DOE/OE Transmission Reliability R&D
Load as a Resource (LaaR)

Demonstrating Load as an Ancillary Service Resource

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Presentation Outline

- Introduction: LaaR research areas

- Context of 2014 research

- FY2014 demonstration in PJM

  – Objectives

  – Synchronous Reserve Demo

  – Regulation Demo

  – Energy and Value Capture

- FY2015 Research and Demonstrations

  – Project Details and Research Questions

  – Schedule and Deliverables

  – Risks

Introduction:
LAAR - Challenges and Opportunities

- Communication
  - Security
  - Poll vs. Push
  - Telemetry – technology and cost
  - Latency

- Controls
  - Closed-Loop vs. Open-Loop
  - Automation

- DR Characterization
  - Which end-use, how long, how often, how much?
  - Variable ramp rates
  - Individual loads (small vs. large)
  - Aggregation

- Measurement, Verification & Settlement
- Economics (cost & value)
- Regulatory/Market Issues

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FY2014 AS Demo - Objectives

- To demonstrate how loads in commercial buildings can respond to regulation signals from the ISOs;

- To refine the concepts developed in the first two phases of this research project

  - Support of OpenADR 2.0b development
  - Communications architectural/technology latencies
  - Controls technology evaluation
  - Market opportunities / enablement costs

- To investigate how the costs per site or for kW delivered can be further reduced.
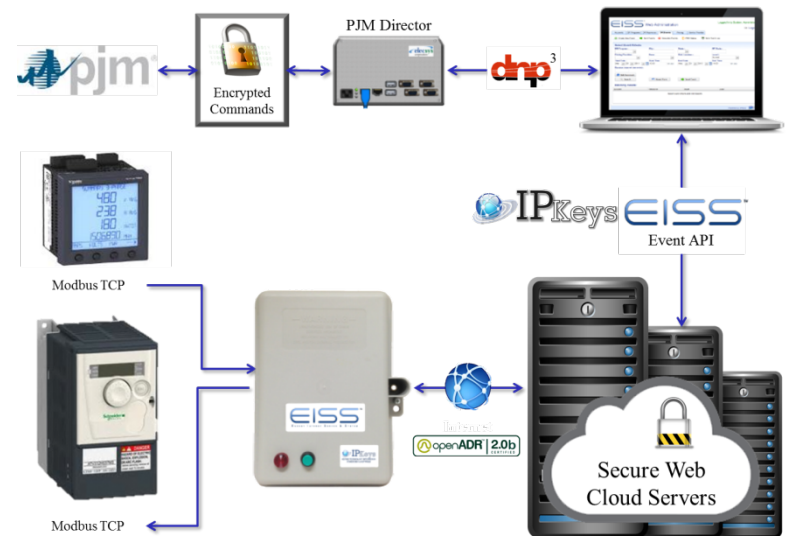
DR for AS Field Demonstration

- Two demonstration projects using OpenADR 2.0b building loads to provide (1) Synchronous Reserve and (2) Regulation in PJM Territory.

- Partnership with IPKeys, WalMart, and Schneider Electric

- IPKeys provides OpenADR 2.0b certified hardware/software
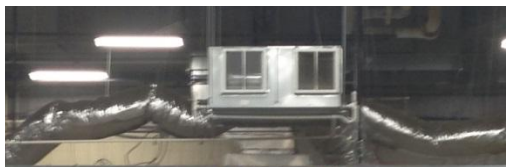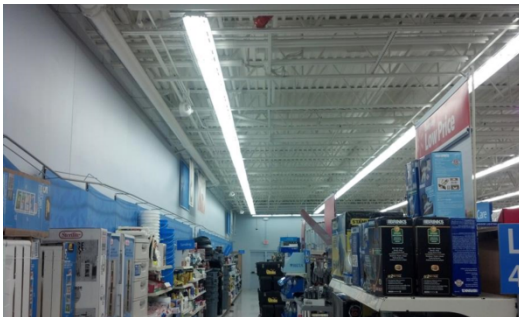

