Whitepaper

CO_2 - and Cost-saving Potential in Data Centers

Using the Cloud&Heat Cooling System with Waste Heat Utilization

Contents

Executive Summary

Data centers transform 100% of the IT electrical energy into heat which necessitates extensive cooling. Currently, the most common cooling systems utilize air cooling and compression cooling technology, which then transport the heat away while consuming high amounts of energy, only to have the waste heat often go unused and released into the environment. This approach is not energy efficient and causes enormous amounts of energy consumption, as well as high costs and substantial CO_2 emissions.

In order to make data centers sustainable, Cloud&Heat has developed a cooling system with hot-water/direct-cooling and waste heat recovery. This innovative approach results in significant savings potential in three areas. First, onboard fans, which consume up to 25% of the server power, can be dismantled or powered at a lower rotational speed. Second, hot-water/direct-cooling is considerably more energy efficient than air cooling, which constitutes 40-60% of data center energy consumption. Third, generated waste heat can be recovered and re-utilized, for instance to heat buildings rather than go unused and simply released to the environment.

A model computation based on the Eurotheum Project in Frankfurt/Main demonstrates the magnitude of potential savings. A 500 kW data center running at 50% capacity that incorporates air cooling consumes 1,000 MWh per year for the cooling alone. In comparison, Cloud&Heat Cooling under the same circumstances consumes ca. 320 MWh/a. Further savings potential in the area of onboard ventilation results in a possible total energy savings of ca. 950 MWh/a, saving 70% of the energy consumption through cooling. At the same time, the data center delivers over 900 MWh/a heat.

Depending on the electricity tariff and price for heating, this results in a cost advantage of up to 255,000 € per year. At the same time, 710 tons of CO_2 per year are also saved. To compensate for the same amount of CO_2 per year, the equivalent of 56,800 deciduous trees or 90 football pitches of forest would be necessary.

1 Introduction

Through the development of this idea to use waste heat from servers to heat buildings, Cloud&Heat has become a specialist for energy-efficient, secure, and scalable data centers and supports businesses with the construction and operation of sustainable IT infrastructures. A variety of advantages can be had with this specially developed cooling system based on hot-water/direct-cooling technology.

The Cloud&Heat Cooling Solution:

- consumes considerably less energy than the classic air-cooling system
- allows for an uncomplicated utilization of the generated waste heat
- reduces noise pollution
- achieves high power densities with low space usage through a considerably more compact design

Although energy efficiency and waste heat recovery are receiving more focus in the data center industry, there is a lack of reliable data and model computations regarding the savings potential of liquid cooling, specifically hot-water/direct-cooling. The goal of this whitepaper is to show the savings potential of Cloud&Heat Cooling in comparison to classic air cooling, through the use of a concrete model computation that explains and illustrates the Cloud&Heat technology in an easily understandable manner.

1.1 Hot-water/direct-cooling with Cloud&Heat technology

IT-hardware transforms 100% of its electrical energy supply into heat energy. A server with 500 W electrical power consumption therefore produces 500 W thermal power. Because of this, cooling is a basic requirement for the reliable operation of data centers. It ensures that the waste heat is transported away and that the operating temperature limits of the (semiconductor) components are maintained.

Cloud&Heat follows the principle that an efficient hot-water/direct-cooling system can minimize the energetic expense of cooling and utilize its waste heat. This cooling technology pushes water through heat sinks that have direct contact with components needing cooling, such as processors (see Illustration 1). Thus, the direct-water cooling removes the thermal output of the IT components directly where it is created.

Illustration 1: 100 % water-cooled Blade from Megware

Cloud&Heat goes beyond simple waste heat removal and specializes in recovering the waste heat so that it can be utilized in heating systems by precisely controlling the volume flow rates in the data centers to achieve the necessary high temperatures. This is accomplished by circulating the water through a software-controlled hydraulic system until it reaches the necessary decoupling temperature, at which time it can then be fed into a heating circuit via a heat exchanger. In doing so, the cooling system achieves the practice-oriented minimum temperature of 60 °C typical of applications in the building sector.

1.2 The Eurotheum Project

The Eurotheum Project provides the basis for the following model computation shown here. Within the framework of this project, Cloud&Heat planned, built, and put into operation an energy-efficient data center within the space of the former data center of the European Central Bank, located in the Eurotheum skyscraper in the middle of Frankfurt/Main. Extensive renovations were carried out in 2018, involving the modernization of the server rooms and offices, the installation of Cloud&Heat server cabinets, as well as the integration of a hydraulic-heating circuit within the skyscraper infrastructure.

