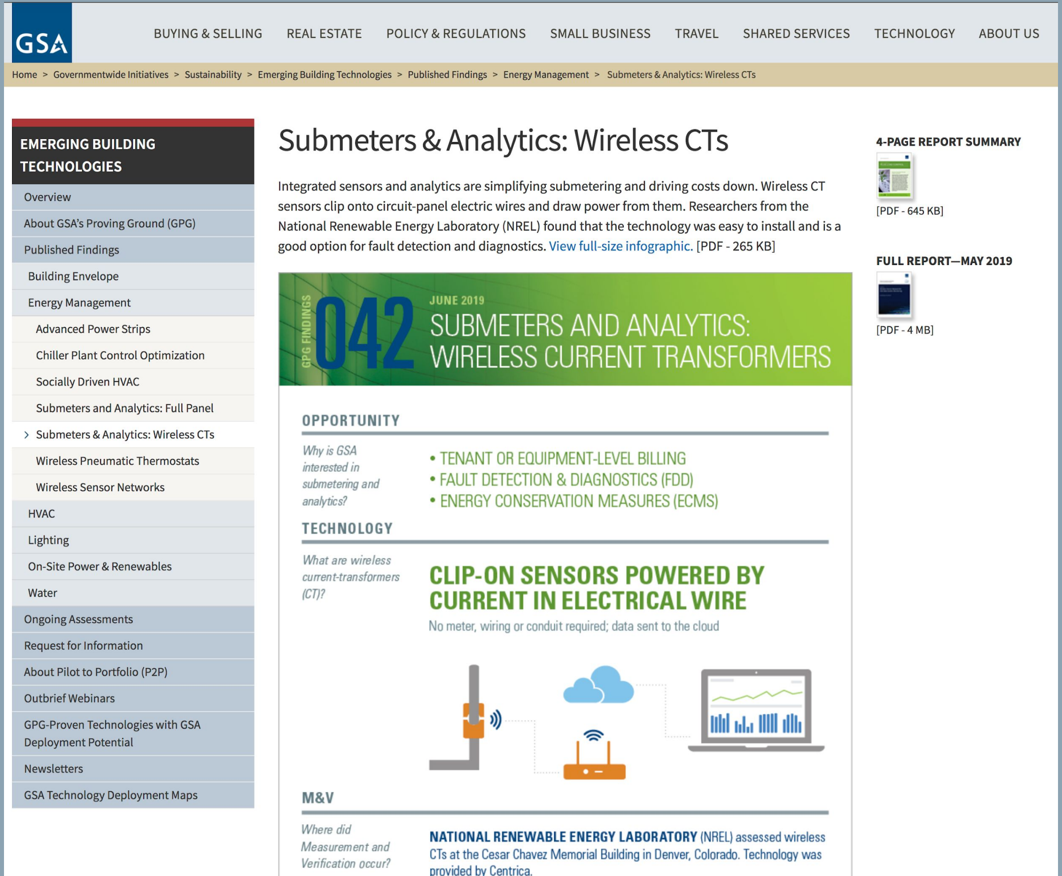
GPG Outbrief 20

# Submeters & Analytics: Wireless CTs

Emerging Building Technologies, GPG Program | U.S. General Services Administration | June 20, 2019

# GPG-042 Submeters & Analytics: Wireless CTs @ gsa.gov/gpg

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



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

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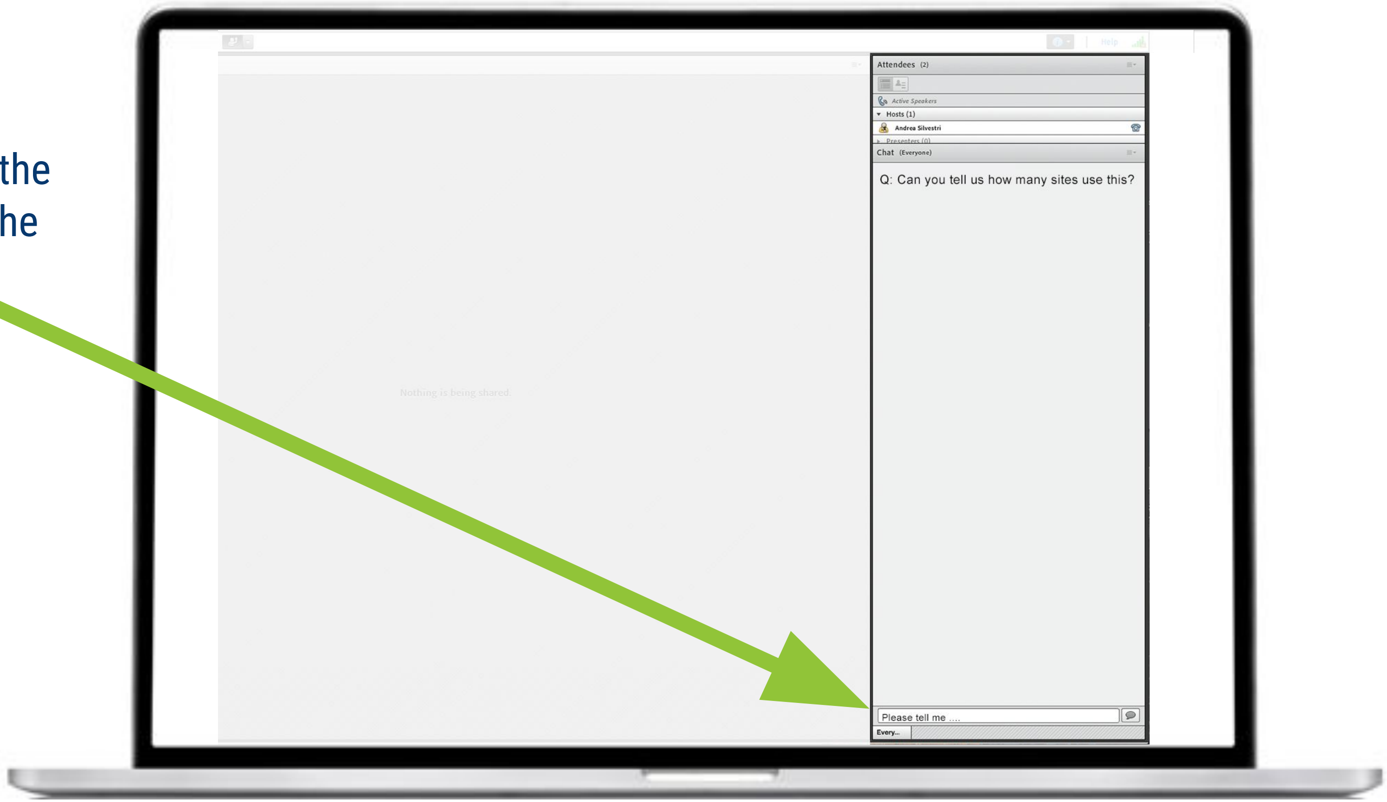

