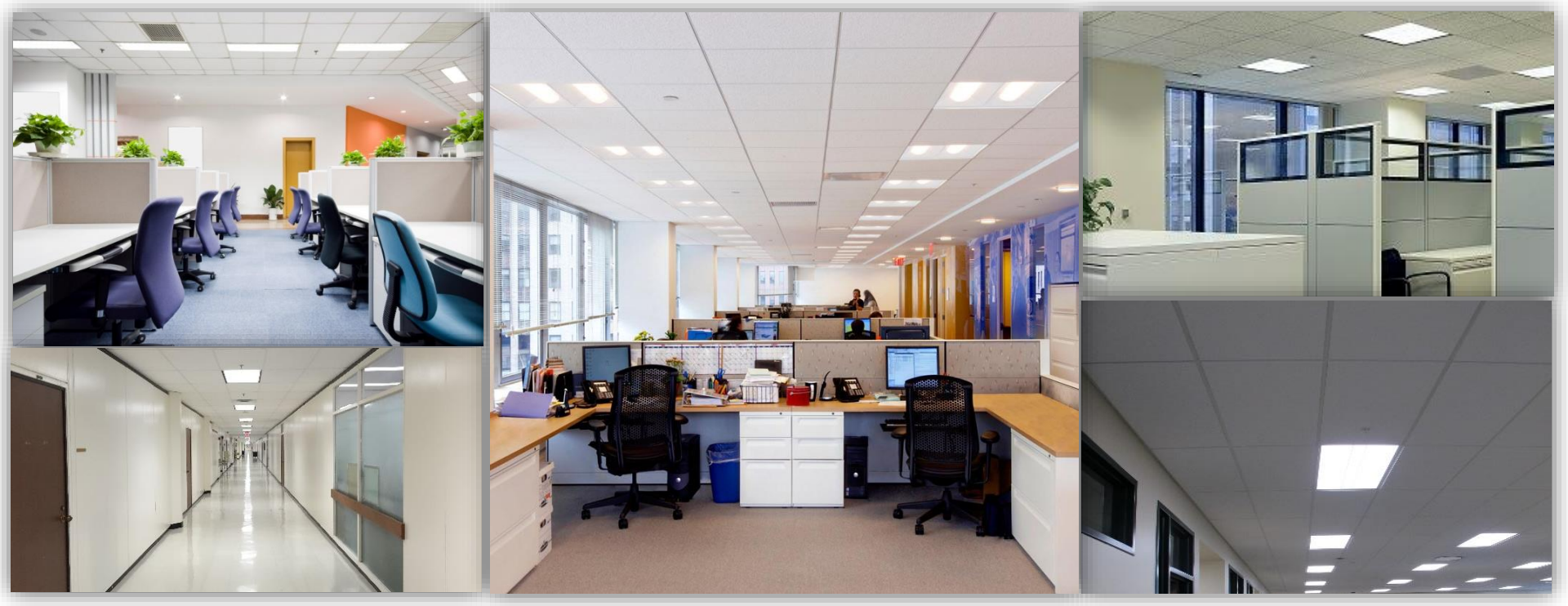
Innovation Challenge: Low Cost Wireless Submeter

2017 Building Technologies Office Peer Review



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Project Summary

Timeline:

Start date: June 2013

Planned end date: April 2017

Key Milestones:

1. Draft spec released for comment March 2013
2. Selected technology field tested February 2017

Budget:

Total Project $ to Date:

- DOE: $1,011,00
- Cost Share: No cost share, however interested companies used their own funds at all times

Total Project $:

- DOE: $1,215,000
- Cost Share: $0

Key Partners:

Pacific Northwest National Lab
Better Buildings Alliance EMIS Team
U.S. General Services Administration
FEMP

Project Outcome:

Focus: Partner with market to identify unmet need, with industry to set performance targets, with manufacturers to produce a product that meets the performance specification and price point.

