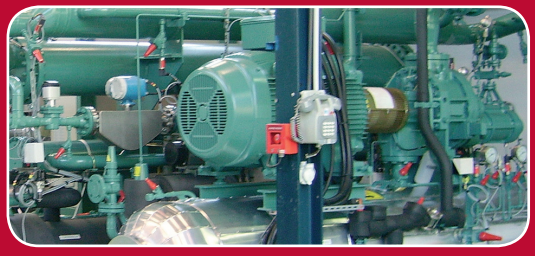
Annual Report 2011



2011

HEAT PUMP PROGRAMME

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





International Energy Agency

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)

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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), the 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.

Pictures front cover:
Industrial heat pump, source: EDF;
Another view of an industrial heat pump, source: EDF;
Mr Carsten Wemhöner, Heat Pump Summit 2011 (source: NuernbergMesse/Frank Boxler)

International Energy Agency



The International Energy Agency (IEA) is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 28 member countries and beyond. Founded in response to the 1973/4 oil crisis, the IEA's initial role was to help countries co-ordinate a collective response to major disruptions in oil supply through the release of emergency oil stocks to the markets. While this continues to be a key aspect of its work, the IEA has evolved and expanded. With a staff of around 260, it is at the heart of global dialogue on energy, providing authoritative and unbiased research, statistics, analysis and recommendations.

The IEA's work focuses on timely issues ranging from the impact of consumer subsidies to energy-technology collaboration, energy efficiency and climate change. For example, the IEA advises member countries on ways to develop their energy policies so they effectively address climate change. Part of this work involves identifying examples of best practice and bringing them to the attention of governments, so they can emulate them. The IEA also conducts a broad range of transport research and analysis, which focuses on ways in which countries can improve the energy efficiency of their respective transport sectors and shift to lower carbon fuels.

Growing economic interdependence and increasingly global energy market and environmental issues make IEA relations with partner countries, industry, international organisations and other stakeholders especially important. Just over half of the world's energy consumption now takes place outside the IEA region. Directed by its member countries, the IEA has, therefore, also developed close co-operative working relationships with major energy consuming nations such as China, India, Brazil, Indonesia, Mexico and South Africa as well as strengthened ties with key producers such as Russia and OPEC members.

Through its broad range of more than 40 multilateral technology initiatives (also known as Implementing Agreements), the IEA also enables member and non-member countries, businesses, industries, international organisations and non-government organisations to share research on breakthrough technologies, to fill existing research gaps, to build pilot plants and to carry out deployment or demonstration programmes. Their work can comprise any technology-related activity that supports energy security, economic growth, environmental protection and engagement worldwide. A new initiative may be created at any time, provided at least two IEA member countries agree to work on it together. These Agreements cover areas ranging from bioenergy to energy storage and heat pumping technologies.

www.iea.org

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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, the 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.

Chairman's Statement 2011



It is once again my great pleasure to write the Chairman's Statement for the IEA Heat Pump Programme Annual Report. The increasing level of activity of the program reveals the high interest in heat pumps as a technology of choice for addressing energy, environmental and economic concerns. We were particularly pleased to have Denmark participating in ExCo meetings as an observer; we anticipate that they will join HPP in 2012.

For the IEA HPP, 2011 was marked by the 10th International Heat Pump Conference. For the first time this conference was a virtual event due to the tragic earthquake and the tsunami that affected Japan on March 11, 2011. Despite these terrible circumstances, Japan was able to make this event a successful one, attracting many participants. I would like to congratulate them for their perseverance under such conditions, and thank the National Organising Committee chaired by Momoki Katakura and the international Organising Committee chaired by Thomas Kopp. The prestigious Ritter von Rittinger award, traditionally announced during the Conference, was awarded at a special ceremony held in Paris in May, at the ExCo meeting. Three people were recognised for their high contributions to heat pumps: Professor Hermann Halozan, category Technology; Professor Per-Erling Frivik, Markets; and Mr John Ryan, Administration and Organisation of heat pumping activities.

Two HPP Executive Committee meetings were held, one in Paris in May, instead of in Tokyo, and one in Atlanta in November. In conjunction with these meetings, workshops were organised by France and the USA respectively, to present their national heat pump activities. A working meeting and a National Teams meeting to discuss future activities and proposals were held in September, in Nürnberg in conjunction with the European Heat Pump Summit. This was also an opportunity to promote the HPP. HPP was also present at international events, and held regular meetings with the European Heat Pump Association.

New international collaborative projects (Annexes) and ideas are being developed. Annex 36 Quality Installation and Maintenance has been running for a year. Three new Annexes are under development in the following areas: demonstration and good examples of field measurements of heat pump systems (37); solar thermal energy in combination with heat pumps (38); and a method for testing and rating of residential HP/AC seasonal performance (39). New ideas include the evaluation of air-source heat pumps in cold climates, heat pumps for net-zero energy houses, heat pumps for smart cities, and refrigerants with low GWP.

HPP worked closely with the IEA, to provide it with updated information on heat pumps, which has been incorporated in the Technology Road Map, Energy-efficient Buildings: Heating and Cooling Equipment, released in 2011.

I invite you to visit the updated Heat Pump Centre website and read recent newsletters, with four published in 2011.