1.2.1 Project background

In 2030, it is predicted that IT will consume ca. 20% of the world's energy demand.[1] In Frankfurt/Main, the number of data centers servicing the banking-, telecommunication- and business sectors has increased considerably. Already today, data centers consume 20% of the energy demand in metro Frankfurt, with the tendency growing.[2]

This stands in conflict with the city of Frankfurt/Main's "Masterplan 100% Climate Protection," which aims to reduce the energy demand by 50% and the greenhouse gas emissions by 95% in 2050, as compared to 1990.[3] For the European capitol of data centers, these reasons make energy efficiency particularly relevant. "Projects like the Eurotheum are absolutely essential if we are to maintain Frankfurt as an attractive location for data centers while also reaching the climate protection goals which we have set," says Max Weber, Climate Protection Manager of the Energy Council for Frankfurt/Main. Consequently, he believes that data centers in Frankfurt will stand under increasing scrutiny in the future. With its energy-efficient data center in the Eurotheum, Cloud&Heat actively supports not only local but national climate protection goals.

1.2.2 Project description

The Eurotheum was built in 2000 and occupied by the European Central Bank until its recent move into new headquarters. The 7th floor and basement housed a redundant, high-security and high-availability data center. In 2018, the existing data center infrastructure was completely modernized within a 6-month period and the server cooling system was converted from classic air-cooling to hot-water/direct-cooling with connection to the building's central-heating system.

The modernization included the following measures:

- Replacement of the existing IT infrastructure
- New design of the data center periphery
- Development of a cooling concept
- Integration of the Cloud&Heat hardware technology with waste heat recovery system
- Heating supply for the local heating and warm water system

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1 https://www.nature.com/articles/d41586-018-06610-y

2 https://www.borderstep.de/netzwerk-energieeffiziente-rechenzentren

3 https://www.frankfurt.de/sixcms/media.php/738/161209_Masterplan%20Brosch%C3%BCre%20Final_web_bf_pdfua.pdf

- Maintenance of the security level tier 3+
- Development of an OpenStack-based IT infrastructure for the provision of Public Cloud services

Cloud&Heat built modern servers with their own specially developed cooling system within the space of the former ECB data center. The cooling system feeds ca. 70% of the hardware-produced heat into the hot-water circuit of the Eurotheum. This heat is used on-site to heat offices, conference rooms, a hotel (Innside Frankfurt Eurotheum) and gastronomy (cafeteria and Skybar) inside the Eurotheum.

Illustration 2: Cloud&Heat server room in the Eurotheum, Frankfurt/Main

2 Savings

Using Cloud&Heat cooling technology opens savings potential in three areas:

1. Savings through reduced energy consumption of onboard fans.
2. Savings through higher efficiency in the cooling system.
3. Savings through recovery and utilization of waste heat.

2.1 Onboard fans

Direct cooling allows for either the complete disassembly of onboard fans or a drastic reduction of their rotational speed. In typical server systems, fans account for up to 25% of the energy consumption (see section 3.1) which can be saved when water-cooling is used. This savings leads not only to a direct savings through less energy consumption, but it also reduces the total amount of heat to be cooled, since onboard fans also produce heat. Furthermore, it reduces the necessary connected loads requiring "IT-electricity" while maintaining the same computing power, since the usual onboard fans are categorized as using IT-electricity.

2.2 Energy efficiency of cooling

Classic air-cooling systems have a high, specific energy consumption. In standard data centers, air cooling accounts for 40-60% of the total energy consumption.[4]

In order to transport heat through air, a high flow volume is necessary because of air's low heat capacity and density. This is achieved through the use of fans with a correspondingly high electrical energy demand.

In comparison, hot-water/direct-cooling is significantly more energy efficient. Water's higher heat capacity and density requires less flow volume, so the energy necessary to transport heat, in the form of pump capacity, is considerably smaller. The volume-specific heat capacity of water (4,183 kJ/m^{3}K at 60 °C) is 3,507 times higher as that of air (1.17 kJ/m^{3}K at 30 °C).

A further advantage of hot-water/direct-cooling over classic air cooling lies in the significantly lower technical and energetic expenditure required to release the heat into the environment.

[4] https://www.datacenterknowledge.com/archives/2016/06/14/impact-of-cooling-and-efficiency-in-modern-data-center-design; https://www.datacenter-insider.de/direkte-wasserkuehlung-im-server-fuer-hoehere-effizienz-im-rechenzentrum-a-718995/

Classic air cooling necessitates a maximum entry temperature of 27 °C in order to avoid hot spots on the hardware.

When outdoor temperatures rise over the maximum allowed temperature, especially in the summer, air cooling must reduce the temperature with compression refrigeration technology, which consumes considerable amounts of energy – 0.3 kWh electrical energy per 1 kWh of cooling energy. In comparison, hot-water/direct-cooling cools at a temperature of 50 °C. Even at the peak of summer, this can be achieved with little energetic expenditure from a starting point at 60 °C, for instance with a dry heat exchanger that releases the captured heat into the surroundings.

