

De-Risking Data Center Temperature Increases, Part 2

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De-risking the process of raising temperatures in the data center involves many steps. In this column, we address the remaining steps of the process we began in January's column.

To this point, we've covered the following steps toward raising temperatures:

- Reviewed the air management approaches;
- Possibly determined the bypass and recirculation airflow metrics (temperature conditions);
- Reviewed the existing thermal conditions and possibly the type of IT hardware class;
- Measured the inlet temperature conditions on the IT hardware;
- Reviewed and defined the boundary conditions on the HVAC system and IT hardware;
- Determined which temperatures to raise to save HVAC energy; and

Possibly evaluated the order of magnitude of energy that could be saved and potential ROI of a more thorough review.

Each data center is unique. The combinations of their air management approach, the HVAC systems used, their operating boundary conditions, types of IT hardware, and geographic areas make for unique conditions.

These unique conditions need to be evaluated for each data center to determine *if*, and what magnitudes of, energy savings are possible through the increase in the temperatures.

Unlike normal commercial HVAC systems, data center systems require a more thorough approach when change is involved to avoid any unplanned failures of the cooling to the information and technology equipment (ITE). While many of the steps can be considered HVAC 101, it's the combination of steps applied to data center applications that removes the barriers in data center operator's minds for raising temperatures in the data center and doing so reliably.

In this column, we'll explore the remaining steps for *how* to raise the temperatures in the data center.

Identify Objectives

Raising temperatures in the data center usually starts with some discussion by management, the chief financial officer (CFO), or the sustainability management looking to save money and/or reduce the company's carbon footprint.

To save the energy and associated money, it's necessary to identify the changes to specific systems that will result in savings. For data centers, this comes from a couple of primary means:

- Raising supply temperatures from the HVAC to the data center information technology equipment (ITE);
- Raising the return temperatures coming back to the HVAC; or
- Both.

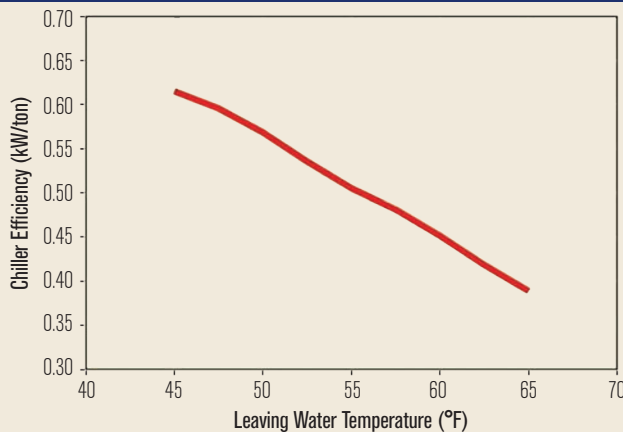
If the HVAC systems are chilled water based, they will benefit the most by raising the chilled water supply temperature, because of the thermodynamic efficiency gain of the chiller (*Figure 1*). If the system has a water-side economizer, this will also be a significant increase in economizer hours for almost all climate zones.

If the HVAC systems are DX or have airside economizers, they will benefit most through raising the HVAC return temperatures (*Figures 2 and 3*).

The temperature difference across the coils may or may not remain the same based on the strategies employed. Strategies such as aisle containment can result in increases to the return temperatures and an increase in the ΔT . This means that the supply

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FIGURE 1 Sample chiller efficiency as a function of leaving chilled water temperature (with chilled water differential temperature constant).



temperatures may not have changed at all unless steps have been taken to do so.

This is why it's important to identify the objectives upfront and ensure the strategies used align with those objectives to saving energy in the data center.

Identify System Limits

Once objectives are identified, the next important step is to determine *if* the systems are capable of achieving those objectives, safely and reliably. Not all systems can perform as desired. Each type of HVAC system has inherited limitations via its original design and internal safeties, settings, and controls.

Beginning with the type of HVAC equipment, a thorough evaluation of the equipment limitations is necessary. For example, is there an economizer on the HVAC system? If yes, what type? What is the form of high-limit control?

