Optimizing Building HVAC through Data and Costs

Gregory Cmar & Bill Gnerre
Interval Data Systems, Inc.

1 Abstract

Most facilities personnel do not know what is really happening with their building operations. They can't because they see only a tiny fraction of the operational data that would give them real insights. Today, optimization happens at a component or sub-system level with little or no information on how the parts work together. Actual hourly operating cost data, and any ability to see how control changes, weather, occupancy, etc. affect costs is simply beyond most organizations.

This session will use case study data from a large hospital to show how the whole approach to operations can change if the facilities group has all the data available at all times. By collecting interval data from every point within the facility, they now have a data warehouse and platform to systematically address every aspect of the buildings' operations and constantly know their hourly operational costs.

We will show the underlying engineering models (built in Excel) used to calculate energy consumption, operational efficiency, and hourly costs. By connecting the models to the operational database a continuous history of data exists, providing engineers with the information needed for real optimization.

We will briefly show the tools that the hospital's facilities team has to perform diagnostics and monitoring of building operations. This includes monitoring cost data, space comfort levels, and the details of air handlers, VAV boxes, etc.

Finally, we will recap the optimization results achieved by the facilities group—improved comfort, staff time savings, priority changes, cost reductions, and the ability to measure and verify exactly how operational or control changes affect comfort and costs.

2 Introduction

A recent news story told how UPS is saving millions of dollars by reducing gas consumption of its delivery vehicles. They use data to analyze dispatch plans and optimize delivery routes and times, saving UPS almost 14 million gallons of fuel annually. It's the data that makes the improvements possible, and enables them to measure and verify results (such as reducing mileage by 100 million miles) as well. Mike Eskew, UPS's chairman and CEO commented, "At UPS, we're never satisfied with the status quo."

What does UPS's gas consumption have to do with your HVAC system? A lot. It's all about using the data to improve operations.

1. Both UPS and your facilities operations group are service businesses. Whether formally structured that way or not, facilities operations is a services business, and the more it is run like a business, the better it will perform.
2. Both strive to provide a high level of service (package delivery or building comfort) that consumes a substantial amount of energy to deliver.

3. Both have customers that take the service somewhat for granted, expect nearly perfect reliability, and give little thought to the costs incurred to make it happen.
4. Both employ technicians/mechanics to keep their equipment (delivery trucks or HVAC systems) running, and benefit if the personnel can work more efficiently and proactively leading to labor savings and extended equipment life.
5. Both can optimize performance using data and calculate detailed operational costs, but in all probability, UPS does a much better job of this than your facility.

Yes, there are some differences. UPS leverages their operational data to great benefit. Most facilities operations groups don't. Without the data, you're guessing, and optimization is not possible on any meaningful scale. Without the data, you're accepting the status quo.

This paper examines how to use operational and cost data to optimize HVAC performance. The examples use case study data from a large hospital in the southeastern U.S. The hospital has approximately 2,000,000 ft^2 of space, 5,700 tons of chilling capacity, and well over 100 air handlers. They started collecting operational data 18 months ago and the impact to operations has been substantial, to say the least.

3 HVAC Optimization—Disciplined Engineering or Random Chance?

There's a saying in this business that chiller plants are run by legend. Unfortunately there is a lot of truth to it. Instead of a disciplined engineering process, based on complete operational data, facilities rely on estimates based on a tiny data sample and educated guesswork.

Nowhere else are decisions with such a large financial impact based on so little information. Even small decisions get more thorough analysis. Imagine buying a computer only knowing the processor speed and hard drive size—it would be a crap shoot. You wouldn't make a $2,000 PC decision not knowing if the screen was large enough to be readable, if there was enough memory to handle your workload or just enough to boot the operating system, if it came with an operating system at all, or even if it were a laptop or desktop. But facilities groups make decisions with 100 times the financial consequences of buying the wrong PC every day as part of standard operating procedure.

It doesn't have to be left to random chance. You can put the engineering back into your operations and make informed decisions based on a complete set of facts. You do it with data.

3.1 All the Data, All the Time

Here's a thing about data—having some of it isn't really that valuable—you need it all. It takes a complete view of operational data, collected from every source, at standard intervals, and saved indefinitely in a centralized data warehouse.

The data warehouse itself becomes a valuable asset—an asset of your assets. Mechanical and electrical systems typically account for 15 – 20% of the value of the buildings, but little or no record is kept about operations. The data asset serves management, internal staff, and external contractors, providing operational facts and information to validate work performed.

