OpenData

CASE STUDY: COOLING & CHILLED WATER EFFICIENCY PROJECT

Part of the Measurement Series™, by Modius

In this case study, Modius examines how its OpenData Data Center Infrastructure Management (DCIM) system allowed our client, a large West Coast tech company, to simultaneously improve the energy efficiency and reliability of its data center facility.

The company used OpenData to monitor, measure and correct imbalances in cooling airflow distribution, which were preventing specific areas in the data center from receiving adequate cooling. By correcting these airflow problems, the company generated a number of benefits, including:

1: eliminating dangerous "hot spots" that prevented IT infrastructure from operating at the optimal temperature,
2: creating supplemental cooling capacity to provide extra redundancy in case of failover, and
3: reducing the chiller's energy consumption approximately 26% by raising the set point temperature in the chilled water loop.

OpenData allowed the company's personnel to easily collect detailed operational-level data across multiple sub-systems, including CRAC (Computer Room Air Conditioner) units, environmental sensors, and the chiller unit. This broad data capture allowed the company to generate a holistic picture of their data center operations, enabling company personnel not only to adjust the devices with confidence because they were tracking day-to-day and hour-to-hour trends, but also to better coordinate across the sub-systems and achieve maximum efficiency.

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I. CASE INTRODUCTION

In this case study, the company uses OpenData, Modius' data collection system, to detect "hot spots" in its data center and optimize the performance of its cooling system. This optimization required collecting measurements from a broad variety of devices and sub-systems in order to capture a holistic view of cooling system performance, including CRACs, chillers, environmental sensors, and other devices. This effort has been an ongoing initiative that the company's personnel have been conducting for several years.

The company's data center had more cooling capacity than it needed, but poor airflow had resulted in "hot spots" in the data center. Cold air was not getting to the right places, so some servers were over-cooled while others were barely kept within their desirable temperature limits. By improving airflow, the company was able to better cool its servers while actually reducing the total work required by the chiller. This optimization allowed the company to raise the temperature set point on the chilled water loop and therefore realize substantial energy savings.

RETURN ON INVESTMENT

Rebalancing the airflow under the raised floor and the subsequent changes in water temperature could not have been done without the OpenData telemetry system to collect continuous measurements. Over the entire project, the company was able to raise the temperature set point on the chiller by 9°F, while simultaneously delivering better cooling to critical IT equipment.

Using energy consumption data adjusted for server growth, the authors found a 26% reduction in chiller energy consumption as a result of the project. This improvement translated to approximately $50,000 to $90,000 in annual energy costs for the company, depending on the price of electricity and other factors. These results were achieved through various incremental cooling improvements made over an extended period of time. This case study focuses on the month of September, during which the company made some specific air flow adjustments and increased the chilled water temperature set point by 2°F and saved a calculated $11,500.

ABOUT THE MEASUREMENT SERIES

This case study is part of Modius' Measurement Series, which examines the benefits of data center systems that provide detailed monitoring and trending of performance information. This case study was produced with the generous cooperation of our client, whose experience using Modius' OpenData system in its data center has been very valuable. The information in the case study comes from interviews with their data center personnel, and data collected from the OpenData software.

The company's data center houses about 1,800 servers in 16,000 square feet of raised floor area. The data center runs continuously 24 hours a day, 7 days a week, 365 days a year. The data center is part of a much larger office building of approximately 220,000 square feet. The data center space is separately metered for electricity, and it has dedicated chillers serving only the data center and some negligible laboratory area.[1]

1) Lab space can be very energy intensive, but the company's lab space requires only about 12 tons of cooling from the 240-ton chiller. Therefore, this case study ignores the lab's effect on data center cooling.

II. CLIENT SYSTEM SET-UP

The company's data center has 20 CRAC units distributed around its raised floor area. These units are fed by a common chilled water loop, with water supplied by a 240-ton centrifugal chiller. Each CRAC unit has a temperature sensor and can adjust itself to deliver more or less cooling as needed. This adjustment is done by valves controlled by the CRAC's internal logic, which determine how much chilled water passes through the unit's coils. When a CRAC unit detects return air that is too hot, it opens the valve wider (up to some maximum) in order to get more chilled water. If a CRAC's return air is already cool enough, it reduces the valve opening and uses less water from the loop.

CRACs deliver their cold air into a plenum beneath the raised floor. Perforated tiles allow this cold air to come out near the racks of computers that need to be cooled. These tiles are movable, so it's possible to take perforated tiles away from server racks that don't need much cooling (replacing them with non-perforated tiles), or conversely to place perforated tiles near racks that are too hot.

A CRAC's water valve position provides a rough indication of how hard a CRAC is working to cool its particular area. A CRAC with a 100% open chilled water valve is delivering as much cooling as it possibly can, while a CRAC with a 10% open chilled water valve is hardly running at all. Since a CRAC's chilled water valve has a maximum flow rate (volume of water per second), the temperature of the chilled water in the loop affects the maximum amount of cooling a CRAC can deliver when it's working its hardest. Colder water allows a CRAC to deliver more cooling, but also forces the chiller supplying the water to work harder and consume more electricity. Importantly, raising the chilled water temperature reduces the power consumed by the chiller.

By looking at the percentage open measurements on the valves from the 20 CRACs, The company's data center personnel discovered hot and cold spots in the computer area. Some CRACs located in cold spots were barely delivering any cooling at all, while other units were operating close to their maximum water flow rate just to keep the area from overheating. The underlying inefficiency problem was caused by the fact that the hottest spots in the data center drove the chilled water temperature for the entire system. If some CRACs were already drawing as much water as they could, raising chilled water temperature would leave them unable to deliver the required cooling.

Figure 1 on the following page shows a diagram of the data center's cooling arrangement. Figure 2 shows an example of moving floor tiles in order to improve airflow and cooling efficacy.