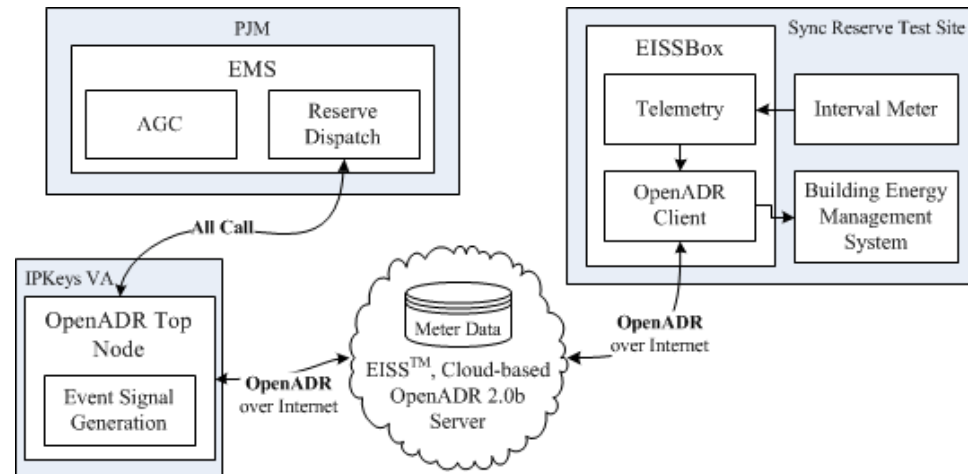This AC Unit was retrofitted with a VFD

FY14 AS Demo – Sync Setup

- Synchronous Reserve using OpenADR 2.0b:
  - Walmart store #2446, in Quakertown, PA
    - Loads: lighting and roof top AC units
  - IPKeys, our contractor providing OpenADR 2.0b communications
  - Control Strategies:
    - Lighting shed (1/3;2/3)
    - HVAC setpoint adj.
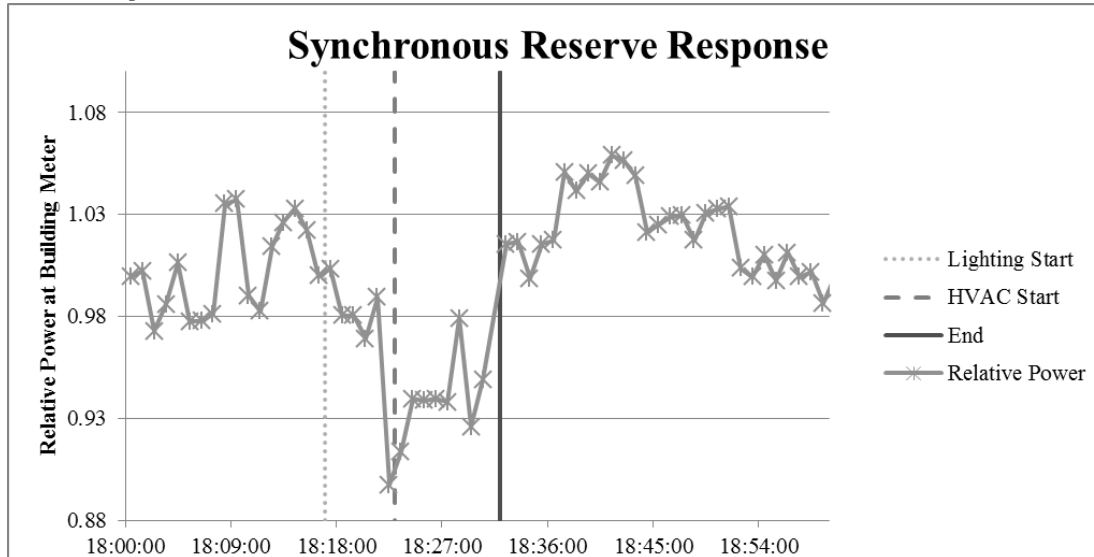

Interior lighting is flexible

- Four shed tests performed

FY14 AS Demo – Sync Reserves

- ## Synchronous Reserve Demo – Results

Synchronous Reserve Response

- Lighting Start
- HVAC Start
- End
- Relative Power

2/3 of lighting shed

Loads successfully responded to synchronous reserve tests
- 1/3 lighting + HVAC response (1 test) ~6% load reduction within 5 minutes
- 2/3 lighting sheds (3 tests) ~ 15-20% load reduction within 5 minutes

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Sync Reserves Demo - Impressions

- Tests with Walmart executives on video conference suggested positive corporate support

- As I walked the floor, heard Walmart employees complaining to eachother

  – A communications methodology in retail and commercial spaces may be important part of solution

