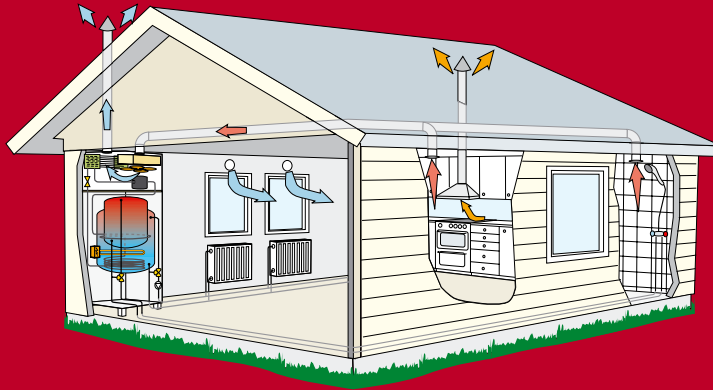


# Annual Report 2007



2007



## HEAT PUMP PROGRAMME

Implementing Agreement for a Programme of  
Research, Development, Demonstration and  
Promotion of Heat Pumping Technologies



International Energy Agency

Pictures front cover:  
Exhaust air heat pump system (Illustration by Lars Fransson, Illustration & Information),  
Drilling at ground-source heat pump installation

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## Ongoing Annexes

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<b>30</b>	<b>Annex 30</b> Retrofit Heat Pumps for Buildings	<b>DE</b> , FR, NL
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<b>33</b>	<b>Annex 33</b> Compact Heat Exchangers in Heat Pumping Equipment	JP, SE, <b>UK</b> , US
<b>34</b>	<b>Annex 34</b> Thermally Driven Heat Pumps for Heating and Cooling	AT, <b>DE</b> , NL, US

The IEA Heat Pump Programme participating countries are: Austria (AT), Canada (CA), France (FR), Germany (DE), Japan (JP), the Netherlands (NL), Norway (NO), Sweden (SE), Switzerland (CH), United Kingdom (UK), the United States (US). All countries are members of the Heat Pump Centre (HPC). Sweden is the Operating Agent of HPC.

# International Energy Agency

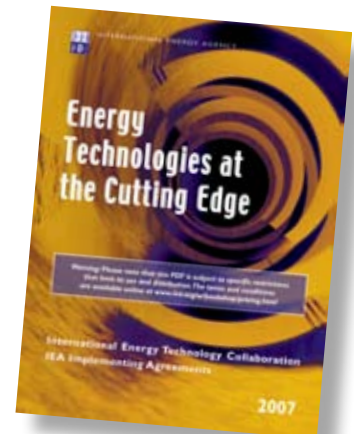
The International Energy Agency (IEA) acts as energy policy advisor for its 27 member countries in their effort to ensure reliable, affordable and clean energy for their citizens. Founded during the oil crisis of 1973-74, its initial role was to coordinate measures in times of oil supply shortages. But during the last decades, the energy markets have changed, and so has the IEA. It now focuses well beyond oil crisis management on broader energy issues, including climate change policies, market reform, energy technology collaboration and outreach to the rest of the world. With a staff of around 150, mainly energy experts and statisticians from its member countries, the IEA conducts a broad programme of energy research, data compilation, publications and public dissemination of the latest energy policy analysis and recommendations on good practices.

To support these core issues, the IEA created contracts – Implementing Agreements – and a system of standard rules and regulations, the IEA Framework, that would allow interested member and non-member governments to pool resources of research, development and deployment of particular technologies.

For more than 30 years, technology collaboration has been a fundamental building block among IEA member and non-member countries in facilitating progress of new or improved energy technologies. There are currently 41 Implementing Agreements working in the areas of End-Use (Buildings, Industry and Transport), Fossil Fuels, Renewable Energies and Hydrogen, Fusion and Cross-Sectional Activities. The IEA Committee on Energy Research and Technology (CERT) and its Working Parties review the effectiveness, achievements and strategy of each Implementing Agreement.

This publication concerns the “Implementing Agreement for a Programme of Research, Development, Demonstration and Promotion of Heat Pumping Technologies”, more commonly known as the IEA Heat Pump Programme (HPP).

More information about the Implementing Agreements can be found on [www.iea.org/Textbase/techno](http://www.iea.org/Textbase/techno) and in the publication “Energy Technologies at the Cutting Edge” (free to download from the IEA website)



# IEA Heat Pump Programme

Organised under the umbrella of the International Energy Agency since 1978, the IEA Heat Pump Programme is a non-profit organisation funded by its member countries. The scope of the Programme covers heat pumps, air conditioning and refrigeration, commonly denoted as heat pumping technologies.

## **HPP member countries are:**

Austria, Canada, France, Germany, Japan, the Netherlands, Norway, Sweden, Switzerland, United Kingdom and the United States.

## **Vision**

The Programme is the foremost worldwide source of independent information and expertise on environmental and energy conservation benefits of heat pumping technologies (including refrigeration and air conditioning).

