heat pump programme

IEA
OECD

Annual Report 2003

Heat Pump Programme

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

International Energy Agency

Contents

Ongoing Annexes

Bold text indicates Operating Agent.

*** Annex 16** IEA Heat Pump Centre	16	AT, JP, **NL**, NO, UK, US
Annex 25 Year-round Residential Space Conditioning and Comfort Control Using Heat Pumps	25	**FR**, NL, SE, US
Annex 26 Advanced Supermarket Refrigeration/Heat Recovery Systems	26	CA, DK, SE, UK, **US**
Annex 27 Selected Issues on CO_2 as a Working Fluid in Compression Systems	27	CH, JP, **NO**, SE, UK, US
Annex 28 Test procedure and seasonal performance calculationfor residential heat pumps with combined space anddomestic hot water heating	28	AT, CA, **CH**, FR, DE, JP, NO, SE, UK, US

* concluded 15-16 May 2003

IEA Heat Pump Programme participating countries: Austria (AT), Canada (CA), France (FR), Germany (DE), Italy (IT), Japan (JP), Mexico (MX), The Netherlands (NL), Norway (NO), Spain (ES), Sweden (SE), Switzerland (CH), United Kingdom (UK), United States (US).

International Energy Agency

The International Energy Agency (IEA) was founded in November 1974 as an autonomous body within the Organization for Economic Co-operation and Development (OECD) to implement an international energy program. Membership consists of 25 of the 29 OECD member countries.

Activities are directed towards the IEA Member countries' collective energy policy objectives of energy security, economic and social development, and environmental protection.

One important activity undertaken in pursuit of these goals is a programme to facilitate co-operation to develop new and improved energy technologies and introduce them into the market. Activities are set up under Implementing Agreements, which provide the legal mechanism for establishing the commitments of Participants and the management structure to guide the activity.

Implementing Agreements are independent bodies operating in a framework provided by the IEA, and hence take full responsibility for their work programmes and publications.

There are more than 40 currently active Implementing Agreements encompassing activities relating to fossil fuels, renewable energy, efficient energy end-use, fusion power and information dissemination. This publication concerns the "Implementing Agreement for a Programme of Research, Development, Demonstration and Promotion of Heat Pumping Technologies", more commonly known as the IEA Heat Pump Programme.

Programme Co-ordination

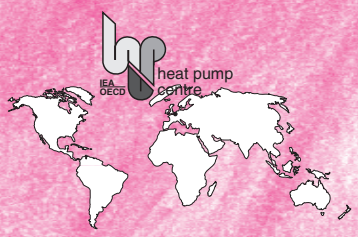
Novem
PO Box 17
6130 AA Sittard
The Netherlands
Tel.: +31 46 420 2244
E-mail: hpp@novem.nl

Effective 1 January 2004, the Programme is co-ordinated by SP, Sweden, tel. +46 33 16 5519

The IEA Heat Pump Programme

The Heat Pump Centre

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



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

Close links have been forged with other international organisations concerned with heat pumps, including:

- *International Institute of Refrigeration (IIR)*
- *American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)*
- *United Nations Environment Programme (UNEP)*
- *European Heat Pump Association (EHPA)*

Organised under the umbrella of the International Energy Agency in 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. The participating countries are:
Austria • Canada • France • Germany • Italy • Japan • Mexico • Netherlands • Norway • Spain • Sweden • Switzerland • United Kingdom • United States.

Mission

The Programme serves the needs of policy makers, national and international energy and environmental agencies, utilities, manufacturers, designers and researchers. It also works through national agencies to influence installers and end-users.

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

Strategic Objectives

Environmental

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

Market and Deployment

To develop and deliver information to support appropriate deployment

Technology

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

Information management

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

Activities

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

There were two meetings of the Executive Committee in 2003:

- 15-16 May in Trondheim, Norway
- 28-29 October in Borås, Sweden

Chairman's Statement 2003

Roger Hitchin,
ExCo Chairman

I took over the chair of the Heat Pump Programme partway through the year, after the ExCo meeting in Norway. The first thing I have to say is to pay tribute to the energy and drive that the previous chairman, Rune Aarlien, provided, not least in the necessary but time-consuming process of re-tendering the Heat Pump Centre. Rune is a difficult act to follow.

