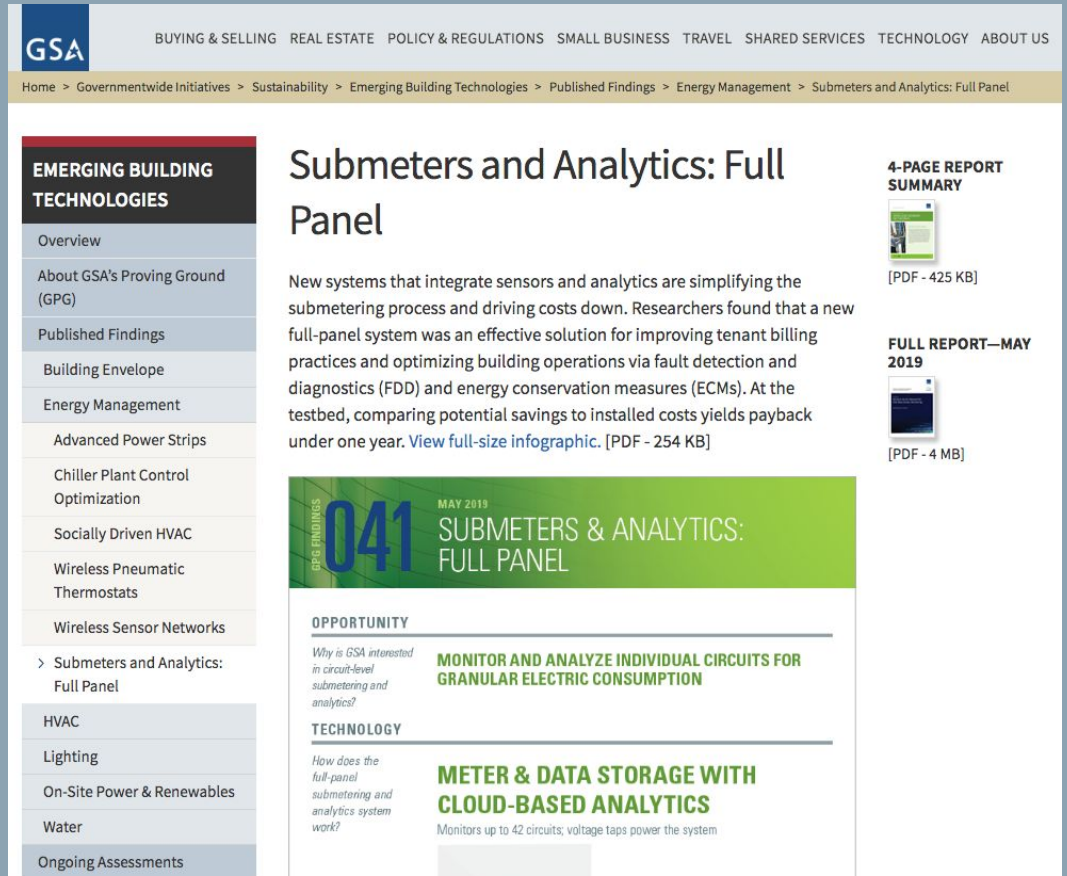
GPG Outbrief 19

Submeters & Analytics: Full Panel

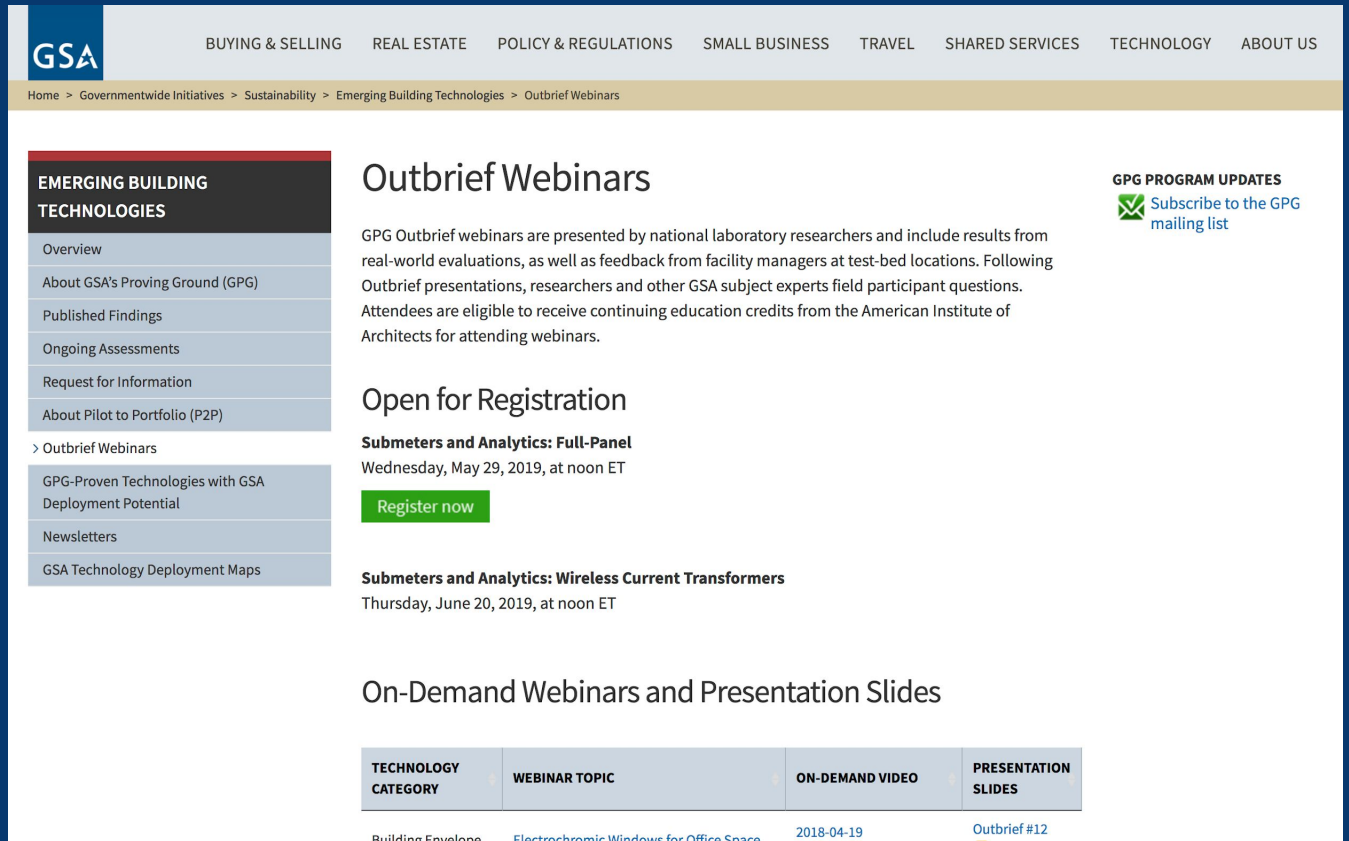
Emerging Building Technologies, GPG Program | U.S. General Services Administration | May 29, 2019

