ENERGY SAVING BENEFITS
OF REAL-TIME TECHNOLOGY

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ABSTRACT
The use of remote monitoring in Energy Information Systems is growing. The most common form of remote monitoring is metered interval data delivered once a day over a telephone line. This paper examines the value of real-time energy monitoring. It examines the cost of making connections to the Internet and discusses what benefits are possible using Internet based energy information systems.

DEFINITIONS

Automated Meter Reading (AMR) System - replaces the monthly walk-by meter read with a radio drive by or fixed radio network for the purpose of billing.
Interval Data - 15 minute kW consumption presented on the Internet as a load profile.
Energy Information System - Interval data used for reducing energy waste and expense.
Building Management System - A centralized system for monitoring and controlling the heating, ventilating, air conditioning, and lighting load in a building.
Remote Monitoring - Energy data viewed and managed at a location some distance from the facility.
Real-time - Data delivered within 5 to 15 minutes of closing the interval.
Small & Midsize Commercial & Industrial (C&I) - Monthly electric bills of $1,000 to $4,000.

OUTLINE

I Efficiency of Small &Midsize C&I
II Monitoring Technology
III Control strategies
IV Cost
V Return on Investment

I EFFICIENCY OF SMALL & MIDSIZE C&I

The average C&I account in an electric utility is a small to medium size business using a peak demand of 50 to 200 kW and paying a bill of $1,000 to $4,000 a month. Typically a utility will assign a key account manager to businesses over this size, but smaller businesses are left on their own. This is unfortunate because the smaller user generally pays the highest rates, is most conscious of the monthly utility bill, has the best understanding of the business, and typically wastes the most energy. The intent of this paper is to demonstrate that Internet technology exists and is available for *all* customers to measure, monitor, and control energy use in this market. The advantage to the business is the opportunity to save 10% to 15% of the monthly bill, while at the same time the advantage to the energy marketer, distributor, and Independent system Operator (ISO) is to improve load factors, increase demand response during critical peak pricing incidents, and increase system reliability.

1) Field conditions with historical billing information: The typical business has only a single piece of energy information - the bill. Weather conditions can affect as much as 30% of the bill and unless the bill is normalized against degree days or some other benchmark, the bill is of little value in optimizing energy use. Mechanical systems in small business are typically not professionally designed. They are designed according to rules of thumb and most often are overly large for conditions and mildly to grossly inefficient. Systems usually have a patchwork of controls, which are often poorly located, and are not properly commissioned or monitored. Preventive maintenance is rare. Most systems are run till until they break. The result is a potential waste of up to 15 to 20% of the monthly bill

2) Field conditions with a Building Management System: A BMS costs $50,000 to $100,000 and is most likely to be installed in a new office, hotel, school, or shopping center. But even a BMS is not a guarantee of savings. The hallmark of a BMS is properly engineered controls and initial commissioning. However, a field survey will show that as soon as a BMS is installed, its performance starts to attenuate unless it is continuously monitored. A common field observation finds that after six months, 20 % of BMS performance is out of commission either in override or at the wrong set points. An additional problem is that the maintenance staff may be afraid to adjust the BMS. Buildings are sold, maintenance personnel leave, and as a result no one knows how to run the BMS. What does result is a "set it and forget it" mentality which overlooks energy savings.

3) Field conditions with remote monitoring: Many commercial buildings are already monitored 24/7 for fire and burglary. In addition to these important functions, they need to adopt remote monitoring of energy. The cost is about the same or around $30 to $90 month, and the advantage of remote energy monitoring is that benchmarks can be set and any deviation spotted and corrected. Alarms can be set to trigger an appropriate response depending on the nature of the alarm, the time of day, and the right person to contact. And remote management is efficient. It brings building information to the manager who is an expert in both building systems and managing this building. He or she has many tools available such as normalizing energy use for real-time degree days. The off-site manager seeks to balance both comfort and cost, whereas the building maintenance staff aims to minimize comfort complaints with little or no consideration given to cost.

The building can also participate in sophisticated energy management programs such as Time of Use (TOU) pricing, Real-Time Pricing (RTP), and Demand Response. There are 8,640 hours in a year, but in energy management there are usually 88 super critical hours per year. During these hours, the cost of energy may rise from $40 per megawatt-hour to $100 or $1000 per MWh. So a good energy management program is most profitable during the 1% of the year when power costs from two to twenty-five times its normal rate. Most utilities offer their large customers incentives to shut down 500 kW or more of operations during a critical peak pricing incident. This cripples business operations. Remote energy management offers the opportunity for non-invasive curtailment by aggregating 10 kW or more of demand response from 50 sites, none of whom will notice the difference. This makes demand response a practical alternative to building costly new generation.

