BEST PRACTICES – ENERGY GENERATION
FACTSHEET

Improving Cold Chain Energy Efficiency in food and beverage sector

Waste heat and heat recovery from refrigeration

Recovering heat from the refrigeration process can save energy and cut energy costs. Heat-recovery equipment can be fitted to existing plants or integrated in new plants. There are two types of heat recovery systems from refrigeration, depending on the installation and refrigerant used: **High-grade heat recovery**, where heat (of between 60 and 90ºC) is recuperated in refrigeration systems from de-superheating the refrigerant between the compressor and the condenser. **Low-grade heat recovery**, where heat (of between 20 and 40ºC) comes from the refrigerant being condensed.

'Heat pumps, aborption chillers & free cooling'

Europe
(Food and Beverage sector)

TRL 9

Investment (depending on size of installation)
3.500 - 200.000 €

Typical payback time
2 - 6 Years

Savings
30 - 45% Energy cost savings

Main NEBs (Other benefits)
Improved performance
Reduced greenhouse gas emissions

Heat recovery in the food sector

The most commonly used heat recovery methods in the food sector are the following:

- direct usage via **heat exchangers** making use of heat as it is in the surplus stream
- **heat pumps** upgrading the heat in relatively cold streams by aid of electrical power

In the food industry it is possible to recover heat from different sources: cooling systems and compressors, pasteurisation, exhaust gases from burners, etc. Recovered heat can also be used for heating tap water or ventilation, thawing deep frozen goods, preheating cleaning liquids and products, and space heating, among other reported applications.

Refrigeration & heat recovery

Heat recovery in refrigeration can be done in two ways:

- Waste heat generated from the refrigeration unit can be used as a heat source; e.g. to preheat water in order to reduce the energy use of the boiler.
- Waste heat from other processes can be used for refrigeration, through the use of absorption refrigeration.

Refrigeration systems cannot make heat disappear – they just move it from one place to another.

The refrigeration process includes a heat rejection stage to cool the refrigerant for reuse in the cycle. About 20 % of heat expulsion is due

to 'de-superheating' of the refrigerant prior to condensation, and this heat has potential to be recovered as 'high-grade' heat for other purposes. One way you can do this is to install a de-superheater ahead of the condenser in the circuit.
The amount of heat that can be recovered from a refrigeration system will be heavily influenced by

Useful tips for implementing heat recovery systems in refrigeration:

- Ensure that the system is operating as efficiently as possible
- Ensure that there are no refrigerant leaks
- Consider linking a heat pump (in case you need upgrade remaining low-grade heat)

the temperature required for use. The higher the required temperature (typically up to a maximum of around 65°C), the lower the amount of heat from refrigeration that can be recovered. Heat pumps are generally only a good solution when the site energy recovery has been fully optimized and only low-grade heat remains.

Absorption chillers: Best practice for optimizing performance

Absorption chillers use heat, instead of mechanical energy, to provide cooling. Compared to mechanical chillers, absorption chillers have a low coefficient of performance (COP = chiller output/heat input). Nonetheless, they can substantially reduce operating costs because they are driven by low-grade waste heat, while traditional vapor compression chillers must be motor- or engine-driven.

Example:
In a plant where low-pressure steam is currently being exhausted to the atmosphere, a mechanical chiller with a COP of 4.0 is used 4,000 hours per year (hr/yr) to produce an average of 300 tons of refrigeration. The cost of electricity at the plant is 0.13 € per kilowatt-hour (kWh). An absorption unit requiring 2.4 tons per hour of 2 bar steam could replace the mechanical chiller, providing annual electrical cost savings of:

Annual Savings =
300 t x (3.5 kWh/t / 4.0) x
4,000 hr/yr x 0.13 €/kWh
= 136,500 €

Use waste heat only if waste heat is unavoidable

For the improvement of industrial energy efficiency waste heat recovery takes on a certain special role, as it should only be considered after the causes of the heat generation have been reduced as far as possible. Therefore, the following questions should be answered before a more detailed examination of waste heat recovery

- **Dimensioning**: Is the underlying process correctly dimensioned or is there unnecessary capacity?
- **Control**: Is the plant or process correctly controlled (e.g. inefficient operating points or idle times)?
- **Temperature level**: Is the currently selected temperature actually required?
- **Insulation**: Can better insulation reduce the amount of waste heat?
- **Alternatives**: Are energetically more advantageous alternative processes applicable?

No recovery, then free cooling

Free cooling is a fast and effective, economic method of using low external air temperatures. It can be used to assist in cooling water for industrial processes or in HVAC systems. When outdoor temperatures are lower relative to indoor temperatures, this system utilizes the cool outdoor air as a free cooling source. In this manner, the system replaces the chiller in traditional air conditioning systems while achieving the same cooling result. A free cooling coil is installed in series with the chiller system's evaporator so in lower ambient conditions partial or 100% free cooling can be achieved.

Free cooling operation, makes the most of natural low ambient temperatures and in doing so benefits from a reduction in energy costs of up to 80%.

In winter, when outdoor temperatures are low enough, the water is chilled solely by the free cooling coil. This allows the chillers' compressors to stop operating, saving significant amounts of energy. The only electrical power used in winter operation is for fan operation. This can be achieved once the ambient air temperature is 3 °C to 5 °C below the process supply water temperature.

Opportunities and barriers to implementation

Opportunities	*Barriers*
Optimization of heat fluxes in a plant (optimized heat recovery)	Modifications in production processes might be necessary
Combined heating and cooling in one system (heat pumps)	
Reduced operating and energy costs	

References

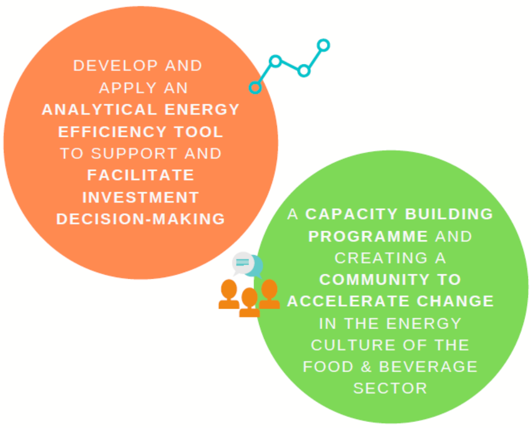
[1] Aermec S.p.A, Industrial Refrigeration.
[2] Reindl, Douglas & Jekel, Todd. (2007). Heat recovery in industrial refrigeration. 49. 22-28.
[3] U.S. Department of Energy Washington, Energy Efficiency & Renewable Energy - Advanced manufacturing office, Steam Tip Sheet #14. January 2012.
[4] JRC (EU), Best Envionmental Management Practice for the Food and Beverage Manufacturing Sector. 2018.
[5] Publicatins Office of the European Union, Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries. 2019.

About ICCEE

The project ICCEE, www.iccee.eu, funded by the EU programme Horizon 2020, aims at improving energy efficiency in the cold chain of the food & beverage sector and making it easier for the sector:

- to undertake energy efficiency measures across the entire supply chain
- to accelerate the implementation of energy audit results

ICCEE follows a holistic approach that moves from a single company perspective to the assessment of the entire cold supply chain. Existing financing schemes for SMEs will be assessed: the optimal ones will support the implementation of energy efficiency measures. ICCEE objectives build on 2 pillars:



The ICCEE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 847040