



*How We See It: Informal Explainer*

# CHILLING OUT:

How and Why Data Centres Use (or Don't Use) Water

October 2025

# TABLE OF CONTENTS

EXECUTIVE SUMMARY	3
1 INTRODUCTION	4
2 DATA CENTRE COOLING SYSTEMS	5
2.1 Closed loop systems	5
2.2 Evaporative, ‘wet” and open loop systems in the data hall	8
2.3 Liquid cooling	9
2.4 Free cooling	10
3 NON-COOLING-RELATED WATER USE IN DATA CENTRES	11
3.1 Humidifiers	11
3.2 Fire suppression	11
3.3 Domestic and staff wellbeing functions	11
4 WATER USE IN COOLING: SUSTAINABILITY CONSIDERATIONS	12
5 COOLING OPTIONS: WATER CONSUMPTION READY RECKONER	13
6 ANNEXES	14
6.1 Annexe I: Death by Terminology	14
6.2 Annexe II: ASHRAE Envelopes	14
6.3 Annexe III: CRAH Units – Computer Room air handlers explained	15
6.4 Annexe IV: Quick Glossary and Jargon buster	16
7 CONTACTS FOR FURTHER INFORMATION	17
8 FURTHER READING	17

## EXECUTIVE SUMMARY

This document explains why and how data centres use water. It focuses primarily on cooling systems, which are the main driver of water consumption in these facilities. It outlines the most common approaches to cooling and examines the implications for sustainability and water stewardship.

Fundamentally, cooling systems involve several components: a *heat source*, a *heat transfer system* to move heat away from the source, a *transport medium* to “hold” the heat while it is removed, and a *heat rejection system* which removes the heat from the building. All approaches to cooling involve these components in one form or another. In data centres the heat source is the server, the motherboard or the chip, the transport medium can be air, water, dielectric fluid or coolant. The transfer system can be closed loop or open loop and there are multiple options for heat rejection (see Annexe I)

Data centre cooling solutions usually involve one or more of the following systems in various combinations: closed loop cooling, open loop cooling, evaporative cooling, dry cooling, liquid cooling and free cooling.

Closed loop systems are heat transfer systems that constantly recirculate the cooling medium (usually water and glycol). So they depend on being filled with water but they do not consume it as part of the cooling process. Think of a domestic central heating system which pipes water from boiler to radiators, or the blood circulating around your body. A closed loop system like this tends to be called a ‘dry’ system. These systems usually rely on mechanical chillers which need energy to run.

In contrast, evaporative or “adiabatic” systems are considered to be “wet” as they cool by means of water evaporation, which removes heat in a way that is very energy efficient, but which consumes relatively large amounts of water. Think about sitting in a hot room – you can either turn on an electric fan and stay cool, or you can sweat, and if you sweat a lot you have to drink water to replenish the fluid that has evaporated from your skin. Using the fan – the equivalent of a dry system - means your skin stays nice and cool and dry but you do use electricity.

Liquid cooling is less widely deployed but gaining traction. Despite the name, this approach doesn't consume water – it refers to the fact that these systems use liquid, not air, to cool the servers, or parts thereof. Approaches include immersion, where the motherboard is submerged in a bath of dielectric fluid, and direct to chip (DTC) where a miniature closed loop system transfers heat from the processor into the circulating fluid. Free cooling uses only ambient air or water without the need for mechanical chillers. Back to our analogy, this is the equivalent of opening a window, wrapping a wet towel around your head or putting your feet in a basin of cold water.

The target temperature that is required in the data hall is critical in determining how we cool our facilities: loosely speaking, if the target temperature is higher and/or the external temperature is lower, we have more cooling options at our disposal.

Other uses of water – for humidifiers, fire suppression, and staff facilities – are minor. Choosing the most sustainable approach to cooling is a complex process that depends on carefully balancing multiple factors and taking into account environmental conditions and resource constraints associated with each specific location. These may change over time and retrofitting older data centres to reflect changes in technologies or circumstances is often constrained by cost, technical complexity, and client requirements.

# 1 INTRODUCTION

Data centres are often thought of as clean, abstract places full of humming servers. But like most modern infrastructure, data centres have physical needs. One of the most important is cooling. That's because servers — the individual computers that data centres use to do their work — produce heat.

An easy way to imagine how much heat a data centre can produce is to think about your own computing experience. You might sometimes use a computer for some processing-intensive task, like playing graphics-heavy games or editing holiday videos. Or sometimes you might simply have a lot of applications open at once. Either way, you probably notice the device gets warm as it works hard. Now imagine thousands of computers — servers in a data centre — all operating at that temperature. They are stacked on top of each other in racks, and they're all in one room (a 'data hall'). They are going to generate a lot of heat.

If that heat isn't moved away quickly and efficiently, it won't be long before the servers overheat and fail. The goal of any data centre cooling system is to carry heat away from the servers and reject it somewhere harmless, usually into the outside air. The more efficiently heat can be removed, the more efficiently the building operates as a whole.

Computing hardware is also sensitive to changes in humidity, so conditions must be kept within defined ranges. These limits are known as *operating envelopes*, and the limits for temperature and humidity are defined by industry standards such as the ASHRAE guidelines (see Annexe II).

There are multiple ways to stay within the ASHRAE envelope, but they have four things in common. They all have the same *heat source* — the computing hardware. They all have a *heat transfer system* to remove heat from the servers and a *transport medium* to "hold" the heat while it is being moved from place to place. Finally a *heat rejection system* removes the heat from the building altogether. However, how these elements are delivered varies — for instance the transport medium could be air, water, refrigerant or synthetic fluid. The heat transfer system could be open loop, closed loop, evaporative, dry, liquid or free. The approach also depends on how cool the data hall has to be (the *target temperature*), external (*ambient*) temperature, availability of power and water, customer requirements and the operator's policies.

