

# Annual Report 2005



International Energy Agency



2005

## HEAT PUMP PROGRAMME

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

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2005

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*\* concluded in 2005*

The IEA Heat Pump Programme participating countries: Austria (AT), Canada (CA), France (FR), Germany (DE), Japan (JP), the Netherlands (NL), Norway (NO), Spain (ES), 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 the HPC.

# International Energy Agency

The International Energy Agency (IEA) acts as energy policy advisor for its 26 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 emergencies. 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 26 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 a contract – Implementing Agreement – and a system of standard rules and regulations, the IEA Framework, that would allow interested Member and non-Member governments to pool resources and research the 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 40 Implementing Agreements working in the areas of Fossil Fuels, Renewable Energies and Hydrogen, End-Use (Buildings, Industry and Transport), 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).

For more information visit  
[www.iea.org](http://www.iea.org)

## Heat Pump Programme Co-ordination

Heat Pump Centre  
SP Swedish National Testing  
and Research Institute  
PO Box 857  
SE-501 15 Borås  
Sweden  
Tel.: +46 33 16 55 19  
Fax: +46 33 13 19 79  
E-mail: [hpc@heatpumpcentre.org](mailto:hpc@heatpumpcentre.org)  
[www.heatpumpcentre.org](http://www.heatpumpcentre.org)



# IEA Heat Pump Programme

## Heat Pump Centre

The Heat Pump Centre is the central information activity of the Programme



The Centre links people and organisations worldwide in support of heat pumping technologies and communicates through National Teams in its member countries.

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 technology.

## Participating countries:

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

## Mission

The Programme develops and disseminates factual, balanced information to achieve environmental and energy efficiency benefits through deployment of appropriate high quality heat pump, refrigeration and air-conditioning technologies.

By serving the needs of policy makers, national and international energy and environmental agencies, utilities, manufacturers, designers and researchers the Programme covers all levels of expertise. It also works through national agencies to influence and encourage installers and end-users.

## Strategic Objectives

### *Environmental*

To quantify and publicise the environmental and energy efficiency benefits of heat pumps.

### *Market and Deployment*

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

### *Technology*

To maintain and develop international technical RD&D collaboration that furthers the environmental and market objectives.

### *Information Management*

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

## Activities

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

In 2005 there were two meetings of the Executive Committee:

- June 4–5 in Las Vegas, USA
- November 8–9 in Vienna, Austria



Mr Yoshii and Mr Ryan, ExCo-meeting, Vienna

# Chairman's Statement 2005

It is a pleasure for me to write the Chairman's Statement for this IEA Heat Pump Programme (HPP) Annual Report. This has been a very intense and fruitful year for the HPP, highlighted by the International Heat Pump Conference in Las Vegas in the United States, and the recognition of the excellent technical papers and conference presentations. This event also saw the first presentation of the Peter von Rittinger award, for outstanding contributions to the advancement of international collaboration in research, policy development and applications for energy-efficient heat pumping technologies. Five well-deserved medals were awarded to individuals and teams.

Three new annexes have been launched in 2005, bringing the number of on-going annexes to four. Many new ideas are also being considered. Two strategic documents have been prepared, highlighting the potential impacts of heat pumping technology in terms of greenhouse gas emission reductions and energy savings. The two documents formed the basis of the HPP's official response to the IEA Office of Energy Technology and R&D, and to the Committee on Energy Research and Technology, welcoming and supporting the IEA initiative to deliver the IEA G8 Plan of Work developed after the Gleneagles summit.

The IEA HPP participated at COP-11 to the UNFCCC<sup>1)</sup>, which took place in the fall in Montreal. Professor Halozan, the Austrian delegate at the HPP ExCo, was invited as a keynote speaker at a parallel event on ground-source heat pumps, presenting the HPP and Annex 29.

Two workshops were held in conjunction with the conference, presenting and discussing ongoing annexes. In addition, a National Teams meeting identified topics of mutual interest. A workshop was also organized in Vienna in conjunction with the ExCo meeting. It provided the opportunity to learn about the Austrian National Heat Pump Programme and present the HPP to Austrian representatives. Four newsletters have been published during the year. The HPP has also continued to reach out and coordinate activities with relevant organizations: IEA BCG<sup>2)</sup>, EHPA<sup>3)</sup>, and IIR<sup>4)</sup>, in order to encourage activities and information dissemination. Several countries and companies have expressed their interest in joining the HPP. We hope to involve them as new members in our future activities.