A building automation system (BAS) will contain thousands of monitoring and control points (over 100,000 for larger campuses). You need them all. The hospital is collecting data from about 18,000 points within its Johnson Controls system. Ideally, you want data not just from the BAS (although it's a better place to start than meters), but from every data source:

- Building automation systems (all of them if you have more than one)
- Advanced meter systems
- Manually read meters
- Utility interval data
- Utility billing data (including all rate information)
- Weather (from local airport as BAS weather sensors are often faulty)

The hospital collects each point at standard 15 minute time intervals to enable synchronized views, for example, showing chilled water supply temperature, air handler discharge air temperature, and outside wetbulb at the same time. Saving the data indefinitely (for the life of the equipment, 20 years or so) allows the review of past operations and provides a historical record of all the equipment in the facility.

To collect and manage all the data, all the time, requires an enterprise-class data warehouse platform. The hospital uses Microsoft SQL Server as the underlying database technology. Lower-end options, such as desktop databases, are simply not capable of handling the volume of operational data. It is only when you have all the data that you are able to truly optimize your HVAC systems.

3.2 True Optimization Requires a System-Wide Perspective

All parts of the HVAC systems are connected and interdependent. That is everything from the chiller and boiler plants, through the distribution loops, and into the buildings. Control decisions in the plant can affect building operations, and VAV box operations can have an impact all the way back to the chillers. Prior to getting on the path of using data, the hospital operated like most facilities departments, optimizing individual components with little knowledge or consideration of the broader system consequences.

You haven't optimized anything if the changes to make the chillers run more efficiently cause the cooling towers to substantially increase energy consumption. You need a system-wide view of how everything operates, and how changes affect all parts of the system. The hospital's facilities director recognized that they needed a unified measurement mechanism to evaluate scenarios such as an improvement in chiller operations that might have a negative affect on the cooling tower or secondary pumps. That unifying measurement is cost—cost per hour and cost per ton-hour.

4 It's 3:30PM—Do You Know Your Current Operating Costs?

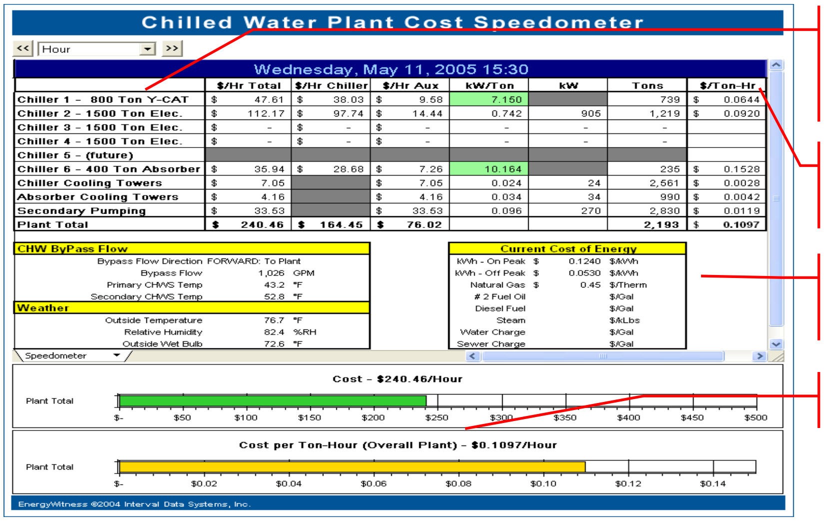
In order to optimize systems based on cost, you first have to know what the hourly operating costs are at any given moment in time. Assessing costs based on monthly utility bills is useless as an optimization tool as the cost data is too general and not even close to current.

The hospital uses the operational data as the basis to perform a series of engineering calculations, ultimately leading to cost per hour and cost per ton-hour performance measurements. The costs are calculated every 15 minutes, using time-appropriate (on- or off-peak) utility rates, providing them with an accurate picture of operating costs at any point in time. The hospital knows their operating costs at 3:30PM, or any other time during the past year.

This is not possible with meter data, trend logs, or utility data alone. Without all of the underlying BAS data, tariff information, and a platform that enables the engineering calculations, it is not possible to tie costs to operations in this manner.

4.1 Measure Just how Fast You're Spending Money

The hospital has an operating cost speedometer that shows the current hourly operating costs. It provides staff with an instant snapshot of performance, in this case for their chilled water plant. You can see each major sub-system within the chiller plant and operating costs for each on both a dollars/hour and dollars/ton-hour basis. The central portion of the display shows information about the current state of the chilled water bypass, weather, and energy costs. The bottom of the display shows overall plant costs as speedometer gauges. This gives the hospital's operations staff a central place to quickly see primary indicators—operating cost facts—for the entire chiller plant.



