Center for Emerging Building Technologies

LOW-COST SUBMETERING

GUIDANCE FOR GSA

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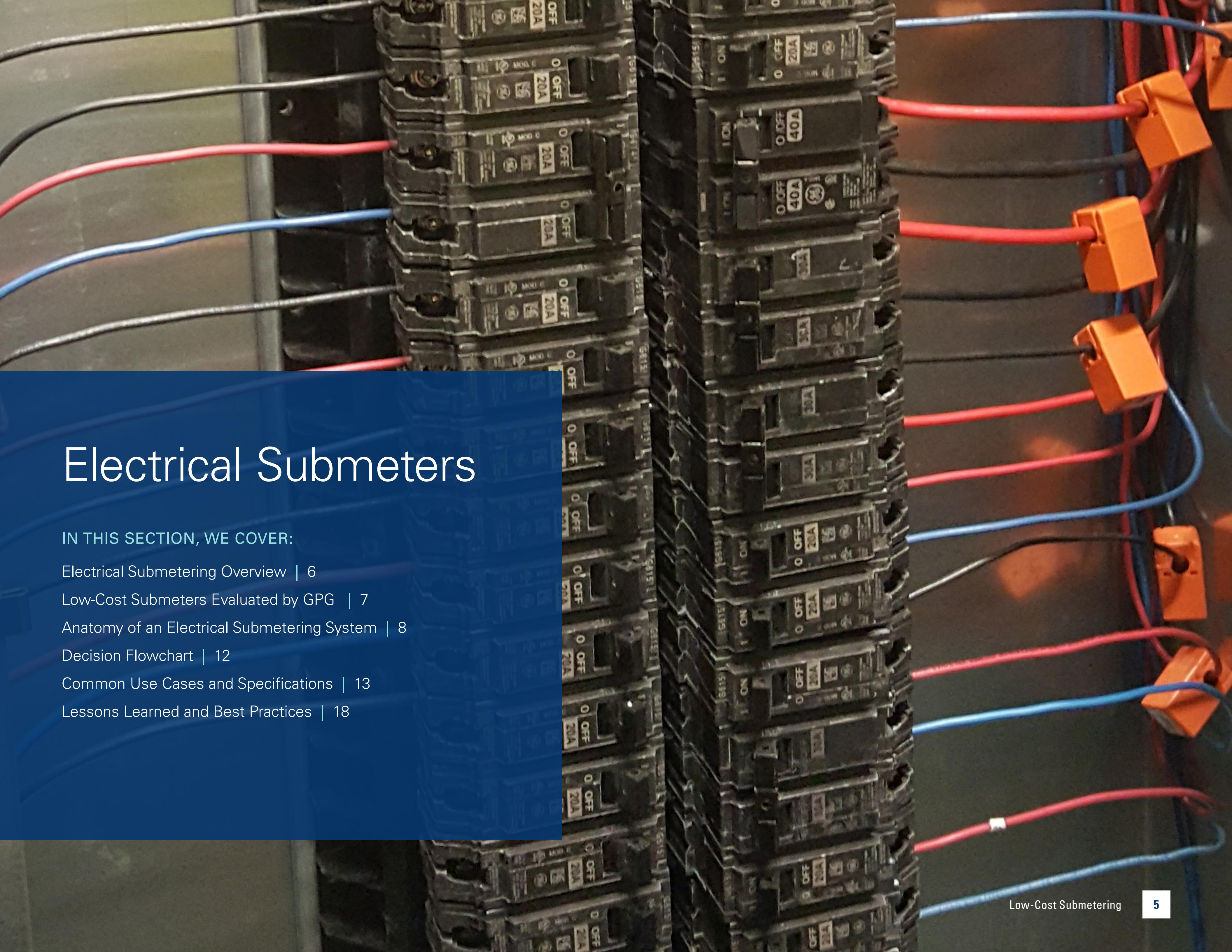
Submetering Overview

Use this guide to assess and select low-cost submeters for your facility.

By measuring the energy consumption of individual spaces or pieces of equipment, submetering can improve tenant billing practices and optimize building operations through fault detection and diagnostics (FDD) and the identification of energy conservation measures (ECMs). It can also support policy goals and reporting requirements.

This document provides guidance on selecting submeters and summarizes the findings from GSA Proving Ground (GPG) evaluations of three low-cost electrical submeters (~$200/point for standard accuracy, $250/point for revenue-grade accuracy) provided by Enertiv, Meazon, and Emergent Metering and one low-cost gas submeter (~$1,000) provided by Vata Verks. The guide is designed for GSA-owned facilities, but many findings broadly apply to commercial real estate.



Electrical Submeters

IN THIS SECTION, WE COVER:

Electrical Submetering Overview

Electrical meter. Photo credit iStock

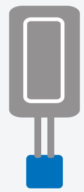
Historically, building operators have had limited ability to quantify and analyze energy consumption for individual spaces or pieces of equipment. Incumbent approaches have used either advanced metering infrastructure (AMI), integrated metering solutions with two-way communication between customers and utilities, or custom installations of circuit-level submeters.

AMI is expensive (installations can range from $2,000 to $10,000 per meter) and typically installed for whole buildings or large end-uses, such as chiller plants, which limits its ability to assess consumption on a granular level. Because AMI provides two-way communication between utilities and customers, it enables participation in demand response programs and can provide additional functionality such as outage management and utility connect/disconnect. While cost estimates vary widely—and are typically based on utility deployments for thousands of meters—GSA experience has shown that AMI deployment is only cost-effective for large, isolated loads.

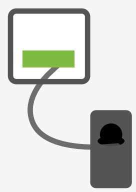
In the past, custom submetering installations have been costly—$800 to $2,000 per point—subject to data reliability and integrity issues and not easily scaled to measure all loads within a building. To address these challenges, the U.S. Department of Energy (DOE) issued a Low-Cost Wireless Metering Challenge in 2017. The GPG program evaluated three new low-cost electrical submeter systems developed in response to the DOE challenge.

Low-Cost Electrical Submeters Evaluated by GPG

All three of the electrical submetering systems evaluated by GPG simplified the submetering process.



Full-panel meters (GPG-041) capture multiple circuits (up to 42 distinct circuits) within a single panel. They use a voltage tap along with wired current transformers (CTs) to enable power calculations. Typically, these meters aggregate data from all monitored circuits (e.g., circuits with CTs) and can transmit those data to the cloud. CTs are available in either revenue grade (+/- 0.5% error according to ANSI C12.1-2022 *Electric Meters: Code for Electricity Metering*) or standard accuracy (+/- 2.0% error).



Single-circuit meters (GPG-046) capture a single or three-phase circuit and use a voltage tap, like the full-panel meters. They combine a meter and split-core CTs. Some vendors provide wireless communication from the meter to a centralized bridge/gateway. Data from multiple meters is aggregated in the bridge and sent to the cloud. These meters are often applied to a main electrical panel or large pieces of equipment. Single-circuit meters are generally available in revenue-grade or standard accuracy.

