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Energy Metering Applications

First Step Towards Energy Sustainability

Efficient use of energy is the first step towards energy conservation, sustainability and carbon neutrality. According to DOE estimates, on average 20% of electric energy in commercial US buildings is wasted. Wasted energy comes in many forms, including:

i) Unused energy, e.g. HVAC systems left on when not needed

ii) System failures, e.g. defective sensors, dampers and valves

iii) Inefficient systems, e.g. inefficient chillers, lights and pumps

iv) Inefficient sequence of operations, e.g. simultaneous heating and cooling, lack of free cooling

Prior to undertaking expensive upgrades of energy infrastructure, or installing alternate energy sources, fundamental principles of energy management must be practiced to achieve the utmost in energy conservation. Energy conservation goes hand in hand with a level of energy metering that offers decision makers the energy visibility needed for setting goals, evaluating and prioritizing energy improvement measures, and the verification of results.

Energy metering is an essential first step towards energy management and charting the path towards sustainability and carbon neutrality.

What is Energy Metering

In today's information age one should not think of energy metering solely as installing hardware at power panels to measure energy data. Rather, as an end-to-end intelligent platform to continuously monitor and report energy information. The platform should be designed with prior consideration for the use of the collected data, and for the course of action that can be enabled by the data. Only data that will be used, or acted upon, should be collected.

Also, one must note that energy is not just electric utility power, but power from multiple sources (utility, site solar, site storage, site generator), and different forms of energy: water (chilled, hot, domestic use), enthalpy (energy level of fluids), gas (natural gas, diesel, propane, etc.), and thermal (ice, chilled water, steam).

A metering platform should also obtain information relevant to the facility's energy usage, such as real time and projected weather, utility rates, relevant grid information (automated demand response events, grid energy alerts, etc.), environmental sensor (air quality, sun sensor, etc.), and wherever possible, building occupancy data or other relevant activity-related data.

Emerging energy metering solutions are sometimes referred to as an Energy Information System, however specifications for such systems are not standard and vary from implementation to implementation.

Planning and Reporting Applications

At the highest levels, facility energy metering – where a facility may consist of a portfolio of buildings (campus, retail), a single building, or a specific piece of equipment - enables the following:

Generate a baseline model for the facility's energy as a function of *measureable* ambient conditions. A validated model is critical for anomaly detection, measurement and verification (M&V), budgeting, and other applications.

Benchmark facility energy usage. Every facility's energy usage can be compared to that of its piers using appropriate key performance indicators (KPIs) that normalize for the facility's location, size, ambient weather, energy rates, etc. Common KPIs include Energy Use Intensity (EUI) in kWh/ft2, Energy Use per Cooling Degree Day (kWh/degree), Cooling Delivered per Energy Use (Cooling Tons/kWh), etc. Benchmarking allows for the identification of outlier facilities that may be primary candidates for energy improvement measures.

Track path towards sustainability and carbon neutrality. Energy sustainability and carbon neutrality are often used interchangeable to measure efforts towards relying on renewable and clean sources of energy. These sources of energy may exist on site or may be located offsite to offset the facility's carbon footprint. Monitoring of a facility's energy carbon footprint is essential for the assessment of progress towards carbon neutrality. Gas and electric energy sources are important contributors to a facility's carbon footprint. While present day green house gas (GHG) emissions attributed to electric energy usage are generally calculated using a fixed conversion factor from kWh to GHG tons, accurate accounting in the near future will require time resolved calculation of GHG tons. This is because the actual GHG emissions rate of utility and site power is a function of the energy source, which can vary by time of day and period of the year. For example, in the afternoon when utility solar energy is abundant, the rate of GHG/kWh is lower than during other times of the day when power is generated using coal or gas fuel sources (at night or early morning). While overnight energy may be cheaper because of low demand, it is not necessarily cleaner. Some states are already considering time of use based GHG/kWh conversions.

Educated energy decisions. Capital budgets can be hard to come, and even when available, knowing what to spend money on is not always obvious. Facility energy data can be used to *identify, prioritize and justify* the need for energy investments whether they be for re-commissioning efforts, replacing old equipment, installing new equipment (e.g. variable frequency drives, thermal storage), installing alternate energy sources, etc. Energy metering takes the guesswork out of making energy decisions for accurate data-driven decision-making. The projected ROI of energy expenditures can be calculated with the needed level of confidence prior to any capital investment.

