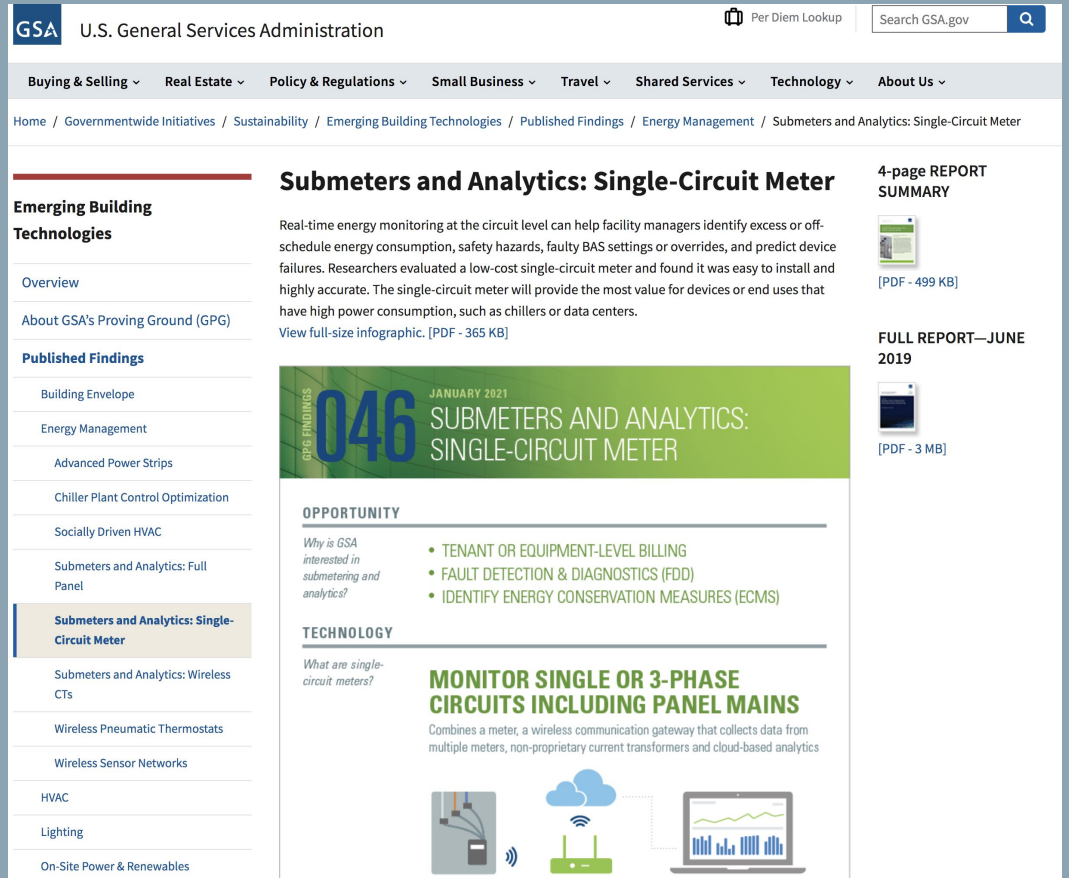
GPG Outbrief 23

Submeters & Analytics: Single-Circuit Meters

Emerging Building Technologies, GPG Program | U.S. General Services Administration | February 25, 2021