This level of activity reflects the importance of heat pumping technologies in the current energy, environmental and economic contexts. Heat pumping is certainly one of the key technologies for addressing energy conservation and CO<sub>2</sub> emission reduction globally. The future activities of the HPP will be orientated to meet these objectives.

Before closing 2005, special thanks go to the members of the International Organizing Committee and the National Organizing Committee of the Las Vegas Conference, and to their chairmen Mr Peter Rohlin and Mr John Tomlinson for their hard works in organizing such a prestigious international conference. Thanks, too, to the Heat Pump Centre for its excellent work during this year. I would also like to acknowledge Mr Roger Hitchin for his continuous support to the HPP as vice-chairman, and for his engagement in the development of the two strategic papers.



*Sophie Hosatte*  
ExCo Chairman



<sup>1)</sup>The 11<sup>th</sup> meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change

<sup>2)</sup>The Building Coordination Group

<sup>3)</sup>The European Heat Pump Association

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



**Las Vegas, Nevada**  
**May 30 – June 2, 2005**

# The 8<sup>th</sup> International Energy Agency Heat Pump Conference

**Global Advances in Heat Pump Technology, Applications, and Markets**

The 2005 conference was the eighth in a series of triennial conferences sponsored by the International Energy Agency (IEA) Heat Pump Program (HPP), and it attracted 225 attendees from more than 20 countries. Experts from research institutions, government, energy companies and manufacturers provided 128 oral and poster presentations at the conference, which also included technical tours to Rocky Research, a heat pump research laboratory, and to Lake Las Vegas, where water-source heat pumps serve the homes and resort buildings. The conference is one of the primary activities of the HPP and is recognized as one of the most important international conferences related to air conditioning, heat pumps and related refrigeration technologies.

The U.S. National Team served as the host committee for the conference, under the leadership of John Ryan, the U.S. delegate to the HPP Executive Committee and John Tomlinson, Chairman of the host committee.

The Plenary Session included a presentation by Jim Gibson, Mayor of Henderson, Nevada, Las Vegas' fastest growing suburb, who noted the extraordinary population growth in the southwestern U.S. and the excellent opportunity for heat pumps afforded by the climate in this region. Antonio Pflüger, Head of the IEA Energy Technology Collaboration Division, commented on the importance of the IEA agreements (there are 26 IEA member countries) to public energy policy-makers. Energy security, environmental protection and economic growth are the guiding principles behind IEA activities. He noted that the IEA forecasts global primary energy demand to increase by 60% over current levels by 2030. Renewable energy sources and conservation will be key elements in these policies. Jeff Littleton, Executive Vice President of ASHRAE, noted that ASHRAE currently has 53,000 members with 11,000 residing outside the U.S. He noted ASHRAE's initiative to publish several "30% Energy Savings Guides" for various building classes and plans for Guides to achieve higher levels of savings.

In the session "Heat Pumps – status and trends" reports by Monica Axell on Europe, Mark Menzer on North America, and by Takeshi Yoshii on the Asia/Pacific region highlighted market expansion, the emergence of new technologies and new policy initiatives as characterizing today's environment. There is significant heat pump market growth in all of these regions, with the greatest growth occurring in Asia.

Professor Hermann Halozan of the Technical University of Graz, Austria, in a keynote address, emphasized that heat pumps have a high potential for GHG emission reduction, as one of the largest contributions to CO<sub>2</sub> reduction that a single technology available on the market can offer. Calculations showed the importance of energy efficiency, refrigerant charge size and refrigerant emissions in reducing the climate change impact of supermarket refrigeration systems, with potential for reducing climate change impact by over 60%. Donald Bivens (U.S.) reported on the development of the IPCC/TEAP report "Safeguarding the Ozone Layer and the Global Climate System", which showed that measures must be taken to reduce losses of refrigerant from supermarket systems and in designing systems to achieve improved leak detection and lower charge levels.

The session on heat pump applications concentrated on the benefits of heat pumps, market situations and successful applications. Gerald Groff (U.S.) noted that heat pumps have been used in industry and for space-conditioning systems in buildings since the later part of the 19th century, based on need for energy-efficient systems and quality indoor environments. Today, more than 130 million heat pumps are installed worldwide, with more than 15 million new heat pump systems being installed each year.