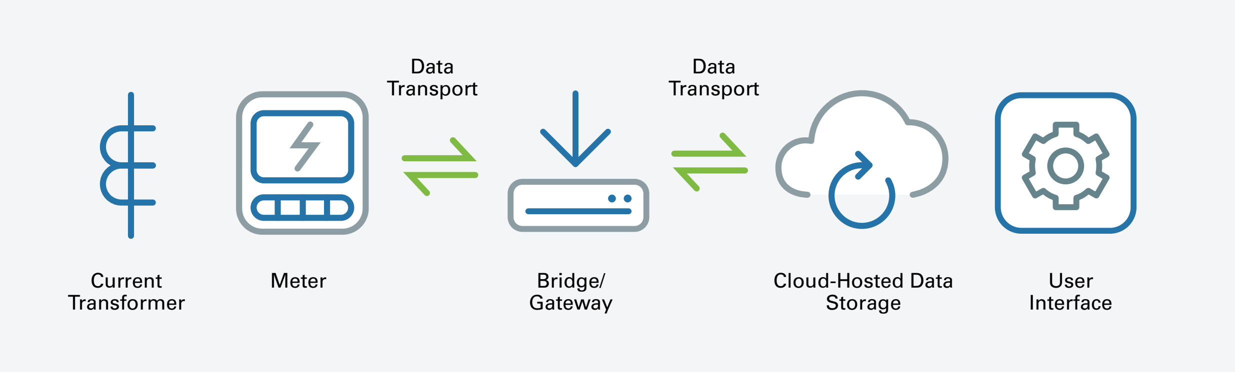
Wireless CTs (GPG-042) clip around the electrical wires and are self-powered by the current running through the wire; therefore, they do not require power supplies or batteries. They do not require a central meter. Data is aggregated in the bridge and sent to the cloud. The tradeoff for ease of installation is typically a reduced accuracy, an error higher than 10% and the inability to measure power factor because the CTs are not paired with a voltage measurement sampled at the same location/rate. Only general accuracy CTs are available in this category. Wireless CTs did not demonstrate revenue-grade accuracy in the GPG evaluation.

Anatomy of an Electrical Circuit-Level Submeter System

Low-cost electrical submeter systems consist of individual components that facilitate data collection and transmittal from a sensor in the electrical panel to usable information in a user interface or downloadable format from a cloud-based server.

Figure 1 shows the primary system components, starting from the current transformer (CT) on the left and moving through to the accessible user interface on the right. Many permutations of these essential components exist, and some vendors combine or omit certain pieces to address specific functionality that aligns with their business model.

Figure 1
Components of a Low-Cost Submeter System



Current Transformer

The CT is the sensor that records the current flowing through the electrical wires in the panel. CTs in low-cost submetering systems are typically split-core, meaning they can be opened and clipped around electrical cabling, allowing easy installation and minimizing disruption to the system they monitor. Generally, CTs are hard-wired to the meter but may also transmit data wirelessly. The accuracy of CT measurements is impacted by ratio error, phase angle error, and burden[1] (load connected on the secondary side of the CT).

The transformer correction factor (TCF) combines the ratio error and phase angle error into a single accuracy metric used to classify the accuracy of CTs in the ANSI/IEEE Standard C57.13, IEEE Standard Requirements for Instrument Transformers. The standard categorizes CTs into three classes (1.2, 0.6, and 0.3), denoting the TCF percentage error at full load.

The accuracy ratings typically define required accuracy values from 10% to 100% of the rated amperage of the CT. Still, many manufacturers will provide additional accuracy data from 1% to 120% of the rated amperage. Errors resulting from phase angle shifts are critical if the devices to be measured have a low power factor, as this is when phase angle shifts introduce the most significant errors into power and energy calculations. It is important to consider accuracy (across the range of expected current to be measured) and phase angle shift of the CT when specifying CTs for a low-cost submetering system.

Meter

The meter calculates power using current data from the CTs and voltage measurements from the same panel where the CTs are installed. The voltage measurement is typically obtained from a voltage tap installed in a spare breaker in the panel; this voltage tap also delivers the power to energize the meter. The meter's accuracy is typically classified according to ANSI standards C12.1 and C12.20, which define classes 1.0, 0.5, and 0.2 that correspond to +/- 1.0, 0.5, and 0.2% error, respectively, of actual value at full load. It is important to consider system accuracy—the combined accuracy of the meter and the CTs that will be paired with it.

[1] For a description, see https://www.eprmagazine.com/tech-view/understanding-errors-in-current-transformers/

Bridge/Gateway

When the CT and associated meter acquire and process data, the data is often communicated to a central bridge/gateway inside the building. This component can provide more extended data storage than is typically available on the meter. The bridge also acts as a centralized hub where multiple meters in the building can push their data for storage, organization, and transport to the cloud-hosted data storage. In some systems, the meter and the bridge/gateway are combined into one piece of hardware that processes the power readings, stores them, and transmits them to the cloud.

Cloud-Hosted Data Storage

Most low-cost submetering systems transmit their time-series data to a cloud-hosted database that can store much larger data volumes and provide remote data access. Additionally, many vendors provide an application programming interface (API) allowing programmatic access to this data storage. The API typically provides machine-to-machine access via machine-readable formats such as JavaScript object notation (JSON), comma-separated value (CSV), or extensible markup language (XML). Data transfer and cloud-based storage must comply with the organization's cybersecurity requirements. Vendor cloud-based applications will need to receive FedRAMP compliance. GSA cloud-hosted applications would need to follow agency IT guidance.

User Interface

The final component in the low-cost submetering stack is the user interface (UI). The UI is typically a web-based front end that communicates to the cloud-hosted data storage (or the datalogger itself in some instances) to present the data in a user-friendly interface. These interfaces provide various capabilities, including:

- Viewing time-series data at different time resolutions and for different date ranges
- Selecting and downloading data in various formats
- Setting basic rules/thresholds and receiving alerts
- Comparing different equipment pieces or periods to benchmark energy usage

These user interfaces can range from straightforward dashboards to complex analytics engines. While most of GPG's research on low-cost submeters has focused on data accuracy and quality rather than the usability or effectiveness of the user interface, this component can significantly impact low-cost submeter utilization and adoption by building operators or energy managers.

Subscription Fees

Cloud-hosted data storage and user interface are often tied to the provider's recurring monthly subscription fee. The software-as-a-service (SaaS) fee can be a significant component of the system's total cost and should be considered when evaluating a system.

If raw data is the primary goal (e.g., integrating data into an existing analytics platform), consider a system with low or no recurring fees.

If analytics are needed, consider the user interface and recurring costs of SaaS systems.

Data Transport and Associated Networks

Communications networks, over which the data is transmitted, are another element of low-cost submeters that must be considered before system deployment. Options for data transport include local area networks (e.g., Ethernet within the building), Wi-Fi or other wireless communication protocols, and cellular.

Regardless of the approach, the interface between the low-cost submeters and the network used to transport data is a critical consideration from a cybersecurity perspective. It is important to engage the cybersecurity and networking teams (for GSA Building Technologies and Services Division) early in reviewing these system configurations to ensure the devices can operate securely on the networks one expects to use.

