

Application of Heat Pumps in Industry

By

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International Energy Agency Implementing Agreement
for a Programme of Research and Development on Heat Pumping Technologies (HPP IA)

Raising the profile and performance of heat pumps as energy-savers in the industrial sector is the focus of a newly created joint project under two collaborative R&D programmes operating within the IEA Framework for International Energy Technology Co-operation. This project is the brainchild of the Implementing Agreement for a Programme of Research and Development on Heat Pumping Technologies ([HPP IA](#)) and the Implementing Agreement on Industrial Energy-Related Technology and Systems ([IETS IA](#)). It has a three-year mandate, starting on 1 January 2010.

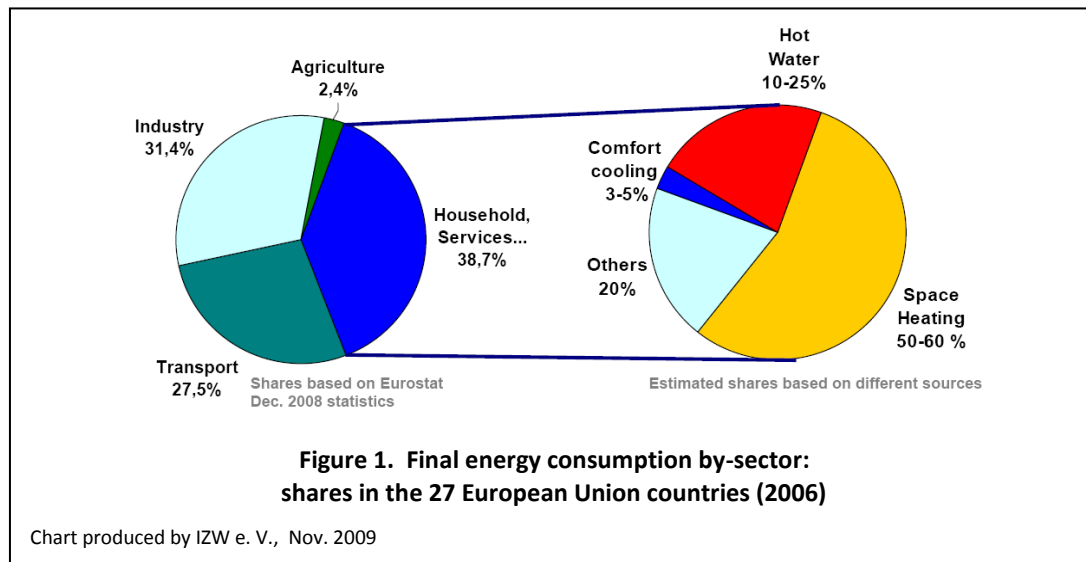
Why this new project?

Markets for heat pumps have been expanding at a healthy rate over recent years. The two major drivers have been uncertainty over energy prices and growing environmental and climate concerns, which have highlighted the need to save energy and optimise renewable energy sources. Traditionally, heat pump markets and policy approaches in many countries have focused chiefly on residential heat pumps for space heating and domestic hot water. Turning to heat pumps for high-temperature applications and in industry has been much less of a natural reflex. Low corporate energy bills have typically made it a much higher priority to invest in productivity improvements than in enhancing energy efficiency. Indeed, increased use of energy has to some extent been an indication of economic growth.

There are major differences between the markets for residential heat pumps and those for industrial heat pumps. While standardised products are generally

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satisfactory for the residential market, the majority of heat pump applications for industry involve special conditions to which products must be adapted. Moreover, a high level of expertise is crucial. The industrial sector is of course a large energy consumer. Figure 1 shows, as an example, how close in size industry's share of total energy consumption is to that of households and services in the European Union.



It is to address the issues and promote industrial application of heat pump technology that this new Industrial Heat Pumps Annex project has been created. The initial steps were taken at a brainstorming workshop in Amsterdam in April 2009, which brought together participants from the Implementing Agreement for a Programme of Research and Development on Heat Pumping Technologies ([HPP IA](#)) and the Implementing Agreement on Industrial Energy-Related Technology and Systems ([IETS IA](#)). The project takes the name of Annex XIII within the IETS IA and Annex XXXV within the HPP IA. These [Implementing Agreements](#) are among some 40 operating within the IEA Framework for International Energy Technology Co-operation.

A strong motivation for launching this initiative is the enormous potential for energy conservation and reduction of CO₂ emissions that industrial heat pumps offer, a potential that policy papers do not currently take into account.

