



# Industrial Heat Pumps, Second Phase

IEA Heat Pump Technology (HPT) Programme Annex 48

## **Task 4: Danish Report**

**Final Report**

**December 2019**

Prepared by  
B. Zühlsdorf  
Danish Technological Institute  
Energy and Climate  
Kongsvang Allé 29, 8000 Aarhus, Denmark  
Contact: [bez@dti.dk](mailto:bez@dti.dk)

P.H. Jørgensen, B. Elmegaard  
Technical University of Denmark  
Department of Mechanical Engineering  
Nils Koppels Allé, Building 403, 2800 Kgs. Lyngby, Denmark  
Contact: [be@mek.dtu.dk](mailto:be@mek.dtu.dk)



## Contents

<b>1</b>	<b>Introduction .....</b>	<b>1-4</b>
<b>2</b>	<b>Information material and tools about industrial heat pumps .....</b>	<b>2-5</b>
<b>3</b>	<b>Organizations working with industrial heat pumps .....</b>	<b>3-7</b>
<b>4</b>	<b>Events and courses about industrial heat pumps .....</b>	<b>4-9</b>
<b>5</b>	<b>Summary.....</b>	<b>5-11</b>
<b>6</b>	<b>Literature .....</b>	<b>6-12</b>

## 1 Introduction

This report summarizes the activities of the Danish consortium related to Task 4 of the Annex 48 about industrial heat pumps.

Task 1 and 2 have shown that there are several successful applications of industrial heat pumps, which comes along with an existing information infrastructure related to industrial heat pumps. This information structure involves different information material and tools, as well as organizations and events. This report summarizes the information material, organizations and events that were found to play a valuable role in the Danish context.

## 2 Information material and tools about industrial heat pumps

The analysis of realized heat pump installations revealed a higher number of installations in district heating, indicating the availability of advanced and proven information material. This material comprises informative material, guidelines and calculation tools. In addition, there is some information material available that is equally applicable to industrial applications. An overview of the most relevant information material and tools is given in the following.

- **Guidebook on large heat pump projects in the district heating sector** – December 2017 (Danish: Drejbog til store varmepumpeprojekter i fjernvarmesystemet) [1]  
The *Guidebook* summarizes all information that is required for the planning and execution of heat pump projects for district heating. It comprises among others the technical knowledge about heat pumps, heat sources and performance testing as well as information about the administrative processes, the project economics and the tendering process. The *Guidebook* was developed in collaboration between *Grøn Energi* and two consultancy companies for the Danish Energy Agency and *Dansk Fjernvarme*. It is mainly directed to support district heating companies that are considering the installation of heat pumps during their decision process. The *Guidebook* is described in more detail in the report of Task 2.
- **Inspiration Catalogue on large heat pump projects in the district heating sector** – December 2017 (Danish: Inspirationskatalog for store varmepumpeprojekter i fjernvarmesystemet) [2]  
The *Inspiration Catalogue* supplements the *Guidebook* with 15 examples of large, operational heat pumps integrated in Danish district heating systems. The information comprises the project background, system information including technical specifications, operational experiences, organization and ownership and budget and economy. The *Inspiration Catalogue* is described in more detail in Task 2.
- **Heat pump calculator** (Danish: Varmepumpeberegner)  
The Heat Pump Calculator is a spreadsheet tool for the analysis of the district heating system economics in order to evaluate the economics of integrating a heat pump. It is suitable for system owners and consultants to gain a first impression of the economic feasibility and match with the existing district heating system. The Heat Pump Calculator is freely available and as well a supplement to the *Guidebook* [1].
- **Heat Pump – First Assessment Tool (HP-FAT)** [3]  
The tool can be used for first assessments of the profitability of heat pump systems without any knowledge about the actual heat pump. The tool is based on an estimation of a Lorenz efficiency and therefore only needs the temperatures of the heat source and heat sink as inputs and returns the COP. In addition, the tool includes simple economic calculations, which can be used for deriving economic key performance indicators based on simple estimations of the specific investment cost.
- **Technology Catalogues** (Danish: Teknologi Kataloger) [4]  
The Danish Energy Agency published Technology Catalogues for among others “Production of electricity and district heating” [5] and “Individual heating plants” [6]. The

purpose of the document is to summarize the most relevant information, such as efficiencies, investment and lifetimes for all relevant technologies for a given application in order to supply a basis for planning activities. The catalogues are available in English and they are directed to an international audience.