Data centre cooling has recently attracted negative and often inaccurate coverage in the media, associating the industry with very high levels of water use. In fact, a data centre's water consumption depends entirely on how it is cooled, so it's worth understanding how those systems work. In discussing them, we're going to use the terminology commonly adopted in the sector. It is important to note, though, that there is a tendency to apply technical terms (such as 'adiabatic') somewhat loosely from the perspective of a mathematician or physicist, and even within the industry we occasionally use the same terminology to mean different things.

Data centre cooling is complex and highly technical. In this document we explain a selection of typical approaches, but in reality there are multiple variations and combinations and the technology is evolving all the time, so it's important to be aware that we have simplified where necessary. This is after all an explainer, not a manual.

## 2 DATA CENTRE COOLING SYSTEMS

A data centre cooling system must remove heat from the servers (the heat source), and then transport that heat away, firstly out of the immediate data hall environment and subsequently out of the building. This often involves transferring the heat from one carrier to another in relays, a bit like the old fashioned Pony Express or stagecoach, but instead of passing mail or passengers across to another rider or coach for the next leg, it is heat that is being transported. However, some approaches do it all in one go, cutting out the need for handover stations, as we will explain.

### 2.1 Closed loop systems

A closed loop cooling system works like a domestic central heating system in reverse. The radiators and pipes in your home are filled with a fluid (water) which circulates, transporting heat from where it is generated (the boiler) to where it is needed (the radiator next to your sofa). In data centres, the system does a similar job, but in this case the pipes of water are removing heat (taking it from the server to outside the data hall), not delivering it.

This approach actually relies on separate circulatory systems interacting with each other through heat exchangers (see figure). A heat exchanger is a mechanism for transferring heat between two fluids (liquid or gas – yes, a gas is considered a fluid for this purpose!) without them coming into direct contact.

Commonly, the first of these circulatory systems uses air flows to remove heat from the servers. Controlled streams of air warm up as they pass through the racks of servers. This warm air is directed towards large heat exchangers called CRAH units – Computer Room Air Handlers (see Annexe III for how a CRAH works).

The CRAH units transfer the heat from the air to a separate, closed loop system through which cold water circulates. Hot air enters the CRAH unit, is cooled, then leaves the unit to recirculate through the server racks again. Cold water enters the CRAH unit, absorbs heat from the air and takes that heat with it out of the data hall (see Fig 1).

Now the heat is away from the servers and out of the data hall, the next stage gets the heat from the water in the closed loop out of the building. This is usually called *heat rejection*. Before the (now warm) water heads back to the CRAH unit to repeat the process and cool some more air coming from the servers, the heat it carries needs to be removed from this water and ejected (rejected) from the building in some way.

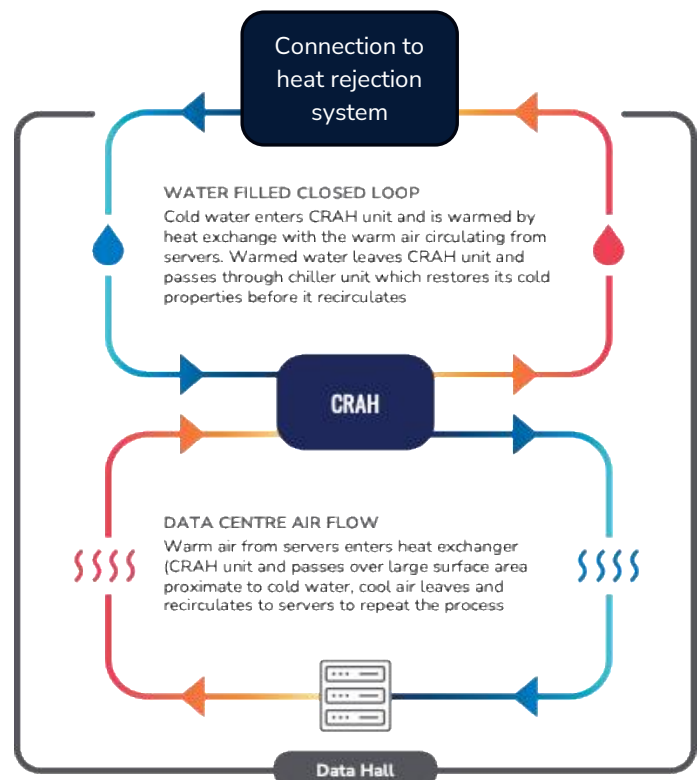


Fig 1: how closed loop systems commonly work

It is at this point (the third loop at the top of our diagram – the heat rejection system) that the water credentials of a closed loop data centre cooling system can vary significantly, because operators have a choice about how to remove the heat from the water in the closed loop and expel it from the building. Some of the options involve the use of additional water. In simple terms, there are three approaches:

1. **“Dry” cooling:** this uses fans to blow cool air over the warmed water in the closed loop and/or a mechanical chiller and refrigerant to cool the water. Most systems use both – relying just on fans to pump the air most of the time (free cooling) and only using mechanical chillers on hotter days (Fig 2). This approach uses no water but is more energy intensive than the options below.

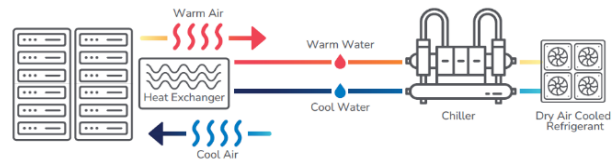


Fig 2: The three stages of closed loop system

2. **Evaporative cooling using cooling towers:** Cooling towers are specially constructed to maximise surface area to facilitate evaporation. They are very energy efficient but relatively water intensive. They minimise the use of chillers and refrigerants. Fans blow air across a large surface area of water which then evaporates. The evaporating water removes heat from the circulating water. In fact there are different types of cooling tower, closed loop and open loop (now you know why everyone gets so confused all the time!). Where the evaporating water is the same as the circulating water it is called an open loop cooling tower because that circulating water is evaporated and therefore lost to the system. Where the circulating water and evaporating water are separate then it is a closed loop cooling tower because the circulating water is contained. Some cooling towers are designed in such a way that they can alternate between dry and evaporative modes and are often referred to as ‘hybrid’. For the purposes of comparison though, all you need to know is that cooling towers use evaporation for heat rejection, and therefore consume lots of water (Fig 3).