The primary strategic objective of the Programme is to produce environmental benefits. To achieve this, it is not sufficient to develop new technology: the technology has also to be deployed, which means that it must meet the needs of the market place. It is good to see that Annexes 27 and 28 have commercial and market value.

This year the ExCo has come up with plenty of promising ideas for worthwhile new activities. Our challenge for 2004 is to translate them into action. Annex 29 – "Ground-Source Heat Pumps: Overcoming Market and Technical Barriers" is already getting under way.

A trend that has been developing over the last few years is towards co-operation with other organisations, and with other parts of IEA. We already have formal links with the IIR, and during 2003 we have established a similar agreement with the European Heat Pump Association (EHPA). Their strengths and ours ought to be complementary, and we look forward to mutually beneficial collaborations.

We also need to work at collaboration with other IEA Programmes and with the IEA Secretariat. The Secretariat has more experience of dealing with policy issues, and more access to policy makers, than do the IEA Programmes. IEA workshops have proved to be an opportunity to work together and to build better links.

Heat pumps are not simply an independent technology. They are usually components of larger energy systems. I am pleased to say that I was able to attend part of the DHC Programme ExCo meeting during 2003, at which we compared our ideas for new activities. We have also established communications with the building-focused ECBCS Programme to explore possible overlaps of interest, and plan to have a joint session with ECES, the Energy Storage Programme.

Perhaps the most poignant development of 2003 has been the change of operator of the Heat Pump Centre from Novem, the Netherlands to SP, Sweden. While we look forward to working with new friends, there is more than a touch of regret at saying goodbye to old ones, who have served the Programme well for more than 14 years. So, thank you Jos Bouma and all your team during my participation in the ExCo, especially to Francien Somers. We wish you well and hope to see you again.

Roger Hitchin
ExCo Chairman

Highlights of 2003

Annex 26 concluded successfully

Annex 26 was the first international project under the IEA Heat Pump Programme that links refrigeration and heat pump technology. The Annex demonstrated that over 10% energy can be saved and global warming (TEWI) reductions up to 60% are possible with low-charge refrigeration systems compared to traditional designs. The conclusions justify that advanced supermarket systems with heat recovery should receive great attention and support. The Annex also included a supermarket spreadsheet model, thorough system cost analyses and proposals for cost reductions. The results of the Annex were presented at the 21st IIR Congress of Refrigeration in Washington.

Annex 29 established

Ground-source heat pumps are increasingly applied because they are cost-effective, user-friendly and good for the environment. More research and development is needed to advance the technology and reduce cost further. The new Annex, which was approved in October, will focus on further improved technical performance, improved cost effectiveness and removing market impediments. Annex work will start in January 2004 and participants include Canada, Germany, Japan Sweden and Austria (operating agent).

Norwegian heat pump industry meets IEA in Trondheim

On May 14 an international heat pump workshop was organised in Trondheim, Norway. The workshop aimed to give a deeper knowledge of the state of heat pump technology in Norway to the IEA country representatives, but also to express the industry's concerns, special needs and hopes about the Programme, thus promoting co-operation among the Programme member countries. The meeting was hosted by Enova SF. Managing Director Ms Eli Arnstad welcomed the participants.

8th IEA Heat Pump Conference announced

The 8th IEA Heat Pump Conference 2005 will be held 30 May-2 June, 2005 in Las Vegas, Nevada, USA. The venue of the conference is the Ceasar's Palace hotel. It will be the second time in history that the USA hosts the conference. The first time was in 1987 in Orlando, Florida, USA.

Agreement with heat pump industry

Collaboration with international organisations is an important strategy for the Programme. In October, during the spring Executive Committee meeting in Trondheim, Norway, an agreement for collaboration with the European Heat Pump Association was signed. Areas of collaboration include, but are not restricted to conferences and seminars, projects, publications such as the newsletter, the Internet and representations.

Signing of the agreement by Mr Roar Rose (EHPA) and Mr Rune Aarlien (IEA)

Programme Achievements 2003

The Heat Pump Centre:

Contact: Mr J. Bouma
Heat Pump Centre
Novem
PO Box 17
6130 AA Sittard
The Netherlands
Tel.: +31-46-4202236
E-mail: hpc@heatpumpcentre.org
Internet: www.heatpumpcentre.org

Participating countries: Austria, Canada, France, Germany, Italy, Japan, Netherlands (Operating Agent), Norway, Mexico, Spain, Sweden, Switzerland, UK and USA.

