Annual Report 2012

IEA OECD

HEAT PUMP PROGRAMME

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

2012

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)

International Energy Agency

The International Energy Agency (IEA) is an autonomous agency established in 1974. The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The aims of the IEA are to:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

To attain these goals, increased co-operation between industries, businesses and government energy technology research is indispensable. The public and private sectors must work together, share burdens and resources, while at the same time multiplying results and outcomes.

The multilateral technology initiatives (Implementing Agreements), supported by the IEA, are a flexible and effective framework for IEA member and non-member countries, businesses, industries, international organisations and non-government organisations to research breakthrough technologies, to fill existing research gaps, to build pilot plants, to carry out deployment or demonstration programmes – in short to encourage technology-related activities that support energy security, economic growth and environmental protection.

More than 6 000 specialists carry out a vast body of research through these various initiatives. To date, more than 1 300 projects have been completed. There are currently 40 Implementing Agreements (IA) working in the areas of

- Cross-Cutting Activities (information exchange, modelling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (international experiments)
- Renewable Energies and Hydrogen (technologies and deployment)

The Implementing Agreement for a Programme of Research and Development on Heat Pumping Technologies (Heat Pump Programme) belongs to the End-Use category above.

The IAs are at the core of a network of senior experts consisting of the Committee on Energy Research and Technology (CERT), four working parties and two expert groups. A key role of the CERT is to provide leadership by guiding the IAs to shape work programmes that address current energy issues productively, by regularly reviewing their accomplishments, and suggesting reinforced efforts where needed. For further information on the IEA, the CERT and the IAs, please consult www.iea.org/techagr.

www.iea.org

IEA Heat Pump Programme

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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, Denmark, 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.

www.heatpumpcentre.org

Chairman's Statement 2012

It is once again my great pleasure to write the Chairman's Statement for the IEA Heat Pump Programme Annual Report. I would first like to welcome Denmark as a new member country.

As you read this report, you will realise that the level of activity of the Programme is constantly increasing, reflecting the significant interest among member countries – and, more generally, world-wide – in heat pumping technologies.

For the IEA HPP, 2012 was marked by approval of the programme extension for another five years, following the programme review by the IEA. This approval was supported by the End-of-Term report for the 2008-2012 period, and by the strategy plan, which highlight the programme achievements during the period and the need to continue to support the development and adoption of heat pumping technologies.

Two HPP Executive Committee meetings were held; one in Stockholm in May, and one in London in November. In conjunction with these meetings, workshops were organised by Sweden and the United Kingdom respectively, to present their national heat pump activities and gather more information on the HPP. A working meeting, a National Teams' meeting to discuss future activities and proposals, and a symposium with HPP and invited speakers were held in October, in Nürnberg, Germany, in conjunction with the Chillventa. This event also provided an opportunity to promote the Programme. HPP also attended international events, such as the IEA Building Coordination Group meeting in Paris in January, and worked closely with the IEA on other issues as well. HPP also held regular meetings with the European Heat Pump Association.

Ten international collaborative projects (i.e. annexes) are ongoing. Annex 42, entitled "Heat pumps in Smart Grids", as well as Annex 43 "Fuel Driven Sorption Heat Pumps", have both recently been approved. This is a good indicator of the level of interest.

HPP worked closely with the IEA and provided them with updated information on heat pumps to be incorporated in the publication "Energy Technology Transitions for Buildings – Strategies and Opportunities to 2050", to be published in 2013 by the IEA (exact title to be determined).

I invite you to visit the heat pump centre website frequently and read the most recent newsletters. Four have been published in 2012.

The organisation of 11th International Heat Pump Conference, which will be held in Montreal in 2014, is running well. I look forward to meeting you there!

Sophie Hosatte
ExCo Chairman

Programme achievements 2012

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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 the HPC.

An extension of the Heat Pump Programme to February 2018 has been granted by the IEA. This decision was preceded by the submission of two major reports, prepared by the HPC: *the End of Term Report and the Strategic Plan*.

During 2012, after intensive contacts with the HPC, Denmark joined the HPP. We are very glad to welcome Denmark to the group of HPP member countries! Contacts and discussions regarding membership are underway with a number of countries, among them Belgium and India.

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.

During 2012, the series of national market report articles was continued. Further, a new type of article was introduced: the Strategic Outlook. This will be published in each issue, and will cover national and regional policy, incentives, as well as other factors that form the background for the market.

A short version of the newsletter, an e-newsletter, is available free of charge to all countries, either by e-mail subscription or by downloading from the HPC website. The number of subscribers to the e-newsletter increased by approximately 7 % compared to 2011. In addition, the newsletter is also disseminated through national teams in the member countries.

