TRANE

Trane Engineering News

Heat! Don’t let it go, reclaim it.

Most commercial buildings and industrial plants in Europe use boilers to produce hot water and chillers to produce chilled water - either to maintain a comfortable environment or to satisfy temperature requirements for industrial processes.

Free cooling systems are a popular option on chillers which saves energy whenever there is a cooling demand in winter. However, operating a chiller, no matter the outdoor air conditions, generates heat which is normally rejected into the atmosphere. There are ways to make substantial energy savings by repurposing that heat.

This paper argues that, in many cases, choosing chillers with integrated heat recovery systems will deliver far more energy savings that free cooling chillers, as long as there is a simultaneous demand for heating and cooling, both in summer and in winter.

When considering the simultaneous heating and cooling requirements of a building or an industrial process, such questions arise:

- Which type of system is best suited for a particular application?
- Is a heat recovery option more efficient than free cooling when a cooling demand has to be satisfied during the winter period?

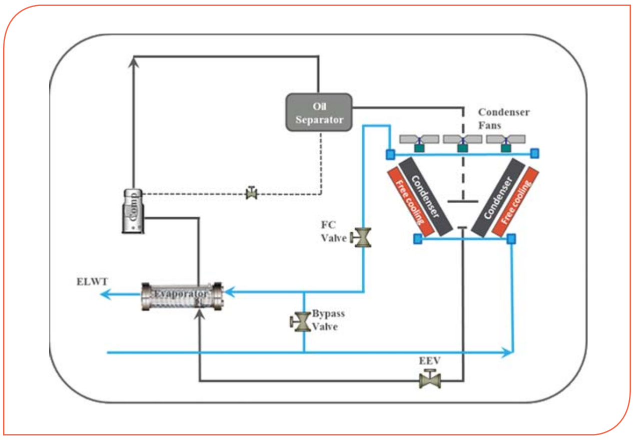
The following paper discusses:

- The benefits of using a heat recovery system instead of free cooling on specific applications.
- The steps to be taken to successfully implement the system.

Introduction

‘Free cooling’ refers to the ‘free’ removal of heat during the colder months of the year.
A chiller with integrated free cooling (see figure 1) takes advantage of low outside air temperatures to produce chilled water without enabling the compressors and by using the ventilation of the unit only.
As compressors are no longer used for producing the chilled water, the efficiency of the unit increases drastically.

Figure 1: Example of an integration of free cooling option in an air-cooled chiller.



However, free-cooling is not completely “free”.

- To extract heat from the water, the fans need to run and consume electricity
- The units equipped with free cooling option are generally less efficient compared to a similar unit without the option due to the higher pressure drop in the system, and therefore penalized when the outdoor conditions do not allow to benefit from free cooling
- The free cooling option (factory-installed, or retrofitted) has an investment cost, which is not negligible

Nevertheless, despite a higher investment cost, free cooling remains a good option to cool down a building or process during winter period while reducing operating costs.

When is it NOT recommended to use free-cooling?

Using chillers with free cooling becomes an irrational practice if the heat rejected in the atmosphere can be repurposed for heating another part of the building or for a water heating process such as producing domestic hot water.
In existing buildings, it is common to see free-cooling systems rejecting heat while the building needs heat.

Chillers with free cooling are only recommended when the total building cooling demand exceeds the building's heating demand during winter period and there is no thermal energy storage system available. This rarely happens for the vast majority of HVAC applications.

Typical applications for heat recovery

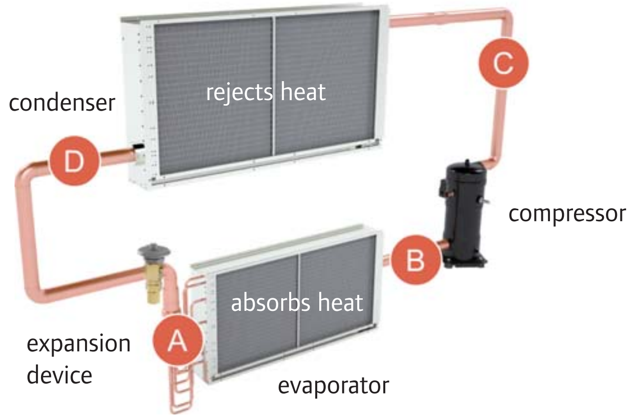
Heat recovered from air-cooled chiller operation can be repurposed for a wide range of applications, including:
1. Hot water production or ventilation pre-heating in hospitals
2. Sanitary hot water production
3. Swimming pool heating in leisure centers
4. Hot water preheating in Industrial processes where demand for chilled and hot water are high (e.g. food industry)

How does heat recovery work on air-cooled chillers?