- **Map of existing heat pump installation [7]**

The consultancy company, PlanEnergi, has developed a geographical map presenting existing heat pump installations connected to the district heating network in Denmark. The map includes information on the heat source, the capacity of the installation as well as year of installation year. Both operating and planned installations are included. The list is continuously updated.
- **Simulation tools available from IPU website**
  - **Coolpack [8]:** A collection of simulation models for refrigeration system and each of them has a specific purpose e.g. cycle analysis, sizing of main components, energy analysis, and optimization. The Coolpack program is freeware.
  - **Pack Calculation Pro [9]:** A simulation tool for calculating and comparing the yearly energy consumption of refrigeration system and heat pumps. The software can compare different system designs, control strategies and refrigerants. A free version with limited functionality is available for download for personal use, use in non-profit organizations and for educational purposes. For commercial use, an annual subscription license must be purchased.
  - **Simple one-stage CO<sub>2</sub> [10]:** The application lets the user do calculations for transcritical CO<sub>2</sub> cycles. Freeware and primarily intended for teaching purposes.

### 3 Organizations working with industrial heat pumps

This chapter aims to give an overview of independent organizations and companies working in the field of industrial heat pumps including their role and interests. The list was compiled based on available data and may be non-exhaustive.

- **Danish District Heating Association** (Danish: *Dansk Fjernvarme*) [11]  
*Dansk Fjernvarme* is the association of the Danish district heating companies and actively involved in the dissemination of heat pumps and their benefits in district heating systems. *Dansk Fjernvarme* is engaged in the development of green, efficient and reliable district heating as part of a green transition of the Danish energy system. Their activities include the organization of courses and information events, dialog with policy makers on framework conditions, technical and legal advice to members of the association and dissemination of information.
- **Grøn Energi** [12]  
Grøn Energi (English: Green Energy) is a think tank focusing on analyzing and developing solutions for future district heating networks. Grøn Energi is an association with a wide range of members including district heating companies, heat pump manufacturers, component manufacturers, consultancy companies and universities. The services comprise the participation in R&D projects, technical and economic analyses, the development of information material such as the *Guidebook* and the *Inspiration Catalogue* as well as the organization of networking and information events. Grøn Energi has many years of experience with large heat pumps for district heating [12].
- **Task force for large heat pumps from the Danish Energy Agency** (Danish: *Rejsehold for store varmepumper*) [13]  
The task force for large heat pumps was initiated and part of the Danish Energy Agency and contributed actively in various R&D projects related to large heat pumps in district heating in the years from 2015 to 2018. They were actively involved in financially supported research projects with focus on collecting knowledge and disseminating it among policy makers.
- **GTS institutes** [14]  
The Danish GTS institutes are not-for-profit organizations. They are self-owned, impartial, and independent of business or political interests, placing knowledge and facilities at the disposal of all businesses on equal terms. All profits are reinvested in infrastructure, facilities and the creation of new technological knowledge.  
The most prominent institute in heat pump project is the Danish Technological Institute (DTI) [3]. The DTI is an accredited technical service institute which is involved in a range of publicly funded and commercial research projects on the development of industrial heat pumps and their integration into industrial applications and district heating. In addition, the DTI is offering courses on industrial heat pumps, including courses on industrial heat pumps as well as on equipment using ammonia and CO<sub>2</sub>.
- **Universities**  
There are different research groups working with heat pumps and their optimal integration into different boundary conditions. The studies reach from integration studies with a focus on the overall system to studies with a specific focus on the heat pump

technology. The research groups are typically working with relevant industry partners and/or policymakers.

- **Consultancy companies**

There is a range of consultancy companies working on the integration of heat pumps in industrial and district heating applications. They are typically independent in terms of technology choice. These companies are experts in the field and typically used commercial software supplemented with own numerical models. Some of the consultancy companies are actively disseminating information about industrial heat pumps and especially about successful implementations.

- **Intelligent Energy** (Danish: Intelligent Energi) [15]

Intelligent Energy is an industry association for energy and supply companies, municipalities, suppliers, consultants, universities and investors, working towards a flexible and integrated energy system. In the area of heat pumps, the association promotes long term stable framework to ensure a fast and extensive implementation.

