Submetering

A Practical Approach

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Every increase in the cost of a barrel of oil just magnifies the importance of conserving energy and you can't accomplish that without tracking its use. More than ever, submetering is being applied in industrial as well as the traditional commercial and residential applications to encourage conservation and increase productivity. This article will describe what it is, why it's important and how to effectively apply it.

Although submetering can be used to perform most critical functions such as equipment monitoring, trending, alarming, predicative maintenance, communication, and power quality analysis, this article will concentrate on monitoring energy. Submetering applications may include market segments such as residential, commercial, industrial, manufacturing, pharmaceutical, data center, and petrochemical, most of which will be addressed here.

Introduction

Submetering is typically a metering process installed by and for the owner and is not in any way related to the utility company providing the electrical service. Therefore, an industrial, or commercial/residential multi-tenant building owner installs the submetering equipment for the sole purpose of metering within – either for allocating costs or for internal billing. Typically for tenant billing applications, submetering guidelines governing usage and installation can be obtained from local Public Utility Commissions (PUC) or the local utility.

Since the utility provides electrical service to a facility, they install their own electrical meter to measure the Kwh and in many cases, the electrical Demand; these installations are classified as either master-metered or direct-metered and should not be confused with submetering The two are described below:

1. By installing a *Master Meter*, the utility provides a single metering point at the service entrance for the purpose of metering all electrical usage within the facility. This is common for industrial/manufacturing or commercial buildings where a single business entity exists. It is also common in multiple tenant buildings such as high-rise commercial or residential structures where the building owner is billed for the entire building's energy usage and must rely on some technological means (i.e. submetering or approximation) to determine each tenant's actual usage.

2. By installing individual electrical meters for each tenant in the building, the utility can *Direct Meter* to accurately read and bill each tenant with the correct energy information based on actual usage. This method has become common practice in multiple tenant applications and has both advantages and disadvantages over master metering. Master and direct metering practices are discussed in greater detail below.

The concept of metering energy in tenant building applications

Submetering is not a new technology; in fact it has been in use for a number of years to measure water and gas consumption. Historically, building owners in metropolitan areas would provide all utility services to their tenants – (i.e. electricity, water, and gas.) In time many building owners saw the advantage of combining a single utility service for the entire facility with a privately owned submetering system for allocating actual electrical usage to the tenants. Let's examine why submetering has been gaining popularity in high-density tenant applications by first understanding the advantages/disadvantages of how tenants can be charged for energy today:

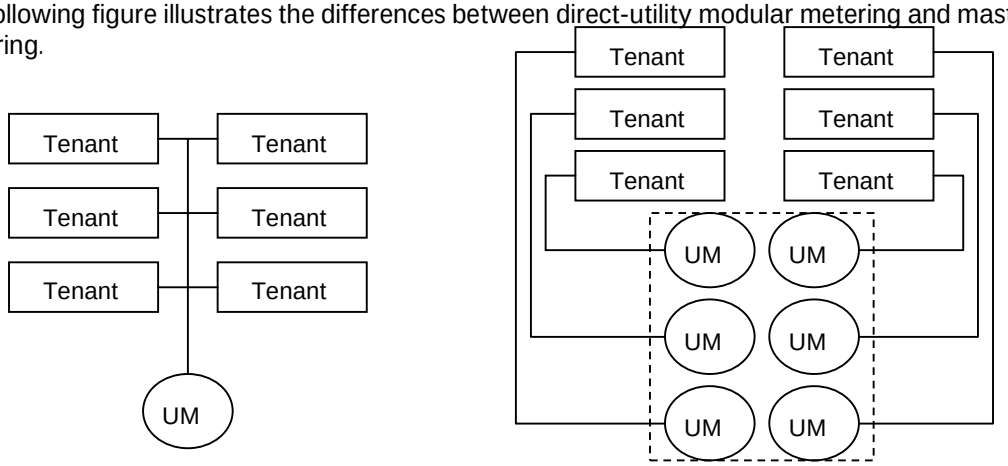
Master Metering – Advantages/Disadvantages

Many cost savings were realized in new construction by simply billing the building owner for total energy usage. Thus, the "master-metered" concept was born – the utilities would provide one main meter for the building for each utility feed and the building owner would allocate the proper cost to each tenant. Although not accurate, this concept stood the test of time because utilities were relatively inexpensive. This RUB (Ratio Utility Billing) method could be based on the number of tenants, square footage of the leased space, number of people or a combination of all factors. While logical and inexpensive to install, it could never be accurate, especially since people's lifestyles might be totally different. For example, an apartment with three tenants might consume less electricity than a similar apartment with one tenant who stayed home all day and kept the air conditioning at its coldest setting. If everyone is sharing the bill, who cares if we crank up the heat or leave all the lights on when we leave? It will get averaged out amongst the other 400 tenants – So much for conservation.