Heat recovery can be applied to most sizes of chilled water plants, from a small single unit to a large plant consisting of multiple units of more than 1,000kW each.

Whatever the compressor technology used (scroll, screw or magnetic levitation), the chiller uses the vapor-compression refrigeration cycle. (See figure 2)

Figure 2: Refrigeration cycle



The refrigeration process includes a heat rejection step to condensate the hot and high-pressure refrigerant vapor (C) leaving the compressor for re-use in the cycle. With a traditional air-cooled chiller, the heat is rejected to ambient air via the condenser. Here lies the opportunity to reclaim and repurpose that heat.

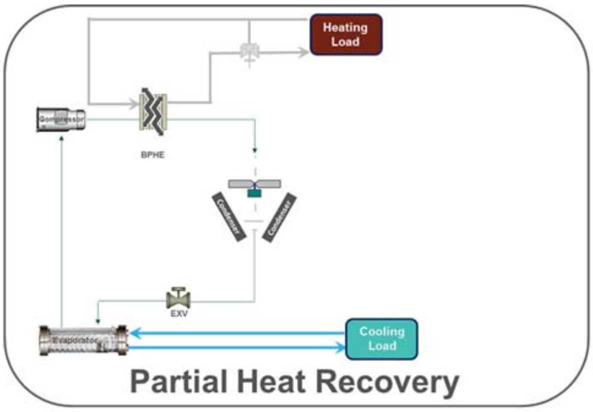
To reclaim the rejected heat from air-cooled chillers, two options are available on the market.

Partial heat recovery.

Partial heat recovery utilizes a supplemental heat exchanger (often named de-superheater) mounted on the hot gas line and in series with the condenser. (See figure 3)

The amount of heat recovered can be up to 30% of the cooling capacity.

Figure 3: Chiller with partial heat recovery option

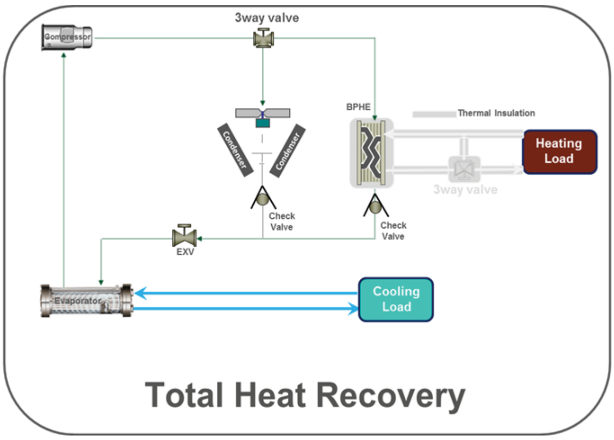


Total heat recovery.

Total heat recovery is usually accomplished by using two condensers in parallel - one heat recovery condenser and one standard condenser. (See figure 4)

With this system, up to 100% of the waste heat can be recovered.

Figure 4: Chiller with total heat recovery option



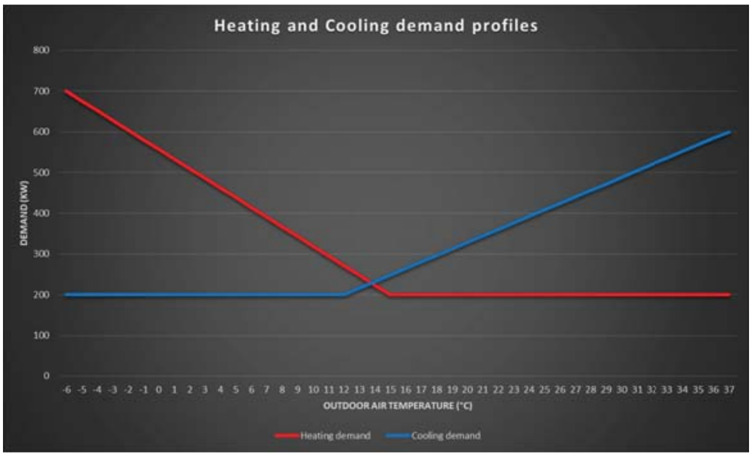
Designers can specify new chillers with factory-installed heat recovery systems. For already installed chiller systems, retrofit kits are available.