GPG-041 Submeters & Analytics: Full Panel @ gsa.gov/gpg

- Infographic
- 4-page Findings
- Full Report
- Additional Resources



Webinar Recording and Slides Available on gsa.gov/gpg



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EMERGING BUILDING TECHNOLOGIES

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Outbrief Webinars

GPG Outbrief webinars are presented by national laboratory researchers and include results from real-world evaluations, as well as feedback from facility managers at test-bed locations. Following Outbrief presentations, researchers and other GSA subject experts field participant questions. Attendees are eligible to receive continuing education credits from the American Institute of Architects for attending webinars.

Open for Registration

Submeters and Analytics: Full-Panel
Wednesday, May 29, 2019, at noon ET

Register now

Submeters and Analytics: Wireless Current Transformers
Thursday, June 20, 2019, at noon ET

On-Demand Webinars and Presentation Slides

TECHNOLOGY CATEGORY	WEBINAR TOPIC	ON-DEMAND VIDEO	PRESENTATION SLIDES
Building Envelope	Electrochromic Windows for Office Space	2018-04-19	Outbrief #12

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June 20 Submeters & Analytics: Wireless CTs

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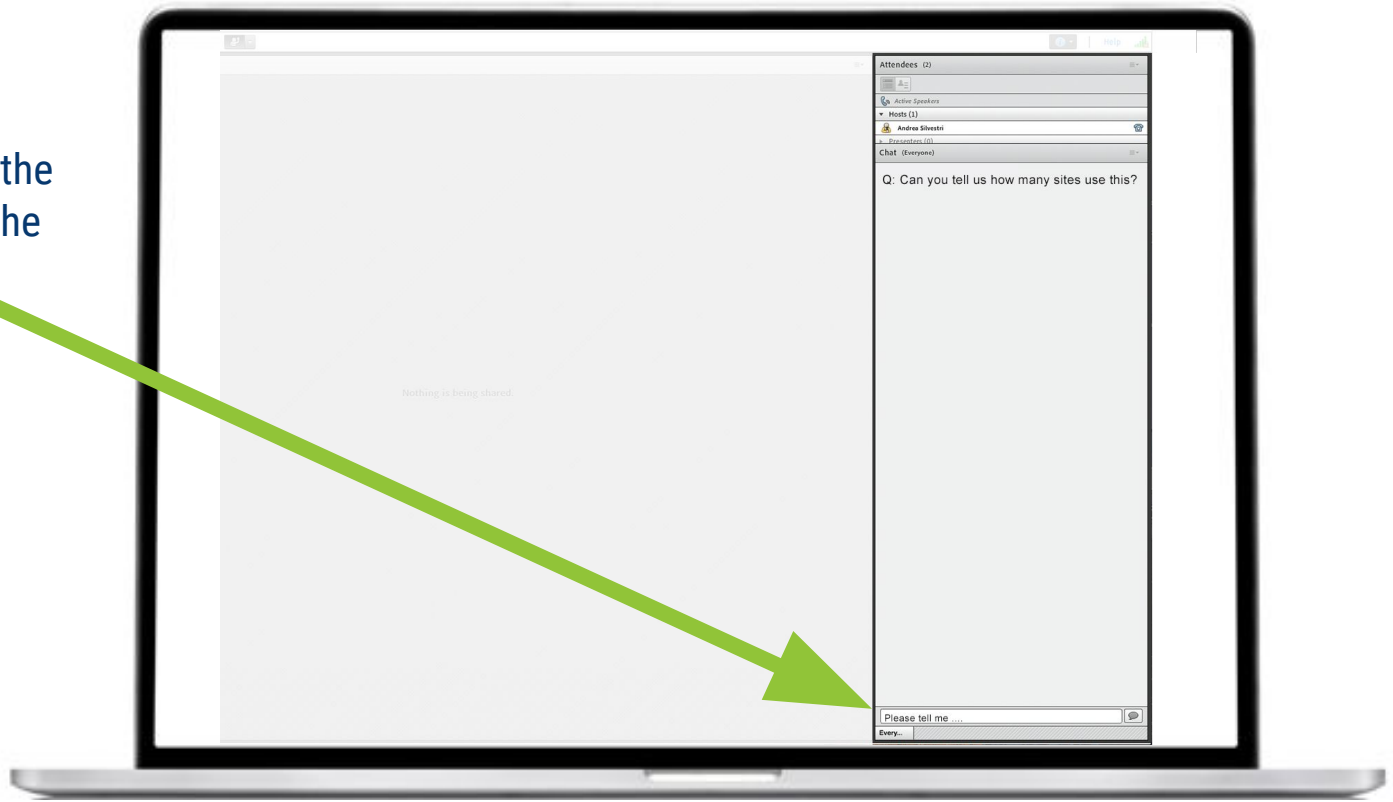

Introduction

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Webinar Agenda

- Introduction (5 minutes)
  Kevin Powell, Director, Center for Emerging Building Technologies
- Submeters & Analytics: Full Panel (20 minutes)
  Dylan Cutler, National Renewable Energy Laboratory
- On-the-ground Feedback (5 minutes)
  Tyler Cooper, GSA Region 8
- Lay of the Land (5 minutes)
  Dylan Cutler, National Renewable Energy Laboratory
- Q & A (20 minutes)

