WHITEPAPER

Your data center's hidden source of revenue

Harvesting heat from data centers with Low Speed Ventilation server coolers

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1. Introduction

Data centers underpin the growing modern economy. The United Nations predicts that by 2018, the world's population will reach 7.8 billion and according to Cisco, half of them will have residential internet.

Data centers are under a lot of pressure. Not only must they meet soaring demand, but also secure safe system performance, assure compliance with current environmental guidelines and future-proof against upcoming regulations resulting from COP21. All of this while curbing growing expenses and remaining competitive. It seems nearly impossible. However, there might be a hidden resource waiting to be capitalized that makes this challenge easier.

2. Challenges

2.1 Rising electricity consumption & carbon emissions

It is estimated that data centers currently consume between 1.5–3% of the world's electricity. This is a substantial portion of the total output, yet forecasts claim that by 2020, this share will reach 7%, making data centers the world's fastest growing user segment for electricity.

The National Resources Defence Council (NRDC) estimates that by 2020, data centers in the United States will consume roughly 140 billion kWh annually (up from 91 billion kWh in 2013), equating it to the output of 50 power plants. The increase in the US will be driven by new data centers going live, but also by increased power densities in existing centers. The NRDC study also concluded that the least energy-efficient centers were not the mega-centers, but the ones in the multi-tenant and corporate segments.

Electricity consumption inevitably leads to emissions of carbon dioxide. At 2013 consumption level, US data centers emitted 100 billion metric tons of carbon dioxide. We have already seen worldwide environmental regulations and financial incentives being employed to reduce carbon emissions from large companies. Tax breaks, grants and carbon taxes have already been introduced and with an accelerated increase of energy consumption and emissions by data centers, legislative pressure is likely to be even stricter down the road.

2.2 Rising electricity prices

US data centers will spend $13 billion on electricity in 2020. Electricity will become an increasingly significant area of operational expenditure for data centers in the US, but at current price disparities, centers in the EU will be hit even harder.

The price of electricity varies greatly between countries within the EU. In 2014, Sweden recorded the lowest price of electricity for industrial consumers at $0.078/kBtu/h — less than half of what was offered in Germany and lower than in the Netherlands at $0.11/kBtu/h.

The average price per kWh in the EU was $0.167 (2015) compared to $0.07 in the US (2015). Data centers' increasing electricity consumption combined with price rises will have a substantial impact on bottom lines.

2.3 Rising server room temperatures—not necessarily a challenge

Cooling is a data center's most electricity-intensive system. Conventional cooling systems account for up to 38% of a data center's total energy consumption. Keeping in mind that data centers are forecast to consume 7% of the total world's energy by 2020, conventional cooling systems mean high operation expenditure.

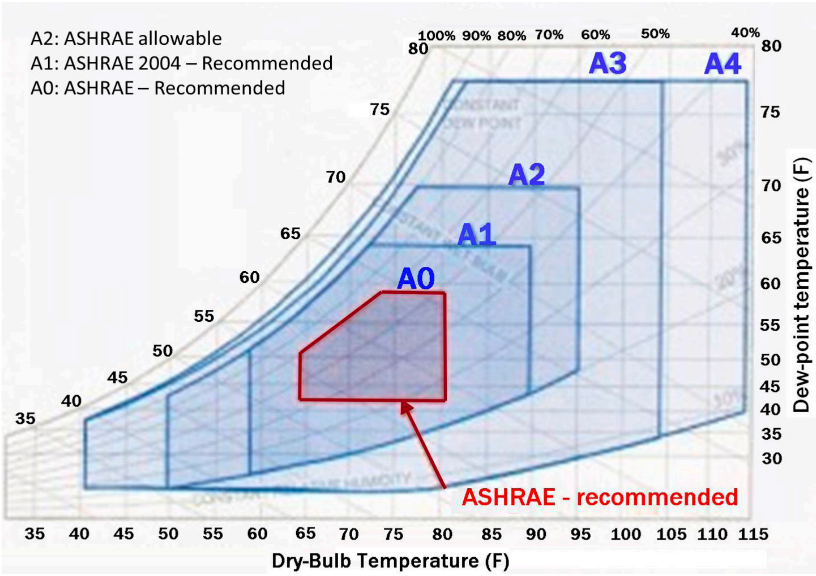

Figure 1: Uploaded temperature diagram for specific data center locations following the ASHRAE recommendations for cooling

One way to lower electricity consumption within the white space is to increase the recommended levels of temperature and humidity. As data center hardware is evolving to operate in harsher climates, the climate guidelines are adapting. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has raised recommendations on temperature three times and a fourth revision—related to humidity—is underway.
Higher temperatures in data centers are additional pieces in the puzzle, refining the opportunities for heat harvesting.