Website

Another important activity is the development and maintenance of the website, which is continuously updated with news, events, press releases, and contact information.

Descriptions of on-going and completed HPP Annexes are also available on the website, as well as HPP publications, which are accessible via a database.

Updates during 2012 include, for instance, information regarding the Heat Pump Conference in Montreal (May 2014), ideas and proposals for new Annexes, links to IEA publications with HPP contributions, and downloadable presentations from the HP Symposium (Nürnberg, Germany, October 2012).

Activity generation

The Heat Pump Centre is also involved in the establishment of new activities within HPP. For example, it publishes on-going 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.

During 2012, two new Annexes have been initiated, and have had their kick-off meetings: "Heat pump concepts for near zero-energy buildings" (Annex 40), and

"Cold Climate Heat Pumps (Improving low ambient temperature performance of Air-Source Heat Pumps)" (Annex 41).

In October, 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 meeting, a number of Annex ideas were discussed. Some of them may be elaborated at a future ExCo meeting: "Zero Leakage, minimum charge", "Mapping of heat pump technology", and "Efficient and cost-effective latent cooling methodologies". In addition, two other ideas, "Heat pumps in Smart Grids", and "Fuel-driven heat pumps" have been developed further and are about to start.

New publications

After the large number of publications prepared for the Conference in 2012, the number of publications published during 2011 was more modest. They included

- Annual Report 2011
- Four Newsletter issues
- Annex report (final) for Annex 31
- General information folder

Contributions to IEA Publications and activities

In the work with the Energy Technology Perspectives 2012 (ETP 2012), the Heat Pump Programme reviewed three chapters: *The global outlook, Heating and Cooling, and Industry*. HPC gathered comments from ExCo and compiled them into one review sheet per chapter. The HPP was not as involved in the preparation work with the ETP 2012 as with the ETP 2010; contacts have been taken regarding future ETP publications to ensure that HPP will be able to make a significant contribution.

The work in order to compile high quality heat pump statistics has continued. A pilot project case study has been initiated. The idea is to find the barriers of obtaining the detailed data that are desired, and to explore ways to overcome them. In the case study, three countries (UK, CA, US) are asked to provide detailed heat pump sales data from the past four years (2008-2011). As before, 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 European Heat Pump Association (EHPA), International Institute of Refrigeration (IIR), American Society of Heating and Air-Conditioning Engineers (ASHRAE), Air-Conditioning, Heating, and Refrigeration Institute (AHRI), and China Energy Conservation Association (CECA). Examples of interactions during 2012 were participation and keynote presentation at the Asian Air-Source Heat Pump Development Forum in November 2012, as well as cooperation with EHPA during the Chillventa.

Newsletters 2012

The four 2012 newsletters and e-newsletters are available on the Heat Pump Centre website.
The topics were:

1. Industrial Heat Pumps
2. Heat Pumps in Smart Grids and Smart Cities
3. The Role of Heat Pumps in NZEB
4. Energy Technology Perspectives 2012

Highlights 2012

Westminster Abbey, London

Interview for Swedish television, Dr Rainer Jakobs, HPP Workshop, Stockholm, May 2012

Executive committee meetings

Two meetings of the HPP Executive Committee (ExCo) were held in 2012:

- May 24-25 in Stockholm, Sweden
- November 14-15 in London, UK

Further, meetings within the International Organization Committee (IOC) for the Heat Pump Conference in Montreal (May 2014) were held in connection with these ExCo meetings.

Workshops in Stockholm and London

Workshops were held in Stockholm on May 23, and in London on November 13, both in connection with an Executive Committee meeting. The objective of these workshops was to provide a heat pump overview from the host country, as well as an international overview on policy and on innovative applications as well as on more specific research and development. Also, presentations were given on a few Annexes and other projects closely related to the HPP. The workshops also included a tour of lab premises (Stockholm) and a site visit (London).

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 January in Paris, with participation from the HPP. The BCG provides an excellent means of exchanging information and making contacts, with IEA representatives, as well as with key persons from other IAs. Specifically of interest are the contacts with the IEA Committee on Energy Research and Technology (CERT). At the meeting, IEA provided updates on work on platforms, networks, and publications, and all IAs reported on ongoing Annexes and other significant work.

Group photo, HPP workshop in Stockholm, May 2012.

