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More Than One Third of America's Commercial HVAC Systems Are Broken. Right Now.

...but some HVAC issues can be addressed remotely, and failed units can be temporarily taken offline to save wear and tear. You just have to find the right ones to focus on . . .

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It's remarkable: In the digital era of instantaneous transnational communication and inspiring TV ads about the Smart Grid, a great deal of the nation's energy is consumed or wasted by broken commercial HVAC units. In the US, this represents a large opportunity to solve our energy problems, by reducing the need to find, deliver, and burn fuels or build new power plants, and earn an attractive return for commercial operators.

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Indeed, according to respected industry studies, 35% of HVAC units at America's commercial buildings are broken and not functioning at optimal levels. Data from the California Energy Commission shows that the problem might be even worse. In a sample of commercial buildings, more than 45% of the Roof Top Units (RTUs) had an improper refrigerant charge, 39% had low airflow, and an astonishing 63% had broken economizers[1].

Improving HVAC efficiency by replacing units is a fine idea, but the percent improvements in efficiency with new HVACs is only in the range of a few percent points, as measured by SEER. A better approach is identifying and repairing failed HVACs within your current asset base. This approach yields a proven track record of more than 15% energy efficiency improvements for entire sites. This is music to the ears of CFOs looking for ways to reduce their total energy costs by 15% or more.

The disruption and waste that failed HVACs cause is breathtaking. If a building has six RTUs (roof-top HVAC units) and one fails, the net energy efficiency of the *entire* system drops significantly. Sometimes by ***much*** more than the 1/6th that the single HVAC represents. The broken RTU continues *trying* to heat or cool, while the adjacent RTUs compensate for the failed unit. The failed unit is pumping unconditioned air into the space, consuming fan horsepower and injecting heat from the fan motor into the air stream. As long as the adjacent units continue to pick up the slack, the failed unit goes unnoticed. We have seen failed units that show evidence of having run for *years*, unnoticed, yet not actually cooling or heating.

Beyond the energy consumption issues, the broken unit (with its nearly continuous runtimes) causes additional wear on all components. Adjacent HVAC units experience increased runtimes, which causes them to fail sooner than normal.

Actionable Information is the Key

The scale of this problem is remarkable, but just as remarkable is how easy it is to fix the problem – *with the right tools*. Indeed, a new generation of Energy Management Systems (EMS) provides accurate, realtime insight into HVAC equipment and energy performance so cost effectively that the net effect is like "found money." The commercial operator can earn a very favorable return, typically better than 40% IRR on just the energy costs, with other side benefits as well, such as reduced costs for overhead staff, maintenance costs, and better comfort for their customers.

Moreover, we are not just talking about a lower cost EMS for a single site, but visibility across all HVAC assets at the enterprise level. And that visibility provides data that is actionable information, not just voluminous streams of data and alerts or icons of spinning fans. This asset information is prioritized and accessible to the various functional managers and external service providers in a secure framework which allows highly efficient operations to manage energy and maintenance costs.

These *next-generation* EMS use *cloud-based computing* to implement very sophisticated analytics. By processing the raw data

streams with *best practice* "rule sets," the above-site EMS function identifies trends, and then detects and scores potential problems. These advanced EMS have the power and scalability to provide visibility tailored to different managers at the local, regional, or national levels across hundreds or thousands of sites, where the most-important issues are presented first. By maintaining the raw data in a central repository that is remotely and securely accessible by all users, someone looking for "fine grain data" can find it almost immediately.

Enterprise-wide Performance Visibility

Today's Energy Management Systems are installed on an enterprise basis, because you never know where the next asset is going to break. But you do know that all HVACs will eventually fail. You need a system to provide enterprise visibility, or it will fail (and will likely keep consuming energy) without your knowledge. Energy Management Systems are particularly important when a commercial operator has many sites spread across various time zones; they enable these sites to operate with basically consistent hours, temperature set points, and service philosophies. Indeed, as the number of sites and distance between sites increases, the positive *Network Effect* of EMS becomes very important.