Introduction

Kevin Powell
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Opportunity

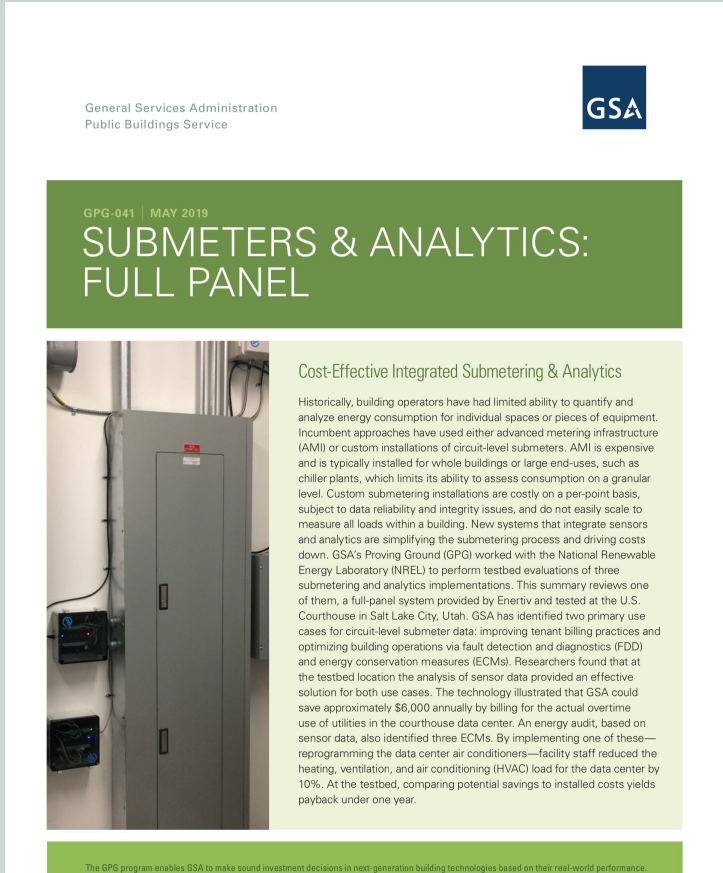
TENANT OR EQUIPMENT-LEVEL BILLING

FAULT DETECTION AND DIAGNOSTICS (FDD)

ENERGY CONSERVATION MEASURES (ECMs)

GPG-041

Submeters & Analytics: Full Panel



General Services Administration
Public Buildings Service

GSA

GPG-041 | MAY 2019

SUBMETERS & ANALYTICS: FULL PANEL

Cost-Effective Integrated Submetering & Analytics

Historically, building operators have had limited ability to quantify and analyze energy consumption for individual spaces or pieces of equipment. Incumbent approaches have used either advanced metering infrastructure (AMI) or custom installations of circuit-level submeters. AMI is expensive and is typically installed for whole buildings or large end-uses, such as chiller plants, which limits its ability to assess consumption on a granular level. Custom submetering installations are costly on a per-point basis, subject to data reliability and integrity issues, and do not easily scale to measure all loads within a building. New systems that integrate sensors and analytics are simplifying the submetering process and driving costs down. GSA's Proving Ground (GPG) worked with the National Renewable Energy Laboratory (NREL) to perform testbed evaluations of three submetering and analytics implementations. This summary reviews one of them, a full-panel system provided by Enertiv and tested at the U.S. Courthouse in Salt Lake City, Utah. GSA has identified two primary use cases for circuit-level submeter data: improving tenant billing practices and optimizing building operations via fault detection and diagnostics (FDD) and energy conservation measures (ECMs). Researchers found that at the testbed location the analysis of sensor data provided an effective solution for both use cases. The technology illustrated that GSA could save approximately $6,000 annually by billing for the actual overtime use of utilities in the courthouse data center. An energy audit, based on sensor data, also identified three ECMs. By implementing one of these—reprogramming the data center air conditioners—facility staff reduced the heating, ventilation, and air conditioning (HVAC) load for the data center by 10%. At the testbed, comparing potential savings to installed costs yields payback under one year.

The GPG program enables GSA to make sound investment decisions in next-generation building technologies based on their real-world performance.

Measurement & Verification

Dylan Cutler
R&D Staff
National Renewable Energy Laboratory

Incumbent Approaches to Submetering

Advanced Metering Infrastructure (AMI)

- Installed on whole building or large end uses
- Limited access to granular data
- Expensive

Custom build of circuit-level submeters

- Data integration and reliability issues
- Don’t scale easily to measure all loads
- Costly on a per-point basis

New Integrated Approaches to Submetering & Analytics

Full-Panel Meters

Monitors 42 circuits. Uses a voltage tap along with CTs. Works with revenue grade and standard accuracy CTs.

Wireless CTs

Clip on sensors powered by current in electrical wire; no meter. Best for fault-detection, low power loads are problematic to track.

Single Circuit Meter

Single, 3-phase circuit. Uses a voltage tap, similar to full panel meters. Best for panel mains, or large pieces of equipment. Available in revenue grade and standard accuracy.

Electromagnetic Field Sensors

Stick-on sensors applied to panel exterior measure current by magnetic fields. Trades accuracy for low installed cost. Best suited for fault detection and diagnostics.

Submeters & Analytics: Full Panel

Technology for M&V
provided by Enertiv

M&V Salt Lake City Courthouse

2 large server rooms

Submeters & Analytics: Full Panel (provided by Enertiv)

