Q&A:
Industrial Heat Pump Innovation

Answers to the most asked questions that we received during the webinar hosted on the 29th of October 2020 by the writers of the white paper on Strengthening Industrial Heat Pump innovation in Europe

Link to webinar: https://channel.royalcast.com/tnowebcasts/#!/tnowebcasts/20201029_2

Heat Pumps and CO_2 emissions

***What is the impact of HP on the CO_2 emissions of industrial process; and how does the electricity mix (amount of renewables) impact this*?**

The CO_2-emissions reduction due to the implementation of heat pumps is depending on the fuel source and the efficiency in the current situation before application of a heat pump, the performance of the heat pump (COP) and the CO_2-emissions of the electricity sector. This is illustrated by the following example calculation. Assume a heat load of 10 MW during 8000 hours, so 80 GWh per year. Natural gas is used in the base case with a CO_2-emission of 171 ton/GWh. The conventional boiler has an efficiency of 90%, so the current CO_2-emissions are (171/90%)*80 = 15.2 kton/year. Assume the heat pump has a COP of 4 and the CO_2-emissions of the electricity sector are 276 ton/GWh (average of EU-28 in 2014). The CO_2-emissions with a heat pump are (80/4)*276 = 5.5 kton/year, corresponding to a reduction of 64%. If the electricity sector is more fossil based, the CO_2-emissions for the electricity sector will be higher and therefore the reduction when applying a heat pump will be lower. On the other hand, decreasing the CO_2-emissions from the electricity sector with the growing shares of renewable electricity generation, leads to larger reductions.

Applications & Integration

Is it more difficult to integrate HP in brownfield applications? If integrated in brownfield applications, what are barriers and should you start brownfield with HP or look at other options first. How flexible are heat pumps?

Integration of a heat pump in brownfield applications are more difficult than greenfield applications, since one has to deal with an existing situation that was not designed for a heat pump. A detailed process analysis has to be carried out to assess whether a heat pump is indeed the most suitable solution for your process. Other options can be identified as well during this process and should be compared using objective merits.

Heat pumps are to some extent flexible with respect to operating temperature (within limits of the working medium) and power.

What are the best applications for HP?

The best applications for heat pumps are situations where the temperature difference between the waste heat and the process heat are relatively low and the physical locations of these waste heat sources and heat demand (sinks) are close vicinity, preferably within the same process. Furthermore, the heat capacity of both source and sink should be of similar magnitude, with both streams being available at the same time period.

Waste heat

What is important to know on the types of waste heat we can use, think on typical temperatures, delta T's?

Waste heat can be contained in many media, including flue gasses, air or water streams and even radiative sources. Most convenient streams are condensing or liquid streams, since the heat capacity is high, resulting in compact equipment. The majority of waste heat has a temperature between 40°C - 100°C, depending on the industrial sector.

Is there an overview on waste heat sources in Europe?

There is very limited information available on waste heat sources. The following articles provide some information on this issue.

- S. Brueckner, L. Miró, L.F. Cabeza, M. Pehnt, E. Laevemann Methods to estimate the industrial waste heat potential of regions - a categorization and literature review. Renew Sustain Energy Rev 2014;38:164–171. doi:10.1016/j.rser.2014.04.078.
- S. Wolf, M. Blesl Model-based quantification of the contribution of industrial heat pumps to the European climate change mitigation strategy. ECEEE Ind. Summer Study Proc. 2016;477–487.
- G. Kosmadakis Estimating the potential of industrial (high-temperature) heat pumps for exploiting waste heat in EU industries. Appl Therm Eng 2019;156:287–298. doi:10.1016/j.applthermaleng.2019.04.082.

In addition, a publication prepared by TNO is accepted by Renewable and Sustainable Energy Reviews that will include detailed waste heat estimates for the EU-28 based on process information.

Is geothermal heat an option for HP?

Geothermal heat can indeed be used as a source for a heat pump.

Heat Pumps at high temperatures (90-200°C)

Until which temperatures are commercial HP available; can we give some examples of suppliers?

Multiple manufacturers can provide products which supply heat up to 90 °C. Beyond this temperature, commercially available products are limited, with only a few pioneering manufactures demonstrating sink temperatures in the range of 120 °C–165 °C. An overview can be found at

- C. Arpagaus, F. Bless, M. Uhlmann, J. Schiffmann, S.S. Bertsch, High temperature heat pumps: market overview, state of the art, research status, refrigerants, and application potentials. Energy 2018;152:985–1010. doi:10.1016/j.energy.2018.03.166.

Qhat information is available on technological developments for Heat Pumps for 90-100 ^{o}C; 100-150 ^{o}C; and above 150 ^{o}C?

A number of research projects are developing heat pumps which aim to demonstrate sink temperatures in the range of 160 °C–200 °C, although implementation in the market is expected to take some years. See for example

- http://www.dryficiency.eu/
- https://www.sintef.no/projectweb/heatup/
- https://projecten.topsectorenergie.nl/projecten/full-scale-industrial-heat-pump-using-natural-refrigants-00031620

- https://projecten.topsectorenergie.nl/projecten/next-generation-compression-heat-pump-00031607

What are current technological barriers?

The technological barriers are related to the operating windows of currently available compressors. These should be capable of reliable operation at higher temperatures, requiring design modifications and test programs to validate them. These test programs also shall include the use of novel working fluids in combination with lubricant, tuned for stable operation.. Working fluids for high temperature heat pumps have become available, and become implemented in certain new developments. Still more operational experience with these novel working fluids is required to build a solid basis for large scale adoption.

What type of refrigerants are available for these T and what developments are needed?

Both synthetic and natural refrigerants are available for high-temperature heat pumps up to 150°C. For higher temperatures, natural refrigerants with the right properties are available but their performance and stability have to demonstrated experimentally.

Business Case of HP

Can we provide some info on the BC of heat pumps? What are currently "normal CAPEX/OPEX figures that we are looking at? Can we say something on Return of Investment numbers? How do HP compare at this point with fossil based heating solutions and what do we think are the prospects?

Ultimately, the business case for an industrial heat pump will be dependent on the achievable operational cost savings. The achievable COP of the heat pump will be an important parameter in determining the operational cost savings from installing a heat pump. A higher COP results in a lower electricity consumption for a given heat pump application. The cost of this electricity for operation of the heat pump should be compared to the alternative energy source which the heat pump would replace. CAPEX numbers are estimated in the range of €200-€500/kW, depending strongly on size of the installation. Integration costs have to be added to arrive at the total capital investment. These integration costs will strongly depend on the process/site where implementation is planned. Payback times of less than 5 years should very well be feasible within a well-developed industrial heat pump market.