Direct Metering – Advantages/Disadvantages

Some of the issues associated with master-metered electrical billing faded away as direct or modular metering became popular. Modular metering equipment consists of an enclosure, which includes the main utility bus subdivided by individual meters, organized in stacks, each servicing a unique tenant. These units are typically mounted at a central service entrance location and represent a utility reading and billing responsibility. The building owners could now avoid the entire billing issue by having the utility provide individual meters direct to each tenant. This should have solved the problem…right? In theory – yes; however it introduced a whole new set of issues. In a high-rise building, real-estate space is extremely expensive, especially as the number of floors increase, and modular metering "stacks" occupy a great deal of space. The location of these meters is also an issue since many utilities require them to be accessible at ground level. This results in a need for "home run" wiring from each meter location to each individual suite (see Figure 1) a potentially costly endeavor. In the case of a submetered system, the meters can be placed at upper floor levels and communicate the data to a central point where the owner will read the data and use this actual point-of-use data for billing purposes. In this way the electrical distribution is essentially configured like the 'Master Metering' scheme, thus providing considerable savings to building owners. A further differentiation between the two approaches is that with modular metering each tenant pays the full residential energy rate in addition to service charges, whereas the submetered system is billed on a larger volume/lower rate basis and only incurs one service charge for the entire system.

The following figure illustrates the differences between direct-utility modular metering and master-utility metering.



Master Utility Metering Direct Utility Modular Metering

Figure 1

The principle of submetering focuses on a master metered building, where the building owner installs meters to individually monitor tenant electrical usage as shown in the figure below:

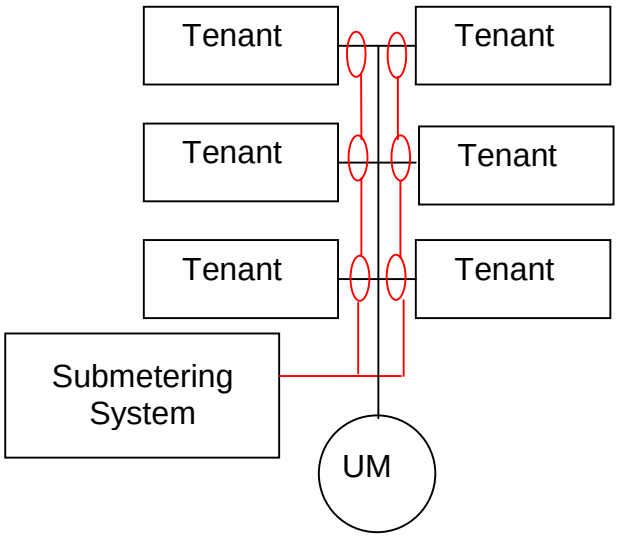


Figure 2

Submetering applications by market segments

Commercial Buildings (Multiple tenant)

Submetering can determine actual energy usage of leased commercial tenant space as a basis for energy billing or cost recovery. In commercial space, energy costs are typically included as part of the lease if they are not direct metered by the utility. As previously mentioned, direct metering by the utility negates the need for submetering since all tenants are billed directly from the utility for their actual usage. However, in the master-metered property, tenant energy consumption can be established as a fixed energy expense and incorporated as part of the lease. This method may be based on a number of factors including square footage, hours of occupancy, or other pre-negotiated factors. The issue with master metering lies in providing equitable billing and the fact that tenants are not encouraged to conserve energy since the building's total energy bill is an aggregate, which is divided amongst all. Also, in some cases, energy expenses may simply be a fixed percentage of the lease, resulting in extreme fluctuations in energy costs due to energy market volatility with possible risk to the property owner. For these reasons, submetering can be quite beneficial in assigning actual energy costs to each tenant. Applications of submetering may be found in any master metered multiple tenant buildings and are also useful in determining common area energy costs such as lighting, parking lot lighting, HVAC, etc. Property management firms often employ larger submetering systems capable of collecting energy data from tenants located in different buildings nationwide.

