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Engineer's Guide to Submetering in New and Retrofit Applications

Seeking to cost-effectively manage their energy consumption and demand profiles, today's proactive facility professionals are standardizing on submeters and energy intelligence software as the front-end data acquisition tool of choice. This white paper presents an overview of submetering for the green facility environment with an eye to how consulting and specifying engineers can deploy metering solutions to help relieve bottom-line pressure, in both new and retrofit applications.

By Don Millstein
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www.emon.com/cse113.asp

Installed on the "facility side" of the traditional glass-covered utility meter, submeters have proven themselves to be effective tools for monitoring, diagnosing and preventing bottom line-impacting problems associated with the facility's energy envelope, especially HVACR and other highly energy-intensive building systems. When combined with energy intelligence software, submeters provide insight on a building's flow and consumption of electricity. In today's cost-conscious green facility

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environment, obtaining such knowledge has become more important than ever to facility engineers, building owners and operators.

Multi-Tenant: Commercial & Residential Facilities

Managers of multi-tenant facilities must keep tenants happy while showing the property owner that building efficiency, occupancy rates and profitability are all in line. Without submetering, the building manager allocates energy costs and Common Area Management (CAM) charges, depending on the lease agreements, based on tenant use or some ratio of x dollars per square foot of space. In these situations, submeters and energy intelligence software can be installed to monitor actual electrical consumption by both tenants and common areas, track energy use and help facility managers analyze the data to identify areas for cost savings.

One of several submetered facilities at California's Mammoth Mountain resort, 100,000 sq ft Canyon Lodge monitors its 480V, 1200A service using E-Mon D-Mon Class 3000 sub-meters. Over the last four years the meters have helped facility engineers save $72,000 per year in this building alone, and overall nine percent for the entire resort.

Beyond cost savings, the benefits of submeters and energy intelligence software include accurate allocation and increased tenant satisfaction. Building managers gain the ability to allocate and recoup costs based on actual usage versus estimation by square footage. This allows tenants to control their own energy usage and costs, and high energy users often find ways to reduce energy use. Providing solutions for tenants to control their utility costs helps keep them as satisfied, long-term tenants.

Building managers can sell submetering to management by pointing out that metering provides a fair allocation of the building's electricity costs among tenants who are only responsible for the electricity they use, not their neighbors'. Submeters also put control back in the hands of the tenant—the more they conserve, the less they pay.

Government Buildings

The U.S. Department of Energy estimates a 20 percent savings when a building or energy manager becomes conscious of his energy use through a monitoring device such as a submeter. The savings

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can be attributed to the manager allocating energy costs to tenants as well as identifying and eliminating areas of operational inefficiency.

Compliance with EPACT 2005 and EISA 2007 regulations and green building initiatives are particularly challenging for government facilities as each complex is unique. Government facilities and complexes run the full range of building types including offices, single and multi-facility dwellings, plant/industrial facilities, medical buildings and educational centers.

EPACT 2005 and EISA 2007 contain several requirements that are supported by submetering:

- Section 102: Federal buildings must reduce energy use by 20% by 2015
- Section 103: All federal buildings must be metered by 2012
- Section 1251: Metering
- Section 1331: Support for $1.80 Federal tax deduction. Provide equivalent metering
- of gas and steam by 2016

Less than three years after the E-Mon D-Mon submetering system was retrofitted at Los Angeles Air Force Base, energy consumption decreased more than 27 percent from the previous year's baseline. Utility costs decreased 23% from the established baseline during a period in which electricity rates actually increased by 4.5 percent. (USAF photo by Joe Juarez)

Leveraging the granular energy data provided by submeters allows government facilities to allocate actual costs back to users, tenants or departments, analyze and verify usage reductions related to green building initiatives and support federal and local requirements for overall energy reduction.

Owner Occupied: Manufacturing & Industrial

Plant managers at industrial and manufacturing facilities require granular energy data to efficiently manage their usage. Submeters are the appropriate tool for this purpose whether they are looking to allocate costs, manage production lines or reduce their carbon footprint.

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Cost Allocation: Manufacturing plants may not just be a building full of machinery. Most contain offices, com-mon areas, various production lines and other machinery that all impact energy use. Submeters allow facility managers to monitor all of these areas and accurately allocate costs back to departments, production runs, HVAC, common areas and other pieces of equipment.

