High temperature heat pumps in Austria: demonstration and application examples

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High temperature heat pump, diary, steel and rolling mill, utilities, drying, demonstration

Abstract

Austrian industry consumed 385 PJ of final energy in 2016 [1]. Approximately 25% thereof were covered by natural gas. It was used for industrial applications that are relevant for heat pumps, such as space heating and air conditioning, steam generation and industrial ovens. Space heating and air conditioning are typical fields of applications for heat pumps. Industrial ovens comprise all kinds of ovens ranging from low-temperature applications, such as drying to high-temperature processes, such as sintering. Steam generation also covers a broad range of temperatures. Both applications are therefore partially relevant for heat pumps. The integration of heat pumps into industrial processes is still in a rather early diffusion phase in Austria despite the large technical potential according to the national technology and implementation roadmap for heat pumps. This roadmap was developed in a comprehensive participatory stakeholder process and was published in 2016. It is based on the strengths of the Austrian heat pump sector and the users' needs. Industrial processes were identified as one of four main fields of applications for heat pumps. The recommendations for research and development institutions comprise the implementation of model solutions and pilot systems, heat pumps for higher supply temperatures and new concepts to enable widest possible market penetration. [2]

Three application examples of high temperature heat pumps are presented, covering the food industry, metal industry and utilities. All examples are brown-field installations, where the heat pumps were integrated into existing processes to recover waste heat from different sources, such as flue gas condensation, chillers and cooling water. In these examples, the heat provided by the heat pumps is fed into district heating grids. The supply temperatures range from 78 – 95°C, the heating capacities from 4 – 40 MW. These heat pumps were commissioned in the last four years, also reflecting the increasing spread of industrial heat pumps in Austria.

European legislation aiming at an increase in renewables in electricity supply and reduction of CO2 emissions, as well as further development of the technology according to the needs of industrial applications are important drivers to spread heat pumps in industry. Current research activities focus on high temperature heat pumps, new refrigerants and efficiency measures, as well as holistic planning approaches for industrial sites. Among other projects, DryFiciency, an H2020 project, is presented in

more detail. Two heat pump demonstrators are developed, constructed and operated in a real industrial environment. They are closed loop compression heat pumps operated on OpteonMZ supplying up to 400 kW heat at 160°C. The heat pumps are integrated in industrial drying process in two Austrian companies, Agrana Stärke GmbH (starch drying) and Wienerberger AG (brick drying). The heat pumps are currently about to be commissioned. Then, extensive monitoring of the operation will start to evaluate efficiency and other important process parameters, as well as stability of refrigerant and lubricant when exposed to high temperatures. There is increasing demand for industrial heat pumps in Austria, as they allow for waste heat recovery, efficiency increase and electrification and will therefore play a major role in the future energy system. With heat pumps that deliver high temperature heat up to 160°C, a larger range of applications in industry can be covered. To satisfy the needs of industry, high availability and short payback periods are required. It is therefore essential to come up with reliable and cost-efficient solutions for the technological challenges for high temperature heat applications, such as temperature resistant materials and components. Successful demonstration projects are an important basis to establish trust in new technologies and for further roll out.

References

[1] Statistics Austria, STATcube – Statistische Datenbank von STATISTIK AUSTRIA, Nutzenergieanalyse 2016 (useful energy analysis), accessed on 23.03.2018

[2] Hartl, M., Biermayr, P., Schneeberger, A., Schöfmann, P., Österrei-chische Technologie- und Umsetzungsroadmap für Wärmepumpen, Berichte aus Energie- und Umweltforschung Nr. 8/2016, im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, Juni 2016

HIGH TEMPERATURE HEAT PUMPS IN AUSTRIA:

Demonstration and application examples

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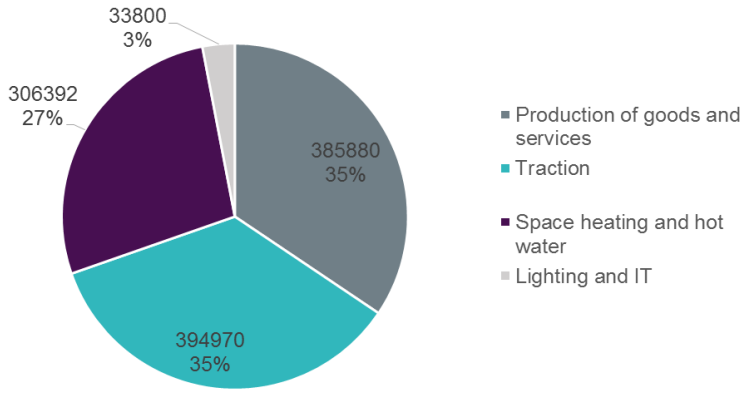
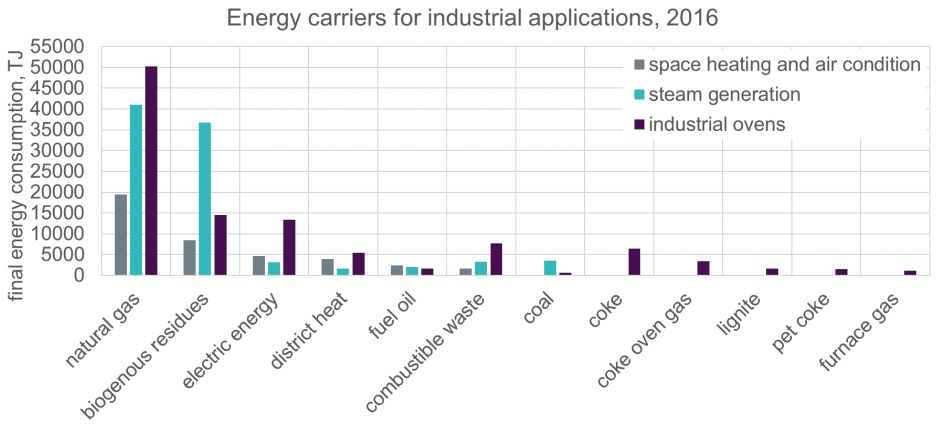
ENERGY USE IN AUSTRIA

Final energy consumption in Austria in 2016: 1 121 042 TJ



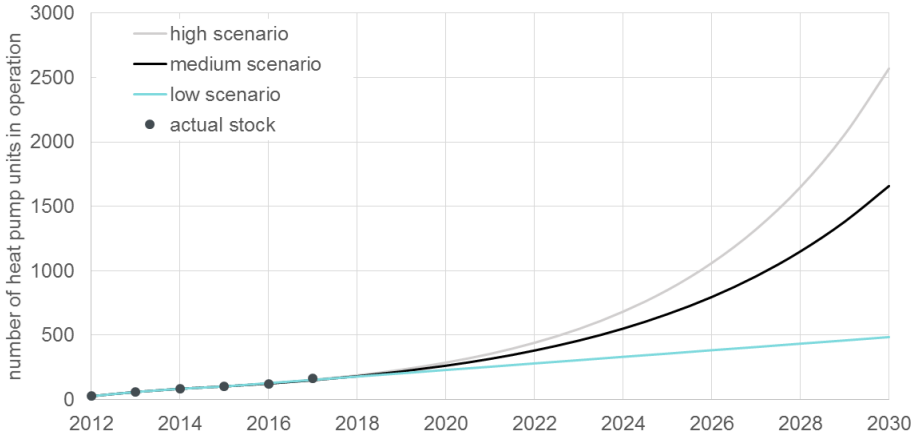
Statistics Austria, STATcube – Statistische Datenbank von STATISTIK AUSTRIA, Nutzenergieanalyse 2016 (useful energy analysis), access 23.03.2018

INDUSTRIAL HEAT DEMAND IN AUSTRIA



Statistics Austria, STATcube – Statistische Datenbank von STATISTIK AUSTRIA, Nutzenergieanalyse 2016 (useful energy analysis), access 23.03.2018

INDUSTRIAL HEAT PUMPS IN AUSTRIA: NOW AND THE FUTURE



Hartl et al. Österreichische Technologie- und Umsetzungsroadmap für Wärmepumpen, Berichte aus Energie- und Umweltforschung Nr. 8/2016, im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, June 2016