Case study

Let’s consider the typical case of a mixed-use building located in Strasbourg, which is most representative of the average climate in Europe. In this example, we will compare both systems: Chiller with Free Cooling, and Chiller with Heat Recovery.

- Application with simultaneous heating and cooling needs of 200 kW
- Peak heating demand 700 kW @ -6°C OAT
- Peak cooling demand 600 kW @ 37°C OAT
- Location: Strasbourg (France)
- Operating time from 6 to 21, 5 days a week and along the year

Figure 5: Heating and cooling demand profiles

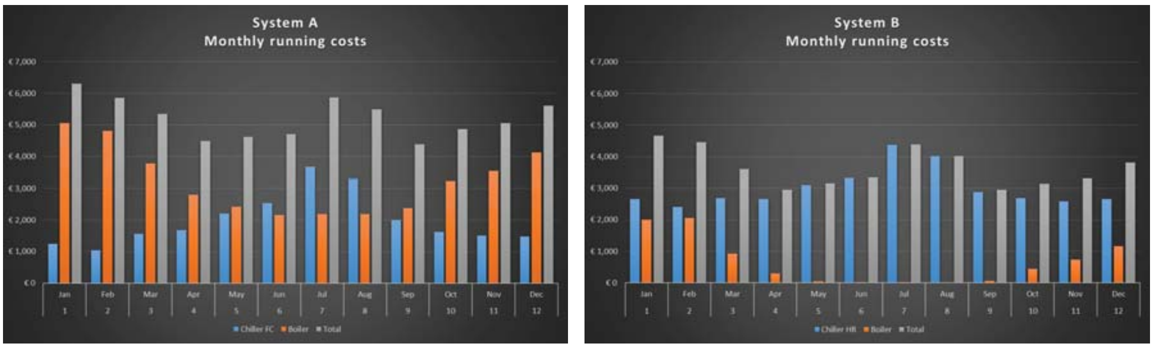


Systems:

- Option A: Air-cooled chiller with direct free cooling option and gas condensing boiler.
  The chiller uses the free cooling option as soon as the outdoor conditions allow it and the boiler runs to meet the heating demand.
- Option B: Air-cooled chilled with heat recovery option and condensing boiler.
  The chiller uses continuously the mechanical cooling for satisfying the cooling demand, the heat is recovered and the boiler runs when the heating demand is not satisfied with the recovery.

Based on the above conditions, the simulation shows that despite a higher consumption of the chiller, the consumption of the boiler is greatly reduced and that the heat recovery option brings significant savings compared to free cooling option.

Figures 6 & 7: Monthly running costs for systems A & B



Summary

	System A	System B
Estimated Yearly Boiler Consumption	1.291.000 kWh	258.200 kWh
Estimated Yearly Chillers Consumption	238.500 kWh	361.000 kWh
Estimated Yearly Running Cost *	62.580 EUR	43.846 EUR
Estimated Yearly Savings*		18.734 EUR

* Assuming 3.910 operating hours a year, 0,030 €/kWh for the gas price and 0,10 €/kWh for the electricity.

Recommended steps to successfully determine if heat recovery is a valid option

1. Identify the heating needs in the building
2. Define the heating requirements (temperature, flow, demand)
3. Estimate the heat available from the chilled water production
   a. For new units, assess both Partial heat recovery and total heat recovery alternatives
   b. For existing units, check if a retrofit kit is available. Usually, refrigerant piping will need to be modified to install the "de-superheater"
4. Ensure that the heat recovered is less or equal to the heating requirements
   a. For plant with multiple chillers, the design (number of units with heat recovery option) should be based on the maximum heating demand rather than the heat available.
5. Verify that the heat is produced at the same time as it is required
   a. If not, consider thermal storage tanks.
6. Check the feasibility of connecting the heat recovery system to the heating or hot water production system.
   a. For existing installations, pipework may be extensive and affect the payback period significantly.

Only a detailed analysis can quantify the heat recovery potential and savings and allow a correct design of the heat recovery system.

References

(1) Installation, Operation and maintenance manual RLC-SVX19H
www.trane.eu

(2) Air-cooled Liquid Chillers with Direct Free-Cooling Trane Application guide - RLC-APG001B

(3) Air-cooled Liquid Chillers with Heat Recovery Trane application guide - RLC-APG002A

(4) Trane Chiller Plant Analyzer – Energy comparison tool

(5) Source: Energy prices (gas and electricity): Eurostat 2015
http://ec.europa.eu/eurostat/web/main/home

BAS-APN008A-GB Dec 2019