GPG-046 Submeters & Analytics: Single-Circuit Meter @ gsa.gov/gpg

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



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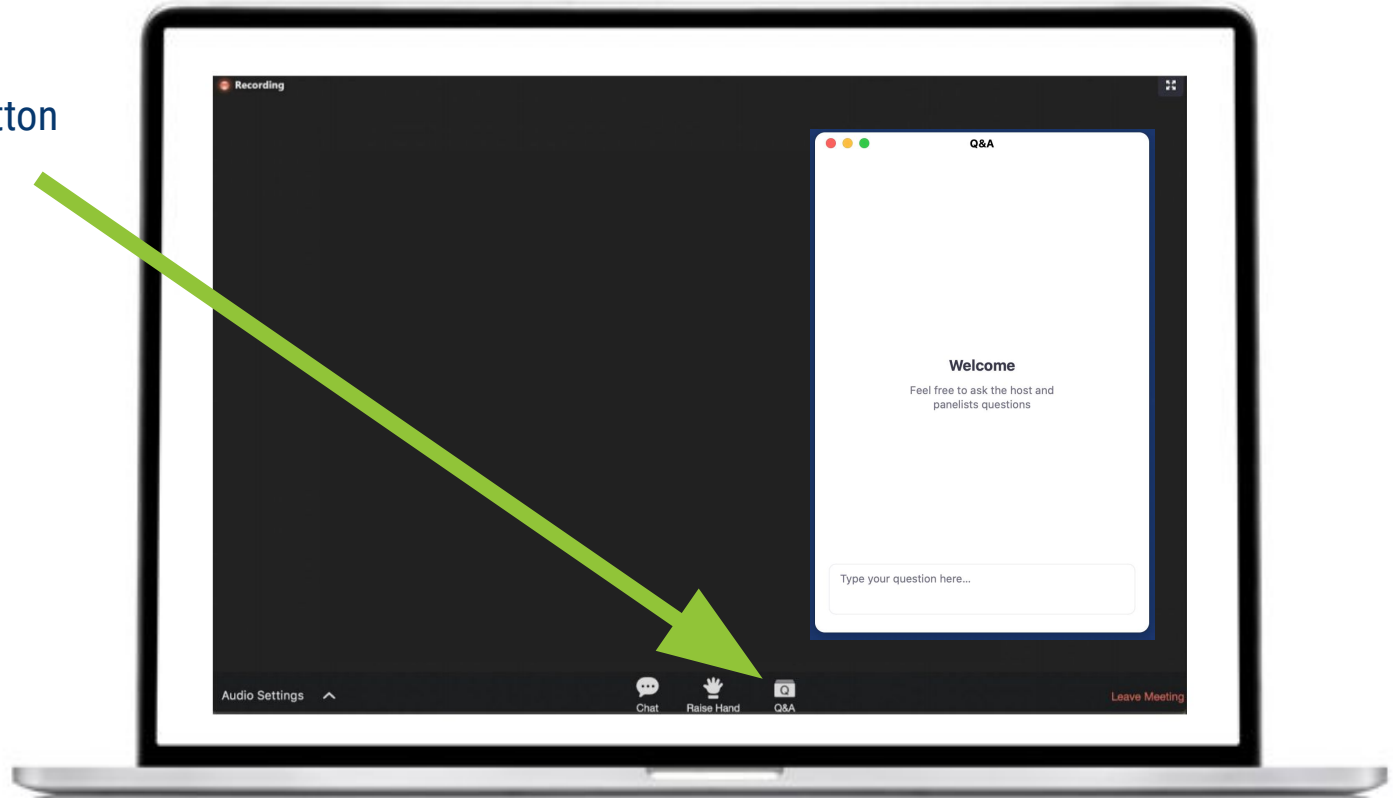
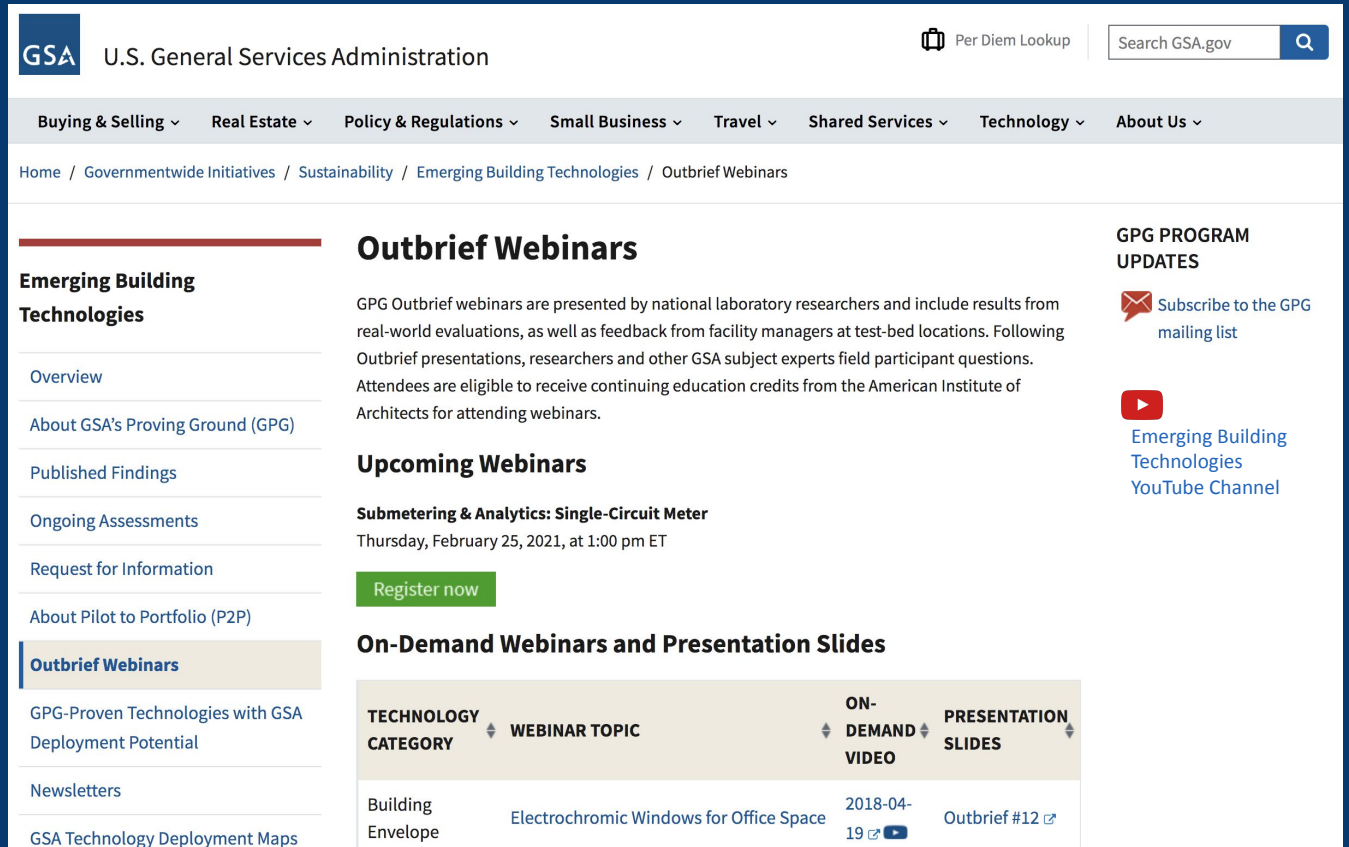


Webinar Recording and Slides Available on gsa.gov/gpg



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Emerging Building Technologies

- Overview
- About GSA's Proving Ground (GPG)
- Published Findings
- Ongoing Assessments
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- About Pilot to Portfolio (P2P)
- **Outbrief Webinars**
- GPG-Proven Technologies with GSA Deployment Potential
- Newsletters
- GSA Technology Deployment Maps

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.

Upcoming Webinars

Submetering & Analytics: Single-Circuit Meter
Thursday, February 25, 2021, at 1:00 pm ET

Register now

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Introduction

Michael Lowell
Project Manager, GPG
mike.lowell@gsa.gov
720.641.8891

Webinar Agenda

- Introduction (5 minutes)
  Kevin Powell, Director, Center for Emerging Building Technologies
- Submeters & Analytics: Single-Circuit Meter (20 minutes)
  Willy Bernal Heredia, National Renewable Energy Laboratory
- On-the-ground Feedback (10 minutes)
  Tyler Cooper, GSA Region 8
- Lay of the Land (5 minutes)
  Willy Bernal Heredia, National Renewable Energy Laboratory
- Q&A (20 minutes)