Residence Buildings (Multiple Tenant)

Since residential submetering is similar to commercial multi-tenant applications, refer to the description directly above. It should be noted that residential applications often involve far more metering points in a building than commercial due to the higher number of tenants. Applications of submetering may be found in any master-metered apartments, condos, time-shares, health care assisted living communities, etc.

Other (Commercial/Retail, Institutional, etc.)

Submetering can provide electrical usage data in situations where a detailed electrical analysis can be determined by studying trends as they relate to electrical costs. For example, a national retail chain can realize that minimizing lighting levels or cooling at certain hours of the day can reduce expensive demand charges on their electrical bill – possibly resulting in a substantial reduction in energy costs. A university might learn that certain campus buildings are less efficient to run during certain daylight hours, therefore may elect to shift class locations to minimize these costs. In order for an analysis to be accurate, an actual means of measuring the energy must be in place before corrective action can be implemented. In most buildings today, the only means to know how much energy is consumed is by waiting for the energy bill at the end of the month – Obviously it is too late.

Industrial/Manufacturing

Submetering can determine actual energy consumption of individual business units, cost centers, or processes for the purpose of providing energy usage data. This energy data often translates to actual cost information, useful in gaining financial an accurate understanding of electrical Kwh and Demand parameters. From a financial standpoint, this information helps an organization establish cost accountability or cost allocation of various internal functions. Also, since electrical energy costs can vary

based on the time of day, process runs can be planned such that they operate during off-peak times when electricity cost less.
In summary, all four of these common segments generally fall in two classifications – *Energy cost allocation* and *Tenant billing/cost recovery*:

Energy Cost Allocation
Industrial/Manufacturing
Other (Commercial/Retail, Institutional)

Key Attributes:
Establishes energy usage by:
Process
Cost Center
Usually tied to energy management system
Provides detailed energy data profiles
Useful for energy analysis and energy planning

Key Benefits:
Reduce peak demand
Increase load factor
Reduce usage
Determine equipment/location efficiency
Encourages energy conservation
Promotes accountability
Helps negotiate better energy purchasing
Peak load shifting via billing Time of Day rates

Tenant Billing/Cost Recovery
Commercial (Multi-tenant)
Residential (Multi-tenant)

Key Attributes:
Determines tenant energy usage for billing
Usually tied to in-house or remote billing system Department
Billing can be outsourced to 3rd party service

Key Benefits:
Actual data promotes fair energy allocation
Encourages conservation
Promotes accountability
Space saving
Reduces modular metering in new construction

Submetering Examples

Commercial Buildings (Multiple tenant)

In commercial space, tenants can be direct metered by the utility. In the absence of direct metering, many existing buildings are only master metered, which results in the property owner trying to allocate energy costs to tenants. Submetering can take the guesswork out of this process. Many utilities prefer to provide commercial buildings (high rise office, retail malls, etc.) with only a few master meters and will provide incentives such as lower rates to accomplish this.

Who could use this system?

- Commercial Property Managers
- REITS
- Landlords
- Shopping Mall Managers

A submetering system designed to allocate and manage energy costs is best suited in applications where one or more of the following conditions apply:

- There is a need to allocate costs for actual electricity usage by tenant in buildings that are master metered when the aggregate total of electrical costs are distributed amongst the

tenants. This is typically based on inaccurate factors such as square footage, hours of operation, etc.

- The electrical costs have been absorbed into the landlord's costs and "rolled" into the annual lease or rent, whereby any volatile fluctuations in energy cost impact the landlord and are not passed to the tenant.
- There is a need to separate lease and energy costs to encourage tenant conservation and minimize landlord risk. As an added benefit, property managers may gain the benefit of Net Operating Income (NOI). The key is to shift risk of fluctuating electric usage and therefore costs from property owner budget to tenant, making the tenant accountable for electric usage while giving incentives for conservation.
- There is a need to retrofit an existing building using state-of-the-art technology such as Power Line Communication (PLC) in order to immediately reap submetering benefits without having to hardwire costly networks into the building.
- There is a need to provide an alternative to individually metering tenants by utilities in new construction. By eliminating modular metering "stacks", valuable electrical supply closet space is freed up and aesthetics are improved.

