"The Future of Heat Pumps in Data Centers is here and supports smarter urbanization"

The idea of a heat pump in a Data Center may sound counterintuitive; after all Data Center servers produce heat and the objective is to cool the servers and get rid of it, right? Why would one want to use a heat pump to produce heat?

To recover and repurpose the waste heat for the residential sector!

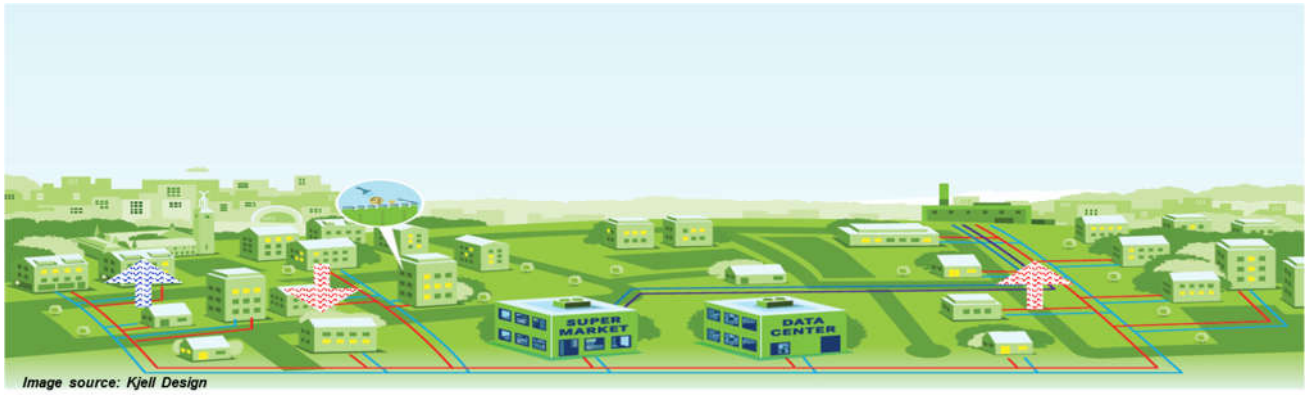


Image source: Kjell Design

Traditional Data Center cooling and heat rejection methods

The main objectives behind cooling a data center environment is to provide the right amount of cooling as efficiently and as reliably as possible where it is needed.

Traditionally this has been achieved using mechanical thermodynamic cooling equipment to provide the necessary cooling with the removed heat being rejected to the outside atmosphere via an air or water heat rejection system.

Since data center cooling represents a significant portion of energy consumed, there is increasing focus on improving the efficiency of cooling solutions, with a trend away from mechanical chiller based cooling systems towards air based systems, often referred to as direct or indirect all air cooling solutions or "free cooling", particularly in the case of larger or hyper data centers.

Environmental and economic considerations of heat rejection?

Whether using mechanical cooling equipment alone or in combination with free cooling systems, the traditional approach to cooling a Data Center still involves 'rejecting' heat to the planet's atmosphere thus contributing directly to the 'warming' of the planet.

The question might well be asked, aren't we then "…simply throwing away good heat that might be put to good use somewhere else" if we can provide it at a useful temperature and avoid producing it with other fuels having a higher rate of CO2 emissions?

Can we recover rejected heat?

The capture and reuse of 'rejected energy' is not new in the commercial and industrial building environment with many businesses in particular involved in industrial processes embracing the economic and environmental benefits of reusing this energy within a manufacturing process itself or whenever other heating needs exist at the site location (office heating, cleaning…)

One common design approach is to recover the rejected heat directly from the cooling system 'as it comes' using heat recovery condensers or desuperheaters added to the cooling equipment and in such systems the achievable water temperatures using heat recovery condensers is typically <50 degC and with desuperheaters <60 degC with significant less recovery of the total quantity of heat available in the latter case.

Depending upon the application requirements, such water temperatures combined with the quantity of supplied heat still offer significant economic advantages. However, the rejected heat is not sufficient to provide the added boost in temperature typically required for district heating networks for example. Hence, an additional heat source is required to do this.

So what about Heat pump solutions for heat recovery?

Before commenting upon the benefits of heat pumps for heat recovery it is worth clarifying that a heat pump is in fact a chiller and vice versa. It is a common mistake to believe that these are different, and in fact are more usually designated by the type of application, cooling or heating. From a manufacturer's perspective this usually results in optimizing or even limiting the different range of operating conditions to those required by the targeted application. After all there is no point in using a formula one racing car to drive around in a city where speeds are likely limited to a maximum of 50km/h, for example.

From the point of view of heat recovery, some of the main advantages of heat pump solutions over cooling solutions with integrated heat recovery are that:

(1) Heat pumps are designed and optimized for the production of heat and are capable of boosting the recovered heat to higher temperatures such as 85 degC.

(2) Heat pumps usually offer extended operating capabilities in terms of operating maps that allow recovery from a wide range of energy sources such as a waste heat process, geothermal or aerothermal source and data centers whilst still providing efficient and reliable cooling.

Beyond adopting a green data center attitude, what are some of the other drivers?

As European legislation continues to evolve and to focus on reducing CO_2 and other emissions, the latest European Union heating & cooling strategy framework used some key words and identified

opportunities to meet goals using renewables, waste heat recovery and district cooling & heating networks.

