The Carbon Question: Answering With Technology-Driven Emissions Measurement

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Abstract

It is clear that the debate surrounding climate change and greenhouse gas emissions has shifted dramatically from the question of whether science indicates that climate change is truly occurring, to the question of how those in the energy services industry can best position for and respond to the challenges posed by a carbon constrained energy landscape. The objective of this paper is to outline technologies and strategies available to downstream energy users to employ robust technology-enabled methodologies to rigorously measure, quantify, analyze, and report their carbon footprint.

Conceptually, carbon measurement should be viewed as a natural extension of energy measurement, fossil or electric, and not as a data parameter in a silo unto itself. In most cases, analysis of an enterprise or facility-wide carbon footprint can be conducted in parallel with an enterprise or facility-wide energy usage/efficiency audit supported by continuous monitoring and verification. A pre-requisite to conducting a carbon footprint analysis is a complete, holistic picture of an entity's energy usage. This type of holistic understanding of an entity's energy usage can only be obtained after conducting a comprehensive study of energy usage and efficiency. Therefore, when undertaking an energy efficiency audit facilitated via sub metering, communication with legacy systems, time series interval data-logging, and sophisticated energy analysis software, carbon should be included as an additional data parameter to be measured and recorded. Including carbon in such a study will prevent the duplication of effort necessitated by a separate carbon audit and integration of carbon data parameters will allow carbon to be reported in flexible and entity specific metrics pertinent to the business needs of the downstream user. In addition, such an approach will provide rigorous and defensible quantification and accounting of entity-wide carbon emissions and may protect against future regulatory developments.

This paper is particularly pertinent since the market for "carbon solutions providers" is currently extremely fragmented and characterized by a wide range of quality and technological sophistication. While initial carbon regulation appears to be focused on upstream point sources such as electric generation, a major portion of any upstream carbon mitigation strategy will rely on actions taken by downstream users. By viewing carbon measurement and management as an extension of any comprehensive energy efficiency program, the issue can be framed in a way that is understandable and accessible to current energy service practitioners and managers at downstream entities. Improvements in energy efficiency and carbon reductions go hand-in-hand and vice-versa, so it is only logical to link the two in any data system. In addition, downstream user costs associated with carbon management can be minimized by integrating carbon measurement and reporting into existing or planned energy efficiency programs.

Introduction

We have entered an era in the post-industrial age where the future of our society is tightly tied to a rapid evolution of technology in the energy industry. This is not the first time that we have arrived at a cross-roads where the path forward is determined by the energy technology we wield: fire, steam, coal, oil, nuclear – harnessing these energy technologies has led to revolutions in our way of life. Today, however, the stakes are very different and, arguably, much higher. If the opinions of the vast majority of scientists and economists are accurate, global climate change, if left unchecked, will wreak havoc on ecological systems and our economy. Successful application of technology in the energy industry is the cornerstone on which most successful global warming scenarios are built. Therefore, we have a clear call to action and we must deliver decisive and measurable results against the goals that have been identified for us.

A Call to Action

The global consensus is now clear: climate change is a serious threat, and can have very grave impacts on our growth and development. But there is still time to avoid the worst impacts of climate change, if we take rapid action. According to The Stern Review on the economics of climate change (Stern, 2007), the risks of the worst impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere are stabilized at between 450 and 500 ppm CO_2 equivalent (CO_2e). Current levels of CO_2e are at 430ppm, and are rising at more than 2ppm each year. Stabilization, at whatever levels, requires that our annual emissions be brought down to more than 80% below current levels.

Although this seems like an impossible task, we do have a range of options at our disposal, all hinging on modifying how we use energy. Emissions can be reduced by increased energy efficiency, the adoption of clean and/or renewable power sources, and changes in our global demand.