The Programme conducts high value international collaborative activities to improve energy efficiency and minimise adverse environmental impact.

## **Mission**

The Programme strives to achieve widespread deployment of appropriate high quality heat pumping technologies to obtain energy conservation and environmental benefits from these technologies. It serves policy makers, national and international energy and environmental agencies, utilities, manufacturers, designers and researchers.

## **Strategic Objectives**

### ***Energy and Environment***

To quantify and publicise the energy saving potential and environmental benefits (local and global) of heat pumping technologies.

### ***Market and Deployment***

To develop and deliver information to support deployment of appropriate heat pumping technologies.

### ***Technology***

To promote and foster international collaboration to develop knowledge, systems and practices in heat pumping technologies through RDD&D (research, development, demonstration and deployment).

### ***Information Management***

To provide effective flow of information to, from and between stakeholders and other relevant entities.

### ***Visibility and Status***

To improve significantly the visibility and status of the Programme, and to be an outstanding Implementing Agreement within the IEA.

## **Activities**

The activities of the Programme include an information service, the Heat Pump Centre, international collaborative projects (Annexes), workshops, analysis studies and a triennial international conference.

## **Heat Pump Programme Co-ordination**

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# Chairman's Statement 2007



It is my pleasure to present the Annual Report of the IEA Heat Pump Programme (HPP) for 2007.

2007 has included approval by IEA of extension of the Heat Pump Programme for another five years, based on the End-of-Term report and the new strategy plan that were presented to IEA during the fall. I would like to take the opportunity to thank everyone who has contributed to this achievement. Also, the Executive Committee delegates unanimously approved renewal of the mandate for SP Technical Research Institute of Sweden to manage the Heat Pump Centre for another four years, based on the excellent work SP has performed these last years.

Two workshops were held during the year respectively in Paris and in Brussels, both in conjunction with the Executive Committee meetings. They provided opportunities to learn about the French and Belgium national heat pump programmes and to present HPP to their representatives. The meeting in Paris allowed enhancing communication and linkages with IEA. In Brussels, a joint meeting between the two implementing agreements, HPP and ECBCS<sup>1</sup>, was held, enabling identification of potential collaborations in common areas. During the year, HPP has supported the NEET<sup>2</sup> initiative launched by IEA to promote IEA Implementing Agreements in the 'Plus five' countries; Brazil, China, India, the Russian Federation and South Africa. In particular, Prof Halozan, the Austrian delegate, participated in the mission in China, where he presented HPP activities.

A new collaborative project, Annex 34 entitled "*Thermally Driven Heat Pumps for Heating and Cooling*", has been launched, managed by Germany. This brings the number of ongoing Annexes to six. Other activities include the publication of four newsletters. HPP has also continued to reach out and coordinate activities with relevant organisations such as IEA BCG<sup>3</sup>, IIR<sup>4</sup> and EHPA<sup>5</sup>, in order to encourage collaboration for activities and information dissemination. Several countries have expressed their interest in joining HPP. More specifically, South Korea and Italy have initiated official processes in this vein, and we soon hope to involve them in our future activities as new members.

For the most recent updates in the heat pumping field, HPP offers you the 9th International Heat Pump Conference that will be held in May in Zurich. During 2007, much effort has been devoted to organising and preparing this unique meeting place where advances and prospects in technology, applications and markets for heat pumps, air conditioning and refrigeration equipment and systems for residential, commercial and industrial applications will be shared.

You cannot miss this event!

A handwritten signature in blue ink, reading 'S. Hosatte'.

Sophie Hosatte  
ExCo Chairman

<sup>1)</sup>Energy Conservation in Buildings and Community Systems

<sup>2)</sup>The Networks of Expertise in Energy

<sup>3)</sup>The Building Coordination Group (IEA)

<sup>4)</sup>The International Institute of Refrigeration

<sup>5)</sup>The European Heat Pump Association

# Preparation for the Next Conference

## 9th IEA Heat Pump Conference

**"Advances and Prospects in Technology, Applications and Markets"**

May 20 – 22, 2008 in Zürich, Switzerland

Planning and preparation of the conference started in the spring of 2006 with establishment of an International Organizing Committee (IOC), under the chairmanship of Dr Rune Arlien, Norway, and a National Organizing Committee (NOC), under the chairmanship of Prof Thomas Kopp, Switzerland. The IOC took responsibility for the scientific program, and the NOC for the logistic organisation in Zürich.

After having launched the first announcement, "Call for Papers", IOC and its regional coordinators - Mr Jerry Groff for North and South America, Mr Makoto Tono for Asia and Oceania, and Dr Monica Axell for Europe and Africa - received more than 200 abstracts.

One of the most important decisions of NOC has been to determine the location of the conference. After intensive evaluations in Switzerland, the decision was made for Swisshôtel, one of the largest conference sites in Zürich.

The second announcement, "Registration", was made at the end of 2007, opening registration for participants, students and accompanying persons.

