Annual Report 2010

2010

HEAT PUMP PROGRAMME

IEA
OECD

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

International Energy Agency

iea
Energy Technology Network

Contents

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

Pictures front cover:
The Helsinki workshop, Roof integrated flat plate collectors on house in Germany (source: Velux/ESTIF),
Air conditioner (source: iStockphoto), Dr Monica Axell at the Vienna workshop.

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The IEA Heat Pump Programme participating countries are: Austria (AT), Canada (CA), Finland (FI), France (FR), Germany (DE), Italy (IT), Japan (JP), the Netherlands (NL), Norway (NO), South Korea (KR), 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 Heat Pump Centre.

International Energy Agency

www.iea.org

The International Energy Agency (IEA) acts as energy policy advisor for its 28 member countries as they work for reliable, affordable, clean energy for their citizens. Founded during the oil crisis of 1973–74, the IEA initially coordinated measures addressing oil supply shortages. Since then, evolving energy markets have brought new challenges and the IEA's programmes have been expanded to ensure energy security, encourage economic growth and protect the environment. The IEA's portfolio now focuses equally strongly on climate change policies, market reform, energy technology collaboration and outreach to the rest of the world. Scenario analysis and roadmapping play a prominent part in the work of the IEA's teams of close to 200 staff. Energy experts and statisticians from member countries conduct a broad programme of energy research, data compilation, publishing and public dissemination of the latest energy policy analysis and good-practice recommendations. Following up on work for the G8, initiated in 2005, the IEA was entrusted at the 2008 G8 Hokkaido Summit in Hokkaido, Japan, with a second set of tasks for leaders of the world's major industrialised nations. These include:

- A commitment by G8 leaders to update their national commitments on energy security activities and provide them to the IEA for evaluation.
- A joint effort by the IEA and the International Monetary Fund (IMF) to carry out further analysis of real and financial factors behind the recent surge in oil and commodity prices, their volatility, and the effects on the global economy.
- A continuation of the IEA to enhance its work on voluntary sectoral indicators through improved data collection, complemented by business initiatives.
- A continuation by the IEA to further implement its 25 recommendations on energy efficiency.
- The assistance from the IEA, together with member countries, in the establishment of the International Partnership for Energy Efficiency Cooperation (IPEEC) to focus on joint efforts to accelerate the adoption of sound energy efficiency improvement practices.
- The establishment of an international initiative with the support of the IEA to develop roadmaps for innovative technologies and cooperation on existing and new partnerships, including carbon capture and storage and advanced technologies.
- A strong endorsement of the IEA's position for the launching of 20 large-scale CCS demonstration projects globally by 2010, taking into account various national circumstances, with a view to beginning broad deployment of CCS by 2020.

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

For more than 35 years, IEA technology collaboration has been crucial in advancing more efficient, cleaner energy technologies. The collaborative vehicles are IEA energy technology R&D Programmes, or Implementing Agreements. These allow interested member and non-member governments to pool resources for R&D and deployment focusing on particular technologies. Operating within the standard rules and regulations of the "IEA Framework", these Implementing Agreement Programmes currently number 42. They cover the areas of: End-Use (Buildings, Industry and Transport); Fossil Fuels, Renewable Energies and Hydrogen; Fusion and Cross-Cutting Activities. The IEA Committee on Energy Research and Technology (CERT) and its Working Parties provide guidance and review the effectiveness, achievements and strategies of each Implementing Agreement.

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, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, South Korea, 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
Heat Pump Centre
SP Technical Research Institute of Sweden
Box 857
SE-501 15 Borås
Sweden
Tel. +46 10 516 55 19
Fax: +46 33 13 19 79
hpc@heatpumpcentre.org

www.heatpumpcentre.org

Chairman's Statement 2010

[1)] For complete definition turn to the *DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC* (published in the Official Journal of the European Union on 5.6.2009)

It is once again my great pleasure to write the Chairman's Statement for the IEA Heat Pump Programme Annual Report. Worldwide pressure to reduce our environmental footprint and energy consumption makes heat pumps a technology of choice for heating, cooling and refrigeration in all application sectors. This is very clear from the level of activity around heat pumps in the IEA Heat Pump Programme, and also in many countries and organizations. Recently, the European Union recognised heat pumps as a renewable energy technology using air, water or ground as a renewable energy source.[1]

Much has happened in 2010. The United Kingdom joined HPP again. On behalf of the Executive Committee, it is my pleasure to welcome them. Their participation will help us to increase the Programme's development and influence. Two HPP Executive Committee meetings were held in 2010; one in Helsinki in May, and one in Tokyo in November. In conjunction with these meetings, workshops were organised by these countries to present their national heat pump activities and to obtain more information on HPP. A working meeting and a National Teams meeting were held in Borås, Sweden, in September, to discuss future activities and proposals for new collaborative projects (Annexes). HPP was also present at international events such as the IEA Building Coordination Group meeting in Paris in January and the European Heat Pump Summit in Nürnberg, Germany, in October, which was an opportunity to promote the Programme. HPP also holds regular meetings with the European Heat Pump Association.

Four new projects were approved by the Executive Committee this year on the following topics: Quality Installation and maintenance (Annex 36); Demonstration of field measurements on heat pump systems in buildings – Good examples with modern technology (Annex 37); Systems using solar thermal energy in combination with heat pumps (Annex 38); A common method for testing and rating of residential HP and AC annual/seasonal performance (Annex 39). The Heat Pump Centre website was upgraded during the year to improve its user-friendliness. It's worth visiting at regular intervals to keep up to date with activities and thus remain at the forefront of heat pump development. During 2010, we continued working closely with the IEA and provided it with updated information on heat pumps that will be incorporated in the road map on Energy Efficient and Low Carbon Buildings: Heating and Cooling, to be released by IEA in 2011.

For the IEA Heat Pump Programme, 2011 will be marked by the 10th International Heat Pump Conference that will be held in Tokyo, on May 16 to 19, under the theme "The Solution for a Low-Carbon World". It is a unique forum for discussing the most recent updates and sharing information on the technology. I look forward to meeting you there!

Sophie Hosatte
ExCo Chairman

Preparation for the next IEA Heat Pump Conference

10th IEA Heat Pump Conference 2011
"Heat Pumps – The Solution for a Low Carbon World"

May 16-19, 2011 in Tokyo, Japan

The planning and preparation of the conference started in the spring of 2009 with the establishment of an International Organizing Committee (IOC), under the chairmanship of Prof Thomas Kopp, Switzerland, and a National Organizing Committee (NOC), under the chairmanship of
Mr Momoki Katakura, Japan. The IOC took responsibility for the scientific program, and the NOC for the logistic organisation in Tokyo.