Example – Commercial Tenant

In the example below, a commercial office building leases space to 14 tenants. The 277/480V three phase electrical service is distributed from two supply closets on the east and west wings and is serviced by the utility through a master meter. Since the landlord receives a single monthly bill from the utility, electrical costs are distributed to the tenants based on a square footage calculation and included in the yearly lease. Many of the tenants are complaining that their energy costs are disproportionately high since other businesses in the building operate for extended hours or operate equipment that consumes great amounts of electrical energy. Management is looking to measure and bill each tenant for actual usage and will retain a 3rd party service to read and bill the tenants on a monthly basis.

The solution would include the installation of a multi-point submeter, capable of monitoring eight – 3 phase tenant loads in each supply closet. The submeters would be mounted in close proximity to the electrical distribution system feeding power to each tenant space using split core current transformers. The submeters would then communicate the collected energy data though the AC Power lines to a transponder/data collector device located near the service entrance. No communication wiring is necessary in this example. A telephone line is routed to the transponder, where a third party billing service collects the data and generates monthly invoices.

Components needed:
2 Multi-point (8 ckt) Submeters w/data logging and PLC communication capability
42 Split Core CT's
1 PLC Transponder w/modem interface

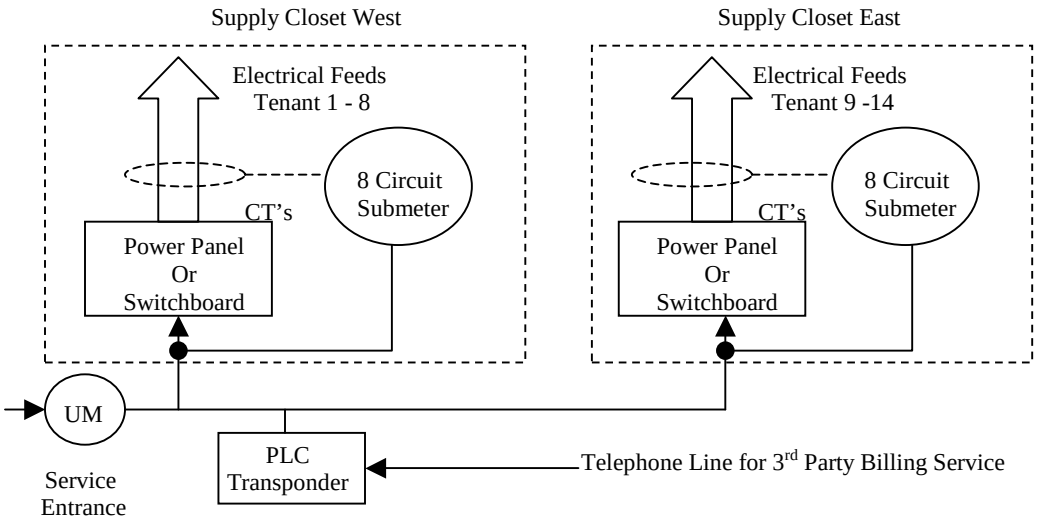


Figure 3

This example should position a very important concept to commercial building owners – Tenant billing can be provided at an *Enterprise level.* In other words, this type of submetering system can be applied regardless of the number of properties managed – all electronic data can be communicated via telephone modem to a central point.

Residence Buildings (Multiple tenant)

Similar to commercial property, residential space tenants can be direct metered by the utility. In the absence of direct metering, many existing buildings are only master metered, which results in the property owner recovering energy costs in the lease. It is also subject to extreme volatility due to energy rate costs resulting in financial risk to the building owner – especially since residential properties often house several hundred tenants.

Who should use this system?

- Residential Property Managers
- REITS
- Landlords

Since many of the principles associated with commercial tenant submetering apply to residential tenant submetering as well, refer to the commercial description above. A residential metering application differs from a commercial application in several ways – residential buildings typically involve many more metering points – up to several hundred per building. This will require an extensive metering and data retrieval system capable of measuring the energy consumption from each tenant and communicating the results an energy management system. This must be accomplished working with the electrical supply closet restraints as well.