Chilled Water Plant Cost Speedometer

Wednesday, May 11, 2005 15:30

	$/Hr Total	$/Hr Chiller	$/Hr Aux	kW/Ton	kW	Tons	$/Ton-Hr
Chiller 1 – 800 Ton Y-CAT	$ 47.61	$ 38.03	$ 9.58	7.150		739	$ 0.0644
Chiller 2 – 1500 Ton Elec.	$ 112.17	$ 97.74	$ 14.44	0.742	905	1,219	$ 0.0920
Chiller 3 – 1500 Ton Elec.	$ -	$ -	$ -	-	-	-	
Chiller 4 – 1500 Ton Elec.	$ -	$ -	$ -	-	-	-	
Chiller 5 – (future)							
Chiller 6 – 400 Ton Absorber	$ 35.94	$ 28.68	$ 7.26	10.164		235	$ 0.1528
Chiller Cooling Towers	$ 7.05		$ 7.05	0.024	24	2,561	$ 0.0028
Absorber Cooling Towers	$ 4.16		$ 4.16	0.034	34	990	$ 0.0042
Secondary Pumping	$ 33.53		$ 33.53	0.096	270	2,830	$ 0.0119
Plant Total	**$ 240.46**	**$ 164.45**	**$ 76.02**			**2,193**	$ **0.1097**

CHW ByPass Flow		
Bypass Flow Direction	FORWARD: To Plant	
Bypass Flow	1,026	GPM
Primary CHWS Temp	43.2	°F
Secondary CHWS Temp	52.8	°F
Weather		
Outside Temperature	76.7	°F
Relative Humidity	82.4	%RH
Outside Wet Bulb	72.6	°F

Current Cost of Energy			
kWh - On Peak	$	0.1240	$/kWh
kWh - Off Peak	$	0.0530	$/kWh
Natural Gas	$	0.45	$/Therm
# 2 Fuel Oil			$/Gal
Diesel Fuel			$/Gal
Steam			$/kLbs
Water Charge			$/Gal
Sewer Charge			$/Gal

Cost – $240.46/Hour

Cost per Ton-Hour (Overall Plant) – $0.1097/Hour

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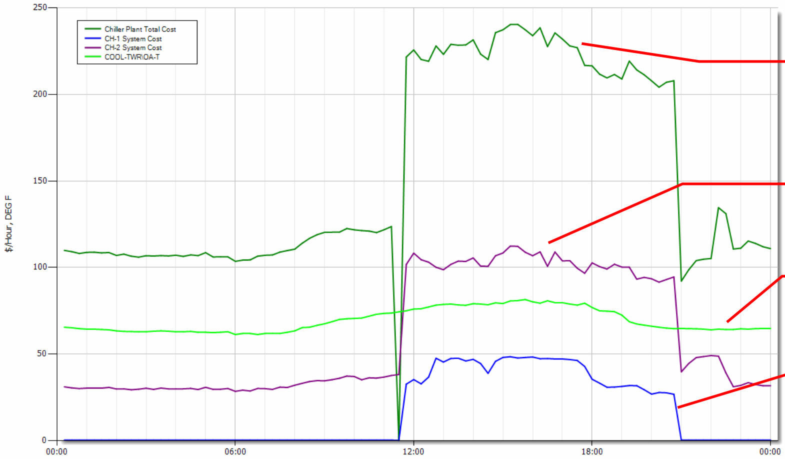
Each major system is broken out to easily see the individual chillers, cooling towers, and secondary pumping as well as the plant total.

Snapshot data includes cost/hour (total, chiller, & auxiliary), kW, tons, kW/ton, and cost/ton-hour.

A few operational and cost parameters are shown, such as bypass flow, weather, and energy rates.

Gauges show total cost/hour and cost/ton-hour for the overall plant.

In addition to the speedometer's point-in-time summary, the hospital also monitors how hourly operating costs change over time. The chart below shows the changing cost/hour for the chiller plant and some of its components over the course of a day. The large rise from late morning into the evening is the result of higher on-peak electric rates. It's during this time that they run their gas chiller, as its operating cost is lower during the on-peak period. The data confirms its lower operational cost—about 1/3 lower cost per ton-hour.



Total chiller plant operating cost ranged from $110/hr to $240/hr on this particular day in May.

Chiller #2 (1500 ton electric) operating costs shows the on/off-peak difference.

Outside air temperature is included for reference.

Chiller #1 (800 ton gas) is used just during peak electric hours.

4.2 The Calculations Behind the Costs

Any good engineer might want to know where the cost numbers come from. They come from the actual operational data and a set of engineering calculations based on that data. The process for the hospital was to model the plant, identifying each energy-consuming component (chillers, pumps, motors, etc.). The model encompasses four chillers, an absorber, cooling towers for the chillers and absorber, and secondary loop pumps. (The model for the boiler plant is in progress.)

The table below shows the model for calculating the total energy consumption for one of the hospital's York electric chillers. Their JCI system is the data source for most of the factors within the equations. They measure each component's energy usage separately, and convert to kW where necessary for cost calculations. In all, there are 164 engineering calculations, each saved in the data warehouse, which are applied at every 15 minute interval to calculate costs.