There are three points where data transport occurs in low-cost submeters:

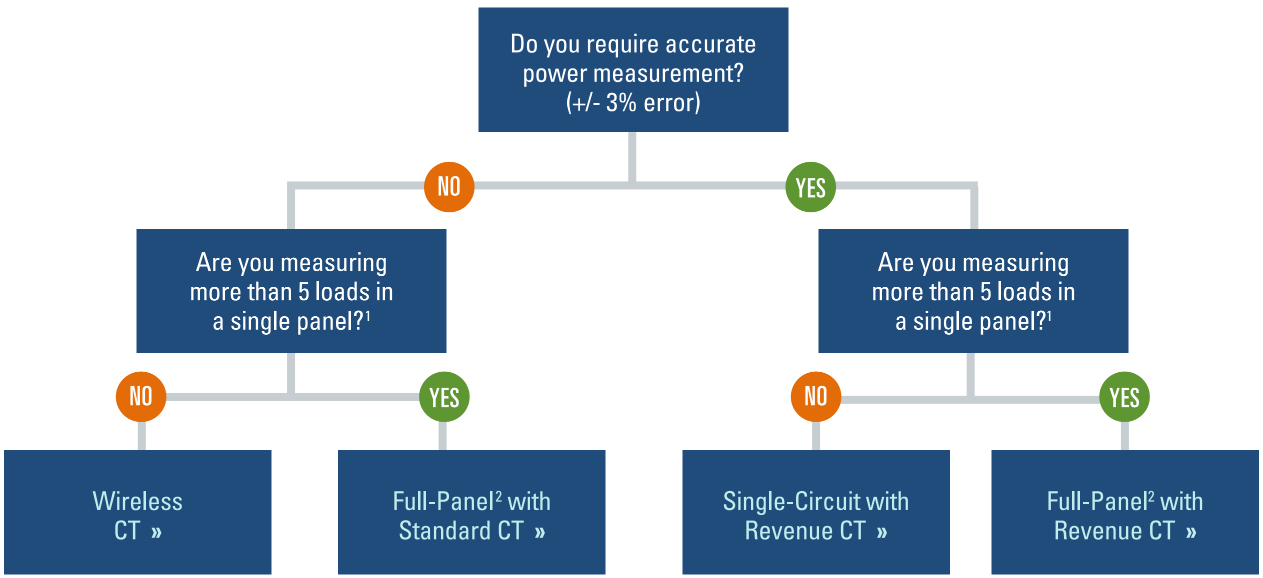
Between the meter and the bridge/data logger: The data transport between the meter and the bridge is often integral to low-cost submetering design and, therefore, may be a proprietary or non-standard communication protocol. Many companies incorporate wireless data transport at this point in their system to avoid running new cables within the building.

Between the bridge/data logger and the cloud: Data transport to the cloud is usually accomplished through more standard approaches, such as connecting to a local Ethernet or Wi-Fi network to transmit data to the cloud servers, yet it may still use unique data structures or APIs.

Between the cloud and user interface: The final data connection from the cloud to the user interface is typically accomplished with standard web server architectures and a web browser interface.

Figure 2
Decision Flowchart for Low-Cost Electrical Submetering

Use this flowchart to determine which electrical submeter system will be best suited to your application. The selection process is influenced by the required level of accuracy and the number of circuits being monitored.



[1] General guidelines based on space available in the panel and set-up costs

[2] Full-Panel requires an annual subscription and FedRAMP compliance

Common Use Cases and Specifications

Table 1
Electrical Submetering Technologies Evaluated by GPG

		Meets Functionality Requirements					GPG Testbed Technology Costs		
		Tenant/ Equipment Billing	Fault Detection & Diagnostics	M&V of ECMs	Energy Visibility	Tenant Engagement	Testbed Equipment	Testbed Installation	Annual Subscription
Full Panel GPG-041	Standard CTs		●		●	●	CTs/3-$5 Meter/$500-$850 Bridge/$330	$890 for 3 full-panel meters and 1 bridge ~10 hours for 1 electrician and ~4 hours for a junior apprentice	$420 per meter
	Revenue CTs	●	●	●	●	●	CTs/$30-$70 Meter/500-$850 Bridge/$330		
Single-Circuit GPG-046	Standard CTs		●		●	●	$200/meter includes CTs $300/Bridge (1 per room)	$431 for 6 loads 6 hours for 3 separate gateways that collected data from 18 individual CTs and 6 meters distributed in 2 panels and 2 HVAC equipment	Optional analytics subscription ($12 to $48 per meter) or download data via API for integration into local systems
	Revenue CTs	●	●	●	●	●	$400/meter includes CTs $300/Bridge (1 per room)		
Wireless CTs GPG-042			●		●	●	$35-$50/per 3-phase circuit No Meter Required	$472 for 219 loads 8 hours for 144 individual CTs, 13 panels and 4 HVAC disconnects	No meter or annual subscription. Download data via API for integration into local systems
Advanced Metering Infrastructure (for reference)		●	●	●	●	●	$150-$2,000 per circuit (estimated)	System integration can add up to $10,000 per meter (estimated)	Varies

Tenant/Equipment Billing

Many GSA buildings have multiple tenants on a single utility meter. Generally, GSA allocates utility charges to tenants based on Fair Annual Rental Rate appraisals and escalates them annually based on the Office of Management and Budget inflation factor. GSA will bill for additional energy costs (or "overtime utilities") for usage outside the agreed-upon hours, usage of agency-owned equipment (e.g., data centers or other specialized equipment), and special use space. Currently, the method for determining overtime utilities is to estimate utility usage based on calculations associated with additional run hours, rated equipment loads, and other variables.

Deploying low-cost submeters can increase accuracy in billing and incentivize tenants to reduce energy consumption. In the full-panel submeter evaluation (GPG-041), researchers found that the estimate for overtime utilities was half that of the actual measured use.

GPG submeter evaluations have demonstrated technical feasibility and cost savings. Consider the following for effective deployment of tenant billing:

Required accuracy: Revenue-grade meters/CTs have higher costs. The minimum acceptable accuracy will need to be determined.

Submeter Specifications for Tenant Billing

- Use revenue-grade CTs
- (+/-) 2% energy consumption error (monthly data) from full rating
- (+/-) 2% power consumption error (15-min data) from full rating
- > 95% data availability
- Measures Current (A), Voltage (V), Power Factor (PF), Frequency (Hz), Power (kW, kVA, kVAR)
- 2 years of storage on server or cloud and local storage with at least 2 weeks of data
- Measurement range: 0–1000A, 100–300VAC Line-to-Neutral

Pricing policy changes: Billing agreements and revenue collection will need to be modified based on actual rather than estimated utility consumption. Modifying GSA billing agreements will require discussion with legal counsel, energy managers, and portfolio and property management. This can be time-consuming, so start the process before project funding.

Circuit mapping: In older facilities, mapping electrical circuits to the corresponding tenants or tenant-owned equipment may require an electrician to trace the circuits.

Fault Detection and Diagnostics

FDD identifies options for restoring system operations to deliver as-designed (or enhanced) performance by monitoring building performance and alerting the building operator to operational problems (faults) in building systems or equipment. FDD with low-cost submeters is typically accomplished by applying pre-programmed rules against real-time data.

FDD requires high-resolution time-series data (< 15-min data) that captures the operating profile of the equipment being monitored. It typically does not require high-accuracy energy consumption data, as rules focus on scheduling, equipment cycling, equipment being on/off at inappropriate times, and operation outside of expected bounds; relative accuracy and accurate capture of operational profiles are most important.

