THE USE OF SMART BRANCH-CIRCUIT METERING TECHNOLOGY TO LOWER BUILDING ENERGY USE

A White Paper

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The purpose of this paper is to examine the need for smart metering of facilities at the branch circuit level and determine if such implementations would pay back their investment. To begin with, a definition of the term "smart metering" is in order. The phrase smart metering is presently used in the context of both home and building metering and has evolved to become a very nebulous term. One definition with which most parties would agree is a follows:

> *A smart meter provides a continuous feedback of accurate energy data that allows consumers to better control their usage and simultaneously allows producers to better manage their production.*

Presently, most installed electric meters provide little in the way of information to their users. Some provide information only via somewhat cryptic rotary dials. Others provide different types of digital displays of energy data. However, few meters provide a real-time and accurate data stream that assists users in reducing their energy consumption while helping the power producer to better match their production to demand levels.

With the knowledge that a value-gap exists in present metering options, we propose using the principals of Management By Information (MBI) to analyze options for a truly smart meter for commercial facilities. The overriding principal of MBI states: You can only manage what you measure and its related corollary further states: You can only manage well what you measure accurately and provide to each user. To take an example of these 2 principals in a general corporate setting, line-item budgets can only be controlled well if each individual and department is given accurate data as to their real time and accumulated costs for each line item expenditure. No one would expect each employee and department's monthly, quarterly and annual line-item expenditures to magically total up to the budgeted figures. Rather, the users are given continuously accurate data about their present rates of expenditures, providing the tools to keep line-item expenses within their budgeted amount. It follows then, that if energy costs are to be reigned-in, they must be accurately measured by user and provided to each user and group in a continuous fashion.

In the context of MBI, it can be quickly understood that a truly smart meter for commercial facilities must be able to do four things:
– Accurately measure the energy used by each circuit within a facility
– Assign each circuit to its appropriate user and department
– Securely provide real-time energy data feeds to each user and producer
– Provide real-time or time-based tariff prices as available

Presently, most electric meters are connected at the main-panel of a facility, where the utility feed enters the building. From this point, sub-panels composed of branch circuits feed power to the individual users within a facility. The main-panel meters are macro in nature and do not provide the ability to see data at the individual circuit level. Thus, main-panel meters do not provide information that can be properly allocated to individuals and departments.

We propose in this paper, a simple and elegant solution of using utility-grade branch circuit meters to meet the four criteria listed above. Specifically, we propose the use of smart branch circuit meters that can monitor each circuit within the sub-panels of a facility, and have circuit data assigned to each user and department. We further propose that this data be securely available to Building Management Systems (BMS), Enhanced Resource Planning (ERP) systems and other IT systems to allow for automated management and accounting of energy consumption. Lastly, we propose that the utility provider also receive this energy data without user's information attached, while simultaneously exchanging real-time pricing information with each smart meter.

The ability to accurately measure individual's and department's energy usage brings energy consumption directly into the budget/forecast/variance process standard in companies and governmental organizations. This allows an energy budget to be established and managed from remote facilities throughout the enterprise. Budgets can be accurately planned by department and finally at the individual level using the branch circuit information as a

management tool. Once sites bring their branch circuit data into budgeting processes, Enhanced Resource Planning (ERP) and other standardized IT tools can be fed data directly from branch circuit meters in an automated manner. This allows energy reporting and energy reduction to be accomplished in a Best Practices manner.

The ability to control energy usage is the key measure of any smart meter's success. In this context, it is vital to understand that most commercial facilities rely on Building Management Systems (BMS) to control energy usage. Yet, according to an American Society of Heating Refrigeration and Engineering (ASHRAE) study, more than 75% of all energy inefficiencies with a facility are related to the BMS.1 It is the proposal of this paper that this is a direct result of one fact:

> *BMS units are tasked with making energy control decisions for individual devices within a building. Yet, BMS units do not consider energy data from these devices as either an input or output in their decision making process. Thus, BMS units make their energy savings decisions in an energy-data vacuum.*

Presently, most BMS units control HVAC systems solely on the basis of distributed temperature and humidity sensors. Unfortunately, temperature and humidity are always lagging indicators of thermal conditions. Temperature, the most commonly used sensor measurement, represents the difference between heating released into a room less the heat being removed. As such, temperature is a dependent variable and is solely based on the independent variables of the wattage of heat released and the BTU's removed. Therefore, trying to control temperature, by using temperature as the sole variable is a circular reference and can never provide an efficient energy management system.

With branch circuit data assigned to end-use and room locations, the energy in watts (which is equivalent to the heat in watts released in that area) can be relayed to the BMS. The BMS can then make concurrent responses to remove the equivalent amount of BTU's of heat via the HVAC system. The result is a much more precise and efficient energy management system.