# Introduction

**Michael Lowell**
Project Manager, GPG
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# Webinar Agenda

- ❑ Introduction (5 minutes)
  Kevin Powell, Director, Center for Emerging Building Technologies
- ❑ Submeters & Analytics: Wireless Current Transformers (CTs) (20 minutes)
  Willy Bernal Heredia, National Renewable Energy Laboratory
- ❑ On-the-ground Feedback (10 minutes)
  Aaron Rodriguez, 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
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510.423.3384

# Opportunity

- TENANT OR EQUIPMENT-LEVEL BILLING
- FAULT DETECTION AND DIAGNOSTICS (FDD)
- ENERGY CONSERVATION MEASURES (ECMS)

GPG-042

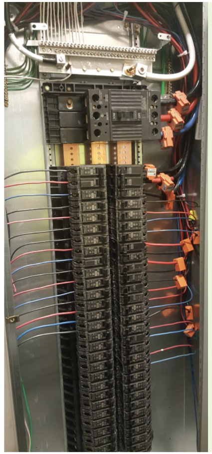
# Submeters & Analytics: Wireless CTs

General Services Administration
Public Buildings Service

GSA

GPG-042 | JUNE 2019

## SUBMETERS AND ANALYTICS: WIRELESS CURRENT TRANSFORMERS



### Clip-On Sensors Read Circuit-Level Consumption

Circuit-level analytics and submetering platforms monitor individual circuits within an electrical panel, providing detailed power and energy consumption data at a much more granular level than was previously achievable in a cost-effective manner. GSA's Proving Ground (GPG) worked with the National Renewable Energy Laboratory (NREL) to perform in-field validation of three circuit-level submetering implementations. This summary of NREL's report reviews one of them, a wireless current transformer (CT) sensor provided by Centrica and tested at the Cesar Chavez Memorial Building in Denver, Colorado.

The technology is easy to install: wireless CTs clamp onto the outgoing electrical wires in the circuit panel and are configured through a desktop application. The sensors are powered by the current running through the wire and do not require an additional power supply. Sensor data is sent to a cloud-based analytics platform that monitors energy use, analyzes performance and provides intelligence to improve system processes.

NREL evaluated the technology's ability to improve the accuracy of tenant overtime billing and to optimize building operations through fault detection and diagnostics (FDD) and energy conservation measures (ECM). Though researchers found that the wireless CTs did not have the accuracy required for billing, the technology successfully identified seven ECMs. Implementing just one of these would cover 87% of the wireless CT system costs. The data from wireless CTs can be integrated into GSA's enterprise-level energy management and information system, GSALink, to provide a cost-effective option for monitoring systems, such as lighting, that are not typically monitored by building automation systems (BAS).

NREL recommends a pilot project to refine best practices, cost-benefit analysis, and site selection.

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

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.

