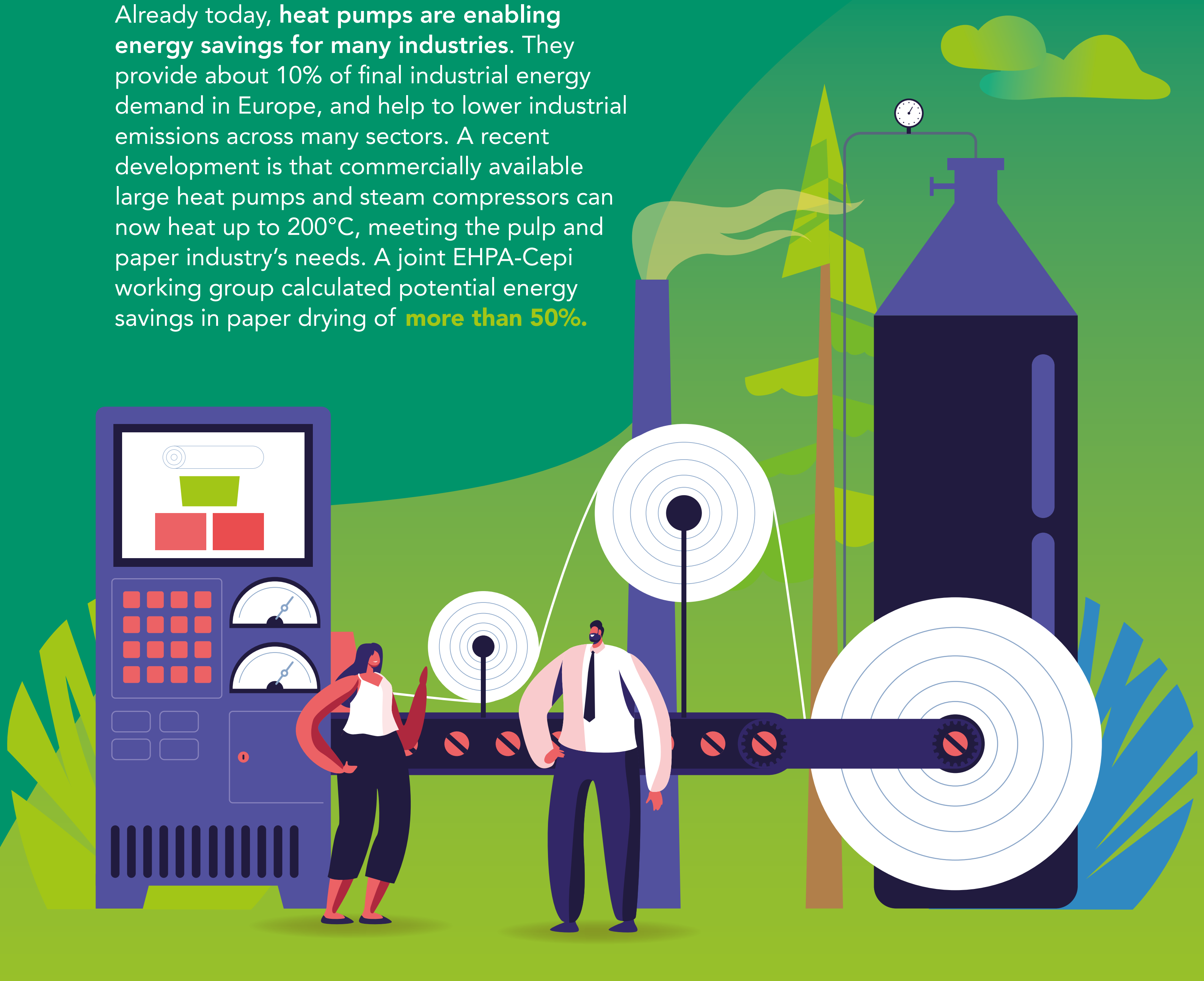
THROUGH PUMPS TO PULP:
GREENING THE PAPER INDUSTRY'S HEAT

A joint paper by the European Heat Pump Association (EHPA) and the Confederation of the European Paper Industries (Cepi)