Targeting many stakeholders

Since reliable data is crucial for estimating a technology's potential contributions to energy savings and emissions reductions for a sustainable society, a high priority will be messages to policy makers for input to directives and legislation, as well as input to statistics.

Since good design is essential for the long-term reputation of the technology, we shall be addressing ourselves to installers, manufacturers and consulting engineers.

Finally, since a fair comparison between different systems is important in the drive for both sustainability and state-of-the-art technology, reliable marketing data will

simplify the selection process for the end users and encourage manufacturers to develop new generations of competitive, efficient heat pumps. The heat pump systems eventually installed must be chosen from the best on the market.

The new Industrial Heat Pumps Annex will commence on 1 January 2010 and run till December 2012.

Our project will draw on existing findings from HPP IA projects that have already broken ground in the domain of industrial heat pumps, namely HPP Annex 9 on High Temperature Industrial Heat Pumps (1990) and then Annex 21 on Global Environmental Benefits of Industrial Heat Pumps (1992 -1996).

Annex 21 generated an overview of potential industrial heat pump applications, but much has happened since it concluded its work. We now have better, more sophisticated software and newly available compact components. Energy costs have risen and are expected to continue rising. More stringent government legislation is now targeting goals like reduction of CO₂ emissions. And we now have new considerations regarding refrigerants.

Objective and scope

The objective of the Annex is to reduce energy consumption and emissions of greenhouse gases through greater use of heat pumps in industry. This will involve the following activities.

- Generating information for policy makers.
- Developing information for key stakeholders in industry and its supply and consulting chain.
- Gaining insight on businesses' decision-taking processes.
- Expanding knowledge and information about industrial heat pumps, creating a database and making existing information available.
- Applying new technologies and identifying needs for technological development.
- Creating a network of experts.
- Finding synergy with renewable energy production to increase flexibility of the grid.

Our objectives will be achieved through joint studies carried out by the participants from each country in the Annex team. The core effort will be to present information on heat pumping technologies for industry in a way that will foster clearer perception of opportunities for these technologies and ways of exploiting them judiciously to reduce primary energy consumption, CO₂ emissions and energy costs.

From a practical angle, the Annex team will work together on the following activities.

- Gathering information on experience in running projects in participating countries.
- Setting up and monitoring demonstration projects or field experiments.
- Publishing the results of these projects and distilling their implications.
- Providing guidelines for new efforts and initiating new collaborative projects.
- Holding regular workshops.

The project will be structured as follows.

Task 1: Market overview, barriers to application

Task 2: Modelling and economic models

Task 3: Technology

- High-temperature heat pumps
- Process technological integration
- Refrigerants

Task 4: Application and monitoring

- Easy to install standard solutions
- Operating experience
- Energy impact

Task 5: Communication

- Awareness of potential (policy paper)
- Internet
- Database
- Training

The tasks will draw on a range of expertise that falls under the two main headings of "Heat pump technology" and "Industrial process integration of new technologies". In this way a platform of collaboration will link the IETS and HPP programmes.

Addressing market barriers

The new project will focus strongly on market barriers. A major barrier is certainly lack of experience, and thus lack of acceptance, on the part of operators, industrial partners and supply and consulting chains. These barriers can be broken down into several focal points for work to be undertaken under the new Annex. As the Annex begins its work, it will be targeting the following four objectives.

- Introduction of heat pumps in process industries such as the chemicals industry with its distillation columns, the pulp and paper industry and the steel industry. Advanced software models are used by large specialised engineering companies. Process intensification and standardised and proven concepts are applied.
- Introduction of heat pumps in industrial processes on a smaller scale, especially in the food industry (breweries and dairies), where both heating and cooling are used. Specialised suppliers are active in this field of standardised machinery and concepts, including complete turn-key factories. Some of these players are already aware of opportunities to increase efficiency of their products by integrating heat pump technology in their concepts and products.
- Expansion of cooling processes to use of condenser heat, and heat wasted in cooling towers, since this is one of the new developments among suppliers of refrigeration and cooling concepts.
- Introduction of heat pumps in small manufacturing companies, often located close together, where heat is largely used to warm offices and the other energy need is power to drive machinery.

Certain technical factors are important to consider. For instance, the temperature level of the waste heat is determined by process fundamentals and process equipment design; for an existing plant it is therefore established. However, the temperature level at which the waste heat becomes available for use is determined by the design of

the utility systems, i.e. cooling water and air. This essential difference is often overlooked when discussing waste heat utilisation.

