



Engineering White Paper

**UTILIZING ECONOMIZERS
EFFECTIVELY IN THE DATA
CENTER**



SUMMARY

A proper balance of temperature and humidity control is essential for efficient data center operation, and integral to protecting the significant investment in computer and network technology in such facilities. However, increasing energy costs challenge engineers to find the most cost-effective ways to control temperature and humidity within acceptable ranges.

The use of economizer systems is one method that has been adopted to lower energy usage, lessen wear and tear on precision air conditioning equipment and decrease operational costs.

The two primary types of economizer systems are air-side economizers and fluid-based economizers. The stringent temperature and humidity requirements of data centers, coupled with the need for 24-hour cooling 365 days per year, typically make fluid-based economizers the system of choice for most data centers environments.

Fluid-based economizers also provide effectiveness in a wider portion of the temperature/humidity band required by today's data center computer systems, so they are more suited to a data center than dual-enthalpy control air-side economizer systems. Within the fluid-based economizer category, glycol-based systems operate effectively at the widest range of outdoor ambient temperatures.

What Are Economizer Systems and Why Are They Useful?

Economizer systems use outside air, when it is cold enough, to help meet cooling requirements and provide so-called “free cooling” cycles for computer rooms and data centers. When an economizer system is operating, the use of an air conditioning system’s compressor(s) and related electro-mechanical components is reduced or eliminated. In certain geographical locations, economizers can satisfy a large portion of data center cooling requirements.

The use of economizer systems can have a significant impact on energy usage. A study on building control systems conducted by Battelle Laboratories and reported by the National Building Controls Information Program found that, on average, the normalized heating and cooling Energy Use Intensity (EUI) of buildings with economizers was approximately 13 percent lower than those without economizers.

The use of economizers is also now required by some building codes. The energy code adopted by the City of Seattle in 2001 requires the application of economizer systems in computer rooms and data centers. The State of Massachusetts Energy Code for Commercial and High-Rise Residential New Construction, effective in 2001, requires, with some exceptions, air or water economizers for all cooling systems with a total cooling capacity of at least 65,000 btu per hour.

Types of Economizers and How They Work

There are two types of economizer systems, typically referred to as air-side and fluid-side economizers.

An **air-side economizer** system serves as a control mechanism to regulate the use of outside air for cooling in a room or building. It utilizes a system of sensors, ducts and dampers to allow entry of the appropriate volume of outside air to satisfy cooling demands. The sensors measure the outside and inside air conditions. If outside conditions are suitable for the use of outside air for cooling, the economizer adjusts the dampers to introduce the outside air, making it the primary source of air for cooling the space. This reduces or eliminates the need for the air conditioning system’s compressor(s), which results in a significant energy savings for cooling the space. Air-side economizers also include exhaust air dampers to prevent the facility from becoming over-pressurized when large amounts of outside air are introduced.

A **fluid-side economizer** system (often called water-side) works in conjunction with a heat rejection loop consisting of either a cooling tower, evaporative cooler or drycooler to satisfy cooling requirements. A fluid-side economizer system is typically incorporated into a chilled water or glycol-based cooling system. For economizer operation, the fluid used in the cooling system passes through an additional coil to cool the room air, eliminating the need for compressor operation.

While they operate in different ways, the ultimate goal of both air-side and fluid-side economizer systems is to provide “free cooling” to a room or facility, thus reducing the operating time of the air conditioning system’s compressor(s). However, fundamental differences between the two types of economizers have a direct impact on the most appropriate economizer choice for a data center environment.

Choosing the Right System for Data Center Applications

Theoretically, if the outside temperature is cool enough, 100 percent outside air can be used to meet cooling demand. In this case, an air side economizer should be sufficient for the job. However, computer systems require special considerations. In most situations, a water or fluid-based economizer is the optimum choice for a data center.

Year-Round 24x7 Cooling

Unlike the seasonal and intermittent heating and cooling requirements of office buildings and similar facilities, the controlled environment of a data center requires continuous, year-round cooling. This makes it an ideal candidate for economizer systems during the fall, winter and spring months. Maintaining consistent, acceptable temperature levels can be done with either system, but humidity control becomes a significant challenge with the air-side system.

Precision Humidification and Temperature Control

A clean, filtered environment with precise control of humidity is mandatory in a data center. Ignoring the impact of humidity can result in serious short and long term problems, including damage to equipment and to the facility’s infrastructure. In most cases, the optimal relative humidity (RH) range for a data center environment is 45-50 percent.

Introducing outside air via an air-side economizer system in the cold winter months is fine from a temperature standpoint, but unless further treatment of the air is done, it can lower RH to unacceptable levels, causing electrostatic discharge that interferes with normal equipment operation. A humidifier can be used to compensate for this, but its operation offsets some of the energy savings provided by the economizer. Depending on the particular location of the data center, humidification costs could run into thousands of dollars per year to maintain a room condition of 72°F/50% RH.