TECHNOLOGY ROADMAP FOR HEAT PUMPS

- published in June 2016
- participatory stakeholder process
- focus on the strengths of the national heat pump sector and the users' needs

- four main fields of applications for heat pumps
  - residential and non-residential buildings
  - smart electric grids
  - thermal grids
  - **industrial processes**

Hartl et al. Österreichische Technologie- und Umsetzungsroadmap für Wärmepumpen, Berichte aus Energie- und Umweltforschung Nr. 8/2016, im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, June 2016

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EXAMPLES FOR INDUSTRIAL APPLICATIONS

Food, metal, plastics, power plants…

FOOD INDUSTRY

Dairy

- Berglandmilch eGen / Tirol Milch Wörgl
- joint project with Stadtwerke Wörgl
- installed by Frigopol in 2015

3 heat pumps with a total

- cooling capacity: 3.2 MW
- heating capacity: 4.2 MW

- heat source: flue gas condensation and waste heat from chillers, up to 45°C
- heat sink: 78°C, for district heating


Innovative Frigopol Hochtemperatur-Wärmepumpen kurz vor der Auslieferung an die Tirol Milch in Wörgl. Höhe 3 m, Gewicht rund 13,5 t pro Anlage.

Photo: Frigopol Hochtemperatur-Wärmepumpen, http://www.frigopol.com/wp-content/uploads/54b8ce0cdfdd6.pdf
Further details: A. Baumhakel, Frigopol Kälteanlagen GmbH, www.frigopol.com

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METAL INDUSTRY

Rolling Mill

- steel and rolling mill Marienhütte GmbH
- Energie Graz GmbH & Co KG

2 heat pumps (Friotherm) with a total heating capacity of 11 MW

- heat source: process waste heat (cooling baths)
- heat sink: district heating at 70 and 95°C, residential area (Graz City center and Reininghaus)

Photo: http://www.energie-graz.at/energie/fernwaerme/projekte/reininghaus , 10.05.2017,
Arnitz et al., Waste Heat Recovery at the Steel and Rolling Mill "Marienhütte" Graz (Austria), Heat Pumping Technologies Magazine, Vol37, No2, 2019, https://heatpumpingtechnologies.org/publications/waste-heat-recovery-at-the-steel-and-rolling-mill-marienhutte-graz-austria/

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POWER PLANT

Wien Energie

- Power Plant Simmering (installed capacity of 1.2 GWel / 1 GWth)
- start up by end of 2018

2 heat pumps (Friotherm) with a total heating capacity of 27 - 40 MW

- heat source: cooling circuit of the power plants, river water also possible, 6-27°C
- heat sink: district heating, up to 95°C
- average COP: 3

C. Segalla, Power 2 Heat Anwendungen für das Fernwärmenetz, Großwärmepumpenforum Vienna, May 2018.

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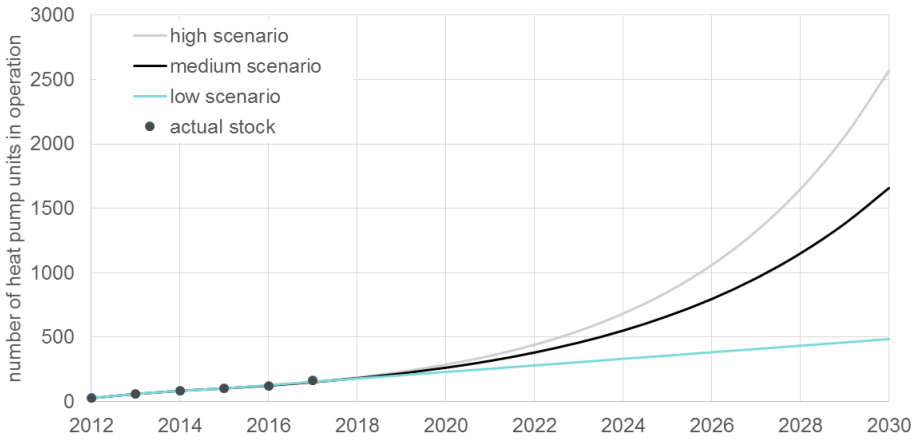
INDUSTRIAL HEAT PUMPS: NOW AND THE FUTURE