Low-cost submeters can extend FDD beyond the operation of major pieces of central plant heating, ventilation, and air-conditioning (HVAC) equipment to include lighting, receptacle loads, data centers, and other plug/process loads. It can also enable FDD in buildings without a central building automation system (BAS), such as small to medium commercial buildings that do not have a centralized control backbone.

Submeter Specifications for Fault Detection and Diagnosis

- Works with either standard or revenue-grade CTs
- (+/-) 10% energy consumption error (monthly data) from full rating
- (+/-) 10% power consumption error (15-min data) from full rating
- > 95% data availability
- Measures Current (A), Voltage (V), Power Factor, Frequency (Hz), Power (kW, kVA, kVAR)
- 2 years of storage on server or cloud and local storage with at least 2 weeks of data
- Measurement range: 0–1000A, 100–300 VAC Line-to-Neutral

After completing any work in the building, researchers recommend seeking insights and feedback from controls contractors, operations and maintenance teams, energy service companies, GSALink (GSA's enterprise-level energy management and information system), and audit teams on what additional metering could be beneficial.

M&V of ECMs

Low-cost submeters provide a more accurate approach to the measurement and verification (M&V) of energy conservation measures implemented as part of energy savings performance contracts. Submeters can be used to validate energy savings and for annual reporting requirements. They can also ensure that the installed equipment and systems operate as intended throughout the year. This allows fine-tuning of measures based on operational feedback.

M&V of energy conservation measures requires higher accuracy data measurements, but fewer total circuits are often monitored.

To pursue this use case, researchers recommend additional research on how energy service companies structure their measurement and verification approaches and relative cost/savings implications.

Submeter Specifications for M&V of ECMs

- Requires revenue-grade CTs
- (+/-) 2% energy consumption error (monthly data) from full rating
- (+/-) 2% power consumption error (15-min data) from full rating
- > 95% data availability
- Measures Current (A), Voltage (V), Power Factor, Frequency (Hz), Power (kW, kVA, kVAR)
- 2 years of storage on server or cloud and local storage with at least 2 weeks of data
- Measurement range: 0–1000A, 100–300 VAC Line-to-Neutral

Energy Visibility and Benchmarking

Low-cost submeters can enable granular visibility and benchmarking. The data can be used to identify high-energy consumers and high baseload consumption or categorize different types of energy end-use consumption. Building-level dashboards can display energy data to increase awareness of occupants, visitors, and management about energy consumption and costs at an end-use level.

This use case may not require highly accurate data readings, but intelligent deploying CTs/meters is essential.

Tenant Engagement

Low-cost submeters can associate energy consumption with specific tenant equipment and behavior. Tenant engagement can include awareness campaigns, usage dashboards, and competitions to reach energy reduction targets.

The most important considerations for using submeters for tenant engagement are the number of circuits to be measured (e.g., monitoring large pieces of tenant equipment like copiers and kitchen appliances, as opposed to isolating individual occupant plug loads) and the ease of circuit mapping that will impact deployment and hardware cost.

Tenant engagement typically does not require high absolute accuracy but rather the ability to group loads and map them to occupants. Depending on the type of engagement desired, this use case may also have specific user interface requirements.

Further study is needed to evaluate the ability to isolate circuits and the associated monitoring costs for low-power devices.

Lessons Learned and Best Practices for Electrical Submetering

Define monitoring goals before deployment. Identifying which loads are associated with which circuits can be challenging because of inaccurate panel schedules, obscure naming conventions, or lack of circuit tracing. Loads can be traced to individual circuits, though this may be an expensive process for locations with many low-load receptacles.

Accuracy can be degraded by low power quality, power electronics, variable-frequency drives, high-variability loads, and high noise-to-signal ratio.

For wireless CTs, use the best estimates possible for metering equipment settings, as data accuracy is impacted by voltage and power factor assumptions. This step might require some knowledge of the main panel's voltage level and power factor and could benefit from spot-checking with appropriate metering.

Line of sight ensures reliable communication between the wireless meters and the gateway. One gateway per electrical room is recommended to avoid interference.

A licensed electrician is required to install any system that opens the panel. A spare breaker for the voltage tap will facilitate system installation.

Perform regular calibration. Follow the manufacturer's recommendations for calibration frequency.

Conduct preventive maintenance. Add meters to the list of preventive maintenance items to ensure their upkeep is not neglected.

Set up data alerts. Configure alerts to notify users of data that stops changing to enable timely investigation of offline submeters.

To decrease measurement uncertainty, size CTs to estimated power levels instead of rated breaker values. An ammeter can estimate amperage draw.

Exercise caution to avoid undersizing the CT; it might lead to inaccurate readings and, eventually, a damaged CT.

Electrical meter. Photo credit iStock

Lessons Learned and Best Practices for Electrical Submetering

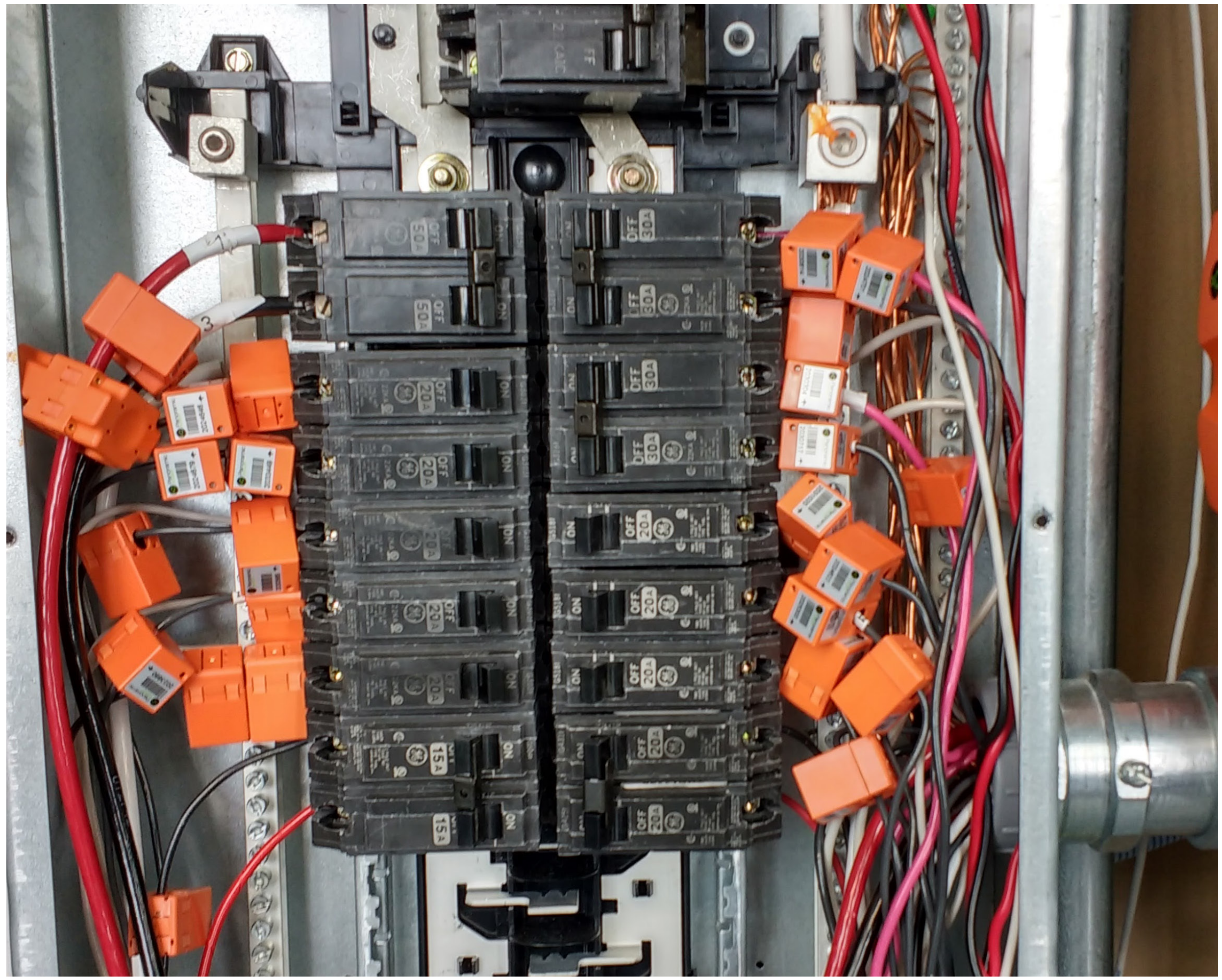
CTs introduce a phase shift in the AC signal they measure, and at low power factors, the error caused by this phase shift is more significant. High-accuracy CTs are designed to limit the phase angle shift to < 0.5° and are necessary to support tenant billing.