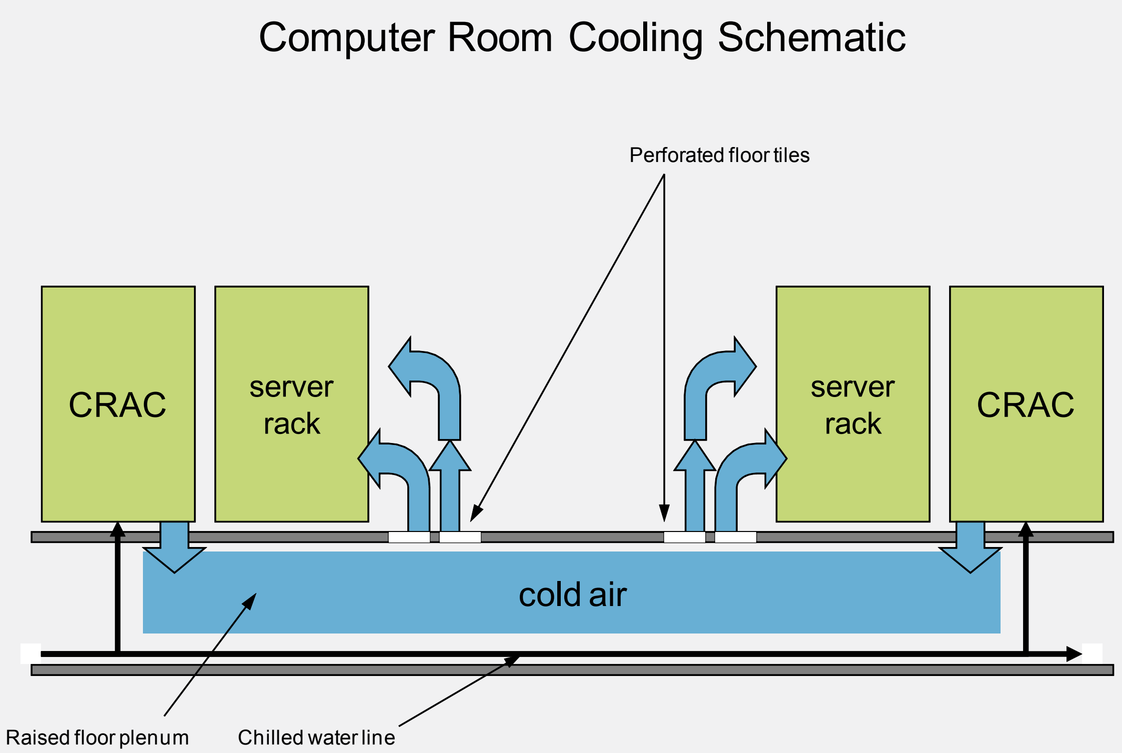


Figure 1 – Data center cooling schematic. Note that CRAC units feed from a common chilled water line and deliver their cold air to a common plenum under the raised floor. Perforated tiles in the floor then deliver this cold air to the servers.

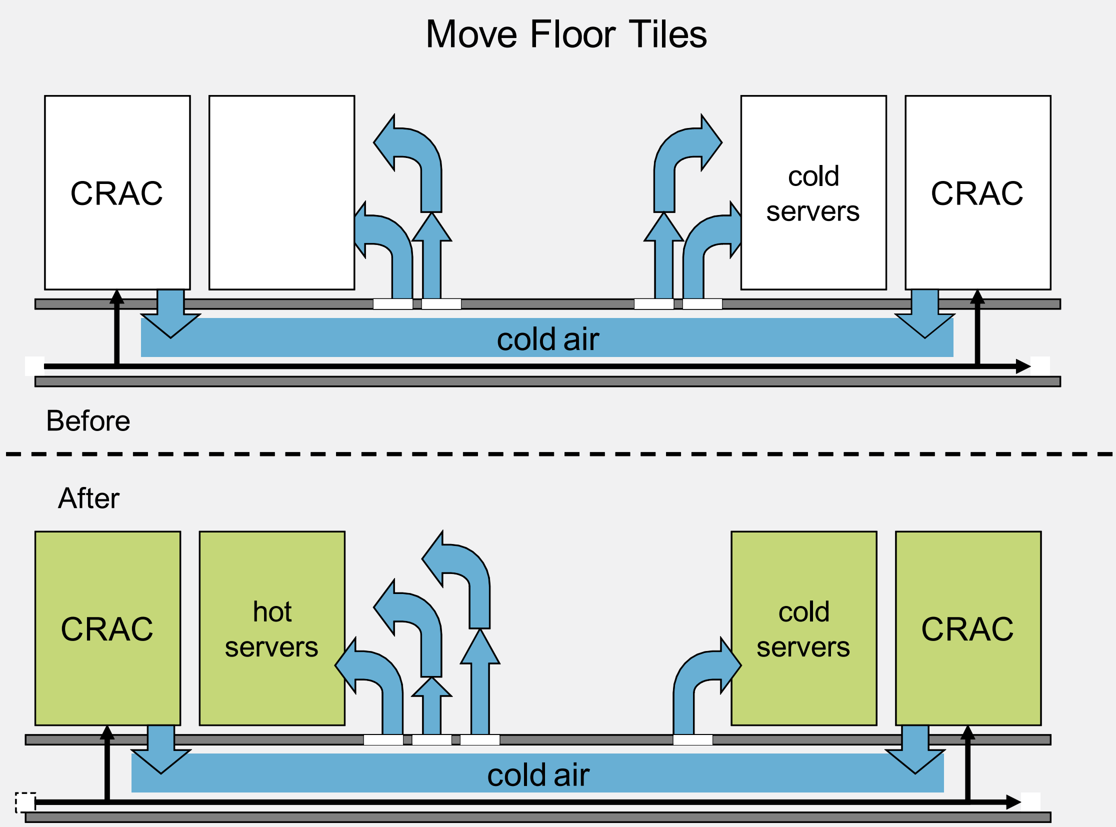


Figure 2 – Redistributing airflow by moving perforated tiles

III. CLIENT ACTIONS TO IMPROVE AIRFLOW AND RAISE CHILLED WATER TEMPERATURE

The percentage open position of each CRAC's water valve is a key characteristic tracked by Modius' OpenData software. In addition, OpenData tracks temperatures in 11 wireless environmental sensors throughout the data center. The current drawn by the chiller's compressor and the tons of cooling delivered are tracked by the Building Management System (BMS), separately from OpenData (OpenData can capture this data either natively from the chiller or indirectly from the BMS, depending on customer requirements.)

The company took the following steps to improve airflow in the data center so that hot spots could be eliminated and chilled water temperature could be raised without allowing any servers to overheat.

1: Review the valve position trend data stored by OpenData to determine the amount of cooling currently being delivered to each area of the data center.
CRAC units with consistently near-closed valve positions indicated the cold spots; these units didn't need to deliver much cooling to keep the nearby servers at an appropriate temperature. CRAC units with consistently wide-open valves, on the other hand, indicated hot spots. Since CRACs may ramp up and down over time in response to changing heat loads (such as servers ramping up and down), the company's data center personnel found it critical to use OpenData's data storage capabilities to view trend data on valves rather than only snapshot spot measurements.

2: Sensibly locate the hot spots.
After locating a CRAC that was working harder than the others (i.e. wide-open valves), the company's data center personnel went to the area and pinpointed the hot spots by feeling the air temperature manually.

3: Place a portable temperature sensor to monitor the hot spots.
The company applied wireless environmental sensors to the areas of concern to collect additional data and safeguard against overheating. This data was collected by OpenData and used to create alarms at specific temperature thresholds.

4: Check temperature readings to establish a baseline before changes are made.
The company used OpenData to collect temperature and humidity data from these portable temperature sensors. Tracking data for a time period allowed temporary trends and spikes in cooling needs to be observed.

5: Relocate perforated floor tiles from coldest area in the data center to hottest area.
The company's data center personnel moved one or more perforated tiles from the coldest part of the data center (which had excess airflow) to the warmest part of the data center (which had barely enough).

6: Observe temperature trends again to verify effectiveness of change.
After the change, the affected areas were monitored for two things. First, the company needed to ensure that the area where perforated tiles were removed didn't begin to overheat. Second, it was important to verify that the area with increased airflow indeed cooled down.

7: Repeat steps 1-6 to identify and correct the next warm spot.
This process was repeated until all the warm spots had been addressed and the team were confident that no hot spots remained.

8: Raise chilled water temperature by 1-2 °F, if possible.
Once all the warm spots were addressed and airflow was better distributed, the company found that none of its CRACs needed to operate at the maximum cooling capacity (again, the company could verify this by checking the valve positions with OpenData.) Thus, the company could safely raise the temperature of the water delivered by the chiller by 1°F without compromising the ability of any CRAC to meet its cooling load. Raising the chilled water temperature meant the chillers would consume substantially less energy.

9: Observe temperature trends again to verify that no areas are overheating.

10: Repeat steps 1-9 to continue raising the chilled water temperature.
If raising the chilled water temperature creates a warm spot, it can often be corrected by simply moving perforated floor tiles and rebalancing air flow. Through these final adjustments, the company was able to remove many of the imbalances in its cooling system.