### Workshops in conjunction with the conference

To increase the attractiveness of the conference, different half-day workshops will be offered, covering topics from HPP Annexes 29, 30, 31, 32, 33 and 34. It was also decided, with the organizers of the GROUNDREACH project of the European Union, to integrate a full-day workshop on the project in the conference's program. In addition, NOC has arranged that the European Heat Pump Association will hold its General Assembly during the conference.

Technical and non-technical half-day tours have been prepared to break the scientific discussions, and to offer participants an opportunity to socialise and to see some interesting places in the surroundings of Zürich.

### Sponsoring of the conference

NOC has prepared a sponsoring concept and has started to attract industrial sponsors. Sponsors will be given the opportunity to show their business and equipment at the conference. NOC and IOC have also addressed HPP member countries for country sponsoring.

### Sessions at the conference

The sessions cover the following topics:

- Heat pumps for a sustainable society
- Heat pump application to low energy buildings
- Ground and water source heat pump systems
- Heat pump application (general)
- Market and application studies
- Technology advancement 1 (components)
- Technology advancement 2 (systems)
- Country research reports



www.hpc2008.org







# Highlights of 2007

## A term completed and a new term starting for HPP

The sixth term of the Heat Pump Programme was concluded at the end of 2007. This provided an opportunity to summarise a very fruitful and intensive term with a lot of activities and challenges for the Programme. During the past term the number of annexes has significantly increased. Membership has been an issue for some countries due to financial constraints but the tendency shows a situation change with two new countries in the process of becoming HPP members and some other ones revealing a high level of interest for the Programme. During the autumn of 2007, two presentations of the HPP End-of-Term report were made to the IEA Working party on Energy End-Use Technologies by the Executive Committee delegate Professor Hermann Halozan, and to the IEA Committee on Energy Research and Technology by the Executive Committee alternate delegate Dr Rune Aarli. Based on the activities performed during the 2003-2007 period and the strategy plan proposed for 2007-2012, the IEA Committee on Energy Research and Technology approved an extension of the Programme for another five years.

## Executive Committee meetings

Two meetings of the HPP Executive Committee were held in 2007:

- May 31 – June 1, in Paris, France
- November 14 -15, in Brussels, Belgium



*Paris workshop*

## The Paris workshop

In connection with the Executive Committee meeting in Paris, a workshop was held to present ongoing activities in France in the heat pumping field. Dr Antonio Pflüger, the head of the IEA Energy Technology Collaboration Division, presented the IEA activities and strategies, and Dr Sophie Hosatte presented the Heat Pump Programme. Other invited speakers were Mr Didier Coulomb, the director of the International Institute of Refrigeration, who spoke about the IIR organisation, and Mr Rajendra Shende, the head of the OzonAction at the United Nations Environment Programme, who talked about the phasing out of ozone-depleting refrigerants.



*ECBCS-HPP technical briefing, Brussels*

## IEA ECBCS-HPP technical briefing

In connection with the Executive Committee meeting in Brussels, a joint technical briefing between HPP and another IEA Implementing Agreement, Energy Conservation in Buildings and Community Systems, was held, in order to explore areas of mutual interest. This event provided a forum to present respective activities of the two Implementing Agreements and to identify opportunities of collaboration. Topics such as "Energy in Belgium", heat pumping technology in an energy and environmental context, inappropriate control strategies etc. were also covered.

More information can be found on [www.labohtap.ulg.ac.be/cmsms/index.php?page=iea-ecbcs-hpp-technical-briefing](http://www.labohtap.ulg.ac.be/cmsms/index.php?page=iea-ecbcs-hpp-technical-briefing)



## HPP participated in IEA NEET workshop

The Networks of Expertise in Energy (NEET) is an initiative "... to enhance awareness of existing research, development and deployment networks, and to facilitate broader participation" in IEA. In November 2007 Professor Hermann Halozan (Executive Committee delegate) participated in a NEET workshop in China.

China expresses that it is willing to support all technologies which will help to achieve a reduction in CO<sub>2</sub> emissions. Regarding heat pumping technologies, the attendees showed a great interest as heat pumps play an important role in the Chinese building sector.



Visit [www.iea.org/Textbase/neet](http://www.iea.org/Textbase/neet)



## IEA Building Coordination Group

During the autumn of 2007, Prof Hermann Halozan was elected vice chair of the building sector of the IEA Working Party on Energy End-Use Technologies. In this capacity, he is also the chair of the IEA Building Coordination Group (BCG). BCG seeks to coordinate efforts and interests among the building-related Implementing Agreements (IAs). The Heat Pump Programme sees this group as a constructive way of intensifying the sharing of experience among the IAs.

## New collaborative projects

**A new project.** Annex 34, *Thermally Driven Heat Pumps for Heating and Cooling*, started in 2007. The aim of the project is to reduce the environmental impact of heating and cooling by the use of thermally driven heat pumps (see page 17).

# Programme Achievements 2007

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## Heat Pump Centre

The Heat Pump Centre plays a central role in the IEA Heat Pump Programme. It aims at disseminating factual and balanced information on heat pumping technologies and promoting the activities of the Programme. During 2007, the ExCo approved an extension of SP Technical Research Institute of Sweden's mandate to manage the Centre for another four years.