The world has already begun to respond to the climate challenge. Through the Kyoto Protocol, which entered into force in February 2005, over 172 countries have committed to reducing their greenhouse gas emissions. In January 2005, the European Union started the operation of the largest multi-country, multi-sector greenhouse gas emissions trading system. The State of California, which is the world's 12th largest source of CO_2 emissions, recently passed Assembly Bill 32, which commits the state to reducing emissions to 2000 levels by 2010, then further to 1990 levels by 2020, and finally to 80% below 1990 levels by 2050. New York City Mayor Michael Bloomberg committed the city to reducing global warming emissions by more than 30% as part of PLANYC.

Corporations are also beginning to react. Many Fortune 500 companies are developing corporate social responsibility platforms, wherein they recognize the need to act on their environmental footprint. As of October 1, nearly 10% of Fortune 500 companies have signed-on to the Environmental Protection Agency's Green Power Partnership, and have effectively met their objective of purchasing over 5 billion kWh annually in green energy. Large corporate players, such as Wal-Mart or General Electric, have taken overt and decisive steps to monitor and reduce their emissions.

How Should We Respond?

Clearly, the world is starting to respond on many fronts: commercial, industrial and institutional organizations; governments and NGOs; individuals and associations. As highlighted above, many parties are committing themselves to reducing their carbon footprint, taking firm steps to achieve reductions in their green house gas (GHG) emissions. In this context, the measurement and verification of emissions is a key element. This paper is particularly pertinent since the market for "carbon solutions providers" is currently extremely fragmented and characterized by a wide range of quality and technological sophistication. Organizations and individuals have started to invest significant time and money in developing GHG emissions strategies as a hedge against financial risks of future regulations or their social responsibility "conscience." However, as recent media reports and embarrassing corporate disclosures clearly reveal, early returns on these investments are uncertain in a voluntary market environment where there is no clearly defined line between "green washing" and "being green." Perhaps the answer to ensuring a higher return on the green investment is in the well-established link between being green and being energy efficient.

So how do we in the energy services industry position ourselves, our customers and the world to effectively respond to the challenges posed by a carbon constrained energy landscape? I believe that an important part of the answer lies in technologies and strategies available to downstream energy users to employ robust technology-enabled methodologies to rigorously measure, quantify, analyze, and report their carbon footprint. The adage "if you can't measure it, you can't manage it" has never been more important, across the gamut between the grass-roots, facility-level and the global-level. Many of the energy efficiency methodologies that have withstood the test of time are valuable tools for carbon footprint management with a very high return on investment, especially when compared to the costs of renewable energy generation projects or annual purchases of offsets and renewable energy credits (RECs).