Measure the ROI of energy improvement measures (EIMs). After energy improvement measures have been implemented, energy metering allows for the accurate verification of energy savings. The practice of measuring the ROI of EIMs is commonly referred to as M&V (Measurement and Verification). The most common standard for M&V is the U.S. Department of Energy's 'International Performance Measurement & Verification Protocol' (IPMVP). It is also good practice to have an M&V plan in place that specifies the M&V practices and processes that will be implemented across facilities or for specific projects.

Allocate energy costs. In many campuses where electricity is purchased at a bulk rate, energy costs are allocated to departments and / or buildings based on a formula proportional to building space. As a result, the more energy-efficient buildings effectively subsidize buildings that use too much electricity. There is no incentive for energy conservation at the level of individual buildings, often leading to larger energy costs for the campus and all its buildings. Metering individual buildings enables accurate allocation of costs, including time of use (TOU) charges and peak demand charges.

Utility bill disaggregation. Utility bills include multiple charges and are often hard to understand even by accounting professionals and energy managers. However, understanding the components of energy bills is necessary to plan energy cost reduction measures. Managing energy costs off a utility bill that only contains monthly totals is akin to attempting to reduce monthly credit card expenses with no knowledge of expense breakdown by purchases and category (food, clothing, gas, entertainment, travel expenses, etc.). Reporting hourly and daily energy costs are important elements of an energy metering platform and will help explain the cost breakdown of utility bills.

Power capacity planning. With the increased electrification of relatively older campus and facility infrastructure, power capacity planning is becoming critical. The power feeds of existing buildings and panels are limited, and the addition of electric loads has to take account the total capacity of the power feed as well as the balancing of individual power phases. Electric loads, such as electric vehicle chargers, on site battery storage systems, data centers, computer labs, AC units, electric space heaters, and other power equipment can maximize the capacity of existing circuits and make the facility vulnerable to dangerous voltage drops and current spikes that can damage equipment. Time resolved metering tracks the capacity of critical power panels as a function of time to detect dangerously high levels of power usage.

Energy Usage and Cost Reduction Applications

Identify and eliminate wasted energy. Through the use of software algorithms, multiple forms of wasted energy can be detected from changes in whole-facility energy usage. These include early ramp up of the facility's energy usage, high overnight and weekend usage, and decreases in facility efficiency or facility energy KPIs.

Detect Abnormal Energy Usage. Abnormal facility energy use is best detected using artificial intelligence algorithms that avoid the use of static thresholds, which result in large number of false alerts typically causing the facility staff to ignore all alerts. For example, a facility using 100 kW at 3 pm may be normal, however 100 kW at 3 am should trigger an alert. Having a threshold-based alert system set to trigger an alert at 110 kW will miss the abnormally high usage at the 3 am hour. Lowering the threshold will increase the number of false alerts at the 3 pm hour. It is important that the metering platform be able to intelligently decide what is the appropriate threshold for 'normal' energy use (as a function of weather, month, day of the week, and time of day) and to detect abnormal usage. Whole-facility energy data alone may not be able to diagnose or infer the root cause of the abnormal energy use, however it can serve as a trigger for a maintenance check or further diagnosis.

Monitor efficiency of critical equipment. The efficiency of equipment decreases with their use and age. Equipment maintenance can help regain some of the efficiency losses, such as with belt-driven systems, systems with air or water filters (air conditioning, water and oil pumps, etc), systems that have components that get used up with time (brushes, leads, etc.), or systems exposed to the elements (solar panels). Monitoring the energy consumption of such equipment and comparing it with a baseline will enable the user to detect efficiency degradation and schedule preventive maintenance. This will avoid expensive non-scheduled downtime and prolong the lifetime of the equipment. Metering at the level of all equipment in a facility is not recommended, however metering of critical equipment that are energy intensive may be justified.

Time-of-Use (TOU) Management. Many utilities have implemented time-of-use billing to penalize high energy consumption during times of peak (grid) demand, and incentivize energy use during periods of low demand. By charging higher rates during peak demand times, utilities hope that consumers will shift their usage to off-peak and thus flatten the utility's total demand curve. The impact of simple conservation measures, such as reducing the lighting level during the day or changing the settings on the HVAC, can be valued and contrasted to inconveniences and changes to comfort levels. Other more advanced measures such as pre-cooling, thermal storage, and battery storage can be implemented for load shifting. Time resolved energy metering is needed to track usage at the different TOU periods and confirm load shifting and load reduction.