Install higher-accuracy CTs for error-sensitive applications. The incremental cost of high-accuracy CTs is approximately 10%.

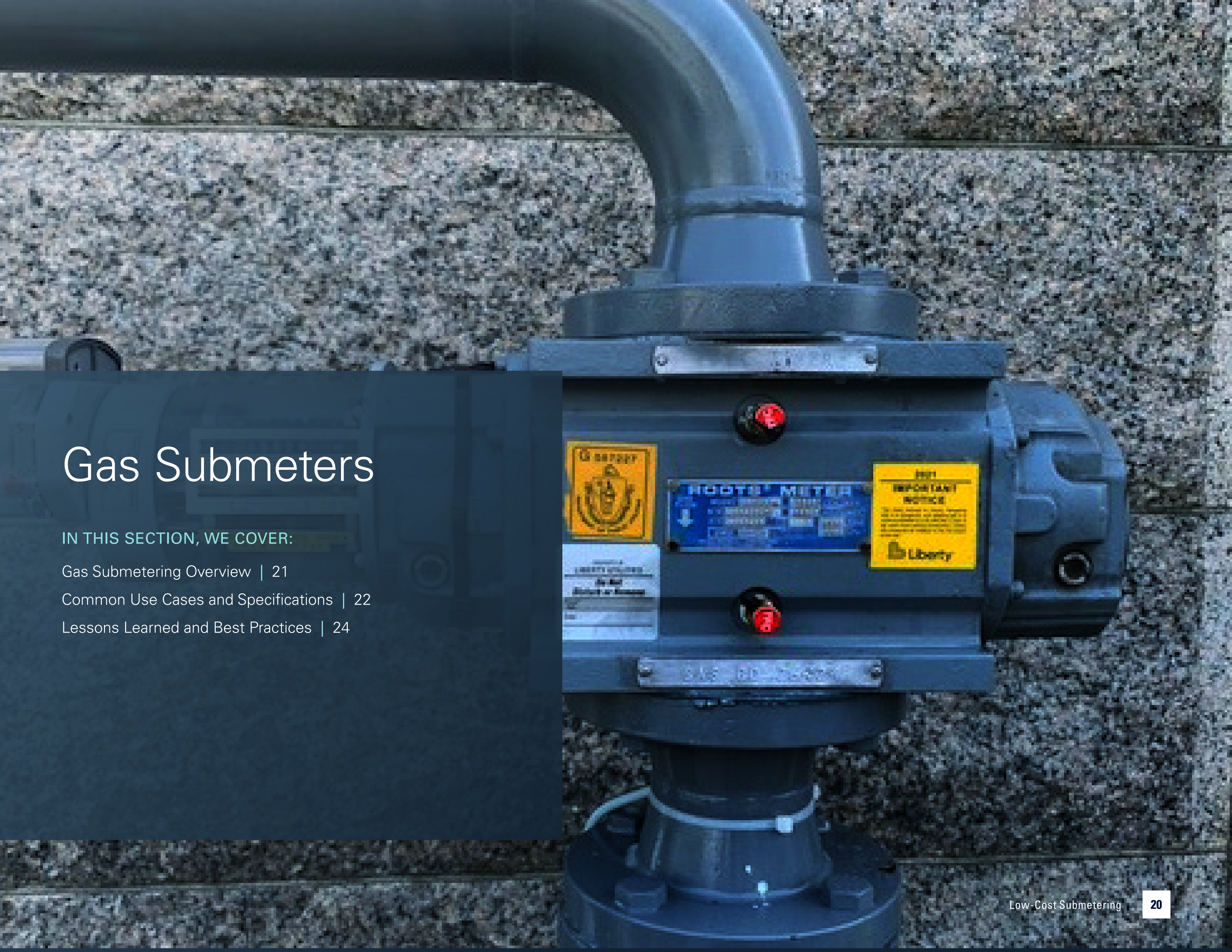
For single-circuit CTs, the load should be well balanced if using a single CT on three-phase equipment.

For single-circuit CTs, install meters in separate enclosures to save time and panel space and simplify future troubleshooting, as electrical panels do not need to be opened.

Wireless CTs can only record currents above 0.75–1A (90–120W for 120V) because they are powered by electric current going through the wires. In both the laboratory and testbed, several devices did not meet this threshold and were not measured.



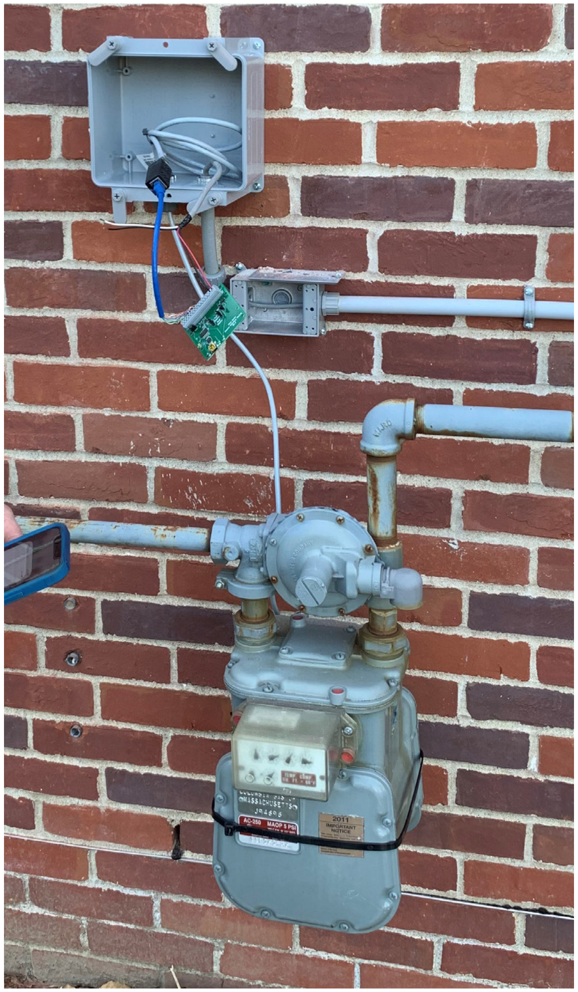
Wireless Current Transformers, Photo credit Emergent Metering