Chillventa and the Heat Pump Symposium

The Heat Pump Programme held a well visited Symposium, during the so-called Chillventa Congressing Day on October 8, before the actual Chillventa fair. 80 people visited the HPP Symposium and listened to presentations about the work and visions of ongoing and planned HPP Annexes. There were also invited speakers, with presentations on current subjects of great interest. These included

- Research on Cold Climate Air-Source Heat Pump Technology at the Ray W. Herrick Labs at Purdue University,
  Eckhard Groll, Purdue University, United States
- Energy Technology Perspectives 2012
  Marc LaFrance, Desk officer, IEA
- Innovations in heat pumping technology as a reaction to changing demands
  Hermann Halozan, TU Graz, Austria
- Trends in Industrial Heat Pump Technology in Japan
  Choyu Watanabe, Central Research Institute of Electric Power Industry, Japan
- Heat pumps and thermal energy storage
  Andreas Hauer, Bavarian Center for Applied Energy Research, Germany
- Heat pumps in future smart cities
  Michael Monsberger, AIT, Austria
- Ground Source Heat Pump systems for large commercial buildings in Central and Southern Europe
  Burkhardt Sanner, European Geothermal Energy Council

All presentations from the symposium can be downloaded from the HPP website.

Other events during the Chillventa Congressing Day included the symposia given by EHPA, by ASERCOM/EPEE, and by ZVKKW (Zentralverband Kälte Klima Wärmepumpen), as well as an ASHRAE Workshop on Nearly Zero Energy Buildings.

Prof Hermann Halozan, IEA HPP Symposium, Oct 2012.

Mr Peter Wagener and Dr Monica Axell Chillventa fair, Oct 2012.

Ongoing annexes

Bold text indicates operating agent

34	**Annex 34** Thermally Driven Heat Pumps for Heating and Cooling	AT, CA, CH, **DE**, FR IT, NO, UK, US
35	**Annex 35** Application of Industrial Heat Pumps	AT, CA, **DE**, DK, FR, JP, KR, NL, SE
36	**Annex 36** Quality Installation/Quality Maintenance Sensitivity Studies	FR, SE, UK, **US**
37	**Annex 37** Demonstration of Field Measurements of Heat Pump Systems in Buildings	CH, **SE**, UK AT, NO (observers)
38	**Annex 38** Solar and Heat Pump Systems	**CH,** DE, FI, UK
39	**Annex 39** A Common Method for Testing and Rating of Residential HP and AC Annual/Seasonal Performance	AT, CH, DE, FI, FR, JP, KR, NL, **SE**, US
40	**Annex 40** Heat Pump Concepts for Nearly Zero-Energy Buildings	**CH,** JP, NL, NO, SE, US
41	**Annex 41** Cold Climate Heat Pumps (Improving Low Ambient Temperature Performance of Air-Source Heat Pumps)	JP, **US**
42	**Annex 42** Heat Pumps in Smart Grids	DE, FI, KR, **NL,** US
43	**Annex 43** Fuel Driven Sorption Heat Pumps	**DE**, UK

The IEA Heat Pump Programme participating countries are: Austria (AT), Canada (CA), Denmark (DK) 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), and the United States (US). All countries are members of the Heat Pump Centre (HPC). Sweden is the host country for the Heat Pump Centre.

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 obtained by substituting the electrically driven compressors of common heat pumps by thermally driven compressors, particularly if the drive heat is provided from solar or waste heat. A main objective of this Annex has therefore been to reduce the environmental impact of heating and cooling through the use of thermally driven heat pumps. One of the main objectives is to quantify the economic, environmental and energy performances of integrated thermally driven heat pumps in cooling and heating systems in a range of climates, countries and applications.

Annex 34 is about to end. Work in 2012 was concentrated on compilation of the Annex 34 Final Report. The report was submitted to the HPP Executive Committee for approval and will soon be publicly available.

Task A - Market overview and state-of-the-art

The country reports of the national frameworks for thermally driven heat pumps in the member states were finalised. Member states tried to catch up with the latest political developments.

Task B - Performance evaluation

A workshop was held in Munich (Germany), bringing together representatives from Annex 38, "Solar and Heat Pump Systems" (jointly with SHC Task 44) and IEA SHC Task 48, "Quality Assurance and Support Measures for Solar Cooling Systems". The similarities and differences in evaluation of heating and cooling systems were discussed intensively, and a common understanding of the system boundaries and representation of the systems was developed. The results were subsequently published in a joint paper at the International Conference on Solar Heating and Cooling in San Francisco.

Task C - Apparatus technology

The international round-robin test between several laboratories has been extended to investigate a modern adsorption material (SAPO). The adsorption characteristics of this material were measured in each laboratory individually and the results were compared. This will lead to a more accurate and more widely accepted standardised measurement procedure for the characterisation of adsorption/refrigeration working pairs.