Driving Adoption of Technology Solutions MYPP Goal #2: *Partner with market leaders to drive the adoption of HIT applications capable of reducing building energy consumption by 10%.*

Project Summary

- 2012/13: building owners & managers express broad interest in sub metering, identify an absence of cost-effective solutions.
- Market analysis revealed that existing technology was too expensive to be cost-effective for many applications.
- Market analysis also revealed many owners expressed interest in a product at a lower price point. DOE facilitated collaborative discussion on performance parameters.
- A specification and price point was created to challenge manufacturers to create a product that would satisfy this market need.
  - A coalition including the DOEs Better Building Alliance Technology Solutions Team issued a challenge to industry in 2013 to produce a wireless sub-meter for $100 or less per metered point.
  - The specifications of the device include essential requirements for electrical energy measurement and wireless data transmission to onsite collection point
- Building owner/operators and other interested stakeholders documented interest

Purpose and Objectives

Problem Statement: Energy Management Information Systems can enable significant energy savings, often with rapid payback, but most systems rely on submetering which can be cost prohibitive for small and medium size business. Submeters provide key data to support analytics with 8-10% whole building energy savings. As a result, a significant amount of energy use is not measured or managed.

Target Market and Audience: Commercial, institutional, and educational buildings: small and medium sized. Audiences targeted:

- Institutional cost managers seeking to reduce energy spend
- Manufacturers of building submeters
- Building owners/managers for small and medium size businesses
- Utility and state efficiency programs looking to access (and possibly incentivize) whole building energy-savings.

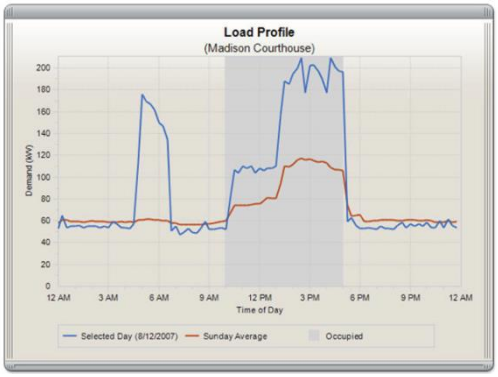
Impact of Project:

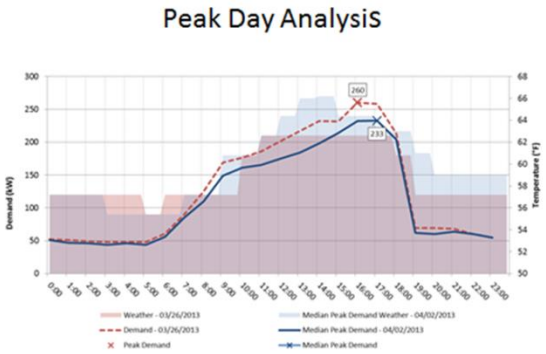
- Near Term – demonstrate market viability of a low cost submeter
- Intermediate – Spur market development of solutions
- Long Term – provide means for small & Medium sized buildings to measure and manage energy use.

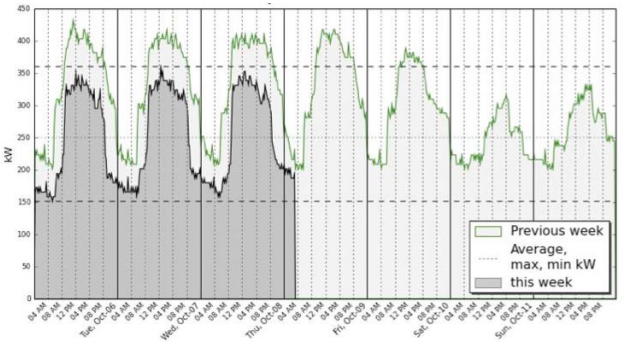
The Importance of Energy Information

- ✓ Identify **operational efficiency opportunities**
  - Scheduling, faults and anomalies, changes in load profile
- ✓ **Track performance and compare** to self and others
- ✓ Monitor peak load and **manage demand charges**
- ✓ Check **utility bills**
- ✓ Convert **energy into $$,** verify energy savings
- ✓ **Set and justify energy goals**

Energy Information can help us save 1 quadrillion BTU in commercial buildings.