Gas Submeters

IN THIS SECTION, WE COVER:

Gas Submetering Overview



Strap-on Submeter with Diaphragm Gas Meter. Photo credit Vata Verks

Real-time, high-resolution gas metering data can help operators run their buildings more efficiently to detect leaks and prevent overuse or misuse of gas. Metering data also helps meet policy goals and provides the necessary data to meet Energy Independence and Security Act of 2007 (Public Law No. 110-140) reporting requirements.

Non-invasive strap-on gas submeters (GPG-051) strap a sensor probe onto the side of a gas (diaphragm, rotary, or turbine) or water utility meter. As gas or water flows, the probe measures oscillations within the magnetic field—from the movement of the utility meter and flow through the line—and transmits real-time high-resolution data to a sensor up to 200 feet from the probe. The sensor calculates consumption and transmits it to a Java Application Control Engine (JACE) Internet of Things (IoT) controller, building automation system (BAS), or on-site gateway. The submeter can be integrated into the BAS to facilitate anomaly detection, including programming and set-back errors, thermostat failures, off-hour usage, and gas leaks.

Common Use Cases and Specifications for Gas Submetering

Detect Leaks and Prevent Overuse or Misuse of Gas

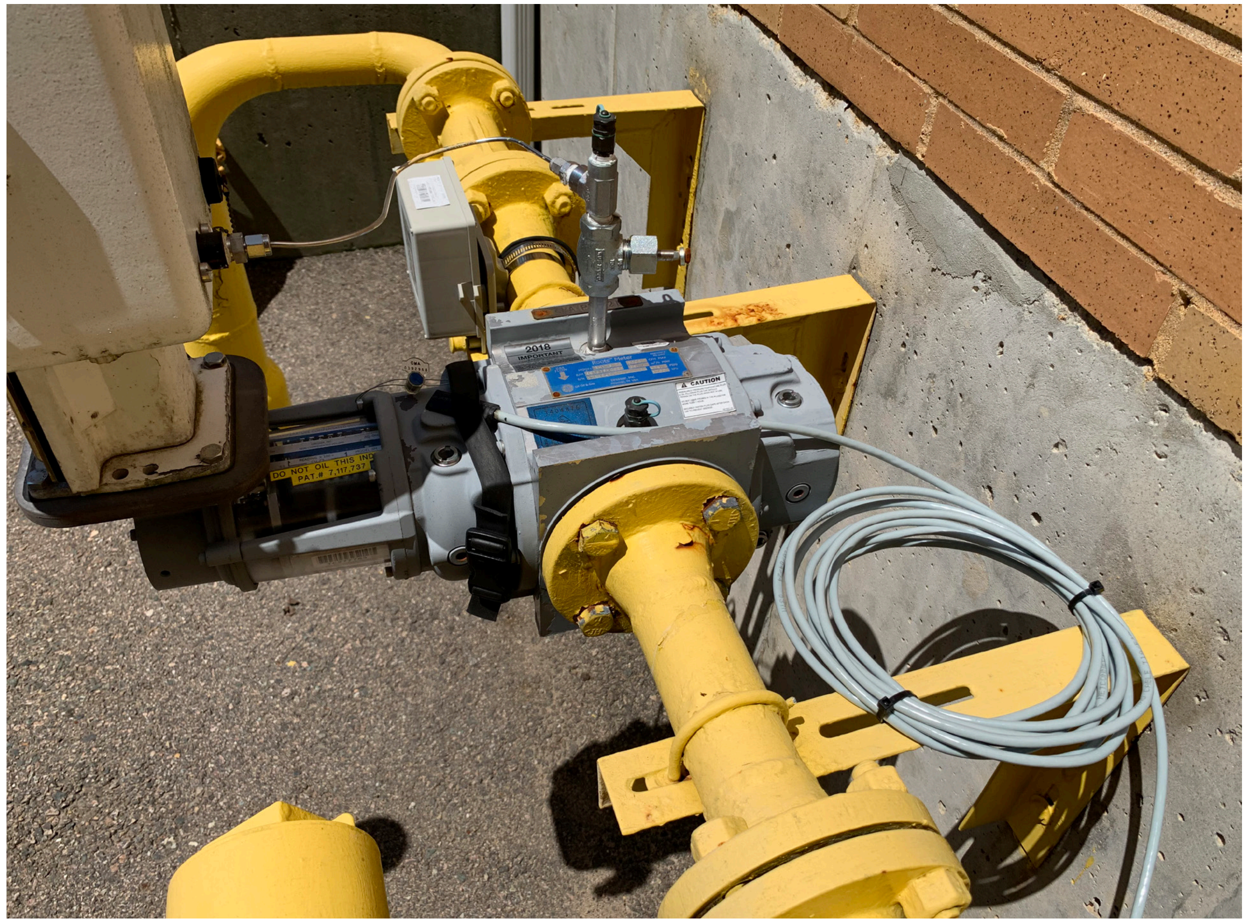
According to the United Nations Climate Change article "Why Methane Matters," leaked natural gas is 34 times worse than CO_2 emissions, and tracking leaks and gas inefficiencies is challenging for two reasons:

- First, many utilities do not readily provide access to this type of data or they send the data infrequently.
- Second, utility data is rarely integrated into the building automation system (BAS), making it difficult for building owners/managers to access and evaluate metering data.

The non-invasive submeter integrates into the BAS to facilitate anomaly detection, including programming and set-back errors, thermostat failures, off-hour usage, and gas leaks.

Support EISA Reporting Requirements

The strap-on sensor is an inexpensive way to meet the Energy Independence and Security Act of 2007 (EISA) requirement for advanced metering on covered GSA facilities.



Strap-on Submeter with Turbine Gas Meter. Photo credit Vata Verks

Specifications for Gas Submeters

- (+/-) 5% energy consumption error (monthly) from full rating
- No pipe cutting, tenant/utility disruption, or plumber required
- Cybersecure and GSA IT-remediated
- Uses a data standard for totalized flow
- 2 years of storage on server or cloud and local storage for at least 1,344 data points (15-min interval for 2 weeks)
- Continuous recharging battery for 3–12 hours of backup
- Options to calibrate automatically or use manual calibration by adjusting the k-factor
- Compatible with diaphragm, rotary, and turbine gas meters (incompatible with ultrasonic meters)
- Immersion-approved probe for outdoor installation. Place controller in a dry location or approved outdoor enclosure.
- Options for wired (e.g., CAT 6) and wireless connectivity
- Compatible with multiple communication protocols including Modbus TCP, Modbus RTU MQTT, HTTP Push, Pulse
- Optional data upgrade for higher resolution data and minimum, maximum, and instantaneous flow readings

Lessons Learned and Best Practices for Gas Submetering

Select the ultra-high resolution option. For ~10% cost difference, you get additional functionality, including minimum, maximum, and instantaneous flow readings and higher-resolution data that can help detect small leaks.