Task D - System technology

The data evaluation and system performance analysis of the selected demonstration plants has been finalised. Taking into account the common performance evaluation method from Task B, and the graphical representation schemes for energy and hydraulic flows developed within Task D, the reports of the demonstration plants give a good overview about existing installations and state of the art.

Task E - Implementation

The most promising papers covering the key topics in the field of thermally driven heat pumps, and published within the framework of Annex 34, were selected. These were edited and compiled in order to produce a handbook for plant designers. The handbook will be published in the near future.

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Annex 35
Application of Industrial Heat Pumps

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

The joint HPP / IETS Annex 35, focused on the reduction of energy costs, fossil energy consumption and CO_2 emissions from industrial heat generation by investigating potential applications for industrial heat pumps, was started in April 2010 with 15 participating organisations from nine member countries of the two Implementing Agreements

The following tasks form the frame of the programme:

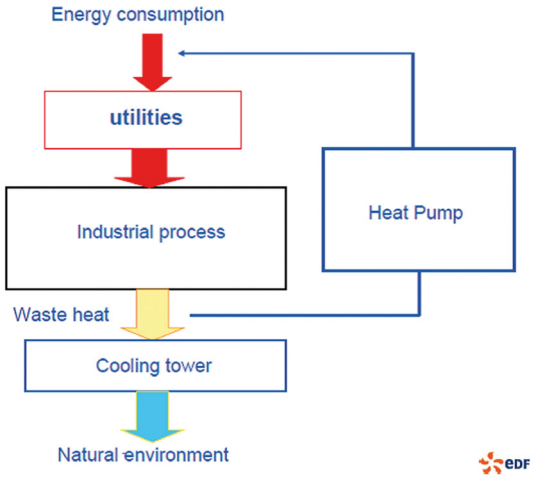
1. Market overview and barriers to application
2. Modelling of performance calculation and economic models
3. Technology
4. Application and monitoring
5. External communication

Work in 2012 was concentrated on an Annex meeting on 10th October 2012 in connection with the Chillventa - International Trade Fair for Refrigeration, Air Conditioning, Ventilation and Heat Pumps, and the IEA HPP Symposium at the Exhibition Centre Nürnberg/Germany. The Annex meeting was attended by 15 participants from nine member countries.

The work of the Annex is still mainly concentrated on Task 2 "Modelling of performance calculation and economic models", to analyse and appraise the possible contribution of heat pumps to energy efficiency and reduction of greenhouse gas emissions in industrial processes.

The status of Task 2 has been discussed at a workshop "Application of industrial heat pumps", organised and led by Roger Nordman directly before the annex meeting on 10th October 2012 in Nürnberg.

In its capacity as operating agent of the Annex, IZW e.V. has analysed Task 2 in detail.



Implementation of heat pumps in industrial processes.

Four IZW notes have been produced:

- 01/2011 Analysis of the Annex 21 IHP Screening Program
- 02/2011 Upgrade of the Annex 21 Screening program
- 11/2012 Some thoughts regarding Annex 35/13 Task 2 report
- 12/2012 Integration of heat pumps into chemical processes: An outline of theoretical methods.

At the workshop, it was stated that the Annex 21 Screening Program needs to be updated. This applies particularly to the data base, as the data are too old and, in many cases, no longer relevant. The Swedish experts in charge of the Annex 21 screening program stated that the present annex does not have the necessary resources to collect all the new data needed. This means that another way must be found for Task 2, which is still in progress.

It was therefore decided to request the ExCos of IETS and HPP for an extension of Annex 35/13 for one year, i.e. until 30th April 2014. The ExCos are in favour of an extension, but need a written request and a working plan.

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 includes:

- 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 HVAC equipment.
- Entities charged with minimizing energy utilization in varied heat pump applications and geographic conditions (i.e. utilities, utility commissions, energy agencies, legislative bodies, etc.)

In 2012, the Annex participants held a second annual progress meeting (24 – 25 September 2012; Gaithersburg, Maryland, USA) and a number of electronic exchanges. An Annex 36 web-conference is scheduled for March 2013 with a third Annex progress meeting planned for Fall 2013 (France). A final workshop to present final results is planned for May 2014 in conjunction with the 11th IEA Heat Pump Conference.

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 heat pump system installations, maintenance, and after-sales service. Lab: Water heating performance tests on sensitivity parameters and analysis.
Sweden	Large heat pumps for multi-family and commercial buildings Geothermal heat pumps	Field: Literature review of operation and maintenance for larger heat pumps. Investigations and statistical analysis of 22000 heat pump failures. Modeling/Lab: Determination of failure modes and analysis of found failures and failure statistics.
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).	Lab: Cooling and heating heat pump tests with imposed faults to develop correlations for performance degradation to be used in seasonal modeling simulations. 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.