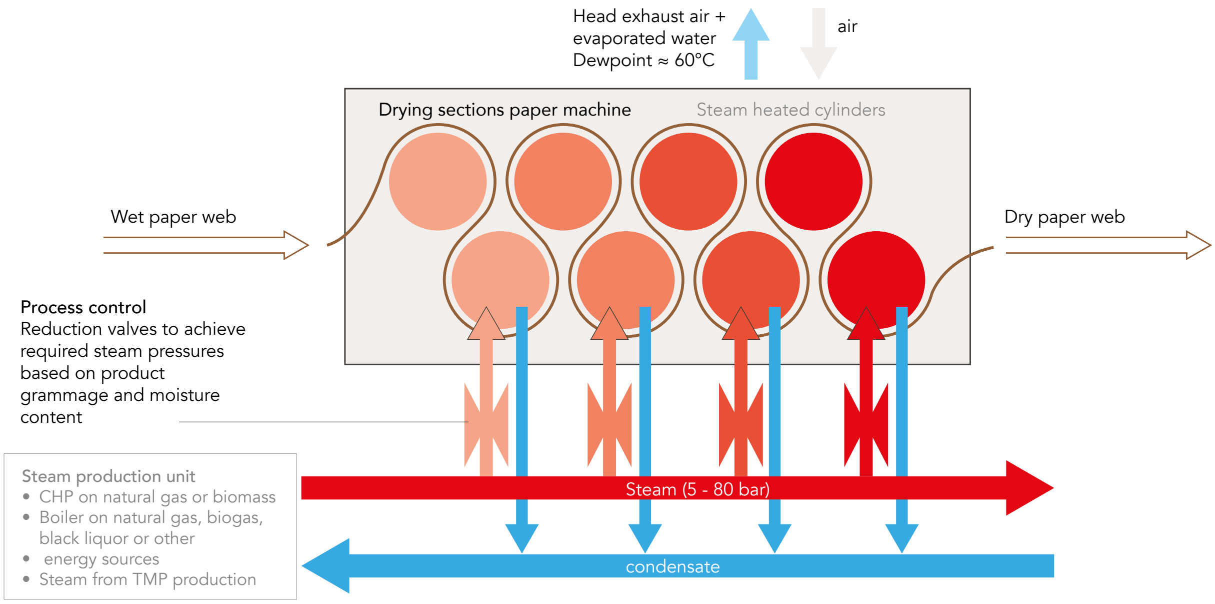
Already today, **heat pumps are enabling energy savings for many industries**. They provide about 10% of final industrial energy demand in Europe, and help to lower industrial emissions across many sectors. A recent development is that commercially available large heat pumps and steam compressors can now heat up to 200°C, meeting the pulp and paper industry's needs. A joint EHPA-Cepi working group calculated potential energy savings in paper drying of **more than 50%.**



01 How papermaking works and why is it ideally positioned to use heat pumps

In a paper mill, a wood-based material called wet pulp is distributed onto a moving screen from which water is progressively removed through different processes. The most energy-intensive process, drying, represents 70% of the energy used by the paper industry. There is large potential for industrial heat pumps to be used by the pulp and paper industry to reduce its energy consumption and greenhouse gas emissions.

Figure 1: Virtual average paper mill: Drying + steam-condensate system

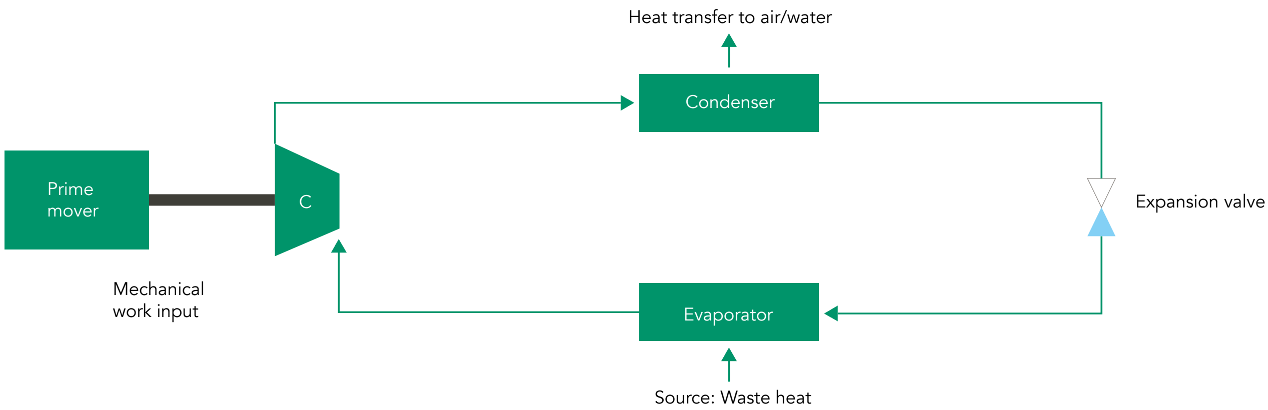


The European paper and pulp industry uses about 1,200 paper machines altogether, each of which produces an average of 80,000 tonnes of paper a year. As part of the production process the industry generates waste heat from the paper machines' drying section. One area of particular impact would be to use it as a source to heat the condensate coming from the cylinders into steam for further drying needs.