Equipment	Calculation	Formula	Data Source
Chiller	Chiller Efficiency (%)	$\frac{\text{Evaporator BTU output}}{\text{Condenser BTU input + Drive Motor Energy}}$	Results of equations below
Chiller	Evaporator BTU output (BTU)	CHW Flow * CHW ΔT * Conversion factor	JCI: CHS-Flow, CHWS-T, CHWR-T; Conversion to BTU
Chiller	Condenser BTU input (BTU)	CW Flow * CW ΔT * Conversion factor	JCI: CWR-Flow, CWS-T, CWR-T; Conversion to BTU
Chiller Drive Motor	Drive Motor Energy input (BTU)	Motor kW * Conversion factor	JCI: CH-kW.Power; Conversion: 3412 BTU/kW
Chilled Water Pump	Motor Brake Horsepower (BHP)	$\frac{\text{CHW Flow * Differential Pump Pressure}}{\text{Mass Flow * Mech Eff \%}}$	JCI: CHS-Flow; Constants: 20 lbs DPP, 60% mech eff; 1714 lbs GPM/HP
Chilled Water Pump	BHP to kW conversion	CHW Pump BHP * Conversion factor	Conversion: 0.746 kW/HP
Condenser Water Pump	Motor Brake Horsepower (BHP)	$\frac{\text{CW Flow * Differential Pump Pressure}}{\text{Mass Flow * Mech Eff \%}}$	JCI: CWR-Flow; Constants: 20 lbs DPP, 60% mech eff; 1714 lbs GPM/HP
Condenser Water Pump	BHP to kW conversion	CW Pump BHP * Conversion factor	Conversion: 0.746 kW/HP

4.3 We Have Operational and Hourly Cost Data—Now What?

Now you change the entire way you run the facility. You have the data to test, measure, and verify everything you do. You can validate the work of internal staff, design engineers, commissioning agents, performance contractors, and hold them accountable. You can change the rules of engagement with your CFO by arriving with facts instead of estimates. You can improve the level of service the operations group provides and increase credibility across your organization.

But this is a paper about optimizing HVAC systems, so let's focus there. At this point the hospital is using cost data and the cost speedometer in a couple of ways:

- *High-level performance indicator:* By monitoring the cost to run the plant, they can easily see sudden changes and inconsistencies. These could represent changes in load within the buildings or plant operational issues. Either way, with all the data literally at their fingertips, diagnosing any anomalies is easily done.
- *Test operational strategies:* Whenever there is an idea for improving operations of any part of the HVAC system, the staff can make control changes and know within minutes if the change is having the desired affect, and if there are any side effects elsewhere in the system. It doesn't help to reduce chiller cost by $14/hour if the change increases costs $7/hour elsewhere and introduces instability throughout the system.

Using the detailed operational data and the cost calculations it is now possible to improve comfort (and verify it), systematically optimize the system, and reduce energy consumption (verify that too), all at the same time.

5 Don't Optimize Your HVAC Equipment

What? Isn't that the whole point of this paper? Optimize your HVAC *system*. Optimize *operating costs*. But to optimize individual pieces of equipment with the expectation that the total will equal the sum of the parts—well, that's just an operational nightmare waiting to happen.

At too many facilities, organizational decisions replaced engineering ones. The staff responsible for the building systems and the central plant staff are separate, with little interaction. The result is that no one takes a system-wide view of optimization. Fingers get pointed. The facility will never reach the levels of optimization possible, guaranteed. These organizations seemingly refuse to acknowledge a simple fact—the buildings and the plant are connected. They interact and compensate for one another. If you have any doubts, the data will prove it.

5.1 Optimizing the Integrated System

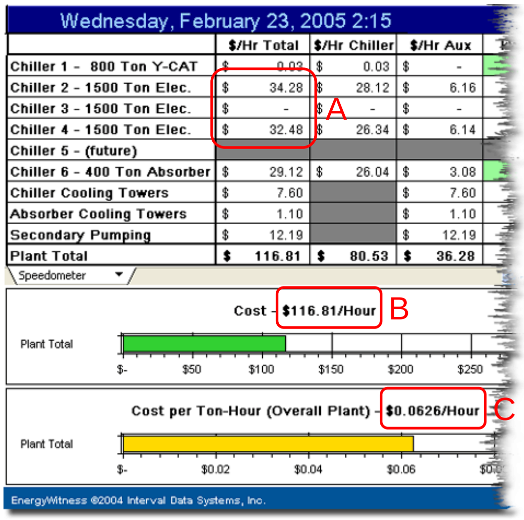
The next few pages show the interaction between the hospital's chiller plant and buildings. A problem with air handlers and VAV boxes was first noticed because of unexpected changes in chiller plant costs when a control change was made. A couple of interesting points before we start:

1. It took just three hours of diagnostic effort to identify that problems existed, track them throughout the facility, measure the cost impact, find the true root cause, and come up with recommendations.
2. The whole effort happened without leaving the office—never even stepped foot on campus.
3. Numbers 1 and 2 were only possible because the data existed and was easily accessible.