3. Heat harvesting in data centers

Harvesting the heat usually released into the atmosphere is an effective, but seldom used, way for data centers to harness higher room temperatures, increase energy-efficiency and ultimately reduce operational expenses. The basic idea is to try to recover maximum amounts of heat released in the data center and reuse it as much as possible, either by utilizing it within the facility or by selling it to heating networks.

“There is enough waste heat produced in the EU to heat the EU’s entire building stock.”

–Celsius City

Viewing the data center as a producer of heat may initially seem hard to believe, but we have already seen several examples in the UK, Sweden and across Europe in which data center waste heat has been harvested and directed to heat everything from swimming pools and neighborhoods to entire cities. Bearing in mind the vast amounts of electricity that data centers consume and given that most of it will be converted into heat, harvesting not only makes good sense from an environmental perspective—but also possibly from a business standpoint, as heat can be sold to commercial networks at spot price.

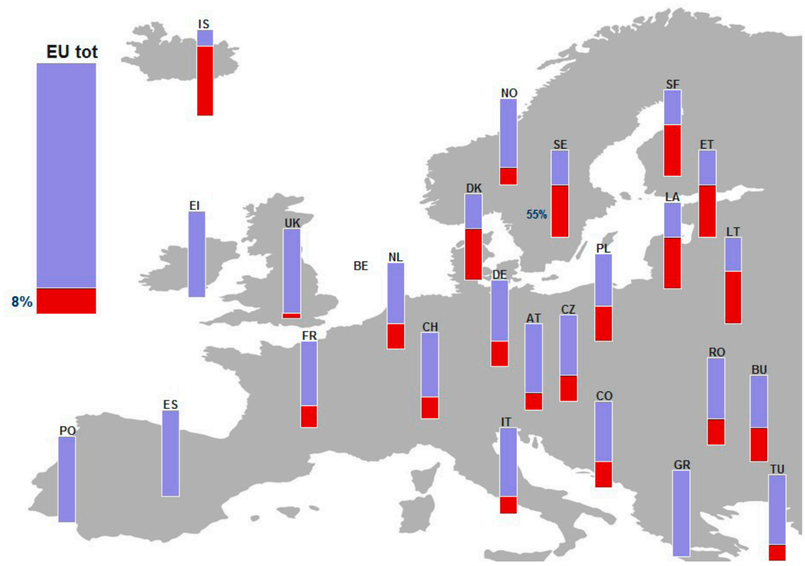

Figure 2: Installed district heating in Europe based on the reached percentage of the population. Northern and Eastern Europe has highest level of development due to climate and heating tradition.

3.1 District heating

District heating is a way to commercially distribute excess heat through a pipe network filled with hot water or steam to a non-restricted number of customers. The heat is conventionally produced by burning oil, coal, natural gas or waste and the networks vary in size from just a few buildings or neighborhoods to systems reaching entire cities. In the EU there are over 3,000 district heating networks and 57% of the EU population live in regions that have at least one district heating system.