For the existing ITE hardware, at what entering temperatures does the ITE power increase based on higher fan speeds? Many existing ITE installations will increase their power consumption above 75°F (24°C) to 77°F (25°C) entering air temperatures.

Is the equipment direct expansion (DX) refrigerant based or chilled water? Is the system air-cooled or water-cooled? What is the existing temperature difference on the coils and what temperature difference are they capable of? What humidity range (either dew point, RH, or both) is desired in the facility, and will the facility be able to adequately dehumidify to this range if the cooling coil temperature is increased?

What safeties are installed on the equipment to prevent damage to compressors? Typical refrigerant compressors

FIGURE 2 Example bin hours versus economizer operation. DB bin hours, Charlotte, N.C.

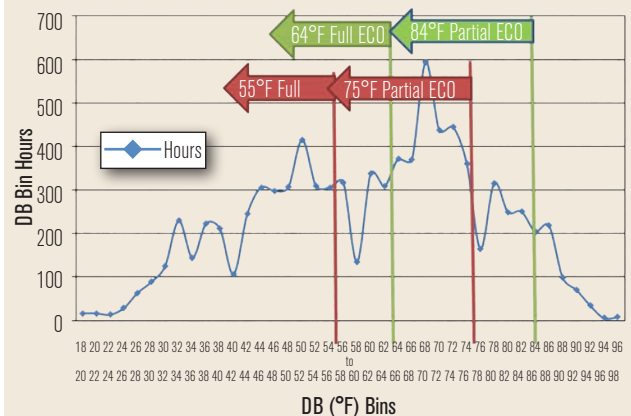
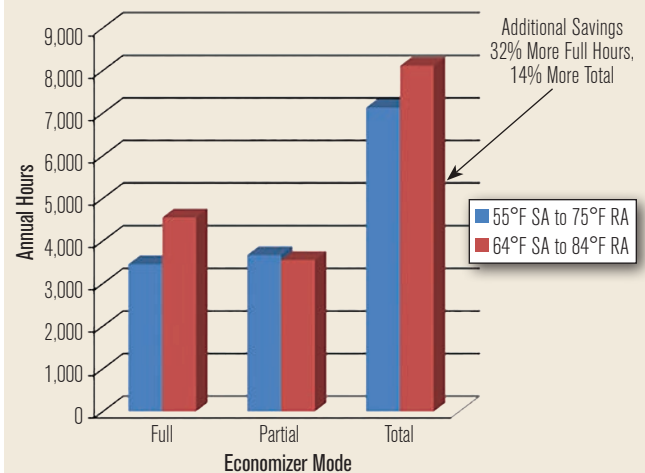


FIGURE 3 Example full versus partial economizer hours. Charlotte, N.C., air economizer.



will include low suction switches, high discharge pressure switches, and motor overload protection.

Additional questions that need answered included:

- What do the equipment efficiency curves look like and are they available?
- What's the potential savings per degree change in return air temperature on DX equipment performance?
- What's the return air temperature limit on the equipment (often limited to 100°F (38°C) to 105°F (41°C) on DX equipment as an example)?
- What were the original design assumptions?
- Do the changes involve a temperature difference on the chilled water or condenser water, which may affect piping, pumps, and towers? Both the temperature difference and temperature limits need evaluated.

Once the equipment limitations are known, the controls

systems (temperature, pressure, humidity) need review.

For temperature controls, the difference between the temperature control setpoint and the actual entering conditions on the ITE should be evaluated. The Temperature Control Index (TCI) is the difference between the set point on the temperature controls and the average intake temperature to the Datacom equipment. This can be evaluated as follows:

$$\text{TCI} = \text{Average Temp Controls Reading} \\ - \text{Average ITE Intake Temperature}$$

Example,

- T-stat on wall, or at CRAC, return reading 77°F (25°C), and the average ITE intake temperature is 66°F (19°C), the TCI = 11°F (6°C), and
- Ideally, TCI would equal zero.