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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, **SE**, UK Observers: AT, NO

The aim of this project is to demonstrate and disseminate the economic, environmental and energy-saving potential of heat pumping technology. The focus is on modern technology, using results from field measurements that have already been made in order to calculate energy savings and CO_2 reductions. It should be possible to predict the most suitable heat source and heat pump system for particular applications in particular geographic regions. It is important that the quality of the measurements is guaranteed, and so the criteria for good and assured quality have been defined in the project.

Results from the measurements will be presented on the HPC website and in a brochure.

Summary of task statuses

Task 1
A common template of what should be communicated has been developed.

Task 2
The criteria for good quality of field measurements have been agreed upon. This includes boundaries of the measured systems, number of and placement of measuring points, and accepted measurement uncertainty. Additionally, the SPF limits for good heat pumps were set to 3.0 for air-source heat pumps and 3.8 for ground-source heat pumps.

Heat pump installation, not a good example

Task 3
Current and concluded field measurements on heat pump systems were collected. Each country has at least three sets of field measurements, but not all heat pumps meet the criteria decided in Task 2.

Task 4
Agreement has been rereached concerning how to calculate the seasonal performance factor, energy savings and carbon footprints for field measurements with different measurement set-ups. These parameters will be compared with those for other heating systems.

Task 5
The field measurements will be presented on the HPC website and in a brochure.

Task 6
Information dissemination. At least three good examples from each participating country will be presented on the IEA HPC website. Guidelines for 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 this Annex 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, used for the supply of domestic hot water and heating in family houses. It is thus dedicated to small systems in the range of 5 to 20 kW.

Any type of solar collector can be considered: using a liquid heat transfer fluid, air, hybrid collectors, or even hybrid thermal and photovoltaic or photovoltaic-thermal (PVT) collectors. All of them can be glazed or unglazed.

Any type of heat source for the heat pump can be considered: air, water or ground source. The main focus will be on heat pumps driven by electricity, as the market is so oriented.

The Annex is a joint effort of the Solar Heating and Cooling Programme and the Heat Pump Programme (HPP). It is Task 44 for SHC and Annex 38 for HPP.

A report entitled "A Review of Market-Available Solar Heat Pump Systems" was produced by Subtask A in 2012. Over 70 companies have been contacted, and more than 120 systems reported. The analysis showed that most systems are designed for both heating and DHW, and most use flat plate collectors. The great majority of systems on the market combine solar collectors and heat pumps in a parallel architecture around a common DHW tank.

Subtask B, working on performance indicators, has produced its final report, containing all definitions of possible seasonal performance factors. These SPFs have been defined along necessary boundaries inside a solar and heat pump system, with two environmental indicators having been agreed upon: the Primary Energy Ratio and the Global Warming Potential.

The modelling subtask, Subtask C, has defined the common framework for simulations that national teams should use to analyse their combinations of heat pumps with solar heating. Four working groups: solar collectors, ground heat exchangers, heat pumps, and heat storage, have issued a report – "Models of sub-components and validation", in which existing and new component models for dynamical system simulations are described.

Annex 38 has published a second newsletter in June 2012, available on the Annex web site, and many publications at several international conferences.

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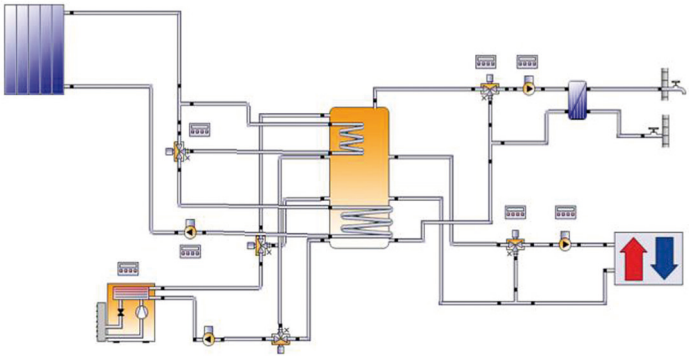
SOLAR + HEAT PUMP