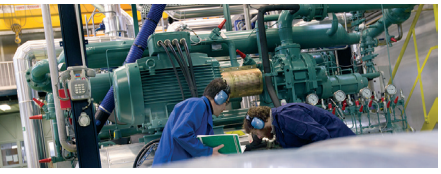
Finally, it is my great pleasure to inform you that the 11th International Heat Pump Conference will be held in Montreal in 2014! I look forward to meeting you there!

Sophie Hosatte
ExCo Chairman

10th IEA Heat Pump Conference

Heat Pumps - The Solution for a Low Carbon World





Source: EDF



Air conditioners in Tokyo

The Conference proceedings can be ordered from www.heatpumpcentre.org.

The 10th International IEA Heat Pump Conference 2011 was open between June 27 and August 31. It was originally intended to be held in Tokyo in May, but the National Organising Committee of Japan suspended it because of the tragic consequences from the earthquake and tsunami of March 11. In its place, a first-of-its-kind virtual Internet conference was held. In this way, the Heat Pump Community had the privilege of following an interesting conference in an innovative website format.

The original conference program was retained, and all papers could be accessed over the Internet. A total of 191 papers, 14 keynote presentations, 7 address speeches and 7 reports on ongoing Annexes were presented. During the full Conference period, 377 participants visited the website 1 665 times and studied 18 108 pages. Thus, also this 10th International Heat Pump Conference was a great success and the important role of heat pumps could undoubtedly be proven.

There are two primary objectives with the IEA heat pump conferences. One is to give the audience a snapshot of international developments within the field of heat pumping technologies over the last three years. The second objective is to give a sense of direction for future trends, and to create a forum that will spur new thoughts and ideas for international cooperation and more widespread deployment of heat pumps.

Conference organisation

The International Organising Committee (IOC) consisted of members from ten IEA HPP member countries. The IOC Chairman was Mr Thomas Kopp, and Mr Onno Kleefkens was Vice-Chairman. The important tasks of Regional Coordinators were taken by Mr Gerald Groff (USA) for North and South America, Mr Makoto Tono (Japan) for Asia and Oceania, and Ms Monica Axell (Sweden) for Europe and Africa.

For the National Organising Committee (NOC), many related bodies were asked to join to improve funding application prospects. The NOC Chairman was Mr Momoki Katakura Chairman; Vice-Chairmen were Mr Fumio Ueda and Mr Tetsuro Kishimoto. The NOC Secretariat consisted of three members: Mr Hirotaka Hara, Mr Ichiro Utsumi and Mr Makoto Tono.

Programme

The conference consisted of nine sessions.

1. Opening session with welcome addresses; reports from the Regions (North and South America; Europa and Africa; Asia and Oceania); report from the Japanese Platinum Network
2. Heat Pumps for a Sustainable Society (Policy and Market), 3 keynotes, 16 papers
3. Systems and Components I, 1 keynote, 39 papers
4. Ground-Source Heat Pumps, 1 keynote, 30 papers
5. Applications I, 1 keynote, 30 papers
6. Systems and Components II, 1 keynote, 30 papers
7. Air-Source Heat Pumps, 1 keynote, 22 papers
8. Applications II, 1 keynote, 24 papers
9. Heat Pump Programme - ongoing activities, 1 keynote, 7 papers

See you at the 11th IEA Heat Pump Conference in Montreal, Canada in 2014!

The Ritter von Rittinger award

The Ritter von Rittinger award is presented triennially at the International Heat Pump Conference to individuals or teams who have distinguished themselves through international achievements in advancing heat pumping technology, markets or applications, resulting in improved energy efficiency and environmental benefits. The award is named for Peter Ritter von Rittinger, an Austrian engineer credited with the design and installation of the first practical heat pump system at a salt works in Austria in 1856.

The 2011 Rittinger awardees are Professor Per-Erling Frivik of Trondheim, Norway, Professor Hermann Halozan of Graz, Austria and Mr John D. Ryan of Bethesda, Maryland, the United States. They received the awards in Paris on May 16, 2011 from Dr Sophie Hosatte, Chairman of the IEA Heat Pump Programme Executive Committee.

Professor Frivik received the award in the Markets category. Throughout his professional life he has been affiliated with SINTEF, and NTH/NTNU in Trondheim, Norway. He built up a large group in heat pumping technology and refrigeration engineering, in which for example Professor Gustav Lorentzen developed the idea of using CO_2 as a working fluid. Professor Frivik also initiated an effective cooperation between his group at SINTEF and the NTH/NTNU's Institute for Refrigeration Engineering, which served internationally as a model of co-existence between academic and applied research. He was also instrumental in the process that led to the launch of the IIR Gustav Lorentzen Conference on Natural Working Fluids. Professor Frivik was a member of the IEA HPP Executive Committee between 1985 and 1997, and the Chairman for several years, shepherding the Programme through a major reconstruction that started in 1989.

Professor Halozan received the award in the Technology, Markets, and Applications category. Professor Halozan has provided his vast expertise in heat pumps to a large number of international associations and organisations for more than twenty years. He has strongly influenced the European heat pump industry by supporting the development of quality standards for heat pumps at European and national levels, promoting international collaborations for developing knowledge, systems and practices in heat pumps through research, development, demonstration and deployment. He has had a significant role at the IEA, as Chairman of the IEA Working Party on End-Use Energy Technology; previous Chairman of the Buildings Co-ordination group (BCG); Austrian delegate (and previous Chairman) at the IEA HPP; and leader of the Austrian National Team at the IEA HPP.