Over a two-year period, the company raised chilled water temperature by a total of 9°F, from 43°F to 52°F. The company's eventual target is to get chilled water temperature to 54°F. Again, fixing hot spots and raising chilled water temperature is an ongoing project for data center personnel whenever spare time is available. If tackled as a single project, company personnel estimate the work could be done in approximately 16 dedicated person-hours of work.

IV. RESULTS - DATA BEFORE AND AFTER

Although the initiative of fixing hot spots and adjusting chilled water temperature is a multi-year, ongoing project, this case study details a one-month period during which the chilled water temperature was raised by 2°F. Table 1 below lists the data used for the calculations in this study (operators used more granular data to make their adjustments).

DATA SET FOR THIS CASE STUDY	
DATA COLLECTION SYSTEMS	• OpenData, provided by Modius • Building Management System (BMS)
DATA USED	• CRAC data: valve positions for all 20 CRAC units, collected by OpenData • Temperature data: degrees F for 11 stationary wireless temperature sensors, collected by OpenData • Chiller data: cooling tons delivered and % of full load current on chiller compressor, from the BMS
TIME GRANULARITY	• CRAC data: daily average valve position • Temperature data: daily average temperature • Chiller data: snapshots of instantaneous values (not hourly averages)
DATES INCLUDED IN THE "BEFORE SET POINT INCREASE" CALCULATION	1 Sep to 11 Sep
DATES INCLUDED IN THE "AFTER SET POINT INCREASE" CALCULATION	13 Sep to 31 Sep

Table 1. – The data used in this analysis

Although the company did not record the exact dates of the increase in chilled water temperature, many CRAC units show a clear opening of their valves between 12 and 14 September. In addition, there is a sudden downward spike in current drawn by the chiller during the hour of 1pm on 12 September. That hour is the Modius case study authors' best point estimate for the time of the increase in chilled water set point.

Figure 3 through Figure 6 show the trends in valve position for various sets of CRACs. In some sets of CRACs, the ramp-up after the change in chilled water temperature can clearly be seen. Daily average values for the valve positions are useful because the company uses an outside air economizer during certain times of day. During these times, the CRAC units ramp down to deliver less cooling. For the purposes of this study, daily average values remove variation and make it easier to see CRAC valve trends due to the higher chilled water set point.

Figure 7 shows temperature trends throughout the data center. The temperature remains flat all month, indicating that no unwanted temperature increase resulted from the set point change. At least, there was no temperature increase that would be reflected in the daily average temperature. It is possible, though unlikely, that temporary temperature spikes could have existed. Modius' OpenData software actually collected temperature data at every-minute or every-hour time resolution, so this could be investigated further if warranted.

Figure 8 shows trends in the chiller operation. Although the compressor power drawn over time shows a noisy trend, a slight decrease in average power draw can be seen after the set point adjustment.

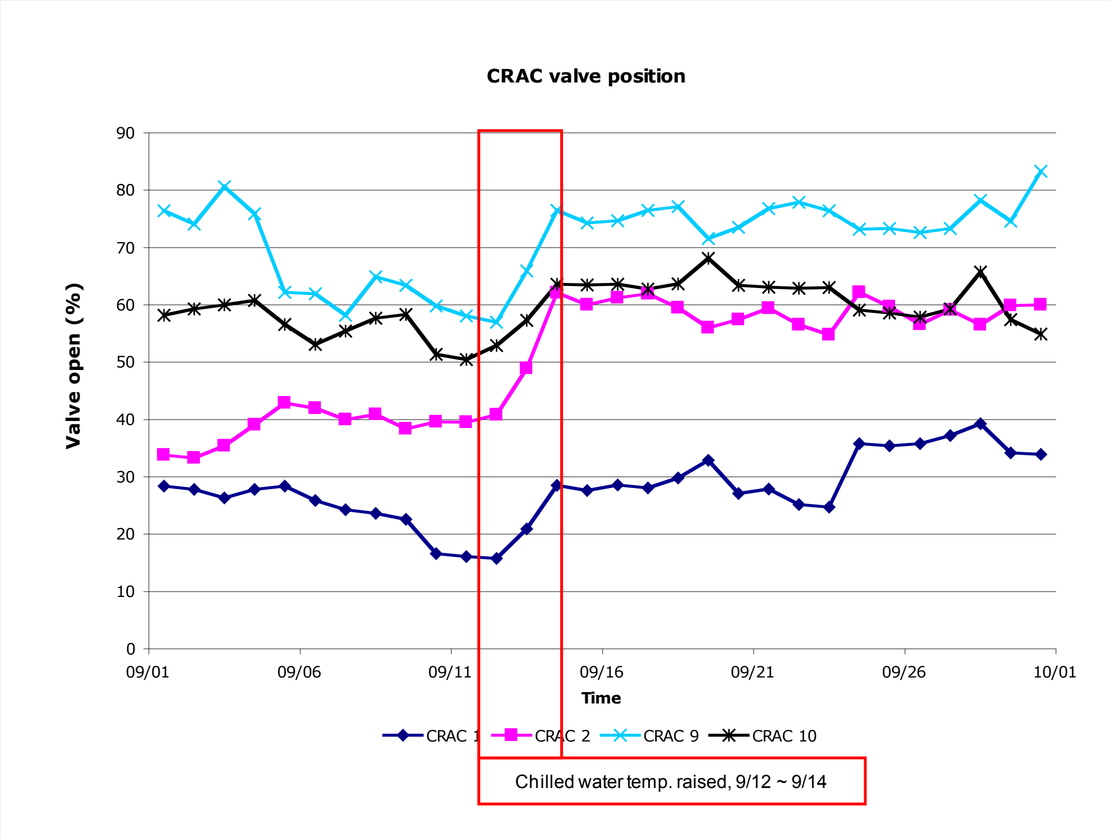


Figure 3 – Some CRACs show clear ramp up after the chilled water temperature is raised.

