Recipe for a Successful Metering Project

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This white paper is a guide towards deploying a metering platform across a portfolio of buildings. While the author attempts to be comprehensive, some additional steps may be required on a case-by-case basis. By the same token, not all steps will be required for all implementations and the appropriate steps can be selected based on the scope of the project. These steps are based on more than 10 years experience in the deployment of real time metering platforms across commercial and industrial buildings, educational campuses, data centers, and retail chains. The responsibility of these steps is divided between the facility's staff and that of the energy metering platform provider's staff. For the purpose of this paper, a metering platform is defined as consisting of the energy metering hardware, connectivity gateways, software analysis modules, and a portal for data visualization and reporting.

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Benefits of Metering

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 US commercial buildings is wasted. 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 data-driven energy management and charting the path towards sustainability and carbon neutrality. The benefits of metering include:

Energy Planning & Reporting Applications

- Generate a facility energy baseline model
- Benchmark facility energy use
- Track path towards sustainability and carbon neutrality
- Make educated energy decisions
- Measure the ROI of energy improvement measures
- Allocate energy costs
- Utility bill disaggregation
- Power capacity planning

Energy Usage & Cost Reduction Applications

- Identify and eliminate wasted energy
- Detect Abnormal Energy Usage
- Monitor efficiency of critical equipment
- Automated Demand Response
- Time-of-Use (TOU) Management
- Peak Demand Management

The benefits are detailed in MelRok's *Energy Metering Applications* white paper available upon request.

Where to Start? The 3 Essentials

When a decision is made of deploying energy meters across a campus, the immediate question that haunts the energy and facility managers is: Where to start?

1. Building the team. Successful deployment and use of a metering platform will involve to different degrees personnel from multiple disciplines and departments including energy management, facility management, IT, sustainability, finance, purchasing, contractors, energy consultants and energy service providers. It is important to identify the departments that will be users or benefactors of the energy information and engage a point of contact from each department during the planning phase.

2. Gather the requirements. With the team assembled, the next step is to solicit requirements from each team member and understand how the respective departments can use the energy meter information. These requirements can include the list of buildings that need to be metered, required metered data, data temporal and spatial resolution, as well as cyber security, communication, data accessibility, performance indicators, alerts, dashboards, and reporting requirements. A good understanding of how the meter data will be used will be critical in specifying some of these requirements, specifically the buildings that need to be metered and the level of metering at each building. If external contractors will conduct the installation, then purchasing or legal will have additional requirements (e.g. insurances, bonds, prevailing wage). A simple requirements document that outlines the needs of each stakeholder can be assembled. The requirements can be included in a Request for Proposal (RFP) document, should one be needed.

The requirements document shall include details of the meter hardware and the associated metering platform that will integrate, analyze and report the energy data and information. Some of the requirements shall be finalized after the site surveys are completed in subsequent steps outlined below. However, there is a set of generic minimum requirements needed to meet best practices of energy metering.

Meter Hardware Core Requirements

The following requirements must be standardized across all meter hardware to simplify and improve the connectivity, logistics, commissioning and servicing of the meters. These non-negotiable requirements include:

- *Modbus TCP or BACnet/IP connectivity a must, dual support of Modbus RTU a plus*
  IP-based published communication protocols (Modbus TCP and BACnet/IP) eliminate the exclusive dependency on the specific gateway system used to collect and stream the meter data. Furthermore, IP-based communication allows for multiple systems to connect to the same meters, e.g. the building automation system and the metering platform can both connect to the same meter. Having a dual capability of Modbus RTU may be a plus in cases where IT restrictions or logistics prohibit the use of the local area network (LAN), or limit the number of Ethernet drops. In such cases, the gateway connects to the meters via serial interface and sends the data to the cloud via broadband modem or a single LAN Ethernet connection. Even in such

scenarios, the meter should have IP-based communication option to allow for potential future Ethernet connectivity.