Simulation of a single storage tank with parallel solar and air heat pump systems

www.iea-shc.org/Task44

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, JP, KR, NL, **SE**, US

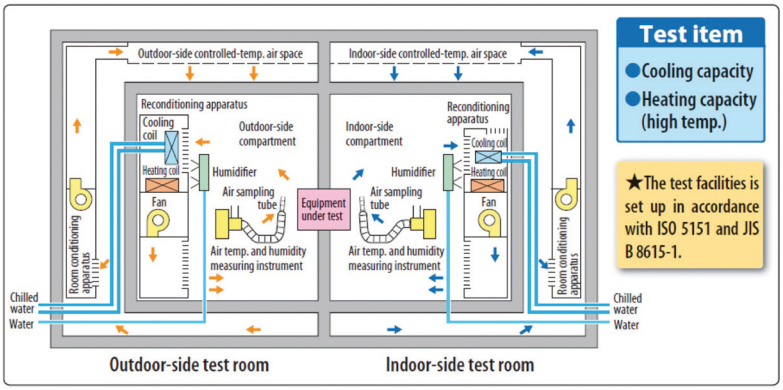
The outcome from Annex 39 will be proposals for a common transparent SPF calculation method for domestic heat pumps, including heating, cooling and domestic hot water production, as well as proposals for global harmonization of test points, to minimize testing efforts. The idea is to conduct pre-normative research, which later can be incorporated in standardization (ISO, CEN, etc.) 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 summarized.
Task 2: Development of a matrix defining needs for testing and calculation methods
Task 3: New calculation methods 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

Two meetings were held in 2012, one in Chicago during the ASHRAE winter meeting, and one in Nürnberg during the Chillventa fair. Information on national and international standards has been collected and analysed, and a SWOT analysis of current standards has been made. In addition, Japan has compiled information on test laboratory accuracy which can serve as a benchmark for minimum requirements in testing. What is extra interesting is the detailed schematics of the set-up of the test equipment.

The Netherlands and Japan have joined the Annex in 2012. The project website, www.heatpumpcentre.org/Annex39 has been set up and contains material from the first meetings and the open workshop that was organised in conjunction with the Heat Pump Summit in Nürnberg 2011.



Balanced ambient room-type calorimeter

Annex 40
Heat Pump Concepts for Nearly Zero-Energy Buildings

Participating countries: CH, JP, NL, NO, SE, US

Outline

Political targets indicate that NZEB are the next step of high-performance buildings. Europe and the USA will both see a broad introduction of NZEB in the new building sector by 2020. In Japan, too, high-performance buildings and heat pumps are seen as key technologies to assist in combating climate change. However, although political targets focus strongly on NZEB, a consistent definition of the various aspects of NZEB has not yet been established.

Heat pumps are already well established in HVAC systems in NZEBs that have been built. However, current NZEBs are essentially prototypes for confirming the zero-energy function. The objective of this annex is therefore to investigate and further develop customised heat pump system designs for the particular requirements of NZEBs. Potentials for further development are seen in building and system integrations, since the NZEB concepts comprise renewable energy sources on-site.

The principal objectives are:

- to improve and further develop heat pump systems for NZEB
- to gather more field experience from operation of novel and existing heat pumps in NZEB
- to develop recommendations and best practice systems for heat pump use in NZEB

Annex 40 has been structured into **four** tasks:
Task 1: State-of-the-art survey of NZEB and applied technologies used in them
Task 2: Optimisation of system concepts in terms of performance and cost
Task 3: Technology development and field-testing of systems (in parallel with Task 2)
Task 4: Integration of NZEB into the energy system (in parallel with Task 2)

Activities in 2012

Annex 40 started in July 2012 with a kick-off meeting at the HSR in Rapperswil, Switzerland. It is therefore in its starting phase, and participating countries joined during the autumn of 2012. Additional countries - Belgium, Canada, Finland, and Germany - are interested in joining. Participating countries have started work on Task 1, the state-of-the-art analysis. It concentrates on the state of the art of the political framework and current definitions of NZEB, existing NZEBs and installed building technologies in the different countries, as well as existing field experience of NZEB in operation. Task 1 should be finished by April 2013, for discussion at the working meeting in May. This meeting will also prepare the following Task 2 for a systems analysis and optimisation, and Task 3 for the technology development and field monitoring. Task 4 is concerned with the integration of NZEB into the wider energy system, where aspects such as storage integration, control and the use of IC technologies may become important.

Group photo, kick-off meeting HSR Rapperswil, Switzerland, July 2012

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Annex 41

Cold Climate Heat Pumps (Improving Low Ambient Temperature Performance of Air-Source Heat Pumps)

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Participating countries: JP, **US**

In May 2012, the HPP ExCo approved IEA HPP Annex 41 with a starting date of July 2012, expected to run through September 2015. Heat pump technology provides a significant potential for CO_2 emissions reduction. This annex will revisit research and development work in different countries to examine technology improvements leading to successful heat pump experience in cold regions.