*The Caesar's Palace Hotel in Las Vegas,  
the conference venue*



In the keynote speech in the session on Ground Source Heat Pumps, Professor James E. Bose (U.S.) discussed the increased benefits of networking by combining or adding thermal loads for the purpose of increasing overall system energy efficiency. Ground- and water-source heat pump systems are gaining in popularity throughout the world.

Increased interest in combined heat, power and cooling systems prompted presentation of this topic in a separate session, with papers from China, Japan, Australia and the U.S. One presentation in this session described development of a new small-scale two-stage absorption chiller/heater/hot-water system.

The sessions on technology advances provided an overview of the technical evolution of heat pumping technologies, which started with custom-built systems and led to mass production. Professor Clark Bullard (U.S.) concluded his keynote presentation with his visions of the future. Professor Emeritus Eric Granryd (Sweden) discussed various challenges in heat pumping technologies. He pointed to the many different types of applications, and to interest in alternative cycles. As building design becomes more advanced, demand for heat will be reduced and cooling and tap water heating will become more important. Many interesting papers in this session dealt with topics such as humidity control with high efficiency air conditioning systems, developments in components and systems incorporating CO<sub>2</sub> as the refrigerant, advanced heat exchanger designs, designs for low energy houses, etc.

A separate conference session was included to present actual experiences with alternate refrigerants. Several presentations dealt with CO<sub>2</sub>, with refrigerant blends, and with other refrigerants for both standard and special applications.

In conclusion, the 8th IEA Heat Pump Conference attendees were very appreciative of the high quality of the papers and presentations, and for the opportunity to meet colleagues with common interests from all over the world. The facilities at Caesars Palace Hotel, the social program and conference organization drew many compliments and, overall, the conference was judged to be one of the best to date. The U.S. host committee is grateful to the numerous country and industrial sponsors who provided financial support for the conference. Additional information on the conference and ordering of proceedings can be obtained at the Heat Pump Centre web site, [www.heatpumpcentre.org](http://www.heatpumpcentre.org).



*Lake Las Vegas with water-source heat pumps.*



### **Peter Ritter von Rittinger international heat pump award**

During the conference banquet, the organizing committee announced the winners of the first time Peter Ritter von Rittinger award. The award recognizes outstanding contributions to the advancement of international collaboration in research, policy development, market development and applications for energy-efficient heat pumping technologies. The awardees were selected from nominations submitted by the IEA member countries and interested individuals.

The awardees were:

- Dr. Bernard Spinner, France
- Dr. Katsuhiko Narita, Japan
- Mr. Nance C. Lovvorn, USA
- Mr. Wayne R. Reedy, USA
- Research Team GEMINI – Center Applied Refrigeration, Norway

The award is named for Peter Ritter von Rittinger, an Austrian engineer who designed and installed the first known heat pump, in 1855, for a salt works in the village of Ebensee in Upper Austria.



## Newsletters 2005

Four newsletters were published in 2005, and are available on the Heat Pump Centre web site.

The topics of the Newsletters are:

1. Systems and Controls
2. Zero Leakage, Minimum Charge
3. The 8th IEA Heat Pump Conference
4. Ground Source Heat Pump Systems



Workshop in Las Vegas.



Workshop in Vienna.

# Highlights of 2005

## National Teams Meeting in Las Vegas

A National Teams Meeting was held in conjunction with the Heat Pump Conference in Las Vegas on June 3. The meeting, which was well attended, focused on new research areas and new joint research projects – Annexes. The following project ideas were discussed:

1. Field-proven best practice of combined heat pump systems
2. Advanced modelling and tools for analysis of energy use in supermarket systems
3. Air conditioning systems for large commercial buildings
4. Heat pumps in buildings without traditional heating and cooling systems
5. Heat pumps in low and ultra low-energy houses
6. Economical heating and cooling systems for low-energy houses
7. Compact heat exchangers

It was suggested that proposals 4, 5 and 6 should be merged into one. More information on the projects and contact persons can be found on the Heat Pump Centre web site, [www.heatpumpcentre.org](http://www.heatpumpcentre.org).

## Workshops on Annex 28 and 29 held in Las Vegas

Two well-attended workshops were arranged in connection with the Heat Pump Conference in Las Vegas on May 30. The purpose was to disseminate information about ongoing activities within the HPP. Half a day was assigned to HPP Annex 28, *Test procedure and seasonal performance calculation for residential heat pumps with combined space and domestic hot water heating*. The final results of this annex were presented. More information can be found on the annex web site [www.annex28.net](http://www.annex28.net).