Select an integration option and establish GSA permissions. Decide if the submeter will be integrated into a JACE or a network switch. Integration is simpler with a JACE, but available ports may be limited. The network switch requires additional permissions to communicate on the GSA network. Before integration:

- Establish IP assignments and whitelisting.
- Ensure there is port availability and that it is configured correctly.
- Update the riser diagrams and switch matrix as necessary.

Install when gas is being consumed. Calibrating during winter months is more accurate, especially for compensated gas meters. The vendor keeps a library of gas meter k-factors, which can streamline calibration.

For maximum accuracy (less than 2% error) measure the k-factor on the specific meter.

Allow for k-factor adjustment within the BAS wire sheet. Updates can be made in the BAS instead of physically connecting to the submeter. Non-GSA sites can remote into the device using Telnet or a web server.

Work with a single contractor for installation, including running the cabling and installing an outlet to provide energy to the submeter. Ensure that the contractor is qualified to run cabling.

Install in an enclosure that has a dedicated electrical outlet to energize the device.

Terminal emulators are needed to configure the device (Terra Term or PuTTY).

Contract BAS integration as part of normally scheduled duties to streamline the process and reduce costs.

Strap-on Submeter with Rotary Gas Meter. Photo credit Vata Verks

Appendix

LOW-COST SUBMETERS EVALUATED BY GPG

Full-Panel

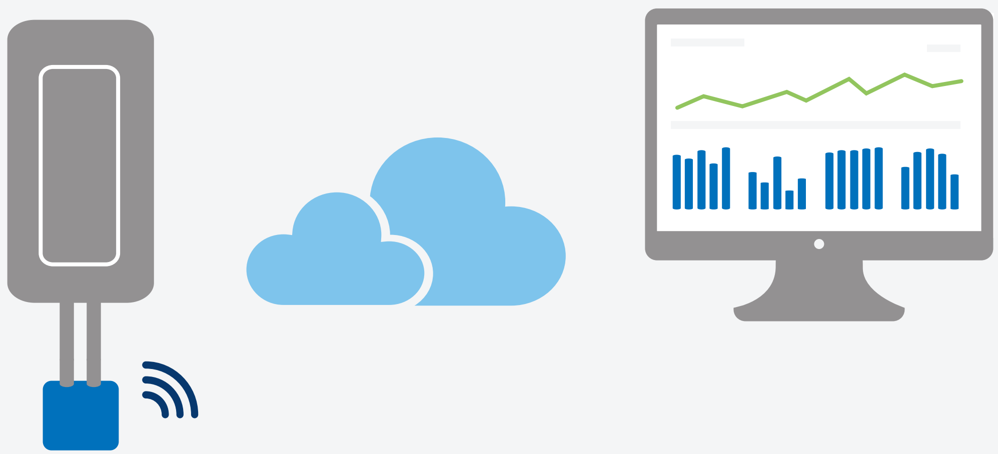
The full-panel meter captures multiple circuits (up to 42 distinct circuits) within a single panel. The meter can monitor both single- and three-phase circuits. The system is typically mounted adjacent to the electrical panel and connected via metal conduit. The submeter relies on third-party current 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 and power for the monitoring system. The system transmits data at one-minute intervals to the vendor's cloud, where the data is stored and made accessible through a web-based analytics platform.

The system also supports a RESTful application programming interface (REST API) to enable the integration of submeter data into existing analytics platforms, such as GSALink.

Figure 3

Meter and Data Storage with Cloud-Based Analytics

Monitors up to 42 distinct circuits; voltage taps power the system



Full-Panel

2019 Testbed Results

ERROR IN ENERGY MEASUREMENT UNDER 3%. The meter, paired with standard accuracy CTs, performed well in laboratory testing, but accuracy was reduced to ~16% in the field due to non-standard loads. High-accuracy CTs in the field demonstrated < 3% error across the range of load monitoring.

INTEGRATED INTO GSALINK It took an engineer experienced with the RESTful API 12 hours to integrate into Skyspark, the analytics software for GSALink.

IDENTIFIED $6,000 IN OVERTIME BILLING. Submeter data also identified programming issues with the computer room air-conditioning units, which saved an additional $1,611.

WORKS WITH LIMITED SPACE. The meter was installed in 120/208 V (low) and 277/480 V (high) voltage panels with limited space in the electrical room.

Full-Panel Submeter
Photo credit Enertiv

Find Out More

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GPG Report 041: Full Panel

2019 Testbed Costs

Equipment: $1,956 for 3 meters, standard CTs, and a gateway for FDD and $2,415 for 3 meters, high-accuracy CTs, and a gateway for overtime utility billing.

Installation: $890 for 3 full-panel meters and 1 gateway ~10 hours for 1 electrician and ~4 hours for a junior apprentice

Annual Subscription: $420 per meter

Single-Circuit

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 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 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, complex benchmarking, and FDD algorithms. Integrating the data into an existing analytics platform, such as GSALink, is also possible via a RESTful API.

Figure 4

Monitors Single- or 3-Phase Circuits, Including Panel Mains

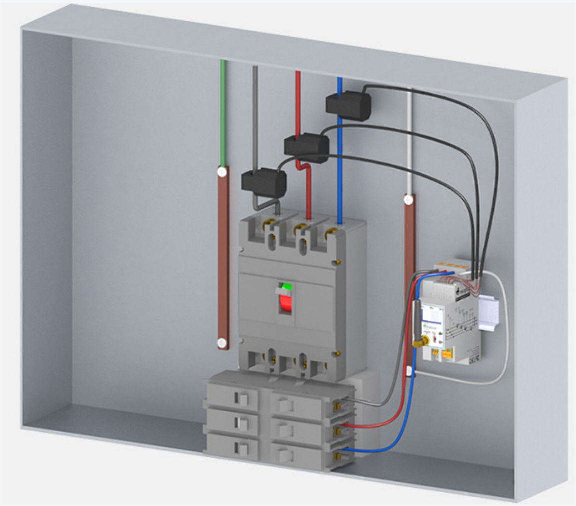
Combines a meter, a wireless communication gateway that collects data from multiple meters, non-proprietary current transformers and cloud-based analytics

Single-Circuit

2020 Testbed Results

< 2% MEASUREMENT ERROR, except when chillers were online but idling. The manufacturer stated that a new meter design combined with high-accuracy CTs should mitigate measurement errors for low-power loads.

INTEGRATED INTO GSALINK. 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.



Single-Circuit Submeter
Photo credit Meazon

Find Out More

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GPG Report 046: Single Circuit Meter

2020 Testbed Costs

Equipment: $200 meter including CTs; $300 gateway; bulk purchase estimate $132/ per load (1,000 meters/100 gateways)

Installation: $431 for 6 measured loads; 6 hours for 3 gateways, 18 individual CTs and 6 meters distributed in 2 panels and 2 HVAC equipment

Annual Subscription: $12 to $48 per meter; No ongoing costs if integrated into GSALink or other analytics platforms

Wireless CTs

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 do not need an additional power supply because they are powered by the electromagnetic field generated from the electrical lines.