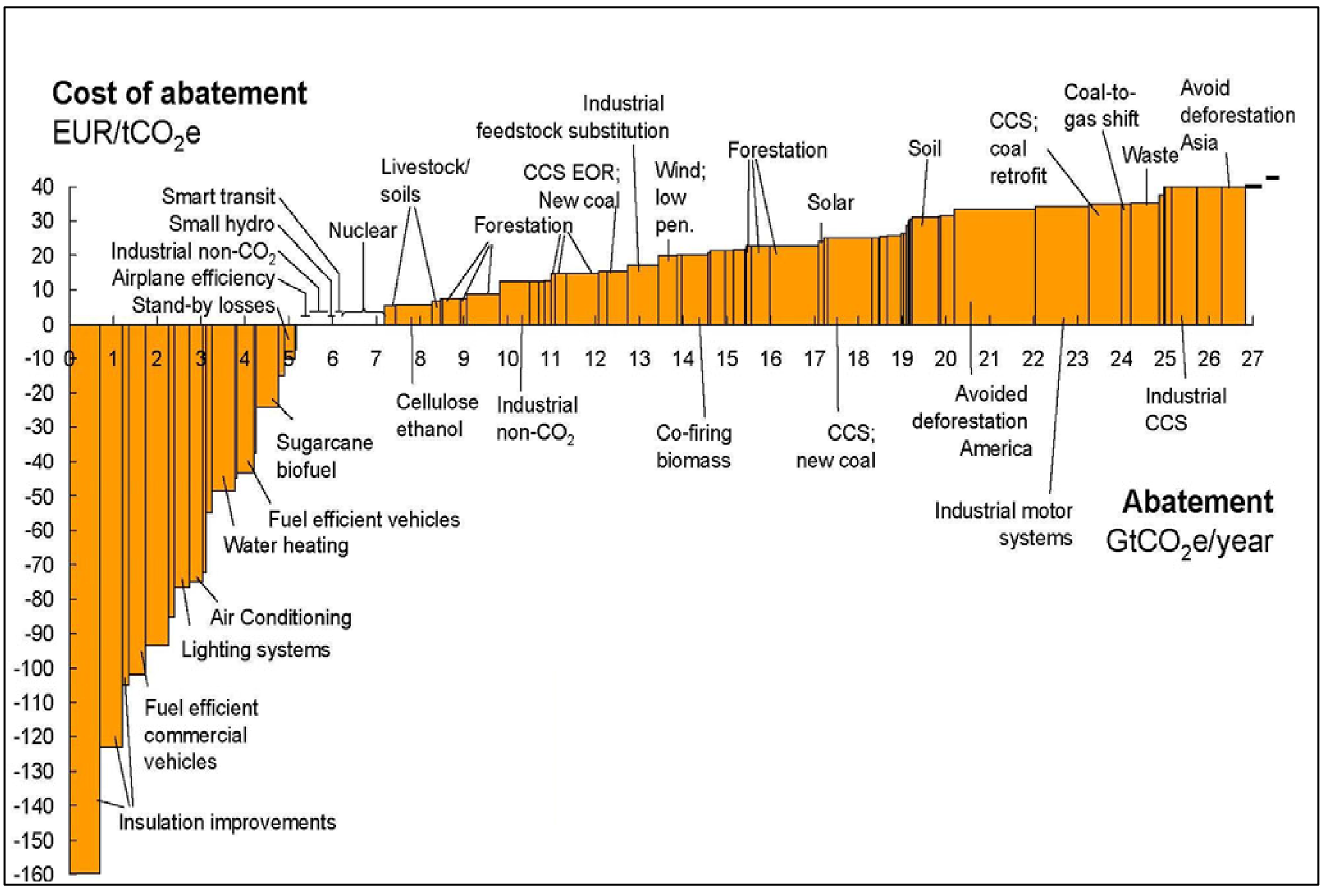


Figure 1. Range of mitigation strategies and associated cost (Vattenfall, 2007)

For example, analysis of an enterprise or facility-wide carbon footprint can be conducted in parallel with an enterprise or facility-wide energy usage/efficiency audit supported by continuous monitoring and verification. A pre-requisite to conducting a carbon footprint analysis is a complete, holistic picture of an entity's energy usage. This type of holistic understanding of an entity's energy usage can only be obtained after conducting a comprehensive study of energy usage and efficiency. Therefore, when undertaking an energy efficiency audit facilitated via sub metering, communication with legacy building management systems (BMS) or energy management systems (EMS), time series interval data-logging, and sophisticated energy analysis software, carbon should be included as an additional data parameter to be measured and recorded. Including carbon in such a study will prevent the duplication of effort necessitated by a separate carbon audit and integration of carbon data parameters will allow carbon to be reported in flexible and entity specific metrics pertinent to the business needs of the downstream user. In addition, such an approach will provide rigorous and defensible quantification and accounting of enterprise-wide carbon emissions and may protect against future regulatory developments.

The challenge at this stage is, more often than not, identifying the source of funds for accurate measurement of GHG emissions. Many organizations have started the process by funding a project to identify current emissions as a basis for future strategy development. This is a natural first-step. However, such a project provides only a snap shot of the GHG footprint. The long-term success of a persistent program to manage and reduce GHG emissions requires regular or near-real-time measurement of emissions. Funding such a program typically requires addition of a new line item in the annual operating budget. In some cases, utility programs and rebates will pay for installation costs and some on-going operational expenses. Another alternative is exploiting a new energy-related source of revenue, such as the regular capacity payments from a demand response program, to fund the on-going GHG emission measurement.

