

IEA HEAT PUMP PROGRAMME

*Sophie Hosatte, Director Buildings Group
CETC-Varennnes, Natural Resources Canada
1616 Blvd. Lionel-Boulet, Varennnes, Québec, J3X 1S4, Canada
Email: shosatte@nrcan.gc.ca*

Abstract The Heat Pump Programme (HPP) provides information and establishes strategic partnerships to support the development and the adoption of heat pumping technologies including heating, refrigeration and air conditioning. It is one of the Implementing Agreements of the International Energy Agency. During its 30 years of existence, the HPP has made a significant contribution to this area. Heat pumping technologies are now commercially available and economically viable in many applications. They offer sufficient multiple benefits to be considered in the portfolio of measures aimed at reducing significantly the greenhouse gas emissions worldwide. With a market share of 30% in the building sector, heat pumps can reduce emissions by 6% and eventually 16% with new developments. The HPP is well positioned and structured to play a major role in the future expansion of the heat pump market.

Keywords: *Heat pump, heating, cooling, refrigeration, research, development, deployment, energy efficiency, greenhouse gas*

1 INTRODUCTION

The Heat Pump Programme (HPP) is one of the Implementing Agreements (IAs) of the International Energy Agency (IEA). It targets research, development, demonstration, and promotion of heat pumping technologies including heat pumps, refrigeration and air conditioning. The HPP falls under the Energy End-Use Technologies/Buildings in the IEA structure (IEA 2007). It has been established in 1978 following the first energy crisis. During its 30 years of existence, the HPP has played a major role in providing expert information and supporting the development and adoption of technologies and knowledge in the continuously evolving energy and environmental contexts.

It is expected that heat pumps¹ will play a significant role in reducing carbon footprint through their utilization in a large number of applications. However, while the technology is commercially available and cost-competitive in many applications, the market forces are not sufficient to allow the full deployment of this technology. Increased R&D, technical and economical barrier removal, and support to decision-makers are key activities that the Heat Pump Programme intends to pursue. In order to increase the penetration of heat pumps into the market, the activities will be carried out in close cooperation with other organizations working with efficient end-use of energy, and with the industry.

2 HEAT PUMP CONTEXT AND POSITIONING

Heat pumps are attractive technologies as they offer the possibility of reducing significantly the energy consumption for heating (heat upgrading) and cooling (air-conditioning and refrigeration) for applications mainly in the building and industrial sectors. Their coefficient of

¹ For clarity of the text, the term heat pumps will be used to designate heat pumping technologies that include heat pumps, refrigeration and air conditioning

performance is generally higher than 200% (COP = 2). Most systems implemented are based on refrigerant vapour compression and are electricity driven (Halozan 2005).

While heat pumps are dominant for cooling applications, their use for heating is still limited because of the lack of awareness of their benefits and their high initial capital cost in comparison with conventional boilers or furnaces.

In the last twenty years, the technology has undergone successive changes imposed by regulations (Montreal Protocol, 1987; Kyoto Protocol, 2005) and by the recent adoption of the accelerated phasing-out of HCFCs (Montreal Protocol conference, 2007) (Hosatte 2007; Coulomb 2007)). This situation creates opportunities to develop new and more efficient technologies, to reintroduce the use of natural refrigerants (e.g. NH₃, CO₂), and hence further reduce their carbon footprint. Greenhouse gas (GHG) emissions of heat pumps systems are caused by the energy source (direct emissions from fossil fuel combustion, indirect from electricity generation) and from the use of synthetic refrigerants (direct emissions). Note that HFCs are accounted for by the Kyoto Protocol.

The possible integration of heat pumps with distributed generation, renewable, short and long term storage (e.g. ground) make them even more attractive for addressing the Climate Change concerns.

3 HEAT PUMP PROGRAMME PRESENTATION

The programme's vision is to be the foremost worldwide source of independent information and expertise on heat pumps for the housing and building, and the industrial sectors. Its mission is to serve the needs of policy makers, national and international energy and environmental agencies, designers and researchers.

The programme objectives aim at quantifying and publicizing the environmental and energy efficiency benefits of heat pumps, developing and delivering information to support appropriate deployment; maintaining and developing international RD&D collaboration that furthers the environmental and market objectives; and to provide effective collaborative and flow of information to, from and between stakeholders and other relevant bodies.

The programme is based upon membership from participating countries. Since its creation the following countries have been members of the HPP:

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|------------|----------------|----------------|
| • Austria* | • Japan* | • Sweden* |
| • Belgium | • South-Korea* | • Switzerland* |
| • Canada* | • Mexico | • UK |
| • France* | • Netherlands* | • USA* |
| • Germany* | • Norway* | |
| • Italy* | • Spain | |

(* designates the current 12 member countries)

The programme is structured to facilitate collaborative activities between its member countries, and is coordinated by the Heat Pump Centre presently located in Sweden.