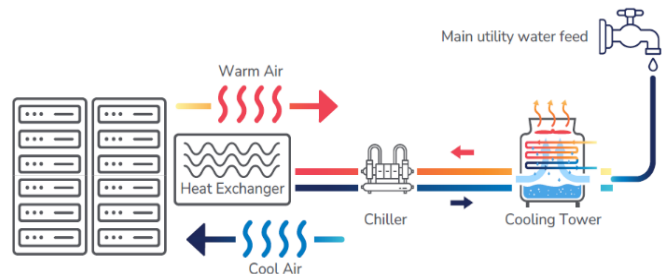


Fig 3: Cooling Towers – note reduced chiller size

3. **Evaporative or ‘Adiabatic’ Assisted cooling:** this tends to restrict the use of water to very hot days to reduce load on the chillers (which in turn means that the facility can be run with less mechanical chiller capacity than you would need for a fully dry system). In this case a fine spray of water is directed to the airflow of the chiller, cooling it by evaporation and significantly reducing the chiller workload. Water consumption depends on how often the adiabatic assistance is deployed: if it is restricted to just the hottest days, then annual water consumption can be very modest. (Fig 4).

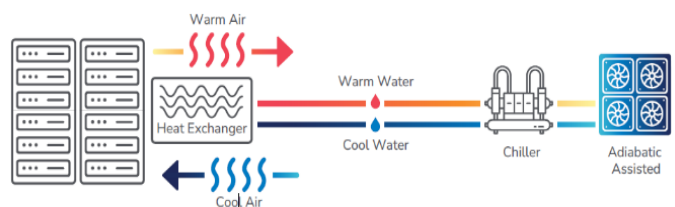


Fig 4: Adiabatic assisted cooling

## A note on water consumption when the data hall system is a closed loop system

So a closed loop cooling system in a data centre is only considered to be 'dry' if the heat rejection system is dry as well as the data hall system. A data centre using closed loop dry cooling in the data hall but adopting adiabatic assisted or evaporative heat rejection is not 'dry' – though it may be more energy efficient.

And just to reiterate, because this point is so frequently misunderstood....although a closed loop cooling system is filled with water, and depends on water to operate, it does not consume water in operation. Just like a domestic heating system, once a closed loop cooling system has been initially charged, its ongoing water consumption is negligible. Typically it only needs occasional topping up, rather as you might top up your heating system when you bleed a radiator. For a more familiar example think about your body's circulatory system, which pumps blood around through tubes of varying size. It's very important that we keep this system closed and try to avoid cuts and bruises which respectively lead to external and internal blood loss. As such, this method of cooling is classed as low consumption. Water is used, but not used up.

Water is used in these systems not because it's cheap or convenient, but because it's good at the job. Its thermal properties – high specific heat capacity, low viscosity – make it excellent for moving heat around. That's why water is the main transport system in almost all living things.

### BOX 1: WHAT IS EVAPORATIVE OR ADIABATIC COOLING?

Within the data centre sector the terms *evaporative* and *adiabatic* tend to be used interchangeably, although strictly speaking they do not mean the same thing. Either way, what happens is that a warm airstream is cooled by passing heat energy to water and by doing so vaporises that water.

Evaporative cooling is very efficient because this phase change of water (from liquid to gas) rapidly removes heat from the air. This is because changing matter from one state to another needs a lot of energy to break the connections between molecules and enable them to move around freely: So it takes much more heat energy to evaporate water from liquid to gas - even though the temperature change is minimal - than it takes to raise the temperature of the same volume of water say from 1°C to 100°C. Evaporative cooling is the reason why your calves feel cool after you've been paddling on a breezy day at the seaside — the seawater evaporating from the surface of your skin takes a lot of energy with it.

This type of cooling is what people are usually thinking of when they raise concerns about water use in data centres. Evaporative or adiabatic cooling is highly energy efficient – far more so than traditional air conditioning – but does consume water in large volumes.

In data centres the deployment of evaporative cooling is not limited to the heat rejection system: evaporative cooling can also be used in the data hall itself. In these circumstances, the need for separate heat rejection is usually dispensed with. All this is explained below.

## 2.2 Evaporative, ‘wet’ and open loop systems in the data hall

A ‘wet system’ is the term generally used to describe a data centre that uses evaporative cooling. As mentioned above, evaporative techniques can be used in heat transfer systems in the data hall as well as at the point of heat rejection. Even though evaporative cooling actually uses air to remove heat from the servers, like the closed loop systems we have already looked at, we use the term ‘wet’ because water is consumed continually as a function of the cooling process: the water that cools the air is evaporated and therefore lost to the system. The term ‘open loop’ is sometimes applied for this exact reason. Some of these systems dispense with the water-filled closed loop within the data hall, and also do not require any heat rejection system, because the water vapour carries the heat out of the building with it. This means that they don’t need chillers, refrigerants or any of the infrastructure associated with them. Again, the terms evaporative and adiabatic are sometimes used interchangeably. There are two main types of ‘wet’ system used within the data hall.

### Direct Evaporative/“adiabatic” cooling

In this system, air from outside is drawn towards the servers through an absorption unit (essentially a large, water-soaked cellulose pad). This cool, humid air moves through the data hall, absorbs heat from the servers and leaves the data hall through vents. Humidity is introduced into the data hall but does not build up because the warm air is ejected, carrying the vapour with it. So the air is not recirculated within the data hall (although these systems typically do have an external air circulation system before it enters to data hall to ensure the air is not too cold or to remove external contamination like particulates). This approach is water intensive but energy efficient, and has no need of mechanical chillers or heat rejection but it does rely on expensive filters. These systems don’t necessarily use water all the time – if the external air temperature is low enough, water can be switched off.