A utility company can also reap significant benefits if branch circuit smart meters are widely deployed. One key area for the utility producer is the operational efficiency of their power plant investment. Utility power plants and the grid that feeds their power are operated in a manner that provides demand as needed plus a cushion for demand spikes. Generally, power producers have access only to macro data and are unable to respond at the substation level, where power is actually distributed to users. By having real-time and historical data available, planning for new and expanded substations and transformers can be much more precisely planned. In addition, real-time responses to energy demand can be made in a more seemless manner. In this way, both utilities and their customers can benefit from fewer unplanned outages and better use of utility infrastructure.

Utility companies are also incented by state public utility commissions to help customers reduce long-term usage. One key area where utility companies are hampered in this effort is in having historical information about the efficiency of individual pieces of equipment such as HVAC and lighting systems within a facility. The availability of branch circuit data for each HVAC unit and lighting sector will allow users and their utility-provider to distinguish between efficient and less efficient systems. It can also provide accurate data for expected savings with retrofit units. These benefits allow the utility company to have the assurance that a rebate for a replacement system is justified while it provides a way to track the actual efficiency for new equipment for future rebate programs.

One final point that benefits both utilities and users alike is related to the price offered by the utility and paid by the consumer. For years, utilities have built fixed tariffs that are generally structured around Time-Of-Use (TOU) pricing. Recently, Real-Time-Pricing (RTP) options have been made available by a number of states. It has been shown that providing RTP smart meters to customers who are prepared to respond to such pricing, offers significant opportunities to reduce energy use. 2

It can be seen then, that using truly smart branch-circuit meters can give users and utility companies the ability to effectively and predictably reduce energy usage. The business question to be posed then is, whether such savings of energy would justify the expense of acquiring such meters. In order to answer this question, we must

examine three specific details of the proposed smart branch circuit meter:
– The cost of acquiring the branch circuit meter
– The cost of installing the meter
– The likely energy savings to payback the cost of each branch circuit meter

To begin with, utility-grade branch circuit smart meters are now available at a price of approximately $85 per circuit. The cost of installing the meter would generally be in the area of $40 per circuit or less, bringing the total cost for an installed meter would be less than $125 per circuit.

In order to determine the savings likely to be derived from the installation of a smart branch circuit metering system, two things must be known:
– the average cost of electricity flowing through each circuit within the facility
– likely savings as a percent of energy used by each circuit.

The average cost of electricity flowing through each circuit can be calculated very simply. It is the total cost of electricity for the facility divided by the total number of circuits. A typical cost figure for a circuit in an energy dense facility such as a data center would be roughly 10 amps x 120 volts * 1.0 pf *8760 hours/1000 = 10,512 kWh or about $1000 per circuit. This figure is based on the average cost of commercial power of slightly less than $.10 per kWh in the U.S.

Buildings such as laboratories and others with high refrigeration and heating usage are typically in the range of $250 - $750 per circuit per year. Commercial office buildings often use $250 per circuit per year or less, depending on the amount of computers within their space. These numbers are merely guidelines, however, and each facility should be examined on the basis of actual utility bills.

Once the average cost of electricity per circuit is known, an estimate must be used to come up with the projected energy savings from using the sub metering system. There are a significant number of studies that have been completed on energy savings from macro sub-metering and branch circuit metering. A US Government Energy Star report on macro sub metering concluded that at savings of at least 10% in peak period energy costs are attainable.3 NYSERDA, the New York State Energy Research Development Authority, estimates that savings from providing energy data with branch-circuit metering of multi-tenant facilities averages between 15% - 30%.4 A study by the University of Illinois coupled a smart branch circuit meter to an HVAC control in a Real-Time Price (RTP) environment. Instead of using temperature as the simple set point, the price of energy was used as the dependent variable for temperature control, similar to that suggested in this paper. This novel process demonstrated a savings of 31.8% in a multi-tenant facility, generally thought to be the most difficult type to affect energy control and savings.5

It can be seen from these studies that the more granular and integrated the energy data, the higher the savings. At a macro sub-meter level, an Energy Star meter demonstrated a savings of only 10% but, a smart branch circuit meter coupled with an RTP response algorithm demonstrated a savings of over 30%. If one were to use a 20% savings as a conservative base, even a lower-density office building or multi-tenant residence with annual energy costs of $250 per circuit could pay back the investment quickly as shown below:

Energy use	$250/yr/circuit
Estimated savings	$ 50/yr/circuit @ 20%
Cost of unit & install	$125/circuit
Payback	2.5 years

Each facility manager can use this method as a guideline to calculate their appropriate energy use and payback and determine if it meets their individual threshold.

In sum, smart branch circuit metering technology offers users and producers alike the ability to reduce energy consumption. For users, smart branch circuit metering can be effectively integrated into BMS systems for energy reduction and into ERP Systems for standard budget/forecast/variance reporting. Utility companies can receive vital equipment operating information, enabling them to reduce system overloads, while providing ef-

fective data for justifying equipment rebates. RTP offerings can simultaneously benefit both users and utility providers to reduce energy consumption. Overall, smart branch circuit metering clearly provides a profitable energy solution that is justified for installation into most commercial as well as multi-tenant residence facilities.

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