Mr John Ryan received the award in the Administration/Organisation category. Mr Ryan was one of the initiators of the IEA Heat Pump Programme after he joined the US Department of Energy in 1978, and served as the US delegate to the Executive Committee until 2007. He was directly involved in the very first HPP project (Annex 1, Common Study of Advanced Heat Pumps). He has been very active in the organisation of the work of the programme. In the early years of the HPP he was a member of the HPC Steering Committee and served as its Chair in 1989 when the HPC underwent a major reorganisation. He was a founding member of the HPP Executive Committee and was its Chairman 1995-1997. He led efforts to establish and maintain a US National Team, which has participated in most of the Annexes. Mr Ryan was also Chairman of the IOC of two International Heat Pump Conferences.



The Ritter von Rittinger awardees 2011, Hermann Halozan and John Ryan. Per-Erling Frivik was unable to attend the ceremony.

Programme achievements 2011

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HPP publications can be downloaded from the Heat Pump Centre website.

Heat Pump Centre

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

Although no new member countries have joined the HPP during 2011, contacts have been taken with Denmark and Belgium. These countries have indicated interest in becoming members, and we hope soon to be able to welcome them in HPP.

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. Individuals in non-member countries can subscribe to the newsletter. Issue 2, 2011, which reported on the *IEA Technology Roadmap - Energy-efficient Buildings: Heating and Cooling Equipment*, was printed in order to achieve a higher profile.

During 2011, each issue of the Newsletter contained a market report from one member country. This type of information, with the first article published in 2010, was requested by several responders in the previous HPP Stakeholder Survey.

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 nearly 2600 to nearly 3000 during 2011, or by approximately 15 %. In addition, the newsletter is also disseminated through national teams in the member countries.

Website

Another important activity is the continuous development and maintenance of the website, which is updated with news, events, press releases 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 database. During 2011, the website has been updated with a number of new items, including press releases, ideas and proposals for new Annexes, the General Information folder and two Position papers, as well as the announcement of the Conference proceedings. After the complete re-organisation of the website in 2010, the changes to the structure of the website in 2011 were only minor, with the introduction of a new sub-page containing press releases and promotional material. A trial to integrate Annex websites into the HPC website structure has been made with Annex 39, which is operated from Sweden. An evaluation of this trial will be reported to the ExCo.

Activity generation

The Heat Pump Centre is also involved in the 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 also maintains regular contact with the Annexes' Operating Agents, supports them with legal text, formal participation letters, etc.

In September, a working meeting and National Teams meeting was held in Nürnberg, Germany, arranged in connection with the European Heat Pump Summit. The main focus of the meetings was to discuss and develop ideas for research projects within the Programme. During the meetings, three new Annex ideas were discussed: "Smart cities", "Refrigerants with low GWP", and "High-temperature heat pumps". In addition, two other ideas, "Improving low ambient temperature performance of Air-Source Heat Pumps", and "Heat pump concepts for near (or net) zero energy buildings", have been developed further and are about to start.

New publications

The Heat Pump Centre has prepared and published a number of publications during 2011. The majority of these were scheduled for release during the Conference.

- Annual Report 2010
- Annex reports (final, executive summary, and/or flyers) for Annex 30, 32 and 33
- Position papers, formerly named Policy papers
  - *Heat Pumps can help to address today's key Energy Policy Concerns*
  - *The Potential Impact of Heat Pumps on Energy Policy Concerns*
  - *Net Zero Emission Buildings (in preparation)*
- CO_2 brochure
- General brochure

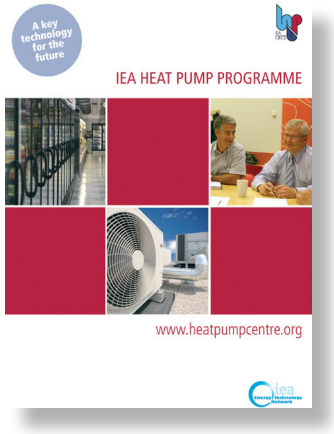
Contributions to IEA Publications and activities

The HPC continued to be very active in coordinating HPP's contributions to IEA publications, as well as participating in other IEA work. HPC was involved in the review of the *IEA Technology Roadmap - Energy-efficient Buildings: Heating and Cooling Equipment* in collaboration with other key actors. This Roadmap was released in May.

In collaboration with the member countries, HPC has continued to work to improve existing global statistics for heat pumps for heating and cooling. Work on developing a common classification terminology (or a "dictionary") of heat pump types is being carried out. The long-term aim is to make reliable, comparable heat pump data available, so that the potential of heat pumping technologies for the energy system will be clearly demonstrated.

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, IIR, ASHRAE and AHRI/AHRTI, and UNEP. Examples of interactions during 2011 were participation and exhibition at the IIR Conference, Prague, and finalisation of the review of the UNEP RTOC Heat Pump chapter of the report *2010 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee, 2010 Assessment*.



