Building Oversight Management: REVISITED

A lot has happened since the author's 2008 article. It's prime time to revisit expectations for BAS and chiller optimization controls, and then have a look at several of today's options for anyone managing chilled water flow to wring the last drop of efficiency out of a system.

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According to most sources, buildings (commercial and residential) use around 40% of the total energy consumed in the U.S. (Figure 1). More than a quarter of that is for HVAC, with the largest share generally for cooling. In large buildings, which are usually more energy intensive than smaller ones, cooling is typically accomplished with chilled water. So it stands to reason that optimizing chiller plants for energy efficiency can significantly reduce a facility's overall energy consumption and reduce its greenhouse gas (GHG) emissions, making it more cost effective and more sustainable.

When I wrote about "Building Oversight Management" in 2008[1], two of the foundational premises for human intervention — that is, a manned process rather than an unattended, automatic operation — in the optimization of chiller control strategies were: (1) the fact that BAS or, as they're also sometimes referred to, building BMS or EMS, can be limited in their ability to trend large quantities of data points over a specified timeline; and, (2) the fact that there were no industry standards for the proprietary algorithms utilized by BAS with integrated optimization capabilities.[2]

The first issue is primarily a function of hardware limitations (e.g., processing speeds, bandwidth, and storage capacity), and the physical performance of these systems is continually improving with advances in technology.

The second issue is more complex since it involves legal and business issues (e.g., intellectual property rights and competitive advantages) and political issues (e.g., potential conflicts between various professional and standards promulgating organizations). Much has happened in the last three years, and this seemed like an appropriate time to revisit the subject.

It could also be inferred in the original article that there seemingly were no systems (then available) capable of the same level of optimization performance as that provided by an engineer's analytics in a manned "operations center." The fact that the previously discussed hardware limitations preclude the compilation of data unrelated to the primary control functions of the BAS and that some data points not required for those control functions — but which could be critical to an energy optimization scheme (e.g., electric power metering) — might be excluded, seemed to strongly imply the need for human oversight of the process.

Of course, a system based on analytics performed by engineers is not without its own problems. Personnel turnover can result in a lack of continuity, based on the anecdotal information acquired over time and rarely adequately recorded. And engineers can and do make errors in observations and judgment, so mistakes can and will still happen. In other applications, automation can often be superior to human intervention or operation, and with all of the advances in both hardware and — perhaps even more importantly — available software, algorithm-driven optimization solutions appear in many applications to be more than adequate to the task.

However, before we examine the available solutions, both auto-

Company	Product	Application	Basic Control Strategy
Smartcool	ESM™	DX, reverse-cycle and chillers	Based on a common and equal optimization algorithm for multiple compressors that allows all of the compressors to share load equally, thereby reducing energy consumption equally. The system interfaces with the chiller through the manufacturer's point of control means, and the manufacturer claims that there is no effect on conditioned space temperature or humidity. The compressor optimization is based on a dynamic adjustment of the length of each operating cycle in order to have the compressor run more often at a higher suction pressure, where its energy efficiency is the highest.
EES	Procos©	Chillers	An industrial PLC-based system (backward compatible) that is suitable for new or retrofit installations. Software is a combination of proprietary algorithms and standard code but is owner maintainable. The system makes thermodynamic decisions, with critical weighting on all variables, and provides automatic backup on all equipment. It provides optimized load differential pressure control, cooling tower optimization, heat recovery chiller control, and load shedding/demand control and is compatible with thermal storage systems.
Hartman Co.	Hartman LOOP	Chillers	Uses a custom "operating system" and variable-speed technologies to control loads in variable-speed chiller plants. They are referred to as "LOOP" technologies because when Hartman developed them, they relied on integrated closed loop controls for the entire plant. In other words, it integrated the operation of the chillers, pumps, and cooling towers to optimize the overall plant efficiency under varying load and climate conditions. Hartman also use LOOP to describe a variable primary chilled water distribution system as compared to a decoupled primary-secondary system. The results of network based flow control are shown in Fig. 2[3].
Siemens	Demand Flow™	Water-cooled centrifugal and screw-type chillers	This system is also algorithm-driven and requires VSDs on all of the pumps and cooling tower fan motors, but not necessarily on the chillers themselves. The manufacturer claims more redundancy by increasing the deliverable total tonnage of the chilled water plant, with an increase in total plant efficiency (reduction in overall kW/ton). This is accomplished by automatically optimizing and maintaining accurate temperature set points for both the chilled water and the condense water, and controlling pump and tower fan speeds to optimize energy consumption at any given plant load condition.