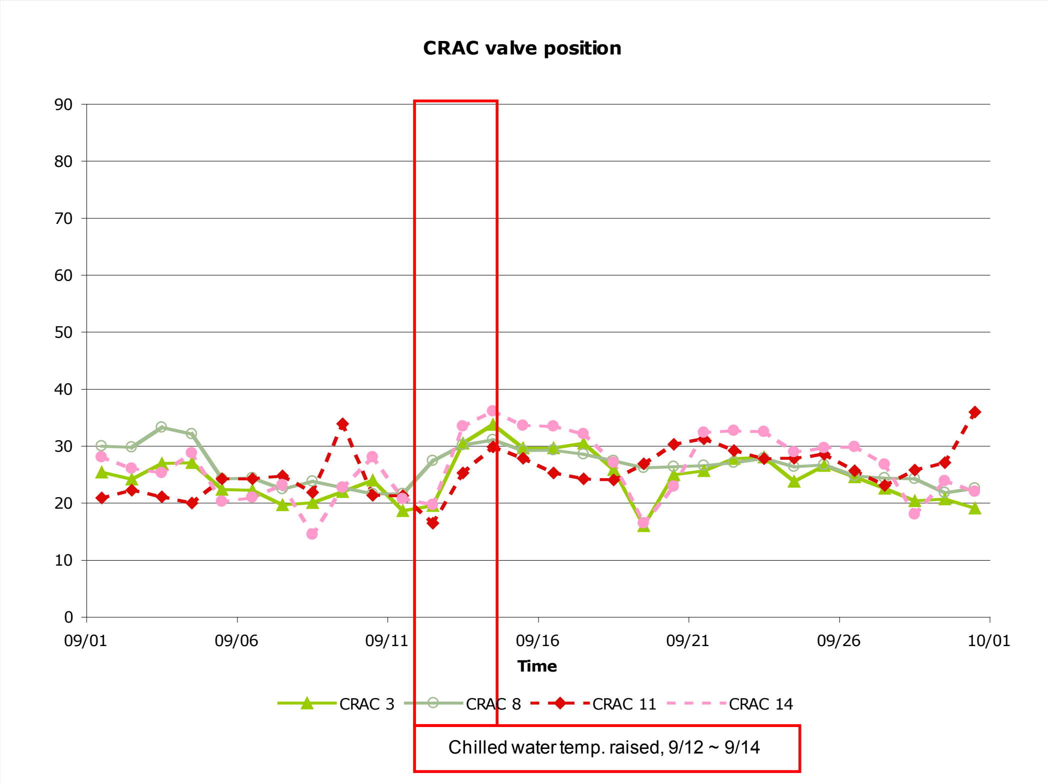


Figure 4 – Some CRACs have noisier trends, but still display a clear ramp-up.

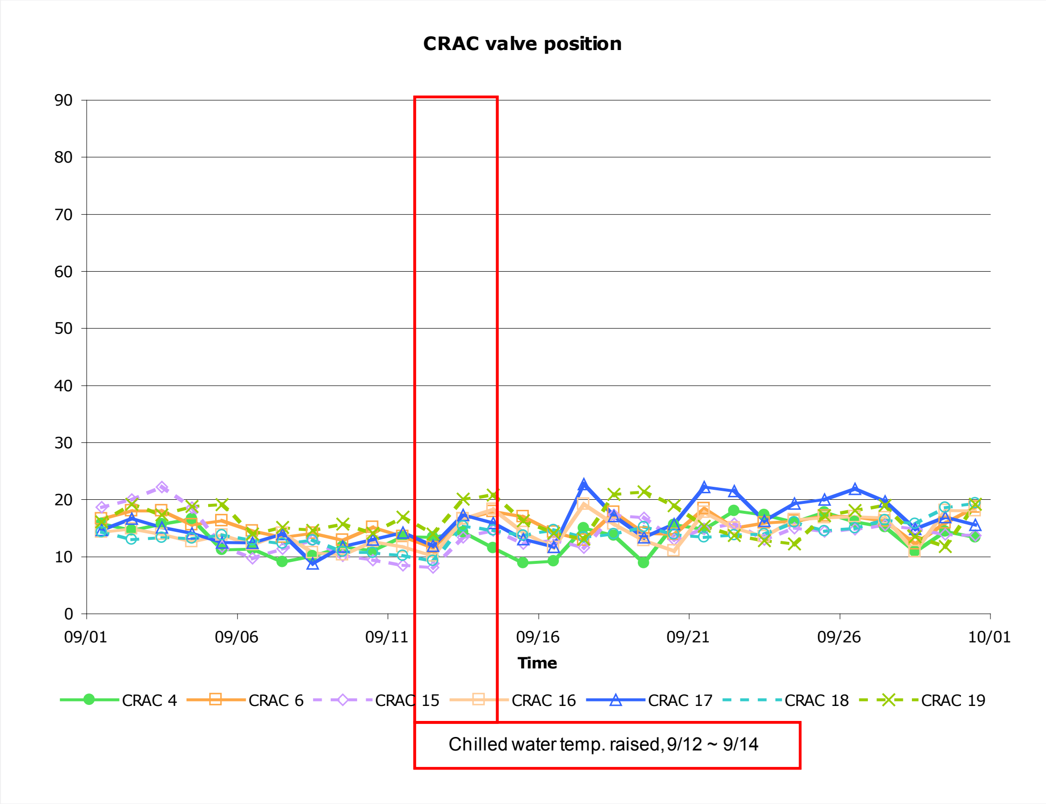


Figure 5 – For many CRACs, the ramp-up (if any) is almost indistinguishable from the background noise. However, a small bump can still be seen around the time of the chilled water set point increase.

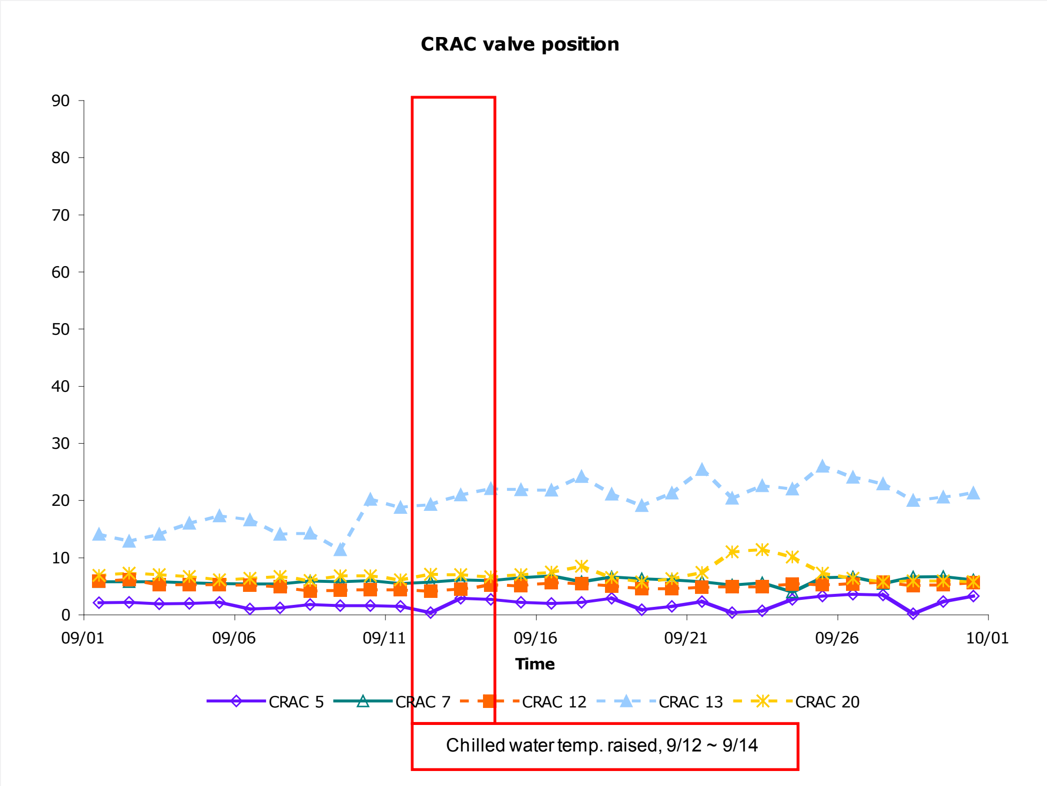


Figure 6 – Some CRACs show no ramp-up at all. Many of these CRACs are at very low loads (i.e., they're not delivering much cooling), so it is expected that an increase in chilled water temperature would not affect them very much.