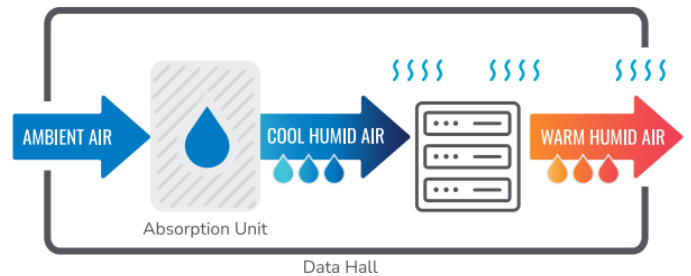


Fig 5: Direct evaporative cooling

### Indirect evaporative / “adiabatic” cooling

The indirect approach uses separate air streams. Air is drawn in from outside, cooled through an absorption unit and then driven through a heat exchanger. The cool, moist air absorbs heat from warm air coming from the servers and warms up. This moist, warmed air is ejected from the data hall, but the dry, cooled air is recirculated within the data hall to repeat the process. Again, this approach is water intensive. There is no need for chillers, refrigerants or heat rejection, so it is highly energy efficient. This system can also run dry if external temperatures are low enough.

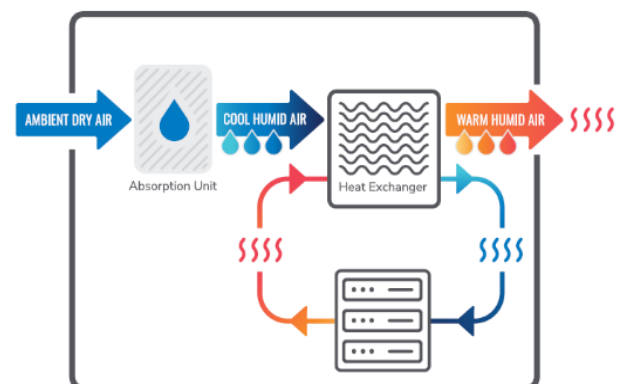


Fig 6: Indirect evaporative cooling

## 2.3 Liquid cooling

Liquid cooling' is a bit of a misnomer and has caused widespread misunderstanding. The process, despite its name, does not consume water. The term is used because liquid, not air, is the medium that removes heat from the servers. Liquid cooling systems provide an alternative first step within a closed loop system, replacing the more traditional air stream that channels heat from server to CRAH unit. In simple terms (because there are many variants) there are two main approaches to liquid cooling: immersion cooling and direct to chip ('DTC') cooling.

### Immersion cooling

The motherboard of the server is immersed in dielectric fluid (i.e. a fluid that does not conduct electricity). The fluid absorbs and removes the heat from the servers. It has several advantages: it reduces the need for cooling infrastructure; the waste heat product is more easily reusable in other applications, and servers can be packed more densely, because the immersive liquid is inherently more efficient as a heat carrier than air. Disadvantages include the weight of the units, which, among other problems, can make retrofitting tricky when trying to introduce this form of cooling into existing data centres. Water is not used for immersive purposes for the obvious reason that water and electronics are a poor mix.



Fig 7: Immersive Cooling

### Direct to chip or DTC cooling

This approach introduces a tube into the server. The tube is filled with a liquid – usually water plus a coolant – and snakes around the processing unit, which is the hottest part of the server. Heat is transferred away via an adjacent 'cold plate' (a tiny heat exchanger). In essence, this works like a miniature closed loop cooling system. The water used is recirculated, not consumed. The advantages of a DTC system are that it is easier to retrofit than the immersive approach, and it targets the points in the data centre where most heat is generated. However, a limited amount of ancillary air cooling is still needed to deal with other heat sources. It is also less space-efficient than immersion cooling.

In both immersion and DTC cooling, the heat transport system that removes heat from the servers is a closed loop system like the first system we looked at. As we said, the difference is that liquid, not air, is the medium that removes heat initially. And the same process of heat rejection still needs to take place, just as it does in conventional closed loop systems. However, liquid cooled systems can run at higher temperatures than air cooled systems. This means that less cooling is needed at the heat rejection stage, and the system is thus more energy efficient.