Newsletters 2011

The four 2011 newsletters and e-newsletters are available on the Heat Pump Centre website.
The topics were:

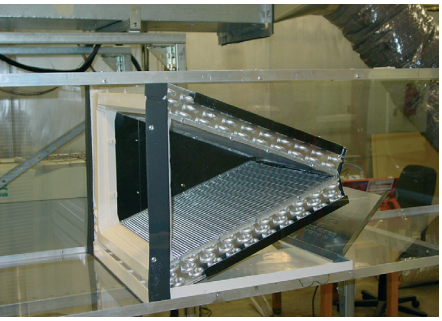
1. Thermally Driven Heat Pumps
2. Energy Efficient Buildings: Heating and Cooling Technology Roadmap
3. 10th IEA Heat Pump Conference
4. Working Fluids for a Sustainable Future



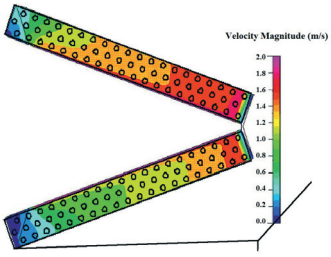
Highlights 2011



ExCo meeting in Paris



Refrigerant-to-air heat exchanger (HX) being prepared for Particle Image Velocimetry (PIV). (Source: W. Vance Payne, US NIST - Energy and Environment Laboratory)



CFD image of HX showing air velocity magnitudes for horizontal flow (Source: W. Vance Payne, US NIST - Energy and Environment Laboratory)

Tokyo Conference

The most important highlight of the year was the Heat Pump Conference, planned to be held in Tokyo in May, but reorganised into a web conference due to the twin disasters that struck Japan in March. As described elsewhere in the Annual Report, the web conference was a success, with many participants studying all the interesting contributions.

Executive Committee meetings

Two meetings of the HPP Executive Committee (ExCo) were held in 2011:

- May 17-18 in Paris, France (originally planned for Tokyo, Japan)
- November 9-10 in Atlanta, USA.

As is described elsewhere, the Ritter von Rittinger Award ceremony was held in conjunction with the meeting in Paris.

Workshop Atlanta

A workshop was held in Atlanta on November 8, in connection with the Executive Committee meeting there. The aim of the workshop was to present the North American heat pump market as well as research activities, and provide an outlook of possible future developments. The presentations covered a broad field, including heat pump market development, product and technician certificate programs, equipment reliability and performance, and academic and government research. The workshop also included a tour of the ASHRAE Living Laboratory Building.

Building Coordination Group meeting

The IEA Building Coordination Group (BCG) consists of representatives from all building-related IEA Implementing Agreements (IAs), and has annual meetings. A meeting was held in February in Paris, with participation from the HPP. IEA provided updates on work on platforms, networks, and publications, and all IAs reported on ongoing Annexes and other significant work. The importance of communication between IAs, as well as visibility to the general public, non-member countries, and policy makers, was stressed. Further, the significance of the contacts with the IEA Committee on Energy Research and Technology (CERT) was specifically noted, to further establish the BCG as a priority area within the CERT and the IEA, and to improve the communication of work and outputs undertaken by the IA's to the CERT and IEA as a whole.

Start-up of work towards ETP 2012

The Heat Pump Centre participated in the IEA CERT-ETP 2012 Energy Systems workshop named "Integrated Energy Systems of the Future" in November. The workshop was attended by CERT members, implementing agreements and private sector organisations. The aim of the workshop was to present and solicit input on initial ETP 2012 energy systems analysis, engage on "systems approach" to energy analysis with the IEA energy community, and determine future areas of interest for further analysis and study.

IEA Energy Technology Network Communication Seminar

The HPC was represented at the second IEA Energy Technology Network Communication Workshop, designed to examine strategic and cross-cutting communication issues identified by the IEA Committee on Energy Research and Technology (CERT). Responding to requests at the previous workshop on 19th September 2010, it focused on communication strategies to address the growing influence of public opinion on decisions-taking for projects that involve the energy technologies with which the network deals. Specialists' presentations explored ways to reach key stakeholder groups and turn public resistance into public trust, notably through heightened awareness of societal benefits and mechanisms for sharing those benefits more equitably.



Professor Hermann Halozan, Graz, at Heat Pump Summit in Nürnberg (source: NuernbergMesse/Frank Boxler)

International Institute of Refrigeration events

The International Institute of Refrigeration (IIR) is a scientific and technical intergovernmental organisation enabling pooling of scientific and industrial know-how in all refrigeration fields on a worldwide scale. An IIR conference on "Sources/Sinks Alternative to the Outside Air for Heat Pump and Air - Conditioning Techniques" took place in Padova, Italy in April. Heat sources and heat sinks of heat pumps and refrigeration systems, respectively, have an immense impact on performance. The conference covered research and development on sources/sinks alternatives to the outside air. At the Conference, Monica Axell, HPC, gave a keynote lecture entitled The heat pump market: present and future.

The 23rd IIR International Congresses of Refrigeration took place in Prague, Czech Republic, in August. The IIR International Congress of Refrigeration is the most prominent event of the International Institute of Refrigeration. The Congress was attended by 944 delegates from 52 countries, with 593 papers given. The Congress, held once every four years, brings together expertise from virtually all refrigeration fields. Notably, the field of Heat Pumps and Energy Recovery had the greatest number of papers accepted and presented at the Congress, showing the growing interest in this area. HPP participated with an information stand at the Congress.