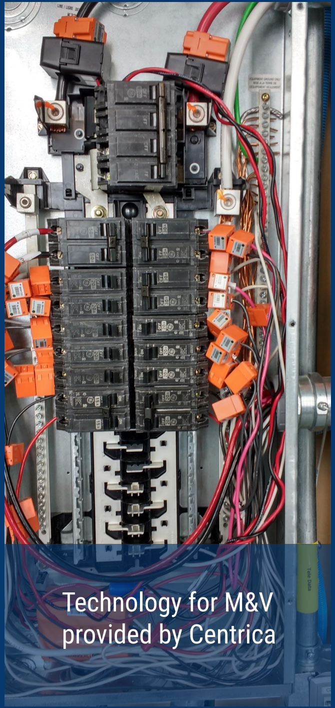
## Single Circuit Meter

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: Wireless CTs



Technology for M&V provided by Centrica

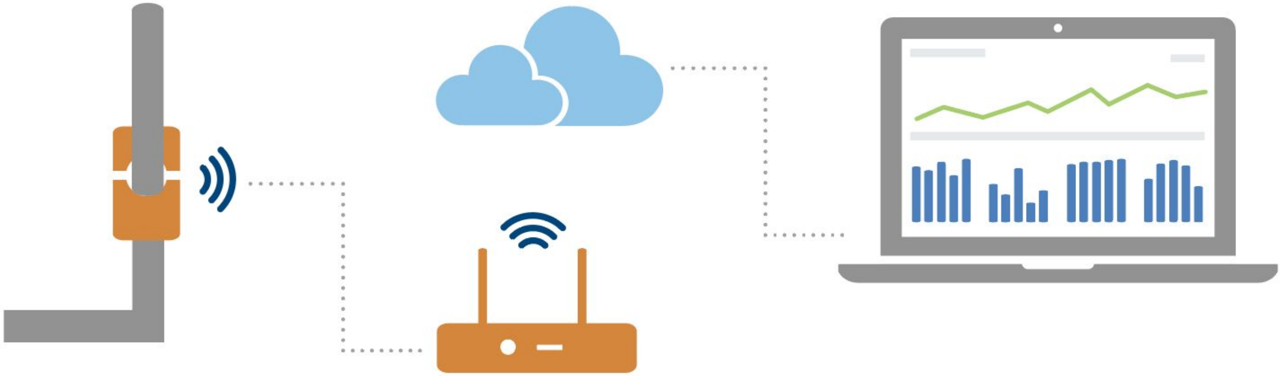
**M&V** Cesar Chavez Memorial Building

# Submeters & Analytics: Wireless CTs (provided by Centrica)

## Clip-on sensors powered by current in electrical wire

- No meter required
- Data sent to the cloud

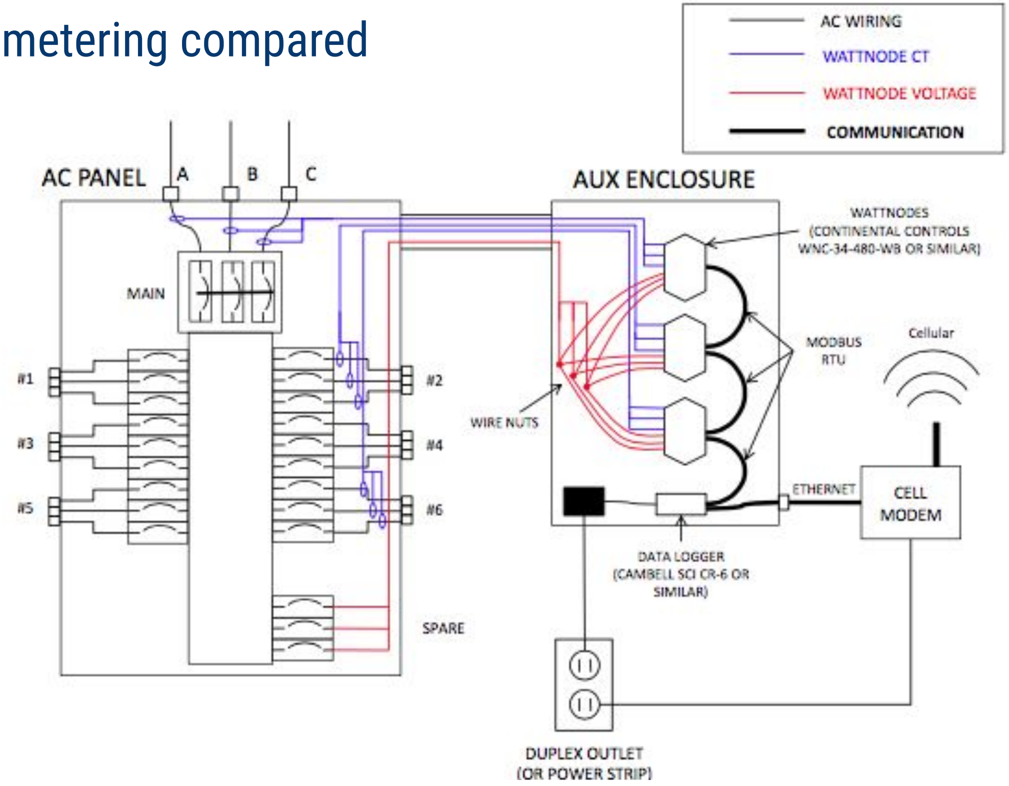
## Circuit-Level Analytics and Submetering Platform (CLASP)



