BENEFITS OF ELECTRICAL SUBMETERS

National Electrical Manufacturers Association

Contents

Introduction

Who is NEMA?

The National Electrical Manufacturers Association (NEMA) is the leading U.S. trade group representing electrical equipment manufacturers, which are at the forefront of electrical safety, reliability, and efficiency. Collectively our nearly 325 Member companies provide some 370,000 American manufacturing jobs in more than 6,100 facilities, with worldwide industry sales exceeding $140 billion.[1] NEMA Members make products and systems in seven industrial sectors, including building systems. The NEMA Building Systems Division[2] includes products such as Electrical Submeters.[3]

What is an Electrical Submeter?

Electrical Submeters are electricity meters and associated data acquisition and communications equipment that measure and track building energy performance. Electrical Submeters are used to measure energy use and production of non-utility operated electrical co-generation and storage equipment. They are connected downstream from the utility meter and provide details of energy use for one or more electrical loads. Such equipment is rated at not more than 1,000 volts AC and 1,500 volts DC.

Electrical Submeters provide building managers, owners, and occupants with information to optimize energy efficiency and to allocate electricity bills equitably. Buildings that use electrical submeters show a 15 - 25% savings in energy usage versus master metered buildings of like construction. Electrical Submeters can also identify wasteful consumption and malfunctioning equipment.

What are the Benefits of Electrical Submeters?

The purpose of this white paper is to provide an overview of electrical submeters as well as provide information about the many benefits electrical submeters can offer, including financial savings, energy savings, environmental benefits, and others.

Benefits of Electrical Submeters:

---

[1] For more information, please visit: https://www.nema.org/.

[2] For more information, please visit: https://www.nema.org/directory/products/view/building-systems.

[3] For more information, please visit: https://www.nema.org/directory/products/view/electrical-submeter.

- Offer Financial Savings
- Increase Energy Efficiency
- Provide Environmental Benefits
- Enhance Energy Management
- Facilitate Identification of Energy Waste Problems in Buildings
- Ensure fair sharing of electrical energy cost in a multi tenant building
- Are Cost Effective
- Align with Existing Codes and Standards

Overview

Need for the Ability to Monitor Real Time Energy Consumption

In the early days of government-led energy efficient programs, rebates, and other monetary benefits, an algorithm-based model was utilized to monitor electrical consumption. A formula (Volts * Amps * Power Factor = Watts) was used to determine electrical consumption. This method, however, did not account for "real time" power consumption and was therefore flawed. The "power factor" is not a "static" condition but varies by load. Without monitoring real time energy consumption—by measuring current, voltage, and power factor—this methodology cannot be relied upon to report accurate information for proper analysis or benchmarking purposes.

NEMA Electrical Submeter Section Formed to Address Existing Need

This flawed method of acquiring data prompted NEMA to take action in what it perceived to be an underserved yet growing market segment. In 2016, an exploratory committee was formed to see if there was any interest in forming an Electrical Submetering Section.[4] Industry professionals from over a dozen companies met and ultimately decided to move forward with the NEMA Electrical Submetering Section based on the principle of educating the public and uniting the industry into one cohesive voice.

The NEMA Electrical Submetering Section product scope includes but is not limited to:

- Enclosed, panel mount, modular, portable, and embedded Electrical Submeters
- Electrical Submeters used for electrical monitoring and tenant billing
- Electrical Submeters with capability to monitor one or multiple electrical circuit

[4] For more information, please visit: https://www.nema.org/directory/products/view/electrical-submeter.

- Electrical Submeters used to measure energy use/production of non-Utility operated electrical co-generation and/or electrical storage equipment
- Current transformers and other current and energy sensing devices for use with Electrical Submeters
- Data acquisition and communication equipment, software, and protocols specifically intended for use with Electrical Submeters
- Components specifically associated with Electrical Submeters

Electrical Submeters Enable Effective Energy Management

Submetering as a Tool

"*If you can't measure it, you can't manage it*" – Peter Drucker

Many have heard or seen this quote, which has limitless applications, and energy management is no exception. An optimal way of measuring and managing electric energy is achieved using Electrical Submetering. While the Electrical Submetering itself does not save energy, it is one of the most effective tools to objectively manage energy which leads to energy savings.