The afternoon was devoted to HPP Annex 29, *Ground-Source Heat Pumps – Overcoming Market and Technical Barriers*. The first results of the annex were presented by the participating countries.

## Workshop held in Vienna

In connection with the Executive Committee Meeting in Vienna, a workshop was arranged on November 7 by Arsenal Research in Vienna and Austrian IEA Heat Pump Programme delegate Professor Hermann Halozan from Graz University of Technology. The workshop programme included presentations of Austrian research and the market for heat pumping technology. The presentations held at the workshop can be found on the Heat Pump Centre web site, [www.heatpumpcentre.org](http://www.heatpumpcentre.org).

## Three new annexes

The following HPP annexes were formed in 2005:

**Annex 30:** Retrofit Heat Pumps for Buildings

**Annex 31:** Advanced Modeling and Tools for Analysis of Energy Use in Supermarkets

**Annex 32:** Economical Heating and Cooling Systems for Low-Energy Houses

# Programme Achievements 2005

## The Heat Pump Centre

**Participating countries:** Austria, Canada, France, Germany, Japan, the Netherlands, Norway, Spain, Sweden (Operating Agent), Switzerland, United Kingdom and the United States.

### Activities

The Heat Pump Centre is the central activity of the Heat Pump Programme. The aim is to disseminate factual and balanced information on heat pumping technology and to promote the activities of the IEA Heat Pump Programme. In addition, the Heat Pump Centre provides support to Operating Agents of annexes and to the Executive Committee. In 2005, support has also been provided to the Heat Pump Conference in Las Vegas. In addition, a National Teams meeting was arranged.

One of the main activities is publication of the Heat Pump Centre Newsletter. Each newsletter covers a particular topic, and contains articles, news and events, together with a contribution from a guest columnist. Four issues were published in 2005, available free of charge to HPP member countries from the HPC web site. 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 web site. The number of subscribers to the e-Newsletter increased by over 70 % in 2005.

Another important activity is the web site, which is continuously updated with news, events and contact information. Descriptions of ongoing and completed HPP annexes are also available on the web site as well as HPP publications, which are accessible via a data base. New features in 2005 included links to standardisation organisations, descriptions of project proposals, searchable conference proceedings papers in the publication data base, National Team pages and workshop pages. The traffic on the web site has increased steadily throughout 2004 and 2005.

The Heat Pump Centre also plays an active part in generating new activities within HPP. In addition to publishing descriptions of project proposals on the web site, HPC has also compiled a report with information on research and development and market development in member countries. The report is available to the National Teams in the member countries.

## International collaboration

The Programme has collaboration agreements with the International Institute of Refrigeration (IIR) and the European Heat Pump Association (EHPA). There are also close links with the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and the IEA Building Coordination Group (BCG).

## New publications in 2005

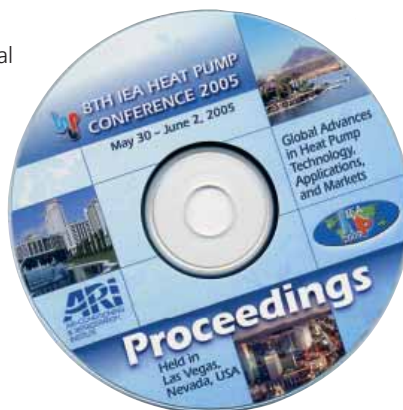
- Conference Proceedings of the 8th IEA Heat Pump Conference (CD ROM)
- Final report of Annex 25, Year-round residential space conditioning systems using heat pumps (CD ROM)
- Report HPC-AR12 "Designing heat pump systems: Users' experience with software, guides and handbooks"

## Contact

Dr Monica Axell  
Heat Pump Centre  
SP  
Box 857  
SE-50115 Borås  
Sweden  
Tel.: +46 33 16 55 19  
E-mail: [hpc@heatpumpcentre.org](mailto:hpc@heatpumpcentre.org)  
[www.heatpumpcentre.org](http://www.heatpumpcentre.org)



Publications can be ordered from the Heat Pump Centre as well as a free subscription to the e-Newsletter.