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Submetering = Energy Information

- **Conservative estimates** of national energy savings potential from low cost panel level meters is about **US $1.7B annually**.
- The **Market has shown a clear demand** for better building information, which has been stymied by first cost.
- **Challenge for innovation** to lower the cost of wireless, panel-level submetering devices from around **$1000 per point to $100 per point.**

Low Cost Wireless Electric Energy Meter Specification
Version 2.6

1. **Background.** Prioritizing building energy efficiency projects is essential to responsible fiscal management whether in the private sector or government. Understanding what systems within a building consume what types and amounts of energy is essential to identifying areas for efficiency improvement. This is especially true in the federal sector, where agencies are required to meet specific metering requirements (e.g., the metering of buildings for electricity use per the Energy Policy Act of 2005); meet aggressive energy efficiency goals established in the Energy Independence

- **The Challenge model** has successfully transformed the market for high efficiency RTUs.

The Challenge Model : Stimulating Innovation (RTU Example)

Documented Demand

2010: DOE and Commercial Building Owners **Issue a Challenge** for manufacturers to innovate toward more efficient RTU performance + features

What does DOE offer manufacturers that meet the specification?

- ✓ Evaluation of the candidate product
- ✓ Test data into DOE modeling & decision tools
- ✓ Potential field demonstrations
- ✓ Public Recognition

Manufacturers Win!

Carrier® turn to the experts℠

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Example Outcomes from the RTU Challenge

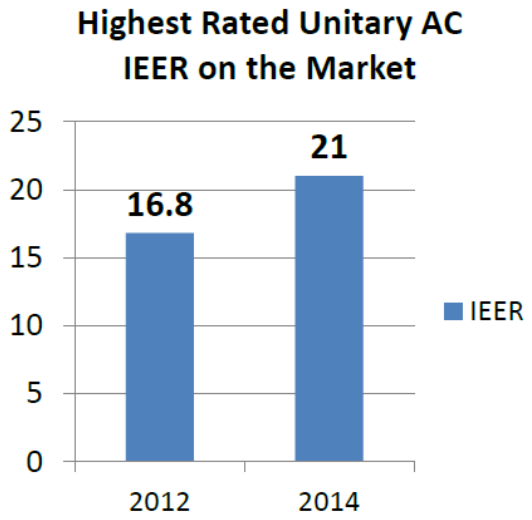
2010: **zero** RTU models met the 18 IEER criteria.

2015: **195** different RTU model variations meet Challenge criteria.

2016: utilities incentivize based on Challenge level performance.

Driver: Advances for Top Performers

- DOE Rooftop Unit Challenge spec of 18 IEER
- 4 OEMs with product lines with ratings >18 IEER
- As of July 2014, >20 models achieving ratings above 20 IEER listed in AHRI Directory.



Credit: Bjorn Jensen, CEE

June 2013, The Challenge is Announced:

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Federal and Industry Partners Issue Challenge to Manufacturers

June 6, 2013 - 10:09am

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NEWS MEDIA CONTACT

• (202) 586-4940

WASHINGTON -- A coalition that includes the U.S. federal government and over 200 major commercial building sector partners has issued a simple challenge to U.S. manufacturers: if you can build wireless sub-meters that cost less than $100 apiece and enable us to identify opportunities to save money by saving energy, we will buy them. A group of at least 18 manufacturers has already agreed to take up the challenge, pledging to produce devices that will meet the specifications outlined by the U.S. Department of Energy and its private sector partners that have signed letters of intent to purchase the wireless sub-meters.

"This is a perfect example of how government can team up with industry to identify a problem and promote the

"Affordable, accu

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Electricity sub-m

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electrical panels

being used, help

strip mall, for example) to bill individual tenants for their electricity usage, creating an incentive

for energy efficiency. Wireless sub-meters are available today, but typically cost about $1,000

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"This is a perfect example of how government can team up with industry to identify a problem and promote the innovation needed to solve it," said U.S. Energy Secretary Ernest Moniz.