Companies need to proactively manage energy use by utilizing the granular data provided by Electrical Submeters. This data allows managers and executives to properly initiate actionable steps to lower their carbon footprint, increase their bottom line, and reduce their waste. Another quote from Peter Drucker, *"Management by objective works - if you know the objectives. Ninety percent of the time you don't"* can also be instituted as a valid argument for utilizing and applying the data gathered from Electrical Submetering.

Electric submeters are an excellent complement to a utility company as a useful tool to ultimately reduce waste and help utilities with load shedding. As is evidence in CA and Hawaii utility companies are experiencing energy shortages causing rolling blackouts to occur. If utility companies embrace these codes and help advocate for better energy management practices we can work together to reduce inconvenient power outages moving forward.

The last year has been a learning experience for the entire world as the Covid pandemic has many people and companies reevaluating common business practices. As it pertains to electric submeters one of the biggest is the work from home practices. A lot of energy management regulations are looking at commercial properties with 20,000 or more square feet, however it could be that more and more of these buildings will not renew leases and stay vacate as people move to work from home. This will only stay that way for a short period of time before owners will find other uses for these buildings, one of the most prevalent example will be repurposing. Retrofitting a building in a manner similar to the warehouses in Brooklyn that were converted

into residences is a very real possibility and electric submeters along with these codes will help make this a reality and eliminate vacant/neglected buildings.

On the other hand, with people working from home more there is an incentive to monitor their electrical usage and charge back to their company or use it as a tax write off, either way electric submetering and complimentary code are going to play a role in post pandemic society moving forward to effectively and efficiently management energy consumption.

Types of Electrical Submeters

Monitoring electrical loads with Electrical Submeters is beneficial within multiple key market segments. Key examples are:

1. Electric kWh Submeters for billing
2. Energy Management/Monitoring Electrical Submeters

"Revenue grade" or "billing" Electrical Submeters are electric meters used for the purpose of measuring the true electrical consumption of a given load with the intent of providing an accurate bill for electricity used. A revenue grade billing Electrical Submeter cannot use any assumed data and must measure actual consumption. Most common applications for billing Electrical Submeters are multi-family housing, boat marinas, recreational vehicle parks, retail rentals, commercial spaces, industrial facilities, or any property manager or owner who wants to pass electrical consumption onto tenants.

Energy management/monitoring Electrical Submeters are used for accurately monitoring real electrical consumption, productivity, quality, benchmarking, regulation, mandates, and preventative maintenance. Energy engineers, facility managers, and plant managers will most often be interested in utilizing energy management/monitoring Electrical Submeters for proper benchmarking and management of electrical consumption. The enhanced electrical data provided by these meters allows the user to make the quality decisions that will result in the best energy management results. There can be no management without measurement.

Data provided for energy management purposes can include any of the following as needed: kWh, Volts, Amps, Power Factor, Frequency, Polarity, Phase Angle, Harmonics, Time of Use, Demand (kW), kVAR, and kVA.

The industry has presented different communication media and protocols to make interfacing with existing, and other, facility management tools possible. These communication types and protocols are: RS-485, Ethernet, PLC (Power Line Carrier), Bluetooth, Modbus, BACnet, I2C, Pulse Output, Radio (RF), Lonworks, Proprietary (by manufacturer), and Zigbee.

Preventative maintenance is a growing Electrical Submeter application as users and specifiers aim to be more proactive—instead of reactive—toward key system maintenance. As an example, by monitoring an HVAC unit, a facility manager can observe volts, amps, or power factor that over a period of time will fall out of its desirable range, thus identifying devices and systems that need maintenance. This can reduce energy consumption and prevent costly equipment failure once the problem is solved or repaired. By monitoring these devices and systems, facility managers can identify, through increased energy consumption, when devices and systems are going to fail—often many months in advance of the malfunction. This advanced notification will allow facility managers to properly prepare and take preventative action, thereby reducing excessive energy consumption and eliminating an unexpected failure. Whether the appropriate action is servicing the equipment or ordering a replacement, the end result will be the prevention of costly shutdowns and wasted energy.

Demand Response Programs

Almost every utility offers some form of a "Demand Response Program" which provides an opportunity for larger consumers to play a significant role in the prevention of overloading the electric grid by reducing, or shifting, their energy usage during peak periods in response to time-based rates or other forms of financial incentives.

Identification of which loads, and how much load to shed, is always a tricky aspect when participating in a demand response program. Electrical Submetering helps energy and facility managers identify which loads to shed and by how much; without jeopardizing their operation. This is done by installing an Electrical Submeter to "shadow meter" the utility's billing meter. This Electrical Submeter is placed so that it monitors the building's main feed, the same as the utility meter. The difference is that this meter feeds energy consumption information to the building's energy management system.

