

# Eight Mechanical Strategies to Reduce Energy in Your Data Center

[www.totalsitesolutions.com](http://www.totalsitesolutions.com)

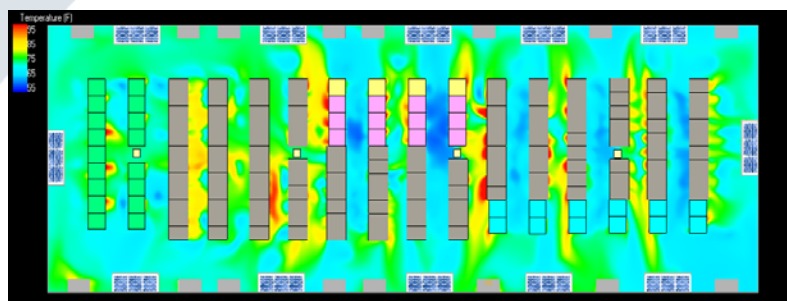
Ramzi Y. Namek, PE, LEED AP BD+C  
Director of Engineering

Engineering is often perceived as the practice of applying scientific principles to achieve an end product that is reliable and efficient. Up through the year 2006, data center efficiency had largely been ignored in favor of availability and reliability. The industry has come a long way in the past five years and new methods to make these complex facilities and systems operate more efficiently are being discovered and refined. This paper presents eight strategies to improve and reduce energy usage in a data center.

### ▲ One – Pay Attention to Airflow Management

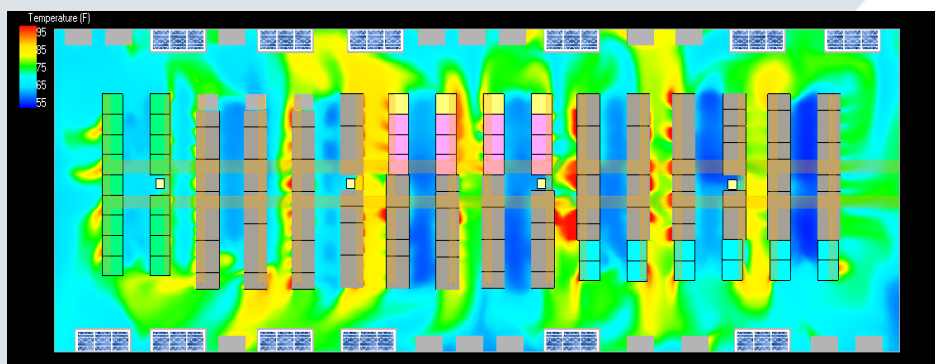
This is usually termed a “low hanging fruit” item but is quite a challenging improvement to achieve; particularly if the data center does not utilize a Hot Aisle (Containment HAC) /Cold -Aisle (Containment CAC) layout. Sealing openings in the raised floor, and will help increase the air pressure in the raised access floor and minimize wasteful leakage. Installing blanking panels and plates in empty U’s in an IT rack will reduce bypass air, where hot air is pulled back into the front of the servers. While the most energy savings will be seen with a HAC/CAC layout, this may prove to be unachievable in an existing data center. The reason is that shutting down live servers and moving them around may not be an easily achievable task. In the example below, before and after improvements were simulated using 6Sigma software; a computational fluid dynamic modeling program. Computational Fluid Dynamics (CFD) is a tool for analyzing the effectiveness of cooling within the racks and aisles of the data center. A CFD model provides a detailed 3-D analysis of how cold air is moving through a data center, revealing potential “hot spots”, and identifying where equipment is receiving too much or too little airflow.

The table below each graph shows the number of servers approaching certain inlet temperature ranges. By blanking the unused spaces in racks and sealing unused floor openings, airflow pressure is increased in the cold aisles and the number of servers approaching 85 drops from 114 to 23.



