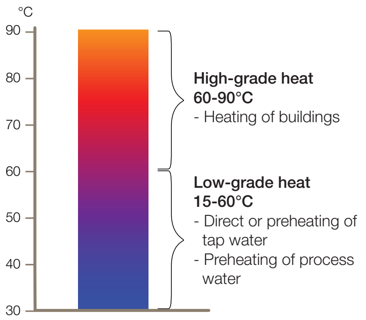
Heat recovery from open cooling tower

Global warming, climate change, carbon foot print is on everyone's agenda, how to be more efficient, more environmentally friendly and saving natural resources is the highest priority. Waste heat is waste energy, because heat is generated by energy obtained by burning natural resources such as fossil fuels, LPG, fuel oil and natural gas. By recovering waste heat, we not only protect the environment, but also save money and contribute to profitability of one's total operations.

Energy from waste heat can be recovered from different grades of temperature and transferred to other fluids which are required to be heated. For example high grade heat can be hot water at 90°C, which can be used for heating buildings and low grade can be that from return cooling tower water, at 35°C at its peak, that can be used to preheat boiler feed water or process water.



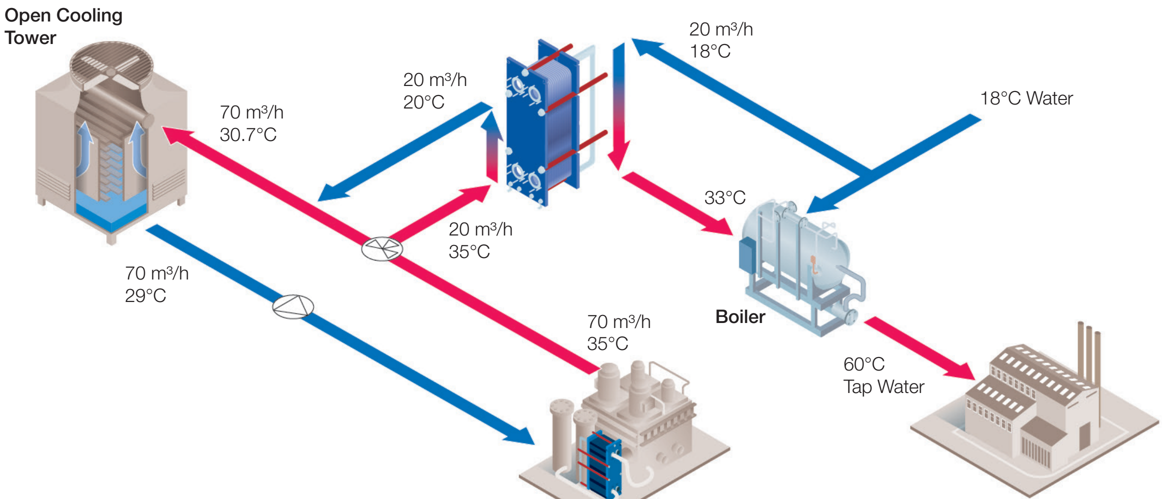
Heat recovery from low- and/or high-grade heat

Manufacturing industries use heat for reactions, treatment and various processes after which, the unwanted waste heat is released to the atmosphere with an open coolin g tower. Similarly, in **HVAC applications**, many people spaces need heat to be removed with the help of a chiller, which in turn releases the unwanted waste heat to an open cooling tower via the chiller's condenser.

Typical open cooling towers

Typically, open cooling towers are designed for peak hottest summer conditions and a ΔT of 6°C. This can be 35°C to 29°C at a dew point of 27°C. Whether or not 35°C return cooling tower water is valuable for recovering, can only be evaluated when compared to a plant using boiler feed water at ambient temperatures of 10°C or 20°C.

Gasketed plate heat exchangers with counter-current flow are commonly used for heat recovery applications because of their excellent flow regime, making it possible to achieve a temperature approach of as low as 1°C. Hence for a cooling tower water return temperature of 35°C, boiler feed water can be preheated to as high as 34°C. However, for best economies of scale and optimum payback period, Alfa Laval recommends a 2°C approach, i.e. preheating to 33°C.



Savings with heat recovery

There are several savings in this heat recovery application.

- Savings with almost halving the boiler fuel bills, as the boiler will heat water from 33°C to 60°C instead of 10°C to 60°C
- Savings with increased cooling tower capacity, as lower return temperature will require lower cooling demands from the cooling tower.

Saving water with less evaporation release to atmosphere

Enthalpy of water at 30°C is 125 kJoules/kg or 522 kCal/kg (multiplied by Cp of 4.18).

Water lost before and after heat recovery:

$$\frac{420{,}000 \text{ kCal/hr}}{522 \text{ kCal/kg}} = 804 \text{ kg/hr} \qquad \frac{120{,}000 \text{ kCal/hr}}{522 \text{ kCal/kg}} = 230 \text{ kg/hr}$$

Saving 804 - 230 = 574 kg/hr x 8 hrs a day and 365 days per year = 110 m³ per year waste of natural sources.

In monetary terms at 1 euro/m³ perhaps this is little, but as chemically treated water with RO is a huge impact to the environment wasting natural resources.

Calculation of savings

Example: Heat recovery from cooling tower 420,000 kCal/hr operating 35° to 29°C and 70 m³/hr. Assume heat recovery form only a partition of the total flow: 20 m³/hr.

Cooling tower water returning to the tower at 35°C cooling to 20°C, preheating ambient temperature boiler feed water at 18°C to 33°C.

Alfa Laval gasketed plate heat exchanger selection:

Cooling tower return water	20 m³/hr	35°C → 20°C
Boiler feed water	20 m³/hr	33°C ← 18°C

What will be the:

a) Amount of waste heat recovered in kW?
b) Duration savings for in kWh?
c) Savings in monetary terms, assuming cost of 0.10 euro/ kWh?
d) Payback period in months?
e) New return temperature to tower?

a) Amount of waste heat recovered in kW?

Heat absorbed by boiler feed water = Heat released from cooling tower

$$\mathbf{Q = m \times c \times \Delta T_{(cold)} = m \times c \times \Delta T_{(hot)}}$$

Q: Waste heat recovered kCal/hr
m: Flowrate m³/hr
c : Specific heat of water (assume as 1 for water)
ΔT: Temperature change, T_{out} - T_{in} °C

Q = 20 x 1 x (35-20)
= 300,000 kCal/hr
= 349 kW (divided by 860)

b) Duration savings for in kWh?

Assuming operation is 8 hours per day and 20 days per month.

Savings = 349 x 8 x 20
= **55,840 kWh per month**

c) Savings in monetary terms, assuming cost of 0.10 euro / kWh?

Savings = 55,840 x 10
= **5,584 euro per month**

d) Payback period in months?

Assuming a total investment cost of 15,000 euro (Alfa Laval gasketed plate heat exchanger 7,000 euro and associated costs such as piping, installation and commissioning 8,000 euro).

The **payback period will be 3 months** to recover the capital investment.

e) New return temperature to tower?

With a total of 70 m³/hr split as 50 m³/hr at 35°C and 20 m³/hr at 20°C. Hence the overall return cooling tower temperature will be:

$$= \frac{50 \times 35}{70} + \frac{20 \times 20}{70}$$

= **30.7°C for 70 m³/hr** total flow instead of 35°C

▼ PRACTICAL TIPS

If preheated water cannot instantly be used at the boiler, this water can be stored in a buffer tank to be used at a later stage when needed. The payback period will be reduced if the cooling tower and boiler are placed close to each other, as the piping investment cost will be reduced.