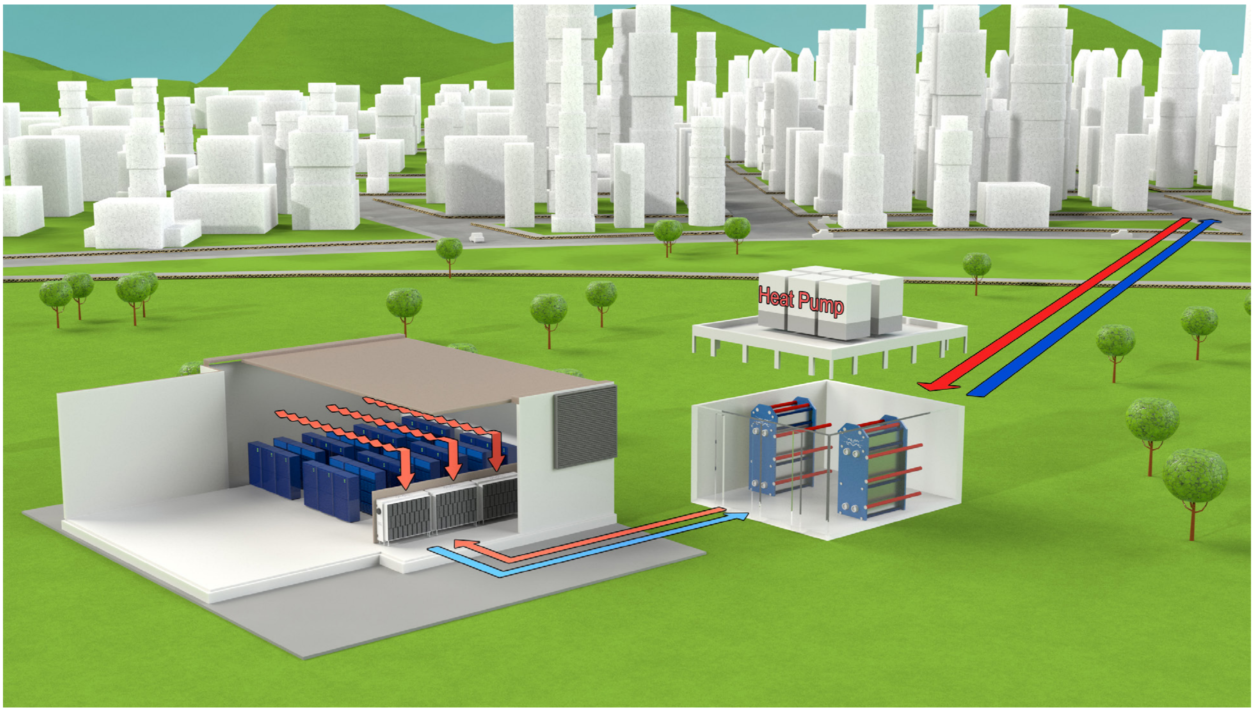

Figure 3:

Looking at district and local heating from a sustainability perspective, an international study confirmed the possibility of saving 400 million tons of CO_2 yearly (corresponding to a 9.3% CO_2 emission reduction, thus more than the whole Kyoto target)[1] with more district and local heating and cooling across 32 European countries.

3.2 How it works in data centers

1. Water from heat exchangers runs through the cooling coil package used by server room fans to cool the room.
2. As the water absorbs some of the heat in the room, its temperature rises. (The increase of temperature determines how financially sound heat harvesting is, and this depends on the type of cooling system.)
3. Warm return water passes through the heat exchanger and is redirected to heat pumps.
4. Using refrigerants, heat pumps further increase temperature to the desired level (104–154°F in Sweden)
5. Water is sold at market price and distributed through the heating pipe.

3.3 Harvesting heat in data centers—a comparison of conventional vs. Low Speed Ventilation

Even though the Low Speed Ventilation (LSV) cooling solution was not specifically designed with heat recovery in mind, it has unique characteristics beneficial to harvesting heat.

1 Possibilities with more district heating in Europe. Ecoheatcool, A Euroheat & Power initiative. (2006)

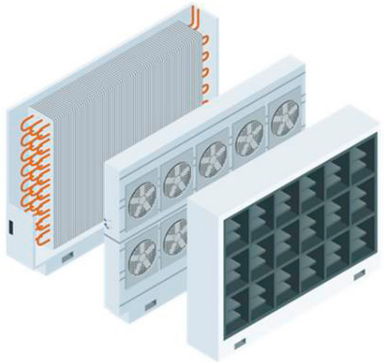

Figure 4: LSV

The primary objective of the LSV cooling system is to create the most effective, balanced and lean server cooling with a normal pressure system. The LSV's cross-sectional area is designed to allow large volumes of air to flow through the server room, under normal pressure. By lowering fan speed, without affecting the air volume needed to cool the servers, the energy consumed by the fans and problematic pressure differences are contained, thus resulting in more economical and sustainable operations. However, the design characteristics of the LSV unit have proven highly beneficial for the heat harvesting process as well.