Inlet Temp. Range (°F)	0	70	75	80	Greater Than
	70	75	80	85	85
# Servers	289	349	280	114	50
% Servers	26.71%	32.26%	25.88%	10.54%	4.62%

Figure. Pre-Improvements – 114 servers have temperature between 80 °F and 85 °F.



Inlet Temp. Range (°F)	0	70	75	80	Greater Than
	70	75	80	85	85
# Servers	811	136	71	23	19
% Servers	76.51%	12.83%	6.70%	2.17%	1.79%

Figure. Post Airflow Management Improvements. Only 23 Servers Have Inlet Temperatures Approaching 85 °F

## ▲ Two – Specify Higher Operating Temperatures for Both the Water and Air Systems

Changing the philosophy from colder is better to a higher room temperature based on ASHRAE's recommended thermal guidelines will result in significant energy savings. Raising the leaving chilled water temperature (LCHWT) is one strategy that will reduce chiller lift on the evaporator side and hence reduce total energy consumption. . Taking an aggressive approach and raising the LCHWT to the low 60 °F's results in significant power reductions in the range of 25-32% as shown in the figure below for a 1000 ton chiller plant simulation. With the proper CAC/HAC containment strategies and chiller controls, raising the supply air temperature in conjunction with the LCHWT is not only achievable, but proves to have significant benefits for data center power reduction.

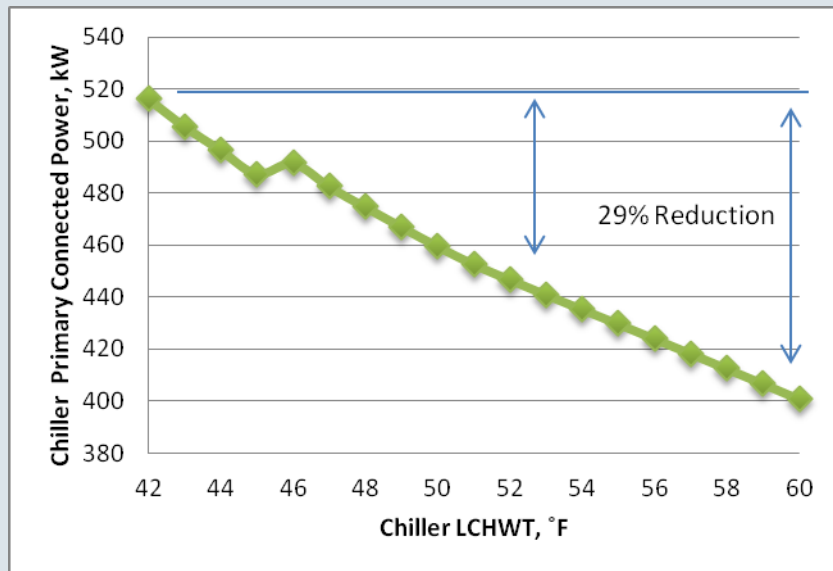


Figure. Chiller Connected Power Compared to LCHWT

Other benefits of raising temperatures are summarized as follows: (1) Setting air temperatures higher means less demand to cool the air streams; this means lower fan energy. Raising the temperatures for either air or water increases the number of hours per year where (2) water side or (3) air side economizers may be used. The compressor is either off or at partial loading during full or partial free cooling and energy consumption is decreased. (4) In addition, smaller chiller power requirements may translate to smaller generator sizes that satisfy the electrical load of the building. In present-day energy “lingo”, all the above translate to (5) smaller Power Usage Effectiveness (PUEs) for data centers and (6) reduced carbon footprint for projects.