Introduction

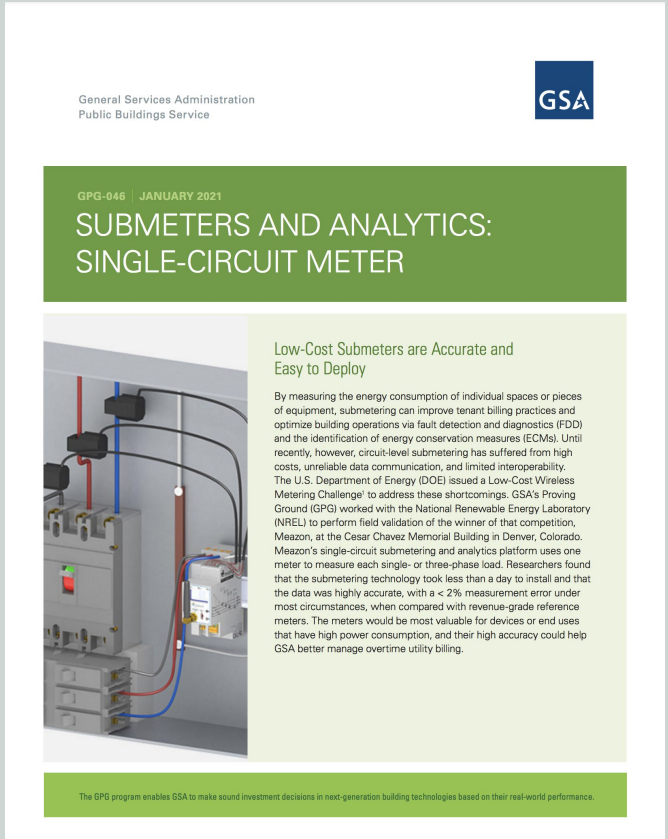
Kevin Powell
Director, Center for Emerging Building Technologies
kevin.powell@gsa.gov
510.423.3384

Opportunity

- TENANT OR EQUIPMENT-LEVEL BILLING
- FAULT DETECTION AND DIAGNOSTICS (FDD)
- IDENTIFYING ENERGY CONSERVATION MEASURES (ECMS)
- PROVIDING M&V FOR ECM MEASURES

GPG-046

Submeters & Analytics: Single-Circuit Meter



General Services Administration
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GSA

GPG-046 | JANUARY 2021

SUBMETERS AND ANALYTICS: SINGLE-CIRCUIT METER

Low-Cost Submeters are Accurate and Easy to Deploy

By measuring the energy consumption of individual spaces or pieces of equipment, submetering can improve tenant billing practices and optimize building operations via fault detection and diagnostics (FDD) and the identification of energy conservation measures (ECMs). Until recently, however, circuit-level submetering has suffered from high costs, unreliable data communication, and limited interoperability. The U.S. Department of Energy (DOE) issued a Low-Cost Wireless Metering Challenge[1] to address these shortcomings. GSA's Proving Ground (GPG) worked with the National Renewable Energy Laboratory (NREL) to perform field validation of the winner of that competition, Meazon, at the Cesar Chavez Memorial Building in Denver, Colorado. Meazon's single-circuit submetering and analytics platform uses one meter to measure each single- or three-phase load. Researchers found that the submetering technology took less than a day to install and that the data was highly accurate, with a < 2% measurement error under most circumstances, when compared with revenue-grade reference meters. The meters would be most valuable for devices or end uses that have high power consumption, and their high accuracy could help GSA better manage overtime utility billing.

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

Measurement & Verification

Willy Bernal Heredia
Research Engineer
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 reliability and integrity issues
- Don’t scale easily to measure all loads
- Costly on a per-point basis

New Integrated Approaches to Submetering & Analytics

Full-Panel Meters

GPG 041- Enertiv

Monitors up to 42 single- and 3-phase circuits in a panel. Uses a voltage tap along with CTs.

Wireless CTs

GPG 042 - Centrica

Standard CT clips on and is powered by current in electrical wire. Best for FDD.

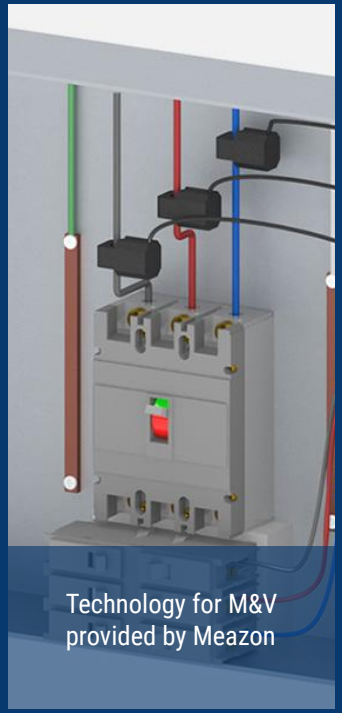
Single Circuit Meter

GPG 046 - Meazon

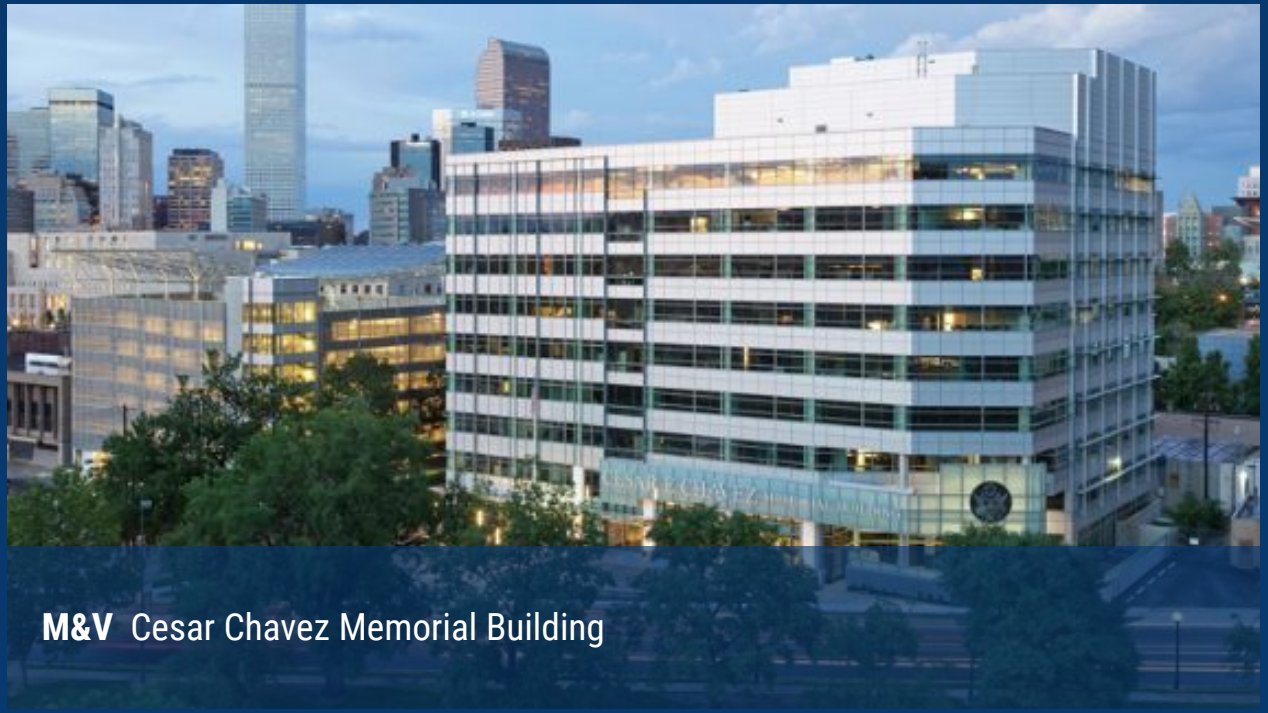
GPG 042 - Centrica

Monitors single and 3-phase circuits. Uses a voltage tap, similar to full panel meters. Best for large pieces of equipment or panel mains.