2.3 Waste heat recovery and utilization

A further possibility to operate more ecological and cost-efficient data centers is to recover and utilize the generated waste heat. Instead of releasing heat without any further usage into the surrounding environment, Cloud&Heat technology makes it possible to integrate the heat into the building heating systems.

Classic air cooling can warm air up to 40 °C. However, heat at this relatively low temperature cannot be economically re-used in most applications. In contrast, hot-water/direct-cooling reaches a water temperature of up to 63 °C, which opens up multiple possibilities to use the waste heat sensibly. Besides connecting to the heating and warm-water systems of buildings, this heat can also be connected to district- and local heating networks, greenhouses, swimming pools or aquaponic systems.

3 Model computation

The following model computation calculates the savings potential using the Eurotheum project as its case study. To begin, the baseline data of the systems and the underlying empirical values are described. Following this, the heat quantities at every level of the system as well as the necessary auxiliary power for the transformation and transport of the heat are calculated (see illustration 3). The savings potential in the areas of more efficient cooling as well as waste heat recovery and utilization stem from these calculations.

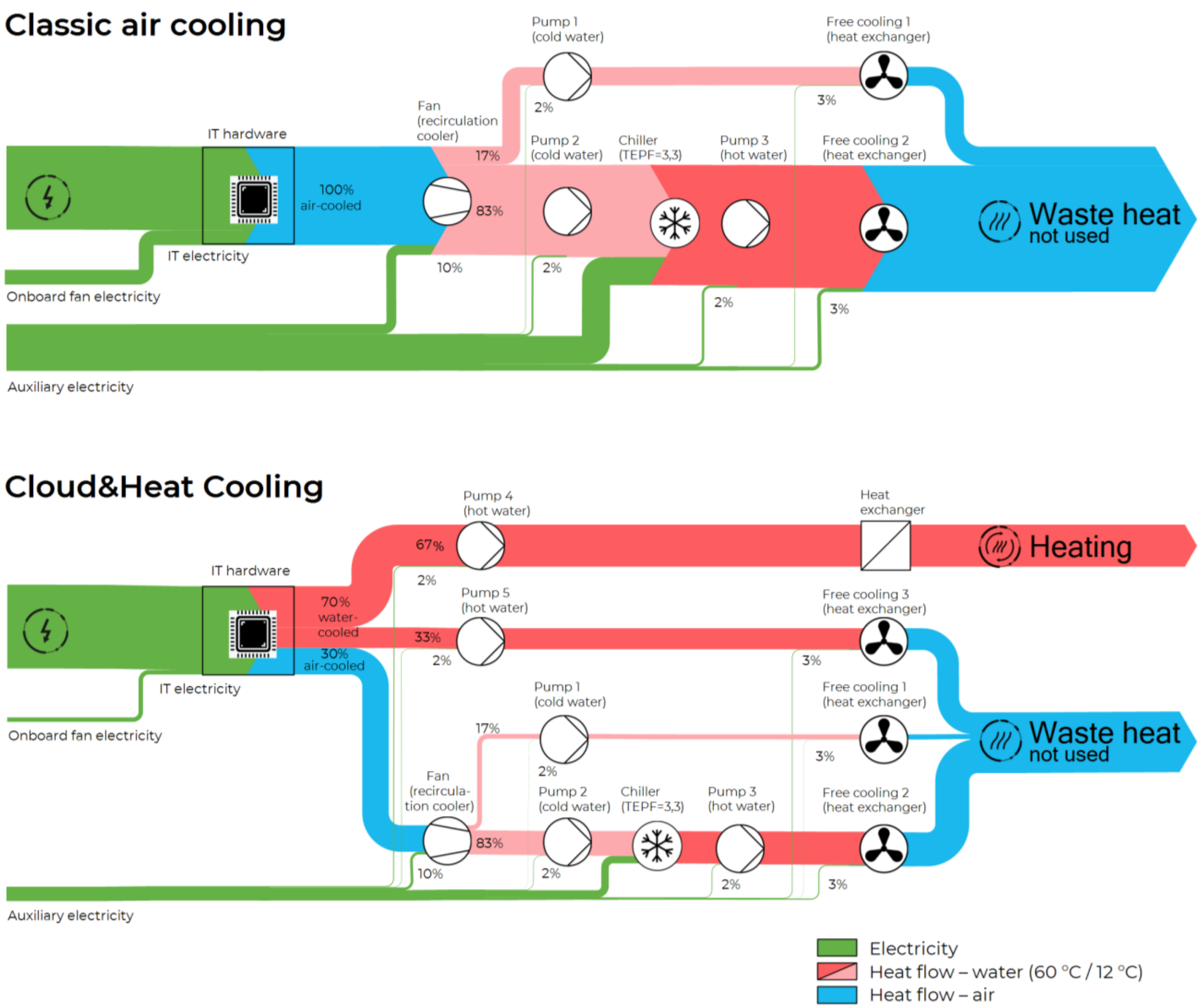

Illustration 3: Energy flow diagram - classic air cooling vs. Cloud&Heat Cooling

3.1 Baseline data and empirical values

Working at full capacity, the data center has an IT power consumption of 500 kW. In addition to the direct power demands of the IT-equipment, the power demands of the built-in onboard fans that remove the generated heat via air must also be considered. Using specifications from various renowned hardware products that had already been converted to use with hot-water/direct-cooling by Cloud&Heat, (see Table 1) it is evident that the share of power consumption by the onboard fans varies considerably in relation to the total power consumption of the hardware. Various sources believe that this share accounts for up to 25% of the total energy consumption.[5,6] For these calculations, the onboard fans were assumed to consume on average 15% of the IT-power demand.[7]

Table 1: Electrical energy consumption of onboard fans

Manufacturer	Hardware	Server power consumption	Number of fans	Total fan power consumption	Fan power consumption/ Total consumption
TradeDX	R5211	800 W	6	172.1 W	21.5 %
Supermicro	SuperServer 4028GR-TRT2	2,000 W	8	345.6 W	17.3 %
Thomas Krenn	2HE Intel Dual-CPU RI2208Scalable	154 W	3	21.6 W	14.0 %