Through real-time tracking of the facility's demand, a program script is developed on the facility's Building Management/Automation System (BMS/BAS) to turn off electrical loads, off-set temperature setpoints, or implementation of other energy consumption reduction measures as the electric demand reaches a specific set point. By adhering to the Utility's Demand Response Program contract, any penalties or increased costs are avoided, and grid overloads are reduced.

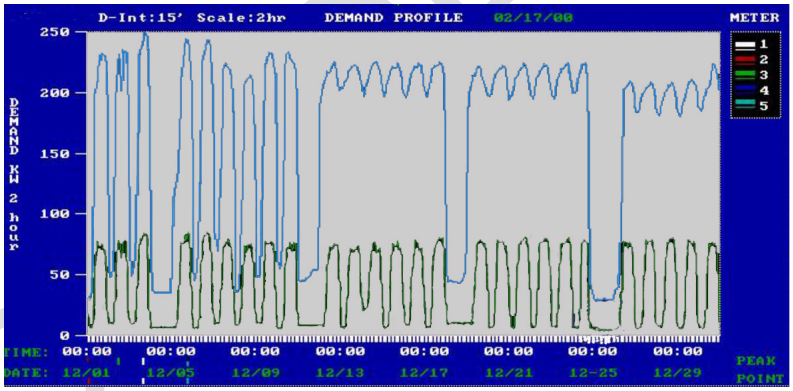
Prevention of Energy Waste Problems in Buildings

Electrical Submetering allows monitoring of the real power consumed, apparent power, and total consumption by various equipment over time. As more data is monitored and stored, patterns and

trends start to appear that grant facility managers the ability to cut costs in a simple, effective, and profitable manner. These patterns and trends help facility managers in numerous ways:

- Optimization of heating, ventilation, and air conditioning (HVAC) and lighting systems schedules
- Lowering baseline by identifying unnecessary loads left "ON" overnight
- Identify changes in efficiency of various equipment through monitoring of power factor values
- Providing data to allow successful shifting of load peaks to reduce kW demand
- Identify BAS modification opportunities or tenant overrides that affected operations

The example of load profiling shown in the graph below provided evidence to the manager of a retail store that the store's lighting (blue line) was not being shut off at the end of normal operating hours during the last three weeks of the month. This caused a considerable increase in the monthly bill for energy.



Retail shop electrical energy consumption

Without the profile data, the cause of the bill increase likely would not have been known nor would it have received the corrective measures to bring it back to normal.

Energy Efficiency Planning Case Studies

Case Study #1: LA Air Force Base[1]

When implementing energy efficiency projects, the task of finding where to dedicate efforts and resources is a difficult, yet crucial, component. Electrical Submetering is key in achieving this task.

An excellent example of this strategy is the LA Air Force Base in El Segundo, California. At this facility, 36 Electrical Submeters were installed to monitor the 14 main buildings of the base to gather data on their energy usage. With the hard data from the Electrical Submeters, the facility's energy manager analyzed the areas that were in need of energy efficiency measures. Based on the data, changes were made to eliminate waste and excessive use.

In less than three years, the final result was that the facility's energy consumption dropped 27 percent from its established baseline. Additionally, utility costs decreased 23 percent—even though the electricity rates increased 4.5 percent over the period.

The results of his actions won the base energy manager the Air Force Material Command Energy Award from the Federal Energy Management Program (FEMP). The base is saving over $1 million annually because of the actionable data derived from Electrical Submetering.

Case Study #2: Energy Efficiency Study

The 2013 Energy Efficiency Indicator (EEI) study, conducted by the Johnson Controls Institute for Building Efficiency, analyzed the energy efficiency technologies, practices and investments made by over 3000 executive decision-makers around the world.

The report found that organization with energy reduction goals:

1. Implemented 50% more efficiency and renewable energy measures than organizations without goals.
2. Are 2.7 times more likely to increase investments next year than other organizations.
3. Adopted more energy management practices (such as frequently collecting and analyzing energy usage data).
4. Indicated they see brand value, property value and other co-benefits as drivers for efficiency and
   renewable energy beyond the energy costs savings.
5. Two-thirds of organizations with public or internal energy reduction goals reported planning to pursue green certification or net zero buildings in the future.

