

# The Different Technologies for Cooling Data Centers

## White Paper 59

Revision 2

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### > Executive summary

There are 13 basic heat removal methods to cool IT equipment and to transport unwanted heat to the outdoor environment. This paper describes these fundamental cooling technologies using basic terms and diagrams. 11 of these methods rely on the refrigeration cycle as the primary means of cooling. Pumped refrigerant systems provide isolation between the primary heat removal system and IT equipment. The direct air and indirect air methods rely on the outdoor conditions as the primary means cooling making them more efficient for mild climates. The information in this paper allows IT professionals to be more involved in the specification of precision cooling solutions that better align with IT objectives.


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## Introduction

Data center heat removal is one of the most essential yet least understood of all critical IT environment processes. As the latest computing equipment becomes smaller and uses the same or even more electricity than the equipment it replaced, more heat is being generated in data centers. Precision cooling and heat rejection equipment is used to collect and transport this unwanted heat energy to the outside atmosphere.

 [Link to resource](#)  
**White Paper 11**

*Explanation of Cooling and Air Conditioning Terminology for IT Professionals*

This paper explains the 13 cooling technologies and their components designed to transport heat energy from the IT environment to the outside atmosphere. The information presented here is a foundation allowing IT professionals to successfully manage the specification, installation, and operation of IT environment cooling systems. For definitions of various terms used throughout this paper, see White Paper 11, *Explanation of Cooling and Air Conditioning Terminology for IT Professionals*.

 [Link to resource](#)  
**White Paper 57**

*Fundamental Principles of Air Conditioners for Information Technology*

### How air conditioners work

White Paper 57, *Fundamental Principles of Air Conditioners for Information Technology* provides information regarding the nature of heat in the IT environment, operation of the refrigeration cycle, and the basic functionality of precision cooling devices and outdoor heat rejection equipment.

### Cooling architectures

A cooling architecture is fundamentally described by:

1. A particular heat removal method (the subject of this paper)
2. A particular air distribution type
3. The location of the cooling unit that directly supplies cool air to the IT equipment

These three elements are briefly described below, along with their white paper references, in order to provide context around the entire data center cooling system.

#### Heat removal


Heat removal is the subject of this paper.

#### Air distribution


This is a very important part of the cooling system as air distribution to IT equipment greatly affects its overall performance. White Paper 55, *The Different Types of Air Distribution for IT Environments* describes the nine basic ways air is distributed to cool IT equipment in data centers and network rooms.

#### Location of the cooling unit

The cooling unit is defined in this paper as the device that provides cool supply air to the IT equipment. There are four basic cooling unit locations. In general, the cooling unit is separate from the other heat rejection system devices. In some cases, the entire cooling architecture is “containerized” and located outdoors adjacent to the data center. The location of the cooling unit plays a significant role in data center design including overall cooling efficiency, IT power density (kW / rack), and IT rack space utilization. For more information see White paper 130, *The Advantages of Row and Rack-Oriented Cooling Architectures for Data Centers*.

 [Link to resource](#)  
**White Paper 55**

*The Different Types of Air Distribution for IT Environments*

 [Link to resource](#)  
**White Paper 130**

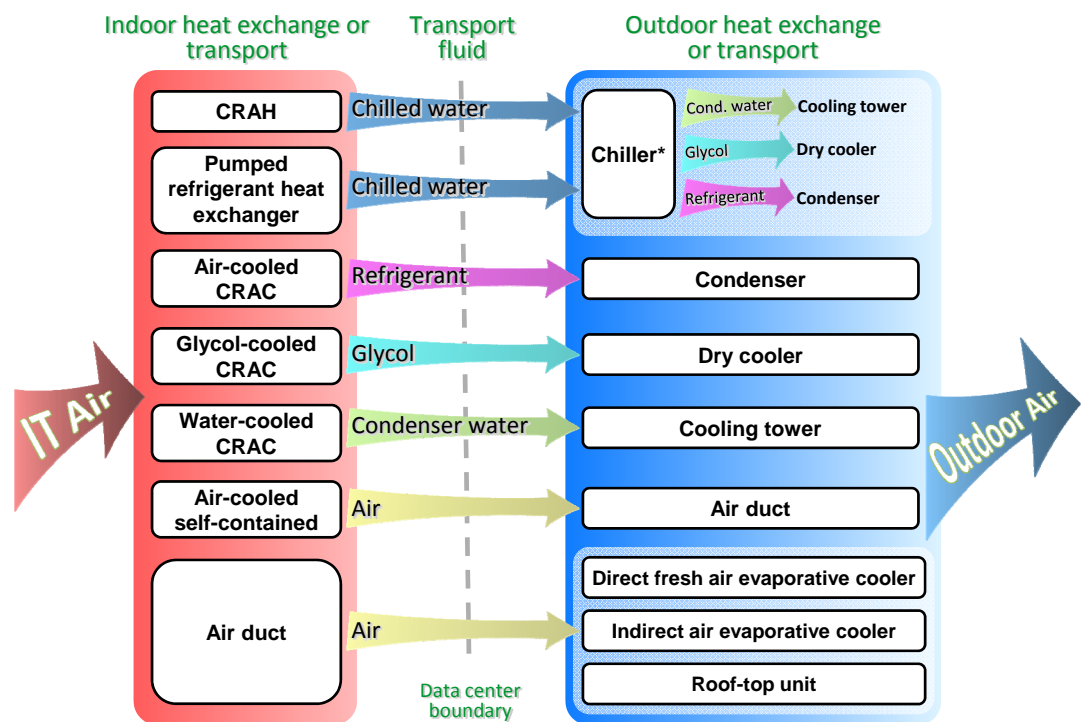
*The Advantages of Row and Rack-Oriented Cooling Architectures for Data Centers*

## Heat removal methods

There are 13 fundamental heat removal methods to cool the IT environment and transport unwanted heat energy from IT equipment to the outdoors. One or more of these methods are used to cool virtually all mission critical computer rooms and data centers. Some heat removal methods relocate the components of the refrigeration cycle away from the IT environment and some add additional loops (self-contained pipelines) of water and other liquids to aid in the process.