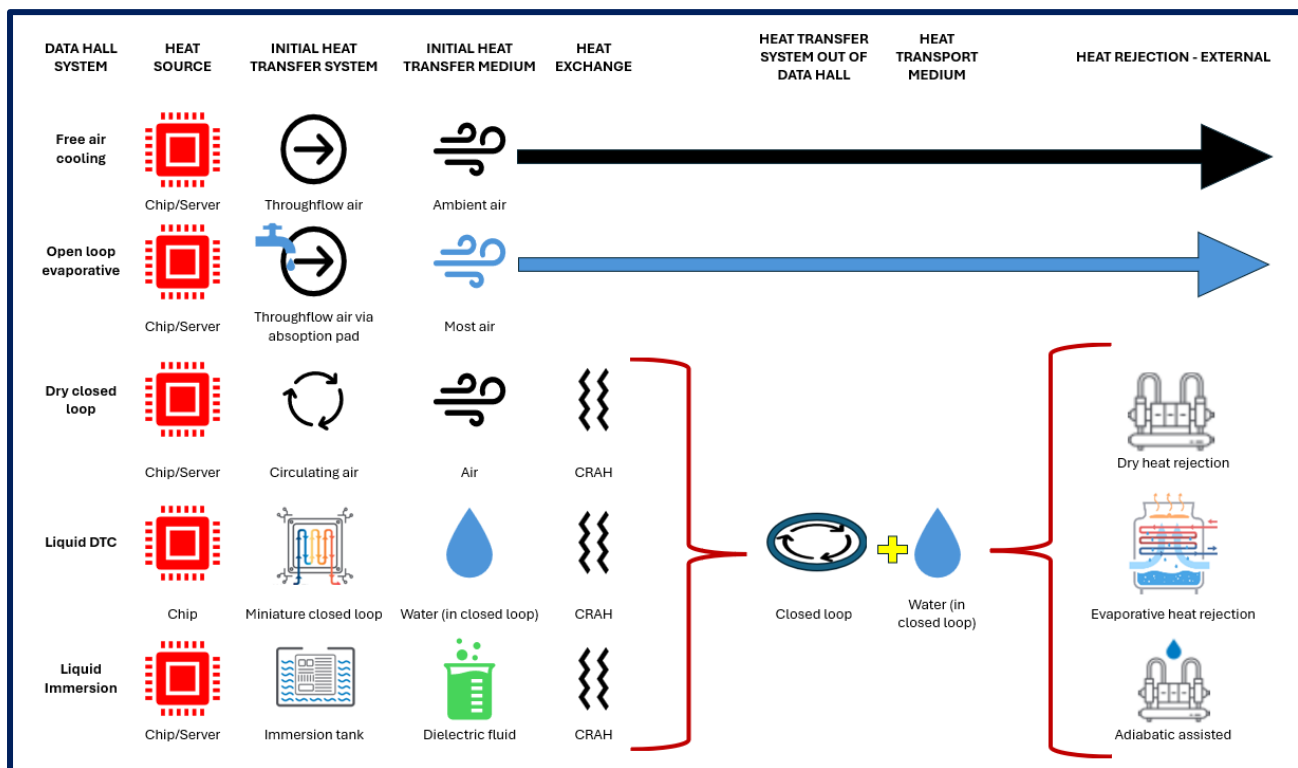
Fig 8: Direct to chip

## 2.4 Free cooling

Some modern facilities use free cooling. This is any method (air or water based) that avoids mechanical refrigeration<sup>1</sup> and relies only on fans and/or pumps. Free cooling can be extremely efficient. There are multiple approaches to free cooling – and include ground source, using (and restoring) water to a dock, canal, or aquifer, or any other suitable body of cold water to remove heat from the closed loop via a heat exchanger. Free cooling can also be achieved by exporting waste heat to a local heat network. All year round free air cooling relies on cool ambient temperature and good air quality so is more feasible in lower latitudes – eg Scandinavia<sup>2</sup>. A high density data centre in southern Spain, for example, will struggle to cool itself with fresh air alone. However, the geographies in which free cooling is feasible may expand as new servers with higher heat tolerances become available – the higher the target temperature in the data hall, the more likely it is that it can be achieved by free cooling alone. On the contrary, if ambient temperatures increase due to climate change these zones may contract. To date, however, server tolerances have outpaced external changes.

Also, the fact that liquid cooling systems run at higher temperatures than air cooled systems means there is greater scope to adopt free cooling for heat rejection in liquid cooled systems because less cooling is needed to restore target temperatures.

Fig 9: Data centre cooling options – sample approaches



<sup>1</sup> There are different definitions of free cooling in the industry. Some consider that evaporative cooling is free cooling provided that no mechanical chilling is used to cool the water. Others prefer a narrower definition that excludes evaporative systems and limits this approach to one that either passes ambient air through the data centre, passes the closed loop through an external body of water or which takes water from an external body of water and returns it to where it came from without consuming it.

<sup>2</sup> Before you ask, building all our data centres in Scandinavia isn't a realistic solution, because many data centres need to be in reasonable proximity to their customers – see our separate explainer about the locational attributes of data centres.

## 3 NON-COOLING-RELATED WATER USE IN DATA CENTRES

At this point it's worth mentioning that all data centres necessarily use some water, whether or not it's involved in cooling. Typical activities that consume water, but which are not associated with cooling, are summarised below.

### 3.1 Humidifiers

As mentioned above, computing equipment is sensitive to extremes of humidity, so operators install humidifiers (and de-humidifiers) to keep the humidity within acceptable levels. Servers are surprisingly tolerant of high humidity, but low humidity is problematic, because static charges can build up and cause short-circuiting. Humidifiers are installed during data centre construction as a matter of course, in order to ensure that the servers keep working even in extreme conditions. However, in the UK the actual use of these humidifiers is rare, since we don't generally encounter very dry conditions.

### 3.2 Fire suppression

Fire suppression systems are installed in all data centres, and operators maintain storage tanks of water on site for sprinkler systems. These tanks may occasionally be refreshed to maintain water quality – sediment or biological growth can block sprinkler systems. However, the probability of this water being used for its intended purpose is extremely low.

### 3.3 Domestic and staff wellbeing functions

Data centre employees need workplace facilities like kitchens, showers and toilets. Landscaped areas outside a data centre may need occasional watering, although most are designed for minimal watering or rainwater reuse. Water usage for these purposes is consistent with other office spaces.

## 4 WATER USE IN COOLING: SUSTAINABILITY CONSIDERATIONS

As we can see, there are multiple ways to cool a data centre — and the list above is by no means exhaustive. Many of these approaches involve water to varying degrees. Choosing between them is a question of balancing resources: energy use, water availability, climate, cost and operational preference.

Water based systems are not inherently wasteful or unsustainable. A data centre in an energy constrained location that has plentiful water will be able to operate very efficiently with an evaporative cooling system and this design would therefore accommodate local conditions better than a dry system, especially if the facility has access to industrial or other non-potable water supplies (for instance sea water evaporation has been used successfully in coastal regions). As we saw above, wet systems remove the need for chillers, coolants, pipework and their associated embedded energy, all of which should be factored in when thinking about a data centre's overall impact.

The decision becomes considerably more complex when you increase your system boundaries to include the water used in generating power and the power used in treating and delivering water.