Figure 1 shows the cost to humidify 1000 cfm of outside air in New York City based on a power cost of \$0.10 per kwhr using a canister-type humidifier. Multiply these values by the thousands of CFM needed to cool a space (assuming that some mixing can be done when the air temperature gets below 50° – 55° F), and it is clear that the humidification costs are not trivial.

| DB Temp Range (F) | < 24 | 25 - 29 | 30 - 34 | 35 - 39 | 40 - 44 | 45 - 49 | 50 - 54 | 55 - 59 | 60 - 64 | < 64 |
|-----------------------------------|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Moisture to be Added* (grains/lb) | 49 | 46.9 | 42.7 | 38.5 | 34.3 | 28.7 | 21 | 12.6 | 2.8 | |
| Hours/Year in Temp Range | 387 | 344 | 512 | 739 | 791 | 733 | 770 | 722 | 776 | 5774 |
| Cost to Humidify* | \$457 | \$386 | \$518 | \$667 | \$629 | \$483 | \$367 | \$205 | \$48 | \$3,761 |

* Based on \$0.10 per kwhr and room conditions of 72F/50% RH

Figure 1. Humidification Costs for 1000 CFM of Outside Air in New York City

In contrast, fluid-side economizer systems use the cold outside air to cool the water/glycol loop, which in turn provides fluid cold enough for the cooling coils in the air conditioning system. This keeps the outside air out of the space and eliminates the need to condition that air.

Figure 2 shows the ambient temperature envelope of operation for this type of system, which has no restrictions for ambient temperatures under 65 degrees F because outside air is not introduced into the space.

Enthalpy Control

The advantages of fluid-based economizers in a data center environment are further demonstrated when comparing their use versus an air-side economizer with dual enthalpy controls. A system with dual enthalpy controls uses two sensors to compare inside and outside air temperature and humidity levels.

Use of dual enthalpy economizer controls is similar in principle to a fluid-based economizer system because they both take advantage of cold outside conditions to cool indoor temperatures and reduce compressor use. However, while a dual enthalpy controlled system is suitable for a wide range of operating conditions in a general facility, it is only effective in a small band of the required temperature and humidity range for a data center environment.

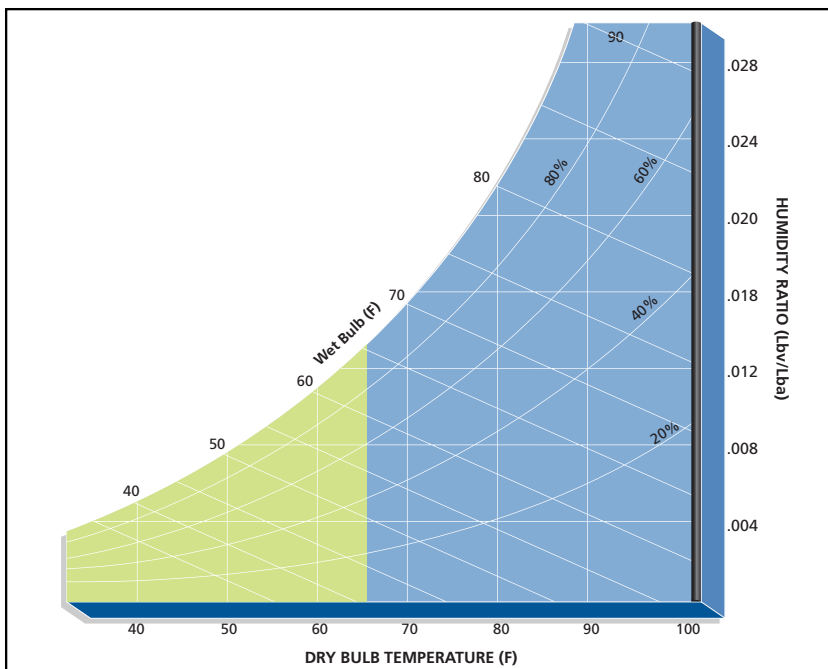


Figure 2. Free cooling circuit (water side economizer) operating range – computer room applications.

