IEA Heat Pump CENTRE
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IEA OECD heat pump programme

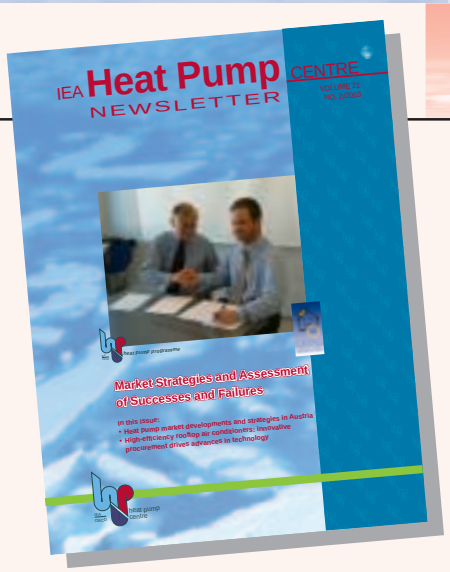
EUROPEAN HEATPUMP ASSOCIATION

Market Strategies and Assessment of Successes and Failures

In this issue:

- **Heat pump market developments and strategies in Austria**
- **High-efficiency rooftop air conditioners: innovative procurement drives advances in technology**

IEA OECD heat pump centre



In this issue

Market Strategies and Assessment of Successes and Failures

Market strategies for introducing heat pumps can be initiated by governments, utilities, heat pump manufacturers, distributors and installers. Ideally, all these groups work together effectively, but reality shows something else. This newsletter highlights different market strategies which have succeeded and others that have failed. By learning of the failures, market strategies can be implemented more carefully in the future.

Front cover: Signing of the collaboration agreement between Heat Pump Programme and European Heat Pump Association.

COLOPHON

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HEAT PUMP NEWS

FEATURES

TOPICAL ARTICLE

NON-TOPICAL ARTICLE

The activities of the European Heat Pump Association

The EHPA was founded in February 2000 with the rationale of developing the market for heat pump technology in Europe as part of an initiative to create a more energy sustainable Europe. The EHPA has now 34 members in 17 countries.

Strategic relationships

The EHPA does not seek to duplicate work that is being done in other organisations. We seek to reach out to other like-minded organisations.

We have recently signed a Framework Agreement for Collaboration with the IEA Heat Pump Programme, which we hope, will lead to beneficial co-operation between our two organisations.

AREA, the European Association of Heating Equipment Installers has become a member of the EHPA and we look forward to working with them on developing materials for educating installers of heat pumps.

The DACH organisation has offered to work with the EHPA to expand its labelling scheme for heat pumps to countries other than Germany (D), Austria (A) and Switzerland (CH), the founding members.

EHPA initiatives

Labelling of heat pumps has become much more relevant with the passing of the new EU directive on energy labelling of room air conditioners, which can also have a heating function. We are currently exploring the possibility of so-called eco-labelling and have had some initial discussions with the European Commission about the feasibility of developing such a labelling scheme.

Transfer and adaptation of knowledge from countries with mature markets to those with emerging markets is a key task. Austrian member Arsenal Research organised an initial workshop in Vienna in April to examine the status of education and training of installers.

Markets

Whilst the initial focus has been on replacing direct (electric) heating by a more efficient form of heating (or heating and cooling), the longer term has to focus on how heat pumps can help provide sustainable solutions for replacing oil heating in some 30 million EU dwellings. Gas is not generally available and together with oil, it will become progressively more expensive as supply saturates whilst demand continues to increase. Electrical heat pumps and biomass-fired boilers are the most likely technologies to replace this technology in the European region.

So big challenges still lie ahead and the EHPA is keen to work closely together with those organisations and companies willing to help us meet our goals.

Rayner M. Mayer,
Chairman European Heat Pump Association
www.ehpa.org

General

International workshop: the heat pump, present and future

Spain - In connection with the IEA Heat Pump Programme Executive Committee, a workshop was hold the day before the Ex-Co Meeting took place in Madrid on 24th and 25th October 2002. In order to facilitate the interaction between the members of the Heat Pump Programme and the Spanish professionals in this sector, the Spanish National Team on Heat Pumps (ENEBC) organized this technical workshop.

The workshop aimed to accomplish two goals:
- to provide the international representatives with a deeper knowledge of the state of this technology in Spain
- to allow the sector to express its worries, needs and prospects to all those present, thereby promoting international cooperation among the Programme member countries.

The session was opened by Mr. Luis Iglesias, Deputy Director General of Energy Planning from the Ministry of Economy, on behalf of Mrs Carmen Becerril, Director General of Energy Policy and Mines. It was closed by Mr Arturo González, Director General of Technology Policy from the Ministry of Science and Technology. Mr Ángel Gómez from ATECYR, Spanish Technical Association for Air Conditioning and Cooling, was the workshop chairman.

The workshop was divided into three different areas: Technology, Markets and New Projects.

Technology

Applications and experiences of Iberdrola in domotic controlled dwellings
Mr. Jose Carlos Toledano, IBERDROLA

Iberdrola, one of the major power utilties in Europe, carried out the installation and supplied the equipment for six 'all-electric' domotic controlled dwellings.

The most relevant features of the six demonstration dwellings are:
- dwellings are permanently inhabited;
- dwellings are open to professional visitors;
- leaflets and videos developed about each dwelling are distributed among the professionals from the sector;
- dwelling energy consumption data are periodically distributed and compared with similar dwellings that have been equipped with other energy systems;
- equipment is divided into five groups:
  - ✓ Air conditioning via heat pumps
  - ✓ Hot water production
  - ✓ Domotic control
  - ✓ Appliances (including dryers working with heat pump)
  - ✓ Other accessories

Analysis of a heat pump life cycle and of environmental external economic costs
Mr. Francisco Javier Rey, University of Valladolid

The University of Valladolid carried out a study that received the First Prize Garcia Ocejo in Energy Quality of Installations. The study analyzes the life cycle of an air to air heat pump for residential climate conditioning. It comprises three main aspects:
- determination of the emissions produced during the heat pump construction as well as during its operation;
- determination of the environmental impact during the heat pump construction as well as during its operation;
- economic profitability study comparing the heat pump and a gas heater.

Market

Spanish heat pump market
Mr Jose Mª Ortiz, Air Conditioning Equipment Manufacturers Association (AFEC)

The heat pump market development in Spain has shown a spectacular increase and this tendency is expected to continue. Some figures about the evolution of the Spanish heat pump market are shown in **Figure 2.**

'Promising', European project domestic market
Mr. Ángel Gómez Heras, Spanish Technical Association for Air Conditioning and Cooling (ATECYR)

ATECYR has developed a project called Promising with the following challenges:
- improve equipment installer training with an easy and complete tool;
- bring installer closer to the user;
- create a new professional status for installers;
- inform the users in order to change their buying habits.

The installer training tool consists on an easy to use CD that includes:
- technical and comfort concepts, highlighting the most important issues related to installation and assembly;
- a brief description of the systems;
- a sheet for system dimensioning and selection and for energy consumption calculation.

New Projects

The heat pump and renewable energies
Mr. Alberto Coronas, Director of the Technologic Innovation Centre CREVER, Rovira I Virgili University

CREVER, in collaboration with ENEBC, presented a study report on the following five existing installations combining heat