02 How a heat pump works

The most common type of heat pump is the compression heat pump. It transfers and upgrades thermal energy from waste heat sources, to 'heat sinks' using a small amount of additional 'driving' energy - usually electricity.

Figure 2: Visual of a compression heat pump



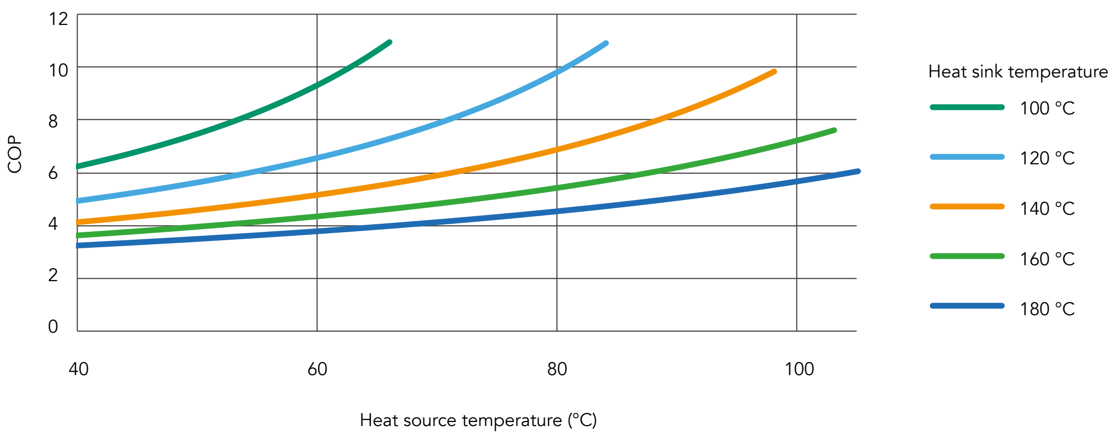
The thermal energy from the heat source is transferred via a refrigerant liquid. Inside what's called a 'heat exchanger' the refrigerant turns into a gas. The gas reaches a 'compressor' which, with the help of a small amount of extra energy, 'squeezes' the gas to a high pressure, causing a rise in temperature. This hot and highly pressurised refrigerant gas then releases its heat into the 'heat sink', the refrigerant turning back into a liquid as it cools. Its pressure is lowered, and the cycle begins again.

03 Why heat pumps are energy efficient

The **efficiency** of a heat pump is expressed as the Coefficient of Performance or COP. It is the relationship between the power input and the useful heat output of the heat pump. The higher the number, the more efficient a heat pump is and the less energy it consumes. This COP highly depends on the temperature difference between the heat source (TC) and the heat sink (TH), where the 'Carnot curve' indicates the theoretically maximum efficiency (COP), depending on the source and sink temperature. For example, a heat pump system with a COP of 2,5 means 60% energy savings can be achieved.

$$COP_{heating} = \frac{T_H}{T_H - T_C}$$

Figure 3: Carnot curve representing the theoretical maximum energy efficiency of a heat pump. Heat pumps generally reach about 50% of the theoretical maximum.



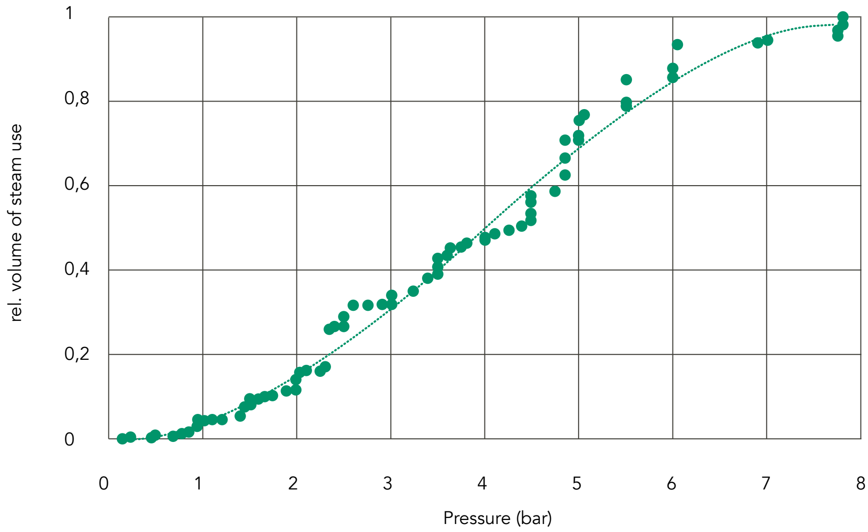
The heat source: exhaust air of drying hood