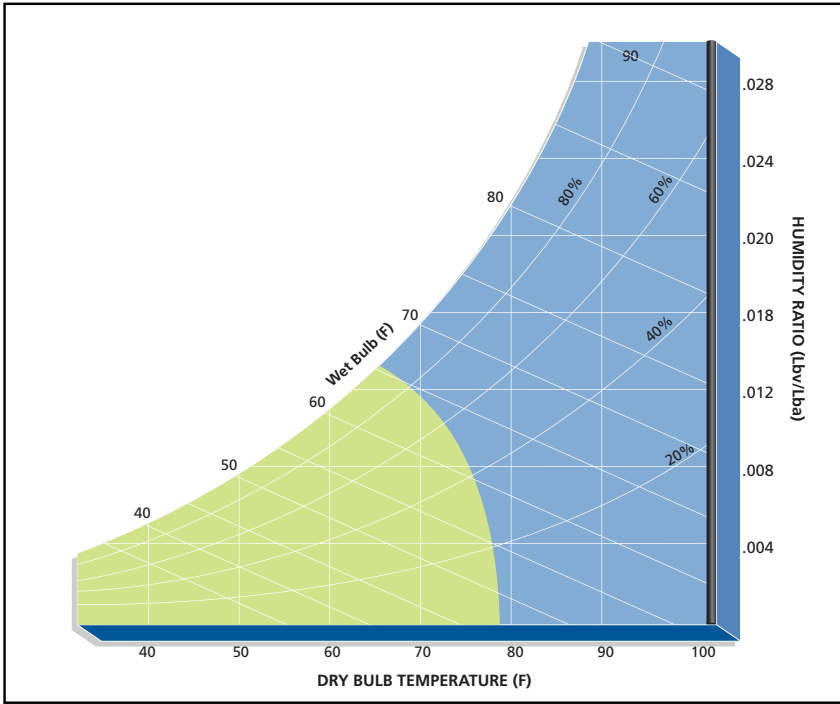


Figure 3. Dual enthalpy controller operating range – comfort cooling application.

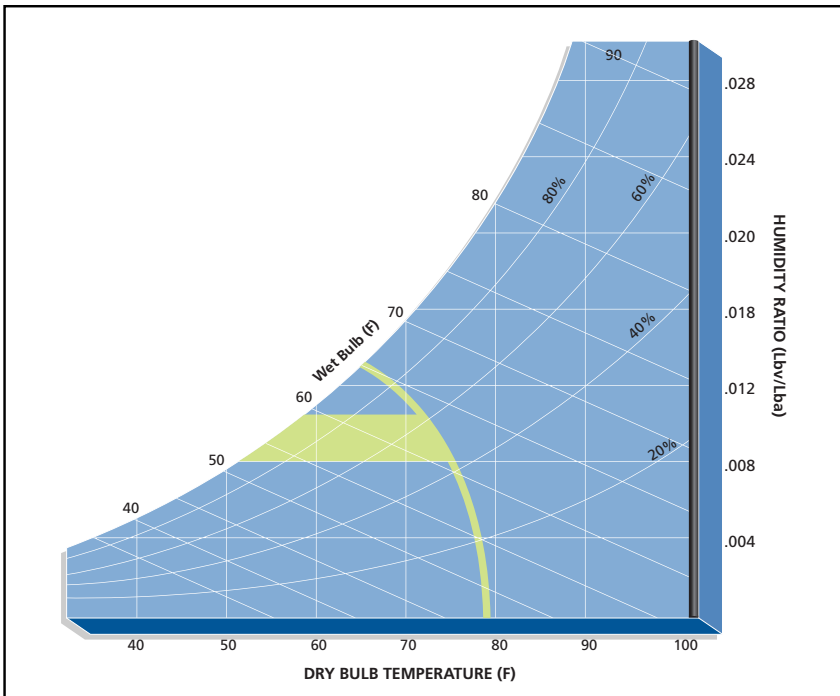


Figure 4. Dual enthalpy controller operating range – computer room application.

Figure 3 shows the effective operating range for optimizing energy in a comfort cooling environment using dual enthalpy controls. Figure 4 is the same analysis, but for a data center application. Bringing in air from outside the band in Figure 4 will require additional humidification as described earlier, plus even some dehumidification for a small period of time.

The Liebert GLYCOOL System

Liebert’s GLYCOOL system is a fluid-based economizer that maximizes energy savings while providing the accuracy and reliability demanded by sensitive data center equipment and operations.

The GLYCOOL system is part of a Liebert glycol-cooled Deluxe System/3. The system is self contained and includes controls to make an intelligent decision about cooling mode: Normal compressorized cooling, full “free cooling” or partial “free cooling.” At ambient temperatures above approximately 65° F, the unit functions as a normal glycol cooled dual compressor system, with the compressors providing the cooling. As the outdoor temperature drops, the temperature of the fluid in the heat rejection loop drops also. Once it is cold enough outside to supply some cooling, the control opens the modulating valve on the econ-o-coil circuit. The econ-o-coil then provides some “free cooling,” while the compressors provide the rest of the cooling to satisfy the load. Once the fluid temperature is cold enough, the econ-o-coil has enough capacity to eliminate the need for the compressors, so they shut off.