An instrumented surface water heat exchanger about to be moved into a pond. (source: Oklahoma State University)

Heat Pump Summit

More than 450 conference participants from all over the world visited the second European Heat Pump Summit in Nürnberg, Germany, 28–29 September. Participants enjoyed an intensive exchange of views on the current political framework, technical solutions and advances in research and development. A triad of events, including the partly parallel Heat Pump Forum and the Symposium on Air to Air Heat Pumps for Commercial Property, concentrated the sector's national and international know-how in Nürnberg. Altogether 83 expert presentations covered the entire spectrum of heat pumps, supplemented by workshops and panel discussions. The highlights included the positive forecasts for the use of heat pumps in the IEA Outlook until 2050, the extensive presentations on refrigerants, heat pumps for smart cities, and the assessment of the EPEE F-Gas directive review.

The Industrial Heat Pump Application workshop organised by the HPP Annex 35 also attracted great interest. In addition, 25 exhibitors used the Foyer Expo as an opportunity to present their innovative products and services. The HPP took the opportunity to spread information about the Heat Pump Programme in a stand at the Foyer Expo.



Mr Gerald Groff, at Heat Pump Summit in Nürnberg (source: NuernbergMesse/Frank Boxler)

Annex 31

Advanced Modeling and Tools for Analysis of Energy Use in Supermarkets

Participating countries: CA, DE, **SE**, UK, US

This Annex, which is completed, has shown that supermarkets are among the most energy-intensive commercial buildings, with a large potential for improvement. Potential improvements are numerous and diverse: the building itself, refrigeration systems, display cases, etc. International comparisons of energy systems are difficult for several reasons: varying climate, opening hours, etc. Some of these differences, such as the typical number of operating hours per year, have been resolved in the project.

Existing supermarkets vary considerably in energy performance, and full understanding of all factors influencing their performance could not be achieved. However, experience from this project may simplify this process in the future.

Three full supermarket simulation models have been evaluated and compared in the project, and will be included in the final report. The comparisons show similarities, but also major differences in the level of detail, input and output data, etc.

Recently, several measures to improve supermarket energy efficiency have been introduced in some countries. Examples are energy-efficient display cases with doors; heat recovery using heat pumps; energy-efficient lighting including smart control; new efficient system solutions with natural refrigerants (mainly CO_2), and efficient secondary coolant systems using laminar flow heat exchangers.

There is a trend to install advanced monitoring. In order to make future evaluation of collected data possible, good performance indices need to be developed.

The energy efficiency of supermarkets is improving, although the rationale for doing so is economy rather than energy conservation and GHG abatement.

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Annex 32

Economical Heating and Cooling Systems for Low Energy Houses

Participating countries: AT, CA, DE, FR, JP, NL, NO, SE, **CH**, US

Heat pumps are the only devices that can generate heating and cooling 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 a single integrated system

The aim of this annex, which is completed, is to investigate different system configurations of heat pump systems, including energy sources and distribution systems, for application in low- and ultra-low-energy buildings. Its principal objectives are to

- further develop multifunctional heat pump systems: energy use, comfort, cost
- gather field experience from existing multifunctional heat pump systems
- develop design recommendations for multifunctional heat pump systems.

The Annex was structured into four tasks:

Task 1 State-of-the-art survey of low-energy buildings and systems
Task 2 Assessment of system solutions and development of prototype systems
Task 3 Field-testing of systems (with Task 2)
Task 4 Develop system guidelines; documentation of best-practice systems.

The Annex was concluded in 2011, with editing of final reports as main activities:

- Umbrella report: main results
- Market report: classification multifunctional heat pumps for low-energy houses
- Prototype report: developed prototypes of integrated heat pumps
- Field monitor report: field monitoring of heat pumps in low-energy houses.

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

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All the Annex 32 deliverables are available at www.annex32.net.

www.annex32.net

Annex 34
Thermally Driven Heat Pumps for Heating and Cooling

Participating countries: AT, CA, CH, **DE**, FR, IT, NO, UK, US

Significant primary energy savings could be made by substituting electrically-driven compressor-type heat pumps by thermally-driven heat pumps, especially if the heat is provided via solar or waste heat. A main objective of this Annex is therefore to reduce the environmental impact of heating and cooling by the use of thermally-driven heat pumps. In order to achieve this we will 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.

Two expert meetings have been held in 2011; in Padova, Italy in April, and at the University of Warwick, UK, in November. As this was the last expert meeting of the project, a presentation was given of the highlights of each task:

- The collection of national situations and documentation of the state of the art have been successfully completed in **Task A**.
- Nearly all existing standards have been reviewed in **Task B**. Several systematic approaches were evaluated in order to produce a definition of performance figures. It turned out that a joint meeting will be needed with participants from HPP Annex 34, HPP Annex 38 Heat Pumps + Solar (Joint with SHC, IEA Solar Heating and Cooling, Task 44) and possibly with SHC Task 48 Solar Cooling, in order to define common rules and create comparable figures etc. An example is that of definition of performance figures, system boundaries, and nomenclature, which is a prominent topic in a number of running adjoining activities dealing with heat pumping technologies. Another important part of this Annex was to deliver input to standardisation committees, such as CEN, e.g. EN 12309.
- Several new materials and components have been developed and discussed in **Task C**. A major outcome of this work has been the presentation of several joint papers at the International Sorption Heat Pump Conference. In addition, a common procedure has been proposed for determining sorption properties of adsorbent materials. Long-term and accelerated ageing methods for sorbent materials have also been discussed. Finally, various theoretical and experimental studies on key components (evaporator, condenser, ab/adsorbers) have been performed at the apparatus level.
- Identification of typical system layouts, creation of a component database, and dimensioning rules have been carried out in **Task D**. A matrix showing an overview of generic systems, including a flow chart diagram and a nomenclature table, has also been proposed. With regard to system integration, the flow chart diagram has been chosen in order to integrate different heat sources and sinks.
- **Task E** has seen the completion of a list of potential simulation tools, and its publication on the website www.annex34.org, which has also been constructed as part of the work. It is used for overall dissemination and publication of the collected data, literature and further website links.