The first announcement was launched in December 2009, with a Call for Papers, and the NOC received more than 300 abstracts as a result of attractive promotion by the IOC, the NOC and regional coordinators – Mr Gerald Groff for North and South America, Dr Monica Axell for Europe and Africa, and Mr Makoto Tono for Asia and Oceania.

One of the most important decisions of the NOC has been to determine the venue of the conference. After intensive evaluations in the NOC, the decision was made for the conference venue of "Chinzan-so", located in the heart of Tokyo.

Online registration opened for participants, students and accompanying persons on 1st Oct 2010. The second announcement, Registration, with a conference program, was made in December 2010 and distributed all over the world.

At the time of publishing this report the status of the conference was as follows:

"The organizing committees of the 10th IEA Heat Pump Conference 2011 regret to announce that we have decided not to hold the actual conference in Tokyo due to the catastrophic earthquake that occurred on 11th March, 2011. However, the National Organizing Committee (NOC) is working on an alternate idea to publish many full papers that the NOC has received. Please visit the conference website to gain the latest information."

Workshops in conjunction with the conference

In order to increase the attractiveness of the conference, different half-day workshops will be offered, covering topics from HPP Annexes 32, 34, 35, 36, 37, 38 and 39. In addition, an ECES workshop will be arranged. ECES stands for Energy Conservation through Energy Storage and is one of the IEA Implementing Agreements which relates to heat pumping technology. In addition, eight technical and two non-technical half-day tours have been prepared to enhance the scientific discussion.

Sponsoring of the conference

The NOC has defined concepts both for sponsoring and an exhibition: an invitation and application form for sponsors and exhibitors can be downloaded from the conference website. Exhibitors will be able to display their business and equipment at the conference, while sponsors will be able to promote their business in the conference program booklet, proceedings, website etc. Last, but not least, HPP member countries are contributing with country sponsoring.

Sessions at the conference

The sessions at the conference will cover the following topics:

- Heat pumps for a sustainable society (policy and market)
- Systems and components I
- Ground source heat pumps
- Applications I
- Systems and components II
- Air-source heat pumps
- Applications II
- HPP reports from ongoing activities

www.hpc2011.org

Programme Achievements 2010

Contact
Dr Monica Axell
Heat Pump Centre
SP Technical Research
Institute of Sweden
Box 857
SE-50115 Borås
Sweden
Tel. +46 10 516 55 19
hpc@heatpumpcentre.org
www.heatpumpcentre.org

Website: www.heatpumpcentre.org

HPP publications can be ordered from the Heat Pump Centre.

Heat Pump Centre

The Heat Pump Centre (HPC) plays a central role in the IEA Heat Pump Programme. It aims to disseminate factual and balanced information on heat pumping technologies and promote Programme activities. SP Technical Research Institute of Sweden has been appointed to manage HPC.

HPC Newsletter

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. The newsletter is available free of charge from the HPC website to HPP member countries. Non-member countries can subscribe to the newsletter.

A short version of the newsletter, an e-newsletter, is available free of charge to all countries, either by email subscription or by downloading from the HPC website. The number of subscribers to the e-newsletter increased from over 2200 to nearly 2600 during 2010, or about 17 %. In addition, the newsletter is also disseminated through the national teams in the member countries.

HPC Website

Another important activity is the website, which is continually 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 entire website has been re-built, resulting in many improvements for the user. The new website has a new web-based interface, which has a number of beneficial features, e.g. it displays the website correctly in any browser and gives the website a well-needed facelift - the style is more up-to-date and makes the website more user-friendly and easier to navigate.

Activity generation

The Heat Pump Centre is also involved in establishment of new activities within HPP. For example, it publishes ongoing descriptions of project proposals on the website in order to stimulate 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 National Teams in the member countries. In September, HPC arranged a working meeting and National Teams meeting in Borås, Sweden. The main focus of the meetings was to discuss and develop ideas for research projects within the Programme.

Contribution to IEA publications and activities

During 2010, the Heat Pump Centre played a very active role in coordinating HPP's contribution to the IEA's coming publications, i.e. the roadmap for *Energy Efficient and Low Carbon Buildings: Heating and Cooling*, the *Energy Technology Perspectives 2010* report, and the *IEA Buildings Sector Book*. As an example of this work, a survey was conducted in the spring of 2010 to gather data on markets, performance and cost issues related to heat pumping technologies. Representatives of national and international organisations were asked to deliver current statistics and trends, as well as to reflect on the future outlook. Input regarding barriers to technology deployment, research status, good examples etc. were also requested.

In collaboration with the member countries, HPC has started work to improve existing global statistics for heat pumps for heating and cooling.

HPC, together with representatives from HPP member countries, supported IEA in its arrangement of workshops relating to the publications in preparation. The workshops were held on March 1 and 2 and May 5 and 6 in Paris, and representatives from both HPC and HPP participated. The roadmap and the Building Sector Book will be completed in 2011.

Newsletter #3 2010 was printed and freely distributed in order to promote HPP.

Communication activities and other issues

The Heat Pump Centre is also involved with general communication and information issues. Communication of results from completed Annexes has been improved and, in addition to the final Annex report, an executive summary and a two-page flyer are produced at the end of the projects. Finally, HPC has a supportive function in assisting HPP Annex Operating Agents (project leaders) and the HPP Executive Committee in their work. In 2010, HPC has been very active in supporting the completion and starting of Annexes.

In addition to the ordinary HPC work, 2010 has to a large extent been characterised by finalising and implementation of the results from the Stakeholder Survey. The results have provided good help on where the most effort is needed, and some examples of actions that has been carried out this year as a result of the survey are:

- Re-design of the website
- The topic of Newsletter #3 2010 aimed for policy makers (an important HPP target group)
- Improved market analysis, with (for example) Member Country reports published in the Newsletter
- A new graphic profile for Annex reports, executive summaries and two-page flyers
- Public Annex reports (both new and previous)
- Publishing of all previous newsletters on the website
- A new design of the Newsletter front page to make it more attractive

Newsletters 2010

The four 2010 newsletters and e-newsletters are available on the Heat Pump Centre website.
The topics are:

1. ATES/BTES systems for commercial buildings
2. Retrofit heat pumps for buildings
3. IEA Energy Technology Perspectives 2010
4. Supermarket refrigeration

International collaboration and promotion

The Heat Pump Programme and the Heat Pump Centre have good relations with a number of national and international organisations, including EHPA[1], IIR[2], ASHRAE[3] and AHRI/AHRTI[4]. UNEP[5] is another body with which HPC/HPP exchange information. At the end of 2009, HPP was invited by Mr Kuijpers, Co-chair of the UNEP Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC), to review its 2010 assessment report. HPC has performed the review process with a task force group consisting of Mr Groff, Dr Jakobs and Mr Tono. The report will be published in the summer of 2011.