In new construction scenarios, the supply closet space can be minimized in architectural designs. Several major advantages exist in high-rise construction when using submetering over direct metering. Naturally, the space requirements are minimized, but other cost saving benefits can be achieved by replacing pipe and wire runs with more cost effective busway. The building owner can also offer more "competitive" energy rates to their tenants since the building now purchases (and passes on) energy at commercial rates – a substantial savings compared to residential rates.

In the example below, an existing high-rise residential building houses over 120 tenants with 4 tenants per floor. The building uses a busway riser 120/208V single-phase service and is billed from the utility

using a single master meter. Currently, each tenant pays energy “surcharge” as part of his or her rent and the annual amount is fixed and based on apartment square footage. The building owner will install a submetering system to measure electrical usage to provide an accurate and fair assessment of energy usage, while promoting conservation.

The solution would include the installation of a multi-point submeter, capable of monitoring twelve, single phase tenant loads in each supply closet. The submeters would be mounted in close proximity to the electrical distribution system feeding power to each tenant space using split core current transformers. The supply closets are located on every three floors and house power panels supplying single phase, 2-pole power to each apartment. Every supply closet distributes power to 12 individual apartments, therefore a 12 circuit multi-point meter will be installed in each closet. The submeters would then communicate the collected energy data though the AC Power lines to a transponder/data collector device located near the service entrance. No communication wiring is necessary in this example. A telephone line is routed to the transponder, where a third party billing service collects the data and generates monthly invoices.

Components needed:
12 Multi-point (12 ckt) Submeters w/data logging and PLC communication capability
288 Split Core CT’s
1 PLC Transponder w/modem interface

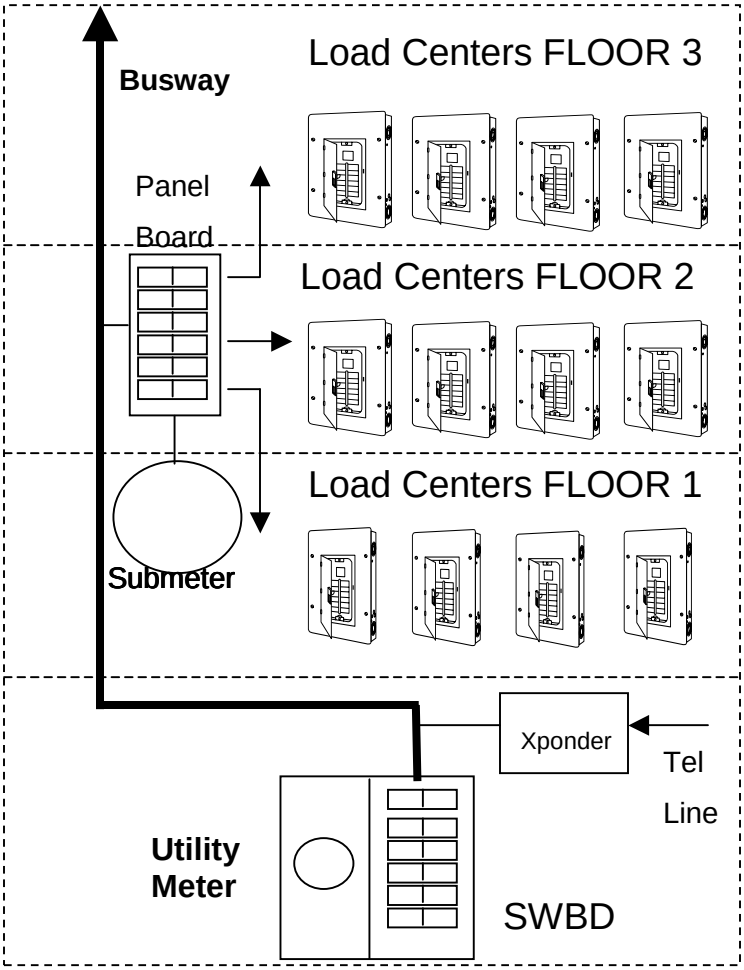


Figure 4

Other (Commercial/Retail, Institutional, etc.)

Another submetering application is common in commercial or institutional space when an accurate means of allocating energy usage is necessary. A university or hospital may start studying how to reduce its total energy usage by first understanding when and where electrical energy is used. A retailer might launch an energy initiative to reduce the energy usage per store in order to save hundreds of thousands of dollars annually. In all of these cases, the utility provides a single meter to determine energy consumption. Submetering provides accurate data to determine usage by department, building, HVAC, or lighting loads.