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Specification

- **Some key requirements:**
  - The submeter has to collect watt-hour energy for a three-phase circuit.
  - Data measurement, transmission and collection must be open protocol.
  - The communications must be wireless, although there was no specification for the type of wireless. It cannot leverage the building's other communication systems.
  - The submeter must be self-contained.
  - The power source has to come from within the power panel it connects to or the system being monitored.
  - The $100 price tag has to include the device, sensor, any base station or repeater, and software, but does not have to include design or installation.
  - No additional software should be required by the user, who is assumed to have internet access.
  - Two-way communication is not required.

Partners Expressed Interest:

- Bullitt Foundation
- CBRE
- Enterprise Green Communities
- Fitzmartin Consulting
- Jonathan Rose Companies
- McKinstry
- Natural Resources Defense Council
- Prologis
- Stanford University
- University of California – Berkeley
- University of Maryland Medical Center
- U.S. Federal Energy Management Program
- U.S. General Services Administration
- Vermont Energy Investment Corporation
- Whole Foods Market
- Yum! Brands

Partners Expressed Interest:

PROLOGIS

May 22, 2013

To: U.S. Metering Manufacturers

Re: Department Of Energy (DOE) Wireless Metering Challenge

Metering data provides visibility to a building's energy use. Better understanding of a building's energy use profile can help owners reduce costs by taking action to resolve problems id
While metering systems do not directly improve energy efficiency, metering
efficiency actions. Implementing metering systems will greatly assist our org
management goals. Due to this fact, we lend our support to the DOE's Wirel

In addition to supporting the Challenge, we expect to strongly consider purc
performance specification set out by DOE, are consistent with our cost-effec
our procurement timeframes. We look forward to working with the manufa
of prototype units that meet this specification. We understand that DOE has
technical assistance to help U.S. manufacturers design and develop products
look forward to the near-term market introduction of reliable, energy-efficie
panel level electric metering devices which increase the collection and mana
ultimately increase the efficiency of the commercial buildings sector.

Sincerely Yours,

Aaron Binkley
Prologis, Inc.
Director, Sustainability Programs

"…we expect to strongly consider purchasing meters that meet the performance specification"

Media Expressed Interest :

greentechmedia:

NETWORKING/AMI

DOE Launches $100 Electric Submeter Challenge

Can a low-cost meter drive energy efficiency?

by Katherine Tweed
May 03, 2013

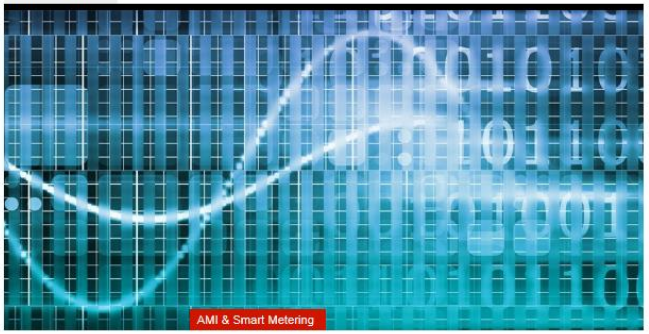
The U.S. Department of Energy's Buildings Technologies Program finalized its latest challenge on Wednesday: an initiative to develop a $100 wireless submeter.

The submeters will have to be able to track energy consumption but do not have to be revenue-grade power meters.

"It's a bit of a *Field of Dreams* thing," Elena Alschuler, a specialist in building energy performance at the DOE, said at the Advanced Energy Conference in New York City. "If you build it, they will buy it."

METERING & SMART ENERGY INTERNATIONAL

LEAVE COMMENT



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5 APRIL 2013

U.S. DOE to launch low cost wireless building metering challenge

Washington, DC, U.S.A. --- (METERING.COM) --- April 5, 2013 - The Building Technologies Office in the U.S. Department of Energy's (DOE) Energy Efficiency & Renewable Energy office is to launch the Low-cost Wireless Meter Challenge to industry to produce a cost effective, wireless metering system capable of electrical energy measurement at various locations in a building and wireless communication to a remote data collection point within the building complex.