HPC has also attended the IEA Building Coordination Group meeting in Paris, France, in January. In October, HPP was honorary sponsor of the Chillventa trade fair in Nürnberg, Germany.

[1] The European Heat Pump Association

[2] The International Institute of Refrigeration

[3] The American Society of Heating, Refrigerating and Air-Conditioning Engineers

[4] The Air-Conditioning, Heating, and Refrigeration Institute/ Air-Conditioning, Heating, and Refrigeration Technology Institute

[5] The United Nations Environment Programme

Highlights of 2010

Many new HPP Annexes have started – also in the industrial sector

2010 has been a creative year with several project ideas evolving into new Annexes. It is with great pleasure that HPP will be working with the industrial applications of heat pumps again (Annex 35) – it was a while back since last time! The industrial heat pump market is still immature, and there is a need of expertise and experience in this field. Annex 35 is a joint project with the IEA "Industrial Energy Technologies and Systems" Implementing Agreement (IETS), which we believe will be a very fruitful collaboration.

The other new projects cover topics such as the quality of heat pump installations and maintenance (Annex 36), experience of field measurements of heat pump installations (Annex 37), combination of solar thermal energy and heat pumps (Annex 38), and testing and rating of annual/seasonal performance (Annex 39).

Annex 38 is also a collaborative project with another IEA Implementing Agreement, namely the Solar Heating and Cooling Programme. We are looking forward to this joint effort in the field.

Coffee break in Helsinki

Executive Committee meetings

Two meetings of the HPP Executive Committee were held in 2010:

- June 3–4, in Helsinki, Finland
- November 10-11, in Vienna, Austria

The Helsinki workshop

A workshop was held on June 2 in connection with the Executive Committee meeting in Helsinki, with the theme of "The role, projects and market of heat pumps in Finland". Dr Jussi Hirvonen, Chair of the Finnish Heat Pump Association, gave a presentation about the heat pump market in Finland.

Discussions in Vienna

The Vienna workshop

A workshop was held in Vienna on November 9 in connection with the Executive Committee meeting there. The workshop aimed to demonstrate the Austrian activities within IEA and EHPA, the impact of these efforts on the heat pump market development and an outlook of possible future developments – market- and technology-wise. The presentations dealt with heat pump research and development in Austria, heat pump market development in Austria and Europe, and a presentation of EHPA by its chairman, Dr Karl Ochsner.

Borås

Working meeting and National Teams meeting in Borås

On September 14-16, a working meeting and a National Teams meeting were held in Borås, Sweden. The working meeting was focused on the following Annex ideas/proposals: heat pump concepts for net-zero-energy buildings, improved performance of heat pumps for cold climates, and integration of heat pumps in buildings.

The main purpose of the National Teams meeting was to generate new activities in the IEA Heat Pump Programme, and to enhance and strengthen cooperation with the National Teams. All countries gave a presentation on the topic "New activity generation in IEA HPP – The need of new research projects in each country".

United Kingdom - new member country

The Heat Pump Programme had the pleasure of welcoming United Kingdom as a new member country in 2010. The British contracting party is DECC, Department of Energy & Climate Change, for and on behalf of the Government of the United Kingdom.

United Kingdom new member country

IEA Energy Technology Network Communication Seminar & Workshop

The Heat Pump Centre attended the IEA seminar and workshop on the topic "Communication… Impact… Growth". It focused on both internal communication within the Network and external communication targeting the global energy technology community and the public at large. The participants agreed on key findings and proposed next steps, and to continue the work at a second meeting that will be held in spring 2011.

Chillventa trade fair

Over 29 000 trade visitors from all over the world attended the Chillventa Trade Fair 2010 on October 13-15, when the Nürnberg exhibition centre was the hub of the international refrigeration, air conditioning, ventilation and heat pump community. 881 companies from 42 countries presented the variety and innovative power of a whole industry. IEA HPP shared a stand with the European Heat Pump Association, EHPA. During the three days, we handed out a considerable quantity of HPP-produced information, mainly the CO_2 brochure, the HPP Annual report, policy papers and issue 3/2010 of the HPC Newsletter, entitled "IEA Energy Technology Perspectives 2010". The fair was considered a success with excellent networking and information dissemination from IEA HPP.

In addition, in conjunction with the fair, a very well organised and well attended Annex 35 workshop was organised by Prof Laue and Dr Jakobs.

Dr Roger Nordman at Annex 35 workshop in conjunction with Chillventa 2010. (source: NuernbergMesse / Thomas Geiger)

Compact heat exchangers with small effects on the environment

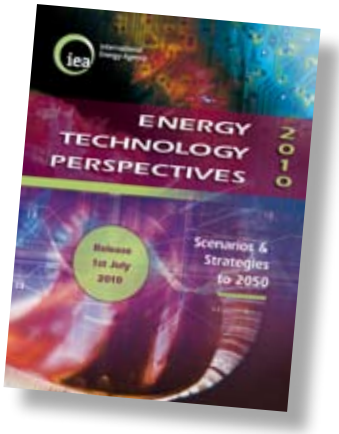
The objective of HPP Annex 33, *Compact Heat Exchangers in Heat Pumping Equipment*, was to present a compilation of possible options for compact heat exchangers, for use as evaporators, condensers and in other roles in heat pumping equipment. The aim was to minimise the direct and indirect effects on the local and global environment due to operation of, and ultimate disposal of, the equipment.

The Annex deliverables consist of a wide variety of data, ranging from fundamental research on boiling in narrow channels to guidelines for selecting and using CHEs in heat pumping systems. The Annex report relates specifically to design data for compact heat exchangers used in heat pumping systems at the process/large commercial level, but also includes much data relevant to domestic heat pumps. There is considerable market information in the report and the cited references, as well as a number of novel heat exchanger concepts, including the use of new materials and the application of process intensification methods, which should assist equipment manufacturers to achieve the Annex aim.

The final results from Annex 33 are published on the website, and are available for downloading.