3.1 Annexes

Joint activities are performed through collaborative projects (Annexes) between member country organizations that are interested to participate at.

3.2 Heat Pump Centre

The Heat Pump Centre (HPC) is HPP's central channel for information dissemination. The Centre takes a number of actions in order to promote the Programme and heat pumping technology. HPC regularly organises workshops, of which some are annex related and others are focussed on a specific country's work related to heat pumps,.

3.3 National Teams

National Teams (NTs) have been established to both disseminate information and promote HPP activities in the member countries and to collect information from HPP experts and stakeholders on the activities and needs of their countries regarding policy developments, barriers to heat pump penetration, and research and development activities

The National Teams are composed at a national level in the member countries, generally under the leadership of the delegates. They can include representatives from industry, universities, institutions or other organisations.

The work performed by the NTs contributes to the achievement of the HPP vision. Their activities include the generation of ideas to new HPP activities/projects of interest to their country, participation in HPP activities/projects, national information dissemination and promotion, and bringing industry and researchers together in an international network.

3.4 International Heat Pump Conference

The International Heat Pump Conferences (as here in Zürich) held every three years, under the auspices of the IEA HPP, is the key event for heat pump stakeholders to learn and exchange about the most recent research results and trends in heat pumps.

3.5 Newsletter and the web site

The Heat Pump Programme offers a website for information dissemination on the Internet (www.heatpumpcentre.org). The newsletters (generally four are published every year) are downloadable from the web site in short and complete versions.

4 ROLE AND INFLUENCE

The HPP activities have been oriented to provide knowledge and technologies in the continuously evolving context of energy and environment. The long list of Annexes is a good indicator of the type of topics that have been addressed, covering a wide range of applications. Table 1 provides a selection of Annexes completed since the beginning of the programme.

Table 1: Examples of completed annexes

Annex number	Title	Year of completion
1	Common study of advanced heat pumps	1980
7	New development of the evaporator part of heat pump systems	1989
9	High temperature industrial heat pumps	1990
14	Working fluids and transport phenomena in advanced absorption heat pumps	1991
20	Working fluid safety	1993
21	Global environmental benefits of industrial heat pumps	1996
24	Ab-sorption machines for heating and cooling in future energy systems	2000
26	Advanced supermarket Refrigeration/Heat recovery systems	2003
27	Selected issues on CO ₂ as working fluid in compression systems	2004
28	Test procedure and seasonal performance calculation of residential heat pumps with combined space and domestic hot water heating	2005

Annex deliverables include:

- Spreadsheet and detailed models for performance analysis of equipment, systems, and applications (e.g. Annex 26)
- Test procedure to calculate performance factors (e.g. Annex 28)
- New correlations (e.g. Annex 27)
- New technologies (e.g. Annex 7)
- Demonstration projects and case studies (e.g. Annex 26)
- Market assessments (e.g. Annex 21)

The Annex final reports are available at the Heat Pump Centre.

5 POTENTIAL IMPACTS

A recent policy paper (IEA -website) published by the HPP reveals that with a 30% market penetration, current heat pump technology would reduce by 6% the present total global emissions. This value could even reach 16% with future technology developments (Halozan, 2005). The benefits are generated by the extension of heat pump applications, mainly for space heating, because of their high efficiency compared to conventional technologies, essentially boilers and furnaces.

In addition to GHG emission reductions, heat pumps help reduce energy demand and therefore vulnerability to energy supply. Since heat pumps are usually driven by electricity, countries can diversify their primary energy source for heating purposes, choosing for instance less carbon intensive electricity generation.

The technology is mature, commercially available and economically viable in a large number of applications. But, to reach these impacts, the market forces are not sufficient. Expanded

R&D, technical and economical barrier removal, and support to decision makers are key activities that the HPP intends to pursue. In order to increase the penetration of heat pumps into the market, the activities will be carried out in close cooperation with other organizations and associations, as well as representatives of the industry working with efficient end-use of energy.

The reduction of outdoor air contaminants resulting from more efficient systems is another impact of heat pump use.

6 OPPORTUNITIES FOR EXPANDING APPLICATIONS

6.1 Buildings and housing

Strongly related to the standard of living, the use of air-conditioning is increasing and will continue to increase in the future, particularly in developing economies.

In addition, the global warming effect combined to higher levels of insulation of houses and buildings, and the utilization of passive heating techniques could in some cases increase the need for air conditioning.

Heat pumps have been identified to play a major role in the development of near-zero and net-zero energy buildings (ASHRAE 2007). The major challenge will be the integration with other technologies such as distributed generation and energy storage (short and long term). Techniques for optimizing the design and the operation in order to simultaneously improve performance and reduce costs are required.

6.2 Neighbourhoods and communities

In a district heating/cooling approach for neighbourhoods or communities, short and long term storage combined with heat pumps provide opportunities for a better utilization of heat available, from solar energy stored naturally or through collectors in the ground, or from waste heat recovered from exothermic buildings (e.g. supermarkets) or industries. This could be considered in urban planning.