- *Revenue grade accuracy*
  The net accuracy of a meter is the combined accuracy of the meter hardware and its associated current sensors (CTs). The accuracy of the CTs can be selected on an as needed basis, and it is important not to handicap the combined accuracy of the system by selecting a non-revenue grade meter. Revenue grade meters mean an accuracy of better than +/- 2% of the measurement. The accuracy of the meters may be of concern if the meter data will be used for utility incentives, equipment financing, performance contracts, etc. The incremental cost of specifying revenue grade meters is minimal at the design stage of the project.
- *Meter remotely configurable via Modbus or BACnet*
  Remote configuration of devices is key to be able to confirm the setup of the meters and to remotely fix any errors. It is important that the meter be remotely configurable via a published protocol (e.g. Modbus) as opposed to just the vendor's software, which limits the capability to configure the meter using other software and may require being within close proximity to it.
- *Channel phase voltage re-assignable remotely via Modbus or BACnet*
  This is not a common feature of energy meters, yet it is a critical one and will save time and money during and after the commissioning of the meters. One common mistake that occurs during the installation of electric energy meters is that the current sensors are installed on the wrong phase. This typically requires an electrician to be sent back to the site, and physically swap at least two sensors to different conductors. This incurs additional (non-budgeted) costs and delays the start of flow of accurate meter data by days or weeks. Being able to remotely re-assign the voltage of each channel to a different phase is a value added feature that will save time and money.
- *120V – 480V Power connection*
  Meters need a voltage connection to power up, measure the voltage, and measure the phase difference between voltage and current. Requiring that meters accommodate 120V to 480V power source will allow for the use of the same meter model across all buildings and panels, simplifying ordering, stocking requirements, installation and commissioning of the meters.
- *Accommodates clamp on current sensors (detachable/split CTs and Rogowski coils) without external signal conditioners*
  These types of current sensors simplify the installation as they can be wrapped around the conductors avoiding the need to disconnect any conductor. Rogowski coils have the added advantage of being flexible, making them the electricians' favorite when it comes to wrapping around main buses, large non-flexible conductors, and bundled same-phase conductors. There are additional advantages to Rogowoski coils, mainly their large rating (typically > 1000A), their linearity across their entire range, and their frequency response (> 1 MHz) that make it ideal for demanding applications. It is important to select meters that do not require any external signal conditioner for Rogowski Coils to simplify installation.

- *Accommodates CTs with voltage output (typically 0-0.5V)*
  Current sensors can come with current or voltage output. Current output CTs require extra care during installation to avoid build up of voltages should the CTs be disconnected from the meter while they are still wrapped around a live conductor. The build up of voltage can quickly exceed thousands of volts, and represent a dangerous situation to people and cause damage to the meter when re-connected.
- *CTs with long leads*
  CTs typically come with 6 ft leads, which are not long enough in many applications. Electricians end up needing to splice the leads to extend their length. This introduces non-necessary risks of poor connections of these thin gauge wires, and adds to the time and cost of the installation. CTs must be ordered with leads of at least 10ft as it is easier to cut a long lead than to splice a short one.
- *Reports a minimum set of energy metrics*
  Electric energy meters shall at a minimum report voltage, current, power, energy and power factor per phase and for the 3-phase totals. Additional requirements (e.g. harmonics measurements) may be needed for specialized applications (e.g. data centers, transformers)

If connectivity to existing meters will be established via a serial or pulse output interface, the converter gateway must support Modbus TCP or BACnet/IP connectivity.

<u>Metering Platform Core Requirements</u>

The specifications of the metering platform must also be completed. A minimum set of metering platform features is given here and forms the nucleus of a detailed set of features:

- Real time connectivity
- Support of Modbus, BACnet protocols
- 1-minute time resolution of collected data. The 1-minute resolution is required for potential real time peak demand management applications, and for detection of short cycling of critical equipment - when equipment turns ON and OFF in short cycles due to some design or logic errors.
- Minimum data retention of 3 years, to allow for generating a baseline and tracking the year-over-year performance of buildings at a monthly, weekly and even daily resolution.
- Consolidate data from all meters and across all buildings into one portal
- Real time physics- or artificial intelligence-based analytics that do not rely on manual setting of thresholds for every building and / or equipment
- Real time visualization
- Data access via secure APIs
- Secure data upload to the cloud
- Able to create virtual metrics that are a mathematical function of one or more measured metric
- Automated weather and / or TOU-normalized baselines of energy use
- Automated standard 10/10ADR baseline for building and equipment