## Annex 28

### Test Procedure and Seasonal Performance Calculation for Residential Heat Pumps with Combined Space and Domestic Hot Water Production

#### Contact

Mr Carsten Wemhöner  
Institute of Energy in Building  
University of Applied Sciences  
North-Western Switzerland  
St.-Jakobs-Str. 84  
CH – 4132 Muttenz  
Switzerland  
Tel: +41-61-467 4573  
Fax: +41-61-467 4543  
E-mail: carsten.wemhoener@fhnw.ch



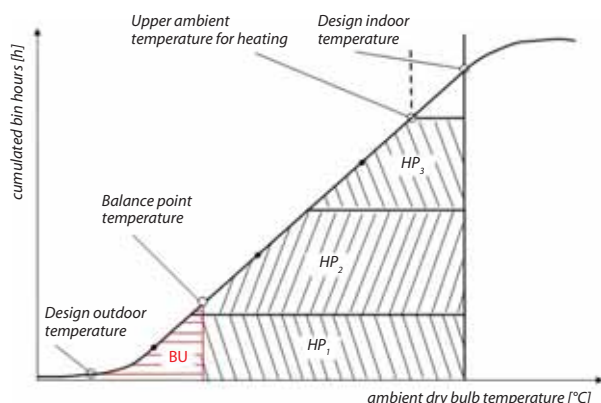
**Participating countries:** Austria, Canada, France, Germany, Japan, Norway, Sweden, Switzerland (Operating Agent) and the USA.

With the reduction in energy consumption for space heating as a result of better building insulation, the energy share required for domestic hot water production is continuously increasing. In terms of overall performance, combined production of space heating and domestic hot water (DHW) is therefore becoming more interesting. However, existing test procedures and calculation methods do not cover combined operation. Annex 28 has investigated the testing and calculation of the most common combined operating heat pump systems with the two principal objectives of:

- establishing a test procedure which provides the necessary data for calculation of the overall Seasonal Performance Factor (SPF) of combined operating heat pump systems
- working out an easy-to-use calculation method for SPF of integrated heat pump systems.

The main objective in 2005 was to complete the work of Annex 28 by integrating the results of the national projects in two joint proposals for standards: one for the test procedure, and one for the calculation method. These two proposals form the first part of the final report, while the second part contains the project and technical backgrounds.

The test procedure is based on a black box method, i.e. only the values at the system boundary are evaluated. Testing is extended to a combined test, with the domestic hot water testing being carried out while the heating system is in operation.



*Principle of the bin method (space heating mode in parallel operation with back-up).*

Calculation is carried out based on a temperature class approach, known as a bin method, and shown in the figure. The method has been extended to cover the three operation modes of heating only, DHW only and combined operation.

#### Results dissemination:

- Workshop in connection with the Heat Pump Conference, Las Vegas, May 2005.
  - For information and presentations, visit [www.annex28.net](http://www.annex28.net).
  - An article on the Workshop and Annex 28 was published in issue 3/2005 of the HPC Newsletter.
  - The final report was accepted in November 2005 and Annex 28 was concluded.
- The final report is available at the Heat Pump Centre.

The proposal for the Annex 28 calculation method has already been integrated in draft standard prEN 15316-4-2 of the European standardisation organisation CEN in the framework of the European Directive on the Energy Performance of Buildings (EPBD). The draft standard is currently out on a six-month circulation for comments. Results from the test procedure will be discussed in a CEN DHW working group, which will start work soon.

## Annex 29

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

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

Annex 29 started officially in March 2004, and will end in September 2006. It will investigate the present status of ground-source heat pump systems, which varies widely all over the world, and will identify 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.

Ground-source heat pumps have become increasingly important with respect to energy efficiency and the reduction of greenhouse gas emissions. Additionally, demand for cooling and air conditioning is increasing significantly, especially in the developing countries, as well as in Europe.

The main elements of the annex are:

- State of the art and market analysis
- Matrix of ground source systems under different climate and site conditions
- Improvement of components and systems
- Overcoming legal barriers
- Increasing acceptance
- Overcoming economic barriers by promotion, subsidy and contracting models.

The state of the art and market analysis surveys are almost finished. Most installations are in the form of small systems. In Europe, they are mainly heating-only systems, while those in Japan and North America are used for both heating and cooling.

In large systems, the ground is generally used as a store. Great efforts are made to reduce energy demand by direct cooling and by transferring excess heat from parts of the building with a cooling demand to parts with a heating demand. One problem of such systems is that heat delivery to, and heat extraction from, the store has to be balanced, as otherwise the annual average temperature of the store will fall or rise and change the operating conditions.

Systems have to be sized in such a way that the average ground coil temperature can be kept stable over the years. Additionally, the temperature drop/temperature increase has to be kept at an acceptable level. Consequently, selection and sizing of a system have to be carried out very carefully.