Peak Demand Management. Many electric utilities include a charge based on the maximum rate of consumption of a facility during the course of the billing period, or even the trailing 12 months. The utility company argues that it has to be ready to supply the peak demand and thus includes a capacity / peak demand charge ($/kW) in addition to the costs of the actual consumption ($/kWh). Energy metering can shed light into the root cause of peak demand usage, and identify whether the peak demand can be avoided or reduced.

Automated Demand Response. Utilities are increasingly relying on automated demand response (ADR) programs that incentivize customers to reduce energy usage during energy emergency events. The incentives can include upfront incentives based on the load reduction capacity, reductions in peak demand charges, or credits based on the amount of kWh reduced during the energy emergency. Load shed, or demand response, if often measured using a utility approved baseline calculation method. Real time comparison of actual usage vs the demand response baseline is critical in guiding the demand response measures and confirming the load shed.

How much to Meter

The level of metering required will depend on the size and type of facility, availability of utility meter data, the heating and cooling infrastructure, the control systems in place to manage the HVAC infrastructure, and the energy improvement measures that are being implemented. As a rule of thumb, for facilities under 30kft2, a whole-building meter should be enough for most applications. However, with larger facilities with multiple rooftop units, chillers, cooling towers, metering at the level of the motor control center (MCC) may be warranted. The MCC is the power distribution panel feeding the main HVAC equipment such as air handlers, DX units, heat pumps, and chillers. A meter at the MCC panel will disaggregate the power consumed by the main units and help in the diagnosis of problems and the accurate calculation of savings at the level of the equipment. If the building automation system is measuring the current of air handler supply fans, chiller compressor units, DX units, variable frequency drives, and other critical units then metering at the level of the MCC may not be needed unless required for measurement and verification.

There are also major cost implications between energy metering and current measurements. Energy metering requires measurement of the voltage at the concerned panel, which in turn may require power shut down to the building, the installation of new circuit breakers or fuse boxes, etc. Current measurements can be made using current sensors that clamp on to the conductors without any need to have a physical tie-in to the panel thus reducing the installation costs. For some equipment M&V and status monitoring applications, current measurements may be good enough.

About MelRok

MelRok is an energy technology and services company that developed and delivers a turn key, automated, scalable and low cost energy optimization platform. MelRok's Self-Driving Buildings™ platform leverages existing metering, building automation systems (BAS), and other energy infrastructure assets to simplify energy management in buildings and eliminate the 20% of energy that is typically wasted in US commercial buildings.

MelRok's energy optimization platform leverages existing and new energy metering assets to offer the ultimate in energy metering benefits and maximize the returns from investments in energy metering. MelRok's platform allows for the real time collection of energy data from multiple sources, including energy meters and building automation systems, multiple vendors, and multiple buildings onto one platform. The data is stored, analyzed in real time, and made available to authorized users via a web-based portal or APIs. Built-in and turnkey analytics, using artificial intelligence and physics-based rules, eliminate the need for expensive energy consultants and data scientists to process the energy data for cost-saving findings and reporting. MelRok's platform is OpenADR 2.0b certified and establishes two-way communication with buildings allowing for the automated and continuous cloud-optimization of building automation systems.

MelRok engineers are experts in the design and implementation of energy metering platforms and assist customers throughout all phases of meter deployment and BAS optimization projects. For more information, please visit www.melrok.com or send an email to info@melrok.com.

About the Author

Dr. Kamel co-founded MelRok and managed its growth to a recognized leader in energy optimization and real time demand management systems. Dr. Kamel led the design and development of a universal Energy IoT gateway, and a cloud-based platform for real time energy analytics, fault detection and control of building energy management systems. Michel was principal investigator in several projects, including a $2.5M California Energy Commission grant for the demonstration of an automated continuous cloud-based energy optimization platform for buildings. He has authored 6 US patents in energy management and optimization, 2 US Patents in aerospace, and 3 international patents in Energy. Dr. Kamel presented his work at dozens of national and international conferences, has served on several technology Boards and currently serves on University of California Irvine’s Dean of Engineering Leadership Council.

Dr. Kamel has a Ph.D. in Mechanical Engineering from Stanford University.