### ▲ Three – Increase the Temperature Difference for Both Water & Air: Higher $\Delta$ → Lower Power Consumption

Another strategy to reduce power consumption is by increasing the Temperature Delta ( $\Delta T$ ) between the entering and leaving water or air temperatures. Flow and  $\Delta T$  are inversely related according to the formula

$$\text{Mass Flow Rate} = \frac{\text{Heat Load}}{\text{Specific Heat} \times (\Delta T)}$$

This brings us back to the Affinity laws whereby reduced flow due to a higher  $\Delta T$  will result in a cube root reduction in energy. We simulated a 1000 ton chiller plant with a 10 °F  $\Delta T$  and a 16 °F  $\Delta T$ . The plant total energy is plotted for various leaving chilled water temperatures. There is at least a 6% energy reduction simply by operating the plant at a higher  $\Delta T$ . With proper HAC/CAC containment practices, this is an easily achievable target for most users.

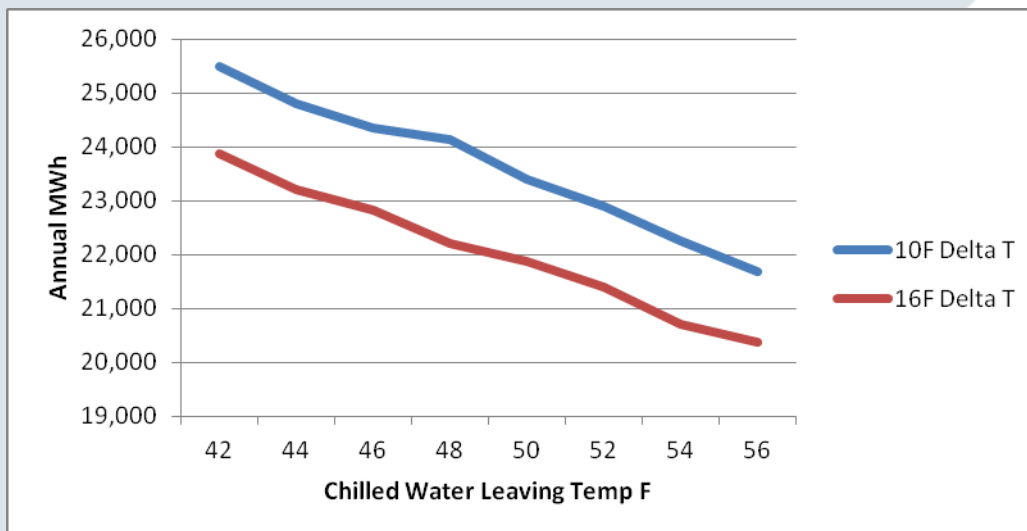


Figure. Effect of Chilled Water Temperature Delta on the Annual Chiller Energy Usage

#### ▲ Four: Specify Variable Speed Systems and High Efficiency Equipment Where Possible, Low KW/Ton Cooling Equipment

Basic pump and fan laws indicate that horsepower (hence energy) is related to the cube of speed. We can safely predict that reducing the speed of a motor will result in a cube root reduction of motor horsepower. A modern mechanical system without speed or capacity control is an energy hog! It is therefore prudent to integrate, where possible, variable frequency drives (VFD's) on pump and fan motors as well as specify variable capacity chillers.

Moreover, specifying the highest efficiency equipment within a family of manufacturers will also reflect in the overall reduction in energy usage. For example, when specifying a chiller, the designer should take into consideration all the kW/ton values as well as Non-Standard Part Load Value (NPLV) values for several manufacturers during the equipment selection process.

## ▲ Five: Employ Air or Water-side Economizers

The latest recommendations from the ASHRAE TC 9.9 committee added two new classes to its allowable and recommended environmental conditions guidelines for data centers; A3, A4 to expand the environmental envelope and kept classes A1, A2, B and C identical to the 2008 version. The primary objective in computer rooms is to deliver a cool air stream to the servers in order to avoid overheating and shutdown of the microprocessor chip. It is enough to look at the allowable inlet temperature ranges to IT servers to deduce that a tight thermal environment is a thing of the past. Users who are not adopting economization as part of their cooling solution be it water or air side, are throwing money out the window. The Greengrid.org provides a free online tool that estimates the total hours of free cooling available per region for both air and water side economizers. Users are urged to visit the website and tinker with various temperature and humidity values that may apply to their data centers.