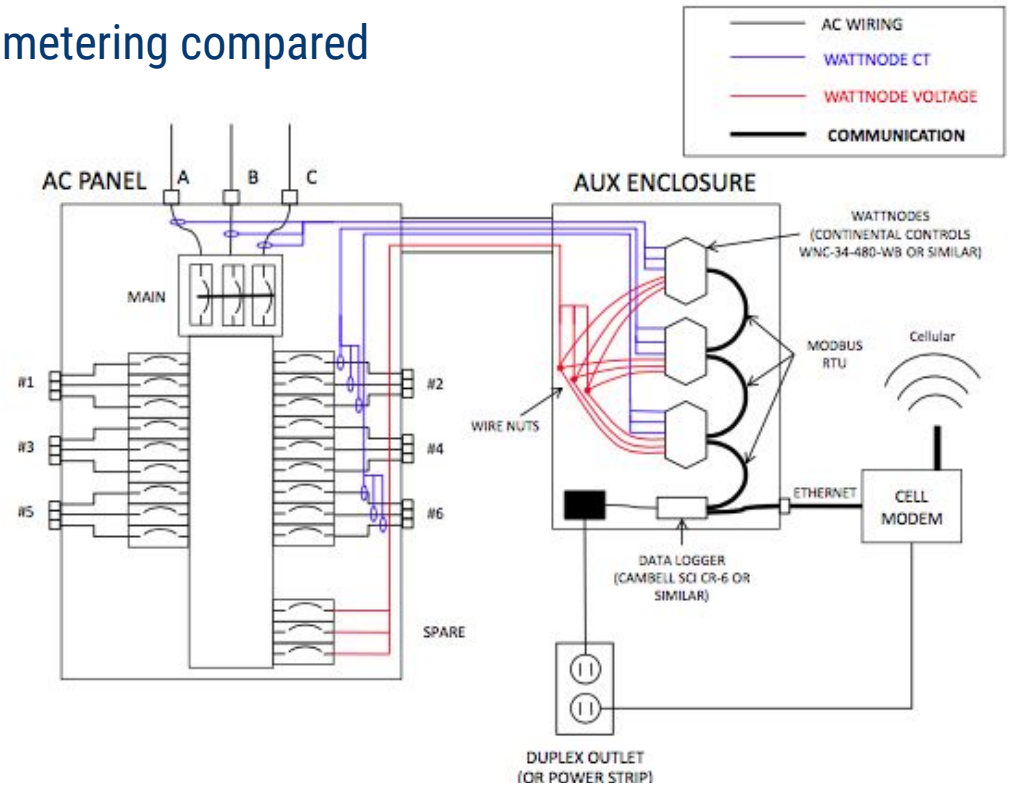
Meter and data storage with cloud-based analytics

- Monitors and provides data on 42 channels
- Voltage tap powers the system
- Can be paired with various CT types

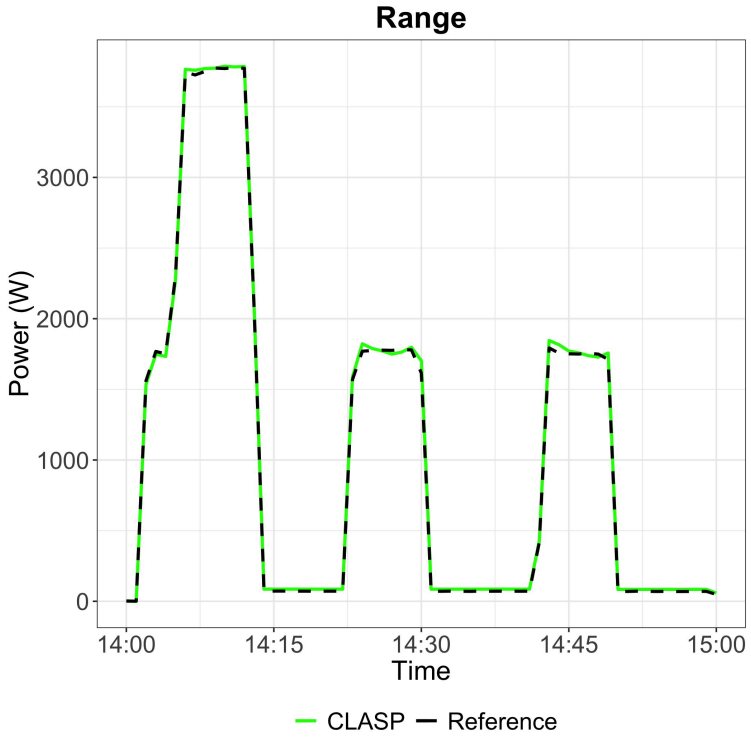
M&V Design

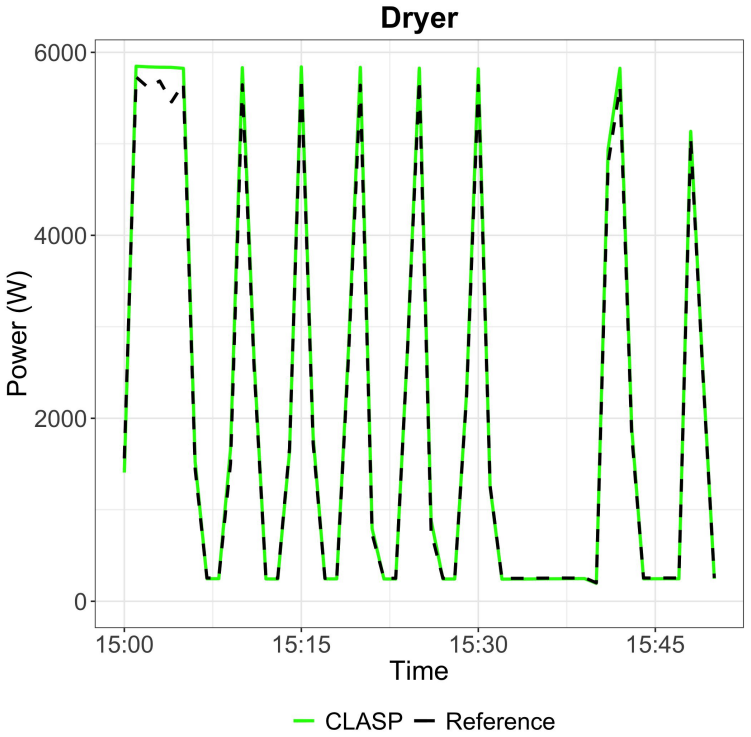
Revenue-grade and circuit-level submetering compared

- Installed revenue grade metering on same set of circuits
- Power and energy data collected at 1-minute intervals
- Compare data recorded over same period of time for accuracy and completeness