Submeters & Analytics: Single-Circuit Meter



Technology for M&V
provided by Meazon



M&V Cesar Chavez Memorial Building

Submeters & Analytics: Single-Circuit Meter (provided by Meazon)

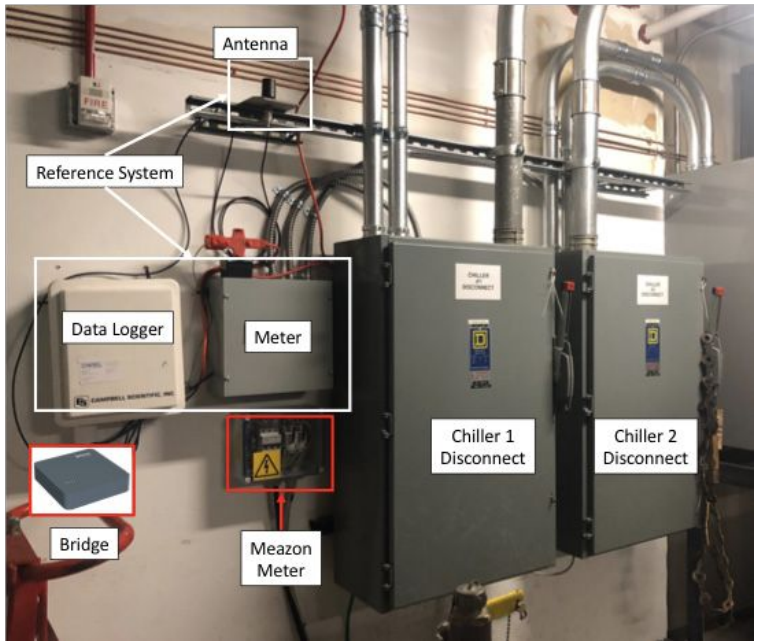
Monitor Single or 3-Phase Circuits Including Panel Mains

- Combines a meter, a wireless communication gateway that collects data from multiple meters
- Non-proprietary current transformers with a voltage tap and cloud-based analytics