II MONITORING TECHNOLOGY

The most common monitoring technology available today is the postal system. 100% of electric and gas accounts get a monthly bill. About 20% of these accounts now offer some form of AMR, through which the consumption data may be monthly or daily. The industry is searching for a real-time technology which will connect meters to the Internet 24/7. Three technologies are vying to be the real-time bridge between the meter and the Internet: power line carrier, public telephone (copper or cellular), and private wireless. The advantage of using the Internet is that it is real-time, inexpensive, ubiquitous, and has readily available security and data mining tools. It is standards driven, and has the potential for mass market pricing.

Monitoring technologies have different parental lines. Telephone technology has contributed a data logger and polling parentage, which requires a logging device and telephone modem. A central server such as the Itron MV-90 system calls the modem once a month for a bill, or every night for the past day's load profile, or even right now to get a snapshot of the latest data. Programmable Logic Controllers (PLCs) have contributed the "wired around the building" technology. Often seen in colleges, the building wires are attached through a concentrator to the Ethernet or directly to the Internet. Power line carrier has contributed the "wire it through the AC" technology, and has the highest technology hurdle because of the difficulty of passing data through a transformer and the inherent noise on an AC line. Private wireless has typically been used over the last 100 feet between a meter and a hard wired concentrator. Recently a new type of "mesh" wireless with a range of five to ten miles per link has been used over wide areas to connect meters to the Internet.

The type of monitoring technology used varies according to the data system and its parentage. Meter pulses represent the opening and closing of a relay in a device in which each pulse represents a certain number of watt hours or kvars. Pulses date back to the 19th century but are in widening use today because they are easy to integrate into the mixed technology systems found in most buildings. Serial interfaces, often using the RS-232 or RS 485 standard, unload the registers of data stored in a meter, device, or concentrator. Tel Modem data uses ATT modem commands to set up a data session between a concentrator and a server over the telephone network. General Packet Radio Service (GPRS), common in Europe, will send packets of data over the cellular network on a "pay by the packet" tariff. And the Ethernet offers high speed, broad band "always on" data to link to the Internet. Devices and their common monitoring technology are:

- Automated Meter Reading - Pulse, Serial, Tel Modem
- Building Management System- Pulse, Serial, Tel modem, Ethernet
- Programmable Logic Controllers - Serial, Tel Modem, Ethernet
- Power Line Carrier - Serial, Tel Modem

III CONTROL STRATEGIES

Monitoring leads along the path to improving control. A load shape contains a lot of information, such as day verses night load, load variation with temperature, equipment operating status and when peaks occur. A load shape also suggests many responses:

- Opportunities for reducing peak demand.
- Opportunities for reducing night load.
- Opportunities for changing utilization.

Comparison of load shape against benchmarks also suggests many responses.

- Why is one school using more energy than another?
- Why is the Energy Star rating of one building above or below average?
- What opportunities exist for efficiency, conservation?
- What are opportunities for distributed generation?

A load shape also suggests what new approaches to monitoring power might be used:

- Purchasing from alternative suppliers
- Participating in load curtailment or demand response programs.
- Buying power with Time of Use or Real time Pricing options

Monitoring and control strategies work hand in hand. We have found an optimum approach is to control locally, but to monitor energy usage and equipment status over the Internet. There is also an option, given adequate security, to change local control instructions from the Internet. In this approach, the "cooking" is local, but the recipe can be changed from the Internet.

What to Control?

HVAC. Air conditioning is most likely to drive peak usage and create a costly peak demand charge. In most buildings, and even in buildings with a BMS, individual compressors cycle according to the demands of a thermostat. There is typically no means to coordinate the timing of compressor units so they do not all operate at the same time, thus driving up the demand peak charge. Controlling the timing of compressors could therefore reduce peak demand charges by 10%.

Refrigeration. A lot of refrigeration is found in small and mid size commercial properties. Refrigeration is used for walk-in freezers in restaurants, reach in coolers in stores, vending machines, standard refrigerators and many other purposes. Most refrigeration units operate on the principle of "set it & forget it". Refrigeration is an ideal candidate for demand response and becomes especially significant when hundreds of refrigeration loads can be aggregated and managed in a single demand response program

Lighting. A lot of effort is expended on changing out inefficient lighting. In many small and midsize properties the problem goes beyond efficiency - there is often too much lighting with poor controls. Savings can be found by turning off or dimming unnecessary lights, especially in well lighted places on sunny days.