Standard-Accuracy Sensor Load Tracking in Laboratory

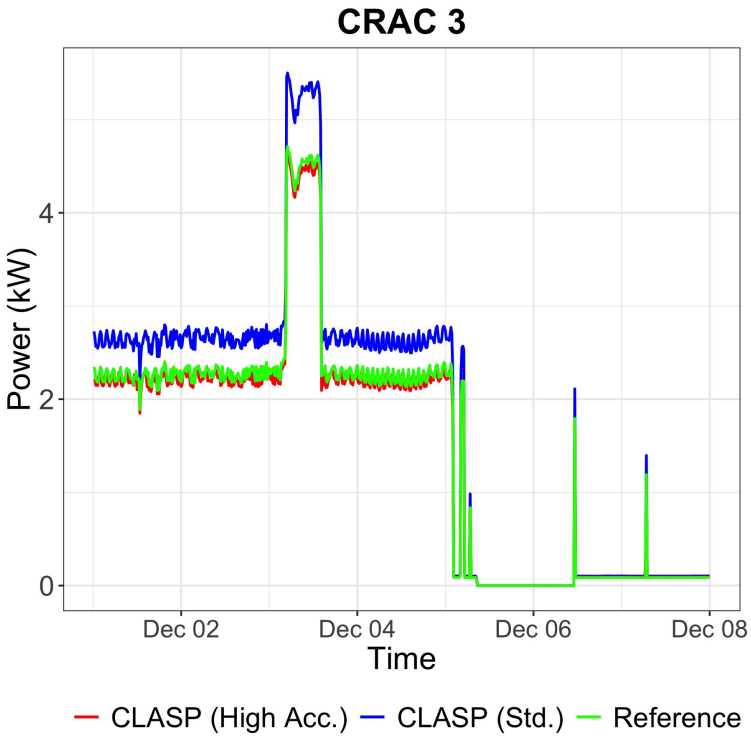


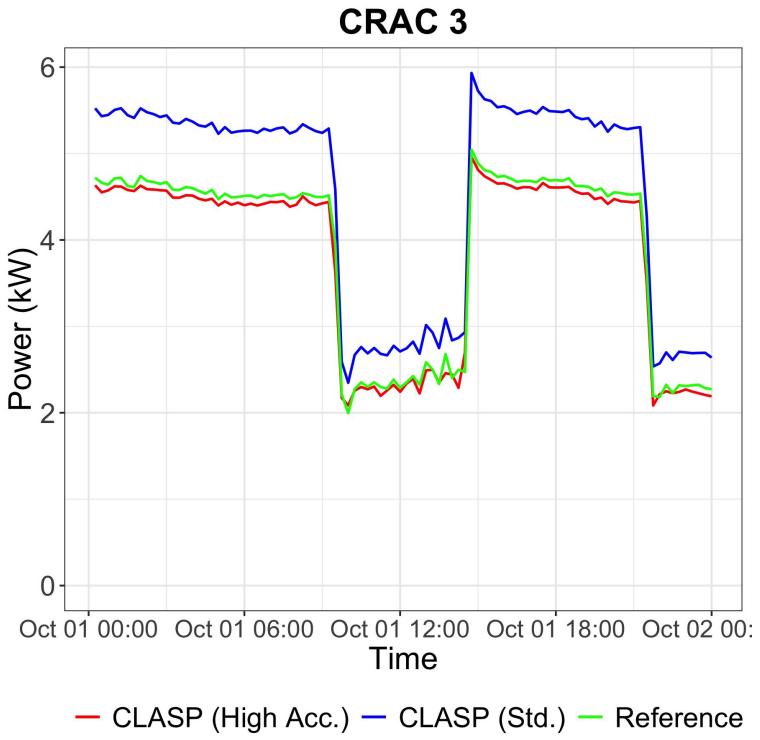


Energy Error in Laboratory

Trial	Appliance	Voltage (V)	Mean Power (W)	Mean Bias (W)	Average Percent Error (%)	RMSPE(%)	Total Energy Error (%)
1	Refrigerator	120	114.30	-1.84	-1.61	1.61	-1.61
2	Washer	120	115.38	4.88	4.60	11.49	4.23
3	Lighting (All)	120	530.53	-12.42	-2.17	3.09	-2.34
4	Lighting (240V)	240	122.16	-23.16	-18.96	18.96	-18.96
5	Dryer	240	2024.44	52.60	0.22	4.49	2.6
6	Water Heater	240	2059.44	53.42	2.38	2.51	2.59
7	TV/DVD	120	103.95	-0.41	-0.87	4.65	-0.39
8	Range	240	1056.91	12.36	10.79	14.31	1.17