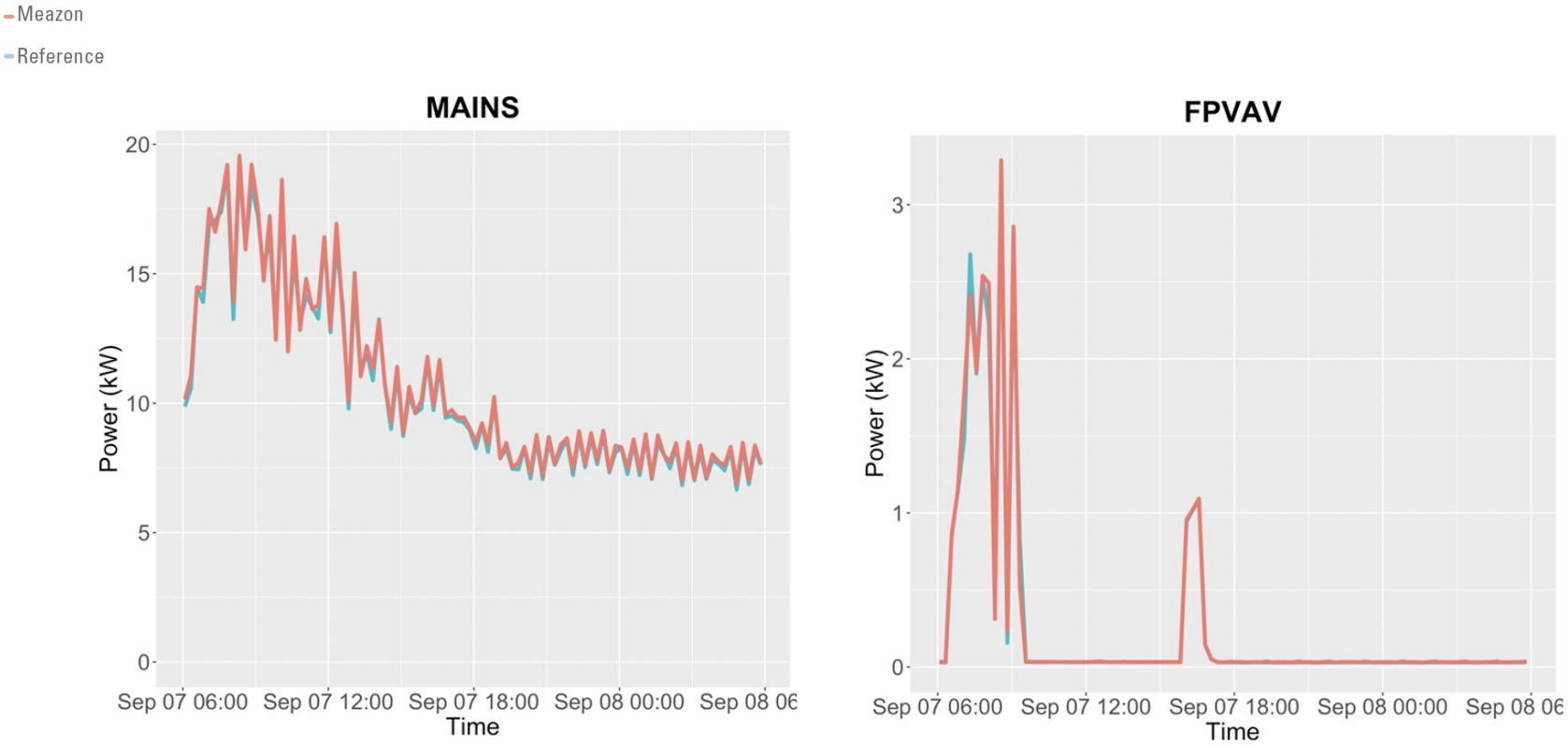
M&V Design

Revenue-grade and circuit-level submetering compared

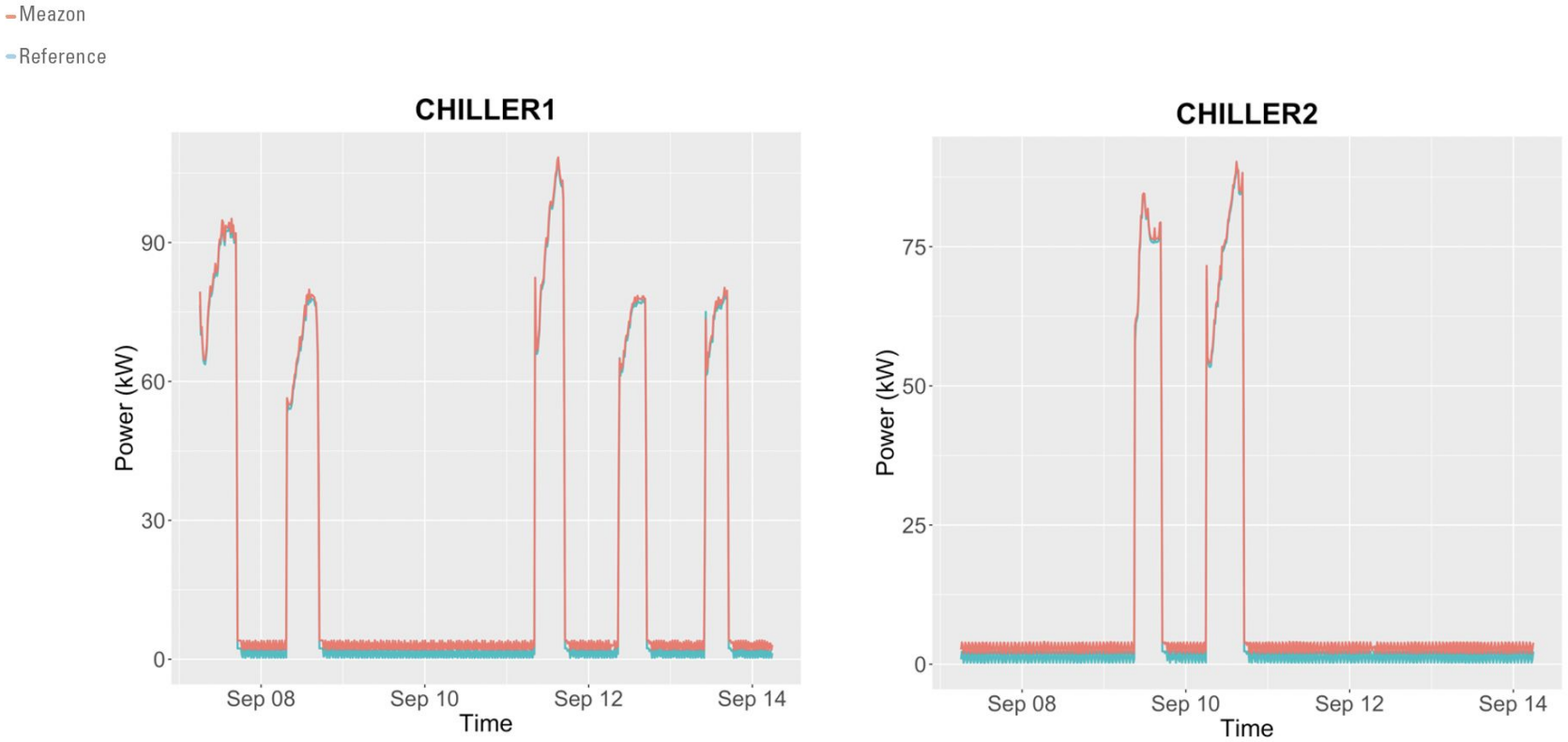
- Installed revenue grade metering on same set of circuits
- Power and energy data collected at 1-minute intervals
- Compare data recorded over same period of time for accuracy and completeness



Accurately Tracks Consumption

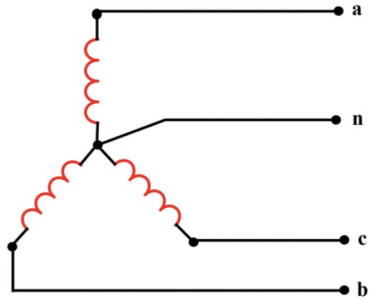


Accurately Tracks Load Profile and Consumption @ >2.5kW Power

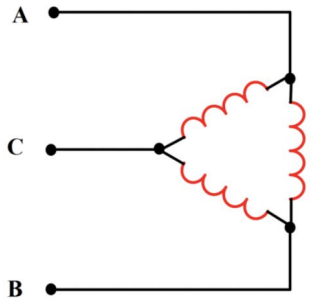


Wye vs. Delta Configurations

- Wye-configuration loads not impacted at low-power factor and low currents.
- Delta-configuration loads are used for large motors or heaters and were less accurate.
- Vendor has developed new meters that should improve accuracy for Delta loads. High-accuracy CTs can also mitigate measurement errors.



Wye Configuration



Delta Configuration

<2% Measurement Error Except when Chillers Idling

Equipment	Range	# Points	Ref. Avg. Power (kW)	Avg. Error (%)	RMSPE (%)	Total Energy Error (%)
Fan-Powered VAV	All	2,280	0.4	3.5	23.1	0.8
Mains	All	2,280	1.1	1.8	3.1	1.7
Chiller 1	All	2,280	11.7	223.7	304.8	13.8
	> 2.5 kW	**308**	**79.3**	**1.14**	**2.3**	**1.1**
Chiller 2	All	2,280	15.8	190.6	293.6	9.0
	> 2.5 kW	**491**	**68.4**	**1**	**2.7**	**0.9**