The findings support developing an obtainable Energy Reduction Goal as green tenant spaces and net zero energy buildings are emerging trends in building energy performance.

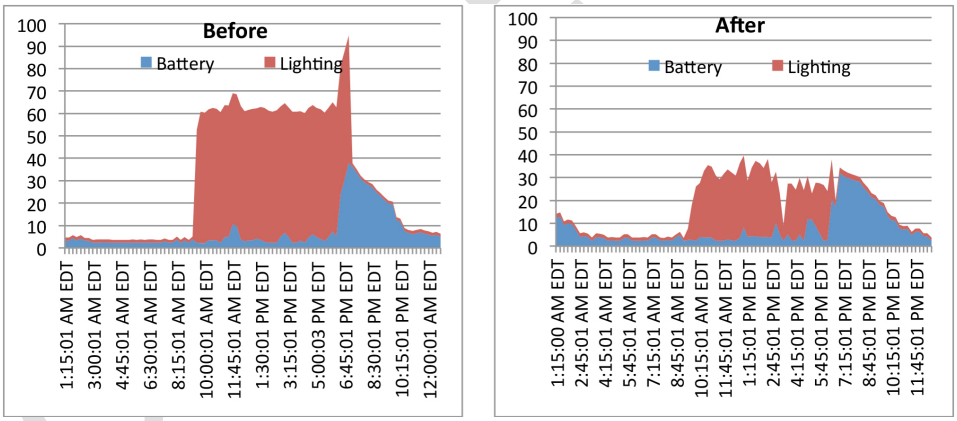
Case Study #3: Legrand North America Peak Demand Savings

In another example, Legrand lowered its peak demand in one California warehouse facility by redistributing the energy demand throughout a few hours. In this particular distribution facility,

the major electrical loads were attributed to lighting and charging the forklift batteries at the end of the day.

In the Before and After energy demand charts below, the energy consumption from lighting is displayed in red, and runs from about 9:15 a.m. to 6:30 p.m. The energy consumed by charging the forklift batteries is shown in blue, and runs from 6:15 p.m. to approximately 1:00 a.m. The Before chart shows that there is a peak in energy demand from 6:15 p.m. to 7:15 p.m., when the forklift batteries are plugged in to begin recharging. To eliminate this peak, the forklift battery chargers were placed on a timer, so the forklift batteries begin charging after the lights were shut off in the facility. Without Electrical Submeters, this level of transparency into the cause behind the peak demand would have been impossible.

This same warehouse facility reduced its demand by 57% by enacting a simple process change. The site energy manager also took the opportunity to retrofit the lighting to more efficient compact fluorescent lamps (CFLs) which reduced overall kWh consumption and demand as seen in these before and after graphs:



Before and After charts of the warehouse facility's energy demand.

Energy Management Equals Energy Efficiency

Occupants' Energy Usage Awareness

When consumers are aware of their energy consumption costs, they often change their use habits which leads to energy savings. When tenants or occupants receive bills for their monthly electric consumption, they will typically try to reduce their costs through energy reduction methods. The

simple awareness by tenants and building occupants of being metered for their electrical usage will often cause them to consciously take some steps toward conservation, such as turning off lights, shutting of computers, and other energy saving habits.

In most cases, building tenants are unaware of the ability they possess to reduce energy consumption within their place of work or living. These occupants don't realize that plug loads, lighting, and HVAC in tenant spaces often account for 50 percent or more of a building's total energy use.[5] Many facilities managers have made this realization and are beginning to urge their occupants to change their habits to save energy by hanging awareness posters in lobbies and through other innovative means. For example, asking tenants to use revolving doors in lobbies helps maintain building temperatures. These small changes add up to big energy savings.

Using the same data from the Electrical Submeters that was used to implement the strategies discussed previously, energy dashboards can be provided which feature metrics depicting a building's energy performance. Energy dashboard technologies can create awareness, generate interest, and cultivate an energy savings mindset within a facility. ENERGY STAR partners have demonstrated that it's possible to save 10 percent or more through employee education and behavioral change.[6]

ASHRAE's 90.1 Energy Code calls for this data to be available to all the building tenants and New York City LL88 requires that a monthly statement be provided to each tenant that is Submetered.