There are two further considerations that we can't ignore: firstly, energy efficiency has tended to be the dominant consideration for data centres and not just from an industry perspective: legislation has sometimes encouraged data centre operators to be energy efficient at the expense of other sustainability credentials and this has pushed up water use in some locations<sup>3</sup>. There is also a historical element: there was a period, less than a decade ago, when wet systems were considered to be the most sophisticated approach to cooling. As a result, they were installed in some facilities as a state-of-the-art solution because of their energy credentials. But technology in the data centre industry changes very fast, so things have moved on. Servers, for instance, have become tolerant of much larger temperature and humidity ranges (see the discussion of ASHRAE envelopes in Annexe II) which can change the ways we compare different approaches.

The big problem here is that changing the cooling system in an existing data centre is a very significant retrofitting exercise. A data centre must keep running all the time – you can't just switch bits off while you re-engineer the infrastructure, like you can cone off lanes of motorways for repairs. Retrofitting may also require significant structural changes – replacing an evaporative system with a chiller-based system, for example, means you have to find space for lots of new, very heavy equipment. That might mean upgrading the whole building to increase floor loading levels. Colocation providers (who build and operate the infrastructure that houses servers belonging to other organisations) also have to get approval from their customers before implementing major changes like these.

---

<sup>3</sup> In Germany the EnEg requires operators to meet such challenging energy efficiency targets that many are having to consider water intensive systems. In the UK the Climate Change Agreement targets are encouraging the same behaviour in seeking gains in energy efficiency that are otherwise unachievable.

## 5 COOLING OPTIONS: WATER CONSUMPTION READY RECKONER

COOLING TECHNOLOGY ADOPTED	DATA HALL SYSTEMS	HEAT REJECTION	PROS AND CONS	ENERGY IMPACT	WATER IMPACT
Closed loop data hall system with mechanical chillers for heat rejection.			No water consumed but less energy efficient, more chillers and chemical refrigerants are needed. Perfect solution for areas suffering water stress.		
Closed loop data hall system with mechanical chillers and evaporative assistance for heat rejection.			Water consumption variable depending on the external temperature at which the operator deploys the evaporative boost. This reduces chiller workload at peak times and improves energy efficiency.		
Closed loop data hall system with evaporative cooling tower for majority of heat rejection.			Significant water consumption for heat rejection. While chillers are still needed, the evaporative system significantly reduces chiller workload, so is more energy efficient. This approach is appropriate for locations where water is plentiful.		
Direct evaporative system passes air through the data hall (in one side and out of the other) using absorption pads to generate cool moist air through phase change.		Integral	Water intensive during hot periods but very energy efficient. No need for mechanical chillers, coolants or closed loop infrastructure. Humidity is introduced into the data hall, but does not build up because the warm air is ejected, carrying vapour with it.		
Indirect evaporative data hall system using absorption pad, dual air flow and heat exchanger, so humid air flow is expelled but dry air recirculates.		Integral	Moderately water intensive but very energy efficient. Humidity is not introduced into the data hall as it is contained in a separate air stream. The dry air is recirculated. No need for mechanical chillers, chemical coolants or closed loop infrastructure.		
Liquid cooling: Immersion: motherboards are immersed in tanks of dielectric fluid, mechanical chillers for heat rejection.			Can support denser computing activity and waste heat is higher grade. However retrofitting can be tricky because of the additional weight, plus the fluids need careful handling. Heat rejection tends to be more efficient with liquid cooling because the liquid needs less cooling. The chiller-only approach is water free, making this system 'dry'.		
Liquid cooling: Immersion: motherboards are immersed in tanks of dielectric fluid with chillers and evaporative assistance for heat rejection.			Can support denser computing activity and waste heat is higher grade. However retrofitting can be tricky because of the additional weight, plus the fluids need careful handling. Heat rejection water use depends on operator choice, but liquid cooling is more efficient at this stage than other systems.		
Liquid cooling: Immersion: motherboards are immersed in tanks of dielectric fluid with cooling tower for bulk of heat rejection.			Can support denser computing activity and waste heat is higher grade. However retrofitting can be tricky because of the additional weight, plus the fluids need careful handling. Although liquid cooling needs less heat rejection, cooling towers are still water intensive (but energy efficient).		
Liquid cooling - Direct to chip: Fluid is piped around the processor to remove heat, with heat rejection by mechanical chiller.			Miniature closed loop targets the hottest component, waste heat is higher grade than warm air and retrofitting is easier. However, the approach needs space and ancillary cooling of other heat sources. Liquid cooling is less demanding of heat rejection, so more efficient at this stage. This chiller-only approach is 'dry'.		
Liquid cooling - Direct to chip: Fluid is piped around the processor to remove heat with chillers and evaporative assistance for heat rejection.			Miniature closed loop targets the hottest component, waste heat is higher grade than warm air and retrofitting is easier. However, the approach needs space and ancillary cooling of other heat sources. Liquid cooling is less demanding of heat rejection, so more efficient at this stage.		
Liquid cooling - Direct to chip: Fluid is piped around the processor to remove heat with cooling tower for bulk of heat rejection.			Miniature closed loop targets the hottest component, waste heat is higher grade than warm air and retrofitting is easier. However, the approach needs space and ancillary cooling of other heat sources. Again, liquid cooling is less demanding of heat rejection, so more efficient at this stage.		
Direct free air cooling: Ventilation and fans draw in cool external air and circulate it before expelling it.		Integral	This is a very energy efficient and water efficient system, but all-year-round free air cooling is only possible in certain locations where temperatures are low and air quality is high. No need for coolant or mechanical chillers.		
Free water cooling – this uses an external body of water, and usually a heat exchanger to cool the water in the closed loop.		Integral	This is very energy efficient and water efficient (the external water used to cool the closed loop is not consumed but returned to source) but relies on an adjacent cold water body. No need for coolant or mechanical chillers.		