Inertia explains a lot of wasteful energy practices. “We have always done it that way" is a common mantra among building managers, but real time monitoring offers an opportunity to revisit the way things have always been done.

IV COST

The cost of an Internet based monitoring and control system can be divided into the cost of Instrumentation and controls, communications, and installation. In small facilities, the cost of each element is in the range:

- Metering and controls - $ 500 to $1000
- Communications to Internet - $500 to $1,000
- Installation $500 - $1,000

The minimum cost for a small facility might range from $1,500 to $3,000. This would provide a basic real-time monitoring capacity and perhaps the control of one appliance such as a reach-in cooler. Wired or wireless options are available for both connecting to the appliance and the Internet. A new type of wireless mesh technology is now available from several manufacturers. For example, both Elster and Landis+Gyr announced mesh technologies for AMR in the fall of 2003. The advantage of the mesh technology is greater reliability in radio communications as a radio signal can take several different paths from device to device to a concentrator or the Internet.

Many state Public Utility Commissions mandate energy conservation and efficiency programs funded with $10s of millions per year. Program requirements vary but most will pay 60% to 100% of project costs including monitoring and communications equipment. In the New England states, a priority has been established for the re-commissioning of existing facilities and to target small businesses which the programs recognize are often the least efficient energy users.

The typical cost of monthly monitoring over a telephone link or the Internet ranges from $30 top $90 month. Many distribution companies such as NSTAR, Southern Company, and SDG&E make interval data available over the Internet, usually on a day behind basis. Interval data feeds into energy management and bench marking software programs on web servers.

The Energy Service Company or ESCO is at the center of the monitoring model. An ESCO may help to purchase power from the Power Marketer, and installs monitoring and control equipment. The ESCO maintains a long term relationship with the facility owner working together to reduce costs, analyze capital expenses, install equipment, maintain and monitor equipment, re-commission equipment, and find subsidy programs to help finance improvements.

V ROI

As a rule of thumb, the Return on Investment of a capital intensive energy efficiency project can fall in the range of three to seven years. By installing a variable speed drive or co-generation facility, the savings in operating efficiency will offset the engineering, equipment, and installation expense in three to seven years. This is a long time horizon for many businesses and institutions. In contrast, increasing efficiency through monitoring and control can produce a much shorter pay back period - usually measured in months.

The reason is that monitoring and control technologies add intelligence to existing equipment and suggest better ways to manage the in-place equipment. As the waste in poorly engineered, commissioned, or installed equipment typically falls between 5% and 15%, a significant amount of savings can be harvested with relatively low cost monitoring and controls. Consequently, the ROI period is very short.

One final example is heating of domestic hot water. Universally, hot water is maintained at a set point - typically 140 degrees F. Water is heated both because hot water is used and because the storage tank cools. A monitoring and control strategy would preheat water before it is needed and let it coast when it is not needed. An optimizing strategy can save 50% of the stand-by heating cost and reduce total domestic heat expense by 10 to 15%. The same type of strategy applies to other mechanical and electrical systems.

The amortized cost of a remote monitoring system is about $30 month for a small facility. The monitoring ROI will depend on conditions in the facility:

- Building without previous data - Cut waste 5 to 20%
- Building with BMS - Save 5% by better operation
- Install better controls - Save 5% to 15%

A monitoring system also enables a facility owner or manager to participate in a wide variety of new time-of-use and demand response programs. In California, several new demand side programs are being proposed, piloted, and promoted by the CA-ISO, CA PUC, the three large utilities, and the municipal electric systems. Many of these programs are in the embryo stage and will develop more fully by about 2007. They will require more sophisticated monitoring, management, and communications which will largely be Internet based. We believe the best programs will be found to be those that are largely invisible to occupants promoting sustainable curtailment. Annual savings of 5% from TOU and demand response can be anticipated.

SUMMARY

Most small and mid-size C&I facilities waste energy because energy has been cheap in this country and there has been no practical system for monitoring or benchmarking consumption. The Internet, operating in real-time, offers a relatively inexpensive means to monitor, manage, and control building systems. The key technology is to make facility data accessible to remote personnel with the experience and interest to optimize operations. Monitoring, managing, and controlling systems cost relatively little, but produce significant gains with ROI that can be measured in months. Monthly savings of 5% to 15% or more are achievable.

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