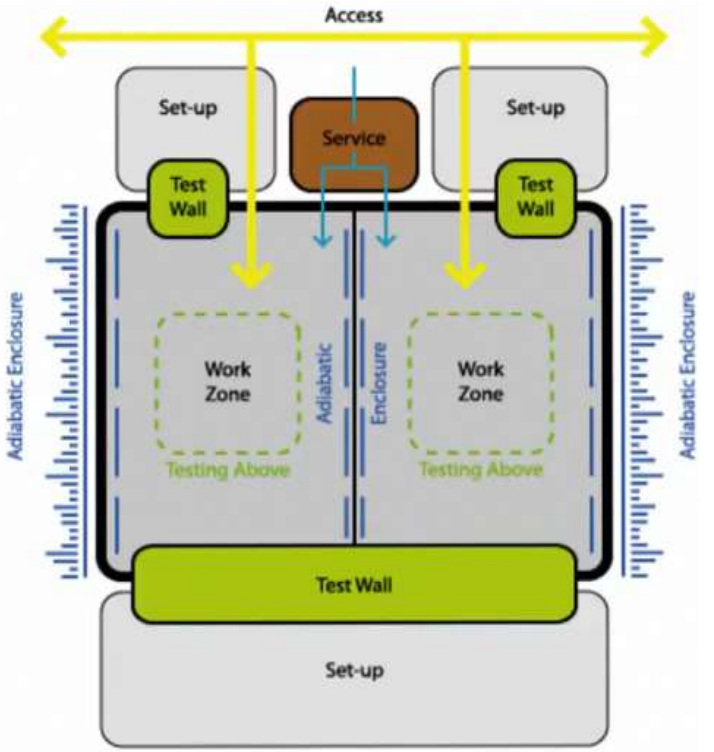
Controlled environment
- Controlled internal loads
- No externalities such as occupant behavior

Well instrumented and metered
- High granularity of power measurement
- High accuracy sensors

Provides access to multiple flexible systems

Highly flexible testbeds – interior and exterior assemblies

Mockup new construction and retrofits



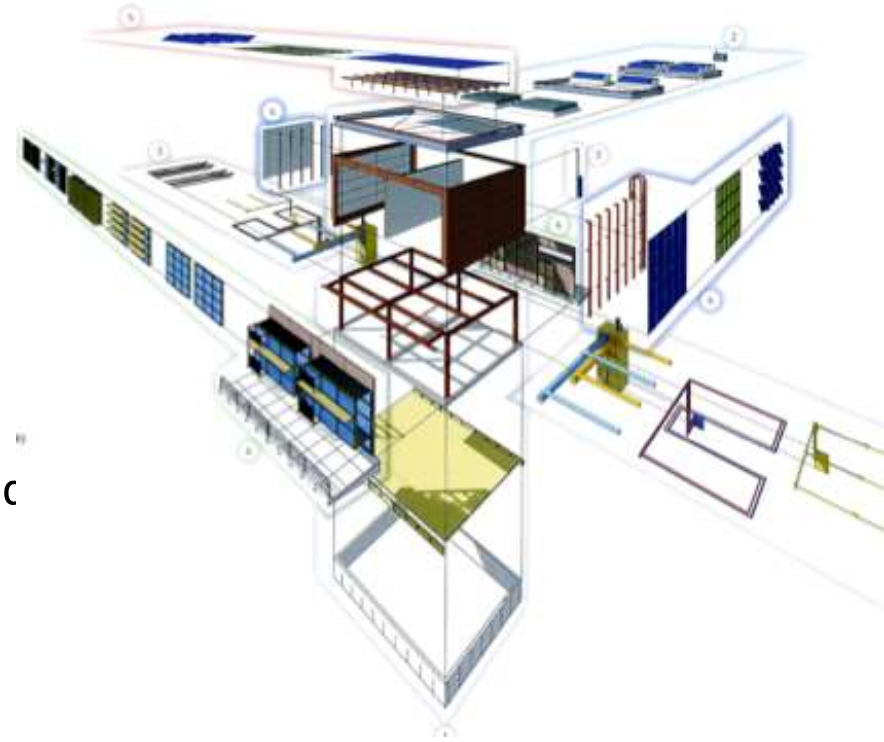
FLEXLAB Technical Features

Flexible interior space- variable ceiling heights, raised floor heights, and interior partitions may be relocated for zonal studies