- OpenADR2.0b certified VEN
- Secure cloud- or web-based portal (to consolidate all facilities into one)
- Multi-user access privileges
- Visualize cost, EUI and other energy metrics in real time
- Built-in M&V reports, EUI reports, energy cost, and anomaly reports
- Advanced built-in energy data plotting tools including load duration curves, heat maps, profile plots, scatter plots and box plots
- Able to integrate (and display) electric energy, water, and gas metrics
- Able to integrate data from onsite weather stations, NOAA weather stations, or other weather services
- NIST-synchronized time clock
- Time stamping of meter data at the source (before upload to cloud)
- Consolidates building automation data and facility data from all buildings on same portal
- Provides fault detection, diagnosis, visualization and reporting of building data

The last two requirements are critical for the continued relevance of the metering platform. Energy Metering is only the beginning of the journey towards energy optimization, sustainability and carbon neutrality. A subsequent step will be the integration of data from building automation system and other facility data. Selecting an energy platform that is expandable to include building automation data and other data will streamline the process, and minimize future costs, of integrating with building management platforms. It will also increase the ROI of the metering project by coupling the meter data with building management system data for improved diagnostics and optimization.

3. Find the right partner. Most facility and energy managers barely have enough work hours in a day to manage the day-to-day of their facilities. It is important to find the right service provider who can ensure that the meter deployment project will be successful, most economic, on time and on budget. The service provider partner will work with the stakeholders to help find the right balance of roles and responsibilities that accommodate the organization's human resources capacity while meeting schedule and budgets. This effort is not a one-time sale of hardware or software, but a true partnership that will require responsible and transparent communication between all parties throughout the deployment period.

Taking the Plunge: Deployment and Commissioning

1. Contract award. The entity awarded the project shall be responsible for preparing the detailed bill of material (meters and CTs), ordering the hardware, managing the installation process, commissioning of the meters, setup of platform, user training, reviews of the system performance, and review of initial findings a month or so after commissioning is complete. This will ensure that no blame game is played between the different hardware and service providers should anything go wrong, and leaves one entity responsible and accountable for the metering project.

2. Survey the existing metering infrastructure. Existing metering infrastructure should not be discounted no matter how old it is. Many legacy meters have remote connectivity ports, serial or pulse output, that are not being used. The useful life of these meters can be extended with real time data connectivity to the meters, effectively turning them to smart meters. Information available may be a pulse count proportional to usage (kWh energy, water, gas) or a wider range of parameters if the connection is via Modbus. At a minimum, one-minute demand data (average usage over a minute) can be obtained even with meters that only provide pulse outputs. The survey should include information of the location of the meter (building and room), the load it is measuring (panel, flow in pipe, etc.), the make and model of the meter, whether it is currently being accessed, the original purchasing documentation if available, and the availability of historic meter data if it was being logged. Wherever possible, a picture of the meter needs to be taken, and notes made as to the availability of a power outlet and Ethernet drop in the vicinity of the meter.

When original purchasing documentation is not available, a picture of the side or back of the meter where the meter's catalog and serial numbers are printed will be needed. Many legacy meters come with communication options specified at the time of purchase. When the original purchasing documentation is not available, the only way to confirm which communication option was purchased is through the specific meter catalog number or serial number.

The survey of existing metering infrastructure should also record the availability of any utility meter, the meter number, supported protocol (pulse, ZigBee SEP), value of pulse multiplier (if available), whether a pulse junction box is already installed and if so, whether it is being used. This information will be used to attempt real time connectivity to the utility meter data, and to request available historic interval data form the utility.

3. Survey the buildings that need to be metered. The requirements gathered in the first step will include the list of buildings that need to be metered and possibly the level of metering for each building. Often times, the level of metering can only be finalized after the building has been surveyed and cost factors considered, as the panel layout can impact the cost of metering. The survey of buildings starts with collecting available electrical single line diagrams for each building, as well as metadata on the building including: building name, number, square footage, primary function, year built, schedule (if fixed), power shutdown restrictions, accessibility restrictions, point of contact, and emergency contact. The survey will also specify whether the building includes a chiller, cooling tower, central plant (feeding other buildings), boiler, commercial kitchen, and whether the building feeds power to other buildings or to parking lots and garages. The survey should also include a walk through of the facility to confirm the accuracy of the single line diagram, the availability of spare breakers (with same voltage) in or within proximity of the panel that needs to be metered, the location of the panels, the closest Ethernet drop to the panels, the labeling of the circuit breakers on the panels of interest, and pictures of the panels clearly indicating the panel and breaker labels. It is recommended that whenever possible, the electrician(s) that will be doing/bidding the installation takes part of the site survey as they may need specific information (conduit distances, need for new breakers, etc.) to provide an accurate quote.