Tracking Computer Room Air Conditioner Power at the Testbed



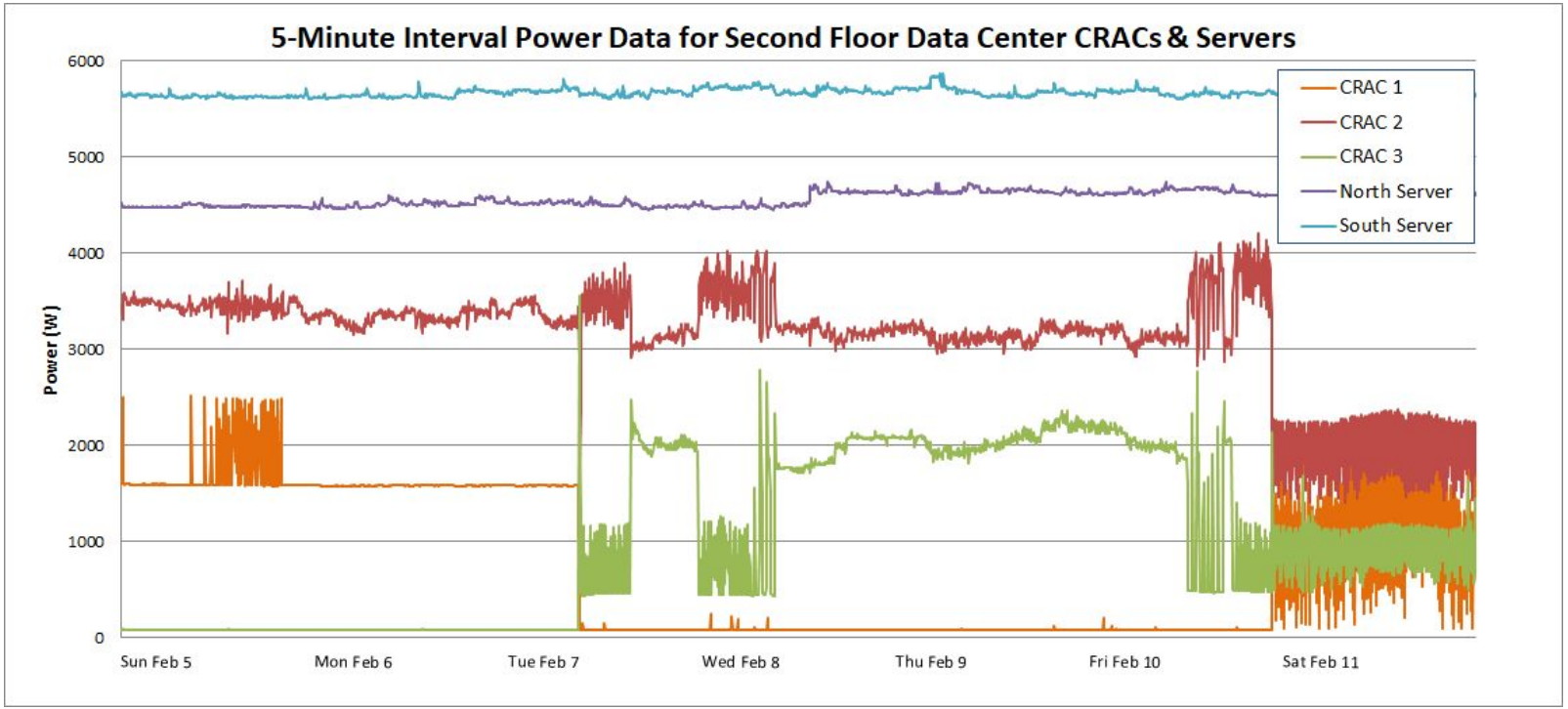


<3% Error in Measurement with High-Accuracy CTs

Equipment	Aug 17	Sep 17	Oct 17	Nov 17
CRAC 1 (Std.CT)	16.54	16.64	16.58	16.15
CRAC 2 (Std.CT)	15.87	15.83	16.3	16.28
CRAC 3 (Std.CT)	-11.76	5.86	16.96	16.83
CRAC 1 (Accu-CT)			-3.18	2.59
CRAC 2 (Accu-CT)			-2.99	-3.19
CRAC 3 (Accu-CT)			-1.64	-1.7

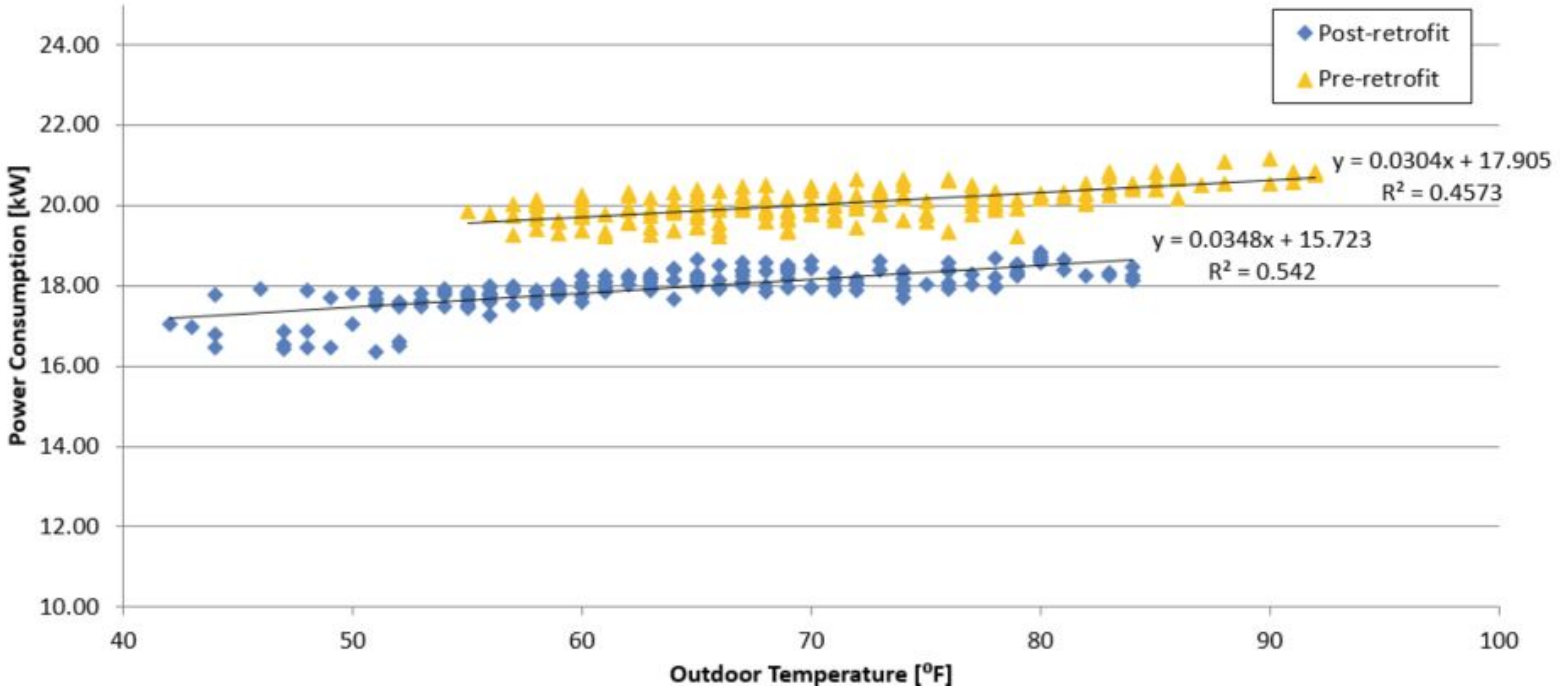
Identifying Energy Conservation Measures