Activities

The Heat Pump Centre used to be an Annex (16) of the IEA Heat Pump Programme. On 15-16 May 2003, Annex 16 was concluded after almost fourteen year. The Heat Pump Centre continues as the central activity of the Programme with full membership.

2003 was the final year for the Heat Pump Centre in the Netherlands, where Novem was the operating agent. From 1 January 2004, SP in Sweden operates the Heat Pump Centre.

The main activities were publishing the newsletter (the Heat Pump Magazine) and the Annex 26 final reports, providing news and information about Programme accomplishments via the Internet, and providing secretarial support to operating agents and the Executive Committee.

The Heat Pump Centre also contributed to the development of new Programme activities. A Special Task proposal was developed on the role of heat pump systems in a sustainable energy structure. The Task includes an assessment of the CO_2 emission reduction potential in selected countries, when traditional heating systems are replaced by heat pumps. That will provide an indication to what extent heat pumps can contribute to achieving national Kyoto target commitments. Such information could be relevant for policymakers.

International collaboration

The first Programme collaboration agreement was made with the International Institute of Refrigeration (IIR) a few years ago. The Institute held its 21st Congress of Refrigeration in August in Washington, DC, USA. At that occasion, Programme results were presented at a short course on Advances in Supermarket Refrigeration. The results of Annex 26 were presented by operating agent Oak Ridge Laboratory and the results of the study Refrigerant Recovery, Recycling Reclamation and Disposal were presented by the Heat Pump Centre.

Publications
New publications launched in 2003:

- Refrigerant Recovery, Recycling, Reclamation and Disposal – Part 2;
- Advanced Supermarket Refrigeration/Heat Recovery Systems – executive summary book and country studies CD (embargo).

Publications can be ordered from the Heat Pump Centre via e-mail: hpc@heatpumpcentre.org

Annex 26: Advanced Supermarket Refrigeration/Heat Recovery Systems

Participating countries: Canada, Denmark, Sweden, UK and USA (Operating Agent).

Because there are world-wide a great number of supermarkets that offer frozen and chilled food and further growth of this sector may be expected, the amount of energy used for refrigeration is enormous and will likely increase substantially in the near future.
Annex 26 analysed several advanced supermarket refrigeration systems and came to remarkable conclusions as far as energy conservation and TEWI reduction is concerned (see section Highlights).

The work of the Annex was concluded in 2002. In 2003, the final reports were completed, which consist of a summary report and a CD with detailed country studies. This Annex has been the first within the Programme to combine refrigeration and space conditioning and was a great success. Plans exist to continue work in this area with a new Annex.

Contact: Mr Van D. Baxter
Oak Ridge National Laboratory
Building Technology Center
PO Box 2008, Bldg. 3147, MS-6070
Oak Ridge, TN 37831-6070
USA
Tel.: +1-865-5742104
E-mail: vdb@ornl.gov

Annex 27: Selected Issues on CO_2 as Working Fluid in Compression Systems

Contact: Rune Aarlien
SINTEF Energy Research
Refrigeration and Air Conditioning
N-7465 Trondheim
Norway
Tel.: +47-73-593929
E-mail:
Rune.Aarlien@energy.sintef.no

Participating countries: Japan, Norway (Operating Agent), Sweden, Switzerland, (United Kingdom, partly for 2001) and the United States.

The main objective of Annex 27 was to bring CO_2 heat pumping technology closer to commercialization, by addressing issues of both basic and applied nature. The scope of the work included compression heat pump, refrigeration and air conditioning systems and components. Each of the contributing research teams conducted individual projects.

The projects were grouped in six different categories:
- Literature survey;
- Systems;
- Heat transfer;
- Compressors;
- Safety issues;
- CO_2 as secondary refrigerant.

One project evaluated the use of a compact CO_2 cooler in a standard freezer with thermosyphon evaporator and condenser, while another project explored the feasibility of transcritical CO_2 systems in mobile space conditioning. CO_2 heat transfer phenomena were analyzed in three experimental studies. As a result, a new correlation of heat transfer coefficient was proposed and another correlation for supercritical CO_2 was developed. Heat transfer and pressure drop phenomena were also studied in a multi-port extruded aluminum micro tube configuration. In addition, flow vaporization phenomena and two-phase flow patterns were studied.