This photo shows a compact heat transfer surface studied in Annex 33

Energy Technology Perspectives 2010



Read more about the Energy Technology Perspectives 2010 at www.iea.org

The IEA report *Energy Technology Perspectives 2010 - Scenarios & Strategies to 2050 (ETP 2010)*, as well as the IEA Roadmap report (see below), is the result of a collaborative effort between the International Energy Agency (IEA), its member countries, and various consultants and experts worldwide, among them members of the HPP. The ETP 2010 was published by the IEA during 2010.

The HPP was first involved in the work with the ETP in the 2008 edition. Based on the experiences from that work, the Executive Committee of IEA HPP decided that involvement in the 2010 edition was of high importance. Consequently, members from many of the participating countries and the Heat Pump Centre have been present at the workshops held by the IEA.

Summary of ETP 2010, from a Heat Pumps perspective

In order for policy makers to be able to arrive at informed decisions about energy and climate change policies they require detailed analysis of the technology options available and their potential to meet energy policy goals. The ETP 2010 builds on the analyses in ETP 2006 and 2008 to provide this information.

ETP 2010 presents two contrasting scenarios. *The Baseline scenario* follows *the Reference scenario* outlined in the *World Energy Outlook*, extending it to 2050. It assumes no new energy and climate policies. In contrast, *the BLUE Map scenario* is target-oriented: it sets the goal of halving global energy-related CO_2 emissions by 2050 and examines the least-cost means of achieving that goal. Heat pumps play a central role in the BLUE Map scenario, along with efforts to improve building shells, as space heating represents as much as a third of global energy use in the residential sector.

Introducing heat pumps for heating and hot water production often implies that CO_2 emissions are moved from the building sector to the power generation sector. The BLUE Map scenario predicts a high level of decarbonisation of the electricity grid by 2050. Thus, the renewable electricity production will be close to 100% in 2050. Heat pumps are the technology that benefits the most by this greening of the grid.

The potential energy and CO_2 savings from the wider use of heat pumps are substantial, given their high efficiency and relatively low market penetration for space and water heating. The efficiency of today's Best Available Technology for air-conditioners is considerably higher than average installed efficiencies, offering further scope for CO_2 emission savings.

In Figure 1, it can be seen that all heating and cooling technology solutions, that will allow the buildings sector to shift to a more sustainable energy and environmental future, contribute in total with two Gt CO_2 emissions savings. The increased deployment of heat pumps for space and water heating, as well as the deployment of more efficient heat pumps for cooling, account for 63% of these savings.

Although heat pumps are often competitive today, the large-scale global deployment of heat pumps for heating and higher efficiency air-conditioning devices will require additional R&D, demonstration programmes and support policies to help transform the market for heating and cooling. Thus, in the BLUE Map scenario, total CO_2 emission reductions is 7% higher when heat pump R&D is successfully implemented than without this R&D.

As an overall conclusion to the ETP, the following can be said:

- There is a need for an energy transition revolution.
- Heat pumps can play an important role in this aspect.
- It is now up to policy makers to make the right decisions.

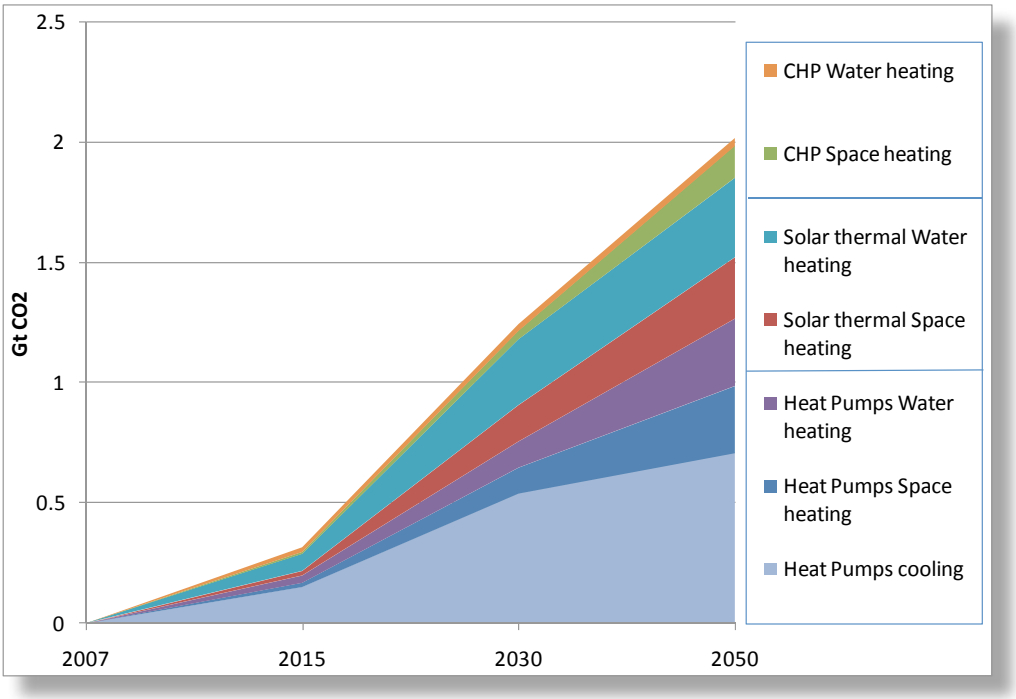


Figure 1. CO_2 emissions reductions in buildings from heating and cooling systems in the BLUE Map scenario (reductions below the Baseline)
Source: Energy Technology Perspectives 2010 © OECD/IEA, 2010

IEA Roadmap *Energy Efficiency in Buildings – Heating and Cooling*

As part of the workshops that were organised during the work for the ETP study during 2009 and 2010, material was also collected for the technology Roadmap. The HPC organised the review of the roadmap draft within the HPP, and many reviewers contributed with immense knowledge to further improve this roadmap. A truly massive effort has also been put into developing the text on heat pumps.

The Energy Efficiency in Buildings – Heating and Cooling Roadmap identifies a detailed scenario for the evolution of the key underlying technologies and, just as importantly, their levels of deployment in the marketplace. It finds that urgent action is required if the building stock of the future is to consume less energy, leading to lower CO_2 emissions. The roadmap concludes with a set of near-term actions that stakeholders will need to take in order to achieve the roadmap's vision.