Predictive Maintenance: As the cost of doing business increases and budgets are more constrained, it is more important than ever to avoid production interruptions and costly equipment replacement. Submeters can be installed on key pieces of equipment to monitor usage and identify potential failures. This allows facility managers to take proactive steps to schedule repairs before equipment fails, thus avoiding costly and unexpected downtimes.

Demand Analysis & Load Control: Users are billed high kilowatt demand rates for an entire month or multiple months even if the demand only occurs for a 15-30 minute period during a given month. The key to avoiding these exorbitant costs is to identify peaks in usage and proactively take steps to reduce those peaks. Graphic profiling of individual or aggregated loads will pinpoint peak usage areas or equipment. With this data manufacturers are able to employ load controlling devices to set high/low thresholds, control loads and reduce energy costs.

Educational Facilities

With today's schools and universities facing mounting financial pressure, controlling the bottom line is key to maintaining current programs and keeping education affordable. However, in spite of tightening budgets, energy conservation and cost reduction are realistic goals that any district or educational facility can achieve using submeters.

Timnath, Colorado's Bethke Elementary School, the nation's first Gold-certified facility under the LEED for Schools rating system, continuously monitors its electrical parameters for evaluation by the district energy manager. Two Class 2000 E-Mon D-Mon electric submeters record and communicate kilowatt-hour (kWh) data every 15 minutes to the monitoring location, which helped the facility qualify for Energy & Atmosphere (EA) points towards the LEED Gold certification. The collected energy data is also viewable on the display terminal as a teaching tool by the faculty.

Student Housing/Dormitory Monitoring: Students use energy. Those held accountable for what they use will use less. This is the premise for metering energy consumption in student housing and dormitories. Individual areas are monitored and students are held accountable for the energy they

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use, making them more inclined to take energy saving measures such as closing windows or turning off lights and other electronic items when no one is there.

Energy Allocation: Whether allocating energy costs to departments, leased spaces or for school events, holding users accountable for their energy use not only helps reduce their carbon footprint, but allows the facility to recoup the costs and ease the pressure on their bottom line.

Equipment Maintenance: It is more important than ever for schools to avoid costly equipment replacement. Submeters can be installed on key pieces of equipment to identify potential equipment failures. This allows facility managers to take steps to schedule repairs before equipment fails, thus avoiding costly and unexpected downtime.

Education/Green Building Programs: LEED Certification for educational facilities is an ideal use for submetering. Many point opportunities exist for using submeters for education (display carbon footprint data in common areas to educate students and faculty), Measurement & Verification (M & V) and Optimizing Energy Efficiency.

Advanced submeters like E-Mon's Green Class series provide a scrolling LCD display of CO2 emissions, kWh and other sophisticated energy measurements that can help users gain green facility certification points under the LEED rating system.

Role of Submeters in the Facility "Greening" Process

Submeter manufacturers have responded to the green challenge by developing next-generation hardware and software tools that specifically address the needs of the sustainability market. Certified to ANSI C12.1 & C12.16 national accuracy standards, new-generation green meters offer a number of important features for new construction or retrofit applications, including:

- Scrolling LCD display of kilowatt-hour (kWh) usage
- kWh in dollars
- Current demand load (kW)
- Cost per hour, based on current load
- Estimated CO2 emissions in pounds, based on DOE standards

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- Estimated hourly CO2 emissions based on current load
- Net metering, including utility-delivered vs. user-received power and net usage
- Compatibility with BACnet, Modbus, Ethernet, RF and other popular building automation system communications
- Compatibility with pulse-output utility meters, including electricity, water, gas, BTU, steam, etc.

Integrating Meters into Building Automation Systems

First introduced in 1987, the Building Automation and Control Network, or BACnet, has evolved into ANSI / ASHRAE Standard 135-1995. Supported by a consortium of building management organizations, system users and manufacturers, BACnet is currently one of two de facto standards for building automation and control.

LonWorks, the other leading open-protocol industrial networking platform, enjoys an installed base of more than 60 million devices since the technology's introduction by Echelon Corporation in the 1980s. According to industry sources, LonWorks and BACnet share an approximately equal 40 percent share of total available market (TAM), with the remaining 20 percent of the building automation system market being made up of other protocols.