Typically, a closed-circuit drycooler lowers the glycol temperature to the required 45° F needed to get full capacity from the econ-o-coil. Closed circuit evap coolers can also be used to take advantage of low wet bulb temperatures in very dry climates. By controlling the fluid temperature off of the ambient wet bulb temperature, significant “free cooling” can be obtained in cities such as Phoenix.

Figure 5 compares power consumption of three glycol-cooled environmental systems and one glycol-cooled free cooling system (GLYCOOL) in their ranges of outdoor ambient temperature operation. Power consumption varies with outdoor temperature due to changes in system operating head pressure, system cooling

capacity and amount of compressor operation required. Actual energy usage varies based on the hours of operation at each ambient range.

The GLYCOOL fluid-based economizer system enables “free cooling” that significantly lowers power consumption at outdoor temperatures below 35° F, and relatively lower power consumption as temperatures approach 65° F.

The Liebert equipment is also designed to operate as efficiently as possible even at high outdoor temperatures because it utilizes semi-hermetic compressor systems and A-frame coils. Adding cylinder unloaders to the compressors provides even more efficient operation, especially if the system is not fully loaded.

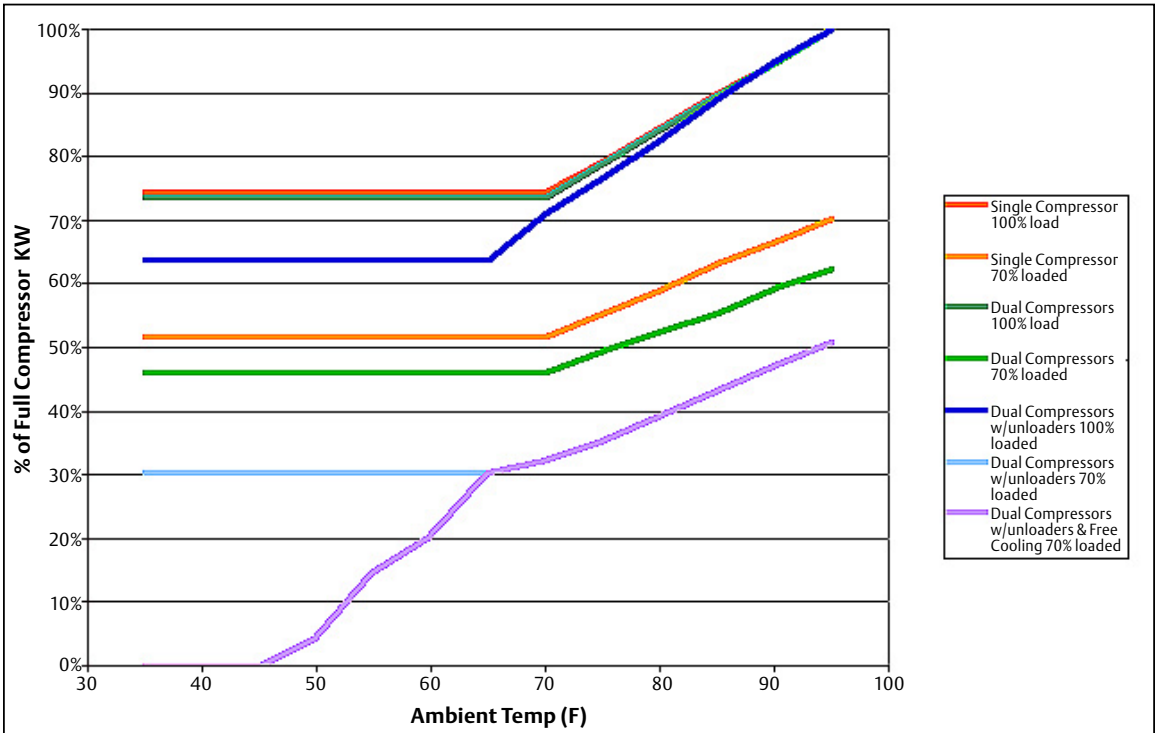


Figure 5. Compressor power consumption for 15-ton system

Precision air conditioners with dual compressors and unloaders operate 25 to 30 percent more efficiently than single compressor, non-unloading systems, while providing N+1 redundancy and capacity for future expansion. The GLYCOOL system uses dual compressors and unloading features to take full advantage of part load operation and lower outdoor ambient temperatures. Because start-up of each compressor is with the unloader valve activated, initial current surge and wear on the compressor is reduced.

Conclusion

The nature of today's computer and communications systems requires a more complex and thoughtful approach to environmental control planning for data centers than ever before. In most situations, air-side economizer systems do not meet the stringent temperature and humidity control requirements necessary for these mission-critical facilities. Glycol-based fluid economizer systems are the most appropriate choice to help reduce data center cooling costs, decrease energy usage and provide efficient, economical heat dissipation in a wide range of outdoor temperature and humidity conditions.



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