- **Industrial associations**

There are several associations within the field of refrigeration and heat pump technology. "Dansk Køl & Varme" [16] is a trade organization for authorized refrigeration and heat pump companies representing the technical, economical and legal interests of the members. "Dansk Køle og Varmepumpeforening" [17] is a technical association for refrigeration and heat pump technology. The association disseminates technical and scientific development within the field and arrange a number of member-events during the year.

In addition to the independent organizations working with industrial heat pumps, there is a range of manufactures of industrial heat pumps.

## 4 Events and courses about industrial heat pumps

In addition to the information material, there are several events and courses where various parties can acquire knowledge. The available events range from conferences and workshops about R&D projects to smaller events where heat pump owners can exchange experiences and ideas. In the following, a selection of events with a relevance for industrial heat pumps is presented.

- **One-day information events on large heat pumps in district heating**

- Organization: Dansk Fjernvarme/Grøn Energi
- Format: One-day event with invited speakers with and room for networking
- Language: Danish

The event is a one-day event with different focusses, such as political frameworks, technical solutions, specific applications, exchange of experiences and aims to develop practical approaches for problem solving. The events are directed to all with an interest in large heat pumps in district heating and participants are typically coming from district heating companies, manufacturers, consultancies and universities.

- **Member-Networking-Group for large heat pumps in district heating** (Danish: ERFA gruppe om store varmepumper i fjernvarme)

- Organization: Dansk Fjernvarme
- Format: Closed group for members of the association, two one-day events per year
- Language: Danish

Dansk Fjernvarme organizes meetings for their members to exchange information about large heat pumps for district heating. The discussions include current challenges, ongoing developments and practical experiences.

- **“Symposium on High-Temperature Heat Pumps”**

- Organization: DTI, DTU, SINTEF
- Format: 2017, 2019
- Language: English

The conference consists of different sessions of presentations and room for debates. International speakers from academia and industry are presenting current developments, realized cases and analyses of the potential and demand of high-temperature heat pumps. The conference contributions are summarized in a booklet and publicly accessible [18], [19].

- **“Refrigeration and heat pump forum”** (Danish: “Køle- og Varmepumpeforum”)

- Organization: Danske Køledag, DTI, DTU
- Format: 2019
- Language: English and Danish

The one-day joint event includes both the “International Symposium on Advances in Refrigeration and Heat Pump Technology” and “Danske Køledag”. The purpose of both events is to disseminate new results related to the field of refrigeration and heat pump technology. “Dansk køledage” focuses on commercial and industrial applications, while the “International Symposium on Advances in Refrigeration and Heat Pump Technology” focuses on research and development with international speakers. The presentations are collected in a booklet and publicly accessible [20].

- **Course on Refrigeration and Heat Pump Technology [21]**
  - Organization: DTU
  - Format: One-day during 13 weeks each autumn
  - Language: English

The course is a part of the DTU engineering program and offered under Open University/single-course studies. The course teaches refrigeration systems and heat pumps with focus on vapor compression cycles. The course content covers modeling of typical cycle layouts, knowledge on refrigerants, calculation of heat transfer, compressor types and efficiencies, moist air processes and control strategies of heat pump and refrigeration systems.

- **Courses on industrial heat pumps [22]**

There is a range of regularly organized courses, which are typically one or more days and directed to potential plant owners, consultants and other parties that might be involved in the project handling of large-scale heat pump installations. In addition, there are various courses with a stronger focus on the heat pump system and directed to servicing staff. These courses are often classified by the refrigerant type and several courses are available for ammonia and CO<sub>2</sub> systems. Courses are among others organized by DTI or manufacturers.

## 5 Summary

In this report, three chapters summarize the available information material and tools about industrial heat pumps, organizations working with industrial heat pumps, and events and courses about industrial heat pumps.

The second chapter includes the guidebook on implementation of heat pumps in the district heating network, information on installed heat pumps, and different tools for simulation and evaluation of heat pump cycles, as well as integration in district heating systems.

The third chapter lists several organizations working with dissemination and the market penetration of industrial heat pumps within a Danish context.

The fourth chapter list a selection of repeated events and courses on industrial heat pumps held by Danish associations and institutions.