6.3 Industry

A huge opportunity for energy savings and GHG emission reduction exists in the industrial sector. Process heat that is currently released in the atmosphere could be reclaimed and upgraded. There is strong need for developing technologies and knowledge enabling heat upgrading at medium to high temperatures, in viable economical and reliable conditions.

Also, refrigeration in process industry (Chemicals, agri-food, plastics, electronics...) represents opportunities for performance improvement. Heat integration with the building heating system or other processes is still not fully exploited.

6.4 Distributed generation

Thermally activated heat pumps (ab- or ad-sorption, ejectors) are very attractive solutions to upgrade heat available from microturbines for heating or cooling, in tri-generation applications.

7 ACTIVITIES FOR IMPROVING HEAT PUMP PERFORMANCE AND COSTS

Wider acceptance and adoption of heat pumping technologies will come from working in parallel on different aspects: Improving the performance at the equipment, system, and applications levels (Bullard 2005); supporting the development of codes and standards; providing information to policy development.

Heat pumps may benefit from recent technology advances and innovations. Some examples are provided below. The list is far from exhaustive.

7.1 Equipment and systems

- Ejectors and electronic valves as replacement of the expansion valve, or for improved cooling/heating cycles
- Compact heat exchangers (microchannels). The HPP Annex 31 is presently working on this topic
- Working fluids: environmentally neutral working fluids (e.g. CO₂ NH₃)
- Heat transfer fluids: CO₂, slurries, nanofluids, and more generally phase-change secondary fluids
- Small capacity turbo-compressors: variable speed on a wider range of operation, no oil
- Thermally-activated heat pumps. The HPP Annex 34 is presently working on this topic.

7.2 Control and operation

- Fault detection and diagnosis using artificial intelligence techniques for equipment and systems
- Commissioning practices for systems and applications
- Improved control techniques and sequences
- Guidelines and computed-tools for optimizing the system design and operation.

7.3 Deployment and support to policies

The following actions have been identified in this area.

7.3.1 Communication

- Publicise the energy saving potential and environmental benefits (local and global) of heat pumping technologies
- Increase awareness of heat pump system's annual performance
- Provide support information and knowledge so that it is widely accepted that heat pumps reduce carbon footprint.

7.3.2 Codes and standards

Have heat pumps included in building codes as an option to reduce GHG emissions.

7.3.3 Support to policies

Support the development of financing programs to stimulate heat pump adoption
Have policies in place in most countries to recognize and credit renewable resource utilization of air, water and ground source heat pumps.

7.4 Collaborations

Collaboration with other organizations will be maintained in order to leverage the programme activities and information dissemination. Collaborations already exist with the International Institute of Refrigeration (IIR), European Heat Pump Association (EHPA), the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) and other relevant bodies or IAs of the IEA: the IEA Buildings Coordination Group (BCG) whose role is to coordinate efforts and interests among the building-related IAs, Energy Conservation through Energy Storage (ECES), Energy Conservation in Buildings and Community Systems (ECBCS), District Heating and Cooling (DHC), Demand-Side management (DSM), and Solar Heating and Cooling (SHC).

The HPP also maintains good relationships with organizations such as the United Nations Environmental Program (UNEP), and the Air-Conditioning and Refrigeration Institute (ARI)/Technology Institute (ARTI) in the USA.

The role of the industry is also essential in the strategy of having the heat pumps widely adopted. Industry is represented at the HPP through its participation in the National Teams, at different events (e.g. conferences, workshops), and in the Annexes, either directly as an active partner, or indirectly under the flag of a university, a research institute, or a government body. Since 2006, the HPP also offers the possibility to industry to become a sponsor when its country is not a member of the HPP.

8 CONCLUSION

Launched in 1978, the IEA HPP has established a good track record in terms of developing high-skilled knowledge and technologies in heat pumps, for heating, air conditioning and refrigeration applications, in the buildings and industry sectors, in the continuously evolving energy and environmental contexts. It is expected that heat pumps will play a major role in the portfolio of technologies to reduce significantly energy consumption and GHG emissions worldwide, in different applications in particular in the building and industry sectors. The current scenario is that 6% GHG emission reduction globally is accessible through a 30% market share of existing technologies, 16% could be reached with future technologies.

In order to increase HP adoption, the following key actions have been identified: Further RD&D to develop more energy efficient, sustainable and cost-effective heat pumps for heating cooling and refrigeration, particularly for retrofit and new buildings and industrial applications; objective information to increase awareness, acceptance and knowledge of heat pumps; support to policies to position heat pumps in the portfolios of technologies enabling the reduction of carbon footprint and recognize and credit as renewable resources the utilization of air, water and ground in heat pump applications.

The IEA HPP is well positioned through its members, partnerships and activities, to play an active role in making heat pumps a major solution to a more sustainable, viable and reliable world.

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