The actual energy consumption of a data center strongly depends on its capacity. This in turn varies according to its usage scenarios. For example, Google reports a capacity between 10-50% for mixed applications (including online services) and a capacity of 60-80 % for batch-workload clusters.[8] Assuming an average yearly capacity of 50% results in an average power consumption of 250 kW. In the case of a classic air-cooling system, 37.5 kW would go towards the operation of the onboard fans and 212.5 kW would be distributed amongst all other IT components. Within one year (8760 h) of such a scenario, a heat quantity of 2,190,000 kWh/a would be produced. The job of the cooling system is to get rid of this heat. Therefore, the energy demands of classic air cooling and Cloud&Heat Cooling will be calculated and compared.

The calculations of the electrical auxiliary energy demand of individual units such as pumps, fans, etc. use empirical values listed in Table 2. This data is based on experience drawn from multiple Cloud&Heat projects. The listed percentages show how much electrical energy must be supplied to the respective units to transfer the corresponding amount of heat. Here the

5 https://searchdatacenter.techtarget.com/tip/Optimizing-server-energy-efficiency

6 https://tolia.org/files/pubs/interpack2009-1.pdf

7 https://www.asperitas.com/wp-content/uploads/2019/04/Asperitas_Immersed_Computing_rev4.pdf

8 https://www.morganclaypool.com/doi/pdf/10.2200/S00516ED2V01Y201306CAC024

electric energy is converted to heat and added to the respective heat flow (see Illustration 3). The same logic applies for chillers. The electrical energy demand of a chiller can be determined using its Total Energy Performance Factor (TEPF). This describes the ratio of the amount of heat dissipation to the electrical operational energy of the chiller. The TEPF of 3.3 assumed for chillers in data centers therefore means that 1/3.3, i.e. ca. 30% of the heat quantity is required as additional auxiliary electricity.

Table 2: Empirical values for the energy demands of auxiliary units

Auxiliary unit	Empirical value	Source
Pumps	0.02[9]	Empirical data of Cloud&Heat
Fans	0.10[9]	Empirical data of Cloud&Heat
Free cooling	0.03[9]	Empirical data of Cloud&Heat
Chillers	0.303 (according to Total Energy Performance Factor (TEPF))	Becker (2011)[10]

3.2 Classic air cooling

3.2.1 Free cooling

Heat dissipation, the release of heat into the environment, occurs in classic air cooling through free cooling or with compression air-conditioning technology. Free cooling is the more energy-efficient option here. However, it can only be utilized when the ambient temperature differs enough with the desired flow temperature of the coolant. In the case of the Eurotheum, free cooling can take place when the ambient temperature remains below 3 °C[11]. Based on the local temperature data[12], free cooling can deck 17% of the annual cooling needs. The remaining cooling requirements of 83% require the energy-intensive use of refrigeration technology.

3.2.2 Heat quantities

Calculating the heat quantities of the individual process steps is a prerequisite for calculating the electrical energy demand for cooling. For simplification, it is assumed that the respective heat quantity is increased by the inflowing auxiliary electricity (see Illustration 3). Heat losses from the auxiliary units into the environment are not accounted for.