The products of Annex 29 will be a web site, a final report and, more importantly, national dissemination, workshops, presentations at conferences and seminars at national and international levels.

One workshop has already been held in connection with the Heat Pump Conference in Las Vegas in May 2005. The annex has also been presented on an international level as a side event of the COP-11 meeting and on the occasion of a Quebec Hydro meeting in Montreal in December 2005.

#### Contact

Prof Hermann Halozan  
Institute of Thermal Engineering  
Graz University of Technology  
Inffeldgasse 25 B  
A-8010 Graz  
Austria  
Tel: +43-316 873 7303  
Fax: +43-316 873 7303  
E-mail: halozan@tugraz.at



## Annex 30

### Retrofit Heat Pumps for Buildings

#### Contact

Dipl.-Ing. Carmen Stadtländer  
IZW e.V.  
Welfengarten 1a  
D-30167 Hannover  
Germany  
Tel.: +49-511-16 74 75 12  
Fax: +49-511-16 74 75 25  
E-mail: [email@izw-online.de](mailto:email@izw-online.de)

**Participating countries:** Germany (Operating Agent), France, the Netherlands, Sweden (represented by a German/Swedish Company).

The market potential of heat pumps for retrofitting existing buildings is much greater than for new buildings. However, the heat pump market for existing buildings today is small compared with the presently dominating market for new buildings. This annex should therefore help to overcome technical and market barriers in this interesting market sector.

The objective of the annex is 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, bearing in mind that heat pumps can significantly reduce fossil fuel energy consumption and related greenhouse gas emissions.

The annex started in April 2005, and will run for a total period of 24 months. The programme is subdivided into four tasks:

- Task 1** State of the art, market analysis
- Task 2** Matrix of heat pumps
- Task 3** Overcoming economic, environmental and legal barriers
- Task 4** Improvement of components and systems

The programme proposal was discussed, modified and work distributed between the participants at a first annex meeting in May 2005 in Bonn, Germany.

The work started with Task 1 "State of the art, market analysis". In order to cover all aspects, the participants are developing a matrix of information covering not only the current building structure but also heating and cooling systems' design and preferences/suitabilities in different regions, depending on climatic and cultural aspects, type of power generation, legal aspects, support programmes etc., as well as types of heating systems, centralized or decentralized, water or air heat distribution systems, domestic hot water production etc.

The second meeting took place in December 2005 in Bochum-Wattenscheid, Germany, and was attended by nine representatives from all the participating countries. The main task of the meeting was a discussion of the status, content and presentation of the results of Task 1, "State of the art, market analysis", as well as preparation of Task 2, "Matrix of heat pumps".

The common information source for participants is a password-protected web site for the annex, accessible via the IZW web site: [www.izw-online.de](http://www.izw-online.de).



## Annex 31

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

**Participating countries:** Sweden (Operating Agent), Canada and Germany.

This new annex is building on experience and findings from Annex 26, Advanced Supermarket Refrigeration/Heat Recovery Systems.

The kick-off meeting was held at the 2006 ASHRAE Winter meeting in Chicago. Participating countries so far are Sweden, Canada and Germany, but there is strong interest from a number of other countries to join the annex.

Supermarkets are the most energy-intensive buildings in the commercial sector: it has been estimated that, in industrialized countries, 3–5 % of the total use of electricity stems from supermarkets. In addition, it is estimated that annual refrigerant losses are as high as 15–30 % of the total charge, thus making supermarkets the second largest emission source after mobile air conditioning. The supermarket sector has therefore a significant role to play, not only from the point of view of the energy consumed but also from the point of view of the impact of refrigerant leakage.

The overall objective of the proposed annex is to provide new knowledge, methods and tools for enhanced energy efficiency, and thus reduced environmental impact from supermarkets.

The objective will be approached by development of reasonably accurate simulation tools that can be used to assist in the analysis of energy performance, and for the development of energy-efficient strategies for supermarkets. Such tools should facilitate a comparison of system solutions to minimize global energy consumption, environmental impact and life cycle costs of supermarkets, within constraints such as required quality of products, maximized comfort of the occupants and so on.

The aim of the annex is to increase the level of understanding of the interaction between the refrigeration system, indoor climate, the HVAC system and the building envelope.

The annex aims also at development of indices for energy use and environmental impact for different countries and systems. Methods for comparisons between different regions and climates will be developed.