## Activities

One of the main activities is publication of the Heat Pump Centre Newsletter. Each issue covers a particular topic, and contains articles, news and events, together with a contribution from a guest columnist. Four issues were published in 2007, available free of charge from the HPC website to the HPP member countries.

Non-member countries can subscribe to the Newsletter. In addition, a short version of the Newsletter, an e-Newsletter, is freely available to all countries, either by e-mail subscription or by downloading from the HPC website. The number of subscribers to the e-Newsletter increased by over 20 % in 2007, to a total of over 1100. In addition, dissemination through the National Teams reaches approximately another 1100 readers. In order to identify the target groups reached by the newsletter, new subscribers are asked as of March 2007 to fill in a short form at registration, asking for the type of organisation that they represent.

The Heat Pump Centre also plays an active part in generating new activities within HPP. For example, it publishes ongoing descriptions of project proposals on the website in order to stimulate the initiation of new annexes. HPC has also compiled a report with information on research and development and market development in HPP member countries. The report is available to the National Teams in the member countries.

Another important activity is the website, which is continuously updated with news, events and contact information. Descriptions of ongoing and completed HPP annexes are also available on the website as well as HPP publications, which are accessible via a data base. The traffic on the website has decreased somewhat throughout 2006 and 2007. A number of actions to attract visitors will be taken during 2008.

In 2007, the Heat Pump Centre was closely involved in the preparation of the End-of-Term report for the period 2003-2007. The report includes the activities undertaken during the sixth term of HPP. During the autumn it has been presented to the IEA End Use Working Party and to the IEA Committee on Energy Research and Technology by two Executive Committee delegates.

Finally, the Centre has a supportive function by assisting Operating Agents (project leaders) of HPP annexes and the HPP Executive Committee in their work.



Website: [www.heatpumpcentre.org](http://www.heatpumpcentre.org)

## International collaboration and promotion

The Heat Pump Programme and the Heat Pump Centre have good relations with a number of national and international organisations, such as EHPA<sup>1</sup>, IIR<sup>2</sup>, ASHRAE<sup>3</sup> and ARI/ARTI<sup>4</sup>. Two liaison meetings took place between IIR and HPP/HPC in 2007 in conjunction with the ExCo meetings. Important activities discussed were the IIR Congress in Beijing in 2007 and the IIR 100th anniversary in June 2008. HPP and IIR are also discussing different ways of more effectively disseminating information through the organisations' existing channels (e.g. the IIR FRIDOC publication data base and the HPP newsletter).

Prof Hermann Halozan and Mr Roger Hitchin, both Executive Committee delegates, participated in the Future Buildings Forum workshop held in Espoo, Finland, in March 2007. The Forum gathers representatives from the buildings-related IEA Implementing Agreements, aiming at "Identifying long term energy, environmental, economic and technical issues related to buildings and the R & D needs associated with them".

Dr Roger Nordman from the Heat Pump Centre participated in the IEA Biennial Ministerial-level meeting in Paris in May to disseminate information on heat pumping technology. Dr Sophie Hosatte, the Chairman of the Executive Committee, promoted HPP at the UN's 20th anniversary of the Montreal Protocol in September.

<sup>1</sup>The European Heat Pump Association

<sup>2</sup>The International Institute of Refrigeration

<sup>3</sup>The American Society of Heating, Refrigerating and Air-Conditioning Engineers

<sup>4</sup>The Air-Conditioning and Refrigeration Institute/ Air-Conditioning and Refrigeration Technology Institute

## New publications in 2007

- The IEA Heat Pump Programme Strategy Plan 2007-2012

In addition, promotional material including a leaflet and PowerPoint presentation with general information on HPP, HPC, membership etc., has been updated and is freely available from [www.heatpumpcentre.org](http://www.heatpumpcentre.org).



## Newsletters 2007

Four newsletters and E-newsletters were published in 2007, and are available on the Heat Pump Centre website. The topics were:

1. Industrial heat pumps
2. Mobile air conditioning
3. Heat pump components development trends
4. Combining heat pumps and other technologies

*Publications can be ordered from the Heat Pump Centre.*



# Annex 29

## Ground-Source Heat Pumps – Overcoming Market and Technical Barriers

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www.annex29.net

**Participating countries:** Austria (Operating Agent), Canada, Japan, Norway, Sweden and the USA

Annex 29 is investigating the present status of ground-source heat pump systems (GSHP), which varies widely all over the world, and identifying systems – depending on climate and application – that could improve the performance and market attractiveness of ground-source heat pump systems. The objective is to demonstrate the economic and environmental benefits of ground-coupled heat pump systems.