9 Proportion related to the amount of heat to be transferred

10 https://www.glt-anwendertagung.de/images/2011/Vortraege/manuskript_klteanlagen.pdf

11 Flow temperature of the water chiller is 6 °C

12 Hourly temperature data (2008-2018), Frankfurt/Main (1420) weather station, German Weather Service

Depending on the cooling option used, classic air cooling incorporates, in addition to fans (recirculation coolers), the following process steps:

Free cooling:

- Pump 1 (cold water)
- Free cooling 1 (heat exchanger)

Air-conditioning:

- Pump 2 (cold water)
- Chiller
- Pump 3 (hot water)
- Free cooling 2 (heat exchanger)

Results for the heat quantities of the corresponding process steps are listed in Table 3.

Table 3: Heat flow calculations – classic air cooling

Process step	Heat quantity	Calculation
before Fan	2,190,000 kWh/a	= 500 kW x 0.5 x 8.760h/a
before Pumps 1 and 2 (after fan)	2,409,000 kWh/a	= 2,190,000 kWh/a x (1 + 0.1)
to Free cooling	399,027 kWh/a	= 2,409,000 kWh/a x 0.17
before Free cooling 1 (after Pump 1)	407,007 kWh/a	= 399,027 kWh/a x (1 + 0.02)
to Air-conditioning	2,009,973 kWh/a	= 2,409,000 kWh/a x 0.83
before Chiller (after Pump 2)	2,050,173 kWh/a	= 2,009,973 kWh/a x (1 + 0.02)
before Pump 3 (after Chiller)	2,671,437 kWh/a	= 2,050,173 kWh/a x (1 + 1/3.3)
before Free cooling 2 (after Pump 3)	2,724,866 kWh/a	= 2,671,437 kWh/a x (1 + 0.02)

3.2.3 Electrical energy demand

The required auxiliary energy demands are calculated using the calculated heat flows shown in 3.2.1 in combination with the empirical values from Table 2. To do this, the quantity of heat received before each process step is multiplied by the additional auxiliary energy share of the respective units (see Table 4).

Table 4: Electrical consumption of auxiliary units – classic air cooling

Process step	Auxiliary energy	Calculation
Fan	219,00 kWh/a	= 2,190.000 kWh/a x 10 %
Pump 1	7,981 kWh/a	= 399,027 kWh/a x 2 %
Free cooling 1	12,210 kWh/a	= 407,007 kWh/a x 3 %
Pump 2	40,199 kWh/a	= 2,009.973 kWh/a x 2 %
Chiller	621,264 kWh/a	= 2,050,173 kWh/a / 3.3
Pump 3	53,429 kWh/a	= 2,671,437 kWh/a x 2 %
Free cooling 2	81,746 kWh/a	= 2,724,866 kWh/a x 3 %
Sum	1,035,829 kWh/a	

Using classic air cooling to cool a 500 kW data center working at 50% capacity requires 1,000 MWh per year.

3.3 Cloud&Heat Cooling

3.3.1 Heat quantities

Dependent on the geometry of the server hardware, hot-water/direct-cooling allows for the complete disassembly of onboard fans or a significant reduction in the rotational speed of the remaining fans. In the example given here, with the direct-water cooling system, air cooling is reduced to 30% of classic air cooling, thus the power requirements of the onboard fans are reduced to 11.25 kWh (= 30% air cooling x 75 kW rated fan power x 50% actual power of rated onboard fan power). This reduces the IT-power required for direct-water cooling to 223.75 kW. In comparison to classic air cooling, the annual amount of heat produced is correspondingly lower at 1,960,050 kWh/a. As shown in Illustration 3, these heat quantities can be divided into three areas:

- Water cooling when using the heating system
- Water cooling without using the heating system (no heating requirements)
- Air cooling of non-water-cooled components

The distribution is determined by two amounts: the percentage of water cooling and the average percentage of heating system usage per year. In this case, 70% of the IT-heat can be water-cooled. The heating and warm-water system can be used 2/3 of the time[13]. On summer days without warm-water requirements, the heat must be dissipated without any use. This occurs 1/3 of the time.

Outfitting certain components, like power supplies or storage racks, with water cooling can be difficult and is not always economically viable. This is the reason for air cooling the remaining 30% of the IT-heat.

Calculating the quantity of heat for the air cooling is analog to that used with classic air cooling. The calculated results for all heat flows are compiled in Table 5.

[13] According to VDI-Guideline 2067/DIN 4108 T6, the heating limit lies at 15 °C. This temperature has not been exceeded for 66 % of the hourly temperatures in the last 10 years in Frankfurt/Main. In addition, there is an independent warm water requirement.