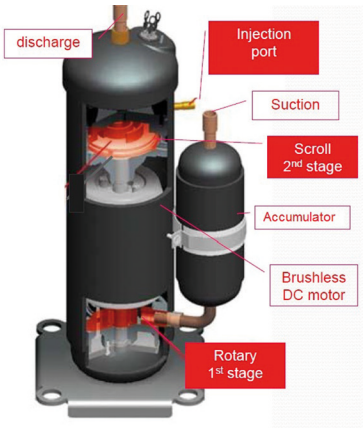
The primary focus is on electrically driven air-to-air or air-to-water air-source heat pumps (ASHP), with air or hydronic heating systems, since these products suffer severe loss of heating capacity and efficiency at lower outdoor temperatures. Thermally activated (engine-driven, absorption, etc.) ASHPs and ground-source heat pumps (GSHP) may also be included in individual country contributions if desired. The main technical objective is to identify solutions leading to ASHPs with heating SPF ≥ 2.63 W/W. The main outcome of this Annex is expected to be information-sharing on viable means to improve ASHP performance under cold (≤ -7°C) ambient temperatures.

Two organizational meetings were held in 2012 with representatives from Canada, Japan, and the US – June 23 in San Antonio, TX, USA and October 10, 2012 in Nürnberg, Germany.

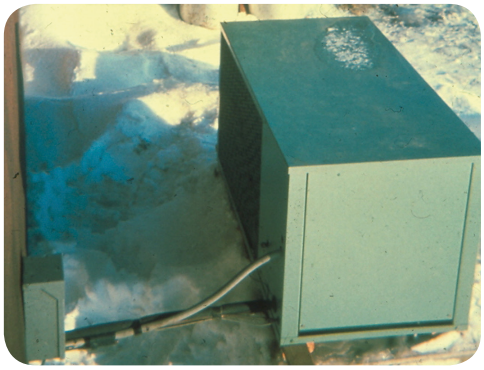
The Annex work is divided into four tasks.

Task 1 is dedicated to a thorough review of prior RD&D activities related to heat pump applications in cold climates to identify potential equipment and system options for detailed evaluation. In Task 2, detailed analyses of promising component/system concepts are performed, considering the system performance and cost implications as well as design and control issues. Laboratory prototype and field prototype testing may be included in this task as well. Task 3 will involve seasonal/annual performance simulations based on the prototypes developed in Task 2 to estimate energy and emissions savings potential. Task 4 is dedicated to development of a final report comparing CCHP design options on a common format.

A 1st working meeting is planned to be held in the US at Purdue University in mid-2013 with a 2nd meeting and open workshop planned for May 2014 at the 11th IEA Heat Pump conference in Montreal. The final Annex meeting is planned to be held in Japan in August 2015 in conjunction with the next IIR International Congress of Refrigeration. Currently Japan and the US (OA) are the only official participants in this Annex, but Austria, Canada, and Italy have all expressed interest in joining. The Annex remains open to new members at least through mid-2013 so other HPP member countries are strongly encouraged to join.



Left: Diagram of two-stage (scroll+rotary) compressor.



Right: Photo of outdoor section of typical US split system ASHP in cold location

Annex 42
Heat Pumps in Smart Grids

Participating countries: DE, FI, KR, **NL**, US

After discussing this item as a potential subject for an Annex in fall 2011, the legal text was further developed in close cooperation between the IEA Heat Pump Centre in Sweden and the undersigned during summer 2012. Initial presentations at the HPP Symposium in Nürnberg in October 2012 about, at that time, the 'Proposed Annex' were received very well by delegates of the member states within the HPP.

During the National Teams' meeting, the member states gave their input for further detailing and elaboration of the legal text. The conclusion at the end of this meeting was that more or less 'a full house' of member states intended to join and support the Annex.

At the ExCo meeting in November in London, a final presentation and brief discussion of the proposed Annex led to a clear positive vote by the ExCo delegates. Commitment to the Annex 42 was expressed by, amongst others, Sweden, USA, Korea, Finland, Germany, The Netherlands, and Austria. Several other member states consider participating in this Annex 42 in due course as well.

Status of activities:

- SP will send the legal text to the ExCo members for electronic approval.
- Template notification letters have been sent to the member states in which they can officially confirm their participation to the IEA office in Paris, HPP and the Operating Agent.
- The first version of a planning scheme is being drafted.
- An online project management tool in ActiveCollab is equipped to enable all participants from all over the world to cooperate within one single online project management environment.
- The first meeting of the Annex 42 project group is foreseen at the 16th of May 2013 (after the EHPA General Assembly and Heat Pump Forum at the 14th and 15th in Brussels).