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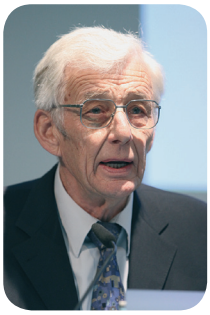




Source: Sorption Energy Ltd

Annex 35
Application of Industrial Heat Pumps

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Source: EDF

Participating countries: AT, CA, **DE**, FR, JP, KR, NL, SE
From IETS: DK, NL

This joint HPP / IETS (Industrial Energy-Related Technologies and Systems) Annex is focused on the reduction of energy costs, fossil energy consumption and CO_2 emissions in industrial heat generation through the use of industrial heat pumps. It was started in 2010, bringing together 15 participating organisations from nine member countries of the two Implementing Agreements.

The frame of the programme consists of the following tasks:

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

The work in 2011 was concentrated on two Annex meetings:

- June 2011 at EDF-R&D, Moret-sur-Loing, France, in connection with the 6th Energy Efficiency Seminar with ECLEER: « Energy Performance of Industrial Sites: from Research to Sober Plant»
- September 2011, at the Exhibition Centre, Nürnberg, Germany, together with the HPP / IETS Annex 35/13 Workshop "Practical Applications of Industrial Heat Pumps" as part of the European Heat Pump Summit 2011.

On request of the Dutch participant the definition of industrial heat pumps was reformulated, and now reads:
Heat pumps which are used for heat recovery and for heat upgrading or cooling/refrigeration in industrial processes, or for heating and cooling in industrial buildings.

The present version of the final report of Task 1 has been approved, and will be continually updated until the end of the Annex.

During 2011, several aspects of Task 2 were discussed. The key sub-task was further specified:

1. A SWOT analysis of available software and calculation procedures for application is to be performed by SP Technical Research Institute of Sweden, with input by the Delft University of Technology, as an in-depth study of available software.
2. Analysis and update of models from Annex 21, which also dealt with industrial heat pumps. Basically, this relates to the Industrial Heat Pump (IHP) data base. The critical review of the Screening Program developed in Annex 21 will be part of Item 1.

The SWOT analysis of available software is an ongoing activity. One important output of this analysis will be the state-of-the-art of approach principles, such as pinch technology and more refined mathematical optimisation methods. Are sophisticated mathematical optimisation models already advanced enough to be used in the framework of a user-friendly software package? A step into modern optimisation methods was presented and discussed at the Annex meeting in June 2011.

The IHP Screening Program, a tool to analyse the possibility of integrating heat pumps in industrial processes, has been analysed by IZW on the basis of the Annex 21 report on Industrial Heat Pumps. Proposals for improvements and further developments are given. In this connection, special attention needs to be paid to the relevance of the economic analysis.

Annex 36
Quality Installation/ Quality Maintenance Sensitivity Studies

Participating countries: FR, SE, UK, **US**

This Annex is evaluating how installation and/or maintenance deficiencies cause heat pumps to perform inefficiently (i.e., decreased efficiency and/or capacity). Specifically under investigation 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.

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 applica tions and geographic conditions (i.e. utilities, utility commissions, energy agencies, legislative bodies etc.)

In 2011, the Annex participants held a progress meeting on 13 – 15 June 2011 in Stockholm, Sweden. An Annex 36 web-conference was held on 20 March 2012. A face-to-face meeting is planned for 24 – 25 September 2012 (Gaithersburg, MD; USA). A third meeting is planned for fall 2013 (France).

Through the Annex period (November 2010 – November 2013), five tasks are being undertaken: (1) Critical literature survey, (2) Identify sensitivity parameters, (3) Modeling and/or lab-controlled measurements, (4) Simulations of seasonal impacts, and (5) Report and information dissemination. The focus and work to be undertaken by each participating country is identified in Table 1.

Table 1: Annex 36 Focus Areas and Effort

Annex 36 Participants	Focus Area	Work to be Undertaken
France	Space heating and water heating applications.	Field: Customer feedback survey on HP system installations, maintenance, and after-sales service. Lab: Water heating performance tests on sensitivity parameters and analysis.
Sweden	SP - Large heat pumps for multi-family and commercial buildings KTH/SVEP – Geothermal heat pumps	Field: SP - literature review of operation and maintenance for larger heat pumps. KTH/SVEP - investigations and statistical analysis of 22000 heat pump failures. Modeling/Lab: Determination of failure modes and analysis of found failures (SP) and failure statistics (KTH/SVEP).
United Kingdom	Home heating with ground-to-water, water-to-water, air-to-water, and air-to-air systems.	Field: Replace and monitor five geothermal heating systems Lab: Investigate the impact of thermostatic radiator valves on heat pump system performance.
United States (Operating Agent)	Air-to-air residential heat pumps installed in residential applications (cooling and heating).	Modeling: Examine previous work and laboratory tests to assess the impact of ranges of selected faults covered augmented by seasonal analyses modeling to include effects of different building types (slab vs. basement foundations, etc.) and climates in the assessment of various faults on heat pump performance. Lab: Cooling and heating tests with imposed faults to correlate performance to the modeling results.