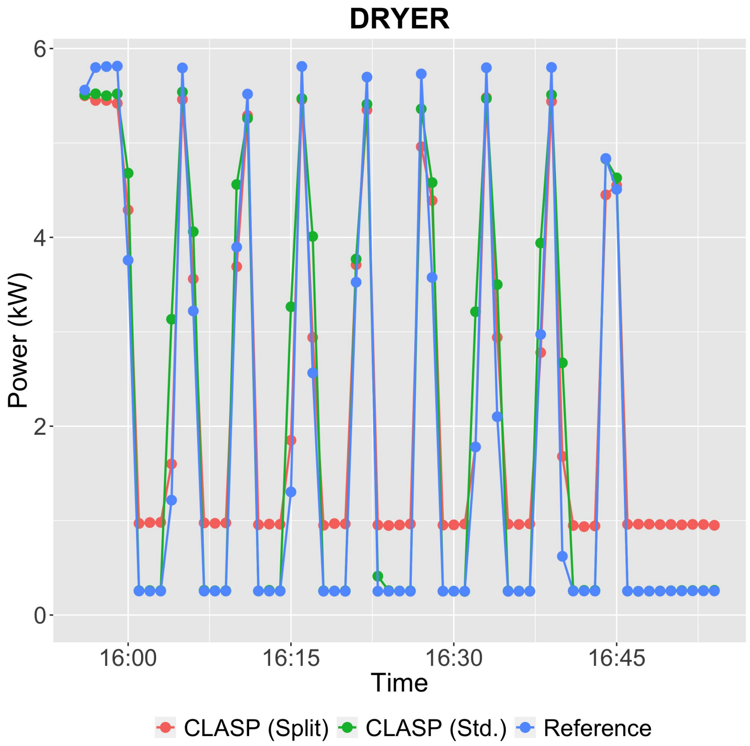
# M&V Design

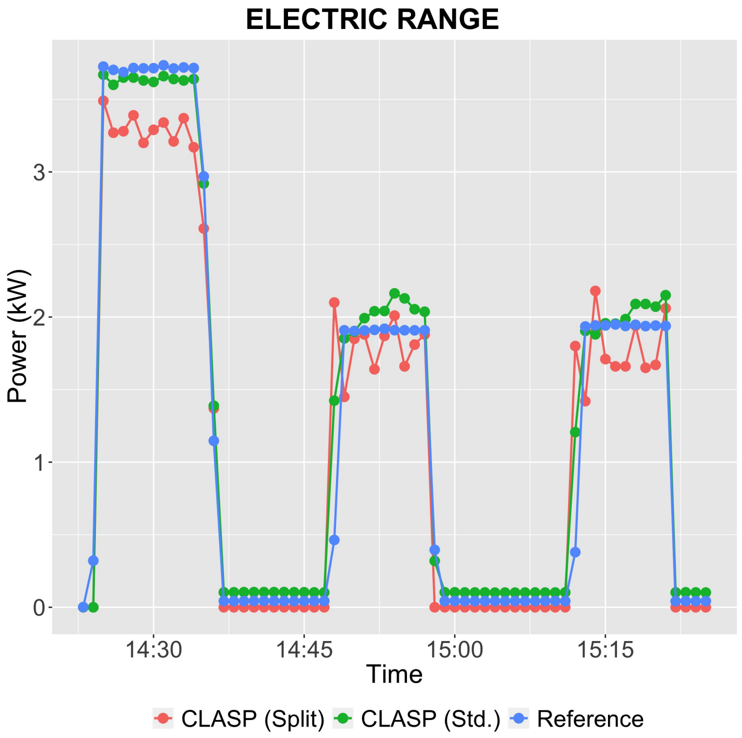
## Revenue-grade and circuit-level submetering compared

