General Services Administration
Public Buildings Service

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SUBMETERS AND ANALYTICS: FULL PANEL

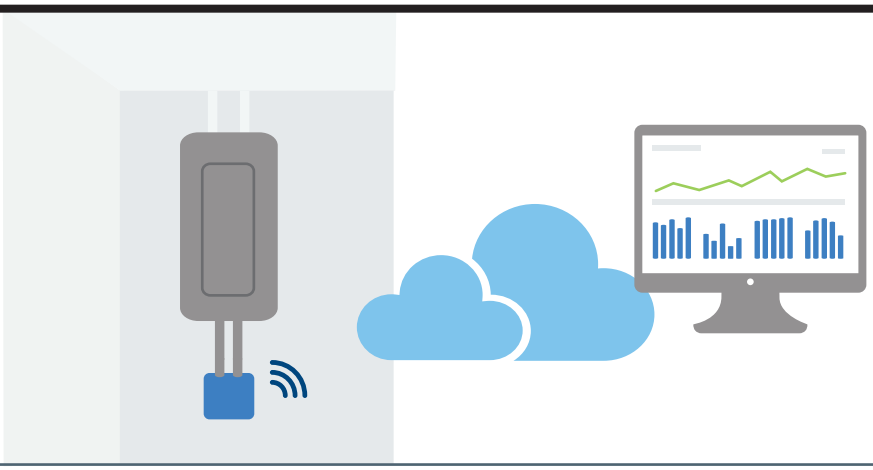
Cost-Effective Integrated Submetering & Analytics

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 Center for Emerging Building Technologies (CEBT) 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 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.

INTRODUCTION

Full-Panel Circuit-Level Submetering System Configuration

Monitors up to 42 circuits; voltage taps power the system



" Equipment-level energy data helps us improve our operations and provide more accurate billing. It also enhances our data analysis capabilities."

— Tyler Cooper
Supervisory Energy Project Manager
GSA Rocky Mountain Region (R-8)
Denver, Colorado

What Is This Technology?

INTEGRATES HARDWARE WITH CLOUD-BASED ANALYTICS

The full-panel submeter provides a compact data acquisition system that can monitor up to 42 separate circuits. The system is typically mounted adjacent to the electrical panel and connected via metal conduit. The submeter relies on third-party current transformers (CTs), which come in standard and high-accuracy configurations. The CTs are installed in the electrical panel, fed through the conduit and interfaced with a circuit monitoring board via pre-wired quick connects. Voltage taps are connected from the monitoring system to the electrical panel and provide voltage measurements for the power calculations, as well as power for the monitoring system. The system transmits one-minute data to the cloud, where the data is stored and made accessible through a web-based analytics platform. The platform helps optimize operations with fault detection and diagnostics, runtime-based preventative maintenance schedules, and actionable insights to reduce operating expenses. The system also supports a RESTful application programming interface (API) to enable the integration of submetering data into existing analytics platforms such as GSA's enterprise-level energy management and information system, GSALink.

What We Did

REVENUE-GRADE AND CIRCUIT-LEVEL SUBMETERING COMPARED

The technology was tested on a residential panel in a laboratory at NREL and on commercial panels at the Salt Lake City courthouse. The field demonstration focused on the evaluation of a data center—and all associated loads—as these spaces have significant, continuous loads and are typically billed separately to GSA's customer agencies. To establish the accuracy of the technology, revenue-grade[1] submetering was installed alongside it, and data was pulled from the two systems at the same frequency. The data obtained from the submeters were then utilized in a detailed energy audit of the data center to identify ECMs.

FINDINGS

ERROR IN ENERGY MEASUREMENT UNDER 3% The meter paired with standard accuracy CTs performed well in laboratory testing, but accuracy was reduced in the field due to non-standard loads. High-accuracy CTs resolved this issue in the field and demonstrated <3% error across the range of load monitoring. CTs introduce a phase shift in the AC current signal they measure, and at low power factors the error caused by this phase shift is more significant. High-accuracy CTs are designed to limit the phase angle shift to <0.5°.

ACTIONABLE DATA FOR IMPROVING OPERATIONS Submeter data utilized in a detailed energy audit identified three promising ECMs: utilizing wet bulb temperature to control tower-free cooling; connecting computer room air conditioners (CRACs) to the building's chilled water system; and reprogramming the CRAC units to coordinate operation. By reprogramming the lead/lag configuration of the CRAC units—a low-cost measure—the facility reduced the data center HVAC load by 10%.

INTEGRATED INTO GSALINK NREL demonstrated the feasibility of integrating the submeter data into GSALink. Integration into Skyspark, the analytics software for GSALink, took approximately 12 hours for an engineer experienced with the RESTful API.