Reports from the participating countries are now available. Work on the state of the art and market analysis, and on a matrix of ground-source heat pumps under different climate and site conditions, is almost finished. The majority of installations are small systems. Systems in Europe are mainly heat-only systems, whereas Japanese and North American systems provide both heating and cooling. Large systems generally use the ground as a heat or cold store. Great efforts are made to reduce energy demand by direct cooling and by transferring excess heat from parts of a building with a cooling demand to parts with a heating demand. Systems have to be sized in such a way that the average ground coil temperature caused by heat extraction/heat removal can be kept stable over the years of operation.

In January 2007 a workshop and a working meeting took place in Sapporo, Japan. It was organised by Prof Katsunori Nagano, Hokkaido University, and his team, and by Dr Li, Heat Pump Technology and Thermal Storage Center of Japan. Presentations were given by the Annex participants, by experts from all over Japan, and by guests from China. Site visits to GSHP demonstration installations and to an ultra-low energy house with a GSHP were organised.

Ground-source heat pumps, and Annex 29, have been highlighted at different events during the year. In August, at the 22nd IIR International Congress of Refrigeration in Beijing, China, ground source heat pumps played an important role, with a technical tour going to a large GSHP plant. In November, at an IEA NEET (Networks of Expertise in Energy) workshop in Beijing, China, one of the few presentations of end-use energy technologies was a session on heat pumps, where GSHP applications and installations in China were presented. In November, in Brussels, Belgium, a joint workshop of the Implementing Agreements, ECBCS and HPP, took place. Annex 29 was one of the Annexes that were presented.

Worth mentioning, too, are the American participants of Annex 29, Dr Ally and Mr Craddick from Oak Ridge National Laboratory, USA, who contributed to the Annex with the very interesting report *"Exploratory Development of Selective Water Sorbent Enhanced Ground-Coupled Heat Pump Technology"*.

It has been decided that Annex 29 will be extended until spring 2008, due to the fact that important contributions to the results are missing. A final Annex 29 workshop will be organised at the 9th IEA Heat Pump Conference in May 2008, in Zurich, Switzerland.

*Working meeting, Sapporo*





# Annex 30

## Retrofit Heat Pumps for Buildings

**Participating countries:** France, Germany (Operating Agent) and the Netherlands

With the exception of Sweden, the present heat pump market for space and water heating and cooling in Europe is largely concentrated on new buildings, and particularly on one and two-family houses. There is, however, a very large potential in the retrofit market to replace old conventional oil, gas or coal-fired heating systems with high energy-efficient and environmentally friendly heat pumps.

The main barrier to the use of heat pumps for retrofitting is the high distribution temperature of conventional heating systems in existing residential buildings, with design temperatures up to 70 – 90 °C. This is too high for the present heat pump generation, for which the maximum, economically acceptable heat distribution temperature is up to 55 °C.

The objective of this Annex is therefore to survey the availability, technology, economy, ecology and possible R & D trends of heat pump systems for retrofitting low-energy efficient space and tap water heating systems in existing residential buildings.

The Annex is subdivided into four tasks:

- Task 1** State-of-the-art and market analysis
- Task 2** Development of a matrix of heat pumps
- Task 3** Overcoming economic, environmental and legal barriers
- Task 4** Identifying success factors for the marketing of retrofit heat pumps

The annex will be completed by October 2008. The two meetings held in 2007 have therefore been concentrated on detailed discussions of the results achieved and the preparation of the final report and related appendices, in particular presenting case studies and R & D, D projects.

A workshop has been organised in connection with the DKV Annual Meeting in November 2007 in Hanover, with presentations of the results of the annex and the present trends of retrofit heat pumps in France, The Netherlands, Sweden and Germany.

At the 9th IEA Heat Pump Conference in May 2008 in Zurich, Switzerland, Annex 30 will organize a workshop entitled “Retrofit Heat Pumps for Buildings”, presenting the major findings of the Annex as well as new developments related to the Annex.

A password-protected website has been set up for the Annex on IZW's website, [www.izw-online.de](http://www.izw-online.de), as a common information source for participants, with detailed protocols of the Annex meetings and all attachments, as well as further necessary information.

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## Annex 31

### Advanced Modeling and Tools for Analysis of Energy Use in Supermarkets

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**Participating countries:** Canada, Germany, Sweden (Operating Agent), United Kingdom and the USA.

Supermarkets are the most energy-intensive buildings in the commercial sector. It has been estimated that 3-5 % of the total use of electricity stems from supermarkets in industrialised countries. In addition, it is estimated that the annual refrigerant losses may be as high as 15 - 30 % of the total charge, thus making supermarkets the second largest emission source after mobile air conditioning, according to the most recent report from the UN Intergovernmental Panel on Climate Change. The supermarket sector has therefore a significant role to play, not only from an energy consumption point of view but also from the point of view of the impact of refrigerant leakage.

The overall objective of Annex 31 is to provide new knowledge, methods and tools for enhanced energy efficiency of, and therefore reduced environmental impact from, supermarkets. The aim is also to share ideas and best practices among participating countries, as well as information on available tools for modelling and analysis, in order to further improve supermarket refrigeration systems. The annex builds on experience and findings from Annex 26, *Advanced Supermarket Refrigeration/Heat Recovery Systems*.