1-Day Installation for Six Measured Loads

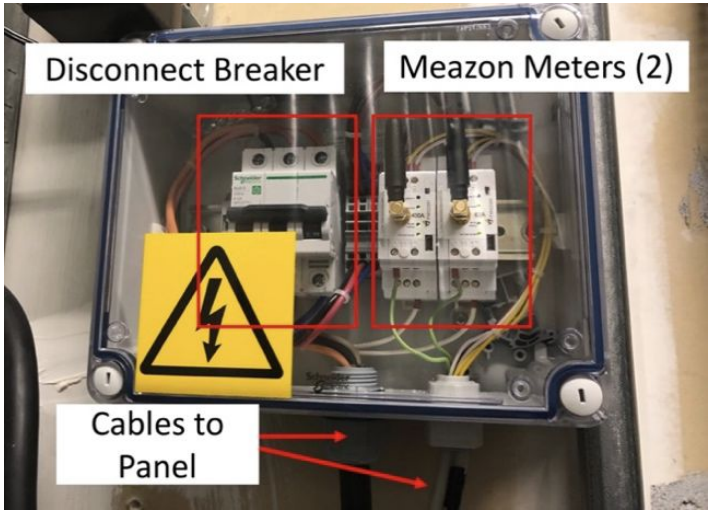
6 hours for 3 gateways* collecting data from 18 CTs and 6 meters distributed in 2 panels and 2 HVAC disconnects

Meters preconfigured with 2 meters and 1 breaker disconnect in 3 electrical boxes

- Reduces panel space requirements
- Reduces onsite installation time
- Simplifies troubleshooting

Installation not disruptive

- Panel did not need to be de-energized
- Requires certified electrician



*15 meters maximum per gateway, 1 gateway per electrical room

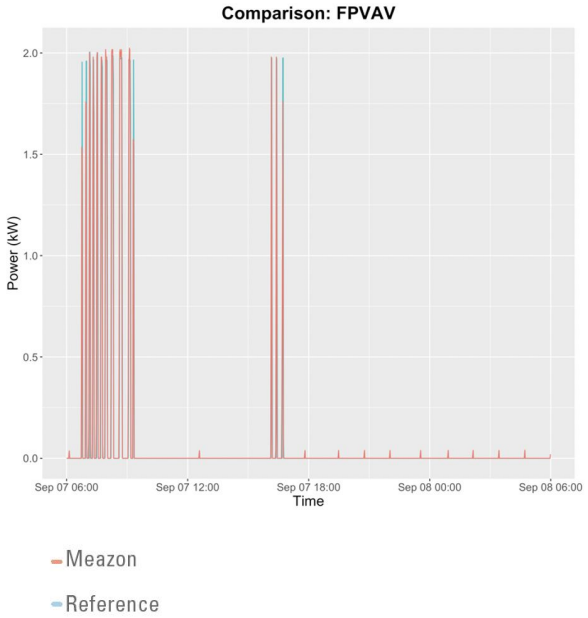
GSA IT Security Clearance

- For the pilot, GPG was permitted to set up a stand-alone network for metering system component communication, and a dedicated cellular service to transmit anonymized data to the cloud.
- Connectivity to any other GSA system, (BAS, metering, GSAlink, etc,) is not permitted without full GSA IT security review and approval of the vendors hardware and software.
- GPG is coordinating with GSA IT Security to determine the cyber-clearance process required for broad deployment.

Accurate High-Resolution Data Supports FDD and Identifying ECMs

Identification equipment faults or inefficient operation not part of the evaluation

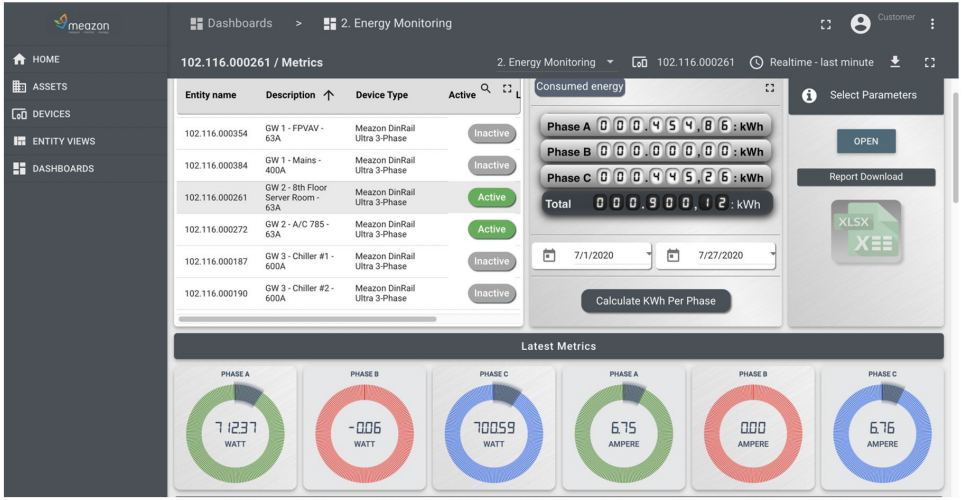
- For facilities without a BAS, accurate high-resolution data could support FDD and ECMs
- For facilities with a BAS, can monitor systems not typically monitored such as lighting and plug loads

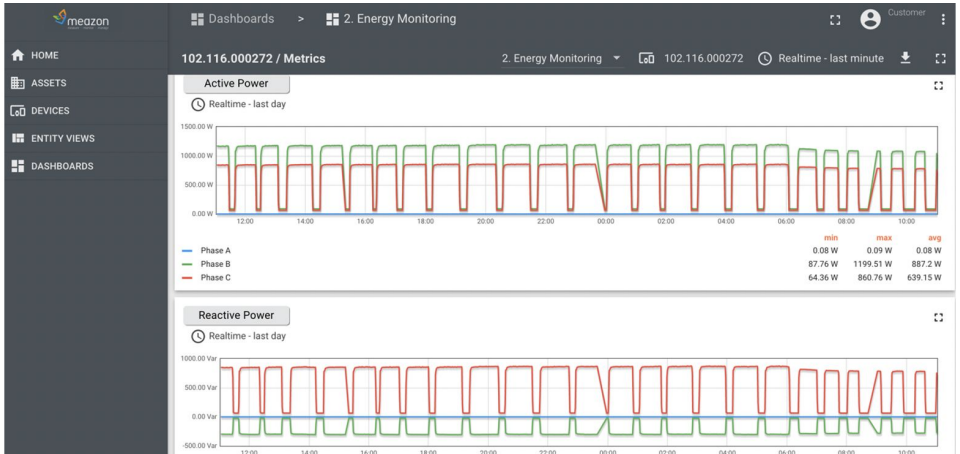


Cloud-Based Analytics

Monitoring, control and analytics

- Rule-based alarms and benchmarking as well as FDD algorithms
- Ongoing annual subscription costs of $12 to $48 per meter depending on features, no ongoing costs to integrate data into GSALink or other analytics package