Who could use this system?

- Health Care Facilities
- Schools/Universities
- Retail stores

A submetering system designed to allocate and manage energy costs is best suited in applications where one or more of the following conditions apply:

- There is a need to analyze energy usage by department, process, building, or function in an institution or commercial retail establishment. This is often followed by actions to modify strategies to reduce costs or increase efficiency/productivity.
- There is a need to retrofit an existing building using state-of-the-art technology such as Power Line Communication (PLC) in order to immediately reap submetering benefits without having to hardwire costly networks into the building.

Example – Commercial Retail Store
In this example, a retail chain is comprised of 250 store outlets nationally. The outlets consume electrical energy to provide heat, air conditioning, lighting, display lighting, signage, security lighting, as well as other electrical loads. Since the cost of electrical energy is escalating in certain parts of the country, management is launching an initiative to reduce peak demand charges wherever possible, which could result in hundreds of thousands of electrical cost savings annually. In addition, the retailer wishes to become engaged in utility company peak-shaving incentives, that are offered for the purpose of shedding electrical loads at certain times of the day. These incentives would also provide a reduction in energy costs, provided the stores can "off-load" demand for a certain period when required. The retailer now requires a means to understand electrical usage within its outlets to develop strategies aimed at future energy efficient measures.

The solution would include the installation of several multi-point or single point submeters, capable of monitoring six – 3 phase 277/480V or 120/208V circuits in each supply closet. Due to the layout of the stores, electrical distribution may be located in several closets throughout the store. The submeters would be mounted in close proximity to the electrical distribution system feeding power to critical circuit using split core current transformers. The submeters would then communicate the collected energy data though the AC Power lines to a transponder/data collector device located near the service entrance. No communication wiring is necessary in this example. A telephone line is routed to the transponder, where either the corporate energy staff or a third party service will collect and analyze the data.

Components needed:
1 Multi-point (6 ckt) Submeters w/data logging and PLC communication capability (277/480V)
1 Single-point (1 ckt) Submeter w/data logging and PLC communication capability (120/208V)
21 Split Core CT's
1 PLC Transponder w/modem interface

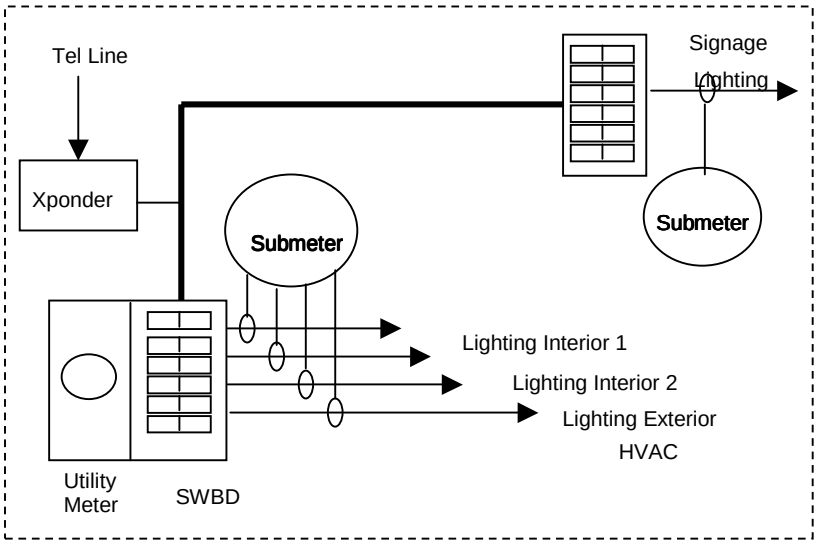


Figure 5

Industrial/Manufacturing Submetering

A firm's energy costs have traditionally been viewed as fixed costs, unable to be controlled to an extent that would reap any significant financial benefit for the firm. However, in virtually every business there is now an opportunity to reduce existing energy costs, making them variable and therefore manageable. Allocating and managing energy costs can realize substantial savings. Energy costs can be managed by shifting non-essential loads to off-peak hours, leveling off energy demand to make it more consistent throughout the day, identifying equipment and process problems, and even by correctly allocating costs to the areas of the business that are consuming the most energy. If you are spending thousands of dollars on electricity, locating a small error on a utility bill can translate to big savings. Even in the absence of utility errors, having the ability to independently verify an energy supplier's billing can improve your negotiating power.