One can think of heat removal as the process of “moving” heat energy from the IT space to the outdoors. This “movement” may be as simple as using an air duct as a means to “transport” heat energy to the cooling system located outdoors. However, this “movement” is generally accomplished by using a **heat exchanger** to transfer heat energy from one fluid to another (e.g. from air to water). **Figure 1** simplifies the 13 heat removal methods by illustrating two major heat energy “movement” points - indoor and outdoor. The “Transport fluid” in between the indoor and outdoor hand off points represents the fluid (liquid or gas) that carries the heat energy between the two points. Note that there may be more than one heat exchange occurring indoors, as in the case of the Glycol-cooled CRAC (i.e. *Computer Room Air Conditioner*), or outdoors, as in the case of the chiller. Also note that each of these systems may be configured to operate in an economizer mode. The following sections provide a detailed look at the systems that incorporate these methods and describe the individual heat energy transfers.

**Figure 1**  
Simplified breakdown of the 13 fundamental heat removal methods



\* Note that in some cases the chiller is physically located indoors.

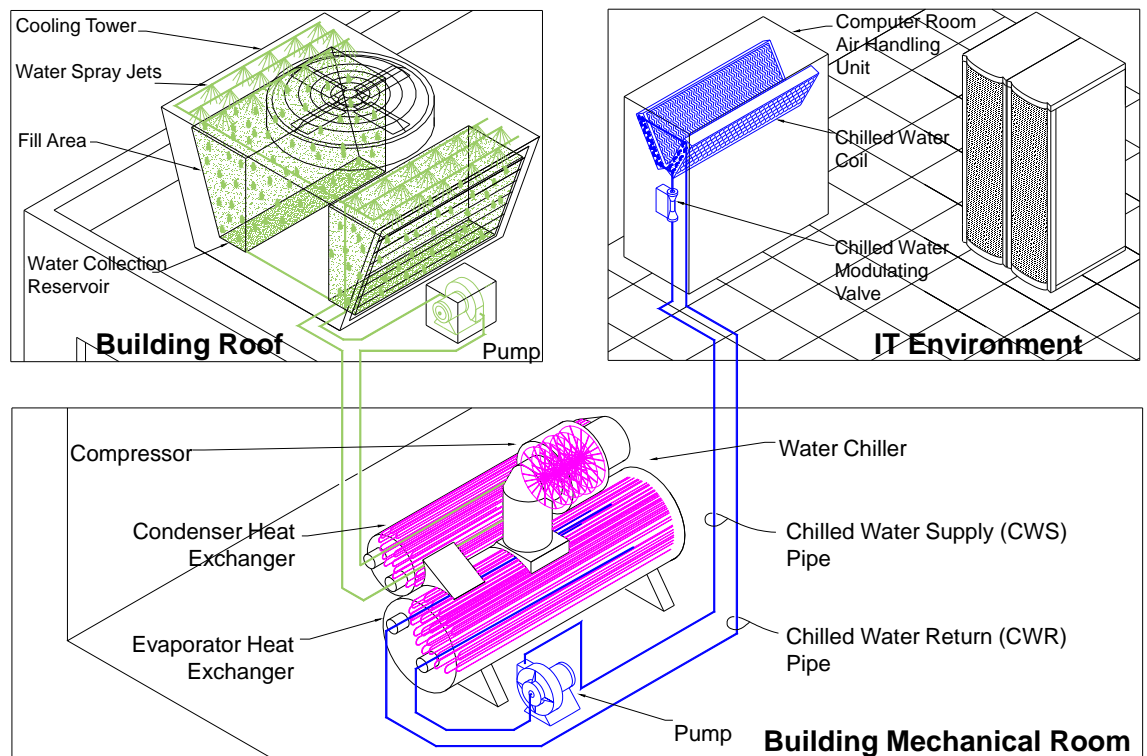
### Chilled water system

The first row in **Figure 1** depicts a *computer room air handler* (also known as a *CRAH*) joined together with a chiller. This combination is generally known as a chilled water system. In a chilled water system the components of the refrigeration cycle are relocated from the computer room air conditioning systems to a device called a *water chiller* shown in **Figure 2**. The function of a chiller is to produce *chilled water* (water refrigerated to about 8-15°C [46-59°F]). Chilled water is pumped in pipes from the chiller to the CRAH units located in the IT

environment. Computer room air handlers are similar to computer room air conditioners in appearance but work differently. They cool the air (remove heat) by drawing warm air from the computer room through *chilled water coils* filled with circulating chilled water. Heat removed from the IT environment flows out with the (now warmer) chilled water exiting the CRAH and returning to the chiller. The chiller then removes the heat from the warmer chilled water and transfers it to another stream of circulating water called condenser water which flows through a device known as a cooling tower.

As seen in **Figure 2**, a cooling tower rejects heat from the IT room to the outdoor environment by spraying warm condenser water onto sponge-like material (called *fill*) at the top of the tower. The water spreads out and some of it evaporates away as it drips and flows to the bottom of the cooling tower (a fan is used to help speed up the evaporation by drawing air through the fill material). In the same manner as the human body is cooled by the evaporation of sweat, the small amount of water that evaporates from the cooling tower serves to lower the temperature of the remaining water. The cooler water at the bottom of the tower is collected and sent back into the condenser water loop via a pump package.

Condenser water loops and cooling towers are usually not installed solely for the use of water-cooled computer room air conditioning systems. They are usually part of a larger system and may also be used to reject heat from the building's comfort air conditioning system (for cooling people).