CRAC unit operation



10% Average HVAC Load Savings

1-week power consumption for the 2nd floor server room



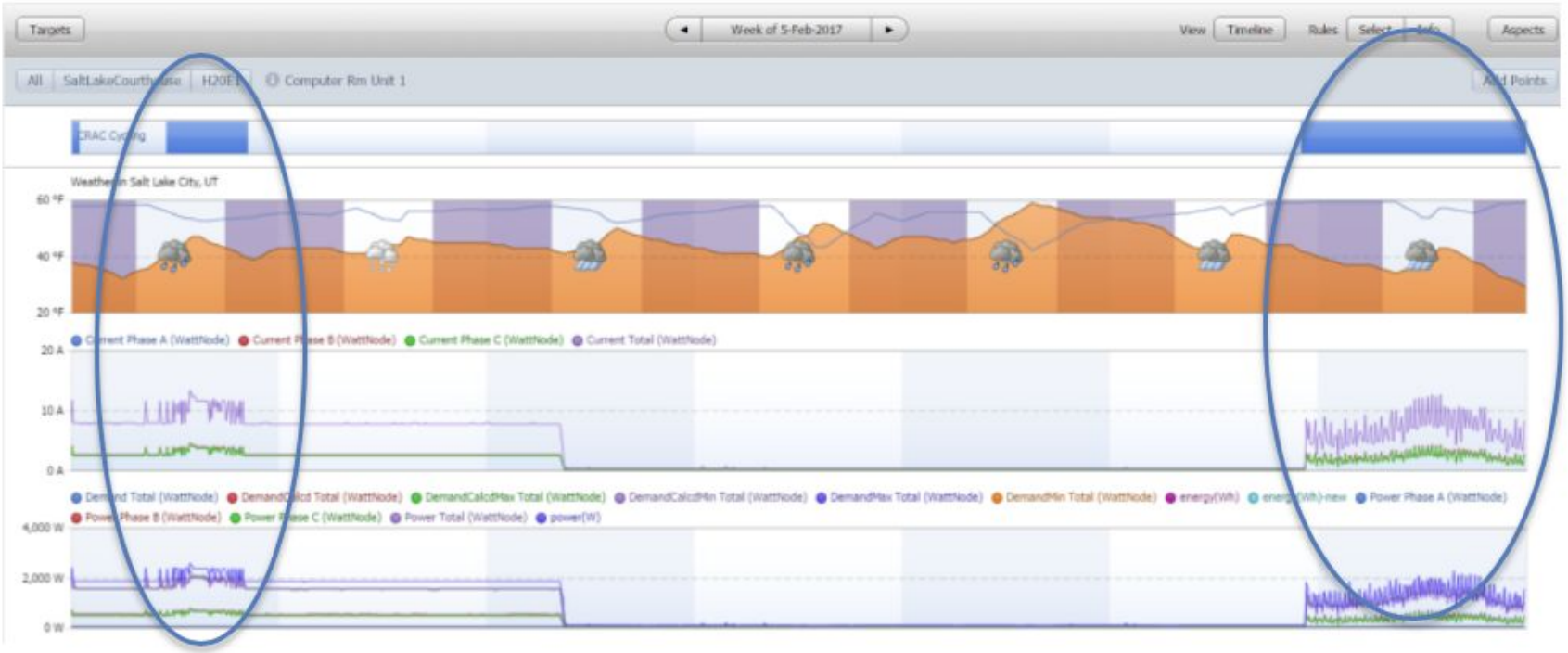
<2-day Installation

14 hours for 5 complete panels with 96 breakers

- Installed in high and low voltage panels with limited space
- Included install in motor control center and cellular gateway integration

Demonstrated Feasibility of GSALink Integration with SkySpark

Integration into SkySpark took 12 hours; screenshot below shows short-cycling on CRAC #1



<1-Year Payback at Testbed

	Full-Panel Circuit-Level Submetering Salt Lake City Courthouse
Equipment Cost for High-Accuracy CTs	$2,415
Installation*	$890
Cost Per Meter ($)	$1,101
Annual Fees ($)	$1,260
Energy Savings from ECM ($)	$1,611
Savings from Tenant Billing ($)	$5,990
Simple Payback (years)	**0.6**
Savings-to-Investment Ratio	**4.8**

*Labor is 2.5 hours per meter @ $59/hr, additional setup and parts cost is estimated at $250/meter

Recurring annual fees are high in comparison to initial expense

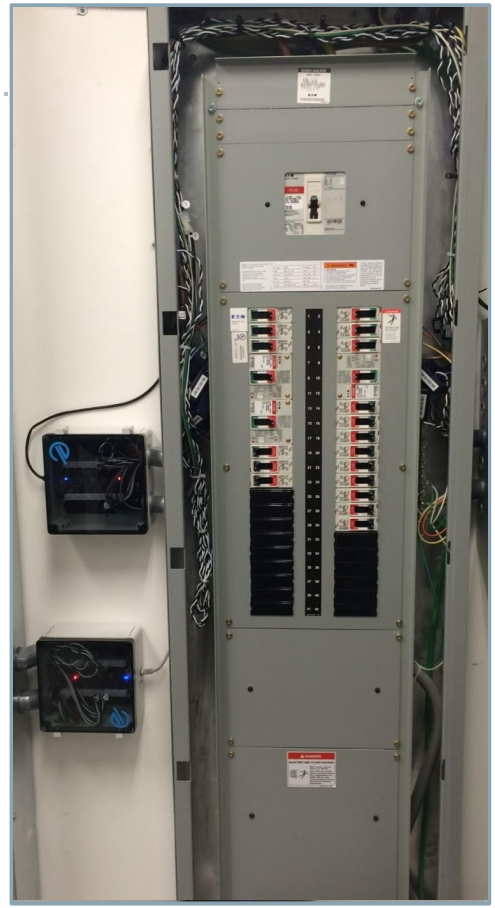
Lessons Learned & Best Practices

- For tenant billing, use high accuracy CTs with a phase angle shift <0.5°.
  High accuracy CT cost: $30–$70. Standard CT cost: $3–$5.
- Size CTs to estimated power levels. Estimate by metering current with an ammeter.
- Identify wall space; the enclosure is 7” x 7” x 3.5”. Conduit runs from the enclosure to the panel so proximity to the panel is desirable. Exercise caution to avoid clutter when laying the cabling of the CTs.
- Tracing loads to individual circuits may be an expensive process for locations with many low-load receptacles. Define monitoring goals prior to deployment.
- A registered electrician is required. A spare breaker in the panel facilitates installation.

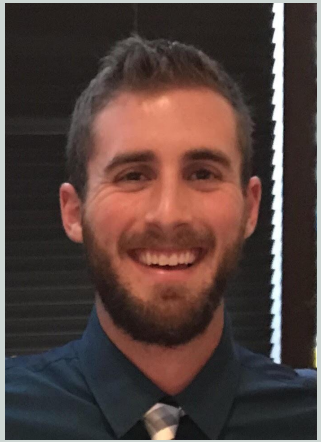
Deployment Recommendation

Best use cases

- Overtime billing for devices with high power consumption
- Loads and devices not currently integrated into BAS could also benefit from FDD and ECMs identification



GSA Feedback—Salt Lake City Courthouse



Tyler Cooper
Supervisory Energy PM
GSA Region 8

Installation

- Choose a targeted approach where there is potential for savings (high operational cost equipment)
- Not cost-effective to install for ECM identification and then move it to another location
- For tenant billing, would want to keep meters in place