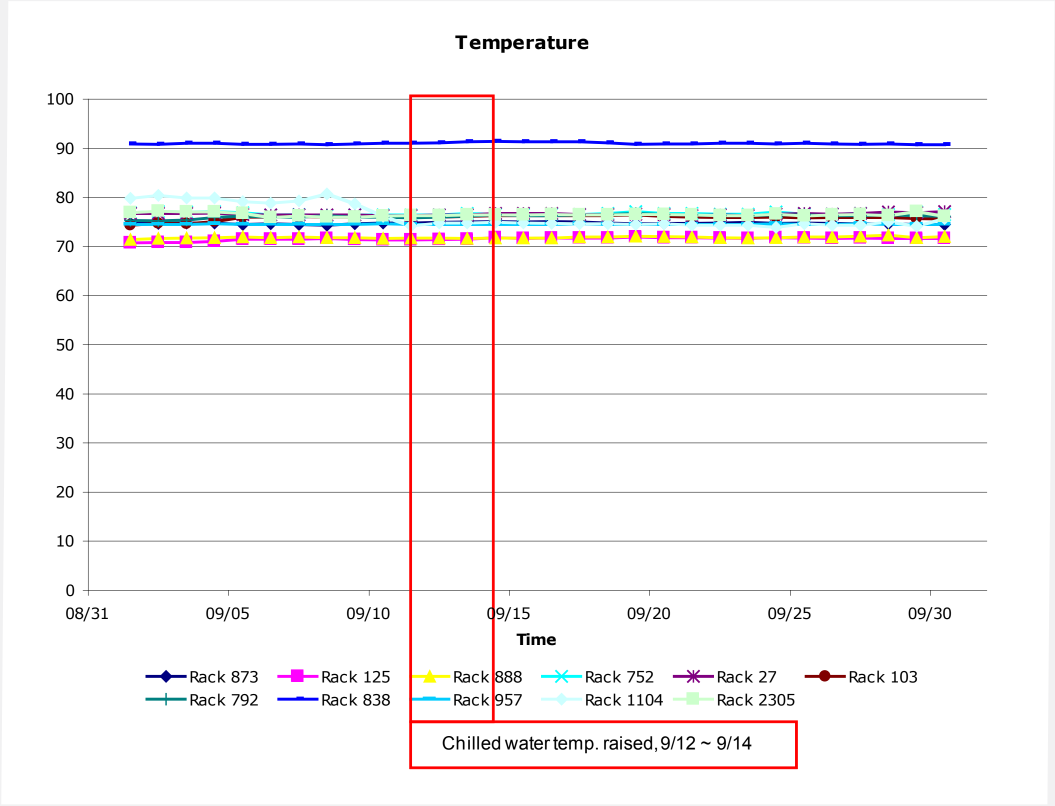


Figure 7 – Throughout the month, temperatures in the data center remain essentially constant, indicating that increasing the chilled water set point did not result in an unwanted temperature rise.

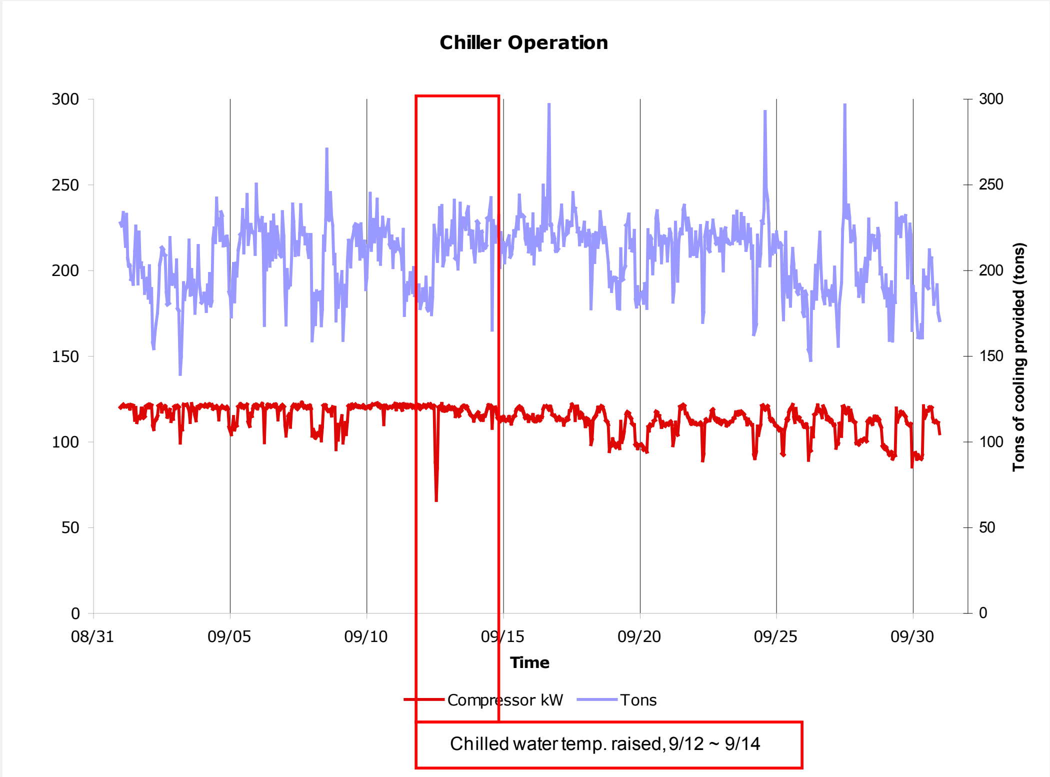


Figure 8 – Although the trend is noisy, the average current drawn by the chiller compressor (as a % of its maximum current draw) appears to decrease slightly after the increase in water temperature. Note the large temporary drop in current during 12 September, marking the time when the temperature change was made.

ADDITIONAL CALCULATIONS TO QUANTIFY REDUCTION IN CHILLER ENERGY USE

In order to further investigate the reduction in chiller current draw, the authors performed numerical calculations on the hourly chiller data. Table 2 shows the calculated difference in average current before and after the chilled water temperature set point was raised. Note that the "before change" and "after change" data sets do not include the day on which the set point was changed, to avoid including transient effects in the data. Table 3 on the following page shows the operating characteristics of the chiller (as described by the company).

CHILLER OPERATION				
	Units	Before Change	After Change	Difference (after - before)
TIME PERIOD	-	1 Sep. ~ 11 Sep.	13 Sep. ~ 30 Sep.	
AVG. COMPRESSOR POWER	kW	117.8	111.3	-6.5
STANDARD DEVIATION	kW	5.5	7.9	
NUMBER OF DATA POINTS	-	264	432	

Table 2 – Average chiller compressor power before and after the increase in chilled water temperature

CHILLER OPERATING CHARACTERISTICS [1]	
MANUFACTURER	Trane
CHILLER TYPE	Centrifugal
MAXIMUM COOLING CAPACITY	240 Tons
MAXIMUM COMPRESSOR CURRENT AT FULL LOAD	165 Amps
OPERATING VOLTAGE	480 V
POWER FACTOR	0.89
TOTAL COMPRESSPOR POWER AT FULL LOAD [2]	120 kW
TOTAL CHILLER POWER AT FULL LOAD [3]	165 kW
NOTES:	
[1] Data from client.	
[2] Total power = (165 amps) x (480 volts) x (0.89) x SQRT(3) /10^3 = 120 kW	
[3] Note: Chiller power is the total power going to the compressor, the tower fan, and chiller pumps. Of these three loads, tower fan power scales approximately linearly with compressor power. Pumping power is roughly constant regardless of compressor power, but pump power is also a negligibly small part of the total. Therefore, the Modius case study authors assume that the entire 165 kW of chiller load will scale linearly with compressor power.	

Table 3 – Chiller operating characteristics

V. HOW DID DETAILED MEASUREMENT AND MONITORING CONTRIBUTE?

OpenData contributed to the company's cooling initiative in several ways.