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Annex 43
Fuel Driven Sorption Heat Pumps

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Participating countries: DE, UK

In parallel with the work on Annex 34, "Thermally Driven Heat Pumps for Heating and Cooling", it became apparent that there was increasing interest in the field of fuel-driven sorption heat pumps, with a growing number of products approaching market release. The work of Annex 34 showed that the fields of solar thermal cooling and fuel-driven heat pumping need to be treated separately for wider market penetration, with the result that a common understanding to continue this work in two different annexes or tasks emerged. The work of Annex 34 concerning solar thermal cooling will therefore be continued as part of the IEA-SHC Task 48 "Quality Assurance and Support Measures for Solar Cooling", while a new annex, "Fuel-driven Sorption Heat Pumps", was proposed to the ExCo in March 2012 for continuation of the work on fuel-driven heat pumps. After an annex definition meeting, a legal text was compiled and accepted by the ExCo in draft form, so a start in May 2013 is planned.

The scope of the work of this Annex will cover the use of fuel-driven sorption heat pumps in domestic and small commercial or industrial buildings applications. If appropriate, the additional possibility of supplying cooling will also be considered.

The planned structure is as follows:

Task A - Generic Systems and System Classification
- Available sources and heating systems
- Existing market and regulatory boundary conditions
- Control strategies
- Evaluate different fuels (oil, gas, wood -> no hot water)

Task B - Technology Transfer
- Link research to industrial development for faster market penetration of new technologies
- Novel materials (e.g., MOFs for adsorption heat pumps)
- Novel components (integrated evaporators/condensers, compact heat exchangers)
- System designs (e.g., façade collector as a heat source)

Task C - Field test and performance evaluation
- Measurement/monitoring procedures standardisation (e.g., how to cope with different fuel qualities, system boundaries, auxiliary energy etc.)
- Continue work from Annex 34 and Task 44, and extend standards to seasonal performance factors at system level
- Develop quality insurance procedures in cooperation with IEA-SHC Task 48

Task D - Market potential study and technology roadmap
- Simulation study to evaluate different technologies in different climate zones, different building types and different building standards
- Combine with market data and actual building stock for technology roadmap

Task E - Policy measures and recommendations, information
- Dissemination
- Workshops for planners, installers and decision makers
- Technology road show
- Develop recommendations for policies, e.g., building codes and funding schemes.

So far, several countries have expressed interest in joining, but of course more participants are welcome. A kick-off meeting is planned in May 2013, and a duration of four years is expected.

Image sources

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Audience, IEA HPP Symposium, Oct 2012. NuernbergMesse/Thomas Geiger
Prof Per Lundkvist, lab tour, Stockholm, May 2012. Johan Berg, HPC
Prof Hermann Halozan, IEA HPP Symposium, Oct 2012. NuernbergMesse/Thomas Geiger
Discussions, NT meeting, Oct 2012. Johan Berg, HPC

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Dr Monica Axell and Peter Wagener, Chillventa fair, Oct 2012. Johan Berg, HPC
Interview for Swedish television. Rainer Jakobs, HPP Workshop, Stockholm, May 2012. Johan Berg, HPC
Group photo, HPP workshop, Stockholm, May 2012. Johan Berg, HPC
Prof Hermann Halozan, IEA HPP Symposium, Oct 2012. NuernbergMesse/Thomas Geiger

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Group photo. Annex 34

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Implementation of heat pumps in industrial processes. DTI Denmark/RdF R&D France

Annex 37 (p. 14)
Dr Marcus Olsson, IEA HPP Symposium, Oct 2012. NuernbergMesse/Thomas Geiger
Heat pump installation, *not a good example*. Johan Berg, HPC

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IEA Solar Heating and Cooling Implementing Agreement logotype. Annex 38
Simulation of single storage tank with parallel solar and air heat pump systems. Annex 38

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Prof Carsten Wemhöner, *Heat Pump Summit 2011,* NuernbergMesse /Frank Boxler
Group photo, kick-off meeting HSR Rapperswil, Switzerland, July 2012. Annex 40

Annex 41 (p. 18)
Van Baxter, IEA HPP Symposium, Chillventa congressing. NuernbergMesse/Thomas Geiger
Diagram of two-stage (scroll + rotary) compressor. Mitsubishi Heavy Industries, Japan
Photo of outdoor section of typical US split system ASHP in cold location. Jerry Groff, USA

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