General Services Administration
Public Buildings Service

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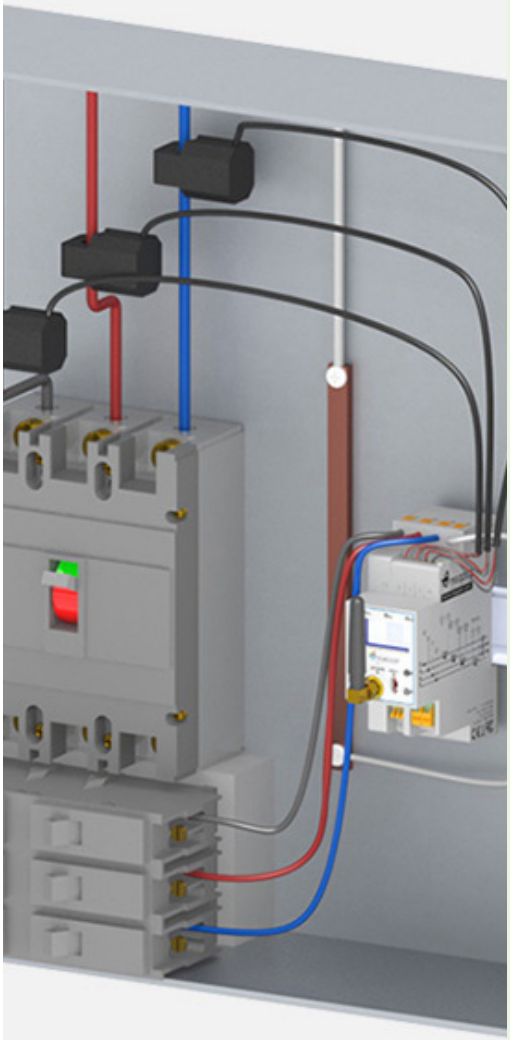
SUBMETERS AND ANALYTICS: SINGLE-CIRCUIT METER



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.

INTRODUCTION

Single-Circuit Submeter and Analytics Platform
Combines a meter, a wireless communication gateway that collects data from multiple meters, non-proprietary CTs and cloud-based analytics

" Historically, GSA has billed tenants for overtime utilities using estimates in lieu of actual energy consumption. Low-cost submeters will allow us to bill based on actual consumption data, which is not only fairer, but because we're conservative with our estimates, it has the potential to save GSA money."

— Christopher Giavis
Director, Pricing Policy and Tools Division
Office of Portfolio Management and Customer Engagement
U.S. General Services Administration

What Is This Technology?

INTEGRATES HARDWARE WITH CLOUD-BASED ANALYTICS

The single-circuit submeter and analytics platform combines a meter, a wireless communication gateway that can collect data from multiple meters, and non-proprietary split-core current transformers (CTs). The system is flexible and allows monitoring of single or three-phase circuits, multiple voltage configurations (e.g. 120 V, 240 V, or 480 V) and power levels with non-proprietary CTs (available in a range of accuracy ratings from several manufacturers). Meter data is transmitted at one-minute intervals from the gateway to the cloud-hosted data storage via a built-in ethernet jack, Wi-Fi, or with a cellular connection using a 3G GSM SIM card slot. To ensure good connectivity, the gateway is mounted near the meters where individual loads or circuits are to be measured. The meters are installed either inside the electrical panel or outside of the panel for quick access. A web-based platform provides monitoring, control and analytics, enabling the development of rule-based alarms and complex benchmarking as well as FDD algorithms. It is also possible to integrate the data into an existing analytics platform, such as GSALink via a RESTful application programming interface (API).

What We Did

REVENUE-GRADE AND CIRCUIT-LEVEL SUBMETERING COMPARED

The single-circuit submetering and analytics platform was installed in two commercial panels and two chiller disconnects at the Cesar Chavez Memorial Building, a 10-story, 180,000 ft^2, all-electric office building in Denver, Colorado. The monitored circuits captured a range of power demand magnitudes and a variety of end uses, including panel mains, a fan-powered variable-air-volume (VAV) box, one heat pump, and two centrifugal chillers. To establish accuracy, revenue-grade submetering was installed alongside the single-circuit submetering system and data was pulled from the two systems at the same frequency. Measured devices performed typical operations during the evaluation period, and power and energy data was collected at one-minute intervals. To assess ease of installation, NREL observed the installation process and conducted informal interviews. Researchers also assessed the total cost of ownership.

FINDINGS

ERRORS IN ENERGY MEASUREMENT < 2% The average error in energy measurement was <2 %, except when chillers were online but idling.[2] The manufacturer states that a new meter design combined with high accuracy CTs should mitigate measurement errors for low-power loads.

ACCURATE HIGH-RESOLUTION DATA SUPPORTS FDD AND ECMS The single-circuit submetering platform captured load profile trends accurately, even for high-variability loads. Identifying equipment faults or inefficient operation was not part of this evaluation, but the accurate high-resolution data can support FDD and ECMs for facilities without a building automation system (BAS). For facilities with a BAS, the submetering platform can monitor systems not typically monitored, such as lighting and plug loads.

CAN BE INTEGRATED INTO GSALINK NREL demonstrated the feasibility of integrating the submeter data into GSALink, GSA's enterprise-level energy management and information system. The only significant challenge to accessing the submetering platform's web-hosted data was ensuring firewall exception requests. NREL engineers developed a stand-alone Python script that communicates with the submetering API and stores the data locally to be uploaded later into GSALink or other analytics platforms.