In order to achieve the objectives of the annex, the following task-sharing activities are planned:

**Task 1** Collection of available data from different supermarkets (benchmarking)

**Task 2** Development of performance indices for supermarkets

**Task 3** Development and validation of a model library for specific supermarket equipment

**Task 4** Development of whole-building simulation models.

**Task 5** Comparison of the results obtained with the different whole-building simulation models for selected case studies

**Task 6** Future perspectives and possibilities

**Task 7** Deployment of the knowledge developed (indices, guidelines, papers, fact sheets)

Meetings and workshops that were organised during 2007 were:

- Meeting at ASHRAE Winter Meeting, Dallas, US, in January
- Internet-based meetings during spring 2007
- Workshop at the 22nd IIR International Congress of Refrigeration in Beijing, China, in August
- Internet-based meetings during fall 2007

A substantial part of the discussions has remained on Tasks 1 and 2, due to difficulties in all participating countries in obtaining good-quality data for supermarket energy use in accordance with the templates for data collection that were decided. However, during the 2008 ASHRAE meeting in January, several presentations showed results from collected data. Collection of data and information on whole supermarket simulation software and sub-models will be intensified during the spring of 2008, using a template that has been developed.

Several new development activities have been initiated during 2007, such as plug-in for RETScreen (Canada), Energy + (US) and a CO<sub>2</sub> transcritical model at KTH, the Royal Institute of Technology (Sweden). A workshop is planned at the 9th IEA Heat Pump Conference in May 2008, in Zurich, Switzerland.



## Annex 32

### Economical Heating and Cooling Systems for Low Energy Houses

**Participating countries:** Austria, Canada, Germany, Japan, the Netherlands, Norway, Sweden, Switzerland (Operating Agent) and the USA

Heat pumps are the only devices which can generate heating and cooling energy, even at the same time. Multifunctional heat pump systems for space heating, domestic hot water (DHW) production, ventilation and space cooling may therefore be a cost-effective means of meeting all building needs with one integrated system.

The aim of this Annex is to investigate different system configurations of heat pump systems, including the respective energy source and distribution systems, for application in low- and ultra-low-energy buildings. The principal objectives are:

- to improve and further develop multifunctional heat pump systems in terms of overall energy use, achievable comfort and costs,
- to gather more field experience from real-world operation of heat pump systems, and
- to derive design guidelines for multifunctional heat pump systems and their control systems.

The Annex has been structured into four tasks:

**Task 1** State-of-the-art survey of low-energy buildings and respective systems

**Task 2** Assessment, calculation and comparison of system solutions

**Task 3** Field testing of systems (in parallel with Task 2)

**Task 4** Develop guidelines for systems and their control and document best-practice systems.

The Annex started in January 2006, and is scheduled to run for three years. Activities in 2007 were dedicated to the conclusion of Task 1, the state-of-the-art analysis of the building and systems markets, and interim results of Task 2 and Task 3. The basic results of Task 1 are:

- Low-energy buildings are seen as a key element in reducing CO<sub>2</sub> emissions and achieving Kyoto targets.
- However, markets differ from one country to another. Germany, Austria, Switzerland and Norway, for example, have growing markets, while other countries, such as The Netherlands, are still in the market introduction phase.
- Heat pumps are well established as building technology in low-energy buildings, and the residential heat pump markets are growing in most of the participating countries.

Two working meetings were held in 2007. At the meeting in Arlington, USA, in May, the results of Task 1 were discussed, and activities in Task 2 and Task 3 were co-ordinated. At the meeting in Kyoto, Japan, in December, interim results of Task 2 and Task 3 were discussed, and an Annex 32 workshop for the 9th IEA Heat Pump Conference was prepared.

Task 2 is concentrating on laboratory testing, prototyping and evaluation of system configurations. Task 3 is starting, or is in progress with, several field tests of marketable units and new developments.

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*Kyoto working meeting*



[www.annex32.net](http://www.annex32.net)



## Annex 33

### Compact Heat Exchangers in Heat Pumping Equipment

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**Participating countries:** Japan, Sweden, United Kingdom (Operating Agent) and the USA.

This Annex, which commenced activities in the autumn of 2006, is directed at widening the use of compact heat exchangers (CHEs) in heat pumping systems. It is believed that these will improve efficiencies, minimise fluid inventories and reduce package size. The data collected during the Annex will, it is hoped, quantify the possible benefits from CHE use, and also highlight any concerns. Ultimately, the use of compact heat exchangers should significantly improve the acceptability of heat pumps across all applications, by allowing improved COPs and reduced materials content.

The principal objective of this Annex is to present a compilation of possible options for compact heat exchangers, used as evaporators, condensers and in other roles in heat pumping equipment. The aim is to minimise the direct and indirect effect on the local and global environment due to manufacture operation and final disposal of the equipment.

Specific technical goals involve identifying and documenting reasonably accurate methods of predicting heat transfer, pressure drop and void fractions in CHEs, thereby promoting their commercial use by heat pump manufacturers by simplifying the design and selection procedures. Integral with these activities will be an examination of manifolding/flow distribution in compact/micro-heat exchangers, in particular in evaporators.