Carbon Footprint Assessment

Measurement of an enterprise's GHG footprint requires both qualitative and quantitative measurement of direct and indirect energy use. There are several very good reference documents describing processes and protocols for measuring an organization's carbon footprint. Perhaps the leading example is the collaborative work assembled by the World Business Council for Sustainable Development and the World Resources Institute: "The Greenhouse Gas Protocol, a Corporate Accounting and Reporting Standard", as illustrated in Figure 2. This Protocol was first published in 2001 and has been revised and updated since that time. The U.S. DOE has issued guidelines for reporting GHG emissions and for registering GHG emissions reductions in the 1605b registry. Several states have also created GHG registries, and there are several voluntary programs in the US that have their own protocols and requirements. Once an organization has made the policy decision to act according to a selected protocol, the next step is actual measurement.

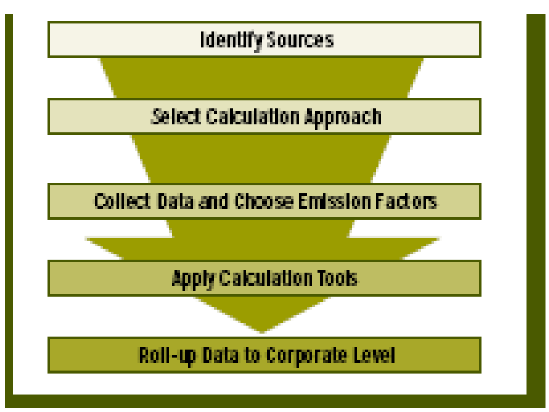


Figure 2. Steps in identifying and calculating GHG emissions (WRI, 2001)

Sources of GHG emissions include direct and indirect sources. Examples of direct sources include on-site fuel combustion from boilers, process and company-owned fleets. These are by their nature typically easier to measure and quantify. Examples of indirect sources are GHG emissions whose source is outside the physical boundaries of the organization, including supply chain-related emissions, employee business travel and commuting, and emissions from the generation of purchased electricity. These are usually more difficult to quantify initially and on an on-going basis. WRI introduced the concept of "scope" as a framework to delineate direct and indirect emissions (WRI, 2001), as illustrated in Figure 3..

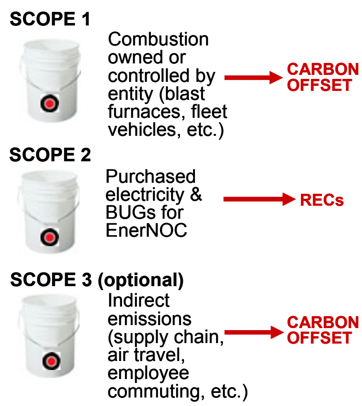
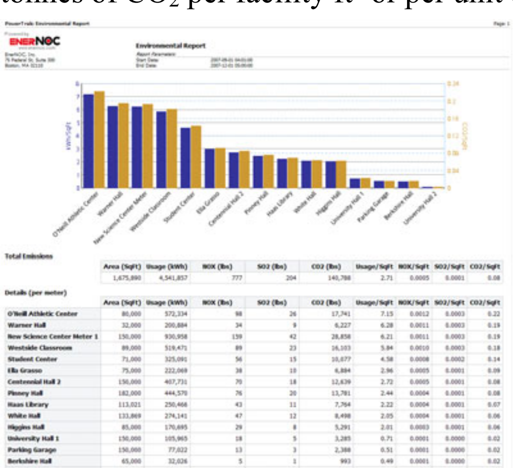


Figure 3. Categorizing GHG emissions sources (WRI, 2001)

EnerNOC has developed a web-based technology platform called PowerTrak to support its demand response business that has the added benefit of automating the quantitative measurement of carbon emissions from electricity consumption. Demand response typically requires near real time measurement of electricity consumption at the utility meter. By capturing and storing this electricity consumption data, EnerNOC can calculate location-specific emissions data with its proprietary CarbonTrak environmental report. CarbonTrak provides granular kWh usage information at the meter-level and specific EPS emissions data for the local utility generation sources (based on data published by the Environmental Protection Agency's eGRID database). Users can aggregate meters and select data ranges to arrive at a quantitative measurement of this critical component of the GHG footprint with the click of the mouse. CarbonTrak also provides the option of reporting emissions on an intensity ration (WRI, 2001), such as tonnes of CO_2 per facility ft^2 or per unit of electricity consumption. An example is provided in Figure 4.