TABLE 1. A partial list of software-driven building management technologies.

matic and human-based, some basic system requirements should be established:

- Replacement control systems must be technology agnostic (i.e., brand neutral) with the existing HVAC equipment, such as chillers and add-on (to existing BAS) systems — including overlaid measurement and verification (M&V) metering/submetering — must also be compatible with the existing controls.
- Systems must be compatible with common open (non-proprietary) standard protocols such as BACnet® and LonWorks®.
- Systems must be capable of reducing energy consumption without sacrificing occupant safety or comfort, and without increasing maintenance costs.
- Systems must be optimizing total plant energy consumption and not shifting loads between subsystems or equipment.
- System displays/dashboards must be web-enabled for off-site viewing (not necessarily control, push only may be acceptable) using a standard internet web browser.

Commercially available algorithm-based chiller optimization controls cover a wide range of complex-

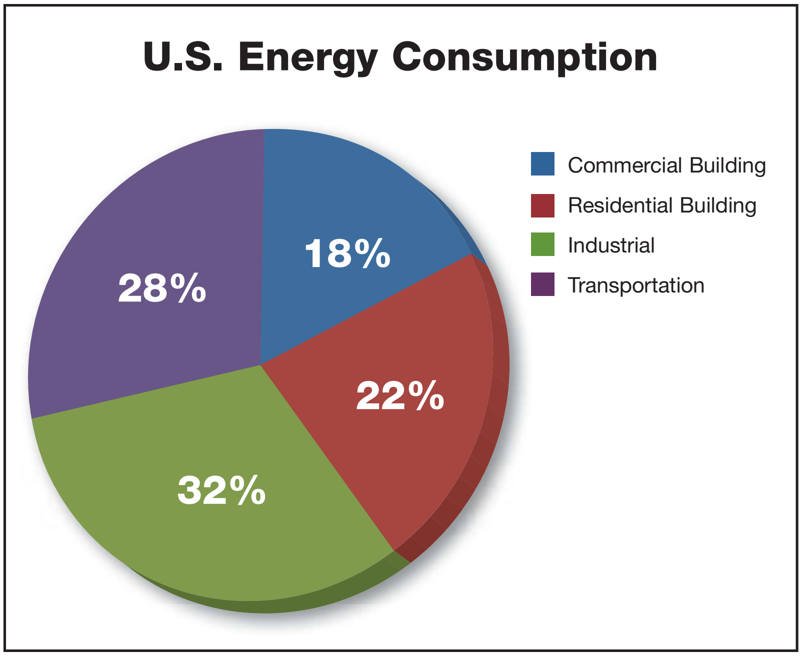

FIGURE 1. U.S. energy consumption by sector.

Company	Product	Application	Basic Control Strategy
UP&M II	utiliVisor	Chillers	A web-based, remote, (near) real-time solution that provides oversight, analysis, and reporting of chiller plant systems, and calculates total energy operating costs. It relies on engineers in a central operations center to recommend operating strategies to the facilities staff and provides no control functions on its own. It works with existing BAS through non-interfering interfaces that monitor, without disrupting, the operation of the equipment, controls or BAS. Using these "technology agnostic" interfaces, the system collects and formats data for delivery over the Internet; monitors for operations and equipment error states (alerts or alarms); provides nearly real-time oversight access via the Internet; and monitors overall systems performance.
Optimum Energy®	OptimumMVM	Chillers	This is a constant management service that uses their two software applications – OptimumLOOP (waterside optimization based on the Hartman LOOP described in Table 1.) and OptimumTRAV, an airside optimizer. The service includes real-time measurement, verification, and management by means of a web-enabled system, allowing energy use tracking operational energy efficiency optimization, identification and correction of system faults, and energy/ GHG emissions report generation. System data are converted into user-friendly graphical displays, and the manufacturer claims "persistent energy reductions."
EffTec®	EffTrack™	Chillers	This is also a "hybrid" solution, that is, a web-enabled analysis and trending tool that also provides for engineering technical support via phone or e-mail. It provides automatic, hourly, data collection and, depending on the existing BAS, may offer integration options. The systems foundation for its cost reporting and diagnostics is a proprietary calculated part load value (CPLV) program that uses design and other data to create a CPLV profile against which all chiller operating data are compared. The system claims to be capable of identifying heat transfer problems, such as poor refrigerant trim or fouling; optimizing the performance of chilled water setpoints, chiller sequencing and load balancing, cooling tower water management; and providing condition-based maintenance vs. scheduled preventive maintenance.