The primary goal of the program is to catalyze the development of low cost panel

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Manufacturers Expressed Interest :

- BLUEdev
- Continental Controls -- MicroStrain
- Dent Instruments
- Eaton Corporation
- Energy Aware Technologies
- Energy Detective
- IE Technologies
- Ingreenium
- Inoscope International
- Lem
- Leviton
- LoadIQ
- Negawatt
- Obvius
- Powerhouse Dynamics
- Schneider Electric
- Smart OES
- Universal Devices
- And More…

2013-14: Phased Review by Experts at PNNL

- Announcement and recruitment, extensive communication
- 29 manufacturers expressed interest by submitting product documentation, either existing or planned, to PNNL for review
- Anecdotally, most of the products submitted were existing and on the market, “feature rich”… and significantly over price point
  - Many not interested in developing a basic wireless meter, instead focusing on other business channels
- Advised which requirements did not comply

> Unfortunately, the xyz™ does not approach our targeted price point so the product will not be invited to participate in Phase II of the Wireless Meter Challenge. A copy of our findings is included with this note.

2013-14: Phased Review by Experts at PNNL

Specification Compliance Documentation
Summary List - Refer to Appendix II for complete requirements

LOG: 07 MZb

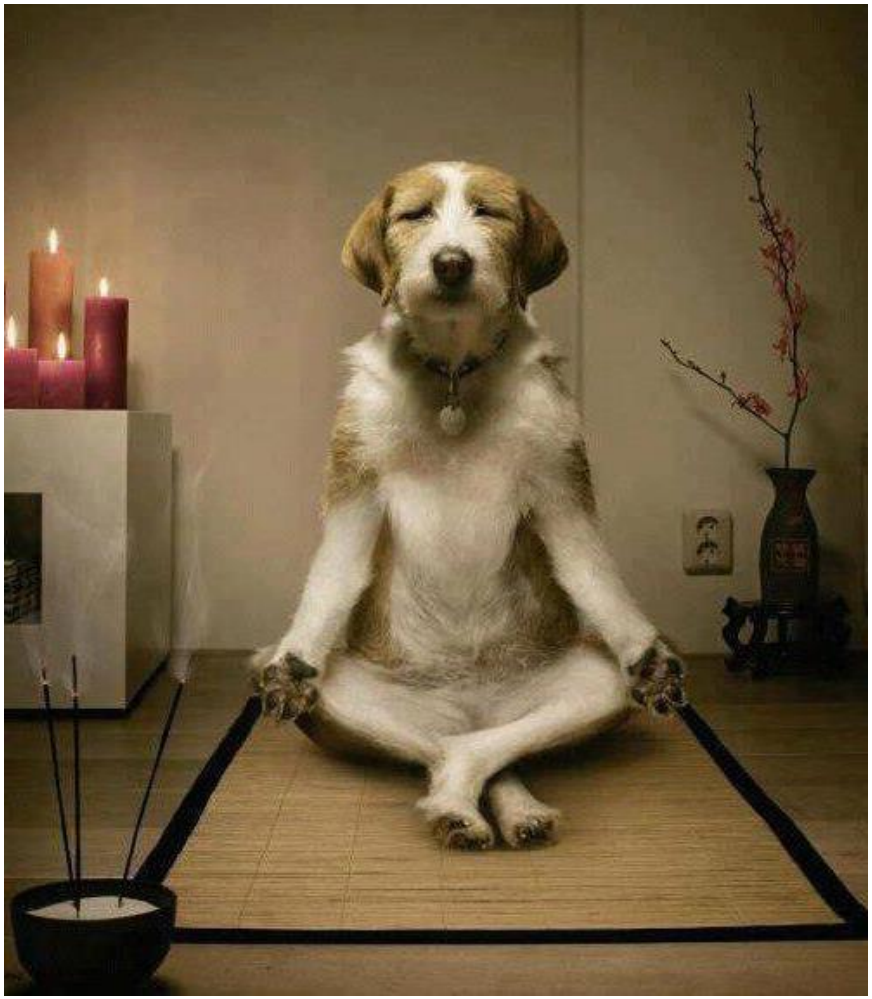
Section I.	Documentation verifying compliance testing	Documentation included		Compliant (Yes/No)		Reviewer Comments	Reviewer/Date
As noted in the Specification, Appendix II, all candidate wireless metering systems must be verified to comply with the Specification. A copy of the documentation showing compliance to the specification must be submitted by the manufacturer for the items identified below.							
Section 4.2 Electrical measurements							
A	Electric energy measurements	Yes		Yes		Meets specification. Email confirms CT up to 2400 Amp in response to question	PNNL-SP 2014-12-22
B	Measured parameters (required)	Yes		Yes		Meets specification. Email confirms CT up to 2400 Amp in response to question	PNNL-SP 2014-09-29
B-1	Measured parameters (optional)	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
C	Accuracy of measurements Note 1			Yes		Manufacturer needs to validate/provide accuracy specifications	PNNL-SP 2014-09-29
Section 4.3 Mechanical and environmental							
A	Operating environment (required)	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
A-1	Operating environment (optional)	Yes		No		Meets specification but not optional specification	PNNL-SP 2014-09-29
Section 4.4 Communications							
A	Simultaneous operation of multiple metering systems	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
	Note 1 - Accuracy test reports should document metering system accuracy at test points consistent with NEMA/ANSI C12.1, Table 5						