Environmental Report

Total Emissions

Area (SqFt)	Usage (kWh)	NOX (lbs)	SO2 (lbs)	CO2 (lbs)	Usage/SqFt	NOX/SqFt	SO2/SqFt	CO2/SqFt
1,675,890	4,541,857	777	204	140,788	2.71	0.0005	0.0001	0.08

Details (per meter)

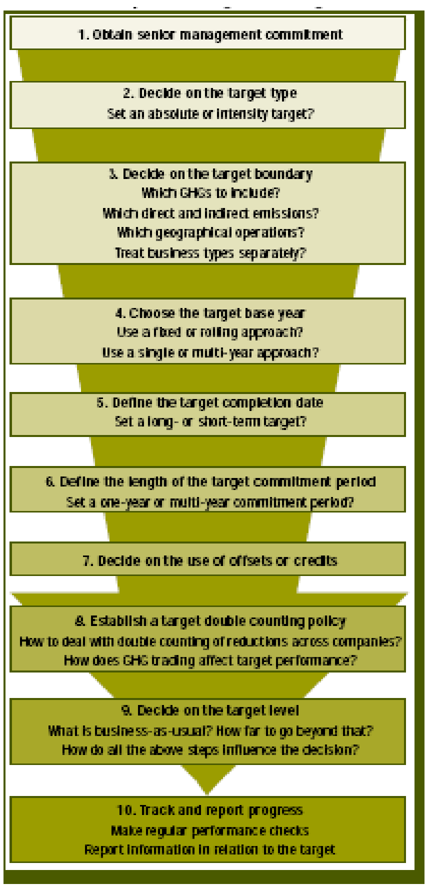
	Area (SqFt)	Usage (kWh)	NOX (lbs)	SO2 (lbs)	CO2 (lbs)	Usage/SqFt	NOX/SqFt	SO2/SqFt	CO2/SqFt
O'Neill Athletic Center	80,000	572,334	98	26	17,741	7.15	0.0012	0.0003	0.22
Warner Hall	32,000	200,884	34	9	6,227	6.28	0.0011	0.0003	0.19
New Science Center Meter 1	150,000	930,958	159	42	28,858	6.21	0.0011	0.0003	0.19
Westside Classroom	89,000	519,471	89	23	16,103	5.84	0.0010	0.0003	0.18
Student Center	71,000	325,091	56	15	10,077	4.58	0.0008	0.0002	0.14
Ella Grasso	75,000	222,069	38	10	6,884	2.96	0.0005	0.0001	0.09
Centennial Hall 2	150,000	407,731	70	18	12,639	2.72	0.0005	0.0001	0.08
Pinney Hall	182,000	444,570	76	20	13,781	2.44	0.0004	0.0001	0.08
Haas Library	113,021	250,466	43	11	7,764	2.22	0.0004	0.0001	0.07
White Hall	133,869	274,141	47	12	8,498	2.05	0.0004	0.0001	0.06
Higgins Hall	85,000	170,695	29	8	5,291	2.01	0.0003	0.0001	0.06
University Hall 1	150,000	105,965	18	5	3,285	0.71	0.0001	0.0000	0.02
Parking Garage	150,000	77,022	13	3	2,388	0.51	0.0001	0.0000	0.02
Berkshire Hall	65,000	32,026	5	1	993	0.49	0.0001	0.0000	0.02
University Hall 2	150,000	8,435	1	0	261	0.06	0.0000	0.0000	0.00

Figure 4. CarbonTrak™ report of facility-level GHG emissions (EnerNOC, 2007)

Similar measurements can be made to track emissions from on-site generation sources in PowerTrak, such as co-generation or on-site sources of renewable electricity. These quantitative measurements and can be integrated with the CarbonTrak report to provide a more comprehensive picture of power-related emissions. Automating the measurement of power-related GHG emissions is helpful in the initial assessment of the GHG footprint, and particularly valuable for on-going performance measurement of actual emissions against the baseline year. In many cases the cost of automating these measurements is more than 100% offset by the demand response payments.