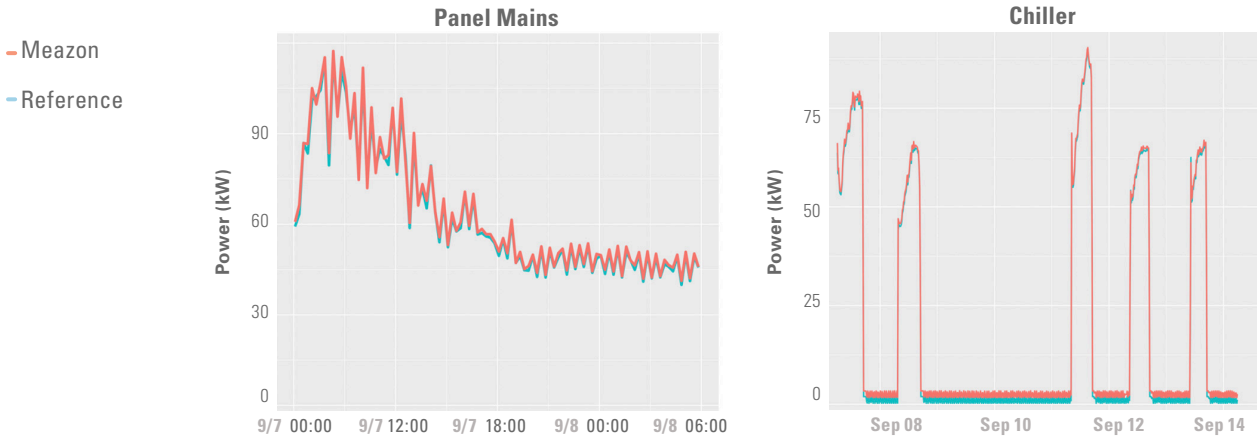
1-DAY INSTALLATION FOR 6 MEASURED LOADS An electrician spent 6 hours installing 3 separate gateways that collected data from 18 individual CTs and 6 meters distributed in 2 panels and 2 HVAC equipment disconnects. The technology distributor preconfigured the meters in 3 electrical boxes, each with 2 meters and 1 breaker disconnect to streamline the installation process and reduce space requirements in the panel. Installation was not disruptive, and it was not necessary to de-energize the panel. Because the panel cover is opened during installation, a registered electrician is required to comply with safety and contracting requirements.

COST PER MEASURED LOAD $900 At the testbed, the cost per measured load was $470 for equipment and $431 for installation. For a bulk equipment purchase (1,000 meters and 100 gateways), the manufacturer estimates $132/per load. Ongoing subscription costs for analytics services range from $12 to $48 per meter per year. There are no ongoing costs if the data is integrated into a separate platform, such as GSALink.

BEST USE CASE: MORE ACCURATE TENANT BILLING Single-circuit metering is applicable throughout the GSA real-estate portfolio. The system can monitor individual loads as well as the entire panel and will provide the most value when monitoring overtime utilities or devices that have high power consumption. Loads and devices that are not currently integrated into GSALink can also benefit from fault detection and diagnostics.

Accurately Tracks Energy Consumption

<2% measurement error, except when chillers were online but idling



CONCLUSIONS

These Findings are based on the report, "Case Study: Field Evaluation of a Low-Cost Circuit-Level Electrical Submetering System," which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

What We Concluded

VALUABLE FOR OVERTIME UTILITY BILLING AND IMPROVED FDD

While single-circuit meters themselves do not save energy, real-time energy monitoring at the circuit level can help building managers identify excess or off-schedule energy consumption, safety hazards, faulty BAS settings or overrides, and predict device failures. With its high accuracy and low costs, the technology would be particularly valuable for more accurate overtime utility billing. Currently, most GSA facilities estimate overtime utility billing based on equipment sizes, ratings, and run-time. In a previous submeter evaluation[3], researchers found that the estimate for overtime utilities was half that of the actual measured use. The single-circuit meter will provide the most value for devices or end uses that have high power consumption, such as chillers or data centers, and has deployment potential throughout GSA's portfolio.

Lessons Learned and Best Practices

- Line of sight is important to ensure reliable communication between the wireless meters and the gateway. One gateway per electrical room is recommended to avoid interference.
- Installing meters in separate enclosures saves time and panel space and simplifies future troubleshooting, as electrical panels do not need to be opened.
- To decrease measurement uncertainty, size CTs to estimated power levels, as opposed to rated breaker values. Caution should be exercised to avoid under-sizing the CT because it might lead to inaccurate readings and, eventually, a damaged CT. The manufacturer recommends installing higher accuracy CTs for error-sensitive applications. The incremental cost of high-accuracy CTs is approximately 10%.
- If using a single CT on three-phase equipment, the load should be well balanced.
- It is important to have clear monitoring objectives before installing submetering because identifying circuits can be a time-consuming process.
- A registered electrician is required to install the system. A spare breaker for the voltage tap will facilitate installation.

Footnotes

[1] https://www.energy.gov/eere/buildings/wireless-metering-challenge#:~:text=Summary,and%20wirelessly%20communicating%20the%20data.

[2] The decrease in measurement accuracy for low-irregular loads is consistent with previous GPG evaluations of a full-panel submetering system (GPG-041) and wireless current transformers (GPG-042)

[3] *Submeters and Analytics: Full Panel*, https://www.gsa.gov/governmentwide-initiatives/sustainability/emerging-building-technologies/published-findings/energy-management/submeters-and-analytics-full-panel

Technology for testbed measurement and verification provided by Meazon.