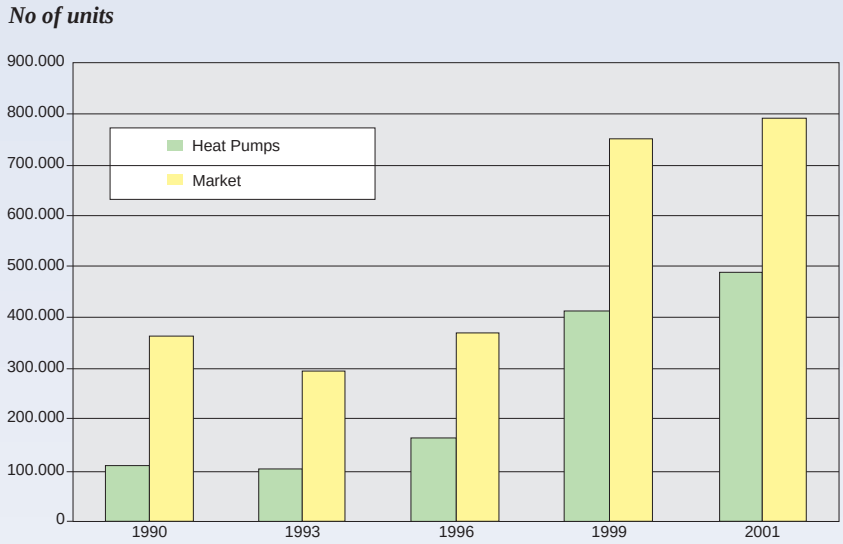

Figure 1: Heat pump and total air conditioner market of Spain

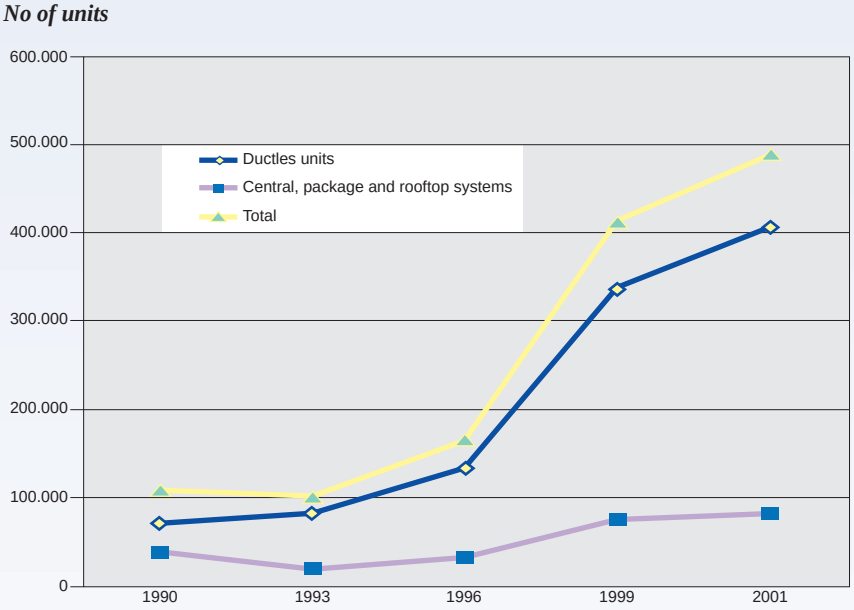

Figure 2: Air conditioner market evolution in Spain

pumps and renewable energy:

1. malt drying with thermal solar energy and heat pump;
2. seawater desalination with hybrid solar technology and heat pumps;
3. geothermal heat pump for heating and cooling in the Mediterranean area;
4. design of a hybrid cooling compression machine with solid desiccants regenerated with low temperature solar energy;
5. development of a compression heat pump with solution circuit, organic fluids and plate heat exchangers for thermal waste recovery.

Heat pump working with propane: applications
Mr. Juan Sáez Cebrián, Director of Industrial Area, CIATESA

CIATESA, in collaboration with other entities, has designed, constructed and tested a reversible heat pump, using propane as working fluid, for heating and cooling in Mediterranean countries, with the aim of increasing the COP by 10% and reducing the working fluid charge by 40%.

The conclusions of the project are that with propane as a working fluid:

- heating and cooling capacity is slightly higher than with R22;
- COP is much higher than with R22;
- working fluid charge is much lower than with R22;
- natural working fluid (zero ozone depleting potential (ODP) and very low global warming potential (GDP);
- working fluid is compatible with mineral oil;
- working fluid is compatible with materials;
- EN378 standard allows the use of propane as working fluid in commercial and residential installations under specific conditions designed to minimize explosion risk;
- equipment design is very similar to conventional equipment design.

IEA Heat Pump Programme

HPP and HPC were represented and introduced by:

Introduction to the IEA Heat Pump Programme
Mr. Rune Aarlien, Chairman, HPP Executive Committee

Annexes
Mr. Jos Bouma, Heat Pump Centre General Manager

The workshop was attended by 75 people, from different organizations with interests in the heat pump sector. Most participants expressed their interest in this technology and expressed their intention to increase their future participation in international activities, which means that the workshop certainly had a measure of success.

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Dutch Heat Pump Quality Mark

Netherlands - The advantages of using heat pump systems include a high comfort level, reduced energy consumption and lower energy costs. Using less energy means less CO_2 emissions and less energy storage. These are additional advantages of using heat pumps.

Energy storage for heating and cooling of commercial buildings is a fairly new, but proven full-fledged technology. Considerable application experience is available with this technology. Energy storage yields substantial savings in energy consumption and therefore in operational costs.

The Foundation for a Dutch Heat Pump Quality Mark (Stichting Kwaliteitskeur Wamtepompen) has been set up to make sure that the quality of these energy-efficient and environmentally friendly heating systems is obtained. The Foundation is independent and aims to implement a quality mark programme for heat pumps applied in the residential, commercial/institutional and if possible, the agricultural sector. The quality mark will give users more certainty and clarity about the performance and reliability of both the product and its suppliers, and will thereby promote the characteristic features of a heat pump. The Foundation has therefore incorporated a number of quality requirements in the test procedures, which are carried out by independent testing institutes.

In 2001 nearly half of the major suppliers in the Dutch market have tested their heat pump according to the Foundation's rules. In an early batch of tests, 4 suppliers were the first to obtain a quality mark during the BouwRAI, a major exposition in the building sector. Among the first suppliers were European companies that offer a wide range of heat pumps.

The Foundation has plans to extend its goals for the years to come. A quality mark for the entire energy system in a building is in course of preparation. This is a big challenge as the environment is complex with a wide variety of actors and rules that are not consistent. It will obstruct present implementation of a system quality mark.

The market becomes increasingly international and some challenges could be met better in a joint effort. Therefore collaboration with European market actors is needed. Internationally operating companies will adhere to established European quality mark organisations. These organisations require local representatives, such as the Foundation for a Dutch Heat Pump Quality Mark.

Manufacturers and suppliers could take a leading role in founding such an international organisation. The Foundation for a Dutch Heat Pump Quality Mark is ready to co-operate with European organisations in the market and will continue to represent the strong position the quality mark has achieved in the Dutch heat pump market.

Source: The Foundation for a Dutch Heat Pump Quality Mark
Stichting Kwaliteitskeur Warmtepompen
www.kwaliteitskeurwarmtepompen.nl

International Congress of Refrigeration announces availability of final invitation and preliminary program

USA - The US National Committee of the International Institute of Refrigeration invites you to its 21st International Congress of Refrigeration (ICR2003). This weeklong event will cover a broad range of refrigeration, cooling and heat pumping technology, and examine the latest research findings from all over the globe. The congress theme, "Serving the needs of mankind," ensures that the IIR, through this congress, provides a forum to share information on better, more efficient, more comfortable, more environmentally acceptable ways to meet the world's growing need for refrigeration.

Whether you have been involved in IIR activities in the past or are involved in other ways with low temperature applications, basic thermodynamics, gas processing, food technology, and/or air conditioning, you will find something of interest to you at ICR2003.

The conference has been designed so that delegates having a specific interest can attend a portion of the congres and focus on their particular interest. We hope you will take advantage of many of the seminars, keynote sessions, technical sessions, short courses workshops, and of course, the social events, where you can meet many of the world's refrigeration experts.

The brochure includes all the basic information registrants need to plan and schedule their attendance at the conference, including dates and times for the various technical sessions, plenary sessions, short courses, technical tours and social program. Also included are the conference registration fee, schedules and information regarding hotel reservations. Over 1000 of the world's leading cooling, heating and refrigeration engineers and scientists are expected to attend this major technical event.

For a copy of the brochure contact the Conference Managers:
Hachero Hill, Inc.
6220 Montrose Road
Rockville, MD 20852
Tel: +1-301-984-9450
Fax: +1-30-984-9411
E-mail: nadine@conferencemanagers.com

The brochure can also be downloaded from the conference internet site, www.icr2003.org. The website also provides author and abstract information for the nearly 450 technical presentations.

Source: Richard Ertinger
Tel: +1-315-451-6145
E-mail: rertinge@twcny.rr.com

ICCR'2003 3rd International Conference in China postponed

China - Due to an outbreak of Severe Acute Respiratory Syndrome (SARS) in Asia, the:

ICCR'2003 3rd International Conference on Cryogenics and Refrigeration in Hangzhou China in April 2003 has had to be postponed even though there have been no cases in Hangzhou. In order to address attendees' concerns about this health issue, the IIR and the organizers at Zhejiang University have decided to postpone ICCR'2003 until autumn 2003. The rescheduled date will be announced as soon as possible.