Section II.	Documentation verifying compliance with requirements	Documentation included		Compliant (Yes/No)		Reviewer Comments	Reviewer/Date
Compliance with the Specification for the items identified below must be verified by a statement signed by the manufacturer's representative.							
Section 4.1 Electrical							
A	Source of electric power for the measurement device	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
B	Source of electric power for base station and other components	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
C	Power loss response	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
D	Safety: Compliant with NFPA 70 and UL 61010					Manufacturer needs to validate/provide UL compliance	PNNL-SP 2014-09-29
Section 4.2 Electrical measurements							
D	Measurement time interval period configurations (required)	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
D-1	Measurement time interval period configurations (optional)	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
E	Data log record	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
Section 4.3 Mechanical and environmental							
B	Enclosure	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
C	Weights of individual metering components	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
D	Dimensions of individual metering components	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
Section 4.4 Communications							
B	Communication architecture	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
C	Frequency band					Manufacturer needs to validate/provide FCC compliance	PNNL-SP 2014-09-29
D	Data communication interval (required)	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
D-1	Data communication interval (preferred optional)	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
D-2	Data communication interval (optional)	Yes		Yes		Meets specification. Data upload is user adjustable down to every 30 seconds	PNNL-SP 2014-09-29
E	Data storage for measurement device (required)	Yes		Yes		Meets specification. Meter can store 2500 readings	PNNL-SP 2014-09-29
E-1	Data storage for measurement device (optional)	Yes		Yes		Meets specification. Meter can store 2500 readings. Gateway has additional 8 GB	PNNL-SP 2014-09-29
F	Data storage for base station	Yes		Yes		Meets specification. Gateway has 8 GB storage. PC used as base station.	PNNL-SP 2014-09-29
G	Response to loss of communication	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
H	Security mechanism	Yes		Yes		Meets specification	PNNL-SP 2014-09-29
I	Use of existing networks	Yes		Yes		Meets specification. Sets up independent ZigBee mesh network. Connects to PC via WiFi websocket	PNNL-SP 2014-09-29

2014-15: Detailed Review and Communication

- 3 manufacturers met the requirements through the phased review
- Each provided ongoing updates, barriers, and milestones on product development.
- Small companies, predictable hurdles to overcome
- UL listing proved to be time-consuming, 6-12 months

Key Word: Patience



2016 Developments:

- Of the 29 Manufacturers that initially expressed interest, most are ruled out by phased review, others withdraw interest, a few cease communicating
- 3 Manufacturers remain and express intent to proceed with UL and other testing
  - Each are small (+/-) startup companies
  - Each are delayed by day-to-day business, funding constraints, and focus on developing existing business
- By mid 2016, 2 remain
- By late 2016, 1 remains