**IMPORTANT:** These approaches summarise the main cooling options available to data centre operators, but, in reality, that choice is complicated by multiple minor variations. Novel approaches like liquid cooling are constantly evolving, and slightly different approaches are being developed, tested and refined all the time. As such, this chart does not attempt to give a comprehensive picture of all the options in detail.

# 6 ANNEXES

## 6.1 Annexe I: Death by Terminology

Much of the confusion around data centre cooling systems comes from misunderstanding and misapplying terminology. It doesn't help that we don't always use terms correctly or even logically in the sector. Liquid cooling for instance doesn't consume water as a function of cooling and dry cooling often depends on water, albeit contained in a closed loop. It's not surprising that people get confused. Let's look at the terms open loop and closed loop which seem to generate a disproportionate level of confusion.

An open loop system is an evaporative system where water is consumed as a function of cooling and therefore lost to the system. In simple terms you are running water into a system that allows it to escape, like leaving the plug out of the bath. (Only water is used in open loop systems because nobody wants synthetic fluids or refrigerants to escape – these substances are always contained in sealed systems.)

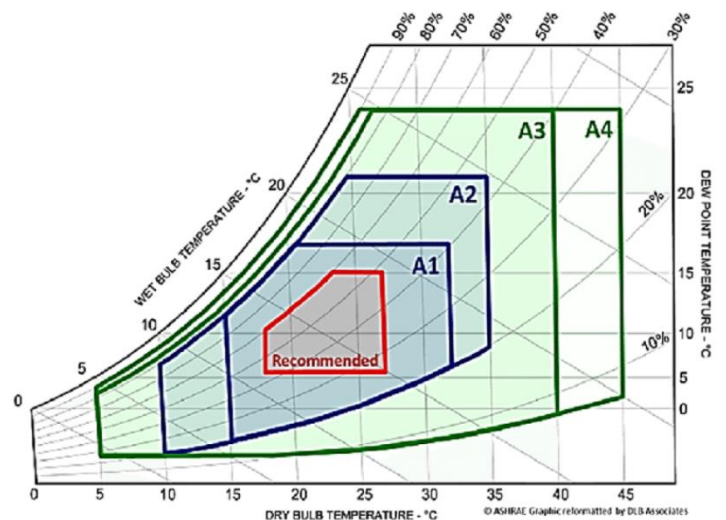
However, while all open loop systems are evaporative / wet, not all evaporative systems are open loop. Some wet systems include the use of a closed loop – for instance indirect evaporative cooling or hybrid heat rejection.

In contrast, a closed loop system transports heat by recirculating water indefinitely within sealed pipework – in one location on the loop, water absorbs heat, at another it discharges it. So a closed loop system does not consume water as a function of the cooling process but it does depend on water. Again there is the confusing part: While all dry systems are closed loop, not all closed loop systems are dry: at the heat rejection stage some cooling towers include a closed loop heat transfer system and a separate body of water is evaporated to absorb the heat.

The human body provides a good analogy for open loop and closed loop cooling: let's compare sweat and blood. When we sweat, we evaporate water from our skin to help cool us but we have to keep drinking water if we want to keep cool by sweating. This water is lost to the system – like an open loop evaporative cooling system. Conversely, our blood circulates through a complex but closed system of blood vessels within our body. Blood should not escape from this system and if it does, it's bad news.

## 6.2 Annexe II: ASHRAE Envelopes

ASHRAE stands for the American Society of Heating, Refrigerating and Air Conditioning Engineers. This illustration is called an ASHRAE psychrometric chart. It may look impenetrable but it has long been both useful and iconic in the industry. Without worrying too much about the detail, the irregular pentagons are known as ASHRAE envelopes and they indicate the maximum



ASHRAE temperature guidelines showing the recommended and allowable ranges

and minimum temperatures and humidities that should be applied in a data centre. These limits are based on formal agreements with the server manufacturers who will warrant (guarantee) the computing hardware to perform normally within these ranges.

The recommended envelope, with the most restricted ranges, indicates the target temperature for normal operation. Larger envelopes indicate allowable ranges that are acceptable under special circumstances, or for limited periods of time. If the environment strays outside these ranges, then the computing equipment warranties may be void.

Over time, the ASHRAE envelopes for computer servers have expanded as server tolerances, especially for higher temperatures, have increased. This means that less cooling is needed in the data hall, which in turn makes it more likely that options like free cooling can be deployed. However, while this improves efficiency, there is a limiting point where, even if the servers are happy operating at high temperatures, our data centre staff will not be, so the conditions need to be suitable for humans as well as hardware.

See also: [2021 ASHRAE Thermal Guidelines for Data Processing Environments](#)

### 6.3 Annexe III: CRAH Units – Computer Room air handlers explained

The combination of air flow, closed loop water flow and CRAH unit work on the same principle as the human body. We're familiar with the way that our lungs work. Lungs are basically pumps that draw air in and out of the body. The air drawn into the lungs enters the alveoli, where surface area is maximized so that oxygen can be passed from the lungs into the blood and carbon dioxide passed from the blood to the lungs. Air is then expelled taking waste gases with it before the next breath starts the process all over again. The air has to be expelled because there is no point breathing back in the carbon dioxide you have just gone to the trouble of removing. The blood in your veins and the air in your lungs are always separated by thin membranes.

A CRAH unit is a heat exchanger. It works in a remarkably similar way to the alveoli in your lungs. It is an integral part of the closed loop system so the water circulates through it but remains sealed in. It has a very high surface area, usually in the form of fins or coils, through which cold water passes at the same time as hot air from the servers is sucked over the surface. The close proximity and large surface area enables heat to be transferred from air to water while both are in motion. Cool air and warm water leave the CRAH unit and thus, it has done its job as a heat exchanger because heat has been transferred from one medium (air) to another (water). This warmed water continues its journey round the closed loop until it gets outside the data hall.