- 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



# Split and Standard Sensor Load Tracking in Laboratory

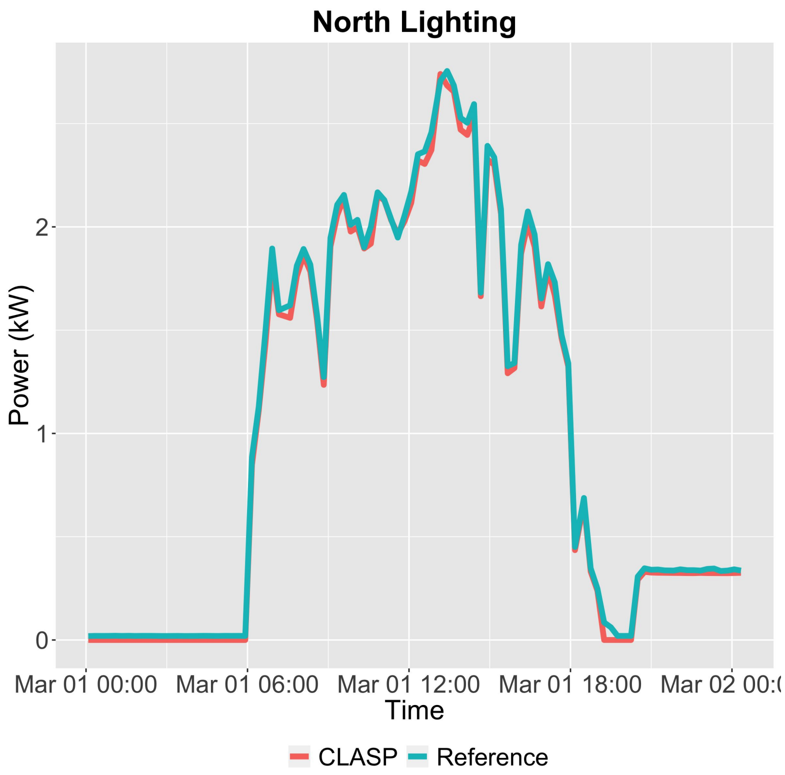


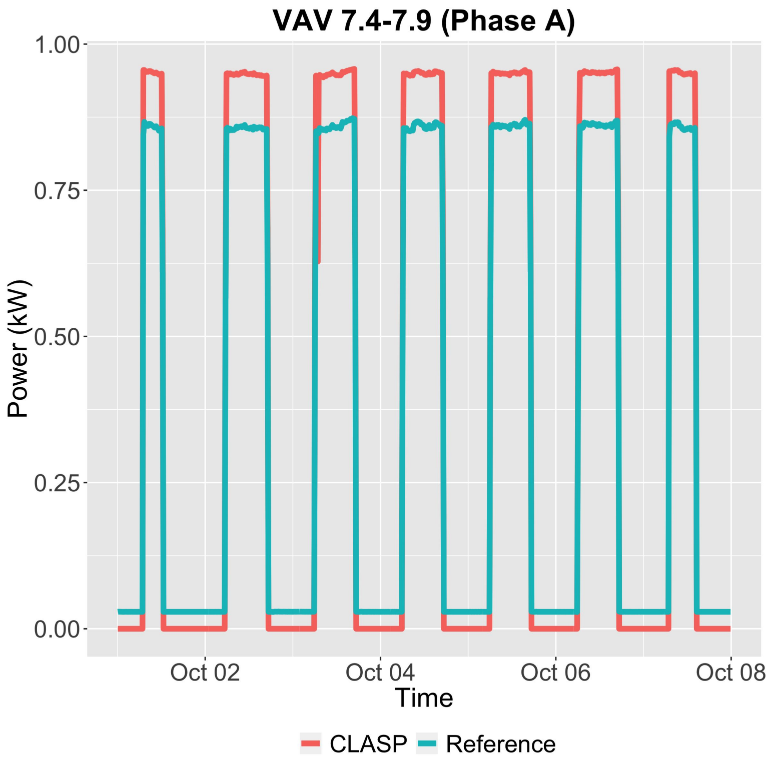



# Up to 32% Measurement Error in Laboratory

| Trial | Appliance | Voltage (V) | Mean Power (W) | Mean Bias (W) | Average Percent Error (%) | RMSPE (%) | Total Energy Error (%) |
|---|---|---|---|---|---|---|---|
| 1 | Refrigerator | 120 | 143.76 | 4.81 | 8.93 | 39.46 | 10.52 |
| 2 | Dishwasher | 120 | 400.58 | 28.4 | 5.54 | 6.22 | 4.92 |
| 3 | Washer | 120 | 130.3 | 118.61 | 103 | 105.31 | 95.3 |
| 4 | Lighting (All) | 120 | 539.6 | 29.78 | 4.77 | 4.79 | 4.78 |
| 5 | Lighting (240V) | 240 | 115.05 | -37.37 | -31.82 | 31.96 | -31.76 |
| 6 | Dryer | 240 | 2204.98 | 330.46 | 31.09 | 39.28 | 22.39 |
| 7 | Water Heater | 240 | 1777.81 | -172.47 | 1.7 | 13.81 | -8.08 |
| 8 | TV/DVD | 120 | 105.9 | -11.34 | -12.33 | 12.39 | -12.32 |
| 9 | Range | 240 | 1309.15 | -90.45 | -4.73 | 8.1 | -7.2 |