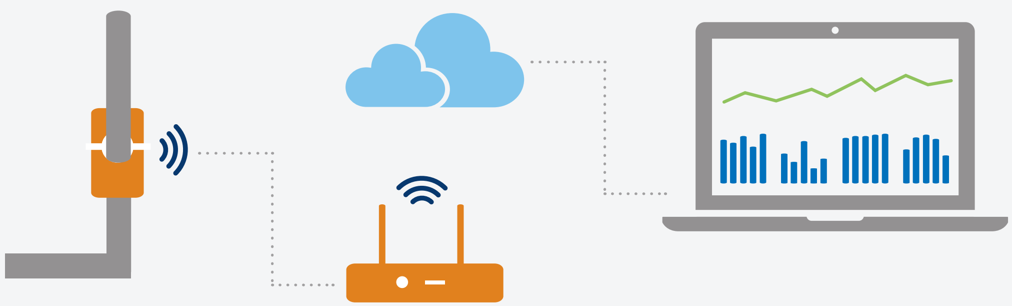
A communications bridge is installed near the circuit panel and collects data from up to 250 CTs. The bridge transmits data via a built-in Ethernet jack, Wi-Fi, or cellular network, to a cloud-based analytics platform. The platform monitors energy use, analyzes performance, detects maintenance issues, and provides intelligence that can improve system processes.

API access enables the integration of submeter data into existing analytics platforms, such as GSALink. The system's flexible configuration accommodates single- and three-phase circuits and multiple voltages (e.g., 120 V, 240 V or 480 V). In contrast to other submeter systems, the wireless CTs do not require a voltage tap, though a voltage tap solution is available for applications that require higher accuracy.

Figure 5

Clip-On Sensors Powered by Current in Electrical Wire

No battery, meter, wiring or conduit required; data sent to the cloud



Wireless CTs

2019 Testbed Results

ERRORS IN ENERGY MEASUREMENT AVERAGE 7%. 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. Higher-accuracy wireless CT configured with a voltage tap decreased the error in measurement by 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 air-handling unit 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. Integrating sensor data from wireless CTs with GSALink provides facility operators with a unified dashboard and a familiar interface while simultaneously extending GSALink's capabilities.

Find Out More

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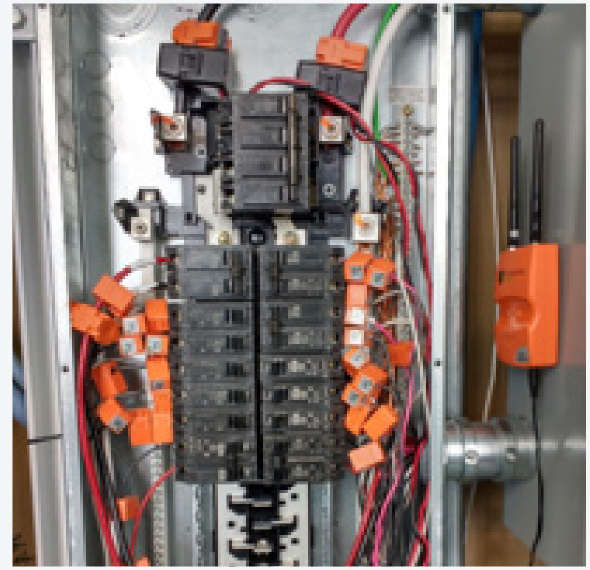
GPG Report 042: Wireless Current Transformer



Wireless Current Transformers
Photo credit Emergent Metering

2019 Testbed Costs

Equipment: $141 per wireless CT; $259 for Bridge; 3 wireless CTs required for 1 three-phase load

Installation: $472 for 219 measured loads; 8 hours for 144 individual CTs, 13 panels, and 4 HVAC disconnects. No need to de-energize the panel.

Annual Subscription: None

Non-Invasive Gas Submeter

Non-Disruptive, Non-Utility Gas Data Acquisition Solution

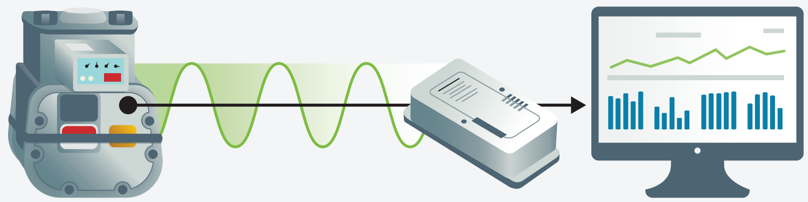
The non-invasive submeter from Vata Verks straps a sensor probe onto the side of a gas or water utility line at the utility meter. As fluid flows, the probe measures oscillations within the magnetic field—from the movement of the utility meter and flow through the line—and transmits real-time high-resolution data to a sensor up to 200 feet from the probe. The sensor calculates consumption and transmits it to a Java Application Control Engine (JACE) Internet of Things (IoT) controller, BAS, or on-site gateway.

The resolution of the data collected is meter-dependent but can be upgraded to ultra-high resolution, which is 100 times greater than the standard high-resolution meter. The submeter is compatible with several industry-standard data communications protocols (e.g., Modbus TCP, Modbus RTU, MQTT, HTTP Push, Pulse) and 95% of existing gas meters, including rotary, diaphragm, and turbine. The submeter also measures water flow, though this functionality was not tested in this evaluation.

Figure 6

Straps on to Any Existing Utility Meter

Real-time, high-resolution data. Can be integrated into BAS for improved visibility.



Non-Invasive Gas Submeter

2022 Testbed Results

99% ACCURATE. For the A. Maceo Smith Federal Building, the submeter showed an average accuracy of 99.05%, with the largest difference of 2.23%. The Terminal Annex Federal Building showed a similar result of 99.23%, with the largest difference of 2.03%.

STRAIGHT-FORWARD INSTALLATION AND INTEGRATION. No plumbers, pipe cutting, or interaction with the utility was required

POSITIVE USER FEEDBACK. In focus group polling, participants rated a value of 4 out of 5 for the submeter's ease of installation. They found the data more consistent, accurate, and accessible than previous data and said they would continue to use the submeter and install it in other buildings.

EASY TO DEPLOY. Duplicating this technology at other locations with compatible BASs can be a simple "copy and paste" of the Modbus integration.

Non-Invasive Gas Submeter

Photo credit Vata Verks

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GPG Report 051: Non-Invasive, Low-Cost Gas Submeter

2022 Testbed Costs

Equipment: $757 for ultra-high resolution gas submeter; 0% to 90% less expensive than incumbent installations at GSA Buildings, which have typically ranged between $10K to $30K

Installation: $2,315; day to install hardware; a few days to connect the submeter to the BAS

Annual Subscription: None

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GSA. GPG-046, Submeters and Analytics: Single Circuit Meter.

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List of Figures and Tables

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National Renewable Energy Laboratory

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U.S. General Services Administration. 12.24