Whether designed in or retrofitted, submeters are installed on the "building side" of the main utility meter to measure energy usage from the enterprise level all the way down to a single device or circuit. Sold through distribution, today's submeters are easily interfaced with water, gas and other pulse-output utility meters to provide a total facility energy snapshot.

Submeter manufacturers like E-Mon have responded to the proliferation of these building automation system protocols by introducing low-cost interface devices that convert electrical submeter pulse-outputs into communications formats compatible with BACnet, LonWorks and others. E-Mon's Class 5000 meter equipped with Option B, for example, converts up to 38 metering data parameters into the BACnet Master-Slave/Token-Passing (MS/TP) protocol, providing measurements such as:

- Energy and reactive energy, delivered and received (kWh)
- Real power (kW), total and by phase
- Reactive (kVAR) and apparent (kVA) power, total and by phase

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- Power factor (percent), total and by phase
- Current (A), voltage (V) and phase angle (degrees) by phase

Such communications capability greatly extends the submeter's value for building automation and controls applications by enabling input of an expanded range of electrical measurements into the facility's measurement and control system. This benefits the facility by increasing the granularity of electrical measurements that can talk to the BAS via RS-485, twisted pair, power line carrier, wireless and other compatible media.

Other types of interface modules are available to extend wireless capability to the facility sector's large installed base of legacy submeters, as well as gas and water for any multi-tenant residential, industrial, commercial or institutional metering application. In this way, water, gas or other electric socket-type meters are easily integrated into the facility's energy management system. Equally suitable for new or retrofit installations, new wireless meter products provide an inexpensive path to monitor any commercial or industrial property using a complete, two-way wireless communication system with interval data collection. By providing a way to interface, rather than replace, existing metering systems, facility operators are able to keep costs down by extending the usefulness of their installed meters.

Submetering for LEED v3 Credits in New and Existing Buildings

LEED v3's energy section offers some of the building assessment system's most targeted guidelines for decreasing energy consumption and increasing alternative energy use. LEED v3 also provides guidance on commissioning, so that facility executives can be sure their systems are functioning at peak efficiency. The backbone of the measurement and verification (M&V) process required for LEED certification at every level is the electric submeter. The primary building performance category in which submetering plays a key role is the Energy & Atmosphere (EA) subset that runs through most, if not all, major assessment categories, including Commercial Interiors (CI), Core & Shell (CS), Existing Buildings-Operations & Maintenance (EBOM), New Construction (NC) and Schools. The following table outlines the EA and other credits obtainable through sub-metering:

Energy & Atmosphere	Description	Points	Schools	EBOM	NC	Retail NC	CI	CS	Retail CI	Healthcare
Prereq 1	Fundamental Commissioning of Building Systems	Required	X		X	X	X	X	X	X
Prereq 2	Minimum Energy Performance	Required	X	X	X	X	X		X	X
Credit 1	Optimize Energy Performance	Up to 18		X						
Credit 1	Optimize Energy Performance	Up to 19	X		X	X				
Credit 1	Optimize Energy Performance	Up to 24								X
Credit 2	On-Site Renewable Energy	Up to 7	X		X	X				
Credit 2	On-Site Renewable Energy	Up to 8								X
Credit 2	Enhanced Commissioning	Up to 5					X		X	
Credit 3	Enhanced Commissioning	Up to 2	X		X	X		X		X
Credit 5	Measurement & Verification	Up to 2	X							X
Credit 5	Measurement & Verification	Up to 3			X	X				
Credit 3	Measurement & Verification	Up to 5					X		X	
Credit 4	Green Power	Up to 5					X		X	
Credit 6	Green Power	1 Point								X
Credit 6	Green Power	Up to 2	X		X	X				

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Energy & Atmosphere	Description	Points	Schools	EBOM	NC	Retail NC	CI	CS	Retail CI	Healthcare
Credit 2.1	Existing Building Commissioning-Investigation & Analysis	Up to 2		X						
Credit 2.3	Existing Building Commissioning-Ongoing Commissioning	Up to 2		X						
Credit 3.2	Performance Measurement-System Level Monitoring	Up to 2		X						
Credit 4	On-site and Off-Site Renewable Energy	Up to 6		X						
Credit 5.1	Measurement & Verification-Base Building	Up to 3						X		
Credit 5.2	Measurement & Verification-Tenant Submetering	Up to 3						X		
Sustainable Sites										
Credit 9	Tenant Design & Construction Guidelines	1 Point						X		
Water Efficiency										
Credit 1	Water Performance Measurement	Up to 2		X						
Credit 2	Water Use Reduction (Measurement & Verification)	Up to 2								X
Credit 3	Water Efficient Landscaping	Up to 5		X						
Credit 4	Cooling Tower Water Management	Up to 2		X						
Regional Priority	**Regional Priority**									
Credit 1	Regional Priority	Up to 4	X	X	X	X	X	X	X	X