Benefits of Various Submetering Methodologies

Electrical Submeters are still the best choice for tenant billing, especially for retrofit applications, where they really shine because of their flexibility. Tenant billing, however, is only one of the reasons to utilize submeters; there are many other reasons to install and use them. A publication from the Department of Energy describes the various energy savings that can be achieved through various methodologies. A chart from this publication is shown below:

Electrical Submetering Savings Ranges

Action	Observed Savings
Installation of meters	0 to 2% (the "Hawthorne effect")[a]
Bill allocation only	2-1/2 to 5% (improved awareness)
Building tune-up	5 to 15% (improved awareness, and identification of simple O&M improvement)
Continuous Commissioning	15 to 45% (improved awareness, ID simple O&M improvements, project accomplishment, and continuing management attention)

This chart shows that energy savings can be significant as the Electrical Submeter user does more

development/grid-modernization-and-smart-grid/demand-

y_commercial_buildings/ways_save/checklists

with the energy data than only utilize it for billing. With a proactive approach, energy usage can be lowered by up to 45%. When translated to cost savings, a large facility has the potential to save tens of thousands of dollars per month. Therefore, a properly utilized Electrical Submeter system can have a great return on investment.

Installation of Meters:
The simple awareness by tenants that they are being metered for their electrical usage will often cause them to consciously take some steps toward conservation, such as turning off lights, shutting of computers, and other energy-saving actions.

Bill Allocation Only:
When tenants receive bills for their monthly electric consumption, they will typically try to reduce their costs through energy reduction methods.

Building Tune-Up:
When a building manager or owner receives detailed energy usage data this allows them to make operating and maintenance decisions based on this actionable data to lower usage through planning, training, and behavior modification. Proper utilization of Electrical Submeters will facilitate identification of energy wasting issues of a building.

Continuous Commissioning:
When the energy usage is constantly being monitored that usage is controlled through manual steps or through a Building Automation System which greatly increases energy savings.

Energy Efficiency Delivers Financial Savings

Electrical submeters provide significant financial savings for consumers through increased accuracy and awareness.

Prior to the advent of submetering, tenants were typically billed for their electrical consumption by calculating the percentage of the building that they occupied and then charged for the percentage of the building's total monthly electric bill. Alternatively, energy costs were factored into tenants' leases. Neither method provides an equitable charge for tenants' actual electrical consumption; they were either charged too much or too little for their true usage. Through the installation of electrical submeters, tenants are fairly charged for their actual usage.

Studies have shown that providing a bill to end users through billing Electrical Submeters reduces overall consumption. Electrical submeters deliver data to users so that they are informed about their energy usage which can lead to reduced energy bills.

Energy Efficiency Provides Environmental Benefits

The reduction in energy usage is not only beneficial in saving costs, but it also reduces the building's carbon footprint as well. The reduction in Greenhouse Gas Emissions is achieved through the curtailment of electrical energy usage. There are a number of state and federal mandates requiring a reduction in carbon that must be achieved to eliminate possible penalties. These mandates vary in scope and compliance dates that must be considered to avoid any penalties.

Electrical Submeters Are Cost Effective

Electrical Submeters are cost effective because they are a relatively inexpensive investment as compared to the tangible financial savings. In some cases, depending on the location and the utility tariffs, the return on investment (ROI) can be achieved quite quickly. In areas where the kW demand component of the utility tariff is high, controlling the facility's electrical demand can often provide very good results in cost savings.

For example, in New York City where the local Utility Demand tariff rates were very high, an Electrical Submeter system was installed to "shadow meter" the utility's twin feed of a certain office building. The *real-time* kW (Demand) data was supplied via an annunciator system located in the building energy manager's office. When the building demand exceeded a pre-set figure, the annunciator immediately provided this information to him.

When the threshold was exceeded, the building energy manager quickly took whatever steps were required to drop the building load below the pre-set figure to avoid a higher demand cost on the next utility bill. This action reduced the demand charge by approximately $25,000.00 per month. The cost for the Electrical Submetering system was actually less than the first month's demand savings and, in this exceptional case of proactive metering, the ROI was achieved in just a few weeks.

Model Policies Align with Existing Codes and Standards

NEMA Model Policies

:

In order to help state and municipal officials NEMA developed two model policies.