When considering a cooling system for efficient heat harvesting, a data center using server cooling equipment resulting in high return temperature (and by that a large temperature difference delta T [ΔT]) will largely benefit from the required pumping effect needed to pump and distribute the cooling liquid in supply and return from the server cooler.

3.4 Energy effectiveness in pumping power

In a conventional server cooler, the coil package cooling the distributed air is small—due to the size of the cooler. Obtaining a large temperature difference between the incoming and outgoing water is impossible, as the water's traveled distance is short. Conventional server coolers such as Computer Room Air Conditioning (CRAC)/Computer Room Air Handler (CRAH) and in-row coolers can therefore never reach high return temperatures. They typically deliver a return temperature of 72°F while incoming water is supplied at 64°F giving a ΔT of 4°F.

Using Low Speed Ventilation technology via Alfa Laval's Arctigo LSV cooler allows much larger temperature differences. The physical cooler and the coil package inside the unit are larger. Their size enables the unit to handle large volumes of air and maintain the airflow at low speed.

With the properly dimensioned coil package, the traveled distance of the water within it allows the water to be heated much more from the inlet of the unit to the outlet. The water is heated a longer distance, resulting in higher output temperature—typically about 82.4°F. The input temperature feeding the LSV cooler is still the same as the other server coolers' (64°F). Although a typical ΔT on the water side in an LSV cooler is about 50°F. The formula for the load of the system combined with flow, temperature difference and a constant is as below:

$$\textbf{Load} = \textbf{flow} \times \Delta T \times 0.99838 \text{ BTU/lb °F}$$

The load is to be seen as fixed, as a data center has a constant load independent of season or time of day. The constant 0.99838 BTU/lb °F (J/kg K) is fixed as well, so the only remaining parameters that will have an effect are flow and temperature difference, ΔT. With this in mind, it's easy to see that the ΔT over the server cooler considerably influences the distributed flow.

3.5 Energy effectiveness in higher heat pump efficiency

As described above, the LSV coil package is larger—for good reasons—and this provides the positive effect that the supplied temperature to the LSV cooler can be higher than to a conventional CRAC server cooler.

If a CRAC server is supplied with 64°F cold water, the LSV cooler can be supplied with 67 – 68°F, with the same thermal performance to the servers, as the coil package allows for this. A heat pump supplying server coolers water at 64°F vs. 67 – 68°F will have a direct impact on the heat pump's COP (Coefficient of Performance).

A rule of thumb says that every degree higher in supply temperature from the heat pump will contribute 3–4% to the heat pump's effectiveness. The raised effectiveness due to using LSV coolers—from a heat harvest point of view—will be in the range of 5–8% in comparison to CRAC unit systems.

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4. Conclusion

Data center operating costs (energy consumption, rising prices) are increasing. Legislative pressure on energy consumption and share of emissions is also increasing. It is time to progress beyond conventions towards proven, financially viable alternatives.

Harvesting and selling waste heat for profit is already employed in neighboring industries. It makes sense from a sustainability standpoint and—even without other factors—from a business perspective as well. And, the addition of regulatory incentives for going green make an even more compelling case for viewing waste heat differently.

Selling hot water to a city's energy supply can raise the effectiveness of a data center and lower the PUE (Power Usage Effectiveness), as it will act as a second income in addition to the data services the data center sells to the market. Harvesting heat from a data center requires a piping network of supply and return pipes connected to the heat pump, a positive mindset towards district and local hydronic heating and the will to use the environmentally-friendly technology of large-scale hot water production, rather than small individual boiler units.

Such a shift is, of course, associated with investment, but regulatory incentives combined with a Low Speed Ventilation system that maximizes heat recovery, shorten payback time and increase rate of profit, meaning that conventional CRAC cooling can become a thing of the past.

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