4. Finalize the energy meter specifications. At this stage, the specifications of the metering hardware and those of the metering platform can be finalized based on the requirements and the findings of the site surveys. For the hardware, the requirements will specify for each meter:

- Type of meter (e.g. 3 phase, multi-channel)
- Voltage and wiring configuration of meter (e.g. 480/277, 480 Delta, 208/120, 208 Delta)
- Number of CTs (current sensors)
- Rating (e.g. 200A, 3000A) and type (e.g. clamp on, Rogowski coil) of each CT
- The accuracy class of the CT
- The length of the CT leads

5. Preparing for the deployment. Ahead of the deployment kickoff, a packet needs to be prepared to document the deployment processes, schedule and milestones. The packet should include the installation sheets for the electrical contractors that specify the meters to be deployed, the panels and specific breakers, the type of CT for each breaker, etc. These sheets are prepared based on the information from the site surveys. The packet will also include the sign-off sheets for the individual meters to be signed by the point of contact for each building confirming the installation of the meter and satisfaction with the quality of the installation (proper mounting, wiring, labeling, etc.). The packet will also detail the commissioning process and have the commissioning checklist. A digital copy of these forms and checklists should be kept as a record of installation for reference.

6. Contractor kickoff meeting. The kick off meeting will review the installation schedule, milestones, installation and commissioning processes. Instructions are handed to the electrical contractor in the presence of the customer. Any special instructions for scheduling of installations, site access procedures, emergency procedures, and coordination with IT for installation of new Ethernet ports will be explained.

7. Installation. Installation of a single meter can take from 4 to 16 hours depending on the number of channels (up to 48), the number of panels, and the distance between the meter and the panels. Whether installations can be done live or require a power shutdown is a function of the panel, customer requirements and the local electrical code. Even if a shutdown is required, it is only for a short period of time (in the order of minutes) to finalize the critical connections. Installation is complete when the meters are powered, all sensors installed, the installation sign off sheet is signed by the customer, and the meter is connected to a live and permanent Ethernet connection.

8. Meter commissioning. Meter commissioning is the effort of confirming that the meter is powering up and properly configured, the sensors have been installed properly, the data is flowing to the cloud, and the readings are consistent with expectations. Commissioning is best done automatically using software that analyze the (1-minute) meter data over a period of time. The first pass at commissioning has to be done while the electrician is on site using data from a relatively short period of time (typ. 15 minutes). Any problems can be easily diagnosed and fixed while the electricians are onsite. Backup communication channel (cellular router) have to be provided should the site Ethernet access not be available at the time of commissioning. It is possible that not all loads measured be active during the commissioning process. A second pass at commissioning is required at least a week after the installation is complete, and uses the data collected over a minimum period of a week to confirm the proper operation and configuration of all meters and sensors. A commissioning report is created for each meter and attached to the meter's installation file.

9. Platform setup. The platform setup shall proceed in tandem with the installation process to ingest the meter data as the meters are brought online. Setup includes configuring the buildings and monitored equipment on the platform, registering the meters, tagging the data collected by the meters to the appropriate building or equipment, and creating any needed virtual meters. Platform setup shall also include the upload of any historic data, setup of notifications, any custom KPIs and custom reports needed beyond the KPIs and reports that come out-of-the-box.

Post Deployment

1. Training. As buildings are being commissioned, user training can be scheduled to review the details of the metering platform and the features of the portal. The training is also an opportunity to learn of any new requirements or specific demands the users may have. Multiple training sessions are typically scheduled to accommodate user schedules and user advancement.

2. One-week review. One week after the commissioning of 10% or more of the buildings, a review of the collected data and platform performance should be schedule to acquaint the users to the platform and learn what additional support users may need in terms of custom KPIs or reports, and / or services.

3. One-month review. At least a month after all buildings have been commissioned, a meeting is scheduled to review the performance of the platform and the initial findings from the different buildings. This is another opportunity to get feedback from the customer on any KPIs or reports that will be useful to them.

4. Project completion. After the 1-month review, a meeting is scheduled to review the project requirements and confirm that all requirements have been met. The meter deployment project is officially closed. Processes for continued expansion of the metering platform and for any ongoing support services the user may need are discussed and put in place.

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.

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