Strategic Development and Tactical Implementation

The development of a comprehensive strategy for management of GHG emissions provides the frame work for all future actions. Policy most be embraced by senior management and there are several strategic decisions that will dictate the ensuing tactical implementation. For example, there is the choice of how to measure the GHG footprint, discussed briefly in the previous section. How far along the value chain will measurements be made? There is the choice of what type of target is most relevant to the organization: 1) an absolute emissions target reduction, or; 2) an intensity ratio target reduction (e.g., reduce GHG emissions per ft2, or per unit of production, or unit of service, or per employee). And of course there is the decision of the reduction target amount and the time allotted to achieve the targeted reduction. Figure 5 illustrates some of these decisions that must be made in developing the GHG management strategy.



While initial carbon regulation appears to be focused on upstream point sources such as electric generation, a major portion of any upstream carbon mitigation strategy will rely on actions taken by downstream users. By viewing carbon measurement and management as an extension of any comprehensive energy efficiency program, the issue can be framed in a way that is understandable and accessible to current energy service practitioners and managers at downstream entities. Improvements in energy efficiency and carbon reductions go hand-in-hand and vice-versa so it is only logical to link the two in any data system. In addition, downstream user costs associated with carbon management can be minimized by integrating carbon measurement and reporting into existing or planned energy efficiency programs. A practical, three-step process for tactical implementation is illustrated in Figure 6 in the next page.

The following are examples of technology-enabled energy efficiency and demand management that make meaningful reductions in GHG emissions at a no cost to the facility owners. In fact, these tactical measures can and do generate revenues for more costly approaches to GHG mitigation, such as the purchase of RECs or carbon offsets.

Figure 5. Steps in setting a GHG target (WRI, 2001)

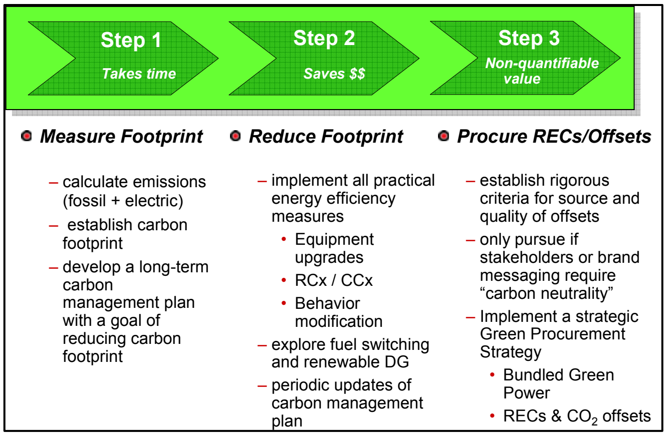


Figure 6. Three-step tactical implementation (EnerNOC, 2007)

Energy Efficiency

Energy efficiency is the first and most important approach to reducing our global emissions. While we have made great strides as a community in promoting and implementing energy efficient measures in all sectors of the economy, plenty of opportunity still remains. In particular, advances in information technology, combined with novel or creative approaches, are making it possible for us to unlock efficiency which previously was out of reach, or not considered a 'low hanging fruit'.

As a case in point, consider the recent trends in continuous commissioning or monitoring-based commissioning. Even though the buildings we design today use high-efficiency equipment and design, they do not necessarily continuously operate at peak performance.