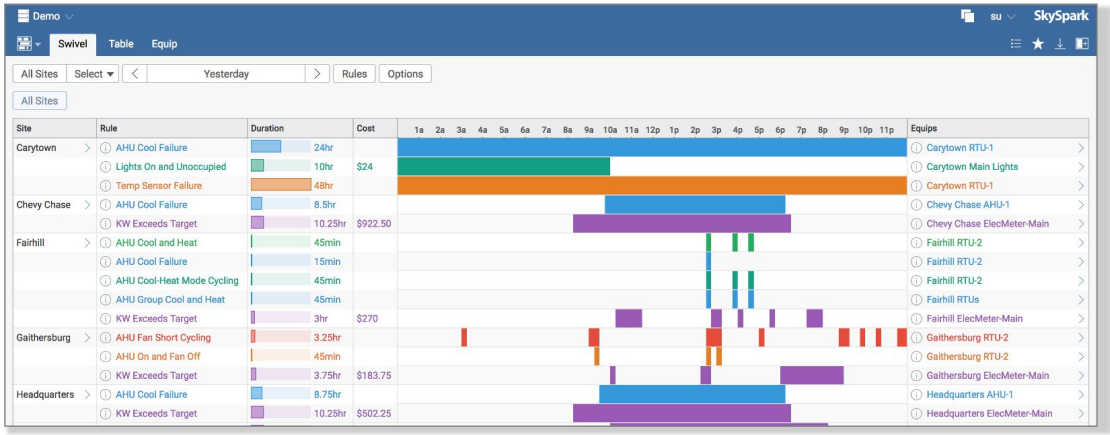




GSALink Integration

Demonstrated feasibility of integration with GSALink, no ongoing subscription costs

- Challenge accessing web-hosted data and ensuring firewall exception requests
- Developed stand-alone Python script that communicates with submetering API and stores data locally to be uploaded later into GSALink



Cost Per Measured Load at Testbed $900, Bulk Price

	Single-Circuit Meter Cesar Chavez Federal Building
Equipment Cost	$2,818
Equipment Cost, Volume Discount*	$1,980
Pre-configuration	$2,140
Electrical Installation	$450
Subscription	$0
Total Cost	$5,408
Per-Point Cost Testbed	**$901**
Per-Point Cost Volume Discount	**$443**

*1,000 meters and 100 gateways

Lessons Learned

- Line of sight is important to ensure reliable communication between wireless meters and the gateway
- One gateway per electrical room is recommended to avoid interference
- Preconfiguring meters in separate enclosures saves time and panel space and simplifies future troubleshooting, as electrical panels do not need to be opened
- If using a single CT on three-phase equipment, the load should be well balanced

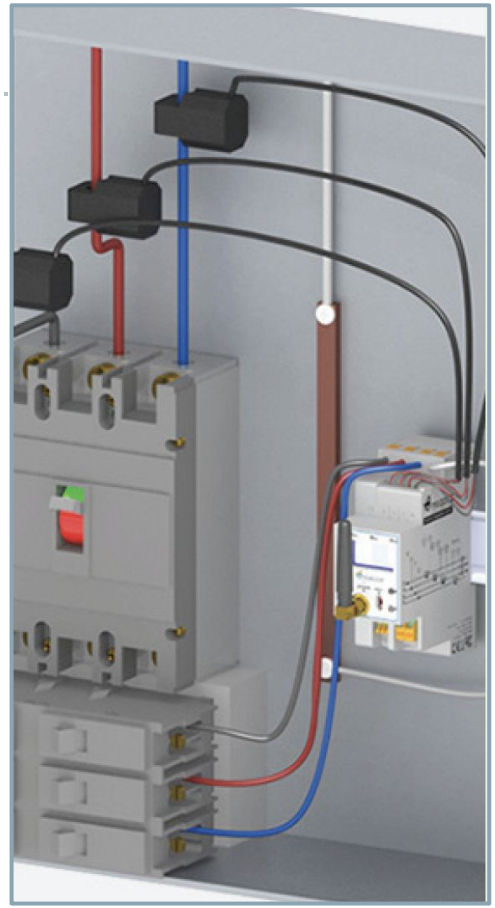
Best Practices

- Size CTs to estimated power levels, as opposed to rated breaker values, to decrease measurement uncertainty
- Use amp meter to spot check current at full load
- Avoid under-sizing a CT because it might lead to inaccurate readings and, eventually, a damaged CT
- Install higher accuracy CTs for error-sensitive applications. The incremental cost of high-accuracy CTs is approximately 10%
- Have clear monitoring objectives before installing submetering because identifying circuits can be a time-consuming process

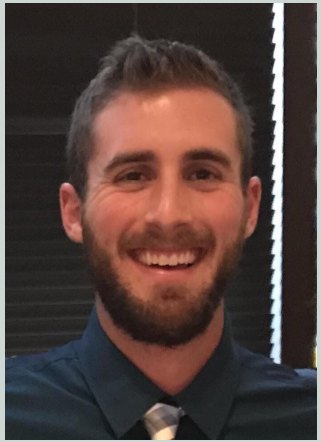
Deployment Recommendation

Best Use Case

- More accurate tenant billing
- Monitors entire panel (mains) or individual loads
- Most value for overtime utilities or devices that have high power consumption
- Loads & devices not currently integrated into GSALink can benefit from FDD or ECM identification



GSA Feedback—Cesar Chavez Memorial Building



Tyler Cooper
Supervisory Energy PM
GSA Region 8

Installation & Maintenance

- Preplanning, do a complete electrical panel inventory in your building, choose what you want to monitor
- Installing meters in a separate panel gives more freedom and is easier for maintenance
- Set and forget technology and tells you when it’s not working because it stops communicating data

Low cost compared to full scale metering efforts

Primary Use Case

Accurate billing for tenant equipment

In a previous submetering evaluation in R8 at the Salt Lake City courthouse, estimate for overtime utility billing was ½ of the measured use

Secondary Use Cases

Guiding Principles and energy allocation across buildings

- Chillers, other central plant equipment
- Fault detection and diagnostics for facilities without GSALink

ESPCs and M&V activities

R8 Pilot Integrating Meter Data and Skyspark (GSALink)