Annex 33 involves the following tasks:

- Task 1** Market research
- Task 2** The evaluation of the performance of compact heat exchangers relevant to heat pumps
- Task 3** The evaluation of properties and operating limits of such equipment
- Task 4** Information sharing.



The first meeting of the Annex took place in Stockholm, Sweden, in May 2007. It was held at the Royal Institute of Technology and was hosted by Prof Björn Palm. On the first day a well-attended open session included extensive presentations by researchers and companies, including Alfa Laval and Laminova. The second day an Annex meeting between the four participating countries took place. Extensive research activities relevant to the Annex topic were visited during the two days in the University laboratories. The presentations in the open session are available on the Annex website.

There will be further opportunities for open meetings at which industry and academia can put forward their views and contribute to the project, including a workshop at the 9th IEA Heat Pump Conference in May 2008, in Zurich, Switzerland.

The Annex has as Operating Agent the School of Engineering and Design, Brunel University in London, UK, represented by Prof David Reay or his Deputy, Dr Peter Kew of Heriot-Watt University, Edinburgh.

[www.compactheatpumps.org](http://www.compactheatpumps.org)

## Annex 34

### Thermally Driven Heat Pumps for Heating and Cooling

**Participating countries:** Austria, Germany (Operating Agent), the Netherlands and the USA

Most heat pumps are driven by electricity. However, the use of heat as the driving force of a heat pumping device used for heating or cooling buildings might lead to significant primary energy savings, especially if the heat source is solar or waste heat.

The objective of this Annex is therefore to reduce the environmental impact of heating and cooling by the use of thermally driven heat pumps. It will continue from the results from Annex 24, "*Absorption Machines for Heating and Cooling in Future Energy Systems*", and cooperate with Task 38, "*Solar Air-Conditioning and Refrigeration*" of the IEA Implementing Agreement Solar Heating and Cooling.

One of the main objectives is to quantify the economic, environmental and energy performance of integrated thermally driven heat pumps in cooling and heating systems in a range of climates, countries and applications. From this, those areas and applications with the greatest environmental benefit, the most favourable economics and the greatest market potential will be identified.

An Annex definition meeting in April 2007 collected interest and input for an Annex focusing on thermally driven heat pumps. After the start of the work in October 2007, a first draft of a work plan was written, proposing the following structure of the Annex:

**Task A** A market and state-of-the-art overview will investigate applications and markets for small and large thermally driven heat pump systems for domestic applications in each participating country.

**Task B** Performance evaluation - A methodology on how to determine and report the Coefficient of Performance (COP) of the machine itself, and of whole systems, will be developed. The method will be extended so that a comparison of the primary energy consumption for different configurations and a reference system will be possible.

**Task C** Apparatus technology - Components will be developed, taking into consideration experience of their components' long-term running performances. The resulting data, together with data on material properties, will be gathered and listed in a data base.

**Task D** System technology study includes designing the way the equipment is integrated into the system: for example, factors such as heat rejection, air/ground heat sources, efficient burners, control strategies and so on. Available software for different design stages will be surveyed, and increasing the availability of the equipment will be investigated. The system technology aspect will also include the integration of large devices into district heating networks and industrial processes.

**Task E** Implementation - Case studies will be carried out in order to monitor and describe the thermally driven systems in their applications and in their specific market segments. From this, good practice guidelines and calculation models based upon experience will be developed. In addition, advice on training, dissemination and policies will be reported.

At the next meeting, planned for April in Bolzano, Italy, the work plan will be finalized and the first results of national projects will be presented.

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Adsorption chiller - cooling with solar heat in summer and heating as a thermally driven heat pump in winter

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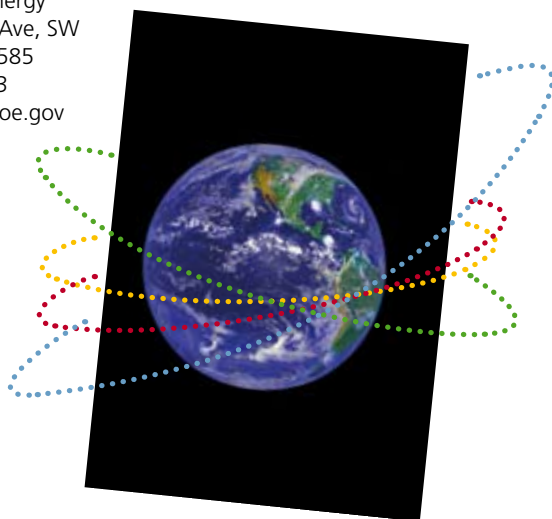
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# Summary of Annexes