EASY DATA COLLECTION AND TRENDING

First, OpenData allowed the company to easily collect and trend CRAC valve data. While it is possible to access instantaneous readings of valve position on each CRAC manually (by reading from a display on the CRAC itself), this process is too cumbersome for data center personnel to do reliably for all 20 CRACs. The Modius OpenData software collects this data quickly and easily, and places data for all CRACs side-by-side for comparison.

VIEWS OF DAY-TO-DAY AND HOUR-TO-HOUR TRENDS

More importantly, OpenData allows data center personnel to examine the valve trends of a CRAC as it varies through out the day and across days. CRACs often cycle up and down during a day in response to changing conditions, so one instantaneous reading of the valve position is often unhelpful (because data center personnel have no way of knowing if a single reading represents the CRAC at a high point, a low point, or somewhere in between.) Data center personnel at the company often comment that "snapshots are worthless."

Instead, OpenData provides high resolution monitoring and recording of trends, which allows managers to understand detailed fluctuations. Since the company's operations are global, being able to view trends at different hours of the day is essential: Where are the permanent hot spots? Where are the temporary hot spots? Are any of the temporary hot spots reoccurring?

MONITOR CHANGE IN REAL-TIME AND CONTINUOUSLY

In addition to monitoring change at different times of the day, the data center managers also require immediate feedback if a change causes one area to begin overheating. As can be seen in Figure 3 through Figure 6, even daily average CRAC valve positions vary from one day to the next (in response to the installation or removal of IT equipment or changes in air flow configuration). OpenData has the ability to monitor this change in real-time (i.e. multiple times per minute) and then set alarms based on specific temperature thresholds.

IDENTIFICATION OF POSSIBLE COOLING PROBLEMS

Although other available CRAC data is not detailed in this case study, this data can also help operators identify different types of cooling problems. For example, the OpenData software can collect data on return air temperature in addition to valve position. If a unit is running at high load in response to its temperature sensor, but the monitored return air temperature is already very cold, it could indicate a "short circuit" in the airflow path. A problem may exist that causes the cold air from the CRAC to cycle back too quickly, without making it to the computers to be cooled.

Another example is fan belt slippage. A CRAC that is running hard but seeing a low return air temperature might also be experiencing slippage in the belt driving its air blower. Data center personnel at the company note the importance of such checks: a $14,500 CRAC unit can have its performance negatively affected by a $7.50 fan belt.

THE CONFIDENCE TO ACT

Finally, OpenData gives data center personnel the confidence they need to make changes. Without high resolution time series data and long term trending, data center personnel might be hesitant to risk changes in existing air flow or chilled water configurations. Armed with this data, they can confidently make these beneficial changes.

VI. BENEFITS TO THE COMPANY

This section examines how the company has benefited from the initiative to reduce hot spots and increase chilled water temperature.

IMPROVED RELIABILITY AND BETTER UTILIZATION OF COOLING CAPACITY

First, the cooling initiative allowed the company to improve its data center reliability and make the most of its cooling capacity.

1: Improved reliability by eliminating hot spots

Hot spots indicate that some IT equipment is not getting the cooling it needs. Fixing hot spots protects this equipment from overheating and failure.

2. Improved failover redundancy between CRACs

Before the initiative to correct poor air flow and hot spots, some CRACs in the data center were working their hardest just to keep their areas cool. If a neighboring CRAC unit failed, these overworked units had no extra capacity to take over the failed unit's cooling load. Conversely, other CRAC units barely needed to provide cooling at all.

By better directing air flow, the company's goal was to distribute the work of the CRAC units much more evenly. The eventual objective is to have each CRAC operate at 60% or less of its maximum chilled water throughput. This way, if a single CRAC unit fails, the two CRACs on either side of it could in crease their chilled water throughput to 90% and pick up the cooling load. This would allow time for repairs on the failed CRAC without danger of the area overheating.

Not only did Modius' OpenData software help the company locate these hot spots and correct them, it also allowed the company's personnel to verify that all CRACs were running with enough spare capacity to act as failover redundancy to the neighboring CRACs. Often, efficiency and redundancy can be opposing objectives. However, in this case, the company was able to raise chilled water temperature and still have plenty of extra capacity left over for desirable redundancy.

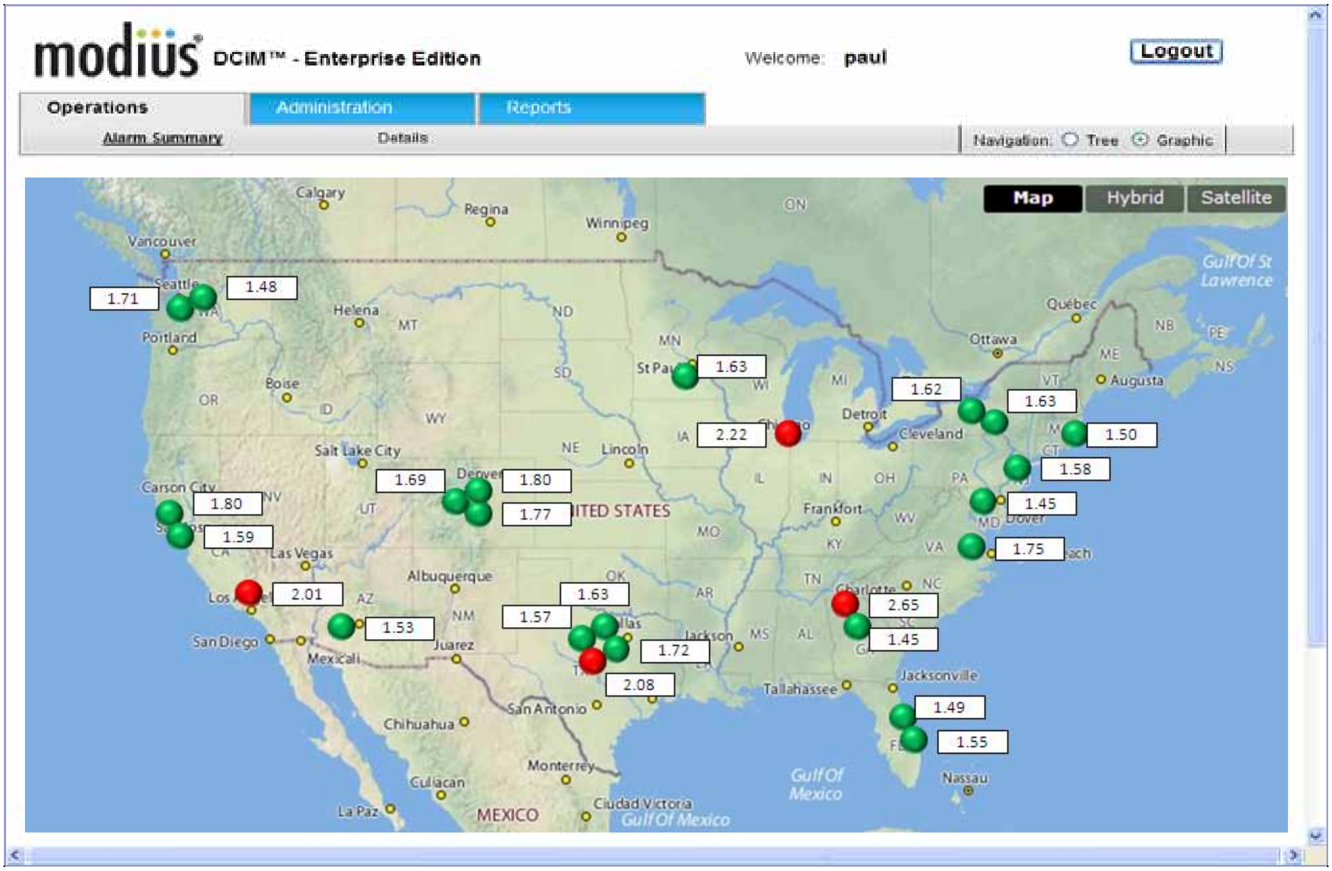
3. Better utilization of existing cooling capacity

Optimizing air flow also allows the company to get the best use of its installed CRAC units, without having to buy more cooling equipment to correct hot spots.