**Figure 2**

*Water-cooled chilled water system*

There are three main types of chillers distinguished by their use of water or air to reject heat

- With **water-cooled chillers**, heat removed from the returning chilled water is rejected to a condenser water loop for transport to the outside atmosphere. The condenser water is then cooled using a cooling tower - the final step in rejecting the heat to the outdoors. The chilled water system in **Figure 2** uses a water-cooled chiller. **Figure 3** shows an example of a water-cooled chiller and a cooling tower. Water-cooled chillers are typically located indoors.

Water-cooled Chiller



Cooling Tower



Figure 3

Example of a water-cooled chiller (left) and cooling tower (right)

Link to resource  
**White Paper 163**  
 Containerized Power and Cooling Modules for Data Centers

**> Dry vs. fluid? cooler vs. condenser?**

What's the difference between air-cooled condensers and, dry-coolers, and fluid-coolers? This terminology raises many questions and is a source of confusion for many and is briefly explained here. First, all three terms describe a heat exchanger; similar to the radiator in a car with a fan that blows air through the radiator. In all cases, air (no water) is used to cool the fluid running through the coils, so one can say all three heat exchangers are "dry". The key difference is the type of fluid that flows inside. The fluid inside a "condenser" is "refrigerant". The fluid inside both a "dry" and "fluid cooler" is "glycol". So why two "cooler" names to describe this? Because some heat exchangers spray water into the air stream to boost cooling i.e. evaporative cooling. A fluid cooler that uses "wet" evaporative cooling is called an evaporative fluid cooler. Perhaps this is why the term "dry" cooler is used because it's clear that there is no evaporative cooling used.

- **Glycol-cooled chillers** look identical to water-cooled chillers. With glycol-cooled chillers, heat removed from the returning chilled water is rejected to a glycol loop for transport to the outside atmosphere. The glycol flows via pipes to an outdoor-mounted device called a *dry cooler* also known as a *fluid cooler* (see sidebar). Heat is rejected to the outside atmosphere as fans force outdoor air through the warm glycol-filled coil in the dry cooler. Glycol-cooled chillers are typically located indoors.
- With **air-cooled chillers**, heat removed from the returning chilled water is rejected to a device called an *air-cooled condenser* that is typically integrated with the chiller. This type of chiller is known as a packaged chiller and can also be integrated into a cooling facility module. White paper 163, *Containerized Power and Cooling Modules for Data Centers*, discusses facility modules. **Figure 4** shows an example of an air-cooled chiller. Air-cooled chillers are typically located outdoors.

Advantages

- Chilled water CRAH units generally cost less, contain fewer parts, and have greater heat removal capacity than CRAC units with the same footprint.
- Chilled water system efficiency improves greatly with increased data center capacity
- Chilled water piping loops are easily run very long distances and can service many IT environments (or the whole building) from one chiller plant.
- Chilled water systems can be engineered to be extremely reliable.
- Can be combined with economizer modes of operation to increase efficiency. Designing the system to operate at higher water temperatures 12-15°C [54-59°F]) will increase the hours on economizer operation.

Disadvantages

- Chilled water systems generally have the highest capital costs for installations below 100 kW of electrical IT loads.
- Introduces an additional source of liquid into the IT environment.

Usually used

- In data centers 200 kW and larger with moderate-to-high availability requirements or as a high availability dedicated solution. Water-cooled chilled water systems are often used to cool entire buildings where the data center may be only a small part of that building.

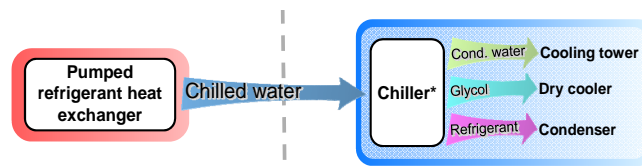
Figure 4

Example of an air-cooled chiller





## Pumped refrigerant for chilled water systems

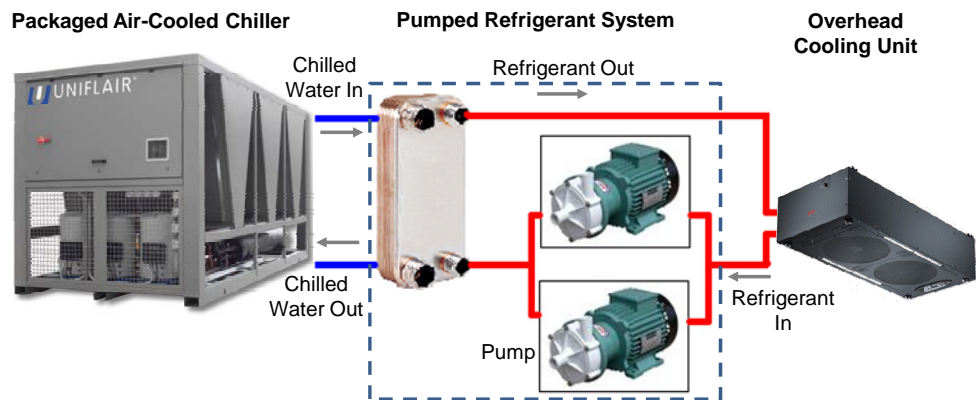


The second row in **Figure 1** depicts a pumped refrigerant heat exchanger joined together with a chiller. This combination is generally known as a pumped refrigerant system for chilled water systems. Concerns regarding availability and the drive toward higher densities have led to the introduction of pumped refrigerant systems within the data center environment. These systems are typically composed of a heat exchanger and pump which isolate the cooling medium in the data center from the chilled water. However, the system could also isolate other cooling liquids such as glycol.