As an example, a Connecticut-based university faced data and resource challenges when analyzing its energy usage across campus. The university lacked the ability to obtain building-specific energy consumption and profile data and make comparisons across buildings or years. Understaffing prevented the university from performing detailed evaluations of its building management system (BMS).

EnerNOC worked with this university to integrate a web-based energy management platform with its meters and BMS to monitor and store energy data. With PowerTrak, the university identified efficiency opportunities by monitoring, comparing, and analyzing set points, operating schedules, and outside air economizers. EnerNOC developed detailed reports that documented baseline consumption and benchmarks; usage profiles; and energy and monetary savings from implemented efficiency measures, while continuously monitoring energy consumption across campus to ensure the university maintained its increased efficiency status.

The university also adjusted its equipment schedule from 16 hours daily to 14 hours and identified and replaced problematic and inefficient equipment. Currently, excluding any additional efficiency opportunities, the university expects to be 3-6% below its 2007 forecasted energy consumption with savings projected at nearly $200,000 for the year.

By analyzing its near real-time data, the university identified several significant, low or no-cost efficiency opportunities. An example is illustrated in Figure 7, where the operation of a air handler dose not match the daily on-off cycle programmed into the BMS. In this case, the unit was running 24x7 until the PowerTrak filters picked up the flat static pressure line discontinuity with the programmed schedule on the top and bottom profiles, respectively.

The university's facilities department distilled near real-time energy data into actionable strategies that identified anomalies and inefficiencies, increased energy efficiency, optimized operations, and saved energy and money. The facility manager also has the ability to provide reports from PowerTrak to the university's finance department to demonstrate the budget impact from capitalizing on energy management, and PowerTrak will continue to flag inefficiencies and opportunities for operational improvements. This added intelligence sets it apart from traditional energy and commissioning services, which rely on a small, static view of the facility.