	Class	Temp	RH
Recommended	A1 to A4	18°C to 27°C	5.5 °C DP to 60% RH and 15 °C DP
Allowable	A1	15 to 32 °C	20% to 80% RH, 17 °C DP
	A2	10 to 35 °C	20% to 80% RH, 21 °C DP
	A3	5 to 40 °C	8%, -12 °C DP to 85% RH
	A4	5 to 45 °C	8%, -12 °C DP to 90% RH

Figure. ASHRAE TC 9.9 2011 Summary

## ▲ Six: Move Cooling Closer to the Load: In-row Cooling

In lieu of an air handling unit that is 50 feet away from the racks, why not move the cooling closer to the load. This practice saves on total fan horsepower, provides a faster reaction time to varying IT loads within racks, and may also eliminate the need for a raised access floor altogether. This however, does bring water or refrigerant piping close to the servers and will require additional maintenance activities and leak prevention strategies.

## ▲ Seven: Conserve Water. Operate Cooling Towers at Higher Cycles of Concentration Automate the Blowdown Process

Water usage eventually translates to energy as municipalities pay to store, filter, maintain, and pump water to the end user. In cooling plants, evaporation from cooling towers, particularly in the summer can be substantial. Blowdown rate is a term that refers to the amount of water that needs to be drained off occasionally to reduce the concentration of solids and contaminants in the system. Water evaporates from the tower as pure water leaving behind dissolved solids and contaminants. As more water evaporates, the concentration of solids in the remaining volume of water increases, which will eventually cause a buildup of scale in the condenser tubes and heat exchanger plates. In order to reduce this concentration, a portion of the recirculating water is automatically or manually drained off.

CoC or “Cycles” is the shortcut term for Cycles of Concentration and is the ratio of the quality (dissolved solids) of the Blowdown water  $BQ_{solids}$  to the Quality of the Makeup water,  $MQ_{solids}$

$$CoC = BQ_{solids} / MQ_{solids}$$

Cycle values are determined by factoring in data from water samples provided by the municipality. Typical CoC's range from 2.0 - 3.5 and as high as 7; the higher the cycles, the more savings in Makeup Water (Mw) . The graph below shows a plot of Makeup Water against various CoC's for a 5000-ton chiller plant operating in peak summer conditions. The water savings per day when running the plant at higher CoC's equate to roughly 40,000 gallon/day.

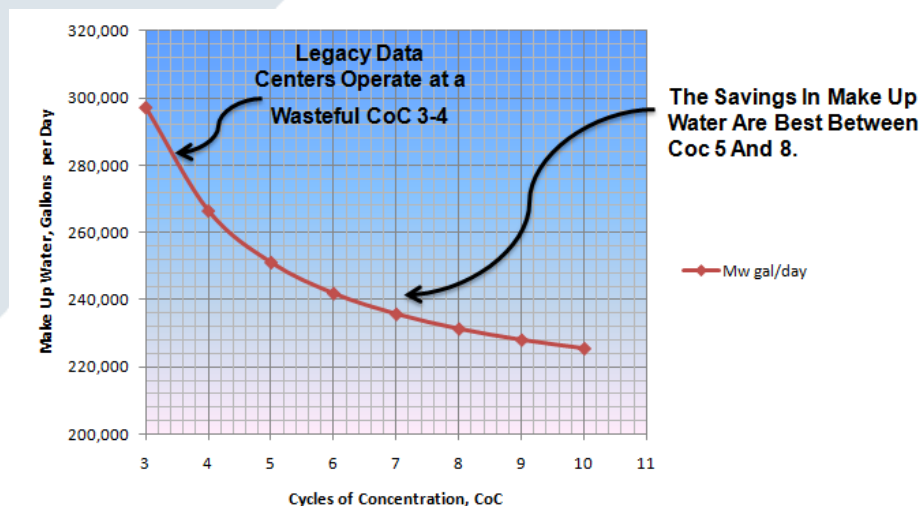


Figure. Make Up Water Consumption Compared to Various Operating Cycles of Concentrations