Typically these pumped refrigerant systems use some form of refrigerant (R-134A) or other non-conductive fluids like Fluorinert that is pumped through the system without the use of a compressor. **Figure 5** shows an example of a pumped refrigerant system connected to a packaged air-cooled chiller using an overhead cooling unit. Chilled water is pumped in pipes from the chiller to a heat exchanger which transfers the heat from the pumped refrigerant. The colder refrigerant returns to the cooling unit to absorb more heat and returns again to the heat exchanger.

**Figure 5**

*Example schematic drawing of a pumped refrigerant system connected to chilled water*



### Advantages

- Keeps water away from IT equipment in chilled water applications
- Oil-less refrigerants and non-conductive fluids eliminate risk of mess or damage to servers in the event of a leak.
- Efficiency of cooling system due to close proximity to servers or direct to chip level.

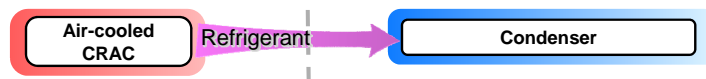
### Disadvantages

- Higher first cost as a result of adding additional pumps and heat exchangers into the cooling system.

### Usually Used

- These systems are usually used for cooling systems that are closely coupled to the IT equipment for applications like row and rack based high density cooling.
- Chip Level Cooling where coolant is piped directly to the server

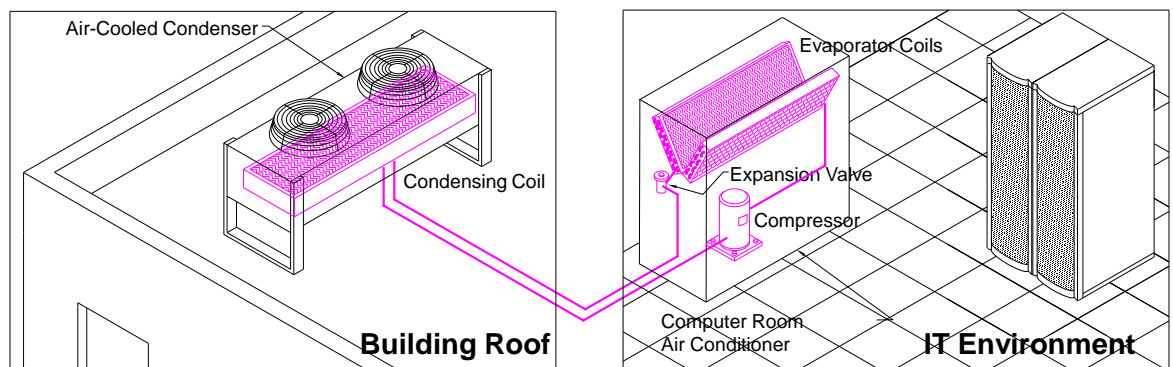
## Air-cooled system (2-piece)



The third row in **Figure 1** depicts an air-cooled CRAC joined together with a condenser. This combination is generally known as an air-cooled CRAC DX system. The “DX” designation stands for direct expansion and although this term often refers to an air-cooled system, in fact any system that uses refrigerant and an evaporator coil can be called a DX system.

Air-cooled CRAC units are widely used in IT environments of all sizes and have established themselves as the “staple” for small and medium rooms. In an air-cooled 2-piece system, half the components of the refrigeration cycle are in the CRAC and the rest are outdoors in the air-cooled condenser as shown in **Figure 6**. Refrigerant circulates between the indoor and outdoor components in pipes called refrigerant lines. Heat from the IT environment is “pumped” to the outdoor environment using this circulating flow of refrigerant. In this type of system the compressor resides in the CRAC unit. However, the compressor may alternatively reside in the condenser. When the compressor resides in the condenser the correct term for the condenser is *condensing unit*, and the overall system is known as a *split system*. **Figure 7** shows an example of an air-cooled 2-piece DX system.

**Figure 6**  
Air-cooled DX system  
(2-piece)



### Advantages

- Lowest overall cost
- Easiest to maintain

### Disadvantages

- Refrigerant piping must be installed in the field. Only properly engineered piping systems that carefully consider the distance and change in height between the IT and outdoor environments will deliver reliable performance.
- Refrigerant piping cannot be run long distances reliably and economically.
- Multiple computer room air conditioners cannot be attached to a single air-cooled condenser.

### Usually used

- In wiring closets, computer rooms and 7-200kW data centers with moderate availability requirements.

**Figure 7**

Example of Air-cooled DX system (2-piece)