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E-mail: iccr2003@cmee.zju.edu.cn
http://www.cmee.zju.edu.cn/ICCR2003.htm

First Announcement and Call for Papers for 6th IIR Gustav Lorentzen Conference

UK - This is the first announcement and call for papers for the next International Institute of Refrigeration **Natural Working Fluids: Conference Current applications and opportunities** which will be held in Glasgow Scotland from **29 August to 1 September 2004**.

About the Conference
The conference is being run as a joint Commission conference of Sections B and E of the IIR. The event is being organised by the International Refrigeration Committee of the UK Institute of Refrigeration. The UK Institute is one of the oldest national societies devoted to the advancement of mechanical refrigeration. The conference themes will include the full spectrum of natural working fluids and their applications:
- Ammonia
- Carbon dioxide
- Hydrocarbons
- Water
- Air
- Sorption systems
- Stirling and other systems
- Ice Slurries
- Heat Transfer and Fluid Flow.

Programme outline
A programme of technical visits, tours and courses as well as a social programme will be available. An introductory reception will take place on Sunday 28 August, and the conference dinner will be held with special access to the Hunterian Museum.

Exhibition
A small exhibition space will provide opportunities to display products and services throughout the four day conference.

Information for authors
- Abstracts will due on 1 February 2004.
- Deadline for final papers will be 1 June 2004.

Interested authors should indicate their interest using the website.
Detailed instructions for the preparation of abstracts and papers will be available on the web site at www.ior.org.uk/gl2004

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Technology & applications

Direct Geo-exchange Systems: accessing the earth's energy

USA - ARI's Direct Geo-exchange Systems (DX) product section was formed in 1999 with the aim of coordinating efforts in this unique sector of the air-conditioning and refrigeration market. A geo-exchange system (also known as 'ground coupled' heat pump system) uses a refrigeration compressor to harvest renewable heat energy from the earth. Direct geo-exchange heat pumps eliminate the need for an intermediate plastic water-circulating loop. Refrigerant is circulated through highly conductive copper earth loops, enabling a direct transfer of thermal energy with the earth. The system is mechanically simpler, costs less to install, and operating costs are lower because of higher efficiency.
Future goals for the section include development of a consumer web site, which will help explain the benefits of geothermal heat pump systems.
For more information about this section, contact Henry Hwong, ARI's director of product sections at hhwong@ari.org.

For more information about Geo-exchange Systems, go to www.epa.gov, search for geothermal heat pumps and then refine the search with geo-exchange. Related websites are: www.epa.gov/appdstar/hvac/geothermal.html, www.ghpc.org and www.alliantgeo.com.

Source: Koldfax, April 2003

Energy from ground source water.

Netherlands - The development of the Geo Valve, a new valve for groundwater systems in production since the middle of 2002, makes it possible to reduce the initial cost of groundwater pumps for heat/cold storage and groundwater heat pump systems.

The GeoValve, which combines infiltrating and extracting groundwater, is a device that controls system pressure to keep oxygen out of the water. It replaces the conventional injection device. The main advantage of the new valve, which is relatively small in size and mounted on top of the submerged pump, is that a substantial reduction of the diameter of pump chamber is achieved, reducing the cost of the groundwater pump. The size reduction of the pump chamber has also a positive effect on the lifetime of the pump, due to improved cooling. In addition, the engineering and installation costs are reduced. The estimated overall cost reduction is 15-30% for small and large installations. Out of 145 heat/cold ground storage systems in operation in the Netherlands in 2000, 15 groundwater systems have now been equipped with the new valve.

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Tel: +31-(0)6-10 723 723
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E-mail: michel.hoek@planet.nl
Or see www.geovalve.nl

Source: TVVL Magazine, March 2002, Vol. 31 nr. 3

Innovative energy system

Netherlands - The 'Paleiskwartier' project is a demonstration project to evaluate and monitor an innovative energy system applied in an apartment-complex. The energy system includes heat pumps and energy-storage combined with a big pond as solar-collector and a fuel cell. The energy efficiency of the system is monitored and evaluated, especially the fuel cell.

Contact: W. van der Plas
Tel: +31 (0)172-635335

Source: DWA Installatie- en energieadvies, Spring 2003

Breakthrough in development of gas-fired absorption heat pump by monitoring of the system

Netherlands -Gas-fired absorption heat pumps are not well known in the Netherlands. They have been used on a small-scale in Eersel. Initially, the technical and energy related performance was not very good. Through monitoring the system it became possible to the increase the Primary Energy Ratio (PER) from 1.0 to 1.6. An advantage of gas-fired absorption pumps is that the source equipment can be half the size of a small electrically driven heat pumps, while the efficiency is comparable.

Contact: J. Bahlman
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Source DWA Installatie- en energieadvies, Spring 2003

China develops gas-powered air conditioner

China - A new type of gas-powered air conditioner for household use, the first of its kind worldwide, has been developed in Changsha, Hunan province. Changsha-based BROAD Air Conditioning Co Ltd has invested USD 13.3 million in developing this new product. Research began three years ago. The new air conditioner is designed to be powered by natural gas, coal

gas or liquefied petroleum gas, with an expected operating life of 15 years. It also serves as a water heater. In contrast to the traditional air conditioner powered by electricity, the gas powered model uses lithium bromide as coolant. The new air conditioner will also be more economical than traditional ones, as its operating cost is less than 59% that of an electrically powered system.

Source: People's Daily, 19 March 2003
Asian Energy News, April 2003

CO_2 heat pump awarded

Germany – The first annual Theo-Mack-Award has been presented to the builders of a split air-to-water heat pump unit that uses CO_2 as a refrigerant. The heat pump has been designed for the retrofit market and can supply heat at relatively high temperatures in existing houses. Traditionally, these houses are equipped with a heat distribution system for 90/70˚C or 70/50˚C. The prototype CO_2 heat pump was tested at –7 and 7˚C outdoor air temperature, and it supplied water temperatures at 76 and 52˚C. At these conditions, heating capacities of 11.1 and 18.9 kW were achieved respectively, and the corresponding COP was 1.7 and 2.6. The prototype unit was field tested in Germany in 2002/2003.

Source: CCI InfoSystem Gebäude Technik, No. 7/2003, 37 Jahrgang

Solar air conditioner

UK - A solar air-conditioning system that uses no moving parts has been developed by scientists at the School of the Built Environment at the University of Nottingham. Although not yet available commercially, investors believe there is a potential market in developing nations where a majority of people live 'off the grid'.

For more information contact:
tonym@beaconenergy.co.uk

Source: The HVAC&R Industry for May 1, 2003
Issue: 18 Volume: 2

Need for propane safety standard

Germany - For several years now, flammable refrigerants such as propane have seen use in household refrigerators and freezers. Safety standards for charges up to 150 g are in place, but specific standards do not yet exist. The advantage of using propane compression technology rather than advanced technologies (Stirling, CO_2) is that reliable, mass-produced, and therefore cheaper components can be used.

In the food refrigeration sector, producers have announced their intention to soon switch from HFC refrigerants to other solutions, including propane refrigerant. This requires that new international standards be developed for light commercial hermetic systems with propane charges above 150 g.

In addition to Denmark and Austria, governments in Sweden, Switzerland, Norway and Germany are considering the preparation of HFC decrees. This could stimulate the use of propane in certain applications, such as in the food sector considered here. However, this will also require the development of adequate international standards for these applications.

Source: KI Luft- und Kältetechnik 3/2003

Working fluids

Austrian HFC decree

Austria – The Federal Minister for Agriculture and Forestry, Environment and Water Management, in agreement with the Federal Minister for Economic Affairs and Labour in Austria, has issued a decree that regulates the market introduction and the use of partly fluorinated hydrocarbons (HFC) and fully fluorinated hydrocarbons (PFC) and their use in appliances, equipment and products, including refrigerating and cooling agents. The decree will come into effect as of 1 January 2008. Equipment for export is excluded from the decree.