The Annex included design, manufacturing and performance testing of a small oil-free CO_2 compressor, a promising alternative to oil-lubricated compressors in automotive air conditioning, domestic water heating and applications in food industry.

A major safety issue for CO_2 is related to the high operating pressure leading to the study of explosion energies. For supermarket refrigeration, CO_2 is a promising alternative to artificial refrigerants. From the analysis it is clear that using CO_2 in supermarket refrigeration does not introduce health risks for people in the shopping area.

The projects show that CO_2 is a very promising refrigerant candidate in a series of application areas. It is the hope of the participants that Annex 27 has contributed to filling some of the holes in the CO_2 technology.

Annex 28:

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

Participating countries: Austria, Canada, France, Germany (partly), Japan, Norway, Sweden, Switzerland (Operating Agent), UK and USA

The heat demand for domestic water heating compared to space heating is growing steadily. The overall efficiency for both functions is decisive for heat pump systems with combined space and water heating. However, existing test procedures are restricted to separate space heating (or cooling) and separate water heating. Annex 28 will investigate the testing of the most common integrated heat pump systems using four different methods.

There are two objectives. The first objective is to establish a test procedure, which yields the necessary data in order to calculate the overall Seasonal Performance Factor of such heat pump systems with a minimum requirement for testing equipment and testing time. The second objective is to work out an easy method to calculate the Seasonal Performance Factor for integrated heat pump systems.

The Annex has been structured around three Tasks:

- Task 1 - Systems investigation.
  This Task has been completed and included an analysis of systems available on the market and the state of the art in standardisation. It was concluded that the most common installations are alternately operating systems of two configurations: condenser/intermediate circuit systems and two condenser systems.

- Task 2 - Developing a test procedure.
  Output data from the test procedure may also serve to further characterise the components involved, for instance operational limits etc. Subtasks of Task 2 are assessment of existing test procedures for integrated systems, determination of missing items for the testing and development of a comprehensive test procedure.

- Task 3 - Developing a calculation method for the overall Seasonal Performance Factor.
  Subtasks are assessment of existing calculation methods and missing items, definition of needed data and development of the calculation method.

The work of the Annex ties in with that of international standards making organizations. Therefore, an official liaison has been established among CEN/TC 113 and Annex 28. A liaison wit CEN/TC 228 will be established.

Contact: Mr Carsten Wemhöner
University of Applied Sciences
Basel
Institute of Energy
CH-4132 Muttenz, Switzerland
Tel.: +41 61 467 4573
E-mail: c.wemhoener@fhbb.ch

Programme Contacts

AUSTRIA
Dr Hermann Halozan
Technical University of Graz
Institute of Thermal Engineering
Inffeldgasse 25,
8010 Graz
Tel.: +43-316-8737303
halozan@iwt.tu-graz.ac.at

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

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

GERMANY
Dr Claus Börner
Forschungszentrum Jülich GmbH
PO Box 1913
52425 Jülich
Tel.: +49-2461-613816
c.boerner@fz-juelich.de

ITALY
Mr Marco Brocco
ENEA
C.R.E. Casaccia
Via Anguillarese 301
00100 Rome
Tel.: +39-06-3048 4948
brocco@casaccia.enea.it

JAPAN
Mr. Kazuhiko Hombu
Research and Development Division
Industrial Science and Technology Policy and Environment Bureau
Ministry of Economy, Trade and Industry (METI)
1-3-1, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8901
Japan
Tel. +81 3 3501 9221
ohhashi-yoshiteru@meti.go.jp
(Attn: Mr Kazuhiko Hombu)

MEXICO
Dr Roberto Best
Departamento de Sistemas Energéticos
Centro de Investigación en Energia de la UNAM
Apartado Postal 34,
62580 Temixco, Morelos
Tel.: +52-5-622 9736
rbb@mazatl.cie.unam.mx

THE NETHERLANDS
Mr Erik Wissema
Ministry of Economic Affairs
Directorate Energy Production
Cluster Renewable Energy
P.O. Box 20101
2500 EC The Hague
Tel.: +31-70-379-7718
E.w.j.wissema@minez.nl

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

SPAIN
Mr Angel Chamero
Ministerio de Economia
Paseo de la Castellana 160
28071 Madrid
Tel.: +34-91-349-7426
achamero@mineco.es