Annex 31

Advanced Modeling and Tools for Analysis of Energy Use in Supermarkets

Contact
Dr Samer Sawalha, Dr Jaime Arias and Prof Per Lundqvist
Royal Institute of Technology
Dept. of Energy Technology
SE-100 44 Stockholm
Sweden
Tel. +46 8 790 78 89,
+46 8 790 86 42
samer.sawalha@energy.kth.se,
jaime.arias@energy.kth.se,
per.lundqvist@energy.kth.se
www.energy.kth.se

Participating countries: Canada, Germany, Sweden (Operating Agent), United Kingdom (partly) and the United States

Supermarkets are the most energy-intensive buildings in the commercial sector. It is estimated that 3-5 per cent of the total use of electricity stems from supermarkets in industrialised countries. In addition, it is estimated that annual refrigerant losses may be as high as 15-30 per cent 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 standpoint of refrigerant leakage impact.

The overall objective of Annex 31 is to provide new knowledge, methods and tools for enhanced energy efficiency in, 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 have been conducted:

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)

A short course, under the title of *Supermarket Systems Simulation Tools - Status and Recent Developments*, and presenting results from Annex 31, was held in conjunction with the Purdue Conferences in July 2010 at the Purdue University in West Lafayette, US. The objectives were to provide attendees with an understanding of simulation tools available, their relative capabilities and intended use, and examples of results/use. The course was sponsored by the United States National Committee for the International Institute of Refrigeration (USNC/IIR) and Herrick Laboratories. Speakers from Europe, Canada and the US were represented.

The work of Annex 31 has now been concluded, and release of its final report is scheduled for spring 2011.

Annex 32
Economical Heating and Cooling Systems for Low Energy Houses

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

Heat pumps are the only devices that can generate heating and cooling energy simultaneously. 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 their respective energy sources 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 operation of existing multifunctional
- to develop design recommendations for multifunctional heat pump systems.

The Annex has been structured into four tasks:

Task 1 State-of-the-art survey of low-energy buildings and associated systems
Task 2 Assessment of system solutions and development of prototype systems
Task 3 Field-testing of systems (in parallel with Task 2)
Task 4 Development of guidelines for systems and their control, and documentation of best-practise systems.

The Annex started in January 2006 and was concluded at the end of 2010. Activities in 2010 were dedicated to conclusion of the Annex and preparation of deliverables. National results have been summarised in four final reports:

- An umbrella report summarises the main results of Annex 32. It also contains an outline of the participating countries, institutions and the national contributions as well as the low-energy house markets and systems.
- A market report gives a more detailed classification of market-available multifunctional heat pumps intended for application in low-energy houses. Classification is by functionality of the system to facilitate system choice.
- The prototype report covers the developed prototypes of integrated heat pumps as covered by Annex 32. The focus of developments have been on extended functionality, including (passive) space cooling and dehumidification functions, as well as heat pumps using natural refrigerants. Laboratory tests and annual results of calibrated system simulations are documented in the report. Field tests of some of the prototypes are in preparation.
- The field monitoring report gives details on extensive field monitoring of more than 100 heat pumps installed in low-energy houses. Field test results confirm a generally good performance, but some optimisation potentials are indicated. Design recommendations have been derived from the field monitoring experience.

In addition, single systems are documented in a four-page Best Practice leaflet.

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
carsten.wemhoener@fhnw.ch
www.fhnw.ch/habg/iebau

www.annex32.net

Annex 34
Thermally Driven Heat Pumps for Heating and Cooling

Contact
Dr Peter Schossig
Dept. Thermal Systems and Buildings
Fraunhofer-Institut für Solare Energiesysteme ISE
Heidenhofstraße 2
DE-79110 Freiburg
Germany
Tel. +49 7 61/45 88 5130
Fax/VoiceMailbox
+49 7 61/45 88 9130
peter.schossig@ise.fraunhofer.de
www.ise.fraunhofer.de

Participating countries: Austria, Canada, Germany (Operating Agent), Italy, the Netherlands, Norway, Switzerland and the United States

Significant primary energy savings could be obtained by substituting the electrically driven compressor of common heat pumps by a thermally driven one, especially if the heat is provided via 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 (TDHPs).

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, areas and applications with the greatest environmental benefit, the most favourable economics and the greatest market potential will be identified.

Here follows a summary of task statuses and results of meetings:

Task A Market overview and state-of-the-art – More country reports were collected. A lot of work has been carried out to rebuild the website to simplify the teamwork of the contributing participants. Unfortunately, an application for EU funding, aiming to ensure the co-operation of the participants beyond the project duration, failed, but will be resubmitted.

Task B Performance evaluation – The database of existing standards was updated with new and revised documents currently under revision or development (e.g. EN 14825, EN 12309) and is accessible on the internal website. The German directive, VDI-Richtlinie, has already been published. Definition of performance figures have been agreed on. This includes a proposal for a description of a standard to determine COP values and other energy performance figures of TDHPs and of systems using TDHPs (described in four technical reports).

Task C Apparatus technology – The sorption material database has been expanded on the internal website with further material data as needed for the proposed measurement procedures. This includes mainly new promising commercial available silica gels and zeolites. A technical report on the different technologies, their potentials and limits, and a description of standards to determine sorption material properties, will be provided soon. In parallel, the database, material sources and information on experimental expertise are constantly updated

Task D System technology – A template to collect data of existing plants has been developed. First results have already been obtained in respect of information on system knowledge, i.e. how does the TDHP work (proper functioning), how is it integrated (system components) and how does it operate within the whole system (control strategies). This includes calculation of system performance by analysing monitoring data. In addition, available tools applicable to the design of TDHP systems, and for calculation of their energy and economic performance, were summarised.

Task E Implementation – A number of useful demonstration projects have been identified. Authors for the planned handbook have been defined. The plan is to finish the first chapters, an overview of standards (outcome of Task B), at the beginning of 2011.

The website of Annex 34 has been fundamentally rebuilt

www.annex34.org

Annex 35

Application of Industrial Heat Pumps

A joint project with the IEA Implementing Agreement "Industrial Energy Technologies and Systems" (IETS), Annex 13

Participating countries: Austria, Canada, France, Germany (Operating Agent) Japan, South Korea and Sweden
and from IETS: Denmark, the Netherlands, Sweden

While the residential heat pump market already has stabilised towards standardised products and installations, most industrial heat pump applications need to be customised to their particular conditions. In addition, a high level of expertise is crucial.

The main market barrier for the introduction of industrial heat pumps is expected to be lack of experience, which leads to little market acceptance among operators and industrial actors, including the industrial supply and consulting chains.

A joint Annex, with the aim of studying applications of industrial heat pumps, was started by HPP and IETS in April 2010, with 16 participating organisations from ten member countries of the two programmes.