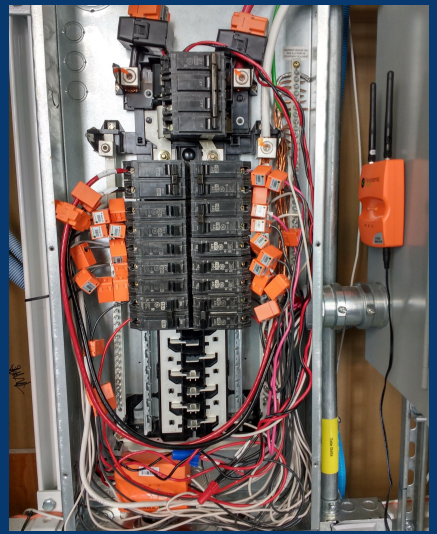
Integrating advanced metering data into Skyspark via R8 server

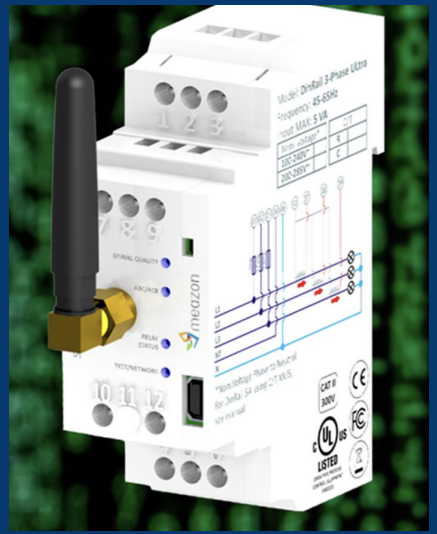
- Duplicate of national server that R8 has access to and can modify
- Connects AMI data from facilities that don't have GSALink
- R8 has been pursuing AMI since 2007
- Data is used by Energy and Sustainability team, will bring in building managers down the line
- Looking for another metering solution, current AMI provider, Schneider, is discontinuing current option and it's expensive to maintain
- Single-circuit data is more granular and not at switchgear

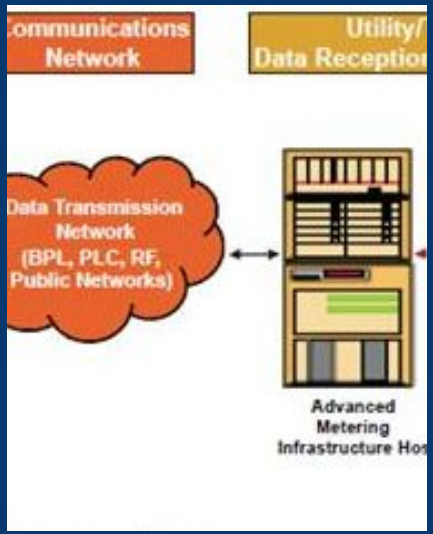
Deployment Hurdles

- GSA IT-Security clearance
- Connecting data to GSALink

Submeter & Analytics Types







Submeter & Analytics Types

	GPG 041 Full Panel Meter Enertiv	GPG 042 Wireless CTs Centrica	GPG 042 Voltage-Tap CTs Centrica	GPG 046 Single Circuit Meter Meazon	AMI Advanced Metering Systems
	Monitors up to 42 single- & 3-phase circuits in a panel. Uses a voltage tap.	Standard CT clips on and is powered by current in electrical wire	Monitor single & 3-phase circuits. Uses a voltage tap, similar to full-panel meters. Best for large pieces of equipment or panel mains.		Combines interval data with remote communications. Revenue grade. Only cost-effective for large, isolated loads.
Tenant-Equipment Billing	✓		✓	✓	✓
Fault Detection & Diagnostics	✓	✓	✓	✓	
Energy Visibility	✓	✓	✓	✓	
ECM Capturing	✓		✓	✓	✓
Testbed Accuracy	<3% measurement error with high accuracy CTs	7% avg. measurement error (-10% to +25% total error) Accurately tracks load profile	<2% measurement error	<2% measurement error	
Testbed Cost	$1,100/meter	$740/3-phase load*	$840/3-phase load*	$900/3-phase load*	Meter: $150-$2,000 System integration can add up to $10,000 per meter
Annual Subscription ($)	$400/meter	None, includes energy use dashboard	None, includes energy use dashboard	None, if integrating data into other systems; $12-48/meter for cloud-based analytics	Varies

*costs decrease when monitoring multiple loads in a panel or room

Q & A

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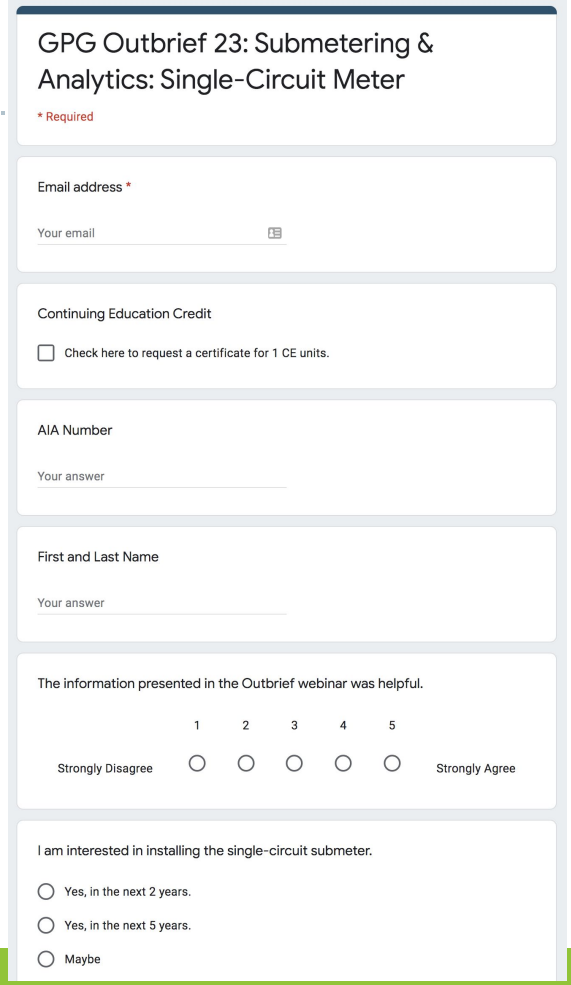

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AIA Number

Your answer

First and Last Name

Your answer

The information presented in the Outbrief webinar was helpful.

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

I am interested in installing the single-circuit submeter.

- ○ Yes, in the next 2 years.
- ○ Yes, in the next 5 years.
- ○ Maybe

Thank you

For more information: gsa.gov/GPG

Michael Lowell, Project Manager mike.lowell@gsa.gov 720.641.8891
Kevin Powell, Program Manager kevin.powell@gsa.gov 510.423.3384