SWEDEN
Dr Björn Sellberg
FORMAS
PO Box 1206
S-11182 Stockholm
Tel.: +46-8-775 4028
bjorn.sellberg@formas.se

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

UK
Mr Jeremy Tait
AEA Technology plc
ETSU
Project Manager/Refrigeration
Utilities
156 Harwell, Didcot
OXON OX11 OQJ
Tel.: +44-1235-433611
jeremy.tait@aeat.co.uk

USA
Mr John D. Ryan
US Dep. of Energy, EE-40
1000 Independence Avenue, SW
Washington DC 20585
Tel.: +1-202-5868823
john.d.ryan@ee.doe.gov

Summary of the 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, UK, USA	1980
2. *Vertical Earth Heat Pump Systems*	Sweden	Austria, Canada, Denmark, Sweden, USA	1983
3. *Heat Pump Systems Applied in Industry*	Belgium	Austria, Belgium, Canada, Denmark, Finland, Germany, Italy, Japan, the Netherlands, Sweden	1984
4. *IEA Heat Pump Centre*	Germany	Austria, Belgium, Canada, Finland, Germany, Italy, Japan, the Netherlands, Norway, Sweden, USA	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, USA	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, USA	1992
9. *High Temperature Industrial Heat Pumps*	Belgium	Belgium, Germany, Finland, Japan, the Netherlands, Sweden, Switzerland, USA	1990
10. *Technical and Market Analysis of Advanced Heat Pumps*	USA	Sweden, USA	1991
11. *Stirling Engine Technology for Application in Buildings*	USA	Japan, Sweden, USA	1989
12. *Modelling Techniques for Simulation and Design of Compression Heat Pumps*	USA, Italy	Austria, Belgium, Germany, Italy, Japan, Switzerland, USA	1992
13. *State and Transport Properties of High Temperature Working Fluids and Non-Azeotropic Mixtures*	Sweden	Canada, Germany, Japan, Norway, Sweden, USA	1992
14. *Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps*	Japan	Belgium, Denmark, Germany, Japan, Sweden, USA	1991

Annex	Operating Agent	Participants	Completed
15. Heat Pump Systems with Direct Expansion Ground Coils	Canada	Austria, Canada, Japan, USA	1993
16. IEA Heat Pump Centre	The Netherlands	Austria, Japan, the Netherlands, Norway, UK, USA	2003
17. Experiences with New Refrigerants in Evaporators	Sweden	Canada, the Netherlands, Norway, Sweden, Switzerland	1993
18. Thermophysical Properties of Environmentally Acceptable Refrigerants	USA	Austria, Canada, Germany, Japan, Sweden, UK, USA	1999
19. Cancelled			
20. Working Fluid Safety	Belgium	Belgium, Japan, the Netherlands, Norway, Switzerland	1993
21. Global Environmental Benefits of Industrial Heat Pumps	USA	Canada, France, Japan, the Netherlands, Norway, Sweden, UK, USA	1996
22. Compression Systems with Natural Working Fluids	Norway	Canada, Denmark, Japan, the Netherlands, Norway, Switzerland, UK, USA	1999
23. Heat Pump Systems for Single-Room Applications	Canada	Canada, France, Switzerland, Sweden, US	1999
24. Ab-Sorption Machines for Heating and Cooling in Future Energy Systems	Sweden	Canada, Italy, the Netherlands, Norway, Japan, Sweden, UK, USA	2000
25. Year-Round Residential Space Conditioning Systems using Heat Pumps	France	France, the Netherlands, Sweden, USA	Ongoing
26. Advanced Supermarket Refrigeration/Heat Recovery Systems	USA	Canada, Denmark, Sweden, UK, USA	2003
27. Selected Issues on CO_2 as Working Fluid in Compression Systems	Norway	Japan, Norway, Sweden, Switzerland, UK, USA	Ongoing
28. Test Procedure and Seasonal Performance Calculation of Residential Heat Pumps with Combined Space and Domestic Hot Water Heating	Switzerland	Austria, Canada, France, Germany (partly), Japan, Norway, Sweden, Switzerland, UK and USA	Ongoing

Publications from all these Annexes are available from the Heat Pump Centre:
http://www.heatpumpcentre.org