## ▲ Eight: Invest in Modern Web-based Control System

A modern data center should be operated using Web-Based control systems. These systems allow multiple users to communicate through a web-server using any device that can link to the world wide web; be it a lap top, a smart cell phone, a tablet, a PC, or a Mac. For that matter, they offer unsurpassed flexibility and enhancement to the operations of the facility. Modern web-based controls provide a communication platform that makes use of control protocols such as BACnet and Modbus in a seamless manner between devices and the web server. This essentially eliminates the need for gateway translators between equipment and proprietary control languages that were necessary with conventional control systems. Conventional control systems have rigid communication barriers that limit the operation of your facility in an energy efficient manner.

A modern data center is also an integrated entity at all levels including IT, mechanical, and electrical infrastructure. Data Center Integrated Management (DCIM) software provides such a management platform between servers, network, storage, and the rest of the electrical/mechanical. It enables the management and understanding of the complex switching infrastructure between IT equipment and the operating systems. With the growth and uptick of cloud computing and virtualization, DCIM applications are essential for record keeping, management, control, and interface between IT and facilities under one platform.

## ▲ Conclusion – Be Creative! Think Outside the Box

Accumulating years of work experience is a great asset to cherish but as years pile up, we sometimes find it hard to break away from traditional and standard design procedures. Before the year 2006, energy in data centers was not on anyone's mind; engineers designed and operated data centers in a wasteful energy manner. Then came the EPA report to Congress on energy consumption - the rest is history. Since 2007, we have seen a surge in innovative design, revisiting of thermal guidelines, and collaboration from industry and end users to deliver systems with less waste and higher energy efficiency without jeopardizing the availability of the data center. There's more to be achieved.

Below are three more ideas that will reduce energy consumption but fall outside the comfort zone of most design engineers:

- a. When designing air cooled chillers, add a timer-based water spray system that operates based on an ambient temperature on the roof. While most engineers would tell you air cooled chillers are not meant for evaporation, they are certainly designed to handle a rain shower. With proper filtration and water softening, a quick spray burst will reduce the head pressure on the condenser coils and lower lift on the chiller. You will save energy.

- b. After reviewing the 2008, and the draft 2011 ASHRAE TC 9.9 Thermal Guidelines, ask yourself and your client: why do you need humidification and reheat? If you are not comfortable eliminating humidifiers, at least specify Ultrasonic tied to an RO/DI water source. Infrared or steam canister humidifiers consume five to seven folds the energy consumed by an Ultrasonic humidifier. In your spare time, check the manufacturer's electrical MCA and Max Fuse for a CRAC unit with and without humidification and your electrical engineer will eventually thank you for eliminating humidifiers.
- c. Why not use the blowdown water from cooling towers for irrigation? You will put less pressure on the municipal sewer systems and save yourself some dollars.

### ▲ About the Author

Ramzi Namek, PE, LEED AP BD+C  
Director of Engineering, Total Site Solutions

Mr. Namek is located out of the headquarter office of TSS in Columbia, Maryland and has over 17 years of experience in both Design and Project Management of mechanical systems for mission-critical, commercial, and government projects. He is skilled in HVAC, plumbing, and fire protection design, construction management, engineering economics, *as well as* energy analysis. With over ten publications in various leading industry journals, his current areas of interest are in data center energy efficiency, the cloud computing environment, and the dynamics of change in the data center business model. Mr. Namek was awarded his B.S. Degree in Mechanical Engineering from American University of Beirut and his M.S. Degree in Engineering Management from Virginia Tech. He is a board member in the ASHRAE National Capital Chapter.