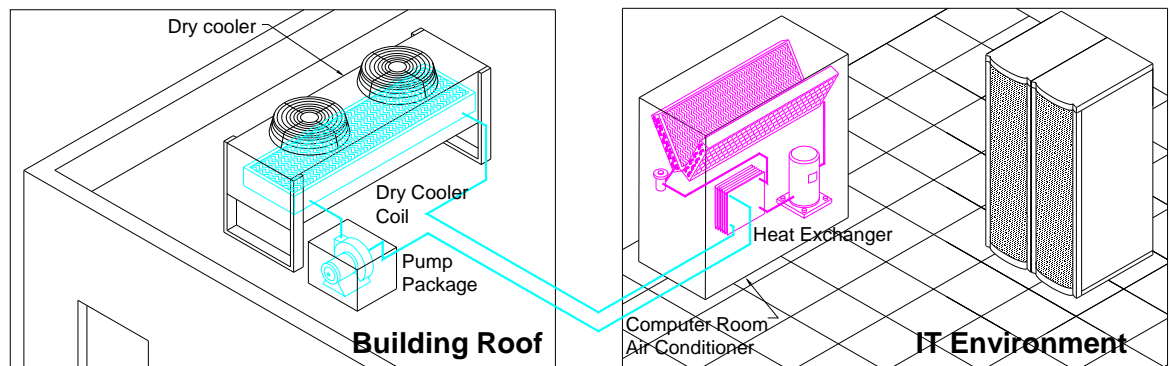
**Glycol-cooled system**



The fourth row in **Figure 1** depicts a glycol-cooled CRAC joined together with a dry cooler. This combination is generally known as a glycol-cooled system. This type of system locates all refrigeration cycle components in one enclosure but replaces the bulky condensing coil with a much smaller *heat exchanger* shown in **Figure 8**. The heat exchanger uses flowing glycol (a mixture of water and ethylene glycol, similar to automobile anti-freeze) to collect heat from the refrigerant and transport it away from the IT environment. Heat exchangers and glycol pipes are always smaller than condensing coils found in 2-piece air-cooled systems because the glycol mixture has the capability to collect and transport much more heat than air does. The glycol flows via pipes to a dry cooler where the heat is rejected to the outside atmosphere. A pump package (pump, motor, and protective enclosure) is used to circulate the glycol in its loop to and from the glycol-cooled CRAC and dry cooler. A glycol-cooled system is very similar in appearance to the equipment in **Figure 7**.

**Figure 8**

Glycol-cooled system



Advantages

- The entire refrigeration cycle is contained inside the CRAC unit as a factory-sealed and tested system for highest reliability with the same floor space requirement as a two piece air-cooled system.
- Glycol pipes can run much longer distances than refrigerant lines (air-cooled split system) and can service several CRAC units from one dry cooler and pump package.
- In cold locations, the glycol within the dry cooler can be cooled so much (below 10°C [50°F]) that it can bypass the heat exchanger in the CRAC unit and flow directly to a specially installed *economizer coil*. Under these conditions, the refrigeration cycle is turned off and the air that flows through the economizer coil, now filled with cold flowing glycol, cools the IT environment. This economizer mode, also known as “*free cooling*”, provides excellent operating cost reductions when used.



Disadvantages

- Additional required components (pump package, valves) raise capital and installation costs when compared with air-cooled DX systems.
- Maintenance of glycol volume and quality within the system is required.
- Introduces an additional source of liquid into the IT environment.

Usually used

- In computer rooms and 30-1,000 kW data centers with moderate availability requirements.

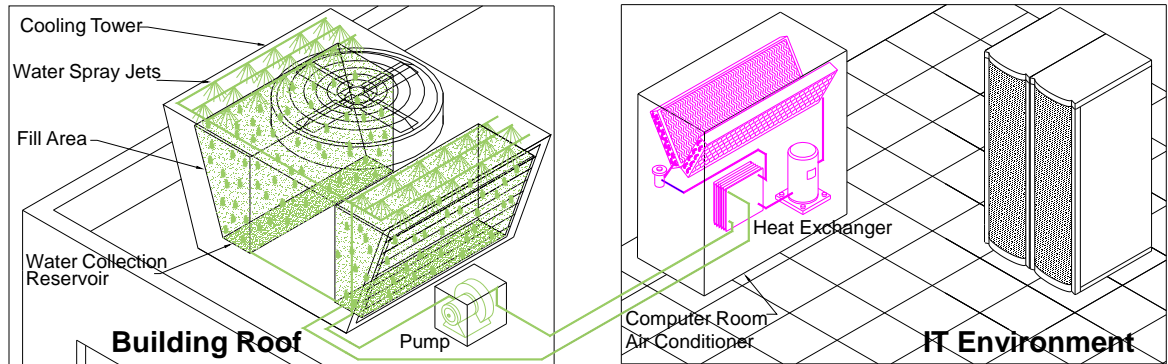
**Water-cooled system**



The fifth row in **Figure 1** depicts a water-cooled CRAC joined together with a cooling tower. This combination is generally known as a water-cooled system. Water-cooled systems are very similar to glycol-cooled systems in that all refrigeration cycle components are located inside the CRAC. However, there are two important differences between a glycol-cooled system and a water-cooled system:

- A water (also called *condenser water*) loop is used instead of glycol to collect and transport heat away from the IT environment
- Heat is rejected to the outside atmosphere via a cooling tower instead of a dry cooler as seen in **Figure 9**.

**Figure 9**  
Water-cooled system



Advantages

- All refrigeration cycle components are contained inside the computer room air conditioning unit as a factory-sealed and tested system for highest reliability.
- Condenser water piping loops are easily run long distances and almost always service many computer room air conditioning units and other devices from one cooling tower.
- In leased IT environments, usage of the building's condenser water is generally less expensive than chilled water (chilled water is explained in the next section).

Disadvantages

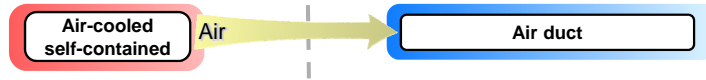
- High initial cost for cooling tower, pump, and piping systems.
- Very high maintenance costs due to frequent cleaning and water treatment requirements.
- Introduces an additional source of liquid into the IT environment.

- A non-dedicated cooling tower (one used to cool the entire building) may be less reliable than a cooling tower dedicated to the computer room air conditioner.

Usually used

- In conjunction with other building systems in data centers 30kW and larger with moderate-to-high availability requirements.