New Construction Case Study: Nebraska's First LEED Platinum Facility

As a state-of-the-art corporate headquarters, Omaha-based Morrissey Engineering, Inc.'s all-electric 15,580-square-foot building features recycling stations, bike storage, showers with changing rooms, a preferred parking for fuel-efficient vehicles and carpools and a host of other sustainability features.

LEED 2.2 for New Construction — Project Checklist by Major Category		
Certification Category	*Possible Points*	*Morrissey Points*
Sustainable Sites	14	10
Water Efficiency	5	4
Energy & Atmosphere	17	15
Materials & Resources	13	7
Indoor Environmental Quality	15	15
Innovation & Design Process	5	5
Project Totals	**69**	**56**

Certified: 26 - 32	**Silver:** 33 - 38	**Gold:** 39 - 51	**Platinum:** 52 - 69

Morrissey's LEED-NC certification showing points received by category. Submeters are especially useful for measurement & verification in the EA category, in which MEI achieved nearly the maximum allowable points.

For the energy monitoring function required for Morrissey's LEED-NC Platinum certification, a network of seven Green Class E-Mon D-Mon submeters was installed to measure and verify the applicable certification points shown in the table above.

Installed in the facility's mezzanine-level electrical closet, the 3-phase meters accept raw energy data from lighting, mechanical and plug loads throughout the facility. The meter data from these key loads is continuously transmitted over the RS-485 network to an E-Mon Interval Data Recorder (IDR), which stores the data in 15-minute intervals and communicates with E-Mon Energy, the facility's PC-based energy intelligence software.

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In operation, E-Mon Energy software lets management read and monitor energy consumption (kWh) and demand (kW) via on-site or off-site non-dedicated computers. Graphs and energy data profiles are generated for demand analysis, load profiling and energy management functions, including itemized electrical bills for departmental allocation or even tenant billing, if desired.

E-Mon Energy software accepts and stores raw submetered data for demand analysis, load profiling and other energy management functions. Stored interval data can also be converted into spreadsheets for further analysis.

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Early in its operational life, the submetering system proved its mettle by identifying a potentially costly problem—an unanticipated demand spike—before it resulted in an automatic 10% utility rate hike. Analysis of the facility's load profiles quickly revealed the culprit, a coincident power demand during morning warm-up from the night set-back condition.

E-Mon Energy's data visualization capability showed power demand during warm-up to be three times higher than normal daytime operation. The metering system allowed corrective measures to be identified and implemented.

Morrissey Engineering's recent experience illustrates the benefits of combining an efficient facility design with the use of submeter data to optimize building performance. As exemplified by MEI's state-of-the-art corporate headquarters, balancing aesthetics and functionality through the complementary integration of architecture and engineering best practices can produce striking results. From an operational standpoint, submeter data helped MEI identify further energy savings opportunities and lower cost by understanding and controlling its electrical load profile—key factors in the Morrissey's LEED Platinum certification and subsequent ranking among the top 10 percent of energy-efficient facilities in the country, according to the EPA's Energy Star program.

Retrofit Case Study: Meters Help High-Rise Condo Recover $16K/month in Electrical

Pressured by rising costs, the property manager for Pittsburgh's Park Plaza Condominiums was faced with either raising monthly fees to offset the property's $20,000 per month electric bill or find a way to allocate and bill each owner's electrical usage in order to recover a significant percentage of the facility's operational overhead. The property manager estimated that running additional power company metering to each of the building's more than 120 units would be five or six times costlier than simply submetering each apartment, including all residential units, to isolate each owner's electrical usage (kWh) behind the main utility meter.

