General Services Administration
Public Buildings Service

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SUBMETERS AND ANALYTICS: WIRELESS CURRENT TRANSFORMERS

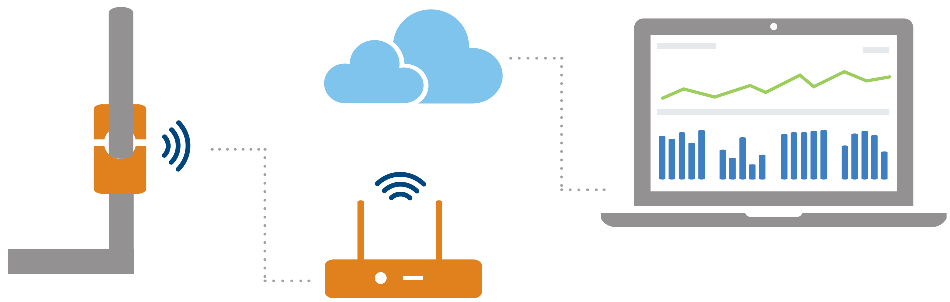
Clip-On Sensors Read Circuit-Level Consumption

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.

INTRODUCTION

Wireless Current Transformer System Configuration
No need for wiring or conduit accelerates installation



> *"This GPG pilot project helped us better understand GSA's submetering needs. We learned that though wireless CTs weren't a good fit for our building, because we need higher accuracy for tenant billing, they could be a great solution for facilities without GSALink, by providing a lower cost solution for fault-detection and diagnostics."*
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> — Aaron Rodriguez
> Recurring Services Program Manager
> GSA Rocky Mountain Region (R-8)
> Denver, Colorado

What Is This Technology?

POWERED BY ELECTROMAGNETIC FIELD FROM ELECTRIC WIRES

Wireless CT sensors clip onto circuit-panel electric wires and measure the current flowing through the wire. They do not require a central meter, and because they are powered by the electromagnetic field generated from the electrical lines they do not need an additional power supply. A communications bridge is installed in the vicinity of the circuit panel and collects data from up to 250 CTs. The bridge transmits data via a built-in Ethernet jack, wifi or cellular network, to a cloud-based analytics platform. The platform monitors energy use, analyzes performance, detects maintenance issues, and provides intelligence that can improve system processes. Application programming interface (API) access enables the integration of submetering data into existing analytics platforms, such as GSALink. The configuration of the system is flexible and accommodates both single and three-phase circuits, as well as multiple voltages (e.g. 120V, 240V or 480V). In contrast to other submetering systems, the wireless CTs do not require a voltage tap, though a voltage tap solution is available for applications that require higher accuracy.

What We Did

REVENUE-GRADE AND CIRCUIT-LEVEL SUBMETERING COMPARED

Wireless CTs were tested in a residential panel in a laboratory at NREL and in commercial panels at the Cesar Chavez Memorial Building, a 10-story, 180,000 ft^2, all-electric office building in Denver, Colorado. The Cesar Chavez building is well operated and has dedicated electrical rooms for each floor. To establish the accuracy of the circuit-level submetering, revenue-grade[1] submetering was installed alongside it, and data was pulled from the two systems at the same frequency. Measured devices were cycled on for 1-hour periods, and power and energy data was collected at 1-minute intervals. To assess ease of installation, NREL observed the electrician on the day of installation and conducted informal interviews after the installation was completed.

FINDINGS

ERRORS IN ENERGY MEASUREMENT AVERAGE 7% At the testbed, the average level of accuracy was 7% the CT sensors underestimated energy by as much as 52% and overestimated by as much as 38%. The measurement of low-irregular loads was the least accurate. NREL also evaluated a higher-accuracy wireless CT configured with a voltage tap but overall improvement was limited; the error in measurement decreased less than 1%.

ACTIONABLE DATA FOR IMPROVING OPERATIONS The system identified seven ECM opportunities: short-cycling of AC loads; AC loads not correlated with outside temperature; uncoordinated behavior between condenser and AHU equipment; permanent baseline consumption on both chillers; potentially unnecessary HVAC operation during warm outdoor conditions; cycling of lighting loads during off-hours; and high energy consumption of lights during off-hours.

INTEGRATED INTO GSALINK NREL demonstrated the feasibility of integrating the submeter data into GSALink. Integrating sensor data from wireless CTs with GSALink provides facility operators with a unified dashboard and a familiar interface, while at the same time extending GSALink's capabilities.