## 6 Literature

- [1] Kortegaard Støchkel H, Lava Paaske B, Clausen KS. Guidebook for large-scale heat pump projects in district heating (Danish: Drejebog til store varmepumpeprojekter i fjernvarmesystemet). 2017.
- [2] Kortegaard Støchkel H, Lava Paaske B, Clausen KS. Inspiration Catalogue for large-scale heat pump projects in district heating (Danish: Inspirationskatalog til store varmepumpeprojekter i fjernvarmesystemet). 2017.
- [3] Danish Technological Institute. Heat Pumps 2019. [www.dti.dk/specialists/heat-pumps/calculation-programme-hp-fat/23543,2](http://www.dti.dk/specialists/heat-pumps/calculation-programme-hp-fat/23543,2) (accessed 20 December, 2019)
- [4] Danish Energy Agency (Danish: Energistyrelsen). Technology Catalogues (Danish: Teknologikataloger) 2019.
- [5] Danish Energy Agency, Energinet. Technology Data for Energy Plants for Electricity and District heating generation 2018.
- [6] Danish Energy Agency, Energinet. Technology Data for Individual Heating Installations 2018.
- [7] PlanEnergi. Large scale heat pumps in Denmark n.d. <http://planenergi.dk/arbejdsomraader/fjernvarme/varmepumper/> (accessed December 20, 2019).
- [8] IPU, Department of Mechanical Engineering DTU. CoolPack. 2000-2012. Version 1.50. [www.ipu.dk/products/coolpack](http://www.ipu.dk/products/coolpack) (accessed December 20, 2019)
- [9] IPU. Pack Calculation Pro. Version 4.20. [www.ipu.dk/products/pack-calculation-pro/](http://www.ipu.dk/products/pack-calculation-pro/) (accessed December 20, 2019)
- [10] IPU, ELFOR Project 339-046. Simple One-stage CO<sub>2</sub> 2009. Version 2.40. [www.ipu.dk/products/simple-one-stage-co2](http://www.ipu.dk/products/simple-one-stage-co2) (accessed December 20, 2019)
- [11] Danish District Heating Association (Danish: Dansk Fjernvarme) 2019.
- [12] Grøn Energi. Acquir Knowl about Large Heat Pumps Dist Heat (Danish Få Viden Om Store Varmepumper i Fjernvarmen) 2019.
- [13] Danish Energy Agency (Danish: Energistyrelsen). Task force for large heat pumps (Danish: Rejsehold for store varmepumper) 2019.
- [14] GTS-institutter. [www.gts-net.dk/gts-institutter/](http://www.gts-net.dk/gts-institutter/) (accessed December 20, 2019).
- [15] Intelligent Energi. [ienergi.dk](http://ienergi.dk) (accessed December 20, 2019).
- [16] Dansk Køl & Varme. [www.koeleteknik.dk/om-os/om-dansk-koel-varme/](http://www.koeleteknik.dk/om-os/om-dansk-koel-varme/) (accessed December 20, 2019).
- [17] Dansk køle- og varmepumpeforening. [www.dkvf.dk/](http://www.dkvf.dk/) (accessed December 20, 2019).
- [18] Elmegaard B, Zühlsdorf B, Reinholdt L, Bantle M, editors. International Workshop on High Temperature Heat Pumps. B. Present. Int. Work. High Temp. Heat Pumps, Copenhagen: Technical university of Denmark; 2017, p. 176.
- [19] Zühlsdorf B, Elmegaard B, Bantle M, editors. Book of presentations of the 2 nd Symposium on High-Temperature Heat Pumps. 2nd Symp. High-Temperature Heat Pumps, Copenhagen: SINTEF; 2019, p. 269.

- [20] Elmegaard B, Markussen WB, Poulsen CS, Nielsen JS, Bülow S, editors. Køle- og Varmepumpeforum 2019 Dansk Køledag 2019 & 6th International Symposium on Advances in Refrigeration and Heat Pump Technology Samling af præsentationer Collection of presentations. Køle- og Varmepumpeforum 2019, Kgs. Lyngby: DTU Mechanical Engineering; 2019, p. 237.
- [21] Department of Mechanical Engineering. 41420 Refrigeration and Heat Pump Technology. [www.kurser.dtu.dk/course/41420](http://www.kurser.dtu.dk/course/41420) (accessed December 20, 2019).
- [22] Danish Technological Institute. Varmepumpe kurser. <https://www.teknologisk.dk/kurser/varmepumper-kurser/c610> (accessed December 20, 2019).