Table 5: Calculating heat flows - Cloud&Heat Cooling

Process step	Heat quantity	Calculation
Water cooling when using the heating system		
before Pump 4	914,690 kWh/a	= 1,960,050 kWh/a x 0.7 x 2/3
Water cooling without using the heating system		
before Pump 5	457,345 kWh/a	= 1,960,050 kWh/a x 0.7 x 1/3
before Free cooling (after Pump 5)	466,492 kWh/a	= 457,345 kWh/a x (1 + 0.02)
Air cooling		
before Fan	588,015 kWh/a	= 1,960,050 kWh/a x 0.3
before Pumps 1 and 2 (after Fan)	646,817 kWh/a	= 588,015 kWh/a x (1 + 0.1)
to Free cooling	107,139 kWh/a	= 646,817 kWh/a x 0.17
before Free cooling 1 (after Pump 1)	109,281 kWh/a	= 107,139 kWh/a x (1 + 0.02)
to Air-conditioning	539,678 kWh/a	= 646,817 kWh/a x 0.83
before Chiller (after Pump 2)	550,471 kWh/a	= 539,678 kWh/a x (1 + 0.02)
before Pump 3 (after Chiller)	717,281 kWh/a	= 550,471 kWh/a x (1 + 1/3.3)
before Free cooling 2 (after Pump 3)	731,626 kWh/a	= 717,281 kWh/a x (1 + 0.02)

3.3.2 Electrical energy demand

The energy consumption of the auxiliary units listed in Table 6 are calculated by multiplying the cooling load with the empirical consumption values of the auxiliary units listed in Table 2. This results in a total auxiliary energy consumption of almost 320 MWh/a.

Table 6: Energy consumption of auxiliary units - Cloud&Heat Cooling

Process step	Auxiliary energy	Calculation
Water cooling when using the heating system		
Pump 3	18,294 kWh/a	= 914,690 kWh/a x 0.02
Water cooling without using the heating system		
Pump 4	9,147 kWh/a	= 457,345 kWh/a x 0.02
Free cooling	13,995 kWh/a	= 466,492 kWh/a x 0.02
Air cooling		
Fan	58,802 kWh/a	= 588,015 kWh/a x 10 %
Pump 1	2,143 kWh/a	= 107,139 kWh/a x 2 %
Free cooling 1	3,278 kWh/a	= 109,281 kWh/a x 3 %
Pump 2	10,794 kWh/a	= 539,678 kWh/a x 2 %
Chiller	166,809 kWh/a	= 550,471 kWh/a / 3.3
Pump 3	14,346 kWh/a	= 717,281 kWh/a x 2 %
Free cooling 2	21,949 kWh/a	= 731,626 kWh/a x 3 %
Sum:	319,556 kWh/a	

3.4 Savings

3.4.1 Energy savings

3.4.1.1 Electrical energy savings

Direct-water cooling can reduce the output of the onboard fans by 26.25 kW and accordingly, the electrical energy consumption by 229,950 kWh. Additional energy savings potential can also be seen when comparing the electrical energy consumption of 1,035,829 kWh/a with classic air cooling to the energy consumption of 319,556 kWh/a with Cloud&Heat Cooling. Thus, the total electrical energy savings equals 946,224 kWh/a (see Illustration 4).