Who should use this system?

- Manufacturers/Industrials

A system designed to allocate and manage energy costs is best suited in applications where one or more of the following conditions apply:

- There exists a need to allocate costs for electricity usage by department, business unit, or process.
- There is a need to verify actual electricity usage with the electrical utility bill or compare the costs of different power providers.
- There is a desire to reduce electrical energy costs by identifying where peak demand usage is greatest and then applying alternative strategies to control these costs (i.e. load shedding, peak shaving, off-peak use, etc.).
- A centralized means of viewing and storing electrical usage data for future analysis is desired.

In the example below, a manufacturer of machined aircraft components operates 2 work shifts per day consisting of 8 major processes. Management is looking to reduce energy costs by 15%, which translates to $75K annual savings. Since productivity cannot be affected by this initiative, savings can only obtained by avoidance of demand charges, which are responsible for over 50% of the electrical bill.

The solution would involve metering each process and inputting the data into an energy management system via a communication LAN. The collected data will provide the basis for identifying when energy peaks occur and help analyze if shifting the process can reduce the peak demand. By shifting consumption peaks to coincide with the utility's off-peak period, substantial savings can be realized.

Components needed:
8 KwH/Demand meters with data logging and RS-485 communication capability
24 Split Core CT's
1 PC
1 Energy Management (Cost Allocation) Software package

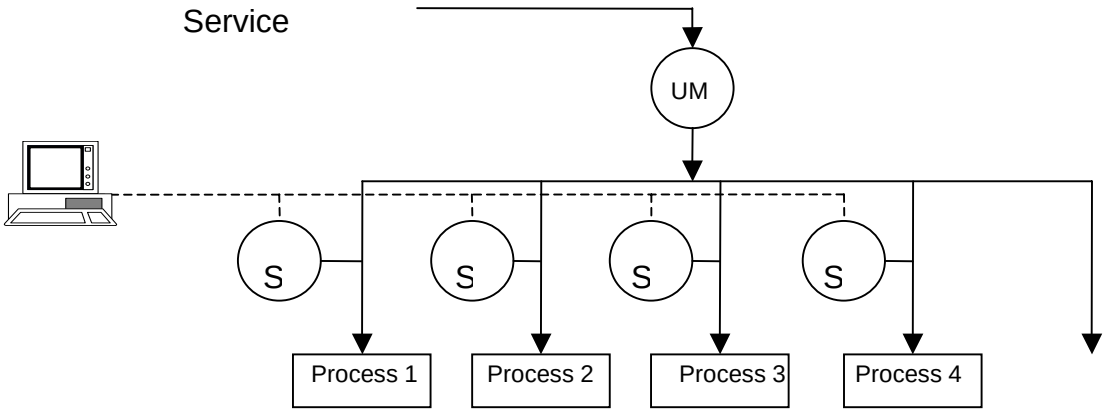


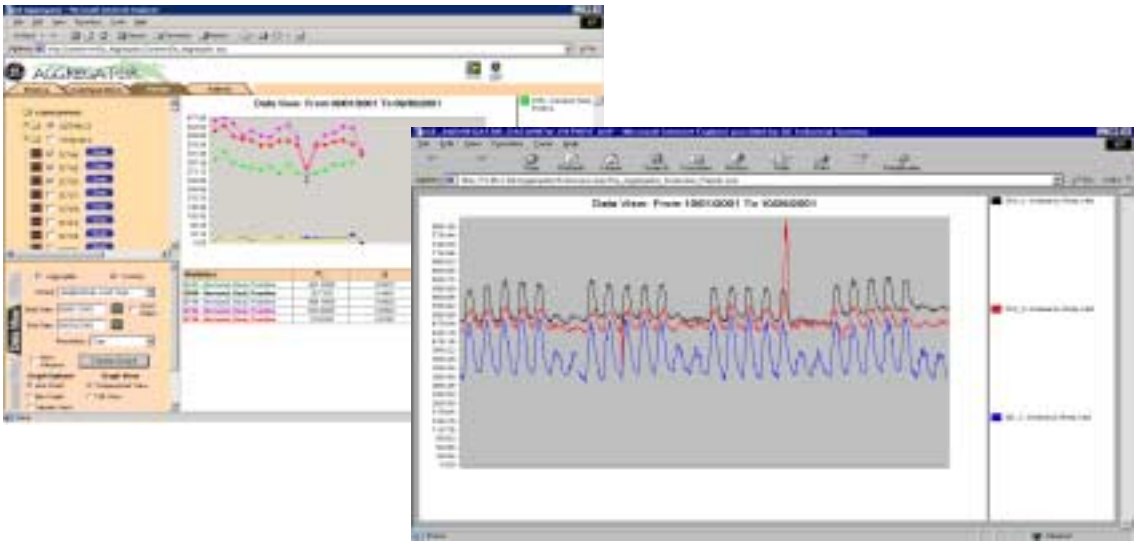
Figure 6
Industrial/Manufacturing Process Example