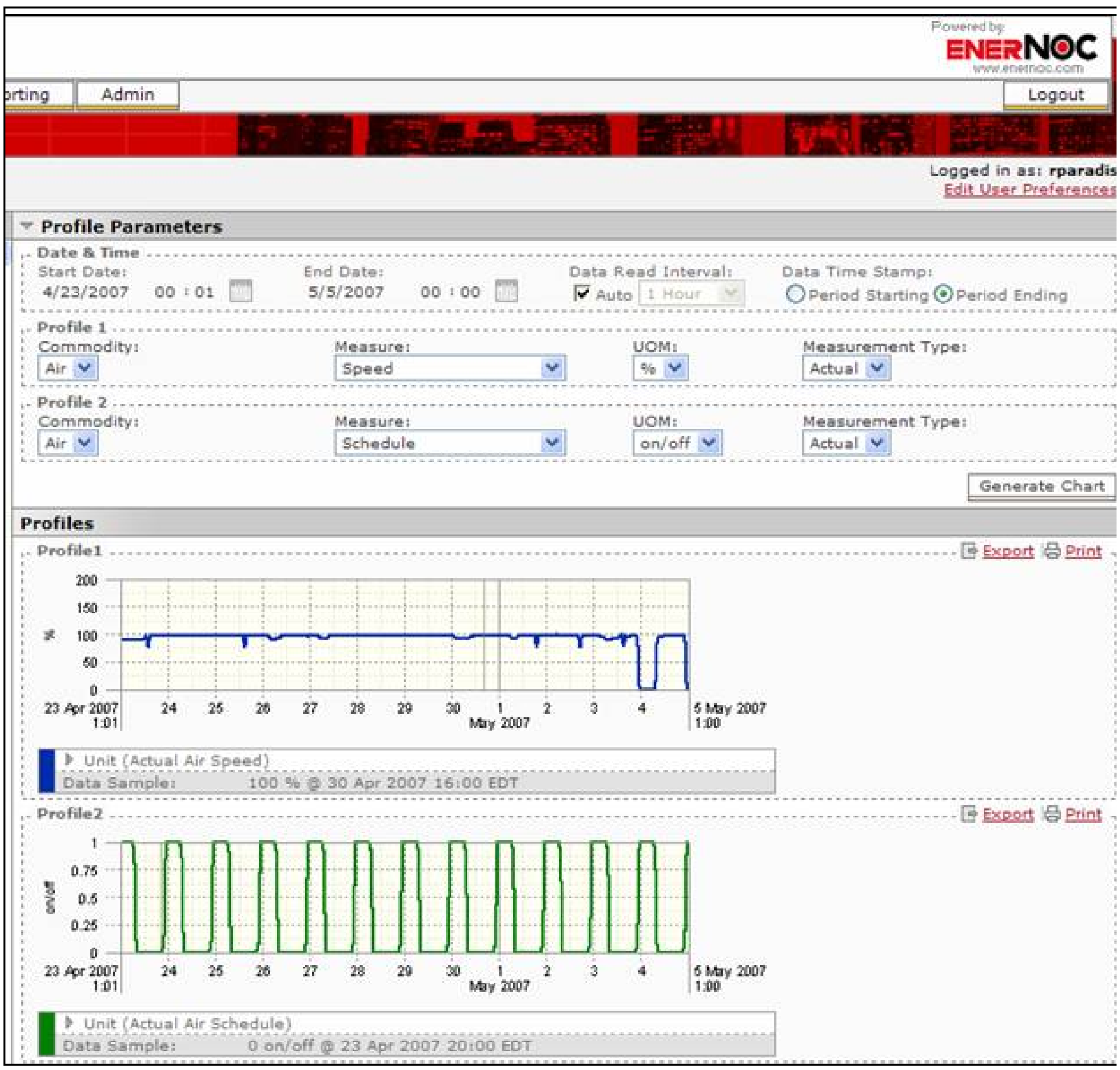


Figure 7. Analysis of BMS and meter data yields no-cost energy efficiency (EnerNOC, 2007)

Demand Response

Another tool in our arsenal, one closely linked to energy efficiency, is demand response (DR). DR is expanding rapidly in the electric industry as a way to mitigate the need to build new power plants. Traditionally, DR has not been associated with energy efficiency or environmental stewardship, but this perception is beginning to change.

In a well-received article published in the March 2007 edition of Public Utilities Fortnightly (Nemtzow, et. al., 2007), David Nemtzow, Dan Delurey and Chris King effectively argue that demand response programs yield real and measureable energy savings. Their review of several studies shows that demand response effectively reduces energy consumption, primarily during the peak periods, and has the potential to be a major indirect factor in increasing overall energy efficiency nationally.

One of the most important aspects of demand response is that it helps to increase awareness of the end-user's energy consumption. According to an EPRI Solutions Report published in 2006 (EPRI, 2006), many studies have shown that end-use customers respond to feedback on their energy usage, resulting in savings from four to fifteen percent. Demand response enables this type of feedback, by providing end-users with near real-time information on their energy usage.

Nemtzow et.al., also address how DR reduces environmental impacts. The issue here is that some demand response programs allow customers to switch to back-up generation, in various forms, to meet part or all of the load they remove from the grid; and some argue that while DR contributes to a net reduction in total grid consumption, it may not necessarily lead to reduced emissions as a whole. However, Nemtzow et. al. point to other factors that indicate that DR is a viable strategy for reducing energy-related greenhouse gas emissions, and the most intriguing link may be between DR and renewable resources, including distributed renewable resources. Many intermittent renewable resources, such as wind or solar, are well suited to work with DR. DR can be used to load-balance the system as the intermittent resources ramp up or down, thus providing more value to the renewable resource.

Conclusions

One of the many challenges we face in taking meaningful, proactive steps to mitigate climate change impacts at the facility- to enterprise-level is technology deployment. Technology is required to implement a scalable level of:

1. GHG footprint measurement
2. Energy efficiency and demand response programs
3. On-going measurement and verification

Scalability is really the key concept here. If we are to make a meaningful contribution through energy efficiency and demand management, it must leverage technology and automation to achieve the maximum effectiveness at the least cost.

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