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

The Annex will focus on:

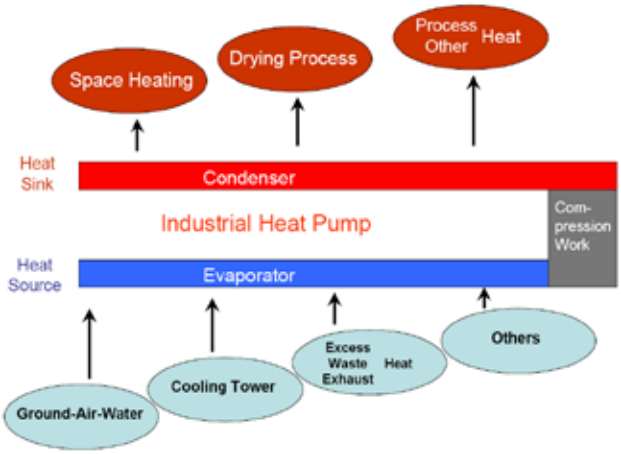
- Reduction of energy costs, fossil energy consumption and CO_2 emissions in industrial and commercial heat generation.
- Constraints related to medium and high temperature refrigerants with low GWP.
- Modified compressors for high-temperature applications
- Process methodology for integration of heat pump

A first kick-off meeting took place in April 2010 at the European Academy of Refrigeration and AC in Maintal, Germany. The meeting discussed and decided on the objectives, contributions, activities and time schedule of the Annex. It was agreed that the following tasks should form the frame of the programme:

1. Market overview and barriers for application
2. Modelling performance calculation and economic models
3. Technology
4. Application and monitoring
5. External communication

The first Annex meeting took place in October 2010 in connection with Chillventa trade fair in Nürnberg, Germany. The Annex coordinator, IZW e.V., presented the present status of contracting parties / participants, specific obligations and responsibilities of the participants and the status of the work. The main topic of the meeting was a presentation of Task 1 status, with an overview of the energy situation and energy use in industry segments in the participating countries, as well as a detailed discussion of the work programme.

Contact
Prof Dr - Ing Hans-Jürgen Laue
Information Centre on Heat Pumps and Refrigeration
(Informationzentrum Wärmepumpen und Kältetechnik)
IZW. e.V
Unterreut 6.
D-76135 Karlsruhe
Germany
Tel. +49-721 98 62 85-6
Fax. +49-721 96 62 85-7
izwev.laue@t-online.de



The principal of an industrial heat pump

Annex 36
Quality Installation/Quality Maintenance Sensitivity Studies

Contact
Glenn Hourahan
Air Conditioning Contractors of America (ACCA)
2800 Shirlington Road, Suite 300
Arlington, CA 22206 USA
Tel. 703-824-8865
Fax. 703-575-9147
glenn.hourahan@acca.org

Co-Operating Agents are
- Van Baxter
  Oak Ridge National Laboratory
- Piotr Domanski
  National Institute of Standards and Technology

Participating countries: France, Sweden, United Kingdom and the United States (Operating Agent)

It is widely recognised that residential and commercial heat pump equipment suffers significant performance loss (i.e. decreased capacity and efficiency), depending on how the components are sized, matched, installed, and subsequently field-maintained. This Annex will evaluate how installation and/or maintenance deficiencies cause heat pumps to perform inefficiently and waste energy. Specifically to be investigated are the extent that operational deviations are significant, whether the deviations (when combined) have an additive effect on heat pump performance, and whether some deviations (among various country-specific equipment types and locations) have greater impact than others.

In this sensitivity analyses, each Annex participant will quantify impacts on HVAC system performance related to varying quality installation (QI) / quality maintenance (QM) practices and attributes. The objectives for Annex 36 are:
- To develop information for use by industry stakeholders, policy makers and owners/operators
- To evaluate heat pump equipment types and applications that are germane to each participant's general equipment applications for residential and commercial buildings
- To enable more efficient heat pump operation by reduced energy utilisation, reduces greenhouse gas emissions, and/or to provide for enhances penetration of heat pumps

The intended audience for the Annex 36 output are:
- HVAC practitioners responsible for designing, selecting, installing, and maintaining heat pump systems in varied applications.
- Building owners/operators interested in achieving improved comfort conditioning and efficiency performance from their HVACR equipment.
- Entities charged with minimising energy utilisation in varied heat pump applications and geographic conditions (i.e. utilities, utility commissions, energy agencies, legislative bodies etc.)

The Annex has been structured into five tasks:
Task 1 Critical literature survey
Task 2 Identify sensitivity parameters
Task 3 Modelling and/or lab-controlled measurements
Task 4 Simulations of seasonal impacts
Task 5 Report and information dissemination

Annex 37

Demonstration of Field Measurements on Heat Pump Systems in Buildings - Good Examples with Modern Technology

Participating countries: Austria, Sweden (Operating Agent), Switzerland and the United Kingdom

The aim of this Annex is to demonstrate and disseminate the economic, energy-saving and environmental potentials of heat pumping technology. The focus will be on modern technology, and results from existing field measurements will be used to calculate energy savings and CO_2 reduction. It should be possible to predict the most suitable heat source and heat pump system for particular applications in particular geographic regions. In order to draw the right conclusions it is most important that the quality of the measurements should be guaranteed. The criteria for good and assured quality will be defined in the project. An additional aim is to establish a data base, linked to the Heat Pump Centre website, where data from field measurements are presented.

The Annex will have the following structure:

Task 1 Definition of criteria for good quality of field measurements (e.g. boundaries of measured systems, number of and placement of measuring points, uncertainty of measurement, time steps etc.) and decision on what parameters are important for guaranteed quality.

Task 2 Collection and evaluation of existing and performed field measurements on heat pump systems. The focus is on the best available technique.

Task 3 The task includes:

- Developing a common template for what should be contained in the data base established in this project.
- Agreement on how to calculate the chosen annual performance quantifiers, such as seasonal performance factor (SPF), energy savings and carbon footprints.
- Calculation of SPF, electricity consumption, energy savings and CO_2 reductions from the collected measurements. These parameters will be compared with those from other heating systems, such as oil and gas heating.

Task 4 Setting up a database with data from field measurements using the common template developed in Task 3.

Task 5 Activities using experiences from field measurements/Information dissemination activities:

- Showing the potential for heat pump systems by good examples of "state-of-the-art", based on reliable data from field measurements
- Case studies to be used as input data for improved statistics on heat pump systems
- Using the outcome to improve and extend existing guidelines, to include all types of heat pumps, for installation of energy-efficient and reliable heat pump systems, taking into account regional constraints as well as building standards.