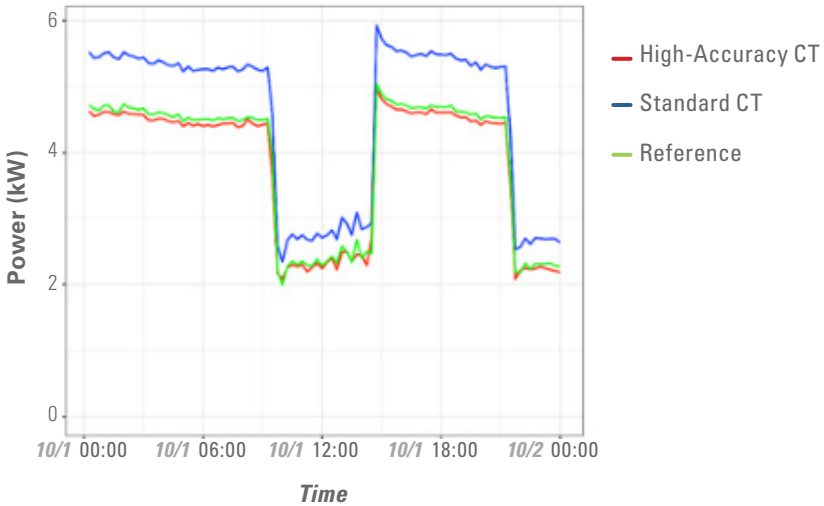
< 2-DAY INSTALLATION The system took 14 hours to install in 5 electrical panels with 96 breakers. The technology was installed in high- and low-voltage panels and with limited space in the electrical room, demonstrating applicability throughout GSA's inventory.

PAYBACK UNDER 1 YEAR AT THE TESTBED GSA could save approximately $6,000 annually by billing for actual overtime utility use of the data center (metered energy use was double the estimate). Responding to submeter data that identified programming issues with the CRAC units saved an additional $1,611. Comparing the installed costs per meter—$950 plus an annual subscription of $420—to the savings, yields payback under one year. Payback is site-specific and, because annual savings vary year to year and recurring annual fees are high in comparison to the initial expense, does not fully reflect return on investment.

BEST USE CASE: MORE ACCURATE TENANT BILLING Full-panel submetering and analytics is applicable throughout the GSA real-estate portfolio. It 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 the Building Automation System (BAS) can also benefit from fault detection and diagnostics. A pilot project is recommended to refine best practices, site selection, and GSA billing processes.

High-Accuracy CTs Tracked with Revenue-Grade Reference Submeter

Standard-accuracy CTs did not meet requirements for tenant billing



CONCLUSIONS

These Findings are based on the report, "Laboratory and Field Evaluation fo Circuit-Level Submetering with and Integrated Metering System," which is available from the GSA website, www.gsa.gov/cebt

For more information, contact GSA's Center for Emerging Building Technologies
cebt@gsa.gov

What We Concluded

SENSOR DATA INTEGRATED WITH ANALYTICS IMPROVES OPERATIONS

The full-panel submetering and analytics system met all of the performance objectives in the U.S. Courthouse field demonstration. In conjunction with third-party high-accuracy CTs, the full-panel system can be an effective solution for optimizing tenant billing. Currently, most GSA facilities estimate overtime utility billing based on equipment sizes, ratings and run-time rather than actual use, at the testbed the metered energy use was double the calculated estimate. Circuit-level submeter data can also help facilities improve operations by identifying ECMs using FDD. For buildings with GSALink, this would enable monitoring of end uses not typically integrated into the BAS, such as lighting and plug loads. For GSA buildings without a BAS or GSALink, the full-panel system enables the identification of ECMs and FDD for a set of buildings that would not otherwise have this capability. Using data to improve operations continues to be a priority for GSA and submetering systems that integrate individual sensor data with analytics support this goal.

Lessons Learned and Best Practices

- High-accuracy CTs with a phase angle shift of <0.5° are necessary to support tenant billing. High-accuracy CTs cost between $30 and $70. Standard CTs cost between $3 and $5.
- Size CTs to estimated power levels, as opposed to rated breaker values. An ammeter can estimate amperage draw.
- Identify wall space in the electrical room for the system and the associated conduit. The enclosure is approximately 7 x 7 x 3.5 inches, and conduit needs to run from the enclosure to the existing panel, so proximity to the electrical panel is desirable. Exercise caution to avoid clutter inside the panel when laying CT cabling.
- Tracing loads to individual circuits can be challenging due to inaccurate panel schedules, obscure naming conventions, or lack of circuit tracing. Tracing loads may be an expensive process in locations with many low-load receptacles. Define monitoring goals prior to deployment.
- A registered electrician is required to install the system. A spare breaker for the voltage tap will facilitate system installation.

Footnotes

[1]Revenue grade as defined in ANSI C12.1

Technology for testbed measurement and verification provided by Enertiv.