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Annex 37

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

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Participating countries: CH, NO, **SE**, UK

The aim of this project is to demonstrate and disseminate the economic, energy and environmental potential 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 reductions. The Annex results should make it possible to predict the most suitable heat source and heat pump system for any particular application in any particular geographic region. In order to ensure correct results, it is most important that the quality of the measurements is guaranteed. The criteria for good and assured quality will be defined in the project. Results from the measurements will be presented on the HPC website and in a brochure. The Annex is planned to run until December 2012.

An additional goal was originally to establish a data base connected to the IEA HPC website, where data from field measurements could be presented. However, the ExCo meeting in Atlanta in November 2011 decided not to support this, which implies that Task 5 (see below) will be left out of the Annex.

In 2011, the Annex was initiated with a kick-off meeting in February, in Borås, Sweden.

Summary of task statuses and results of meetings

Task 1 Make a common template of what should be communicated – SP Technical Research Institute of Sweden presented a proposal for which parameters would be presented in the template, which was discussed by the Annex 37 group. The group agreed on the content after some revisions. Layout was not discussed in this task.

Task 2 Define criteria for good quality of field measurements – Planair Engineering, Switzerland, suggested criteria in a presentation held on September 2011 in Nürnberg. The meeting discussed the criteria and agreed on relevant requirements and levels. The criteria were then accepted, except for the requirement level of SPF, which is still under discussion in the Annex 37 group.

Task 3 Collection and evaluation of current and concluded field measurements on heat pump systems – each country to collect at least three field measurement data sets, of which the performance meets the criteria decided in Task 2.



Task 4 Agree how to recalculate the selected annual performance measures, such as seasonal performance factor, energy savings and carbon footprints. Planair Engineering, Switzerland, has started this work, which is planned to be finished in May 2012. These parameters will be compared with those for other heating systems.

Task 5 Establish a database connected to the HPC website with data from field measurements – this was removed from the project according to a decision by the ExCo.

Task 6 Information dissemination – At least three good examples from each participating country will be presented on the IEA HPC website. Guidelines to manufacturers and installers will be provided.

Annex 38
Solar and Heat Pump Systems

Participating countries: CH, DE, FI, UK
and from SHC: AT, BE, CA, CH, DK, ES, FR, DE, SE, US

The objective of Annex 38 is to assess performances and relevance of combined systems using solar thermal collectors and heat pumps; to provide a common definition of performances of such systems; and to contribute to successful market penetration of these new promising combinations of renewable technologies.

The Annex considers solar thermal systems in combination with heat pumps, supplying domestic hot water and space heating in family houses. It therefore concentrates on small systems in the range of 5 to 20 kW, combined with any type of solar collectors. The Annex is a joint effort of the Solar Heating and Cooling Programme (Task 44) and the Heat Pump Programme (Annex 38).

More than 100 different systems were identified in 2011. A two-page leaflet, describing the systems in detail, is available for more than twenty systems. A draft report covering this material has been issued.

Four categories of concepts have been defined: the parallel concept, where solar collectors and heat pumps are running almost independently; the serial concept, the regenerative concept and the complex concept. The "square view" scheme developed in 2010 became the reference tool of the work, and every system is represented in this format.

Many projects are already monitored, and results presented in 2011 will be analysed in a common format.

As far as system performances are concerned, one important question when dealing with hybrid systems such as S+HP systems is how to calculate the benefit of the "solar and heat pump" combination. Is benefit to be calculated against other alternative solutions, such as solar and wood or solar and gas, or against "solar only" or "HP only" solutions? There is still some way to go before the Annex participants issue a document on this issue.

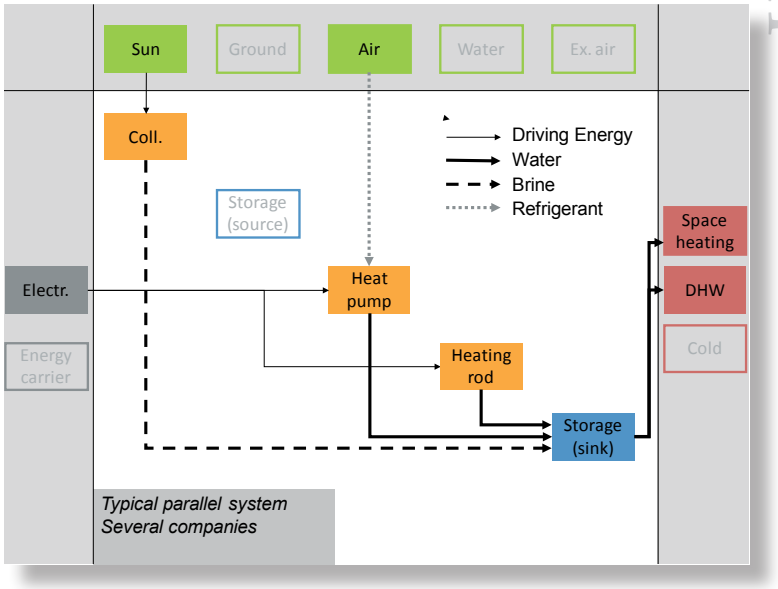
A number of institutes participating in Annex 38 are already testing S+HP total systems, or at least system components, on test stands. A common test procedure that might be a standard in the future is still being discussed.