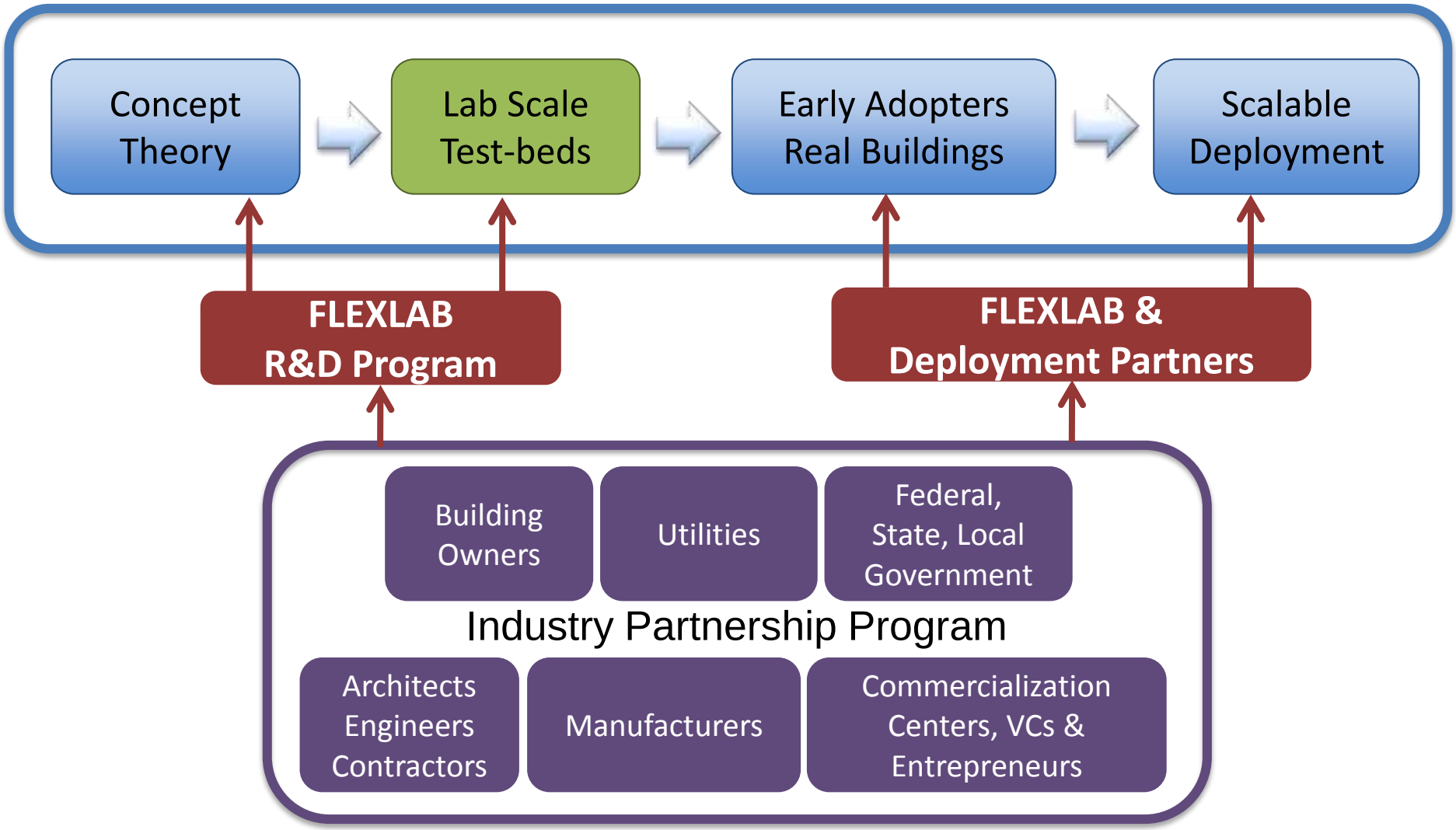
Interchangeable façade elements- shading, glazing, skylights - permits study of high performance integrated dynamic & façade systems

Interchangeable HVAC systems – air-based systems, (VAV, UFAD, DOAS etc) and water-based systems (fan coils, radiant heating and cooling, VAV)

Interchangeable lighting – direct/indirect light fixture studies, and lighting designs that emphasize daylighting controls, and task lighting applications



FLEXLAB proves concepts and reduces risk for early adopters



BERKELEY LAB
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