- Test results presented lack completeness, additional (more complete) test results will be available in final report
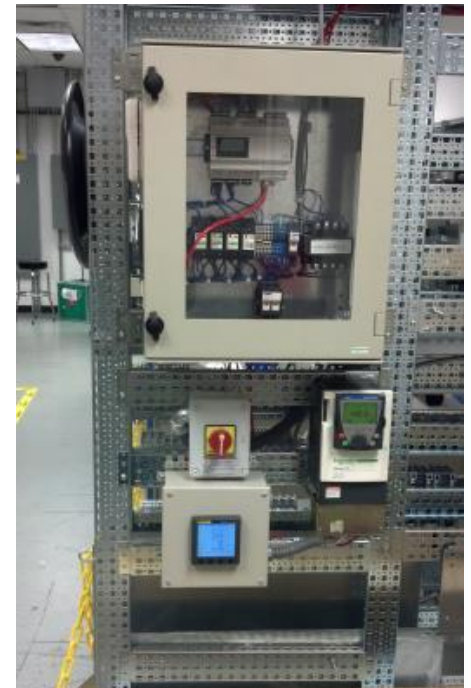
FY14 AS Demo – Regulation Demo
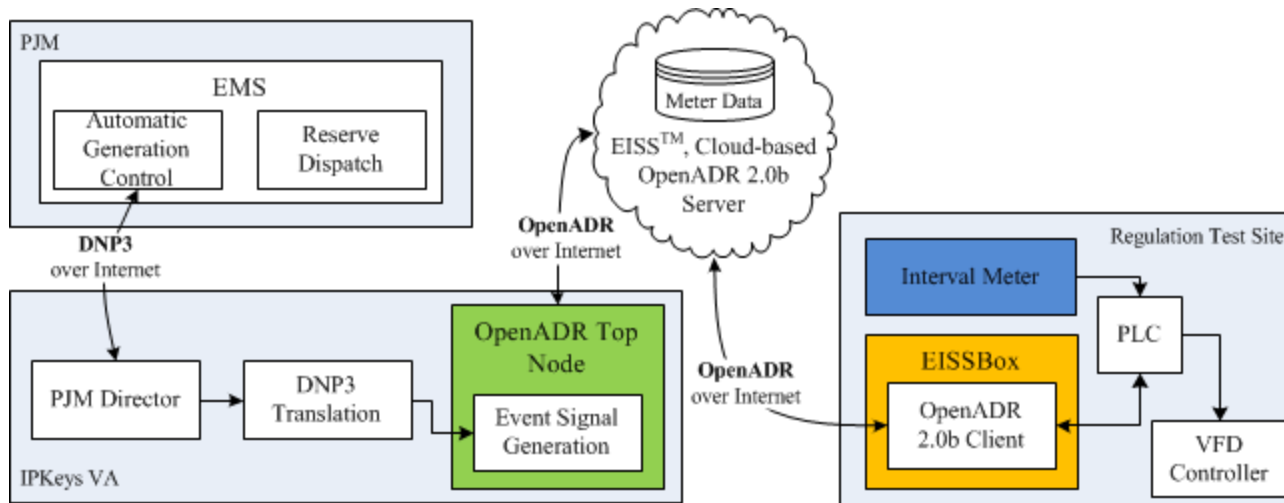
- Regulation Reserve Demo – Setup
  - A heat pump cooling a small laboratory space was retrofitted with a VFD on supply fan
  - Schneider Electric's VFD laboratory in Knightdale, NC
  - Telemetry – Schneider M820
  - Controls:
    - 0.5 Hz fan frequency adjustments
    - Fan frequency range: 55 and 65 Hz.

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Regulation Demo - Metrics

- Latency
- Speed of Response
- Accuracy
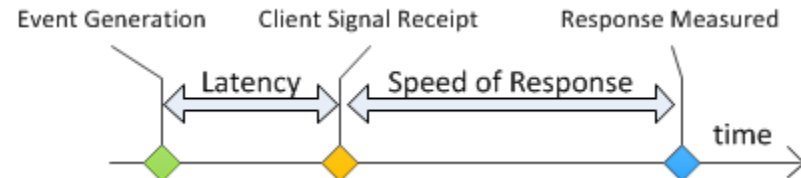
FY14 Accomplishments – AS Demo