> "If all we need to do is have patience, there is no harm in waiting."
>
> J. Hartke

February 2017, GSA Headquarters in Washington DC

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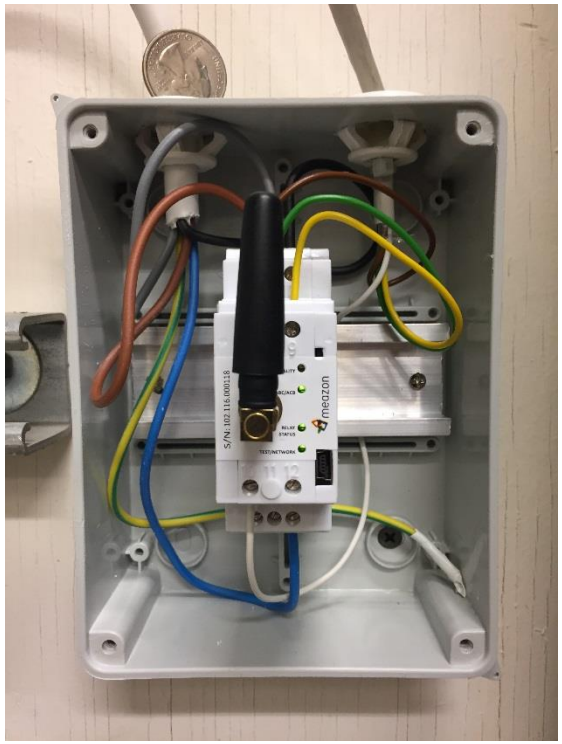

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February 2017, GSA Headquarters in Washington DC

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Results of In-Building Test

- Still preliminary, ongoing analysis at PNNL
- Initial indication look promising; data is consistent and within expectations
- Testing requirement in spec called for communication, which has been successfully demonstrated.
- Final draft in the works

Next Steps and Future Plans

- Close out the project
- Appropriate Recognition for the selected technology may include
  - A follow on announcement to the 2013 S1 quote
  - Plenary Presentation at the Better Buildings Summit
  - Possible presentation at the FEMP - Energy Exchange Conference
  - Individual outreach and/or a webinar to the companies that expressed interest in 2013
  - General press push
- Challenges
  - Will not advertise for a company
  - Selected technology is not US based, but with a US presence

Thank You

Andrew Mitchell

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Appendices

Possible Objections

- Existing pricing models were based on value to end-user, not a “cost- plus” model. This is common in software.
- Generating data from sub meters provides limited use without analysis.
- Feedback from one manufacturer: “Investors don’t want to invest in hardware anymore, nobody else is making money in meters”
  - The real business opportunity is in subscription service for analysis.
- A significant amount of the production cost comes from “off the shelf” router / communication efforts
- Security questions
- Specification too stringent for low cost applications
  - Measuring power on all 3 phases, not calculating
  - Rely on cloud data storage

Partial List of Completed Resources (courtesy of GSA)

- BTRD White Paper: The Power to Control – Submetering of Building Energy and Water Usage National Science and Technology Council, Subcommittee on Buildings Technology Research and Development – October 2011

  http://www.whitehouse.gov/sites/default/files/microsites/ostp/submetering_of_building_energy_and_water_usage.pdf
- Energy Submetering Finance paper – November 2012
- Submeter Comparison
- LEASED ASSET ENERGY AND GHG REPORTING INTERPRETIVE GUIDANCE

  http://www.gsa.gov/portal/mediaId/179639/fileName/GSA_Leased_Asset_GHG_Guidance_FINAL_071713_508_compliant.action
- FEMP METERING BEST PRACTICES: A GUIDE TO ACHIEVING UTILITY RESOURCE EFFICIENCY 2015

  http://energy.gov/eere/femp/downloads/metering-best-practices-guide-achieving-utility-resource-efficiency
- NREL Reducing Plug and Process Loads for a Large Scale, Low Energy Office Building http://www.nrel.gov/sustainable_nrel/pdfs/49002.pdf