Heat pump solutions applied in cooling or simply in waste heat recovery applications offer an ecological and effective way to contribute to meeting those goals.

With the latest F-Gas legislation driving the introduction of the next generation of new refrigerants and the renewed interest in thermodynamic heating solutions, manufacturers are designing a new generation of heat pump products and solutions capable of delivering even higher hot water temperatures. This combined with excellent system efficiencies have still further opened the possibilities for the economical use of such solutions - for example the use of data centers as a heat source for district heating systems.

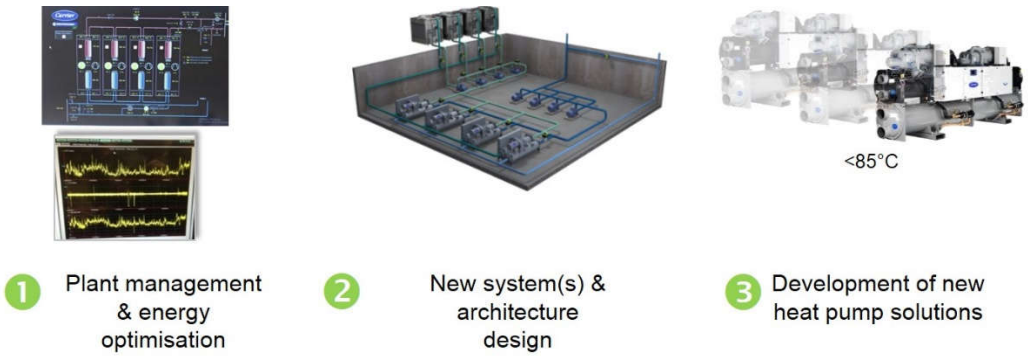
The latest heat pump ranges offer a modular, scalable and cost effective approach to heat recovery usually not achieved by the larger customized project by heat pump plants.

Whilst for existing data centers a full cooling load for heat recovery may already exist, with the newer data centers particularly those focused on colocation, this flexibility and adoption of the right system architecture and design can allow the first capital expense costs to be limited and units added as the data center grows in load and offering the right balance to capital expenditure (CapEx) and operational expenditure (OpEx).

What are the components of a reliable heat solution?

Firstly it is important to engage in a holistic design approach and ensure the relevant parties are involved, the end user/owner or data center operator and the district heating companies to understand the applications, operation and objectives and of course the designer to ensure the correct system design.

These are the basic building blocks on which to deliver the full and correct heat pump solution in three main areas:



1) **Plant controls solution** managing all cooling/heating units, pumps valves etc. to deliver reliable and efficient cooling and heat recovery. This is the brain of the system.

2) Choosing the right **system architecture & design** layout whether in parallel, series or series counter flow based on flows, temperatures, loads and load variations to optimize performance and efficiencies at all loads

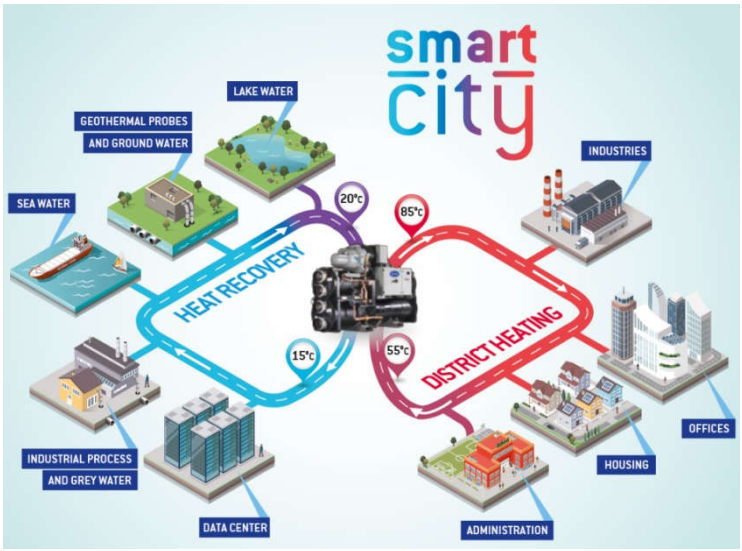
Series counterflow arrangement can improve COP by up to 40%

3) The **heat pumps** sized for the calculated loads and optimized as part of the system.

Data Centers, Heat pumps and Smart Cities?

In conclusion, what does a heat pump need? A source of energy and what does a data Center offer? A year round 8760 hour source of energy obtained from providing cooling!

With heat pumps, data centers can stop wasting the excess heat from the IT-server and instead extract it, boost it to useful temperatures and reuse it efficiently, ecologically and economically for district heating, industrial processes and, in fact, everywhere that heating is needed. With urban densification predicted as a significant trend for the future, the resulting proximity of human habitation need for dwelling heating lends practicality, financial and ecological sense to such solutions.



As of today, more than 60 units have been delivered for a wide range of applications from geothermal to agriculture to data center heat recovery with more than 10 projects in this last application alone here in Stockholm, Sweden. In these projects, the reused heat from data centers replace other, CO_2-intensive, fuels used to produce residential heating, making an important contribution in the fight against climate change.

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