The Annex will be started with a kick-off meeting in February 2011 in Borås, Sweden.

Contact
Dr Pia Tiljander
SP Technical Research Institute of Sweden
Box 857, 501 05 Borås
Sweden
Tel. +46 10 516 51 29
Fax. +46 33 13 19 79
pia.tiljander@sp.se

Annex 38

Solar and Heat Pump Systems

A joint project with the IEA "Solar Heating and Cooling" Implementing Agreement (SHC)

Contact
Jean-Christophe Hadorn
BASE Consultants SA
8 rue du Nant
CH-1207 Geneva
Switzerland
jchadorn@baseconsultants.com

www.iea-sch.org/Task44

SOLAR + HEAT PUMP

Participating countries: Finland, Germany, Switzerland (Operating Agent) and UK
and from SHC: Austria, Belgium, Canada, Denmark, France, Germany, Italy, Spain, Sweden, Switzerland and the United States

The market for heating and cooling systems for buildings is presenting an increasing number of combined heat pump and solar systems. Combination can be achieved in several ways, with the main objective being to increase the overall seasonal performance factor of a heating system. Often the main purpose of the solar part of such systems is to prepare domestic hot water in the summer months, but solar heat can also provide an additional source of energy for air or ground source heat pumps during the winter months.

Annex 38, which will run from 2010 to 2013, is concerned with solar thermal systems in combination with heat pumps, for the supply of domestic hot water and heating in family houses. The objectives are to assess the performance and relevance of combined systems using solar thermal and heat pumps, to provide common definitions of performances of such systems, and to contribute to successful market penetration of these new systems.

Annex 38 analyses monitored installations in several participating countries, as well as laboratory testing of solar and heat pump combinations. The Annex is concerned primarily with air and ground source heat pumps, since the market is dominated by systems of these types. Thermally driven heat pumps can also be included, but fewer projects are available for case studies.

Two expert meetings were held in 2010: the first in April in Bolzano, Italy, and the second in October in Vienna, Austria. More than 50 experts, with solar and/or heat pump backgrounds, attended and discussed a common methodology to assess the performance of combined systems.

The Annex has been structured into the following tasks:

Task A Solutions and generic systems – Collection of information on monitored projects and about 20 monitored installations, which will be evaluated. A map of possible system configurations has been sketched and a new way to describe system configurations has been proposed, so that different types of installations can be more easily understood.

Task B Performance assessment – Discussions of a common seasonal performance factor definition that would embrace both solar and heat pump performance. This could be the basis for an international standard definition. Five technical laboratories are committed within the Annex to define a common testing procedure for a system combining solar collectors and a heat pump, typically in the range of 5-10 kW and 4-20 m^2 of collectors for a single-family house.

Task C Modelling and simulation - Dealing with simulation tools and methods. Initially, existing models for components of a system were recognised.
There is a need for validation of a solar collector model, including condensation and ice formation on the absorber surface, often needed when solar collectors are used as the heat exchanger with air for a heat pump. Transient heat pump models for both air and ground sources are also needed. A reference case has been discussed, and resulted in an extension with TRNSYS simulations and comparisons of the well-documented case of SHC Task 32.

Task D Dissemination and market support – Preparation of the newsletters to be issued every year, the final handbook of the Annex, the website and the Annex logo.

Annex 39

A Common Method for Testing and Rating of Residential HP and AC Annual/Seasonal Performance

Participating countries: Austria, Finland, France, Germany, Japan, the Netherlands, South Korea, Sweden (Operating Agent), Switzerland and the United States

For optimum performance from a heat pump system, the correct type of heat pump must be chosen and installed with a matching heat distribution system. For this reason, it is important to have reliable information on both the heat pump itself and on how it is influenced by the ancillary systems to which it is connected.

A common method of calculating the Seasonal Performance Factor (SPF) would be important for fair comparison between different types of heat pump systems as well as for fair comparison with competing technologies using fossil fuels. A common SPF method could eventually be incorporated in different labelling, rating and certification schemes.

There is therefore a need for an improved transparent and harmonised method of calculation of heat pump system SPF based on repeatability and reliable test data from laboratory measurements.

There are many national standards for both testing and calculation of SPF. Manufacturers have made it clear that they would like to see common testing methods and common SPF calculation methods, since this would make it simpler for them to export heat pumps to different countries. The question has been highlighted in the European countries after the RES Directive was approved. In Japan, too, existing standards need to be updated and a common methodology is desired.

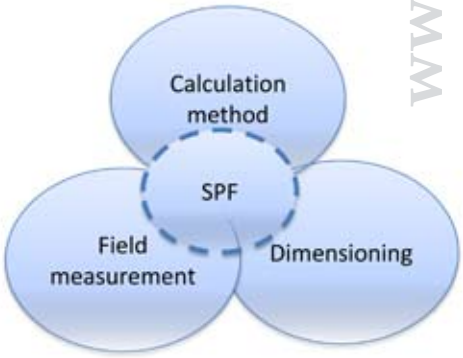
The outcome from this Annex will be a proposal for a common transparent SPF calculation method for domestic heat pumps, including heating, cooling and domestic hot water production. The idea is to conduct pre-normative research, which later can be incorporated in standardisation (ISO and CEN) in the same way as HPP Annex 28, on the results of which Annex 39 will partly build.

The following task-sharing activities have been planned:

Task 1 Review and evaluation of existing test and calculation methods for SPF
Task 2 Development of a matrix defining needs for testing and calculation methods
Task 3 New calculation method for SPF/ commonly accepted definitions on how SPF is calculated
Task 4 Identification of improvements to existing test procedures
Task 5 Validation of SPF method
Task 6 Development of an alternative method to evaluate heat pump performance
Task 7 Communication to stakeholders

A project kick-off meeting was held at the ASHRAE Annual Meeting in June 2010 in Albuquerque, the USA. At this meeting, participants from six countries contributed to the development of the final draft of the legal text. However, the start of the Annex has been delayed, due to the fact that some countries had not settled their financial contributions. The Annex legal text was finally approved at the ExCo meeting in Vienna, Austria in November 2010, and by December 2010, most countries have supporting national projects in place for input to the Annex. The launch of the Annex work has been postponed until the beginning of February 2011.