Source: Austrian National Team

More refrigerators using hydrocarbons

Tokyo – Hydrocarbons are increasingly being used in domestic refrigeration in Japan. A report in the Japan Air Conditioning, Heating & Refrigeration News (JARN) states that in 2001 Matsushita introduced the first model using isobutane (R600a). In 2002, models using isobutane were unveiled by Toshiba, Hitachi, Fujitsu, Sanyo, Misubishi and Sharp. Matsushita remains the most enthusiastic proponent of isobutane. It plans to shift 90% of its output to isobutane. The report says the shift to isobutane is partly the result of environmental factors, but it is also the result of dissatisfaction with HFC-134a due to hydration and clogging

Source: ASHRAE Journal, Feb. 2003

IEA Heat Pump Programme

Important decisions at ExCo meeting

On 15-16 May, the Executive Committee met in Trondheim, Norway on the premises of Enova, the newly established Norwegian Energy Agency. The following are some of the meeting highlights.

New Chair
The new chairman of the Committee is Mr Roger Hitchin of BRE, the Building Research Establishment, Energy Division, at Watford, UK. Mr Hitchin will take on the position for the term of one year, with a possible extension.

8th IEA Heat Pump Conference
The 8th IEA Heat Pump Conference will be held in May 2005 in Las Vegas, Nevada, USA. Mr Peter Rohlin of the Swedish Energy Agency, STEM, has been appointed chairman of the International Organizing Committee.

In this area of the US, there are several opportunities for technical site visits to heat pump installations, including innovative new heat pump demonstration projects. The US will offer a comprehensive programme, building on the excellent history and coordination of past heat pump conferences including the 2nd IEA Heat Pump Conference in Orlando, Florida in 1987.

Collaboration with EHPA
A formal agreement for collaboration between the European Heat Pump Association and the IEA Heat Pump Programme was signed by Mr Rune Aarlien, on behalf of the Programme, and Mr Roar Rose, on behalf of the EHPA. The agreement involves collaboration in several areas including representation at meetings, joint seminars and studies, publications such as the newsletter, the Internet etc.

Signing of the agreement

HPC moves to Sweden
Sweden will be the new Operating Agent of the HPC starting 1 January 2004. The Swedish National Testing and Research Institute, SP, in Borås will operate the HPC from their premises, ending a 13-year period of operation by Novem, the Netherlands.

Annex 26 final reports published

The results of Annex 26, Advanced supermarket refrigeration/Heat recovery systems, are shortly available from the HPC (see also newsletter Vol. 20, Nr 3, page 24-27). The final report consists of two volumes: Vol. 1 – printed Executive Summary (HPP AN26-2) and Vol. 2 – CD ROM Country reports (HPP AN26-3). Vol. 1 is available without restriction. Vol. 2 will remain under embargo for non-participating countries for one year after release of Vol. 1 of the report. Participants of the Annex were Canada, Denmark, Sweden, UK and the USA.

The price for the summary report is Euro 30 for participants and Euro 90 for non-participants. The price for the CD ROM is Euro 50 and Euro 150 respectively. For ordering, contact the HPC.

Workshop on heat pumps in Trondheim

An IEA Heat Pump Programme workshop on heat pumps was organized by Enova on May 14 in Trondheim. Representatives from the Norwegian heat pump industry met with the Executive Committee to discuss heat pump technology matters with the aim of creating better understanding and interaction.

The workshop contributed to improved understanding of the Norwegian heat pump market and technology solutions, and it also helped to inform the ExCo about the industry's concerns, special needs and hopes concerning the Heat Pump Programme. The emphasis of the discussions was on long-term experiences with and and performance of heat pump systems in Norway and on how these results could be used, perhaps as the starting point for a new Annex. The recent Norwegian electricity crisis and resulting boom in heat pump interest and sales was also a widely debated topic, especially the concerns raised regarding system quality and required skills. The information exchanged at the workshop will be collected and issued by Enova and made available through the HPC.

Emeritus Prof. Steimle – A giant personality winds down

On 23 May, Prof. Steimle celebrated his 65th birthday. On this day he also celebrated becoming emeritus Professor of the Institute for Applied Thermodynamics and Space Conditioning at the University in Essen, Germany. Prof. Steimle has many friends and contacts in the (international) field of refrigeration and space conditioning, and several came to the event organized at the institute in his honour.

It is not easy to describe in a few words what he has contributed to the HVAC profession and industry and how influential he has been, not in the least on an international level. His involvement in and support of the IIR is well known. For the IEA Heat Pump Programme, he has been a very valuable and active contributor with suggestions and recommendations concerning new activities, input and contacts. On behalf of the IIR, he represented the academic sector in the Heat Pump Programme Advisory Board. The IEA Heat Programme owes him a lot, and the HPC staff greatly appreciates having worked closely together with him.

Ongoing Annexes

Red text indicates Operating Agent.

Annex 25 Year-round Residential Space Conditioning and Comfort Control Using Heat Pumps	25	FR, NL, UK 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 Calculation for Residential Heat Pumps with Combined Space Heating and Domestic Water Heating	28	AT, CA, CH, DE, FR, JP, NO SE, US, UK

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). All countries are member of the IEA Heat Pump Centre (HPC). The Netherlands is Operating Agent of the HPC.

High-efficiency rooftop air conditioners: innovative procurement drives advances in technology

Brad Hollomon, USA

Summary

The U.S. Department of Energy, the Defense Logistics Agency, and Pacific Northwest National Laboratory [1] (PNNL) recently conducted a technology procurement to increase the availability of energy-efficient, packaged unitary 'rooftop' air conditioners. The procurement encouraged air conditioner manufacturers to produce equipment that exceeded US energy efficiency standards by at least 25% at a lower life-cycle cost. As a result of the project, a web-based cost estimator tool is now available. It helps consumers to determine the cost-effectiveness of purchasing energy-efficient air conditioners based on climate conditions and other factors at their own locations.

Introduction

Air conditioning now accounts for about 12% of the total energy used in commercial buildings in the United States. Air conditioning is the second largest consumer of electricity in commercial buildings after lighting, and it is the largest contributor to peak electricity demand during hot weather. See **Figure 1**.

Figure 1: Unitary rooftop air conditioners dominate the market for small- and medium-sized low-rise buildings, accounting for 55% of air-conditioned commercial floor space in the United States.

In an effort to reduce these high costs and save energy, the U.S. Department of Energy (DOE) and the Defense Logistics Agency (DLA), an arm of the U.S. Department of Defense, challenged the air-conditioning industry to bring new, higher-efficiency air conditioners to the market. DOE and DLA sponsored a technology procurement to promote the development and consumer acceptance of highly efficient and cost-effective unitary air conditioners.

The DOE-DLA procurement focused on rooftop unitary air conditioners, the most commonly used equipment for cooling smaller commercial buildings like schools, restaurants, hospitals, hotels, retail stores, office buildings, public buildings, barracks, warehouses, etc. The packaged units featured in the procurement have cooling capacities ranging from 20 to 40 kW (output). Air conditioners selected for the program reflect the lowest possible life-cycle cost, taking into account both initial price and electricity use.

The procurement program

The DOE-DLA project relied on technology procurement, an interactive method of pulling new energy-efficient technologies and products into the marketplace. By working closely with potential buyers to evaluate their needs and address their concerns about new technologies, project organizers increase the likelihood that new products will be well received by buyers. By organizing large-volume buyers like the DLA, technology procurement reduces the risks manufacturers face with new product introduction and allows these manufacturers to introduce innovative products more readily and at more competitive prices.

The DLA procures and deploys equipment and services for U.S. military and civilian agencies worldwide. The DOE Federal Energy Management and Building Technologies Programs are sponsoring the unitary air conditioner procurement within DOE. Other partners in the procurement include the Consortium for Energy Efficiency (a national organization of utilities and other organizations offering efficiency incentives) and several nationwide private commercial building owners.

On DOE's behalf, PNNL developed the technical specifications, conducted market research, administered the procurement process in partnership with the DLA, and developed marketing materials to increase awareness of high-efficiency air-conditioning equipment. In crafting the solicitation, PNNL formulated an analytical method for estimating the life-cycle cost of candidate air conditioners. Facility managers can access an Internet-based version of this Cost Estimator at www.pnl.gov/uac. This Estimator helps them evaluate the life-cycle cost-effectiveness of investments in energy-efficient air conditioners.

PNNL's research showed that significant reductions in the life-cycle cost of rooftop air conditioners were achievable through energy-efficiency improvements that relied on readily available technologies, especially if part-load-operating characteristics are taken into consideration. Among the available technologies were improved heat exchangers, high-efficiency motors, better fans and compressors, improved controls, electronic expansion devices, and liquid overfeed technology.