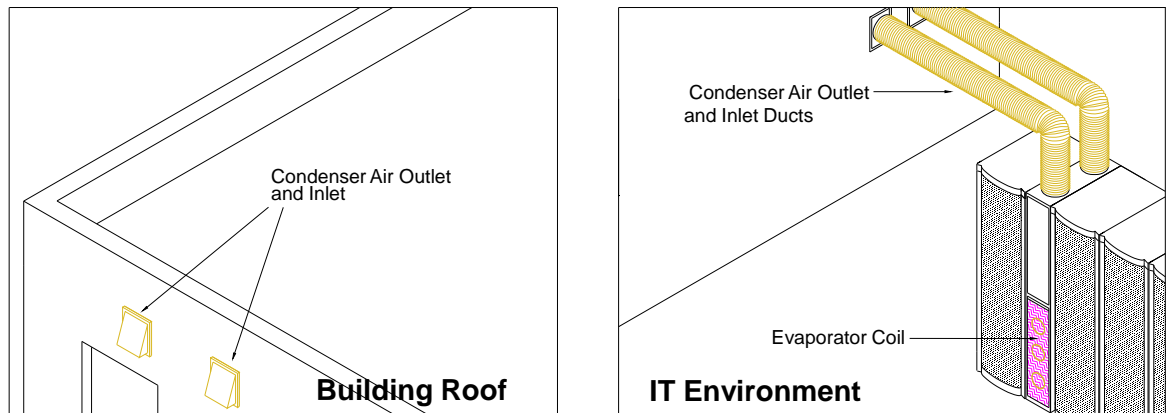
**Air-cooled self-contained system (1-piece)**



The sixth row in **Figure 1** depicts an air-cooled self-contained air conditioning unit joined together with an air duct. This combination is generally known as an air-cooled self-contained system. Self-contained systems locate all the components of the refrigeration cycle in one enclosure that is usually found in the IT environment. Heat exits the self-contained system as a stream of hot (about 49°C [120°F]) air called exhaust air. This stream of hot air must be routed away from the IT room to the outdoors or into an unconditioned space to ensure proper cooling of computer equipment as illustrated in **Figure 10**.

If mounted above a drop ceiling and not using condenser air inlet or outlet ducts, the hot exhaust air from the condensing coil can be rejected directly into the drop ceiling area. The building's air conditioning system must have available capacity to handle this additional heat load. Air that is drawn through the condensing coil (becoming exhaust air) should also be supplied from outside the computer room. This will avoid creating a vacuum in the room that would allow warmer, unconditioned air to enter. Self-contained indoor systems are usually limited in capacity (up to 15kW) because of the additional space required to house all the refrigeration cycle components and the large air ducts required to manage exhaust air. Self-contained systems that mount outdoors on a building roof can be much larger in capacity but are not commonly used for precision cooling applications. **Figure 11** shows an example of an air-cooled self-contained system.

**Figure 10**  
Indoor air-cooled self-contained system



Advantages

- Indoor self-contained systems have the lowest installation cost. There is nothing to install on the roof or outside the building except for the condenser air outlet.
- All refrigeration cycle components are contained inside one unit as a factory-sealed and tested system for highest reliability.

Disadvantages

- Less heat removal capacity per unit compared to other configurations.

- Air routed into and out of the IT environment for the condensing coil usually requires ductwork and/or dropped ceiling.
- Some systems can rely on the building HVAC system to reject heat. Issues can arise when the building HVAC system shuts down in the evening or over the weekend.

Usually used

- In wiring closets, laboratory environments and computer rooms with moderate availability requirements.
- Sometimes used to fix hot spots in data centers.

**Air cooled self contained**



**Portable Self Contained Cooling Unit**



**Figure 11**

Examples of indoor air-cooled self-contained system

**> Evaporative cooling**

Evaporative cooling is the process of spraying water onto a surface or into the airstream, which evaporates and cools the air passing across the surface or spray stream. This is the same cooling effect you feel when leaving a swimming pool. The water evaporating from the skin cools the body.

The evaporative effect enables all “dry” cooling systems including the direct and indirect “economizer modes” to be used more hours of the year by enabling the system to leverage the wet-bulb temperature of the outdoor air (see wet vs. dry bulb side bar below). In dryer climates the wet bulb temperature is substantially lower than the dry bulb temperatures. For example, in Phoenix, AZ (USA) when the outdoor dry bulb temperature is 110F (43.3 C) the wet bulb temperature can be 70 F (21.1C). As a result, using a direct evaporative cooling system air could effectively be cooled to 70F without the use of compressors thereby saving significant energy costs.

**Direct fresh air evaporative cooling system**

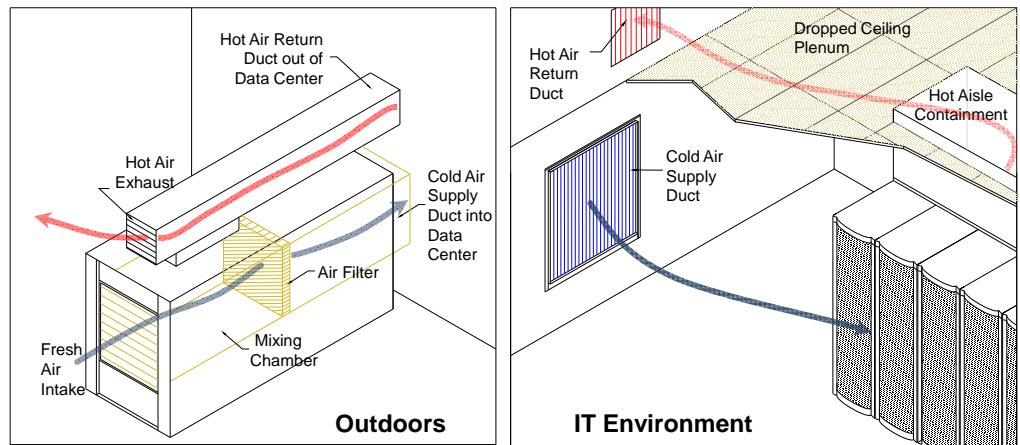


The seventh row in **Figure 1** depicts an air-duct joined together with a direct fresh air evaporative cooler. This combination is generally known as a direct fresh air evaporative cooling system, sometimes referred to as direct air. A direct fresh air economizer system uses fans and louvers to draw a certain amount of cold outdoor air through filters and then directly into the data center when the outside air conditions are within specified set points. Louvers and dampers also control the amount of hot exhaust air that is exhausted to the outdoors and mixed back into the data center supply air to maintain environmental set points (see **Figure 12**). The primary mode of operation for this cooling method is “economizer” or “free cooling mode” and most systems use a containerized DX air-cooled system as back-up. Although supply air is filtered, this does not completely eliminate fine particulates such as smoke and chemical gases from entering the data center.