It should be noted that methods and algorithms developed in the annex could also evolve into tools for continuous optimization of the whole building, continuous commissioning and automated diagnostics of the different systems of the building, i.e. fault detection analysis. A few examples could be reported on and discussed in the annex, but these tasks could also be developed and expanded in future annexes.

#### Contact

Dr Per G. Lundqvist and  
Dr Jaime Arias  
The Royal Institute of Technology  
Department of Energy Technology  
Div. of Applied Thermodynamics  
and Refrigeration  
SE-100 44 Stockholm  
Sweden  
Tel.: +46-8-790-7452  
E-mail: [perlundq@energy.kth.se](mailto:perlundq@energy.kth.se)  
[www.energy.kth.se](http://www.energy.kth.se)



## Annex 32

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

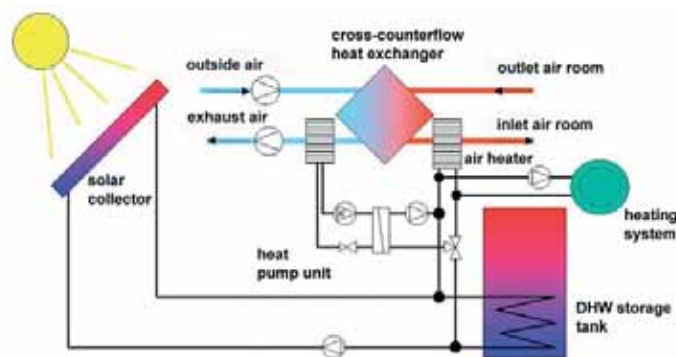
#### Contact

Mr Carsten Wemhöner  
Institute of Energy in Building  
University of Applied Sciences  
North-Western Switzerland  
St.-Jakobs-Str. 84  
CH – 4132 Muttenz  
Switzerland  
Tel: +41-61-467 4573  
Fax: +41-61-467 4543  
E-mail: carsten.wemhoener@fhnw.ch



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

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



*Example of an integrated heat pump system for low-energy houses.*

The aim of the work of Annex 32 is to investigate different system configurations of integrated heat pump systems, and their associated energy source and distribution systems, for application in low-energy and ultra-low-energy houses.

The principal objectives of Annex 32 are:

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

The annex has been structured in four tasks:

- Task 1** System investigation
- Task 2** Assessment, calculation and comparison of system solutions
- Task 3** Field testing of systems (in parallel with Task 2)
- Task 4** Design guidelines for systems and their control systems

Since Annex 32 was approved at the November 2005 meeting of the HPP ExCo, only preparatory activities have taken place in 2005. The project will start in January 2006, and is scheduled to run for three years. So far, five countries are participating, but other countries may join later. The kick-off meeting will be held in April 2006, with an introduction of the participants, general project planning and coordination of work. Until an Annex 32 web site is set up, information on the project can be found on the Heat Pump Centre web site, in the 'Projects' category.

# 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, the United States                                                                             | 1986      |
| 7. New Development of the Evaporator Part of Heat Pump Systems                                       | Sweden                   | Canada, Denmark, Finland, Norway,                                                                                                        | 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                                                                                           | Ongoing   |
| 32. Economical Heating and Cooling Systems for Low Energy Houses                                                                     | Switzerland       | Canada, Germany, Sweden, Switzerland, the United States                                                           | Ongoing   |





# Programme Contacts

## – Executive Committee Delegates

### AUSTRIA

Prof Hermann Halozan  
Technical University of Graz  
Institute of Thermal Engineering  
Inffeldgasse 25/B,  
8010 Graz  
Tel.: +43 316 8737303  
halozan@tugraz.at

### CANADA

Dr Sophie Hosatte  
Natural Resources Canada  
CETC – Varennes  
1615 Bd Lionel Boulet  
P.O. Box 4800  
Varennes  
J3X 1S6 Québec  
Tel.: +1 450 652 5331  
sophie.hosatte@nrcan.gc.ca

### FRANCE

Mr Etienne Merlin  
ADEME/DIAE  
27 rue Louis Vicat  
75737 Paris Cedex 15  
Tel.: +33 1 47 65 21 01  
Etienne.Merlin@ademe.fr

### GERMANY

Dr Claus Börner  
Division ERG  
Project Management Organisation Jülich  
(PTJ)  
Forschungszentrum Jülich GmbH  
52425 Jülich  
Tel.: +49 2461 613816  
c.boerner@fz-juelich.de