The hardware portion of the system called for 122 UL-listed and CSA-approved Class 1000 E-Mon D-Mon meters installed in two sizes of multiple meter unit (MMU) cabinets. Submetering the twelve commercial spaces on the ground floor proved less challenging than metering the residential floors above. "The entire building had finished drywall ceilings with limited access for cabling," said the project manager, who explained that the 200A split-core current sensors were installed in an existing junction box in the hallway just outside each apartment. The hinged construction of the low-voltage (0-2V) output split-core current sensors allowed the electricians to install them non-invasively around the electrical feeds being monitored, thus eliminating the need to shut down the load and resulting in a safer, faster install.

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In the basement, an Ethernet cable was run a few feet from the MMUs to the building's engineering office where a desktop PC running E-Mon Energy™ software analyzes the meter data and outputs monthly owner billing statements with revenue-grade accuracy. The entire submeter installation took only 35 working days to retrofit. The property manager calculates that the system's $113,000 installed cost paid for itself in only seven months—based on $16,000 per month in electrical costs that were recovered as a direct result of submetering the property.

Reducing Your Facility's Carbon Footprint

Department of Energy data reveals the average CO2 emission in the United States to be 1.37 pounds for every kilo-watt-hour (kWh) of electricity generated. This takes into consideration all forms of generation from nuclear to coal-fired plants. To put it in everyday terms, using ten 100W electric light bulbs for one hour will cause 1.37 pounds of CO2 to be injected into the atmosphere. So what can be done to reduce it?

Facilities can start by benchmarking how much CO2 they are generating. Metering technology has reached the point where users now have an easy way to see their own carbon footprint. These so-called "green submeters" come in sizes ranging from 100A to 3200A for both 120/208V and 277/480V applications. Usually they can be installed anywhere and, because they use split-core current sensors to measure the equipment or circuits of interest, they are quickly and easily installed without powering down the load.

A key advantage of the electronic submeter is its 0-2V split-core current sensor that is installed non-invasively around the electrical feed being metered. This eliminates having to power down the load and makes for a quicker, safer install.

Submeters are useful for raising awareness of both electrical consumption and carbon footprint. Meters from E-Mon and other suppliers now come with rolling displays that show kilowatt-hours used, real-time kilowatt load, the estimated total amount of CO2 generated to provide electricity and

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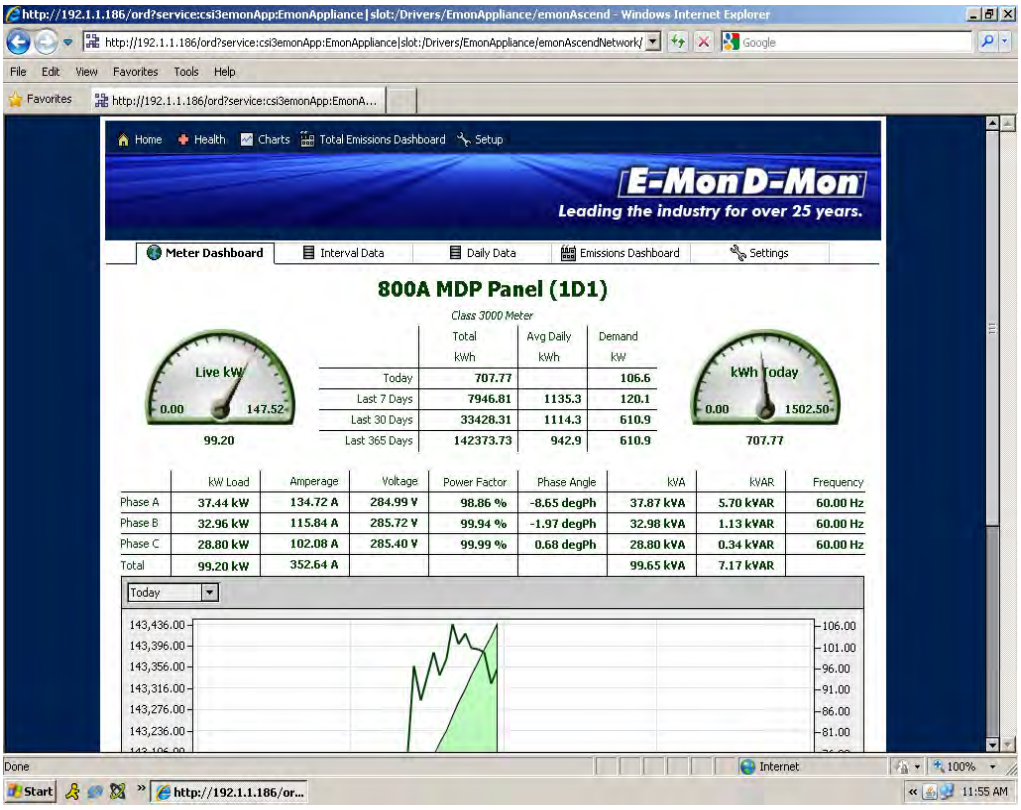
the projected hourly CO2 emissions based on actual load. Another benefit that meters provide is to let users see their total electrical energy cost to date and their projected hourly cost based on actual load. Software automatically graphs CO2 emissions in parallel to demand (kW) figures, while also providing the data in tabular format where the peak CO2 load and the total CO2 emissions are displayed.