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RESEARCH AND DEMONSTRATION ACTIVITIES

AIT Austrian Institute of Technology

RESEARCH QUESTIONS: HIGH TEMPERATURE HEAT PUMPS

Challenges:

- refrigerants
- temperature resistant materials and components
- heat sources with high temperatures
- efficient cycles, e.g. pressure recovery

Requirements for industrial applications:

- high availability and reliability
- short payback time

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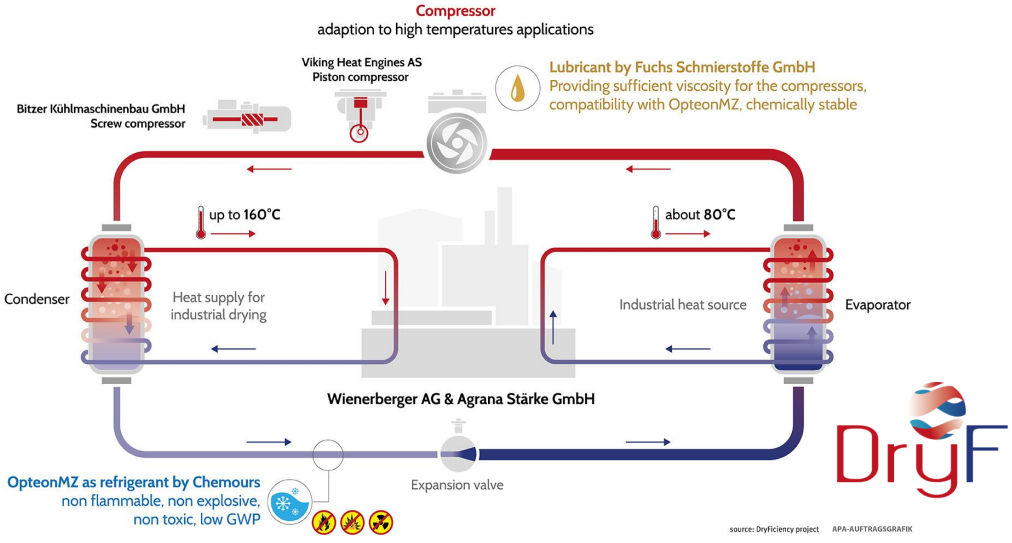
DRYFICIENCY

- H2020 project with 13 partners and 6 Mio € funding
- development and demonstration of three high temperature heat pumps in industrial drying processes
- air drying with closed loop heat pumps
- steam drying with open loop heat pump (mechanical vapor recompression)

The project has received funding from the European Union's Horizon 2020 programme for energy efficiency and innovation action under grant agreement No. 723576.

CLOSED LOOP HP

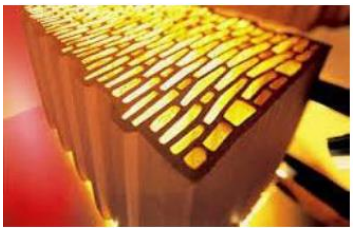


DEMO SITES

STARCH

AGRANA Stärke GmbH
Pischelsdorf (AUT)

BRICKS



Wienerberger AG
Uttendorf (AUT)

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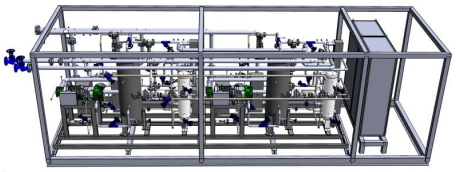
HEAT PUMPS UNDER CONSTRUCTION