Component and system modeling activities are progressing, with the issue in 2011 of the reference framework for simulation, and some new component models for solar collectors and heat pump dynamics. Validation is in progress.

A first newsletter was issued at the end of October 2011, and is available on our web site www.iea-shc.org/task44.

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Annex 39

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

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Participating countries: AT, CH, DE, FI, FR, KR, **SE**, US

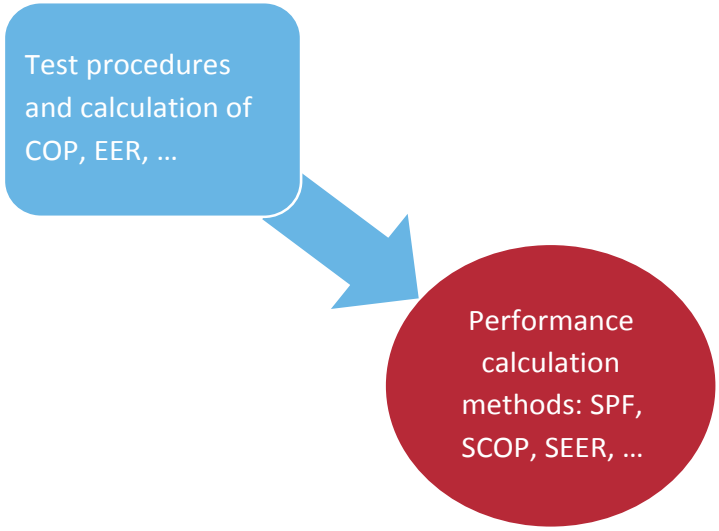
The outcome from Annex 39 will be a proposal for a common transparent SPF calculation method for domestic heat pumps, including heating, cooling and domestic hot water production. The idea is to conduct pre-normative research, which later can be incorporated in standardisation (ISO and CEN) in the same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

The following task-sharing activities have been planned and initiated:

Task 1 Review and evaluation of existing test and calculation methods for SPF.
In Task 1, a template for reporting has been developed, and the national methods are currently being summarised.
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.

Due to financing issues, the Annex start was set to September 1st 2011, with a start-up meeting held in Nürnberg, Germany. At this meeting, the participating organisations presented their intended work in the project, and discussions were held about how to develop the work programme. The Netherlands and Japan have shown interest in the Annex, but are currently not participating.

The project website *http://heatpumpcentre.org/en/projects/ongoingprojects/annex39/Sidor/default.aspx* has been started, and now contains material from the first meeting and the open workshop that was organised in conjunction with the Heat Pump Summit in Nurnberg.



List 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, the 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
13. State and Transport Properties of High Temperature Working Fluids and Non-Azeotropic Mixtures	Sweden	Canada, Germany, Japan, Norway, Sweden, the United States	1992

List of Annexes

Annex	Operating Agent	Participants	Completed
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, the 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, the 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, the United Kingdom, the United States	1996
22. Compression Systems with Natural Working Fluids	Norway	Canada, Denmark, Japan, the Netherlands, Norway, Switzerland, the 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, the 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
26. Advanced Supermarket Refrigeration/Heat Recovery Systems	The United States	Canada, Denmark, Sweden, the United Kingdom, the United States	2003

List of Annexes

Annex	Operating Agent	Participants	Completed
27. Selected Issues on CO_2 as Working Fluid in Compression Systems	Norway	Japan, Norway, Sweden, Switzerland, the 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, the 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, the United Kingdom (partly), the United States	2011
32. Economical Heating and Cooling Systems for Low Energy Houses	Switzerland	Austria, Canada, Germany, France, Japan, the Netherlands, Norway, Sweden, Switzerland, the United States	2011
33. Compact Heat Exchangers in Heat Pumping Equipment	The United Kingdom	Austria, Japan, Sweden, the United Kingdom, the United States	2011
34. Thermally Driven Heat Pumps for Heating and Cooling	Germany	Austria, Canada, France, Germany, Italy, Norway, Switzerland, the United Kingdom, the United States	Ongoing
35. Application of Industrial Heat Pumps	Germany	Austria, Canada, France, Germany, Japan, the Netherlands, South Korea, Sweden	Ongoing
36. Quality Installation/Quality Maintenance Sensitivity Studies	The United States	France, Sweden, the United Kingdom, the United States	Ongoing
37. Demonstration of field measurements of heat pump systems in buildings - Good examples with modern technology	Sweden	Norway, Sweden, Switzerland, the United Kingdom	Ongoing
38. Solar and heat pump systems	Switzerland	Finland, Germany, Switzerland, the United Kingdom	Ongoing
39. A common method for testing and rating of residential HP and AC annual/seasonal performance	Sweden	Austria, Finland, France, Germany, South Korea, Sweden, Switzerland, the United States	Ongoing



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