ENERGY AND POWER SAVINGS FROM THIS 2°F SET POINT INCREASE

In addition to the reliability and capacity-utilization benefits, increasing the chilled water set point by 2°F during September generated a reduction in the power required to operate the chiller. Table 4 on the next page shows the resultant annual savings in kWh and dollars. (Note that the initiative also reduces peak power loads.)

In addition to saving kWh, the 9 kW reduction in chiller power allows the company to install more servers (grow its business) without compromising UPS capacity. The company could utilize the newly-reclaimed 9 kW by adding approximately 30 servers (at 300 W each).[2]



2: This assumes that none of the reclaimed 9 kW would be needed to cool the 30 additional servers. In reality, the company might only be able to add 15-20 servers, with the rest of the 9 kW going towards additional cooling power for the new servers. Still, 20 servers means squeezing in another half rack before having to upgrade the UPS.

SAVINGS FROM CHILLED WATER SET POINT INCREASE		
	Units	
AVG. COMPRESSOR POWER BEFORE SET POINT INCREASE	kW	118
AVG. COMPRESSOR POWER AFTER SET POINT INCREASE	kW	111
MAXIMUM COMPRESSOR POWER	kW	120
POWER SAVINGS AS % OF MAXIMUM COMPRESSOR POWER	%	5.5
MAXIMUM CHILLER POWER [1]	kW	165
ESTIMATED POWER SAVINGS [2]	kW	9.0
HOURS PER YEAR	hours/year	8,760
ENERGY SAVED PER YEAR	kWh	78,812
ELECTRICITY PRICE	$/kWh	0.147
ANNUAL SAVINGS	$	11,585
NOTES:		
[1] Total chiller power includes compressor, pumps, and tower fans.		
[2] Since the pumps are a small part of total chiller load and the tower fans vary with load in approximately the same way as the compressor, Modius case study authors apply the %-savings of compressor power to the total maximum chiller power.		

Table 4 – Chiller savings calculations

According to the company, these utility savings are not obvious on the utility bill, because they are lost in the growth of IT loads as the business expands. However, it is far better to be spending these kW of capacity and utility bill dollars on IT equipment that contributes to the business, rather than spending them operating the chiller.

CHALLENGES IN CALCULATING ENERGY & POWER SAVINGS ESTIMATES

Saving $11,585 per year from a 2°F water temperature increase equates to roughly $5,800 per degree. However, the actual figure could be higher or lower depending on a number of factors, including the actual cost of electricity (which varies at different times of the day), the role of the outside air economizer, the work rate of the CRAC fans, etc. Viewed as entire system, there is a rule of thumb among data center operators of approximately $10,000 per year savings for each 1°F increase in chilled water temperature. Applying this rule to the 2°F increase would yield $20,000 per year, almost double the $12,000 estimate above.

IMPROVED VISIBILITY ACROSS BOTH CHILLED WATER AND CRAC PERFORMANCE

Another key benefit of detailed monitoring is improved visibility across multiple sub-systems in the data center. For example, looking only at average values of chilled compressor power before and after the set point change would not have revealed the fact that the economizer was used more frequently after the change. The hourly data collected across these systems allowed the authors and company personnel to see this pattern on the graph, revealing useful information about the economizer.

Also, while the chiller power draw graph provided clues about economizer usage, there is no definitive log. If monitoring had been more extensive, and reliable information collected from the economizer, the case authors could have separated the chilled water energy savings from the economizer savings. This fact illustrates the usefulness of detailed, cross sub-system monitoring to allow energy savings to be tracked, understood, dis-aggregated, and quantified.

ENERGY SAVINGS FROM THE BROADER CHILLED WATER INITIATIVE

So far, this case study has focused on one specific instance in which the company raised the data center's chilled water set point by 2°F. However, recall that this change was part of a larger, multi-year cooling initiative. Between January of year 2 (the first full year of measurement) and February of year 4 (the final year of measurement), the company was able to raise chilled water temperature by a total of 9°F, from 43°F - 52°F. If the savings estimate above of $5,800 - $10,000 per degree holds, then the company could be saving $52,200 - $90,000 from this 9°F increase.

CALCULATING ENERGY SAVINGS ADJUSTED FOR SERVER GROWTH

This section examines the long-term savings of the entire initiative by comparing the year-on-year consumption rates. Since cooling needs vary over the course of the year, it makes sense to compare cooling energy consumed during a particular month of one year with cooling energy consumed during the same month of the previous year. However, to do this accurately, the Modius case authors took the following steps:

1. Convert hourly data on current drawn by the chiller compressor into average chiller kW for each month for multiple years.

2. Determine "unadjusted" kWh consumed by the chiller each month.
Values for any month can then be compared to values for the same month of the previous year.

3. Calculate a monthly index to compensate for increased cooling energy due to growth in server loads.
Since the company adds new servers to its data center over time, cooling demand will increase, offsetting any cooling energy reductions due to increases in chilled water set point. To compensate, case authors calculated a monthly index of server loads, with November of year 1 (the first month of measurement) normalized to 1.00. For example, a later month with an index of 1.25 indicates that there is a 25% higher server load than there was in November of year 1.

Based on conversations with the company, the case authors grow the index at 12% per year from November of year 1 to July of year 3 (during which time the firm was adding servers rapidly), then hold the index constant from July of year 3 to March of year 4 (during which time the company was not adding servers).

4. Calculate "adjusted" kWh consumed by the chiller each month.
Dividing the unadjusted kWh by the index for the month yields the adjusted value. This has the effect of lowering the apparent cooling energy use in later months to reflect what it "would have been" if server load had not been increasing over time.

Figure 9 shows the unadjusted kWh of energy consumed by the chiller each month.

Note that in many months of the year, even the unadjusted values of year 3 (the year of the specific instance discussed earlier) are lower than the previous year. This means that the reduction in cooling energy use (from efficiency improvements, including the chilled water set point increases) was large enough to dominate the increase in cooling demand from additional servers. The exceptions are the hottest months of year 3, during which the chiller used more energy than in the previous year.