The same principle of high surface area for efficient gaseous exchange in the lungs is true for heat exchange in the CRAH unit.

## 6.4 Annexe IV: Quick Glossary and Jargon buster

This list is just for quick reference – all these terms are explained in more detail in the preceding pages.

Term	Short description
Adiabatic cooling	A form of evaporative cooling using phase change of water to absorb heat. The term often refers to releasing a fine spray of water over a warm air stream.
Ambient air	Outside air, or air coming from the external environment
ASHRAE envelope	The ranges of temperature and humidity within which server manufacturers warrant their equipment to operate reliably.
BREEAM	Building Research Establishment Environmental Assessment Method, assesses and certifies the environmental sustainability of buildings.
Chiller	Heat exchanger that transfers heat from one fluid to another, usually from liquid in a closed loop to liquid in another closed loop, generally using mechanical power and refrigerants.
Closed loop	A constantly recirculating system where a fluid, usually water or coolant, transfers heat from one place to another.
Cooling tower	A specially designed structure with high surface area that uses evaporation to reject heat from a building or system
CRAH unit	Computer Room Air Handler – heat exchanger that removes heat from air and transfers it to water circulating around a closed loop
Direct to chip cooling	A form of liquid cooling that runs an enclosed tube of coolant around the chip, operating as a miniature closed loop system.
Evaporative cooling	A cooling process that uses the phase change of water (from liquid to gas) to absorb heat.
Free air cooling	A one way system that does not rely on mechanical chillers but pumps ambient air through the data centre to cool it.
Free water cooling	A system that usually uses an external body of water for cooling without the need for mechanical chillers.
Heat exchanger	A heat exchanger transfers heat from one medium to another. CRAH units and chillers are both heat exchangers
Heat source	The component that generates heat – the computer processor or chip is the primary heat source in data centres.
Heat rejection	The process of getting heat out of the building and into the external environment, whether open air or a water body, or a heat network.
Immersive cooling	A form of liquid cooling where the server motherboards are immersed in dielectric fluid in a tank, often connected to a closed loop system
Liquid cooling	This describes any cooling approach that uses liquid rather than air to remove heat from the heat source (the server or chip).
Open loop	A system where the fluid within it enters at one point and leaves at another, so is part of an open ended, one-way system, not contained or recirculated.
SuDS	Sustainable Drainage System which manages surface water and run off in line with the natural characteristics of the site, adopting nature based solutions.
WUE	Water Use Effectiveness: this is a data centre-specific metric that measures the use of water as a function of data centre activity. It therefore is a measure of how productively we use water.

## 7 CONTACTS FOR FURTHER INFORMATION

For further information or clarification of the explanations above, please do not hesitate to contact us. Details are below:



**Emma Fryer**  
DIRECTOR PUBLIC POLICY EUROPE  
E: [efryer@cyrusone.com](mailto:efryer@cyrusone.com)  
T: +44 (0)7442 104 145



**Katherine Mustard**  
SUSTAINABILITY ANALYST  
E: [kmustard@cyrusone.com](mailto:kmustard@cyrusone.com)  
T: +44 (0)7900 296 597

## 8 FURTHER READING

### Data centre water use

- CyrusOne: Data centre water use: Informal media coverage critique (on request).
- KAO DATA Infographic: [How much water does an AI data centre actually use?](#) November 2025
- techUK, [Understanding Data Centre Water Use in England](#), August 2025
- Equinix video explainer: [water use in data centres](#):
- Digital Realty case study: [Cloud House dock water cooling](#)
- EUDCA Technical Committee: [Water Use Effectiveness \(WUE\) – What is it?](#)
- EUDCA Position Paper: [Water Resilience Strategy](#)
- EUDCA Viewpoint: [Seeing Through the Mist: Data Centres and Water Usage](#)
- CNDP Water Use Metrics: <https://www.climateneutraldatacentre.net/working-groups/#water>
- House of Commons Library Research Briefing: [Future Water Resources](#) (not DC specific)
- Climate Neutral Data Centre Pact [Commitments](#) and [Water Usage Targets](#)
- J Dunton Associates: [Busting Big Myths about Data Centres and Water Use](#)

### General CyrusOne data centre explainers available on request

- What is the Cloud?
- How data travels round the internet
- PUE: Sith or Jedi?
- What is an Availability Zone?
- Locational attributes of data centres

**Acknowledgements:** This explainer has been drafted by me, a non-technical writer, for a non-technical audience. I have relied heavily on the kindness of our engineering community, both internal to CyrusOne and external, for sharing their expertise, helping me improve my own understanding and correcting the draft during its many iterations. Any residual errors are mine alone. Special thanks to Josh Taylor, Tom Kingham, Steve Hayward, Mark Moloney, Steve Campbell-Ferguson, Dave Smith, Garry Norton, Georgios Mapentzidis, Ivan Castro and Iain MacDougall.

Emma Fryer, October 2025



## About CyrusOne

CyrusOne is a leading global data centre owner, developer and operator, delivering sophisticated digital infrastructure solutions worldwide. Headquartered in Dallas, Texas, the company operates over 60 facilities across the United States, Europe, and Japan.

### European Headquarters

101 New Cavendish Street

London W1W 6XH

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

*This document has been produced within CyrusOne, initially with the intention of helping our newer staff members (who may be unfamiliar with the industry) understand some of the more obscure operational characteristics of the sector. We also share these, on an informal basis, with our external stakeholders to help them develop their personal understanding of the industry. While these explainers are developed in good faith, this is a complex industry and we often have to simplify elements to ensure our materials are accessible. Additionally, technology evolves very quickly and practices may change. Therefore, these explainers should never be regarded as a single source of truth or in any way relied on in an advisory capacity. If this document includes any links to external websites or sources, these are provided for convenience only. We do not control, endorse, or take any responsibility for the content of external sites, nor for any loss or damage that may arise from their use.*