Note: there is a more thorough examination of this analysis in *Diagnosing Complex System Interactions (from 1,000 miles away)*, a paper presented at the 2005 National Conference on Building Commissioning. See references for details.

5.1.1 Costs Provided the Clues

During the winter months the hospital wanted to reduce its chiller costs. After all, nighttime temperatures were in the 60s and occupancy was lower. It seemed reasonable that one 1,500 ton chiller could handle the building load instead of the two they were running. The figure below shows the hospital running with two chillers one night (left) and then 24 hours later running only one chiller (right). Weather and occupancy conditions were nearly identical. But instead of reducing costs by the amount of one chiller (≈ $33/hour), something very different happened.

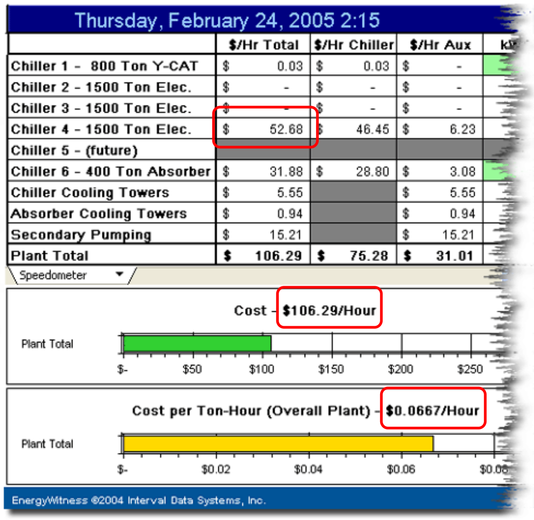


Wednesday, February 23, 2005 2:15

	$/Hr Total	$/Hr Chiller	$/Hr Aux
Chiller 1 - 800 Ton Y-CAT	$ 0.03	$ 0.03	$ -
Chiller 2 - 1500 Ton Elec.	$ 34.28	$ 28.12	$ 6.16
Chiller 3 - 1500 Ton Elec.	$ -	$ -	$ -
Chiller 4 - 1500 Ton Elec.	$ 32.48	$ 26.34	$ 6.14
Chiller 5 - (future)			
Chiller 6 - 400 Ton Absorber	$ 29.12	$ 26.04	$ 3.08
Chiller Cooling Towers	$ 7.60		$ 7.60
Absorber Cooling Towers	$ 1.10		$ 1.10
Secondary Pumping	$ 12.19		$ 12.19
Plant Total	**$ 116.81**	**$ 80.53**	**$ 36.28**

Cost - $116.81/Hour

Cost per Ton-Hour (Overall Plant) - $0.0626/Hour



Thursday, February 24, 2005 2:15

	$/Hr Total	$/Hr Chiller	$/Hr Aux
Chiller 1 - 800 Ton Y-CAT	$ 0.03	$ 0.03	$ -
Chiller 2 - 1500 Ton Elec.	$ -	$ -	$ -
Chiller 3 - 1500 Ton Elec.	$ -	$ -	$ -
Chiller 4 - 1500 Ton Elec.	$ 52.68	$ 46.45	$ 6.23
Chiller 5 - (future)			
Chiller 6 - 400 Ton Absorber	$ 31.88	$ 28.80	$ 3.08
Chiller Cooling Towers	$ 5.55		$ 5.55
Absorber Cooling Towers	$ 0.94		$ 0.94
Secondary Pumping	$ 15.21		$ 15.21
Plant Total	**$ 106.29**	**$ 75.28**	**$ 31.01**

Cost - $106.29/Hour

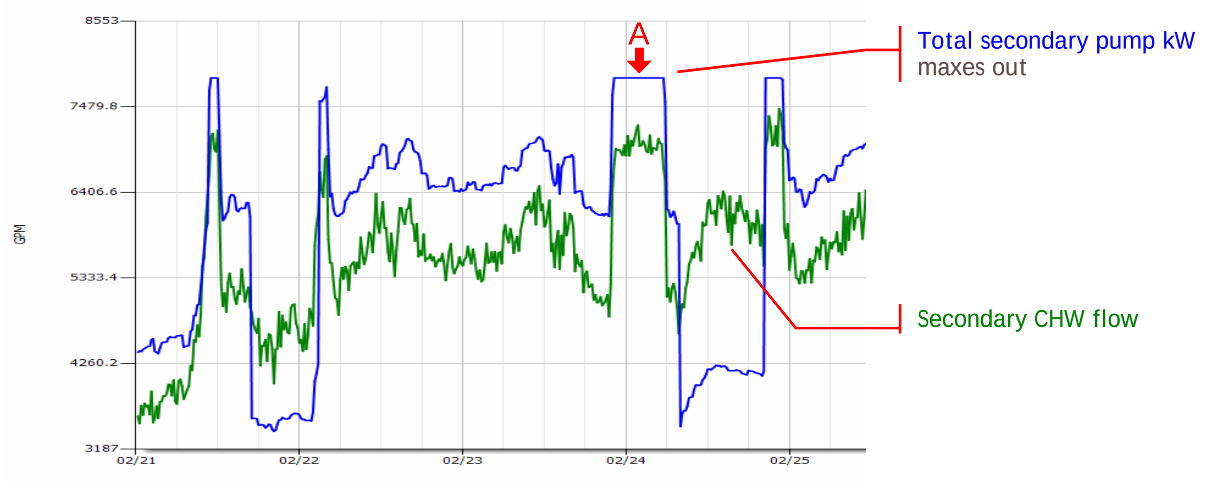
Cost per Ton-Hour (Overall Plant) - $0.0667/Hour