- Regulation Reserve Demo – Results
  - OpenADR 2.0b (XMPP Push architecture) latency:
    - Measured from event generation at IPKeys to signal receipt by client
    - Results (from 1500 2-second signals sent)
      - Average: 0.99s ;
      - Median 0.44 s ;
      - 75th Percentile: 1.04 s;
      - Max: 10.21 s
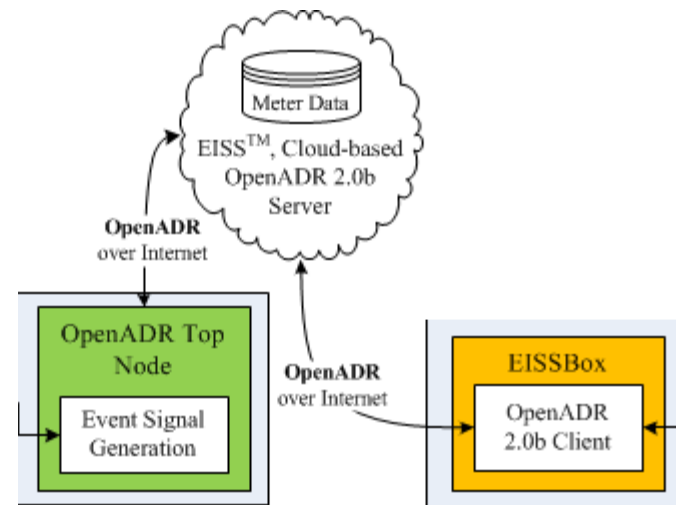
Regulation Demo - Results

- Regulation Reserve Demo – Results

- Speed of Response:
  - Signal Receipt to Meter Read (4 s)
  - Mean = 4.7 s; {2.3-7.2}

- Accuracy of Response:
  - 90% accurate using PJM metric

PJM Regulation D Self Test
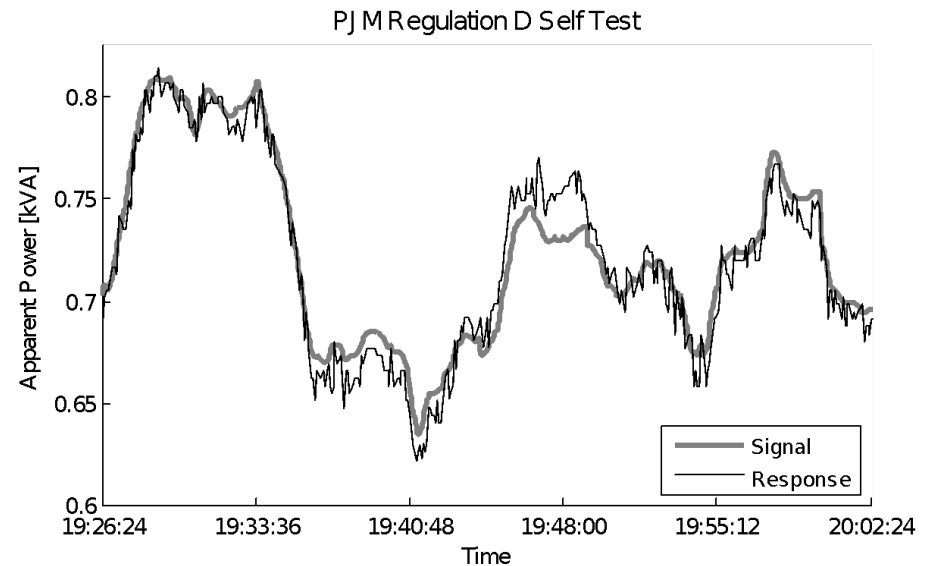
Impacts and Opportunities of AS

- Historical energy impacts of providing capacity in PJM:
  - Typical DR program: 12 calls per year, 100 hours total
  - Sync Reserves on average (2009-2013): 31 events/year, 11 minute duration
  - Regulation: Conversion of capacity to energy over time

Time Horizon	Energy Generation [kWh/kW]			
	Average	Std Dev	Min	Max
5 min	-0.0004	0.019	-0.083	0.083
15 min	-0.0013	0.026	-0.212	0.178
1 hour	-0.0054	0.043	-0.253	0.285

Impacts and Opportunities of AS

- 2013 Historical Value of Ancillary Services:
  - DR is Tier 2 reserve (>50% of the time no value)
  - Based on capacity market clearing price, assuming 8760 hours participation:
    - Regulation is valued at $17/kW-mo (plus mileage)
    - Sync Reserves valued at $2.2/kW-mo
- A single resource that could meet the minimum ISO participation requirement (100kW), will make $220/mo in Sync Reserves if it can participate at all hours
  - This is unlikely to be sufficient to induce participation on it's own.