1 Pacific Northwest National Laboratory is a multi-program national laboratory operated by Battelle for the U.S. Department of Energy.

PNNL issued a request for proposals (RFP) for high-efficiency unitary air-conditioning equipment in January 2002. It awarded basic ordering agreements to Lennox Industries and Global Energy Group for air conditioners that reflected the lowest possible life-cycle cost, taking into account initial price and electricity use. In response to the procurement, Global Energy Group introduced new products with Energy Efficiency Ratios (EERs) of 13.5 (rated COP of 4.0)[2], surpassing the level of any comparable products listed with the American Refrigeration Institute. The equipment selected also meets an array of additional specifications designed to ensure long-term performance and reliability.

Products resulting from the procurement are now available to all federal agencies, both military and civilian, through the DLA. Equipment is available also to non-federal customers, including private institutions, and state and local governments, through a basic ordering agreement administered by PNNL, specifying prices and other terms. The Unitary Air Conditioner (UAC) website (www.pnl.gov/uac) contains the terms and links to manufacturers offering the new high-efficiency models for the benefit of prospective buyers.

Evaluation Criteria

To be considered for the competitive procurement program, equipment offered had to be a single-package air-to-air direct expansion mechanical cooling system with 20 to 40 kW of cooling capacity and had to meet all of the minimum technical requirements set forth in the RFP. (The RFP documents and specifications are available on the project website at www.pnl.gov/uac.) The energy efficiency of the proposed models had to meet or exceed what are now ENERGY STAR® levels with an EER of at least 11.0 (rated COP of 3.2) and an integrated part-load value (IPLV) of at least 11.4 (3.34 expressed as COP). These levels represent minimum requirements, and the federal government sought equipment that substantially exceeded the minimum.

From among models that met these requirements, five winning models were selected based on their anticipated life-cycle cost. Life-cycle cost was calculated as the sum of the initial price offered and the present value of the operating costs over 15 years, discounted at 10% per year, as follows:

$$LCC = P+7.61xE$$

in which LCC is life-cycle cost, P is the unit price offered, and E is annual electricity cost. E is derived from a simulated energy calculation form by multiplying the total annual energy use in kilowatt-hours by USD 0.06.

Life-cycle cost was scaled by the total capacity of the unit, yielding a normalized life-cycle cost in dollars per kW of cooling capacity. Products were evaluated based on simulated performance under representative climate conditions using the energy calculation forms mentioned above.

Cost estimator

PNNL developed the UAC Cost Estimator to help building managers and facility owners see what type of savings they could realize by replacing standard air-conditioning equipment in their buildings with new high-efficiency rooftop air conditioners (see **Figure 2**). The Cost Estimator compares energy and life-cycle costs and provides estimates of energy consumption and costs, including return on investment, helping decision makers determine whether a high-efficiency air conditioner makes sense for their facility.

The UAC Cost Estimator compares candidate rooftop air conditioners with different efficiencies in terms of life-cycle cost. This electronic tool provides an alternative to complicated building simulation models while offering more detail than the commonly available simplified estimating tools. While simplified tools typically are based on full-load efficiencies and full-load equivalent operating hours, the estimator accommodates equipment with one or two compressor stages and accounts for part-load as well as full-load efficiencies.

The Cost Estimator:

- is fully web-based;
- employs a menu-driven format that is easy to learn and use;
- quickly estimates life-cycle cost, simple payback, return on investment, and savings-to-investment ratio;
- simulates operation under specific climate conditions at any of 237 U.S. locations selected by the user;
- reflects user-specified air-conditioning requirements and building use patterns;
- provides results in easy-to-download graphic files for further analysis and presentation (see **Figure 3**).

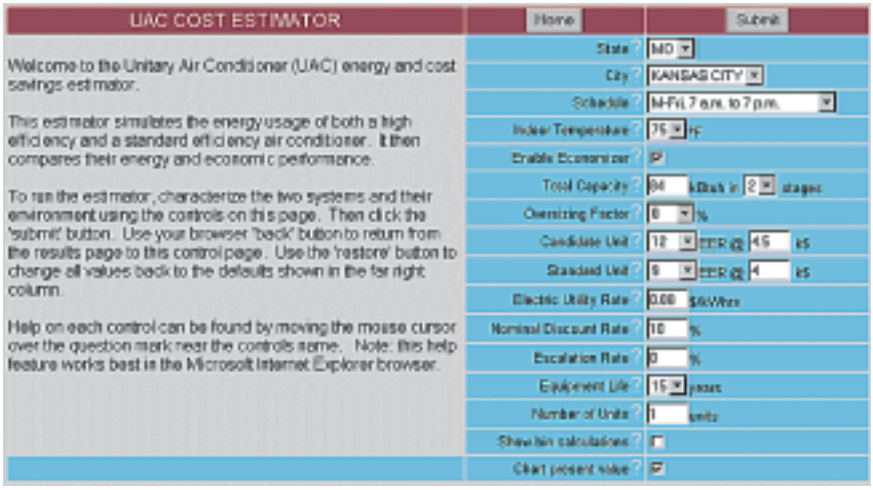

Figure 2: PNNL developed the Unitary Air Conditioner Cost Estimator to help decision makers determine the cost-effectiveness of replacing existing rooftop air conditioners with energy-efficient units.

2 Energy Efficiency Ratio (EER) refers to the coefficient of performance (COP) in cooling mode, expressed as Btu/Watt-hour, under a set of standard test conditions in the United States.

Results obtained with the Cost Estimator will be useful to facility managers, financial officers, energy management professionals, air-conditioning contractors, and other decision makers interested in maximizing both the energy efficiency and cost-effectiveness of cooling system investments. The tool provides estimates for energy and cost, suitable for comparison purposes. It was not designed to replace building load-simulating software for heating and cooling systems design. Due to the dynamic nature of building heating and cooling, actual energy use will vary depending on the application.

Example of life-cycle energy cost savings

Table 1 below compares three air conditioners in Atlanta, Georgia, in the southeastern United States: a high-efficiency air conditioner with a rated COP of 4.0, a slightly less efficient unit with a rated COP of 3.2, and a standard unit with a COP of 2.6. Assuming that all three have cooling capacities of 26 kW, the highest-efficiency unit would cost about USD 1,860 less to operate than the least efficient unit over a 10-year period. That is more than a 25% savings.

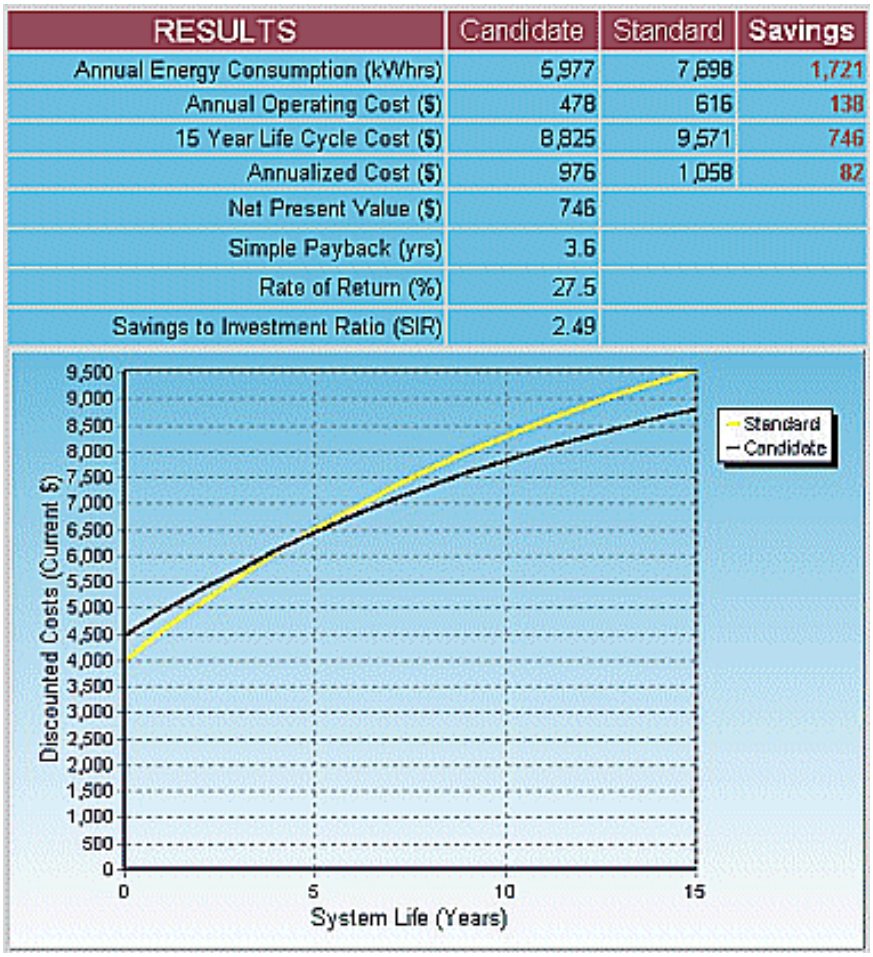

Figure 3: The UAC Cost Estimator shows life-cycle cost savings of USD 746 and a simple payback of 3.6 years when replacing one rooftop air conditioner with an energy-efficient unit.