This heat removal method is normally used with evaporative cooling whereby the outside air also passes through a wet mesh material before entering the data center (see side bar). Note that using evaporative assist increases the data center humidity because the direct fresh air into the data center passes over the evaporative medium bringing the air to saturation which minimizes the effectiveness of this method for data center applications. Evaporative assist is most beneficial in dry climates. For more humid climates, such as Singapore, evaporative assist should be evaluated based on ROI (return on investment). **Figure 13** shows an example of a direct fresh air evaporative cooling system.

**Figure 12**

Example of a direct air evaporative cooling system



Advantages

- All cooling equipment is placed outside the data center, allowing for white space to be fully utilized for IT equipment.
- Significant cooling energy savings in dry climates (e.g. 75%) compared to systems with no economizer mode.

Disadvantages

- May be difficult to retrofit into an existing data center.
- Subject to frequent filter changes in locations with poor air quality.
- Evaporative cooling contributes to humidity in the data center.

Usually used

- In 1,000kW data centers and larger with high power density.

**Figure 13**

Example of a direct fresh air evaporative cooling system

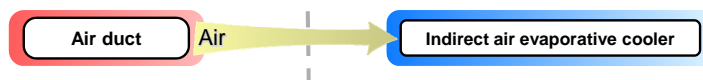


**> Dry Bulb vs. Wet Bulb Temperature?**


The dry bulb temperature is the temperature of air shown on a standard thermometer.


The web bulb temperature is the temperature of air shown on a wet thermometer as water vapor evaporates from it. The difference between Wet Bulb and Dry Bulb temperatures is a way historically used to determine humidity. Today direct measurement of humidity using electrical sensors causes this terminology to be obsolete.

**Indirect air evaporative cooling system**



The eighth row in **Figure 1** depicts an air-duct joined together with an indirect air evaporative cooler. This combination is generally known as an indirect air evaporative cooling system, sometimes referred to as indirect air. Indirect air evaporative cooling systems use outdoor air to indirectly cool data center air when the temperature outside is lower than the temperature set point of the IT inlet air, resulting in significant energy savings. . This “economizer mode or free cooling” of operation is the primary mode of operation for this heat removal method although most do use a containerized DX air-cooled system as back-up. Fans blow cold outside air through an air-to-air heat exchanger which in turn cools the hot data center air on the other side of the heat exchanger, thereby completely isolating the data center air from the outside air. Heat exchangers can be of the plate or rotating type. Like indirect air, this heat

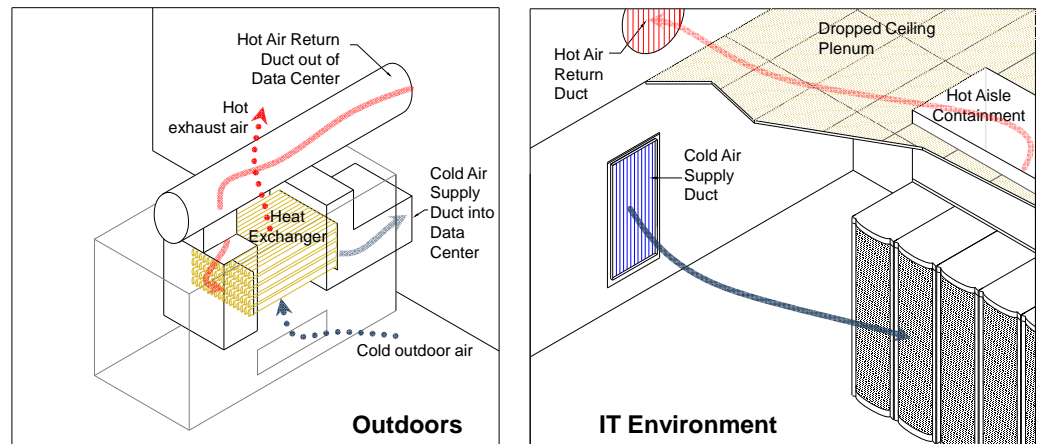
 [Link to resource](#)  
**White Paper 132**  
*High Efficiency Economizer-based Cooling Modules for Large Data Centers*

 [Link to resource](#)  
**White Paper 136**  
*High Efficiency Economizer-based Cooling Modules for Large Data Centers*

removal method normally uses evaporative assist whereby the outside of the air-to-air heat exchanger is sprayed with water which further lowers the temperature of the outside air and thus the hot data center air. **Figure 14** provides an illustration of an indirect air evaporative cooling system that uses a plate heat exchanger with evaporative assist. **Figure 15** shows an example of a complete cooling system with this type of heat rejection method.

Indirect air evaporative cooling systems provide cooling capacities up to about 1,000kW. Most units are roughly the size of a shipping container or larger. These systems mount either on a building roof or on the perimeter of the building. Some of these systems include an integrated refrigeration cycle that works in conjunction with an economizer mode. For more information on this heat removal method see White Paper 132, *Economizer Modes of Data Center Cooling Systems* and White Paper 136, *High Efficiency Economizer-based Cooling Modules for Large Data Centers*.

**Figure 14**  
*Indirect air economizer system*



Advantages

- All cooling equipment is placed outside the data center, allowing for white space to be fully utilized for IT equipment.
- Significant cooling energy savings in most climates (e.g. 75%) compared to systems with no economizer mode.