FY14 AS Demo - Publications

- Publications
  - MacDonald, J., S. Kiliccote, J. Boch, J. Chen, and R. Nawy. *Commercial Building Loads Providing Ancillary Services in PJM*. Proceedings of 2014 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, August 2014.
  - Compete report forthcoming by December 2014

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FY15 - Research Plans

- FLEXLAB demonstration (about 1/3 funded through FY14 carry over)
  - Respond to PJM regulation signals with full telemetry
  - Advanced controller design
    - Feasibility of closed loop control, including model predictive control, to improve accuracy while still responding within 10 seconds
  - Coordination of lighting and HVAC
  - Building management system integrated
    - Expect speed of response to decrease
  - Occupant comfort impacts – dynamic comfort assessments
    - Show little to no impacts of providing regulation
  - Real-time telemetry (cost estimation)
- Forecasting DR availability for market timelines

Schedule and Deliverables

- Schedule:
  - Develop software for PJM system integration will begin October (with recent hire of software engineer)
  - First end use testing within 1 month after completion of the end-to-end set up.
  - Additional end uses (lighting as a first candidate) will be tested if there is time.

- Deliverables:
  - Paper outlining the tests and results, expected end of April 2015

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Risk Factors

- PJM was not able to provide a turnkey communications solution for regulation signals, as initially thought. Timeline for development of software integration is currently unclear (need estimate from our new hire)
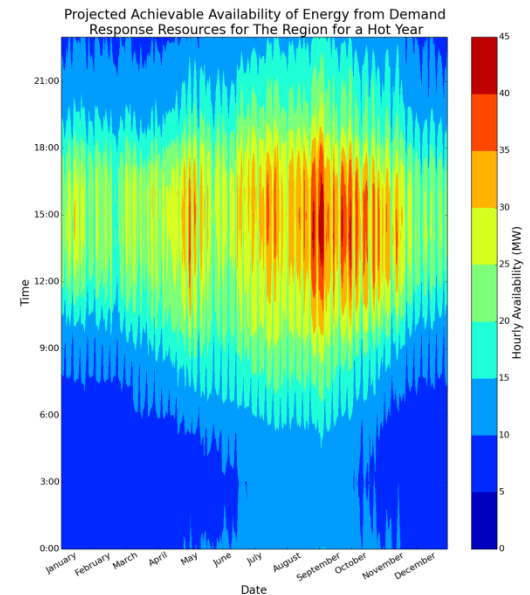
Questions?

DR Characterization

- Planning:
  - EERE, CEC and CPUC funded studies to characterize hourly DR availability in WECC, California and SONGS (served by Johanna, Ellis, Viejo and Santiago), respectively.

Product	Achievable Potential			Theoretical Potential		
	Maximum MW, (%)	Minimum MW, (%)	Mean MW, (%)	Maximum MW, (%)	Minimum MW, (%)	Mean MW, (%)
Regulation	13, (1)	3, (0.4)	7, (1)	271, (17)	70, (8)	133, (12)
Flexibility	30, (2)	7, (1)	16, (1)	271, (17)	70, (8)	133, (12)
Contingency	34, (2)	11, (1)	20, (2)	285, (19)	84, (9)	153, (14)
Energy	34, (2)	6, (1)	14, (1)	178, (12)	29, (4)	72, (7)
Capacity	49, (3)	16, (2)	27, (3)	294, (19)	16, (10)	157, (15)

Projected Achievable Availability of Energy from Demand Response Resources for The Region for a Hot Year

- Publications:

DR Characterization

- Operations: What is available now?
  - Bottom up:
    - Whole building data using a variety of regression models, ARIMA, SARIMA, etc.
    - Used interval meter data. One opportunity is to use telemetry data.
  - Top down: This requires close collaboration with system operators
  - Possible opportunity is to experiment with ASHRAE SPC 201, designed to provide real-time data on:
    - Loads
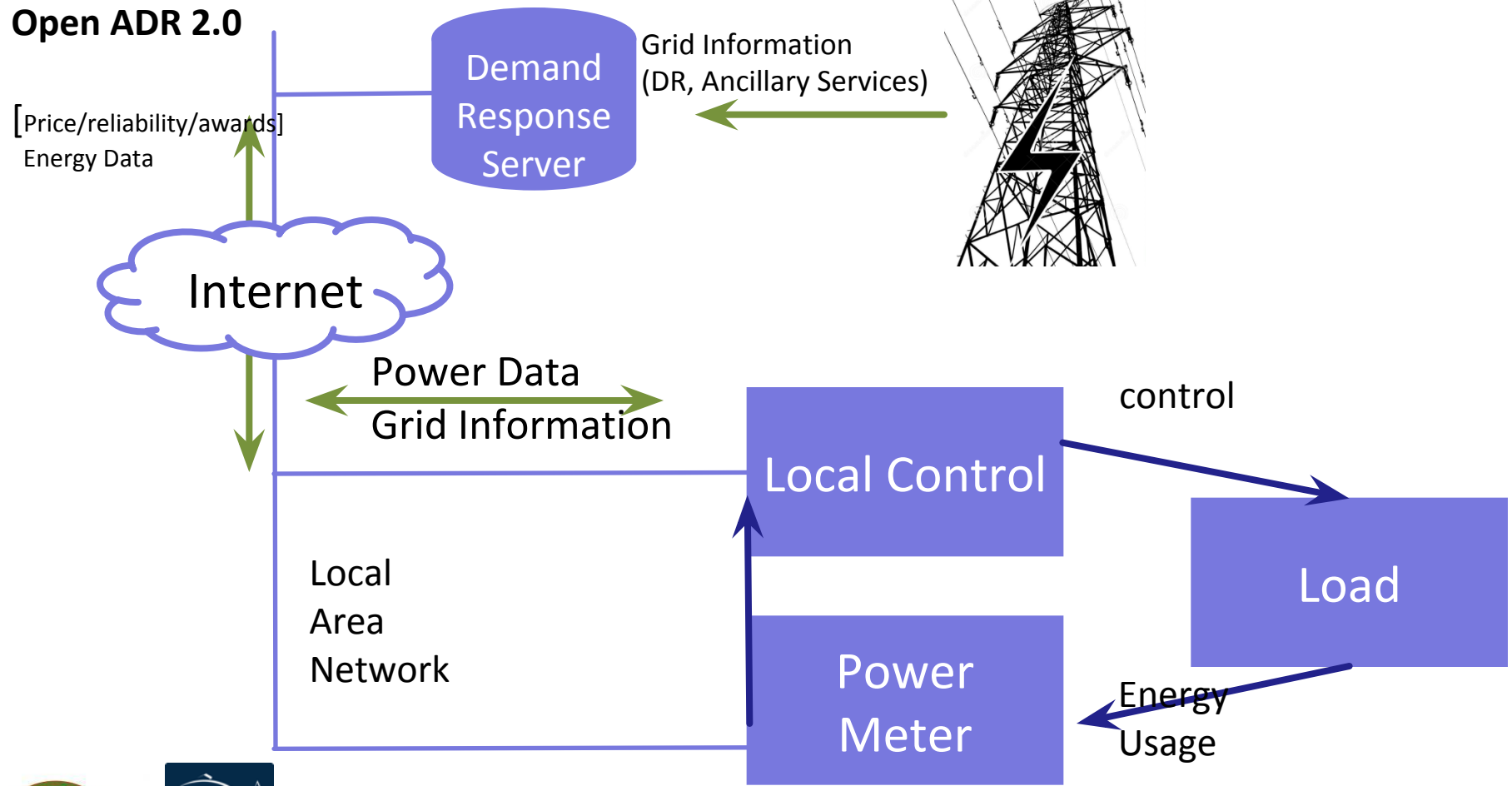   - Generation
    - Storage
    - Meter

Communications

- Security
  - OpenADR 2.0b fully addresses and includes secure communications vetted by NIST Smart Grid Standards process.
- Poll vs. Push
  - Used long polling
  - XMPP as a transport overcomes these issues
- Telemetry
  - Developed low cost (<$100) telemetry and evaluated in 12 buildings (Kiliccote et al. 2014 – ACEEE)

Internet Based Technology Implementation (regulation and non-spinning reserves)

Open ADR 2.0

[Price/reliability/awards]
Energy Data

Demand Response Server

Grid Information (DR, Ancillary Services)

Internet

Power Data
Grid Information

Local Area Network

Local Control

control

Load

Power Meter

Energy Usage

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M&V and Economics

- Working with PG&E's Intermittent Resource Management Pilot to evaluate M&V and Settlement issues. (Report available in December)
- Economics
  - Categorization of costs (taxonomy report under review)
  - Understanding the value of DR in the wholesale markets today and with high penetration of renewables

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