# Wireless CTs track with Reference Sensors at Testbed



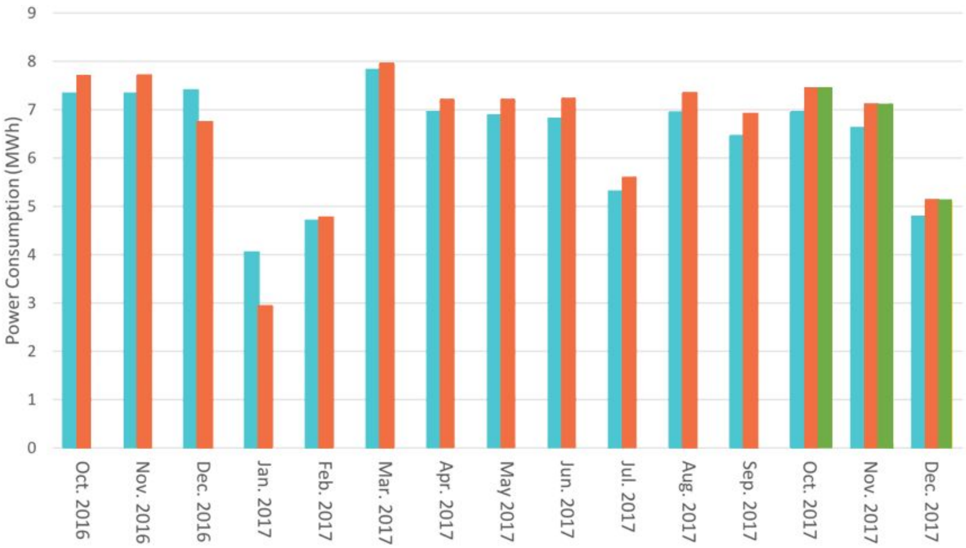



# -53% to +38% Measurement Error at the Testbed

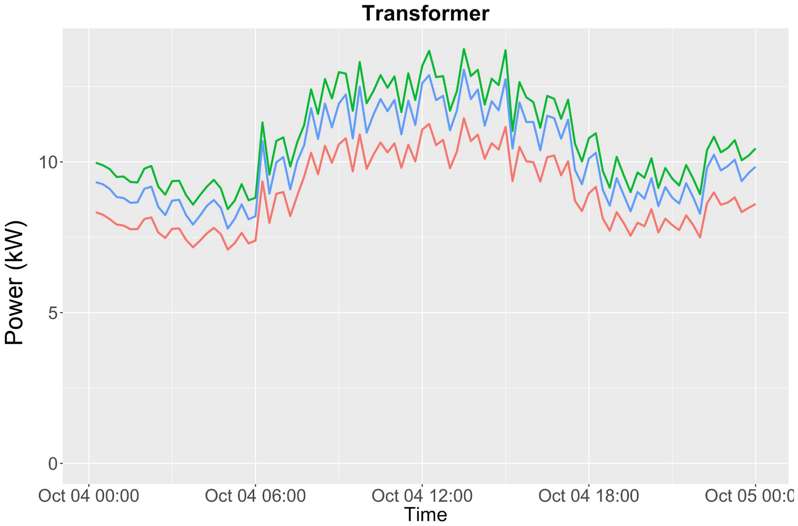
| Equipment | Sep 17 | Oct 17 | Nov 17 | Dec 17 |
|---|---|---|---|---|
| VAV 7.1 (Phase A) | -23.16 | 3.32 | 0.67 | 8.36 |
| VAV 7.2 (Phase A) | 6.94 | 22.13 | 25.33 | 23.25 |
| VAV 7.3 (Phase A) | -13.71 | 1.73 | 3 | 3.12 |
| VAV 7.4-7.9 (Phase A) | -7.11 | 4.8 | 5.06 | 10.61 |
| Lobby Lighting | -8.73 | -7.51 | -7.7 | -7.26 |
| North Lighting | -1.25 | -0.07 | -0.4 | -0.22 |
| West Lighting | -9.74 | -9.29 | -9.4 | -7.9 |
| Transformer (PAN-14) | 7.07 | 7.07 | 7.27 | 7.13 |
| Transformer (PAN-42) | – | 7.06 | 7.21 | 6.83 |

# Energy vs. Power

## Transformer Energy Consumption




## Transformer Power Consumption



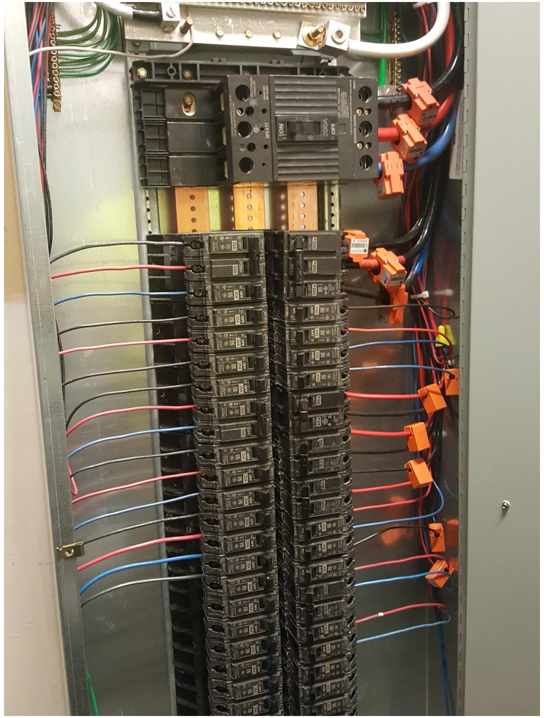

CLASP CLASP (Voltage Tap) Reference

# 8-hour Installation

## 144 individual CTs distributed in 13 panels and 4 HVAC equipment disconnects

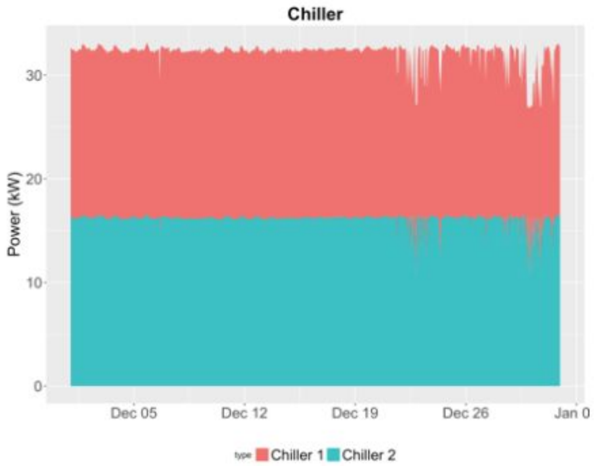
Installed in both high and low voltage panels