- Model Submeter Billing Policy is addressing Electricity Submetering for Multi-Unit Facilities such as apartment buildings, shopping malls and campgrounds. It is targeting jurisdictions that currently do not allow submetering. The model policy provides the legal framework that would allow it, by providing proper protection for customers and clear rules on how to administer it.
- Model Submeter Energy Management Policy is addressing energy monitoring requirements for commercial buildings that are intended to facilitate energy conservation. The key requirement is that buildings shall be equipped to measure, monitor, record, and display energy consumption data for each energy source (utility, solar, wind, etc.) and end-use category (lighting, HVAC, transportation, pumps, etc.) to enable effective energy management.

Legislation is being written now that will turn a $949.7 million dollar ~~a~~ per year industry into a $2.5 billion dollar ~~a~~ per year industry by 2024.[7]

NEMA Standards Development

In order to bring credibility to the submeter policies the devices used need to meet minimum safety and accuracy requirements.

Definitions

. The following definitions were developed:

> ***master meter, electric***. *– An electric watthour meter owned, maintained, and used for commercial billing purposes by the serving utility. All the electric energy served to a submetered service system is recorded by the master meter*
>
> *Submeters are electrical metering/monitoring devices, and associated data acquisition and communication equipment, connected downstream from the master (utility) meter to provide accurate details about electrical energy use for one or more electrical loads and/ or one or more portions of the facility.*

Safety Standards

[7] https://www.navigantresearch.com/newsroom/global-revenue-from-electric-submeters-expected-to-reach-2-5-billion-by-2024

Electrical submeters safety requirements are described in two UL safety certification standards. One treats them as stand-alone devices (UL 61010), and another as mounted in an electrical distribution panel (UL2808).

Accuracy Standards

The ANSI C12.10 and C12.20 accuracy standards used for master (utility) -type electric meters do not cover the unique and different ways Electrical Submeters are used and installed; nor do they cover the proper ways of testing their components. A new standard that would target Electric Submeters for accurate metrological performance was necessary. To that end NEMA embarked on a project to develop what it amounted to a number of related standards designated as SM 31000 family. After developing them NEMA invited other interested stakeholders to be part of an ANSI consensus group involved in approving them. Currently the following modules have been developed

ANSI / NEMA SM 31000-1- 2021	Electrical Submeter—General Requirements
ANSI / NEMA SM 31000-2- 2021	Electrical Submeter—Active Energy Accuracy
ANSI / NEMA SM 31000-7	Electrical Submeter – Current Sensor Accuracy

Several other modules are in the process of completing this major standardization gap.

With these goals accomplished, the foundation will be set for the industry to come together to promote the benefits of Electrical Submetering.

Case Studies

To further expand the call for energy efficiency, a number of mandates and codes have been introduced that call for required Electrical Submetering of facilities.

ASHRAE added an Electrical Submeter requirement to its 90.1 building code in 2013. As this, and later versions of this code, are adopted by the various states, the installation of Electrical Submeters is being required in the design and construction of new buildings sized 25,000 square feet or larger -- to monitor separate load types.
The 2021 version of the International Energy Conservation Code (IECC) requires buildings 25,000 square feet or larger be equipped to measure HVAC, lighting, plug, and process loads.

New York City's Local Law 88 and Local Law 132 call for the installation of Electrical Submeters in commercial buildings, above a given size, to cover most tenant spaces and floors. The call is to implement submetering technology as soon as possible to drive additional energy and GHG emissions reductions prior to the 2025 compliance deadline.

California's Title 24 calls for separation of electrical loads by type, based on the service size to the facility. Service sizes of 50kVA, 50-250kVA, 250-1000kVA, and more than 1000kVA are given different requirements by load. Installation of a metering system is a method that may be utilized to comply with this requirement.

Conclusion

Electrical Submetering is, and will continue to be, the go-to tool for fair and accurate billing of tenants in a building served by a main utility feed. It eliminates the inequity of billing by square feet -- or other various formulas. It also provides the tenants with the ability to control their energy costs through proactive steps based on the monthly billing information.

Electrical Submetering is also the ideal tool for gaining precise and actionable data for energy management and awareness. It gives the user the ability to utilize this data in a great variety of ways – from tenant cognizance to building automation. Through the application of Electrical Submetering, energy and cost savings are achieved, and the facility's environmental impact is mitigated. Additionally, as a maintenance tool, the data can prevent costly shutdowns and equipment failure.

With Electrical Submetering, the user has the ability to save energy, utilize their Building Energy Management System to its best potential, improve their bottom line through reduced energy costs provide equitable tenant billing, decrease their carbon footprint to improve the environment and reduce global warming, and put preventative maintenance information to good use for a better and brighter future