Annex	Operating Agent	Participants	Completed
1. Common Study of Advanced Heat Pumps	Germany	Austria, Belgium, Canada, Denmark, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, United Kingdom, the United States	1980
2. Vertical Earth Heat Pump Systems	Sweden	Austria, Canada, Denmark, Sweden, the United States	1983
3. Heat Pump Systems Applied in Industry	Belgium	Austria, Belgium, Canada, Denmark, Finland, Germany, Italy, Japan, the Netherlands, Sweden	1984
4. Heat Pump Centre	Germany	Austria, Belgium, Canada, Finland, Germany, Italy, Japan, the Netherlands, Norway, Sweden, the United States	1990
5. Integration of Large Heat Pumps into District Heating and Large Housing Blocks	Sweden	Denmark, Germany, Italy, Sweden	1986
6. Study of Working Fluid Mixtures and High Temperature Working Fluids for Compressor Driven Systems	Sweden	Austria, Denmark, Finland, Germany, Japan, Sweden, the United States	1986
7. New Development of the Evaporator Part of Heat Pump Systems	Sweden	Canada, Denmark, Finland, Norway, Sweden	1989
8. Advanced in-ground Heat Exchange Technology for Heat Pump Systems	Canada	Canada, Germany, Switzerland, the United States	1992
9. High Temperature Industrial Heat Pumps	Belgium	Belgium, Germany, Finland, Japan, the Netherlands, Sweden, Switzerland, the United States	1990
10. Technical and Market Analysis of Advanced Heat Pumps	the United States	Sweden, the United States	1991
11. Stirling Engine Technology for Application in Buildings	the United States	Japan, Sweden, the United States	1989
12. Modelling Techniques for Simulation and Design of Compression Heat Pumps	the United States, Italy	Austria, Belgium, Germany, Italy, Japan, Switzerland, the United States	1992

# Summary of Annexes

Annex	Operating Agent	Participants	Completed
13. State and Transport Properties of High Temperature Working Fluids and Non-Azeotropic Mixtures	Sweden	Canada, Germany, Japan, Norway, Sweden, the United States	1992
14. Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps	Japan	Belgium, Denmark, Germany, Japan, Sweden, the United States	1991
15. Heat Pump Systems with Direct Expansion Ground Coils	Canada	Austria, Canada, Japan, the United States	1993
16. Heat Pump Centre	the Netherlands	Austria, Japan, the Netherlands, Norway, United Kingdom, the United States	2003
17. Experiences with New Refrigerants in Evaporators	Sweden	Canada, the Netherlands, Norway, Sweden, Switzerland	1993
18. Thermophysical Properties of Environmentally Acceptable Refrigerants	the United States	Austria, Canada, Germany, Japan, Sweden, United Kingdom, the United States	1999
19. Cancelled			
20. Working Fluid Safety	Belgium	Belgium, Japan, the Netherlands, Norway, Switzerland	1993
21. Global Environmental Benefits of Industrial Heat Pumps	the United States	Canada, France, Japan, the Netherlands, Norway, Sweden, United Kingdom, the United States	1996
22. Compression Systems with Natural Working Fluids	Norway	Canada, Denmark, Japan, the Netherlands, Norway, Switzerland, United Kingdom, the United States	1999
23. Heat Pump Systems for Single-Room Applications	Canada	Canada, France, Switzerland, Sweden, the United States	1999
24. Ab-Sorption Machines for Heating and Cooling in Future Energy Systems	Sweden	Canada, Italy, the Netherlands, Norway, Japan, Sweden, United Kingdom, the United States	2000
25. Year-Round Residential Space Conditioning Systems using Heat Pumps	France	France, the Netherlands, Sweden, the United States	2005

# Summary of Annexes

Annex	Operating Agent	Participants	Completed
26. Advanced Supermarket Refrigeration/Heat Recovery Systems	the United States	Canada, Denmark, Sweden, United Kingdom, the United States	2003
27. Selected Issues on CO <sub>2</sub> as Working Fluid in Compression Systems	Norway	Japan, Norway, Sweden, Switzerland, United Kingdom, the United States	2004
28. Test Procedure and Seasonal Performance Calculation of Residential Heat Pumps with Combined Space and Domestic Hot Water Heating	Switzerland	Austria, Canada, France, Germany, Japan, Norway, Sweden, Switzerland, United Kingdom, (partly), the United States	2005
29. Ground Source Heat Pumps – Overcoming Market and Technical Barriers	Austria	Austria, Canada, Japan, Norway, Sweden, the United States	Ongoing
30. Retrofit Heat Pumps for Buildings	Germany	France, Germany, the Netherlands	Ongoing
31. Advanced Modeling and Tools for Analysis of Energy use in Supermarkets	Sweden	Canada, Germany, Sweden, United Kingdom, the United States	Ongoing
32. Economical Heating and Cooling Systems for Low Energy Houses	Switzerland	Austria, Canada, Germany, Japan, the Netherlands, Norway, Sweden, Switzerland, the United States	Ongoing
33. Compact Heat Exchangers in Heat Pumping Equipment	United Kingdom	Japan, Sweden, United Kingdom, the United States	Ongoing
34. Thermally Driven Heat Pumps for Heating and Cooling	Germany	Austria, Germany, the Netherlands, the United States	Ongoing







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