Meter Dashboards Increase Energy Awareness

Internet-enabled energy monitoring and data presentment dashboards are gaining traction in the facility environ-ment for displaying kWh, kW, peak demand, power factor and other energy measurements in real time, and historically, while also displaying the facility's "carbon footprint." This allows facility occupants to monitor their building's carbon dioxide (CO2), sulfur dioxide (SO2) and nitrous oxide (NOx) emissions—while at the same time observing estimated energy conservation measures needed to compensate for the displayed levels.

The following screen captures illustrate the sheer depth of energy information provided by a single submeter, in this case an E-Mon D-Mon Class 3000 device. For the 800 Amp main distribution panel shown below, the first meter dashboard displays the various metered parameters; the second dashboard shows the rest of the graph at the bottom of screen one, and the third dashboard displays the carbon footprint of the metered 800A panel over time, even extrapolating the data to an estimation of equivalent automobile miles driven and the amount of re-forestation needed to offset the panel's CO2 contribution!



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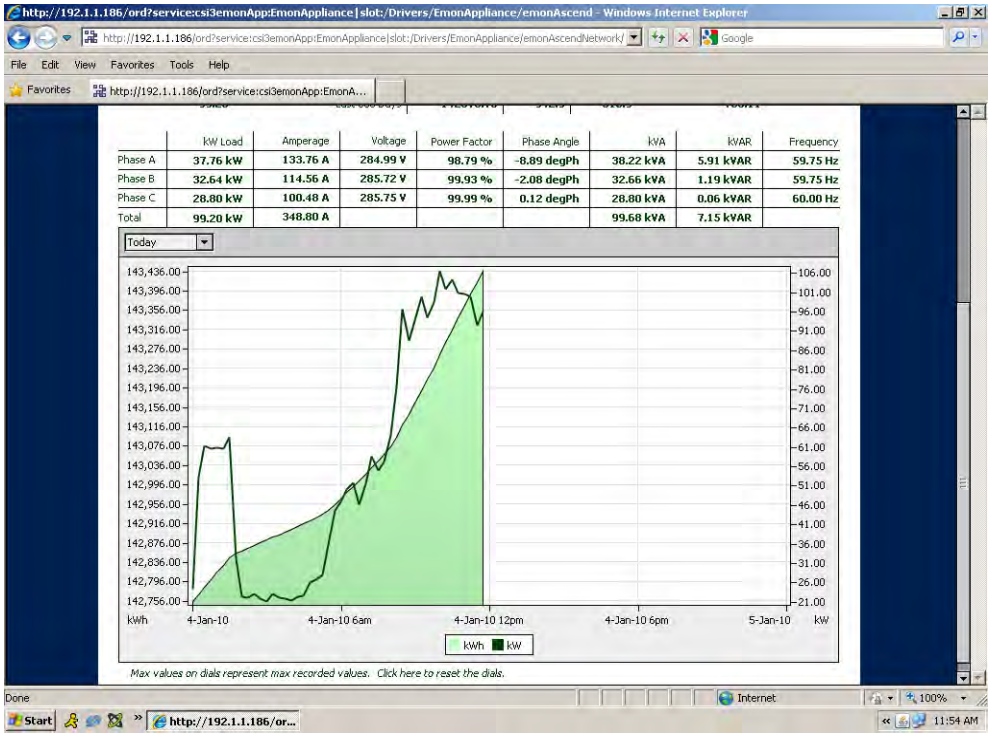
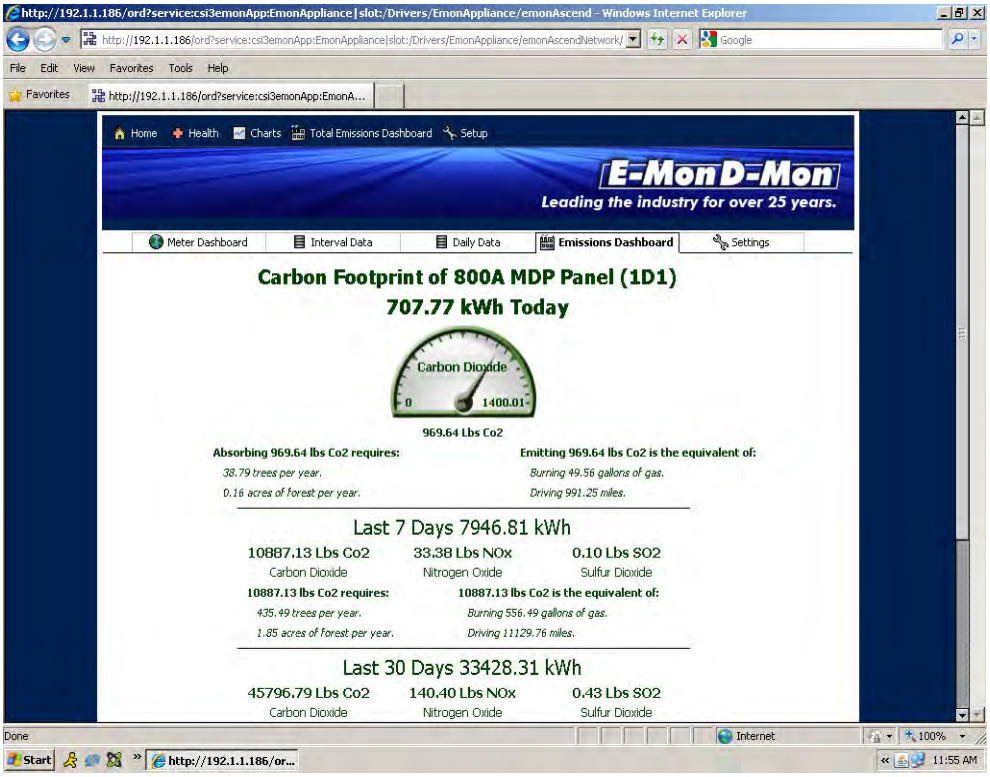


	kW Load	Amperage	Voltage	Power Factor	Phase Angle	kVA	kVAR	Frequency
Phase A	37.76 kW	133.76 A	284.99 V	98.79 %	-8.89 degPh	38.22 kVA	5.91 kVAR	59.75 Hz
Phase B	32.64 kW	114.56 A	285.72 V	99.93 %	-2.08 degPh	32.66 kVA	1.19 kVAR	59.75 Hz