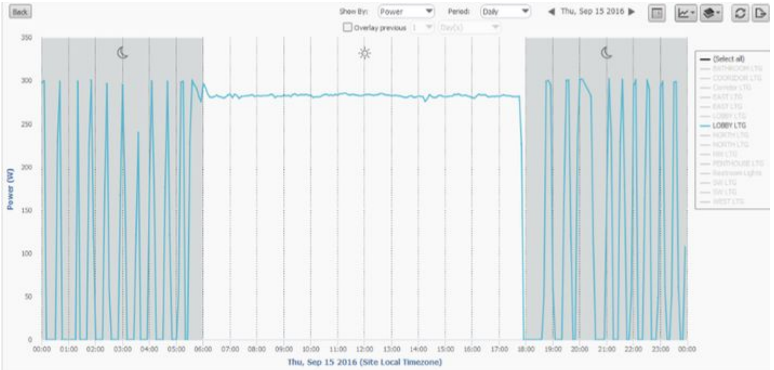
Configuration software streamline the process, providing real-time feedback and helping debug sensor problems

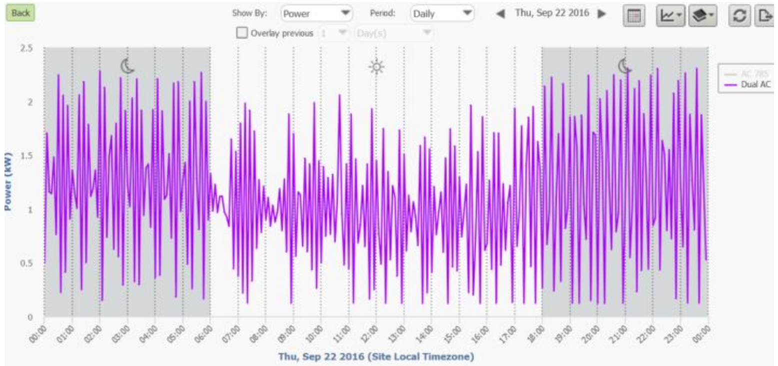


# Identified Seven ECMs

1. Short-cycling of AC loads
2. AC loads not correlated with outside temperature
3. Uncoordinated behavior between condenser and AHU equipment
4. Permanent baseline consumption on both chillers
5. Unnecessary HVAC operation during warm outdoor conditions
6. Cycling of lighting loads during off-hours
7. High energy consumption of lights during off-hours



# 3.5 Year Payback at Testbed with 1 ECM

| | Baseline (Before) | CLES Technology (After) | Difference |
|---|---|---|---|
| Equipment Cost[1] | N/A | $6710 | N/A |
| Installation[2] | N/A | $1325 | N/A |
| Total Installed Cost per Meter | N/A | $63.9/meter | N/A |
| Annual Fees | N/A | $1,926/yr | $/yr |
| Annual Energy Costs (@ $0.03051 kWh) | $226,657/yr | $223,740/yr | $2,917/yr |
| Simple Payback | | 3.5 years | |
| Net Present Value[3] | | $0 | |
| Required Percentage of Energy Reduction | | 1.29% | |

*Labor is 21.5 hours at $52.50/hr

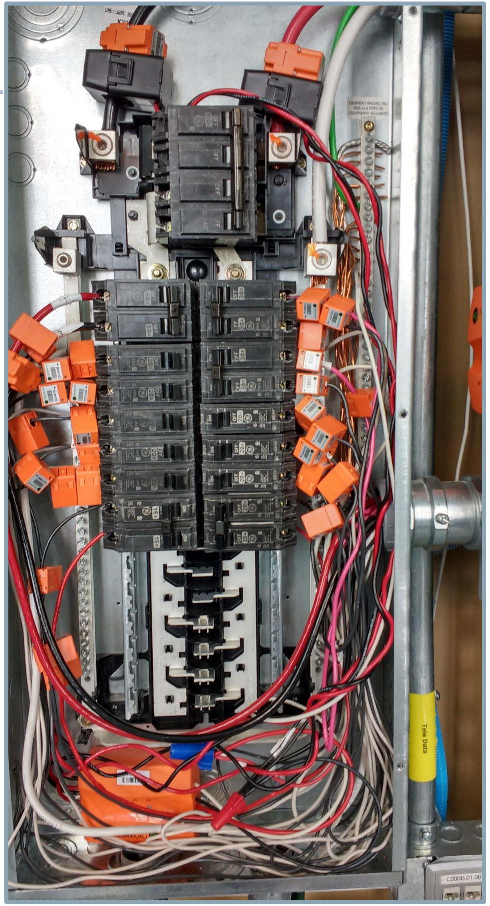
# Lessons Learned & Best Practices

- Because wireless CTs are powered by current going through the wires they meter, they can record only currents above 0.75-1A (90-120W for 120V).
- If integrating into GSALink, work with the technology vendor to lower the annual subscription fees.
- When entering voltage and power factor assumptions, enter the best estimate possible, as this will impact data accuracy.
- Loads can be traced to individual circuits, though this may be an expensive process for locations with many low-load receptacles. Define monitoring goals prior to deployment.

# Deployment Recommendation

## Best Use Case

- Fault detection and diagnostics
- Wireless CTs can monitor systems not typically monitored by a BAS and can be integrated into GSALink.