Table 1: Energy Operating Cost (USD) – Atlanta, Georgia.

Efficiency Level	National Standard	Energy Star	Highest Available
EER (Rated COP)	9 (2.6)	11 (3.2)	13.5 (4.0)
Annual Energy Use (kW)*	8,415	7,146	6,090
Annual Energy Cost**	USD 673	USD 572	USD 487
10 Yr. Lifetime Energy Cost	USD 6,730	USD 5,720	USD 4,870
10 Yr. Energy Cost Savings	–	USD 1,010	USD 1,860

* Annual energy use is derived by applying the cost simulator at www.pnl.gov/uac to a 26 kW (90,000 Btu/hour), 2-stage model operating Mon. - Fri., 7 am - 7 pm in Atlanta, Georgia.
** Costs reflect a typical US electricity price of USD 0.08/kW, including demand charges.

Conclusion

Aggregating buyers and soliciting new products is a viable way to encourage industry to offer innovative products. As large volume purchasers themselves, governments are in a unique position to take the lead in gathering groups of buyers and eliciting technologies in support of broader public purposes, like energy conservation or environmental quality. Finally, if firms in the industry see evidence of serious market interest in such products, they will offer products that provide minimum life cycle cost in contrast to minimum initial price.

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Heat pump market developments and strategies in Austria

H. Halozan, Austria

Market strategies for introducing heat pumps can be initiated by governments, utilities, or heat pump manufacturers/distributors/installers. Ideally, all these groups should work together effectively, but until now this has proved to be the exception rather than the rule. The European experience until now has shown that market strategies must be implemented in a carefully coordinated manner in order to succeed - throwing money at the market does not guarantee success.

Historical background

The first oil price shock in 1973 revealed how heavily dependent Austria - like many western countries - was on imported energy. As a result of this first shock, heat pump marketing initiatives were started in the US and Japan, and solar energy initiatives were started in Europe. However, despite the increased cost of energy, no significant changes took place until the second oil price shock of 1978. This event caused national governments as well as international bodies to give long-lasting and serious consideration to reducing their dependency on imported oil:

- In Austria the first Energy Report (Energiebericht) by the government concluded that the most promising sector for reducing energy consumption was the space conditioning sector. Oil consumption could be reduced drastically via thermal insulation, heat pumps, solar energy and district heat produced by co-generation plants.
- Internationally the IEA (founded in 1974) published its 'Strategy Study' in 1980, which identified the space conditioning sector as the largest potential source of energy savings that could be realized relatively quickly. Solar energy, district heating and heat pumps were thought to be capable of saving 600 million tons of oil per year by the year 2020. The share of heat pumps in this was projected to be about 80%.

Over the next decade, the development of heat pumps for space conditioning took a quite different course in the US and Japan as compared to Europe. In the US and Japan, the process was relatively simple. Air-based space conditioning systems were already quite common, and the necessary expertise regarding vapour compression cycles was broadly available. The main change involved in transitioning from air-based space conditioning systems to heat pump systems was the introduction of a 4-way valve to reverse the cycle. The evaporator, condenser and compressor also had to be modified due to the different temperature levels required. But overall the transition went fairly smoothly.

In Europe, however, air conditioning was much less common (only in larger commercial buildings), and heating was carried out mainly with fossil fuel fired boilers connected to hydronic heat distribution systems. Most of these hydronic systems were sized for design supply/return temperatures of 90/70°C, exceeding the temperature level of heat pumps, with the exception of. new buildings were low-temperature floor heating systems could be installed. As a result, most heat pumps for residential applications had to be sized for heating-only operation and had to be integrated into existing hydronic heat distribution systems. In other words, heat pumps were only one part of a complex system that had to be carefully designed. This, together with the lack of a readily available base of specific expertise, would later cause many problems.

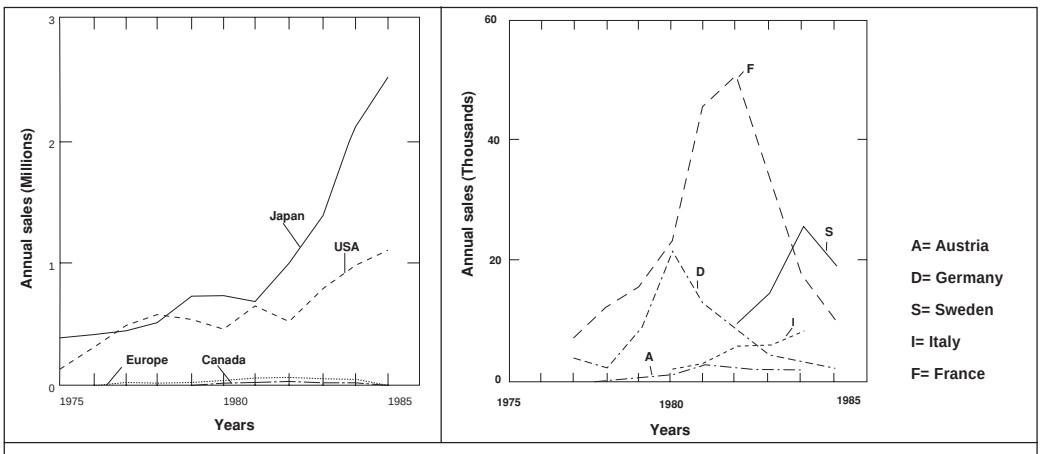

Figure 1: Market development in Japan and the US, and in Europe.

Figure 1 compares the development of the heat pump market in the US and Japan with that in Europe.

In the US and Japan, developments proceeded much more smoothly and sales figures have increased quite impressively. In Europe, after an initial steep rise, sales peaked in 1981, after which the market collapsed before stabilizing and recovering somewhat during the last decade.

Developments in Austria

The Austrian heat pump market also began to develop after the second oil price shock in 1978. It largely followed developments in the German heat pump market. After reaching a peak in heat pump units installed in 1981, the market collapsed in 1982, stabilized at a lower level, then dropped again, and has recovered somewhat during the last decade **(Figure 2)**.

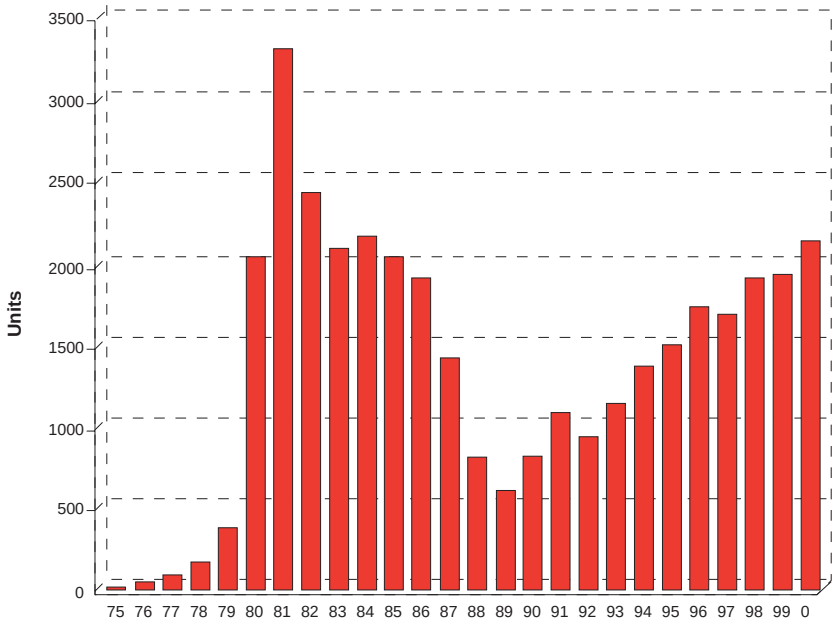

Figure 2: Development of the Austrian heating-only heat pump market.