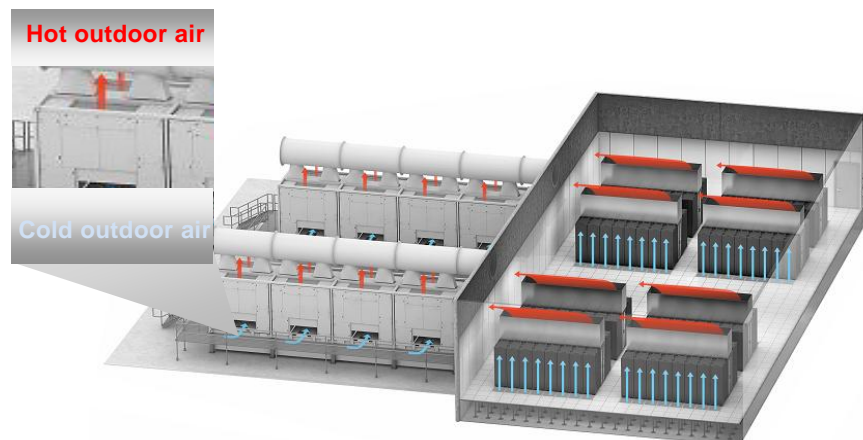
Disadvantages

- May be difficult to retrofit into an existing data center.

Usually used

- In 1,000kW data centers and larger with high power density.

**Figure 15**  
*Example of an indirect air evaporative cooling system*



## Self-contained roof-top system



The ninth row in **Figure 1** depicts an air-duct joined together with a self-contained roof-top unit. This combination is generally referred to as a roof-top unit (RTU). These systems are not a typical cooling solution for new data centers. Roof-top units are basically the same as the air-cooled self-contained system described above except that they are located outdoors, typically mounted on the roof, and are much larger than the indoor systems. Roof-top units can also be designed with a direct fresh air economizer mode. **Figure 16** shows an example of a roof-top unit.

### Advantages

- All cooling equipment is placed outside the data center, allowing for white space to be fully utilized for IT equipment.
- Significant cooling energy savings in mild climates compared to systems with no economizer mode.

### Disadvantages

- May be difficult to retrofit into an existing data center.

### Usually used

- In data centers that are part of a mixed-use facility.



**Figure 16**

*Self-contained roof-top system*

## Cooling system options

Numerous options are available to facilities and IT professionals when specifying cooling solutions. Use the following guide in conjunction with the equipment manufacturer's technical literature. Note that options may vary based on the size and type of the solution considered.


**Airflow direction** - Large floor-mounted systems flow air in a downward direction (down flow) or an upward direction (up flow) and some can even flow horizontally (horizontal flow).

- Use a down flow system in a raised floor environment or in a non-raised floor environment when system is mounted on a pedestal.
- Use an up flow system in an existing up flow environment
- Horizontal flow systems should be considered for IT consolidations and IT environment renovations using a hot/cold aisle configuration.

**Fire, smoke, and water detection devices** provide early warning and/or automatic shut off during catastrophic events.

Use recommended in all units. Use mandatory if required by local building codes. Best used in conjunction with IT monitoring and building management systems for quickest notification.



 [Link to resource](#)  
**White Paper 58**  
*Humidification Strategies for Data Centers and Network Rooms*

**Humidifiers** are commonly located inside precision cooling devices to replace water vapor lost in the cooling process and are used to prevent IT equipment downtime due to static electrical discharge. See White Paper 58, *Humidification Strategies for Data Centers and Network Rooms* for more information on humidifiers and their functions.

- Use a humidifier in all computer room air conditioners and air handlers unless the room has a properly functioning vapor barrier and central humidification system. The room must have no current high or low humidity-related problems.

**Reheat systems** actually add heat to conditioned cold air exiting a precision cooling device to allow the system to provide increased dehumidification of IT environment air when it's required.

- Use a reheat system for rooms in warm, humid climates or in rooms with poor or non-existent vapor barriers.

**Economizer** coils use glycol to cool the IT environment in a manner similar to a chilled water system when the glycol stream is cold enough. It provides excellent operating cost reductions when used.

- Use in conjunction with glycol-cooled units in cold climates.
- Use if required by local building codes (Pacific Northwest region of USA).

**“Multi-cool”** coils enable the use chilled water to be used in addition to the air-cooled, glycol-cooled or condenser water-cooled DX system.

- Use if building chilled water is available but is unreliable or is frequently turned off.

## Conclusion

The 13 basic heat removal methods for data centers are primarily differentiated in the way they physically reside in the IT environment and in the way they collect and transport heat to the outside atmosphere. All of the 13 heat rejection methods possess advantages and disadvantages that cause them to be preferred for various applications. The decision on which heat rejection method to specify should be based on the uptime requirements, power density, geographic location, physical size of the IT environment to be protected, the availability and reliability of existing building systems, and the time and money available for system design and installation. IT professionals versed in precision cooling components and heat removal methods can more effectively work with cooling professionals to ensure the specification of optimized cooling solutions that meet IT objectives.



### About the author

**Tony Evans** is a Director of Systems Engineering with Schneider Electric. As part of the Federal Sales Management Team he consults internationally on risk assessment and design practices to optimize the availability and efficiency of data center environments. He holds a Bachelor of Science Degree in Mechanical Engineering from the University of Rhode Island. Tony is a retired military officer and aviator. He has worked in various technical and sales roles and has more than 20 years of experience in power and cooling system design.



## Resources

Click on icon to link to resource



**Explanation of Cooling and Air Conditioning Terminology for IT Professionals**

White Paper 11



**Economizer Modes of Data Center Cooling Systems**

White Paper 132



**High Efficiency Economizer-based Cooling Modules for Large Data Centers**

White Paper 136



**Containerized Power and Cooling Modules for Data Centers**

White Paper 163



**The Implications of Cooling Unit Location on IT Environments**

White Paper 130



**Fundamental Principles of Air Conditioners for Information Technology**

White Paper 57



**Air Distribution Architecture Options for Mission Critical Facilities**

White Paper 55



**Humidification Strategies for Data Centers and Network Rooms**

White Paper 58



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