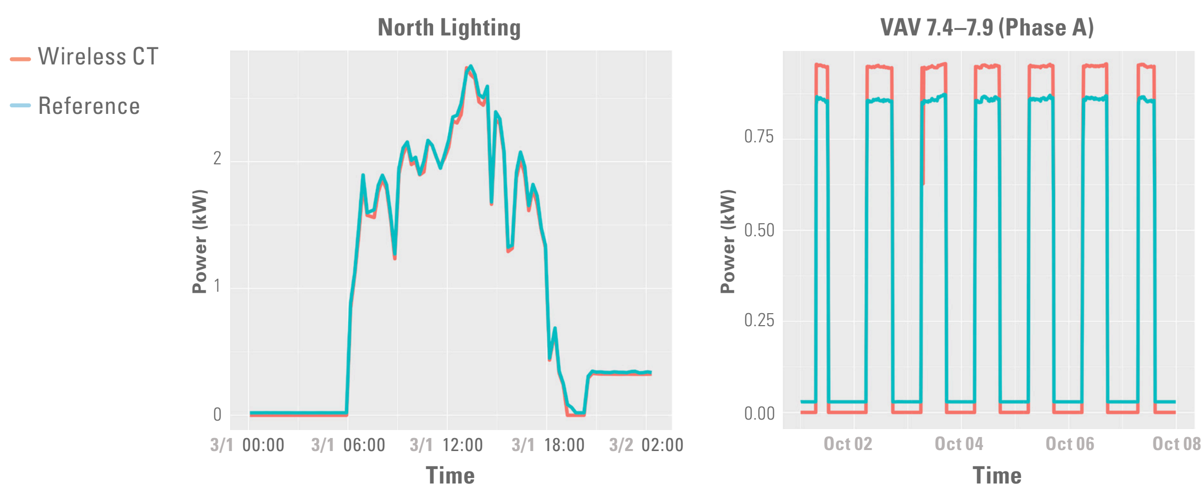
1-DAY INSTALLATION Wireless CTs clamp onto electrical wires and can be installed without de-energizing the electrical panel. Because the panel cover is opened during the process, a registered electrician must perform the installation to comply with safety and contracting requirements. At Cesar Chavez, an electrician spent 8 hours installing 144 individual CTs distributed across 13 panels and 4 HVAC equipment disconnects. Configuration software streamlined the process, providing real-time feedback and helping debug sensor problems.

1.3% ANNUAL ENERGY SAVINGS WOULD YIELD A 3.5-YEAR PAYBACK For a typical 180,000 ft^2 installation, savings would have to be greater than 1.3% of facility electricity costs to realize payback under 3.5 years. Implementing one of the identified ECMs—shutting down a chiller during the winter months—would have reduced facility electricity use by 1.1%. Wireless CTs cost between $80 and $100 to install. Typical costs for a 180,000 ft^2 installation would be approximately $7K, with an annual license fee of $2K.

BEST FOR FAULT DETECTION AND DIAGNOSTICS Wireless CTs can monitor systems not typically monitored by a BAS and can be integrated into GSA's smart building platform, GSALink. A pilot project is recommended to refine best practices, perform cost-benefit analyses, and help with site selection.

Accurately Tracks Load Profile Trends

Precisely tracks on/off state of equipment, supporting FDD



CONCLUSIONS

These Findings are based on the report, "Case Study: Laboratory and Field Evaluation of Circuit-level Electrical Submetering with Wireless Current Transformers," 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

TRADEOFF BETWEEN EASY INSTALLATION AND ACCURACY

Wireless CTs offer ease of installation but they do not match the accuracy of some other submetering and analytics systems, such as the full-panel system assessed by NREL in Salt Lake City.[2] However, wireless CTs can be a good option for fault detection and diagnostics. The submeter data can be fed into GSA's enterprise-level energy management and information system, GSALink, to extend its capabilities and monitor systems, such as lighting and plug-loads, that are not currently monitored by GSALink. Monitoring individual end-uses furthers GSA's goal of leveraging data to improve operations.

Lessons Learned and Best Practices

- Because CTs are powered by electric current going through the wires they meter they can record only currents above 0.75-1A (90-120W for 120V). In both the laboratory and the testbed, several devices did not meet this threshold and were not measured.
- Size CTs to estimated power levels, if possible, as opposed to rated breaker values.
- When entering voltage and power factor assumptions, enter the best estimate possible, as this will impact data accuracy. This step might require some knowledge of voltage level and power factor at the main panel and could benefit from spot checking with appropriate metering.
- Because of inaccurate panel schedules, obscure naming conventions, or lack of circuit tracing, it can be challenging to identify which loads are associated with which circuits. 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.

Reference to any specific commercial product, process or service does not constitute or imply its endorsement, recommendation or favoring by the United States Government or any agency thereof.

Footnotes

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

[2] See "GPG-041. Submetering & Analytics: Full-Panel"

Technology for testbed measurement and verification provided by Centrica.