Phase C	28.80 kW	100.48 A	285.75 V	99.99 %	0.12 degPh	28.80 kVA	0.06 kVAR	60.00 Hz
Total	99.20 kW	348.80 A				99.68 kVA	7.15 kVAR	



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The Bottom Line is Always the Bottom Line

The type of energy data needed by today's sophisticated facility is beyond the capability of the master utility meter to provide. As first-level data gathering tools in the facility load-profiling process, submeters provide high-accuracy 15- or 30-minute snapshots of energy use (kWh) and demand (kW)—at the enterprise level all the way down to a specific circuit or item of equipment. Increasingly, consulting and specifying engineers are turning to submeters as an easily installed, versatile and scalable solution for obtaining the degree of energy intelligence *granularity* needed to optimize today's facility operations—no matter what type of facility is being monitored.

For further information about E-Mon's complete line of hardware and software solutions for automatic meter reading applications, call 1-800-334-3666 or visit us on the web at www.emon.com.

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About the author:

Don Millstein is President and CEO of E-Mon, LLC of Langhorne, PA. As a veteran energy industry speaker and author, Don is a former participant in utility deregulation in California, New Jersey, New York and Penn-sylvania. He is a member of the FEMP task force, Alliance to Save Energy, the U.S. Green Building Council and other energy conservation-related organizations. He may be contacted at dmillstein@emon.com.