The quantity and temperature of the waste heat can be determined by process integration methods, notably by pinch analyses. These methods are powerful tools, giving a total picture of the situation at the plant, including ways to use the heat internally. There are several competing alternatives for exploiting waste heat. Internal use of heat for heating purposes and for new or modified process steps is clearly the best choice, but decision takers are not always aware of how to do this.

While there appear to be many barriers to adopting heat pumps, several sectors are noteworthy for the successful application of heat pumps. It is common practice to opt for heat pumping in some branches of industry today, but large growth potential nevertheless remains in other branches.

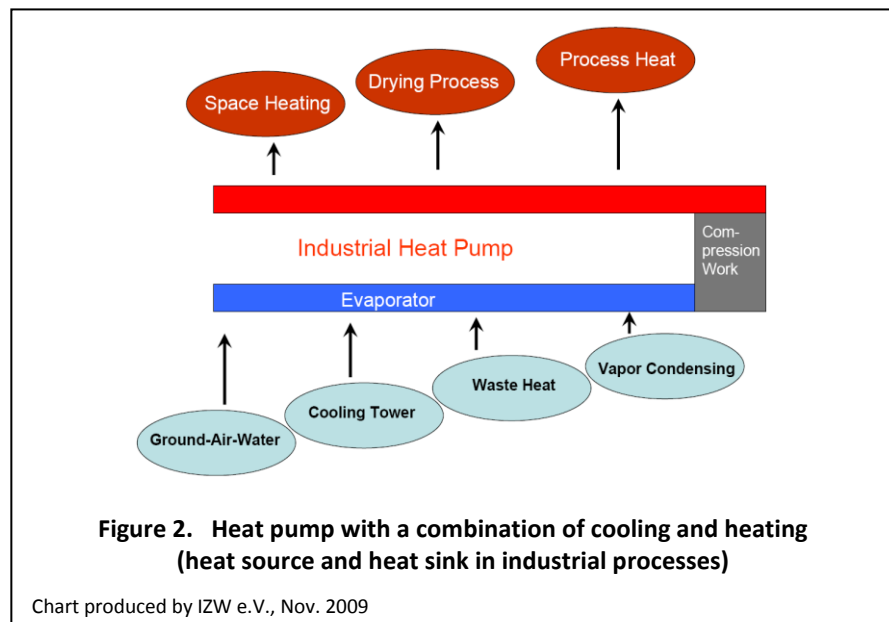
An alternative option is to channel the heat to meet demands outside the plant in a district heating system.

Being fully aware of opportunities and able to choose between different options requires a high level of expertise in system design, process integration and planning. Process integration and design software plays an important role at this stage. Nevertheless, while a complex approach needing much high-level expertise may seem necessary, simple, straightforward small-scale solutions are often perfectly adequate.

Technical aspects

While there is enormous potential and scope to exploit, the work of the new Annex must be tailored to resources available and aim at realistic targets that are smart in terms of economic efficiency. We shall therefore start with an overview of technologies and applications, and with by-business-case analysis of non-technical barriers affecting the decision-taking process in existing and new applications. Findings from this exercise will orient subsequent work.

Industrial heat pumps are defined in this work as heat



pumps in the medium and high power ranges that can be used for heat recovery and heat upgrading in industrial processes, but also for heating, cooling and air-conditioning in industrial, commercial and multi-family residential buildings, also for district heating.

Our goals will be the following.

- Making specialised suppliers of standardised machinery, concepts and turn-key factories aware of options to increase the energy efficiency of their products by integrating heat pump technology in their concepts and products.
- Development and application of high-temperature heat pumps.
- Standardisation in expanding cooling processes to use of condenser heat and heat wasted in cooling towers.
- Interacting with small, often closely grouped manufacturing companies that use heat chiefly to heat offices and require energy to power machinery.

In parallel, we shall be analysing the status of heat pumps in models and looking at the system aspects.

A number of different types of heat pump cycle can be used in industrial applications, the most important being:

- Closed compression cycle, electric motor-driven.
- Closed compression cycle, motor-driven.
- Mechanical vapour recompression (MVR).
- Thermal vapour recompression (TVR).
- Absorption - compression cycle.
- Absorption cycles.
- Adsorption cycle.

To learn more about this new HPP IA/IETS IA joint Industrial Heat Pumps Annex, which will operate within the IEA Framework for International Energy Technology Co-operation, contact the Operating Agent: Information Centre on Heat Pumps and Refrigeration - IZW e.V., Germany (Informationszentrum Wärmepumpen und Kältetechnik - IZW e.V.), in collaboration with Laurent Levacher, EDF-R&D-ECLEER (European Centre & Laboratories of Energy Efficiency Research), France.

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