Enterprise-class EMS implementations have advanced *generations beyond* the old-fashioned, site-based building automation systems that were set up for use by highly trained building engineers who managed a "reactive approach" to energy and service management. Whereas older systems provided dial-up into a system *after* they receive a complaint from the on-site staff, these next-generation EMS provide visibility into the automated results of pro-active trending, detection, diagnosis, and prioritization *before* things spiral out of control. These modern EMS implementations resolve problems *before* the on-site staff personnel are even aware of a problem. Visibility can be provided to any on-site unit at any time but the EMS can also check up on the actual HVAC service calls. That is necessary because all too often a service tech will not fully resolve, or permanently resolve, a problem. If the above-site facilities' manager remotely sees a repair take effect, but then shortly thereafter sees the unit failing again, the cost of the repeat visit is the responsibility of the service company.

To meet the need of high visibility across various user types, these new EMS use dashboards, as opposed to text lines, cute icons, and end-less lists of data and alerts. The dashboard concept provides different dashboards tailored for different users. For example, executives can focus on the highest-level KPI trends for energy consumption, aggregate HVAC asset health, or excessive use of overrides. Finance and Accounting can get a handle on energy usage trends and savings. A procurement manager can see which district manager's sites are causing excessive energy consumption; the operations function can see where space temperatures deviate the most from the corporate standards; and the facility's staff can see where to spend the next maintenance dollar to get the most bang for the buck. For more formal reporting or ad hoc analysis, various on-demand queries, web reports, data filters, and sorting can extract useful information all the way down to the raw measurements from the on-site sensors and controllers if necessary.

As you might imagine, these EMS systems pay for themselves rather quickly with multiple value streams across the enterprise. They provide a hard cash-on-cash payback with the additional benefits to multiple corporate functions, without the negatives of costly proprietary client software, corporate IT overhead or highly specialized user training. The fully deployed, fully functional solutions typically provide a payback of less than two years, *just in energy savings*, with a forward ROI that exceeds 50% IRR.

An Operational Example

How do enterprise-class Energy Management Systems work to create value with fully functioning (as well as failed) HVACs in a real world example? Similar to other ASP-hosted information solutions, such as Google's Gmail or on-line banking applications, the real time "transactions" (thermostat controls and sensors in this HVAC example) occur autonomously at the site to maintain temperatures according to configurable strategies and schedules. Connectivity to the data center cloud-computing is not required to maintain normal revenue operations at each site, even including typical temporary overrides that the on-site staff require. However, a data center will collect and analyze the data. How much data? A typical commercial retail chain with 500 sites will have approximately 3,500,000 data and control points logged per day at 15 minute intervals. That's a lot of data, and those control points and physical conditions exist whether you deploy an EMS for management or not. There is no amount of human capital that could be deployed to watch this data stream. Even if the limited computing power on site could preprocess that data down to 1:1000 with simple alerting mechanisms, that is still 3,500 alerts per day! And the raw data that must be maintained in those systems at the site level is then not centrally available. Traditional EMS deployments that are focused on raw on-site data become hardware intensive. A negative Network Effect from excessive unstructured information flow often thwarts the scalability when these implementations exceed some level, typically around 50 sites, with potentially 350 alerts per day. When you review records in traditional EMS, that is why you find either thousands of unaddressed alerts (the alerting thresholds are so broad many real problems are missed), or alerts have mostly been turned off.

In our HVAC example, an unlimited number of users that are interested in HVAC performance are provided a dashboard of actionable information when performance (for an individual HVAC or in aggregate across many HVACs) is outside of the *best practice* rule sets, with the exceptions presenting highest priority first. Rule sets, scoring methods, and user presentation formats vary depending on the dashboard/user's intent. But given the cloud-computing capability, coupled with the hosted ASP model, they can be as sophisticated as necessary. Plus they can process as much data as is imaginable (scalability) and are subjected to continuous improvements that all users leverage. Performance trends and exceptions can be focused on the various short-term behaviors of HVACs, across time spans of days, weeks or months of data, and that can be cross-correlated against other HVACs at the site or across the client's zone, districts or regional boundaries. The dashboard is typically presented through intuitive graphs, graphics, clear messages, and even suggested next steps from the expert knowledge system running behind the scenes. This lets professionals focus on correcting the few highest priority items, proactively, yet never getting overwhelmed.