The cost to run chillers 2 and 4 only reduced from $66/hr to $52/hr (A). The cost to run the whole plant didn't even drop that much, decreasing by only $10/hr (B), and on a ton-hour basis the cost increased 7% (C). Looking further, we see that in addition to the big jump in chiller 4's cost, the absorber cost increased, offsetting the reductions in the cooling towers, and the secondary pumping cost increased 25%. Not the results expected, but plenty of clues to find out why.

5.1.2 Distribution Loop Can't Keep Up with Demand

When chiller 2 was turned off, there was the drop in the primary loop flow that one would expect. However the secondary flow jumped, and to compensate for the lower primary flow, the bypass direction reversed and its flow increased to meet the demands of the secondary system.

The secondary pumps completely max out when running only one chiller (A), as they attempt to respond to the cooling demands of the buildings. This condition repeats itself each day.

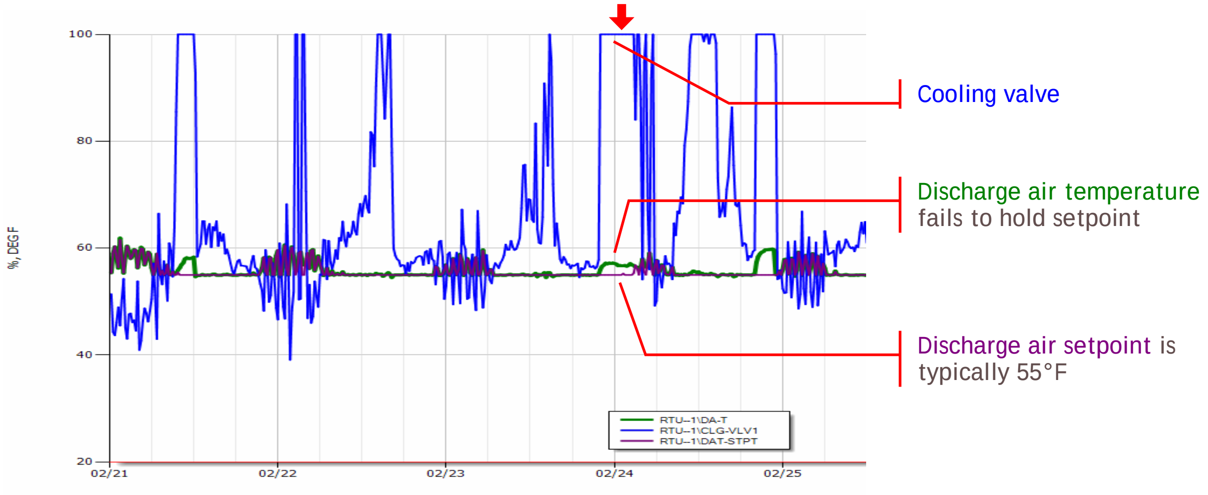


Total secondary pump kW maxes out

Secondary CHW flow

5.1.3 Discovering the Source of the Cooling Demand

This much demand on the chiller plant would suggest that the air handlers are calling for a lot of cooling. Indeed, as we can see below, the AHU cooling valve is 100% open at the time, because the discharge air temperature is not meeting its 55°F setpoint. This explains the demand on the secondary pumps, but why isn't the AHU meeting setpoint?



Cooling valve

Discharge air temperature fails to hold setpoint

Discharge air setpoint is typically 55°F

The answer to that question goes back to the distribution loops. Earlier we noted that the bypass direction reversed and its flow increased in order to feed the secondary loop. That meant warmer return water mixed with chiller 4's output, raising the temperature of the secondary loop supply by 5 – 8°F.