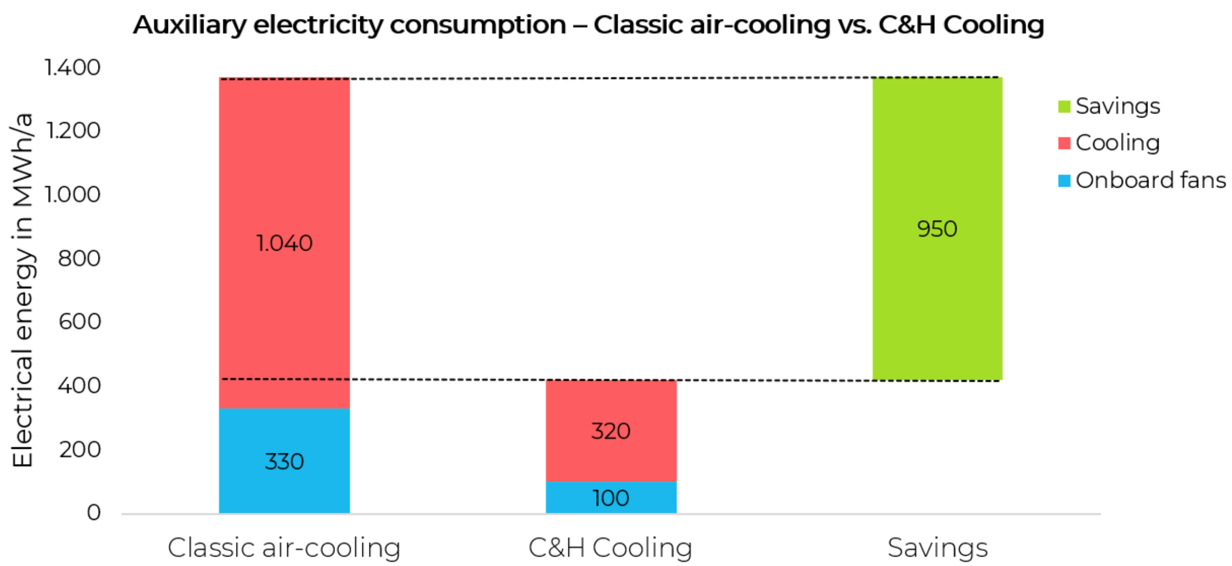

Illustration 4: Auxiliary electricity consumption – classic air-cooling vs. Cloud&Heat Cooling

3.4.1.2 Heat savings

In Central European latitudes, waste heat can be used for heating purposes 2/3 of the year and does not have to be purchased separately, e.g. via district heating. The usable waste heat is calculated from the multiplication of the IT-waste heat (1,960,050 kWh/a) with a 70% share of water cooling, a (2/3) share for heating usage, and the heat generated by the auxiliary power of Pump 3 (2%) and results in 932,984 kWh/a heat.

3.4.2 Cost savings

Cost savings are directly related to electricity and heating prices. Electricity prices vary according to the purchase volume. The German Federal Network Agency (Bundesnetzagentur) calculated for 2018 an average electricity price for commercial customers of approximately 21.5 ct/kWh.[14] Because data centers are able to negotiate lower prices due to greater purchase volumes, we calculated with a simplified 20 ct/kWh. The price for district heating lies at 0.07 €/kWh (net).[15]

More efficient cooling consequently leads to a cost savings of 143,225 €/year (=716,274 kWh/a x 0.20 €/kWh). Reducing the energy consumption of the onboard fans saves another 45,990 €/year (=229,950 kWh/a x 0.20 €/kWh) Utilizing the waste heat for heating purposes leads to a further cost savings of 65,309 €/year (= 932,984 kWh/a x 0.07 €/kWh).

In total, the cost savings potential for the case study presented here equals 254,554 €/year (see Illustration 5).

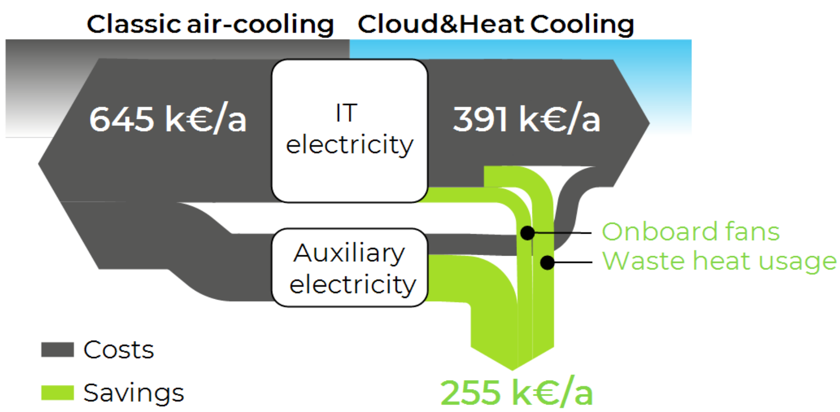

Illustration 5: Cost flow diagram - standard air-cooling vs. Cloud & Heat Cooling

The calculation example presented in the Eurotheum case study is based on a feasible free cooling share of 17%. This results from the cold-water flow temperature of 6 °C alongside the outer building shell, which maximizes the use of the 3 °C ambient temperature necessary for free cooling. However, this temperature limit can vary for other data centers cooled with classic air cooling. The influence of the temperature, and consequently the share of free cooling, are shown in Illustration 6. This clearly shows that the cost savings potential in scenarios with higher ambient temperatures is somewhat lower, but never falls below 150,000 €.