# GSA Feedback—Cesar Chavez Memorial Building

**Aaron Rodriguez**
Recurring Services Program Manager
Office of Facilities Management
GSA Region 8

# Installation & Maintenance

- Simple, < 1 day
- Requires an electrician to open panel; no need to de-energize the panel
- No maintenance, sensors are self-powered

# Use Cases

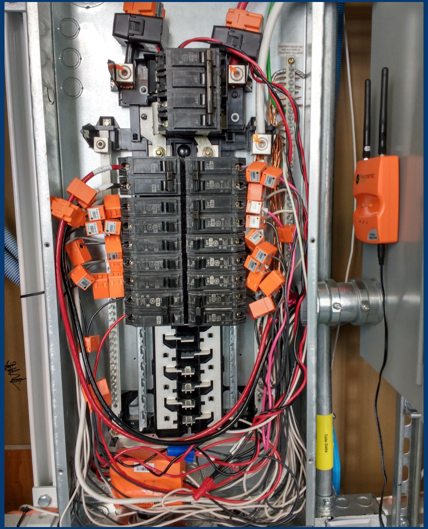
## Primary use case: accurate billing for tenant equipment

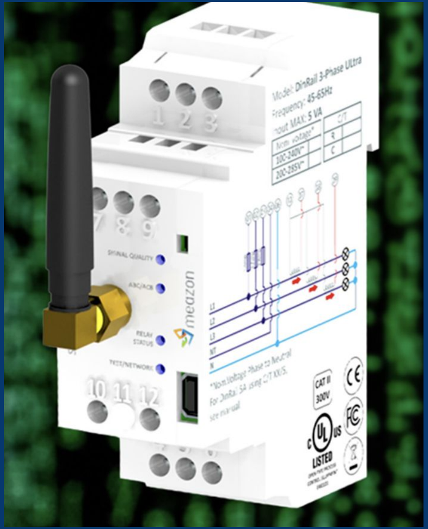
- Wireless CTs were not accurate enough billing
- Could be used for fault detection and diagnostics for facilities without GSALink

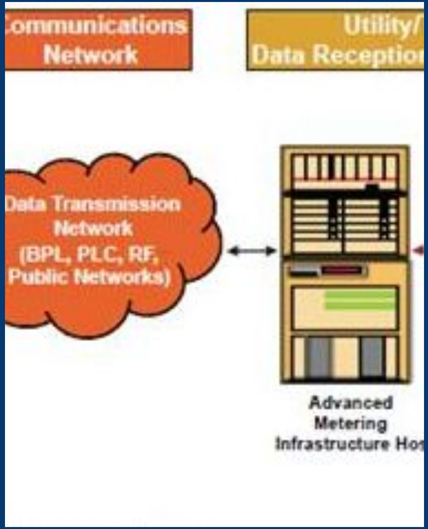
# Deployment Hurdles

- Ongoing subscription costs
- GSA IT-Security clearance
  - If similar to pilot and there no connection to GSA network and data is transmitted anonymously, then streamlined process
  - If data is available to GSALink or other GSA systems, more involved clearance

# Submeter & Analytics Types





# Submeter & Analytics Types

| | GPG 041<br>Full Panel Meter | GPG 042<br>Wireless CTs | Ongoing GPG M&V<br>Single Circuit Meter | Not evaluated<br>Electromagnetic Field Sensors | AMI<br>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<br>Revenue CT: $30-$70<br>Standard CT: $3-$5 | No meter required<br>Standard 3-phase circuit CT: $35-$50 | Meter: $200-$400<br>Revenue CT: $60-$80 | Meter: $100 estimated<br>Not fully commercialized | Meter: $150-$2,000<br>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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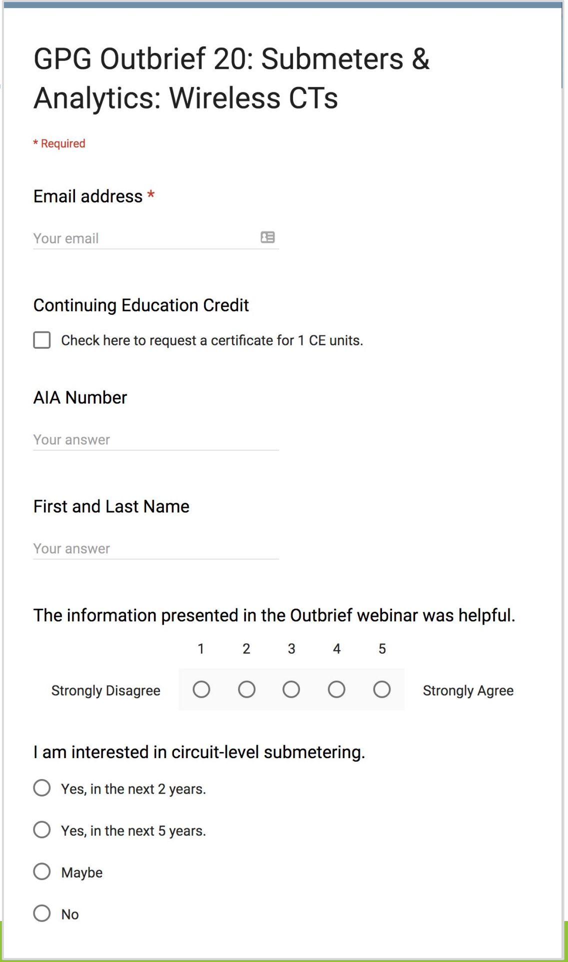

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Your answer

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| | 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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