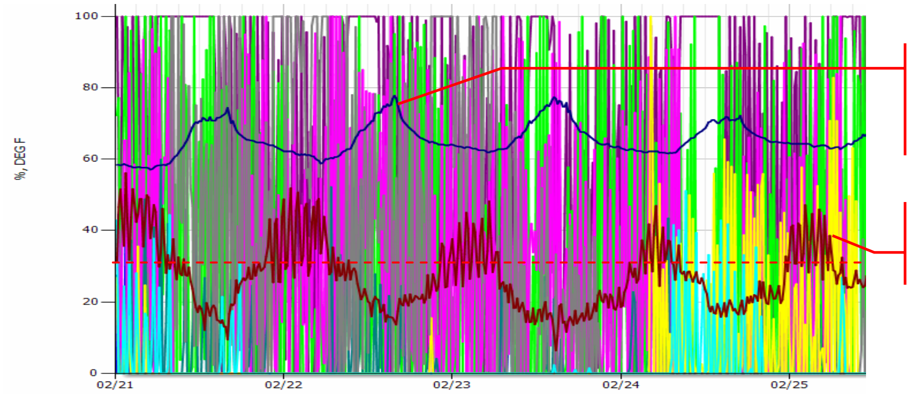
Now we've gone in a complete circle. The net $10/hr savings within the chiller plant from turning off a chiller introduced a lot of system instability. Turning it off caused the secondary supply water to warm up because of the return water mix, which caused the DA temperature to not maintain setpoint, which caused the cooling valve to open wide, demanding even more cooling from the plant. There are only two questions left to answer: in the chart above, what causes the spiky sections in the DA setpoint; and what is causing this much load in the first place given that the nighttime temperatures are in the low 60s?

5.1.4 The Real Problem

When the VAV boxes attached to this air handler were examined, on the surface they appeared to be working fine. In most cases the air flow and zone temperatures were within the desired ranges.

It isn't until you look at the VAV reheat that you start to see what is happening. The VAV discharge air temperatures are all over the place, spiking wildly in most of the boxes. One therefore expects the heating coil dampers to be opening and closing. The chart below shows the heating coil position for ten of the VAV boxes on this AHU (the other 14 VAVs behave similarly). Yes, this chart is a mess, but it does answer our questions if you focus on the right things. The mass of colored lines are the heating coils opening and closing. The fact that they are mostly vertical indicates that there are significant changes in position every 15 minutes.

The blue line across the top is the outside air temperature. It might be reasonable for a small amount of reheat to occur at night, but the thrashing and reheat occurring when temperatures are in the upper 70s is clearly bad news.



A lot of reheat occurring, in some cases even mid-day when outside air temperature is approaching 80°F

Reheat valve average is used to set AHU DA setpoint whenever it exceeds 30%

The red line across the bottom is the average reheat valve position for all 24 VAV boxes. The spikes here correspond to the spikiness of the AHU DA setpoint. It turns out that the control for that setpoint would increase it from its standard 55°F based on the average heating valve position whenever that average exceeded 30% (shown by the dotted red line).

The AHU, at 55°F, is too low for winter nights. This set up a loop, cooling air in the AHU so the VAV could heat it again. That warm air coming back through the AHU return needed to be cooled yet again, causing the load that the chiller plant needed to respond to. To state the obvious, cooling and heating air at the same time wastes a lot of energy.

The hospital has excellent engineers and technicians on staff, but did not discover this situation that had been occurring since at least the start of the cooler winter weather. The moral of our story is that even the best facilities staff cannot find and correct complex, interdependent operational issues without the data.

5.1.5 Implementing the Solution and Measuring the Savings

The AHU and VAV boxes needed rebalancing based on actual needs for operating the space properly (as opposed to original design specs). Balancing is an iterative process—make changes, re-examine the data, make more changes as necessary, etc.

The hospital changed the control program on the AHU's discharge air setpoint to stop using the average reheat setting. They employed a simpler approach based on outside air temperature and a higher baseline setpoint. We monitored the affected spaces and also adjusted air flow settings for several of the VAV boxes.

It's worth noting that this whole scenario and strategy is based on winter conditions. The summer will bring a new set of circumstances and needs, which the data will make clear when it happens.

The results of the optimization didn't change space comfort notably, which is fine as it was never an issue. It did, however, have a significant impact on the operating costs.

Temp Range	Differential DA Temp	Hours at Temp	Delta Enthalpy	Avg Tons Saved	Cooling Savings	Heating Savings	Fan Savings	Total Savings
45 - 50°F	4.64°F	314	1.13	967	$70	$80	$17	$172
50 - 55°F	4.74°F	371	1.15	1,170	$90	$97	$20	$208
55 - 60°F	3.55°F	617	0.86	1,457	$113	$121	$33	$267
60 - 65°F	2.54°F	854	0.62	1,442	$112	$119	$46	$277
65 - 70°F	2.29°F	1,005	0.56	1,531	$118	$127	$54	$300
Totals		**3,160**		**6,567**	**$ 508**	**$ 544**	**$171**	**$1,223**

Total system operating cost: $6612 **Percent reduction: 18.5%**

All of the adjustments made were within the buildings, to the air handler unit and the VAV boxes. Yet as you can see from the chart above, the majority of the savings are realized in the central plant, with approximately equal portions coming from cooling and heating savings. While much of the optimization work happens in the buildings, most of the dollar savings occurs in the plant.