Operator Engagement

Not currently being used

- Integrate into GSALink to minimize platform interfaces
  - Renegotiate ongoing fees to balance costs and savings
- It did its job but this is ongoing
  - Research shows faults are corrected but then they fall out of tune
  - Audit every 4 years is standard practice
- Bridge the gap between M&V and ongoing operation

Potential Use Cases

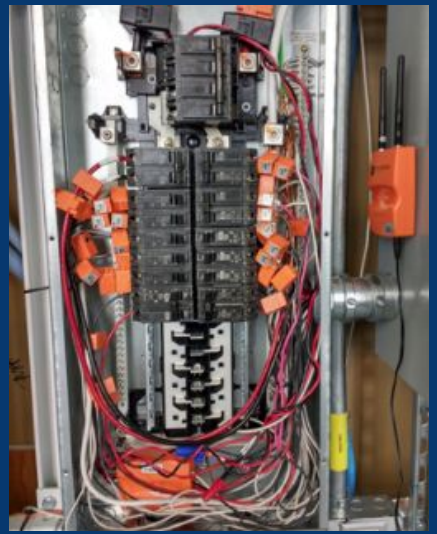
ESPC Measurement and Verification

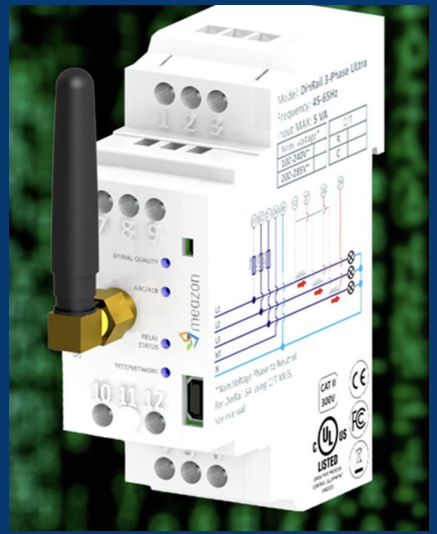
- Any replacement of mechanical equipment
- Operational Changes

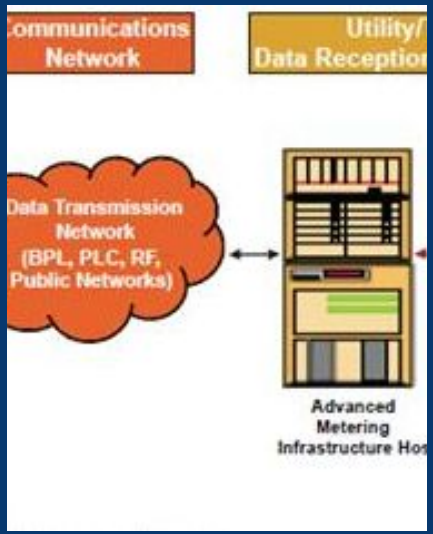
Data Center Metering (Power Usage Effectiveness)

U.S. Courts

Submeter & Analytics Types







Submeter & Analytics Types

	GPG 041 Full Panel Meter	GPG 042 Wireless CTs	Ongoing GPG M&V Single Circuit	Not evaluated Electromagnetic Field Sensors	AMI Advanced Metering Systems
	Monitors 42 circuits. Uses a voltage tap along with CTs.	Clip on sensors powered by current in electrical wire; no meter. Best for fault detection.	Single, 3-phase circuit. Uses a voltage tap, similar to full panel meters. Best for large pieces of equipment.	Stick-on sensors measure current by magnetic fields. Trades accuracy for low installed cost. Best for fault detection.	Hardware and software combine interval data with remote communications. Revenue grade.
Tenant-Equipment Billing	✓		✓		✓
Fault Detection & Diagnostics	✓	✓		✓	
Energy Visibility	✓	✓		✓	
ECM Capturing	✓		✓		✓
Equipment Cost ($)	Meter: $500-$850 Revenue CT: $30-$70 Standard CT: $3-$5	No meter required Standard 3-phase circuit CT: $35-$50	Meter: $200-$400 Revenue CT: $60-$80	Meter: $100 estimated Not fully commercialized	Meter: $150-$2,000 System integration can add up to $10,000 per meter
Annual Subscription ($)	$420 per meter	$15 per CT at the time of the evaluation, ongoing subscription costs have since been eliminated	Ongoing GPG evaluation	Unknown	Varies

Q & A

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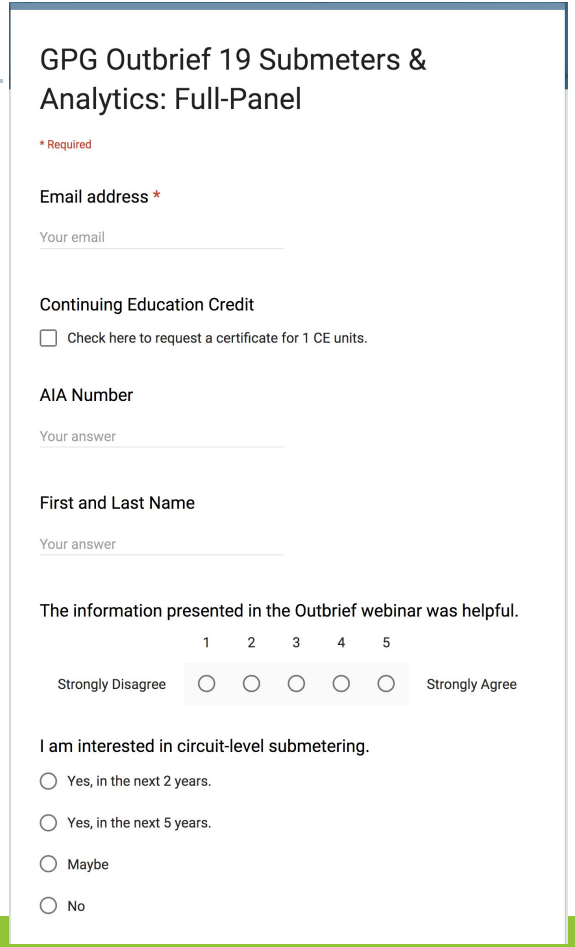

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The information presented in the Outbrief webinar was helpful.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I am interested in circuit-level submetering.

- ○ Yes, in the next 2 years.
- ○ Yes, in the next 5 years.
- ○ Maybe
- ○ No

Thank you

For more information: gsa.gov/GPG

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