In the example above, the adjustments to the temperature controls need to account for the TCI gap. If the goal is to set the ITE intakes at 80°F (27°C), then the temperature controls need to be adjusted up by the value of TCI. In this example, the temperature controls need to be adjusted up to 14°F (8°C), which means it would be set at 91°F (33°C),

For spaces characterized as Case A2, B2, C2, or D2, with a highly variable inlet temperature across the ITE inlets, greater care must be taken. The highest temperature in the inlet range needs to be assessed. The temperature controls setting should be low enough to keep the percentage of the distribution of inlet temperatures below the upper limit of the ASHRAE “recommended” range *or* whatever objective has been set for the data center by the owner.

Next is the review of pressure and humidity controls, if present. If HVAC fans are being controlled by some form of pressure controls, then the location, type, and settings of the sensors needs evaluated. Questions for evaluation include:

- Where are the reference points?
- Location of sensors?
 - Underfloor
 - Cold aisles or containment
 - Ductwork
 - Room
- How many sensors?
- Are they monitoring, control, averaged, or other?

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Finally, if humidity controls exist, there are several questions to evaluate for them as well as follows:

- What type exists?
 - Absolute (specific humidity, humidity ratio)
 - Relative Humidity
 1. Dependent upon temperature at the sensors
 2. Offsets necessary?
- How many sensors?
- Are they monitoring, control, averaged, other?

After the systems and controls have been evaluated, any containment strategies that exist or proposed should also be evaluated (See the September 2015 column, “Complying with NFPA’s Aisle Containment Requirements”).

The above steps are important, particularly in data centers, because they are significant contributors to system failures if not properly verified prior to system changes.

Implement and Review Tradeoffs

Perhaps the most important consideration with the proposed implementation of raising temperatures is to perform it slowly and with iterative measurements. The

performance of systems, temperatures, airflows, etc., is not linear. Therefore, a slow and iterative process is necessary when raising temperatures in the data center.

This implementation process should be planned out very carefully to maximize the efforts commonly performed during “maintenance windows” in the middle of the night. Data center work is almost always accompanied with Methods of Procedures (MOPs) for any work involving changes in the data center systems and operations. Everything described in this column ultimately must find itself mapped into a detailed MOP for review and approval prior to implementation.

The implementation process will reveal surprises and unexpected results. This will often lead to the review of various trade-offs.

Measure, Monitor, and Adjust

Implementation is often considered the final step in obtaining the energy savings; however, this can lead to a lack of obtaining the estimated savings.

Data center systems are complex systems with many

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tradeoffs in performance with the slightest of adjustments.

This is where post measurement, monitoring, and additional adjustments come into play. These are critically important steps because each data center is unique and can have differing results with each adjustment.

The measurement process can be conducted through an existing building automation system (BAS), but may often-times require some further adjustment to do so. Additional means of measurement may be required and includes the continued use of temporary monitoring systems such as data loggers, portable handheld devices, or related equipment. Caution should be exercised in evaluating the accuracy of the equipment, locations of measurement, baselines used, etc.

Final Thoughts

In this column we've covered Part 2 of raising temperatures in the data center. Raising temperatures is rarely as simple as adjusting the thermostat or temperature controls setting on the building automation system.

The process to raise the temperatures involves many steps to do it properly, safely, reliably, and with accountable results. This is particularly true in data centers

where even small changes can result in system failures (a large reason many data center operators are so fearful to raise temperatures in the first place).

It requires a systemic engineering and commissioning approach because each data center, it's information & technology equipment (ITE), HVAC systems, etc., are unique.

The process for raising the temperatures begins with characterizing the temperatures, airflow management, boundary conditions, and determining method and order of magnitude of energy to be saved. With that data in hand, it's possible to identify the objectives, identify system limits to meeting those objectives, and implementing and reviewing tradeoffs. Once implemented, it's time to measure, monitor, and adjust as necessary to sustain the results.

In this month's column we completed the remaining steps necessary to de-risk the process of raising temperatures in the data center.

References

1. Quirk, D., Patterson, M. 2010. "The right temperature in data-com environments." *ASHRAE Transactions*.
2. ASHRAE. 2012. *Thermal Guidelines for Data Processing Environments*, 3rd edition. ■

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