Dr Rainer Jakobs (Alternate)  
IZW e.V.  
Kreuzfeldstr. 10a  
D-64747 Breuberg  
Tel.: +49 6163 5717  
Dr.Rainer.Jakobs@T-Online.de

### JAPAN

Mr Shunichi Tokishita  
New Energy and Industrial Technology  
Development Organization (NEDO)  
Energy Conservation Technology  
Development Dept.  
Muza Kawasaki Central Tower Bldg., 18F  
1310 Ohmiya-cho, Saiwai-ku  
Kawasaki City, Kanagawa 212-8554  
Tel.: +81 44 520 5280  
tokishitasni@nedo.go.jp

Mr Takeshi Yoshii (Alternate)  
Heat Pump & Thermal Storage  
Technology Center of Japan (HPTCJ)  
1-18-5, Nihonbashi, Kakigara-cho  
Chuo-ku, Tokyo 103-0014  
Tel.: +81 3 5643 2404  
yoshii@hptcj.or.jp

### THE NETHERLANDS

Mr Onno Kleefkens  
SenterNovem  
P.O. Box 8242  
3503 RE Utrecht  
Tel. +31 30 2393 449  
o.kleefkens@senternovem.nl

### NORWAY

Mrs Trude Tokle  
Enova SF  
Abelsgate 5  
7030 Trondheim  
Tel.: +47 73 19 04 54  
Trude.Tokle@enova.no

Dr Rune Aarlien (Alternate)  
SINTEF Energy Research  
Dept. Energy Processes  
7465 Trondheim  
Tel.: +47 73 59 39 29  
rune.aarlien@sintef.no

## SWEDEN

Dr Maria Hall  
The Swedish Energy Agency  
Department for Energy Technology  
PO Box 310  
631 04 Eskilstuna  
Tel.: +46 16 544 2174  
maria.hall@stem.se

Dr Björn Sellberg (Alternate)  
FORMAS  
PO Box 1206  
111 82 Stockholm  
Tel.: +46 8 775 4028  
bjorn.sellberg@formas.se

## SWITZERLAND

Mr Fabrice Rognon  
Section Renewable Energy  
Swiss Federal Office of Energy  
3003 Bern  
Tel.: +41-31-32-24756  
fabrice.rognon@bfe.admin.ch

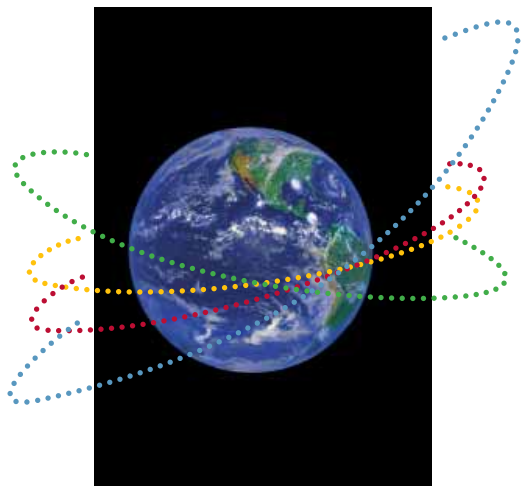
Dr Thomas Kopp (Alternate)  
Hochschule Rapperswil  
On behalf of the  
Swiss Federal Office of Energy  
Energy Renewable Division  
Oberseestrasse 10  
8640 Rapperswil  
Tel.: +41 55 222 4923  
tkopp@hsr.ch

## UNITED KINGDOM

Mr Roger Hitchin  
BRE, Energy Division  
BRE, Garston, Watford, WD25 9XX  
Tel.: +44 1 923 664773  
Hitchinr@bre.co.uk

## THE UNITED STATES

Mr John D. Ryan  
US Dep. Of Energy, EE-2J  
1000 Independence Avenue, SW  
Washington DC 20585  
Tel.: +1 202 5868823  
john.d.ryan@ee.doe.gov



**IEA Heat Pump Programme**  
**Heat Pump Centre**

c/o SP Swedish National Testing and Research Institute  
Box 857, SE-501 15 BORÅS, Sweden

Telephone: +46 33 16 50 00, Telefax: + 46 33 13 19 79

E-mail: [hpc@heatpumpcentre.org](mailto:hpc@heatpumpcentre.org), Internet: [www.heatpumpcentre.org](http://www.heatpumpcentre.org)