The Austrian market was a heating-only market based on various heat sources and hydronic heat distribution systems. The first systems installed were either monovalent systems with groundwater as heat source and a low-temperature heat distribution system, most commonly a floor heating system, or bivalent systems with outside air as heat source and a high-temperature heat distribution system using radiators. Monovalent systems were installed in new buildings; bivalent systems were mainly used for retrofitting existing heating systems based on oil-fired boilers.

At the start of market development, oil was the main fuel in use for heating purposes. The price ratio of electricity/oil per unit of energy delivered was roughly 2.5. To stimulate the introduction of heat pumps, the government provided subsidies in the form of tax deductions. The result was not only a rapid rise and peak in the number of units sold and installed, but also in the number of heat pump system failures. This was caused not by the heat pump unit itself but by its integration into the hydronic system. The most common cause was oversizing, which is a potential cause for future technical problems in bivalent applications with high-temperature heat distribution systems.

After the steep downturn in 1982, the market stabilized. The companies that remained had learned their lesson. The most successful example was OKA (Oberösterreichische Kraftwerksgesellschaft), a small utility that had studied heat pumps before introducing them and supported its customers - not financially - but with effective service when systems failed.

In 1985 two things happened which caused the market to decline over the next few years: oil prices dropped and government subsidies were cancelled. Bivalent systems, which until then had formed the main market, were no longer cost-competitive, and providers had to concentrate on monovalent systems for new buildings. Later, the ground was also introduced as a heat source. In addition to secondary loop systems of ground coupled heat pumps, direct expansion systems have become very popular. The ground coils used are mainly horizontally installed collectors. Due to their higher cost, bore-hole systems are used only if there is not enough space available. Since 1990, the heat pump market has shown a slow but steady recovery. The ground has become the main heat source and, due to better building codes (i.e. better insulated houses, improved compressors and heat exchangers), SPFs (seasonal performance factors) in the range of 4 and more have been achieved, especially with direct expansion systems.

Market development strategies

The role of government

Following the IEA Strategy Study and its own Energy Report, the Austrian government decided to support energy saving measures, via tax deductions subsidies, especially in the building sector. Based on the number of units sold, this strategy was a success during the first few years. Sales increased dramatically from 1978 to 1981. But then the market experienced a severe downturn.

What happened? Encouraged by generous government subsidies, so many people wanted heat pumps that the established companies could not meet the demand. Many smaller and less experienced players, who knew a lot about refrigeration but very little about heating, jumped into the market. These companies worked with installers who knew even less about heat pumps. The installers not only tended to oversize boilers, they also often integrated the heat pump into the heating system at the wrong position. Customers were promised energy and cost savings that had little to do with reality. The market soon collapsed, and only the serious companies with reliable products and trained installers survived.

Of course, governments can also adopt strategies that do more than just subsidize heat pumps directly. They can support the development of new heat pump types, support demonstration projects and provide the public with information on heat pumps as an energy-efficient and cost-effective technology. In Switzerland, where the government has adopted such strategies (after five years of subsidizing heat pump systems directly), market developments have proven the effectiveness of such strategies.

The role of utilities

Electric utilities are generally not very enthusiastic about heat pumps. They often see no reason to support a technology that reduces electricity sales to one third [compared with direct electric heating], and as a result do everything possible to block heat pumps. But there are some utilities which realize that heat pumps are not competition for direct electrical heating systems, and that they offer utilities access to a new market - the market for hydronic heat distribution systems. In this market segment, heat pumps are the competition for oil-fired and gas-fired boilers, and heat pumps use electricity.

OKA, the electric utility of Upper Austria, is a good example. OKA was involved in a government programme for reducing the energy consumption of school buildings, via improved thermal insulation and improved heating systems. Some school buildings had been equipped with heat pumps, and OKA used these heat pumps in an internal staff training programme. When some of OKA's smaller clients wanted to install heat pumps, OKA was able to inform them on reliable installers and heat pumps. If failures occurred, OKA provided their clients with the necessary support. If the installers/manufacturers were not willing to act responsibly, OKA removed them from their recommended list. The results speak for themselves. Today, almost 50 % of all heat pump sales in Austria take place in the region served by OKA. Nearly every second new single family house in the region is equipped with a heat pump!

The role of manufacturers

Manufacturers can use two different strategies

- improving their products;
- demonstrating the advantages of heat pump systems to potential customers.

Several manufacturers have been quite successful in carrying out the first strategy. Milestones include: direct evaporation systems, which are more efficient and cost effective than secondary loop systems; improved units using flat plate heat exchangers; advanced cycle control strategies; improved compressors; the use of refrigerants like propane and R-410A; heat-pipe based ground probes with CO_2 as heat carrier. Heat pump manufacturers have also demonstrated that floor heating systems, sometimes combined with wall heating systems, can work with maximum supply temperatures as low as 35 °C and less. This makes it possible to realize SPFs of 4.5 and higher.

With regard to the second strategy, various manufacturers are competing in the same market, and this often results in one heat pump system competing against another. The winner is then often a boiler system. To deal with such issues, the Leistungsgemeinschaft Wärmepumpe (LGW) association, which includes most Austrian heat pump manufacturers and distributors, was founded in 1990. The aim is to promote the heat pump, solve legal aspects, influence regulations and publicize the importance of the heat pump for reducing greenhouse gas emissions.

The LGW managed to realize its goals in Austria, and was used as an example of a successful marketing strategy by Switzerland, where the Fördergemeinschaft Wärmepumpe Schweiz (FWS) was established within the Swiss programme Energy 2000. The third country to follow this example was Germany with the Informationszentrum Wärmepumpe (IWP).

These three countries formed D-A-CH (D = Germany, A = Austria, and CH = Switzerland), an international association which developed the rules for the D-A-CH quality label for heat pump units. This label was initially developed for use with air/water heat pumps, water/water heat pumps and brine/water heat pumps. Later, direct evaporation heat pumps and exhaust air heat pumps were also included. The D-A-CH quality label includes tests regarding minimum COP requirements and operating range of the heat pump units, as well as providing a three-year guarantee, spare parts for 10 years and 24-hour servicing capabilities.

The technical and marketing issues relating to heat pump units themselves seem well on the way to being resolved. But an issue which is at least as important relates to the heating system as a whole: i.e. the interaction of heat source, heat pump unit, heat sink, control, and building. To help deal with this issue, Austria has started a certification programme for heat pump installers. These installers follow a theoretical and practical course (lasting 84 hours) on heat pump systems, and have to pass an examination. They must also build three installations for the examination.

European coordination
The European Heat Pump Association (EHPA) works on international level. It aims to promote the use of heat pumps by providing information on heat pumps and their role in reducing greenhouse gas emissions, as well as by encouraging uniform and harmonised rules for heat pump systems all over Europe.

D-A-CH has taken steps towards realizing efficient quality management for heat pump systems. The Nordic countries have similar rules, and it should be possible to find a European solution for the quality management of heat pump units and systems. The goal should be to develop harmonised rules for all of Europe.

Conclusion

The key to sustainable development and rational energy management is to avoid destroying our environment. The Kyoto Protocol requires measures, regulation, taxes and subsidies for promoting energy saving technologies and thereby reducing greenhouse gas emissions. Heat pumps are one of the key technologies to achieve this goal. In striving towards this goal, our motto could be:

> *Success in the market is not an accident - it is the result of research, excellent products, skilled installers, the support of the utilities and a political goal.*

To achieve success, it is essential that all the players involved work together in an effective and coordinated fashion. In the end, the entire chain from the consumer through to contractors, manufacturers, utilities and government bodies is no stronger than its weakest link (see **Figure 3**).