TABLE 2. A partial list of building oversight or "hybrid" management technologies.

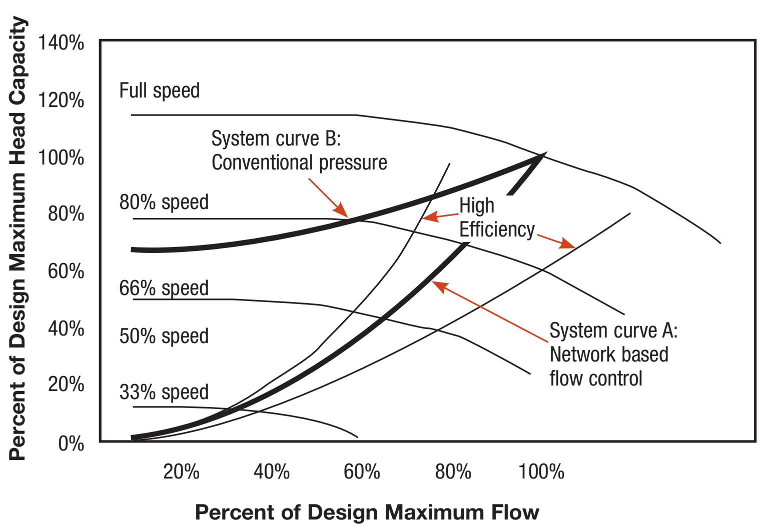

FIGURE 2. System curves for pressure- vs. network-based control for variable-speed centrifugal pumps, fans, or compressors.

ity. There are basic compressor runtime controllers, chilled water supply temperature control, condenser water temperature reset strategies, and very sophisticated adaptive control strategies that optimize not just the chiller but all of the pumps and cooling tower fan motors as well. The algorithms in these more advanced systems can mimic many of the functions of the engineer in the operations center.

Some of the software-driven technologies available today are shown in Table 1, and several so-called building oversight or "hybrid" solutions are listed in Table 2. Note that the use of company and/or brand names does not constitute an endorsement or the author's opinion as to its suitability for a specific application, and those products listed are intended only to be representative of the various available technologies and are certainly not all-inclusive. Control strategy descriptions are based on publicly available documents.

As can be seen from these examples, as the automatic control systems become more sophisticated they rely more heavily on controlling chilled water and condenser water flows throughout the plant. This tendency is further confirmed by the (commercial) pump industry's fastest-growing segment being the conversion of constant speed pump motors to variable speed[4], a trend that apparently resulted from the adoption of the first version of ASHRAE 90.1 in 1975[5].

As previously mentioned, the technologies and services described in Tables 1 and 2 are just the tip of the iceberg in terms of the wide

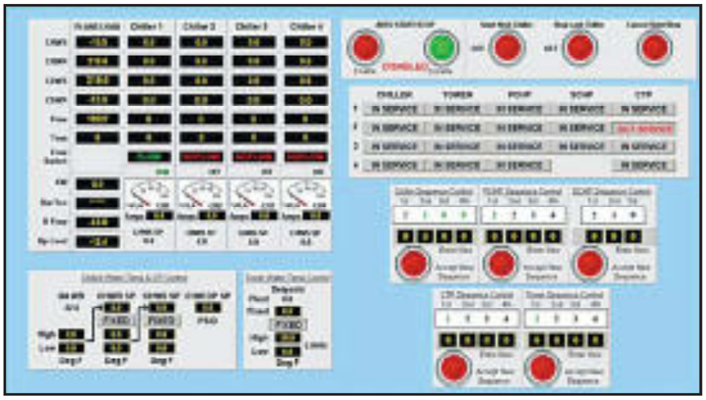

FIGURE 3. An example of a chiller plant optimizer control panel (courtesy of Engineered Energy Solutions Inc.)

array of chiller optimization solutions available today. Since chilled water systems represent such a significant portion of a building's total energy consumption, optimizing the performance of those plants results in significant cost avoidance and noteworthy reductions in GHG emissions. Depending upon the size of the plant and the solution provided, simple payback periods of two years or less may be possible, with a greener facility the result. **ES**

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