What would trigger an exception? Let's say for example that the retail space should be 72 degrees, but it is 75 degrees now, the highest retail space temperature in your region of interest. Why isn't the HVAC system cooling the space to the design temperature? Well, a "spot check" of that HVAC's discharge air and space temperatures won't tell you much. Nor will an indicator icon or light that says the HVAC fan is running right now. And for another matter, there are six HVACs serving the same common area with the HVAC in question. What you need is an analysis of how much above the set points are all the HVACs, and for how long. You also need to know the outside air temp and what else at that site is a possible related issue. If the HVAC has been running for an hour and the duct temperature never gets below 68 degrees (delta T across the evaporator is less than 75 – 68 = 7 degrees), then you have a clear problem. Or perhaps it was cooling (55F is the discharge supply temp) in the morning for an hour but then loses it and only puts out 68F. Maybe the coil is frozen up now?

But in our example, if the HVAC system has been running for just 15 minutes, and the duct air temp is 55 degrees, 75F space temp back near the stockroom is acceptable, explainable by, say, someone opening a loading dock door on a 100-degree day. Or all the other HVACs may have failed and are simply recycling the air, whereas this HVAC you're focused on is actually the only one cooling, efficiently giving it all it can. The point is, a temperature (discharge air or space) out of tolerance could be a non-issue or a real issue but it can only be deduced by going through a truly mind-boggling matrix of possibilities. Moreover, you have to ask: Is this the most important, highest-value site to be focusing your limited budgets on right now, or just this moment's snap shot of the highest space temperature?

An exception-based, prioritized dashboard EMS can provides a number of things. First, it can automate the enormous analytical tasks from the available data across all HVACs. Second, it can focus the user's attention on the highest-value opportunities through an intuitive dashboard. And third, it can provide hints and directions on how to quickly, efficiently, deal with issues. Rule sets can also create exceptions by looking for things such as how much a temperature is out of tolerance and for how long, and then correlate that with other exceptions associated with the most likely root causes. These (or even more complex data combinations), can get scored, sorted, and presented to the user with each update of new data.

Analytics Leverages Staff and Budgets

In many cases, there will be a need for a maintenance service call. But you have enough actionable information and real-time control to know that the maintenance work-order is worth the cost, and you're not sending a costly tech out to simply cycle a breaker. In fact, you can just click on a web link to *reset* the unit or turn it *off* for a few days or weeks as may be appropriate. What's more, the leading EMS out there will allow "live views" where managers can drill down and get instant readings (refreshed every 20 seconds) to do further highly detailed analysis or check on repairs. It is easy to find a failed or failing HVAC. One in three will show up with historical data showing that these failed HVACs have been running for months in that condition. But to get real value, you need to know as soon as possible – essentially the same day – which HVACs need attention first.

New generation Energy Management Systems deliver on the promise to reduce maintenance costs and overhead, wear-and-tear on equipment, and improve comfort at reduced costs. But they hold an equally bright future in reducing energy consumption. When you start aggregating the performance data – and have flexible centralized control of the energy consumption - at 500 or even 5,000 locations, you're affecting energy consumption at a scale that has truly national implications.

About the Author

Bob Bartmess is VP of Engineering for Site Controls. Site Controls is the nation's leading provider of enterprise-wide energy management and "above-site" facilities intelligence solutions. Site Controls systems processes more than 30 million pieces of data daily, approximately a 1 trillion per month, silently and efficiently, prioritizing HVACs exceptions with detailed

recommendations in understandable ways.
Learn more: www.SiteControls.com

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[1]*Small HVAC Problems and Potential Savings Reports, California Energy Commission, October 2003. Review of Recent Commercial Roof Top Unit Field Studies in the PNW and CA, New Building Institute, October 2004.*