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14 https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2018/Monitoringbericht_Energie2018.pdf?__blob=publicationFile&v=5

15 https://de.statista.com/statistik/daten/studie/250114/umfrage/preis-fuer-fernwaerme-nach-anschlusswert-in-deutschland/

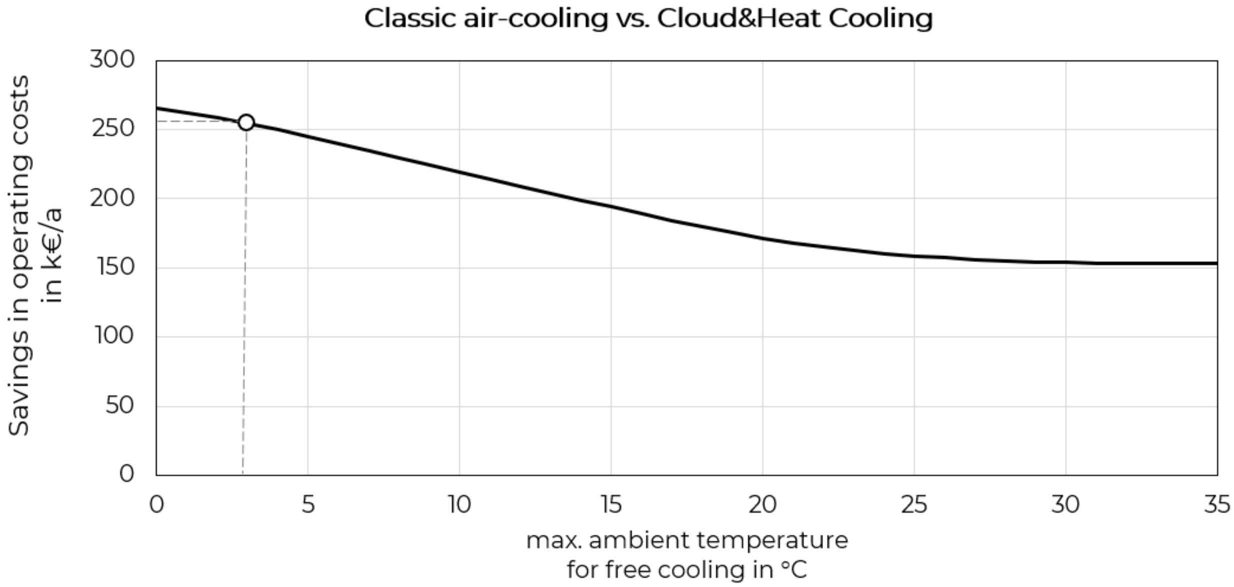

Illustration 6: Potential savings in operating costs, in relation to the maximum ambient temperature[16] at which free cooling is possible - classic air cooling vs. Cloud&Heat Cooling

3.4.3 CO_2 savings

In addition to the potential cost savings, Cloud&Heat Cooling simultaneously reduces CO_2 emissions. With CO_2 emissions of 0.474 kg/kWh from the German electricity mix and 0.280 kg/kWh from the German district heating mix, that equals a CO_2 savings potential of 710 tons CO_2 per year (= (716,274 kWh/a + 229,950 kWh/a) x 0.474 kg/kWh + 932,984 kWh/a x 0.280 kg/kWh). This means that 340 tons CO_2 can be saved per year through more efficient cooling – 109 tons through the reduced power demands of the onboard fans and 261 tons through the utilization of the recovered waste heat.

Putting this to scale, over 56,800 deciduous trees would have to be planted to save the same amount of CO_2.[17] With the German forest absorbing on average approximately 11 tons CO_2 per hectare and year[18], that means 64.5 hectares or 90 football pitches of forest would be necessary to compensate for the same amount of CO_2.

16 Location: Frankfurt/Main
17 https://www.co2online.de/service/klima-orakel/beitrag/wie-viele-baeume-braucht-es-um-eine-tonne-co2-zu-binden-10658/
18 https://www.baysf.de/de/wald-verstehen/wald-kohlendioxid.html

4 Conclusion and outlook

One of the main challenges of the 21st century is to design more sustainable data centers with smaller ecological footprints. One solution that addresses this societal issue lies in the more efficient cooling and waste heat utilization of data centers.

The specially designed cooling system from Cloud&Heat enables a significantly more energy-efficient operation of IT- infrastructures and contributes to the reduction of CO_2 emissions in one of the fastest growing sectors. The computational model shown here clearly demonstrates the magnitude of the savings potential. A 500 kW data center at 50% capacity can save 710 tons CO_2.

Besides the direct positive effects of data centers outfitted with Cloud&Heat technology that are mentioned here, there are also indirect positive effects. Through the high power-density, significantly less building volume and climate-damaging concrete are needed. This in turn reduces land consumption. For example, a Cloud&Heat Container-Data Center reaches a power density of up to 1 MW power on a surface of 60 m^2.

To further better the efficiency of decentralized data centers, Cloud&Heat is also working on an orchestration software for data-intensive computing that distributes the load according to global energy efficiency parameters.

With these approaches, Cloud&Heat is making the vision of energy-efficient and sustainable data centers a reality.

WE BUILD THE MOST ENERGY-EFFICIENT
DATA CENTERS. WORLDWIDE.

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