Conclusion

As illustrated in this article, submetering is a viable approach to gathering large amounts of power system data for the purposes of reducing energy usage, encouraging and directing conservation, keeping abreast of your power system health and long term needs. It can be used for segment billing and the data can easily be communicated locally or to distant hubs for analysis. Examples have been provided to accomplish these capabilities in an efficient and cost effective manner. Further information can be obtained at the following links:
http://www.geindustrial.com/cwc/products?pnlid=5&famid=14&catid=57&id=em-epm1000p and
http://www.geindustrial.com/cwc/products?pnlid=5&id=em-epm4000s&famid=14 or by contacting your local GE Systems Engineer.

Appendix

The screens below illustrate electrical demand information compiled by submeters installed on the various processes in a facility. Note the large spike in demand on the lower screen, which can significantly increase electrical costs in a manufacturing facility. By shifting the operation of this process to an off-peak period, tens of thousands of dollars can be saved annually. Software packages capable of collecting energy data are valuable in identifying inefficiencies such as this.



Integrated Submetering Panels

In new construction applications, submetering can be an alternative to space consuming modular metering in high-rise residential buildings. By combining distribution power panels housing 2-pole feeder circuit breakers and submetering in an integrated assembly, significant savings can be achieved since CT transformers, submeters, and panel interiors are factory assembled, therefore reducing wiring and installation issues.

Choosing a submeter

The selection of key submetering features used in energy allocation or tenant billing applications is listed below.

			Notes	
Feature	**Description**	**Industrial**	**Commercial**	**Residential**
Revenue Accuracy - Energy	Metering Accuracy	0.5 % or better	0.5 % or better	0.5 % or better
KwH and Demand	Consumption & peak demand	KwH & Demand	KwH & Demand	KwH only
Data Logging [1] Capacity	Stores parameter data in meter (i.e. interval data for KwH, demand, etc.)	Required	Required	Required
Local Display	External display on meter for local viewing	Not required if data is communicated to remote energy management system	Often required for tenant viewing	Often required for tenant viewing
Pulse Input [2] Capability	Accepts pulse inputs from other devices	Optional	Useful for inputting energy measuring devices (gas, H_20, steam, etc)	Useful for inputting energy measuring devices (gas, H_20, steam, etc)
Multi-metering [3] Capability	Unit capable of metering multiple loads or tenants –	Required if metering can be grouped in 1 area	Often Required due to supply closet layout	Often Required due to supply closet layout

Comments:

1 – Data logging permits the device to collect and store energy data for periods of 30 days or longer. It is essential to have a data log record at the metering device in the event that communication between the meter and central system is disrupted for a period of time, otherwise critical billing data can be lost.

2 – Pulse Inputs allow the metering device to collect other energy or utility parameters such as gas, water, steam, etc. Typically, flow-metering devices will measure the flow of these parameters and convert the flow to an electric pulse, which can be input to the meter.

3 – Submetering devices are commercially available to be installed in single or 3 phase electrical circuit. In situations where large concentrations of metering points are located, submeters capable of measuring multiple circuits are desirable. These devices can meter 6, 12, or 24 circuits depending on electrical configuration and required far less room than installing individual meters.

4 – Although most submeters can provide local display access for purposes of reading collected data, a communicating meter acts as a gateway to a comprehensive analysis or billing system. These systems can be located in the same facility or accessible hundreds of miles away. Installing submetering in an existing facility requires careful consideration to insure that communication wiring costs and accessibility can be achieved. Non-wired alternatives include RF and Power Line Communication (PLC), however the building layout must be taken into consideration in the design of a system.