- Currently 60 °C is the maximum dewpoint in paper production. **This is an ideal source of waste heat that heat pumps could use.** Developments are ongoing to reach higher dewpoints to improve the system COP. This requires further closing the drying hood. Airless or superheated steam drying would result in the optimum energy efficiency.

The heat sink: steam heated cylinders

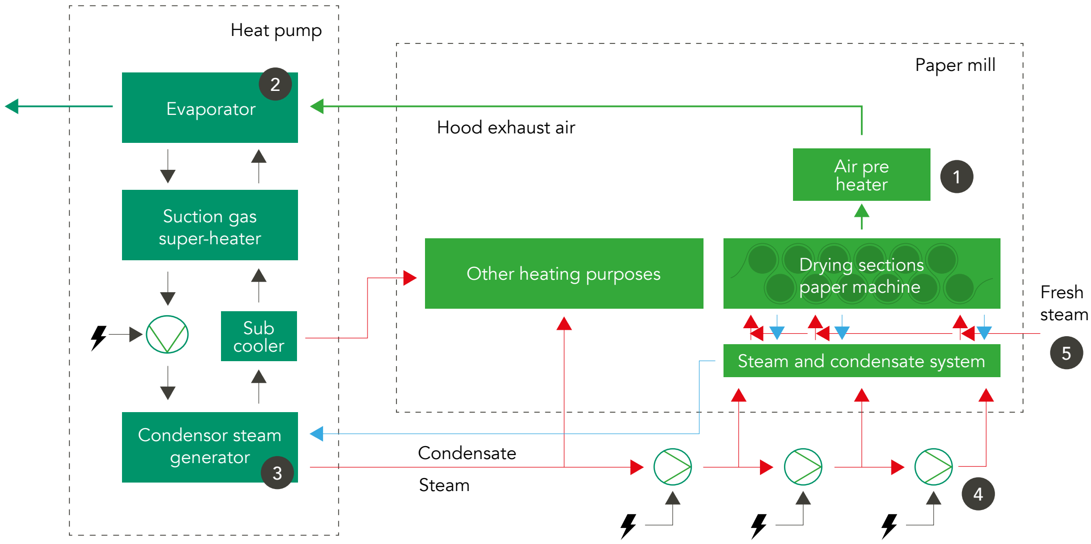
- The amount of steam sections depends on the product manufactured, but paper machines normally have four to six drying sections. The drying is done by steam-heated cylinders.
- On average, the total electricity needed for the steam used by one paper mill is 30 MW – roughly enough to power about 30,000 homes for a year. The cylinders normally require between four tonnes to more than 70 tonnes per hour of steam each.
- Typical steam pressures range from 0 to 8 barg. In most paper mills, steam pressures are different in each drying section, with low pressures in the first sections and higher pressures in the last drying sections. Pressure levels also fluctuate by a maximum of 20% depending on paper grades and grammages.
- Using lower steam pressures in paper drying, by decreasing the heat sink temperature, also increases the heat pump system's efficiency.

Figure 4: Range of typical steam pressures in a paper machine.
70% of steam use in the European paper industry is below 5 bar.



04 Heat pumps can be integrated into the paper manufacturing process

Figure 5: How a heat pump can be integrated into the paper production process



After heat transfer to pre-heat the incoming air feeding the drying sections of a paper machine (1), the latent heat of the water vapour recuperated via the drying hood would be used to evaporate the refrigerant in the heat pump (2). The refrigerant is then compressed and turns back into liquid form, and the resulting heat is used to evaporate the condensate coming from the drying cylinders (3). To lift the steam to higher pressures, steam compressors are installed (4). Fresh steam from boilers can be added to ensure pressure control in the cylinders (5).

Contacts:

Thomas Nowak
EHPA Secretary General
thomas.nowak@ehpa.org
+49 17 66 32 01 140

Annita Westenbroek
Cepi Energy Innovations Manager
a.westenbroek@cepi.org
+31 6 51076774