Contact
Dr. Roger Nordman
SP Technical Research
Institute of Sweden
Box 857, 501 15 Borås
Sweden
Tel. +46 10 516 55 44
Fax. +46 33 13 19 79
roger.nordman@sp.se



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_2 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	2009
30. Retrofit Heat Pumps for Buildings	Germany	France, Germany, the Netherlands	2009
31. Advanced Modeling and Tools for Analysis of Energy use in Supermarkets	Sweden	Canada, Germany, Sweden, United Kingdom (partly), the United States	Ongoing
32. Economical Heating and Cooling Systems for Low Energy Houses	Switzerland	Austria, Canada, Germany, France, Japan, the Netherlands, Norway, Sweden, Switzerland, the United States	Ongoing
33. Compact Heat Exchangers in Heat Pumping Equipment	United Kingdom	Austria, Japan, Sweden, United Kingdom, the United States	2010
34. Thermally Driven Heat Pumps for Heating and Cooling	Germany	Austria, Canada, Germany, Italy, the Netherlands, Norway, Switzerland, the United States	Ongoing

Summary of Annexes

Annex	Operating Agent	Participants	Completed
35. Application of Industrial Heat Pumps	Germany	Austria, Canada, France, Germany, Japan, South Korea, Sweden	Ongoing
36. Quality Installation/Quality Maintenance Sensitivity Studies	the United States	France, Sweden, United Kingdom, the United States	Ongoing
37. Demonstration of Field Measurements Heat Pump Systems in Buildings	Sweden	Austria, Sweden, Switzerland, United Kingdom	Ongoing
38. Systems Using Solar Thermal Energy in Combustion with Heat Pumps	Switzerland	Germany, Finland, Switzerland, United Kingdom	Ongoing
39. A Common Method for Testing and Rating of Residential HP and AC Annual/Seasonal Performance	Sweden	Austria, Finland, France, Germany, Japan, the Netherlands, South Korea, Sweden, Switzerland, the United States	Ongoing

Programme Contacts
– Executive Committee Delegates

AUSTRIA
Prof Hermann Halozan
Graz University of Technology
Institute of Thermal Engineering
Inffeldgasse 25/B,
A-8010 Graz
Tel. +43 316 873 7303
halozan@tugraz.at

alternatively:
Waltendorferhoehe 20
A-8010 Graz
Tel. +43 316 422 242
herman.halozan@chello.at

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

THE UNITED STATES
Mr Antonio M. Bouza
US Department of Energy
1000 Independence Ave, SW
Washington, DC 20585
Tel. +1 202 586 4563
antonio.bouza@ee.doe.gov

FINLAND
Mr Jussi Hirvonen
Finnish Heat Pump Association,
SULPU ry
Robert Bosch Oy
Äyritie 8 E
FIN 01510 Vantaa
Tel. +358 10 480 86 10
jussi.hirvonen@ivt.fi

Dr Arto Kotipelto (Alternate)
TEKES (Finnish Funding Agency for
Technology and Innovation)
PO Box 266
Yrjönkatu 20
FI-28101 Pori
Tel. +358 44 712 4138
arto.kotipelto@tekes.fi

FRANCE
Mr Jean-Michel Parrouffe
ADEME
Service des Réseaux et des Energies
Renouvelables
500 route des Lucioles
FR-06560 Sophia Antipolis
Tel. +33 4 93 95 79 00
jean-michel.parrouffe@ademe.fr

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

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

ITALY
Dr Giovanni Restuccia
Italian National Research Council
Institute for Advanced Energy Tech-
nologies (CNR – ITAE)
Via Salita S. Lucia sopra Contesse 5
98126 Messina
Tel. +39 090 624 229
giovanni.restuccia@itae.cnr.it

Dr Angelo Freni (Alternate)
Italian National Research Council
Institute for Advanced Energy Tech-
nologies (CNR – ITAE)
Via Salita S. Lucia sopra Contesse 5
98126 Messina
Tel. +39 090 624 229
angelo.freni@itae.cnr.it

JAPAN

Mr Yoshiteru Sato
New Energy and Industrial Technology Development Organization (NEDO)
Energy and Environment Policy Department
Muza Kawasaki Central Tower Bldg. 18F
1310 Ohmiya-cho, Saiwai-ku,
Kawasaki-City, Kanagawa 212-8554
Tel. +81 44 520 5280
satoyst@nedo.go.jp

Mr Makoto Tono (Alternate)
Heat Pump & Thermal Storage Technology Center of Japan (HPTCJ)
1-28-5 Nihonbashi, Kakigara-cho
Chuo-ku, Tokyo 103-0014
Tel. +81 3 5643 2404
tono.makoto@hptcj.or.jp

THE NETHERLANDS

Mr Onno Kleefkens
Agentschap NL
Divisie NL Energie en Klimaat
P.O. Box 8242
3503 RE Utrecht
Tel. +31 88 620 2449
onno.kleefkens@agentschapnl.nl

Mr Wilko Planje (Alternate)
Agentschap NL
Divisie NL Energie en Klimaat
P.O. Box 8242
3503 RE Utrecht
Tel. +31 88 620 7999
wilko.planje@agentschapnl.nl

NORWAY

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

SOUTH KOREA

Mr Seong-Ryong Park
Korea Institute of Energy Research
Department of Renewable Energy
71-2, Jang-dong, Yuseong-gu,
Daejeon
Republic of Korea 305-343
Tel. +82 42 860 3224
srpark@kier.re.kr

SWEDEN

Ms Emina Pasic
Swedish Energy Agency
Technology Department
P.O. Box 310
SE-631 04 Eskilstuna
Tel. +46 16 544 2189
emina.pasic@energimyndigheten.se

SWITZERLAND

Mr Andreas Eckmanns
Federal Department of the Environment, Transport, Energy and Communications
Swiss Federal Office of Energy
Energy Research Section
CH-3003 Bern
Tel. +41 31 322 54 61
andreas.eckmanns@bfe.admin.ch

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

UNITED KINGDOM

Ms. Penny Dunbabin
Departmet of Energy & Climate Change (DECC)
Area 6d, 3-8 Whitehall Place
London, SW1A 2HH
Tel. +44 300 068 5575
penny.dunbabin@decc.gsi.gov.uk

Mr. Chris Wickins
Department of Energy & Climate Change (DECC)
Area 6A, 3-8 Whitehall Place
London, SW1A 2HH
Tel. +44 300 068 6880
chris.wickins@decc.gsi.gov.uk

IEA Heat Pump Programme
Heat Pump Centre
c/o SP Technical Research Institute of Sweden
Box 857, SE-501 15 BORÅS, Sweden
Telephone: + 46 10 516 50 00, Telefax: + 46 33 13 19 79
E-mail: hpc@heatpumpcentre.org, Internet: www.heatpumpcentre.org