5.2 Repeat the Process 115 More Times

That optimization did a lot to improve operations and lower costs for the air handler. In the big scheme of things, it is only a start at reducing the hospital load enough so that next winter they could indeed run with just one chiller. Another 115 air handlers need optimization as well.

The implementation of the changes to the rest of the AHUs is still underway as this paper is being written. However, the hospital's facilities director and staff have a plan in place to prioritize and systematically address each one. The director suspected that issues existed for some time, but prior to this analysis didn't have the evidence and facts to put an action plan into place.

Using the data we were able to evaluate every AHU, determine if space comfort requirements were being met, analyze the operations (whether meeting comfort levels or not), and make recommendations where needed. The plan exists because the data exists.

Over one third of the 115 air handlers had issues. A partial list includes:

- AHU discharge air temperature is 50°F but cooling valve is closed.
- AHU discharge air temperature setpoint is 50°F. Cooling valve at 100% all the time
- Discharge air temperature resets to 49°F based on humidity, but humidity rises because space is over-cooled.
- Unit provides 51°F discharge air temperature, but not making return air temp setpoint.
- Unit is not making discharge air temperature. Outside air pre-cooling has capacity.
- Unit is not making pre-cooling temperature, but is making discharge air temp. Pre-cooling valve is 100% open.
- Unit is not making return air temperature, set at 72°F, despite cooling valve @100%.
- Cooling valve is locked at 20% open and space is below setpoint.
- Zone temperature is 68°F but cooling valve is closed.

Oh, did I forget to mention, one diagnostician did the entire analysis and report in less than three (count 'em, 3) days.

6 Conclusions

Data collection is not a waste of time, but represents a lot of time wasted. Let me explain. Collecting data and having it at your fingertips is invaluable. The optimization discussion in this paper is only the tip of the iceberg in terms of what you can accomplish with data. However, in most facilities today, data collection consumes a huge amount of time by senior staff, a situation that is either not realized or accepted as “part of the job.” Conservatively speaking, an engineer is likely to spend 5 – 8 times as long collecting data as doing real engineering analysis. Think of the value your organization would realize if the data collection to analysis ratio were reversed.

Today’s HVAC systems are complex and the components are highly interdependent. The self-compensating control logic often masks problems so they go unnoticed or show up as symptoms in an entirely different part of the facility. A complete view of the data from the plant all the way to the terminal boxes, which can track and show the interdependencies, is the only way to effectively manage and diagnose these systems. The artificial walls that organizations create separating the plant from the buildings, or operations from utilities, are worse than counterproductive, they impede the facilities from operating at peak efficiency.

Operational and cost data are the cornerstones to getting a complete understanding of how your facilities operate. It provides you with the engineering facts to establish a systematic plan to make real progress. And once you look at the data, you will want to establish a new plan—any that you had before will be tossed once you actually see what is going on. Data creates a different world for operations that completely changes what you can do and how long it takes.

Or, as Yoda might say, “The answers you seek, in the data they are.”

7 References

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8 About the Authors

Gregory Cmar
CTO and Cofounder
Interval Data Systems, Inc.
greg@intdatsys.com

Greg is an expert on energy systems and how to manage them using interval data. He has 30 years of experience in facility operations, energy conservation, energy analytics, energy auditing, monitoring and control systems, and utility billing, as well as database, application and automation technologies. Greg leads IDS's product definition and development efforts as well as the energy management services team.

Prior to IDS, Greg was a cofounder and director of engineering at ForPower, an energy conservation consulting firm; engineering manager at Coneco, an energy services company and subsidiary of Boston Edison; vice president of Enertech Systems, an energy monitoring and control systems contractor; and held various roles at Johnson Controls, the Massachusetts Energy Office, and Honeywell.

Greg holds patent #5,566,084 for the process for identifying patterns of electric energy, effects of proposed changes, and implementing such changes in the facility to conserve energy.

Bill Gnerre
CEO and Cofounder
Interval Data Systems, Inc.
bill@intdatsys.com

Bill has twenty-plus years of technology entrepreneurial experience, with an exemplary record of bringing enterprise software applications to market and dealing with user adoption of new technology.

His previous roles include being a vice president at Circadian Software, an energy information software company; cofounder of ChannelWave Software, a partner relationship management systems provider; director of sales & marketing at Wright Strategies, an early PDA data collection application vendor; and product marketing roles at Formtech and Computervision, both vendors of CAD technologies. Earlier in his career Bill worked in various engineering positions and holds a degree in mechanical engineering from Northeastern University.