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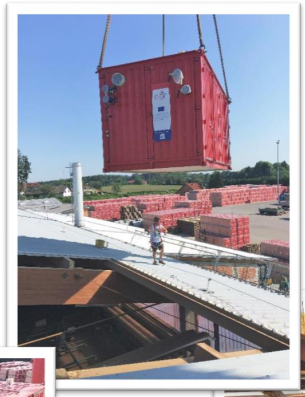
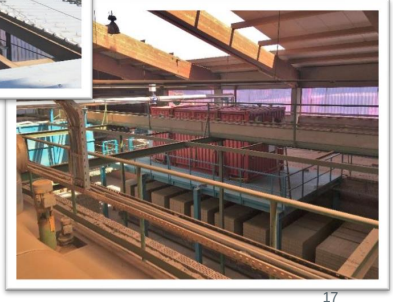
INTEGRATION IN THE BRICK FACTORY





Wienerberger
Building Material Solutions

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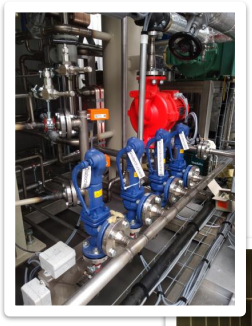
HP FOR STARCH DRYING



AGRANA STÄRKE

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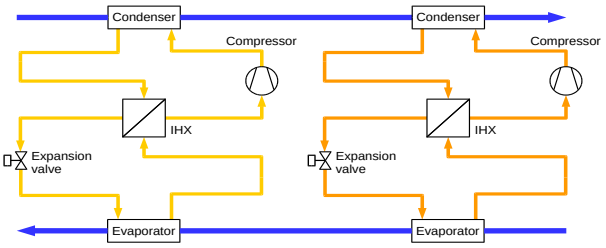
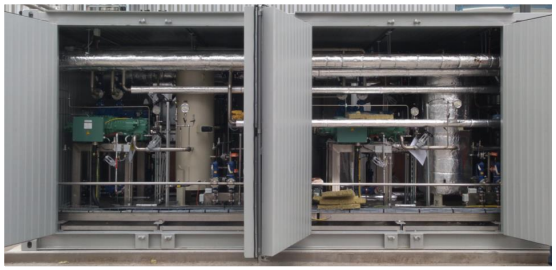
INSIDE…





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NEXT STEPS

- commissioning and start up
- test different operation conditions (heat supply temperatures, part load conditions, etc.)
- monitoring of refrigerant and lubricant quality
- evaluation of efficiency and other important process parameters

www.dryficiency.eu

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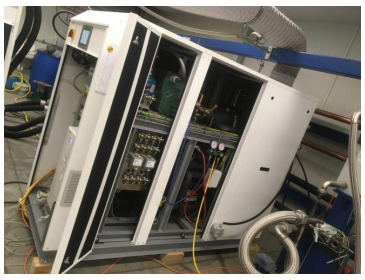
NATURAL REFRIGERANTS

Concept of a new butane high temperature heat pump

- lift industrial waste heat from 60 °C to 130 °C
- validated Dymola model for the heat pump
- ejector utilization
- CFD for heat & mass transfer in heat exchangers
- experimental validation



Results

- successful operation of the functional model in the lab
- performance increase with ejector
- validated CFD model

G. Drexler-Schmid et al.: Messung und Simulation einer 50 kW Butan-Hochtemperaturwärmepumpe mit Ejektor, DKV Tagung Kassel 2016.

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RESEARCH QUESTIONS: PROCESS INTEGRATION

Planning process of industrial heat pumps:

- interaction of multiple stakeholders

Optimization of industrial sites:

- interaction of multiple heat suppliers, storages and consumers
- design optimization
- operation optimization

Method development:

- dynamic simulations: interaction of heat pump and process
- mathematical programming: complex and dynamic systems, discontinuous processes

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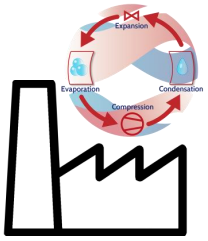
CONCLUSIONS

- increasing interest from industry in industrial heat pumps
  - expect high availability and reliability
  - short payback periods
- solution of technological challenges for high temperature applications essential
  - suitable refrigerants
  - heat sources with high temperatures
  - temperature resistant materials and components
- industrial heat pumps allow for economic and environmental benefits
  - increase on-site efficiency and contribute to decarbonization
  - technology readily available on the market
  - demonstration projects for new developments



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THANK YOU!

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