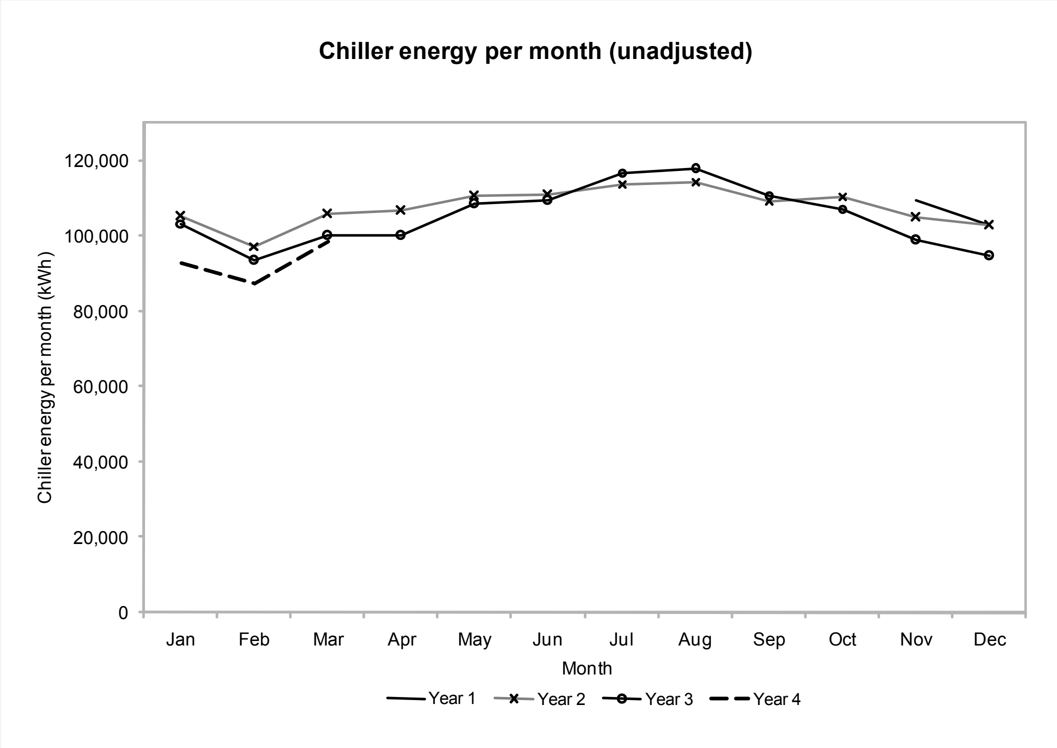


Figure 9 – Unadjusted chiller energy each month, over four years. Note that in most months, the chiller energy is lower than it was during the same month of the previous year. This indicates that improved cooling efficiency over time generated reductions in total energy use, despite the fact that the company was adding IT equipment and growing its business.

Figure 10 on the following page also shows the same chiller energy use data, but with the consumption levels "adjusted" downward to screen out the effects of server load growth.

The total impact of the cooling initiative can therefore be calculated by comparing the Year 1 consumption rate (the first year of measurement) with the Year 4 rate (the final year of measurement). This calculation shows a net saving of 27,000 kWh, based on 105,000 kWh consumed in Year 1 compared to the much lower rate of 78,000 kWh consumed in Year 4.

This saving equates to an overall 26% reduction in energy consumption by the chiller as a result of the 9°F change in the temperature set point made over the life of the project.

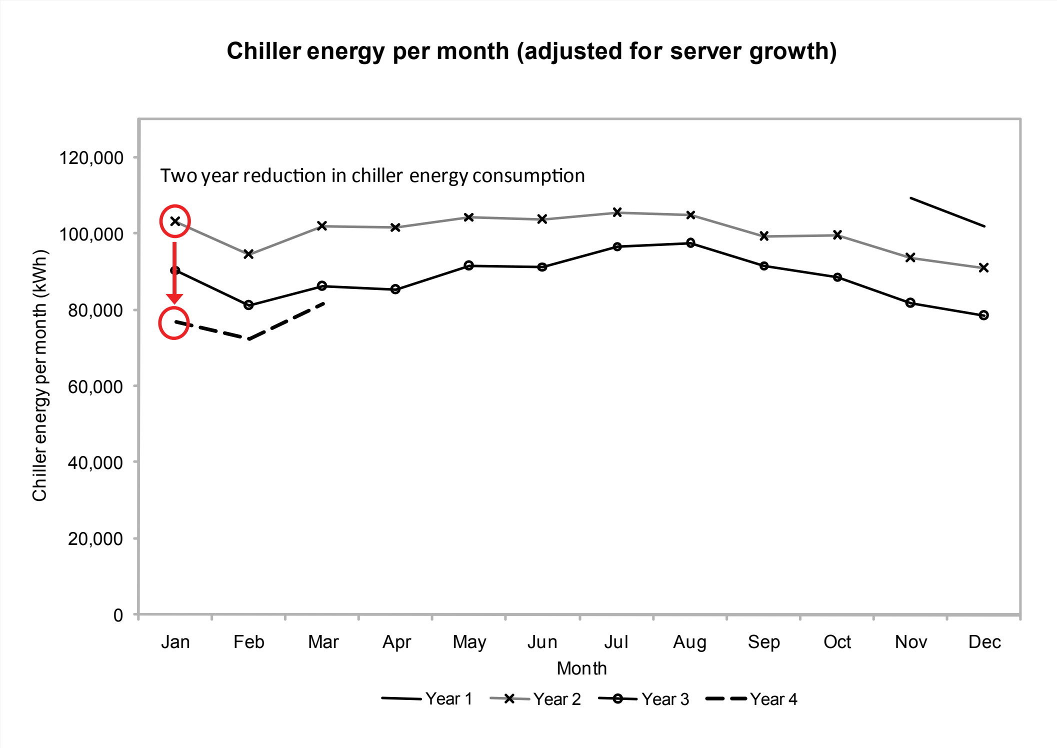


Figure 10 – Adjusted chiller energy each month, over four years.

VII. CONCLUSION

Using Modius' OpenData, the company was able to simultaneously improve several dimensions of its data center operations:

First, the company improved the reliability and redundancy of its data center by locating and eliminating "hot spots" which were not receiving proper cooling. Fixing hot spots keeps IT equipment from overheating, and it also reduces the burden on overloaded CRAC units, which allows excess cooling capacity to take over in case a neighboring CRAC fails.

Second, the company improved the energy efficiency of its data center. Since the hottest parts of a data center are what drive the temperature in the chilled water loop feeding the CRAC units, eliminating the hot spots allowed the company to provide a higher water temperature to the units. This change in the chiller's temperature set point dramatically reduced energy use and generated thousands of dollars in annual utility savings.

Third, OpenData allowed the company's data center personnel to easily collect detailed operational-level data across multiple sub-systems, including CRAC units, environmental sensors, and the chiller unit. This broad data capture allowed the company to generate a holistic picture of their data center operations. This data enabled company personnel not only to view day-to-day and hour-to-hour trends that allowed them to make adjustments with confidence, it also allowed them to see how the different sub-systems worked together.

Finally, the data collection from OpenData helped the company capture a detailed understanding of its data center operations over time. Although this case study primarily focuses on a single instance in which the company raised its chilled water temperature by 2°F, this improvement was part of an ongoing cooling initiative in which the company raised the water temperature by a total of 9 °F from year 1 to year 4. The holistic tracking provided by OpenData allowed the benefits of the broader initiative to be baselined and quantified over time.

TECHNICAL SPECIFICATIONS

Modius OpenData is a software application that can be installed on-premise or hosted in the cloud. Some customers choose to run the application within VMWare ESX. Software platform requirements are as follows:

- **Windows Server** - 2008, 2008 R2, 2012

- **Database** - Express, Workgroup (Up to 2012) and MS SQL Server 2008 - 2016

CONTACT YOUR MODIUS REPRESENTATIVE FOR MORE INFORMATION ABOUT HOW OPENDATA CAN FREE UP TRAPPED CAPACITY IN YOUR DATA CENTER, SIGNIFICANTLY REDUCING OPERATING COSTS.

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