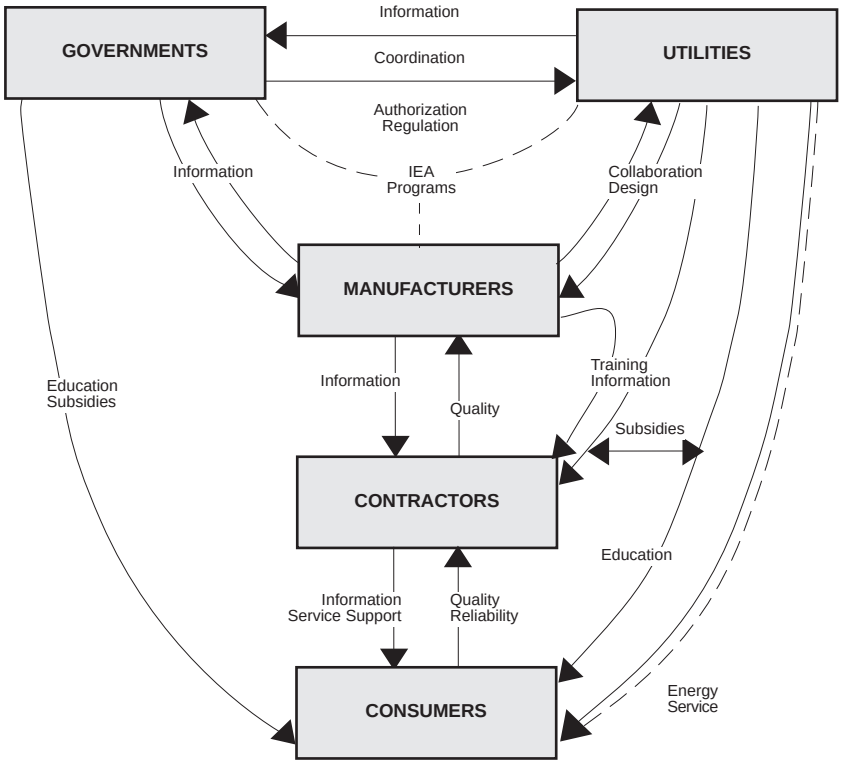

Figure 3: Preconditions for successful development of the heat pump market.

If we take this into account, if governments accept the importance of this technology, and if international agreements to reduce greenhouse gases are effectively implemented, then the heat pump will also succeed in Europe and help contribute to a better future.

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Study of energy requirements for air-source heat pump evaporators: alternatives and efficiencies

Dr. Martin Zogg, Switzerland

Roughly 10% of the total electricity consumption of heat pumps that use air as a heat source is used for defrosting the evaporators. The report described below aims to evaluate various defrosting options and to minimize the energy consumption involved.

In phase one of the project concerned, a theoretical analysis was carried out of the most important defrosting processes. (Verbesserung des Abtauens bei luftbeaufschlagten Verdampfern, Phase 1: Analyse gängiger Abtauverfahren, 12-2000, see www.waermepumpe.ch/fe, Berichte - Kompressions Wärmepumpen) This article summarizes a report on phase two, in which the energetic and economic efficiencies of various defrosting options were evaluated.

Materials and methods

For evaluating the various options, a dataset was used based on standard measurements carried out at the Heat Pump Test Centre in Töss (WPZ), according to EN-255 standards, which characterize the operation of various heat pumps at a range of heat pump operating points. These standard measurements were complemented by further laboratory and field measurements where necessary. Six heat pumps with cycle reversal (PR) defrosting and seven with hot-gas defrosting (HG) were evaluated. The heat pumps tested were selected on the basis of their modern designs (1996 onwards) and their importance in the market.

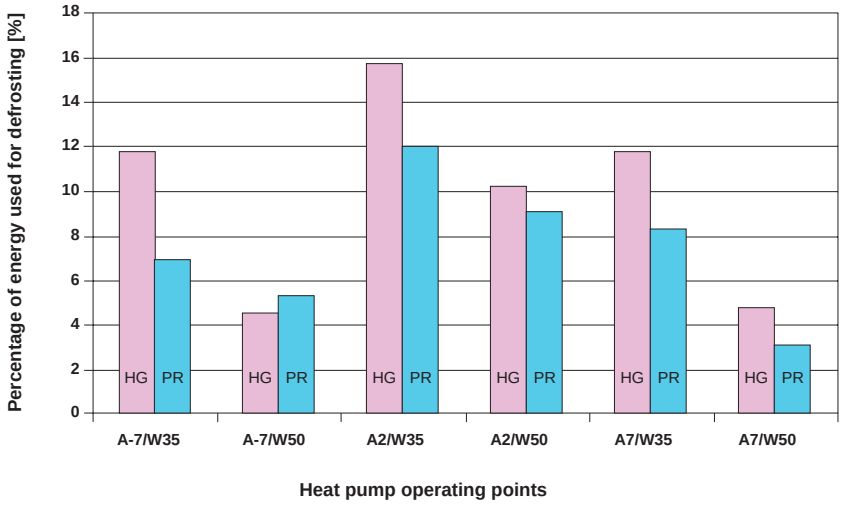
The investigation also took into account aspects otherwise often neglected, which specifically affect PR based defrosting systems, such as:
• pressure drop, leakage, and heat transmission characteristics of the four-way valves required for changeover; additional measurements were carried out to evaluate this aspect;
• the need to again heat up the heat distribution system and condenser after defrosting.

It should be noted that the results calculated for individual heat pump operating points are based on a relatively small number of heat pumps per point. As a result, the statistical uncertainty is relatively large and unexpected deviations can occur.

Results

Energy efficiency: **Figure 1** shows the amount of energy used for defrosting the evaporators at the various heat pump operating points as measured by the WPZ. The energy used is expressed as a percentage of the total energy used by the heat pump. The results calculated and presented in **Figure 1** do not take into account the effect of defrosting by natural convection at higher air temperatures.

The percentage energy for defrosting varies from 3% to 12% for PR and from 4.5% to 15.5% for hot-gas defrosting. This confirms the greater energy efficiency of the cycle reversal method. The energy fraction used for defrosting is actually not as high as is often assumed. However, one should realize that for PR systems the energy required for the compressor drive during the actual defrosting is only about 30% to 55% of the total energy required for defrosting, depending on the temperature change. The rest of the energy is needed for heating up the heating system again after defrosting (25% to 45%) and for covering the extra energy losses as a result of the four-way valve (10% to 30%).



Legend: HG = hot-gas defrosting
PR = defrosting using cycle reversal
A-7/ W35 = Air temperature of minus 7ºC and water temperature of 35ºC

Figure 1: Percentage of total electrical energy consumption of heat pumps required for defrosting (mean values for the heat pumps measured).

The study further revealed that the amount of energy actually used for defrosting at outside temperatures around 2 °C was double the theoretical amount required for just melting the ice. At outside temperatures around -7 °C, about four times the theoretical amount required was used. Therefore, a considerable potential for savings exists, especially with regard to optimizing control systems etc.

Standstill time: **Figure 2** shows the amount of time needed for defrosting as a percentage of the total effective heat pump operating hours. As in **Figure 1**, the calculations do not take into account the defrosting that will occur in actual practice as a result of natural convection at higher air temperatures.

The percentage of standstill time is clearly much less for PR systems than for hot gas systems. The only exception is for the operating point A-7/W50, which can be explained by the small number of measurements (only three heat pumps) used for this calculation and the resulting large statistical uncertainty. It is also noteworthy that the amount of time needed for defrosting is of the same order of magnitude as the time required for again heating up the system after defrosting.

Natural defrosting: At ambient air temperatures above 0 °C, defrosting also occurs through free convection of ambient air during heat pump standstill periods. The indirect energy losses specific to PR systems still take place even when natural defrosting occurs. As a result, 'natural defrosting' has the effect of reducing the difference in energy efficiency between PR defrosting and hot-gas defrosting. To analyze this aspect, natural defrosting was measured for a standard heat pump at several operating points under laboratory conditions. Of course, the contribution made by natural defrosting will increase with increasing standstill time.

For supply temperatures of 35 °C, the fraction of total defrosting due to natural defrosting at an outside temperature of 7 °C and after two hours of standstill was 42%. At an outside temperature of 2 °C, the natural defrosting fraction after two hours of standstill was only 14%. Before it actually starts to melt, the layer of ice must be warmed up to the melting point. This initial 'waiting period' lasted only a few minutes at an outside temperature of 7 °C, but lasted 1.5 hours, at an outside temperature of 2 °C.

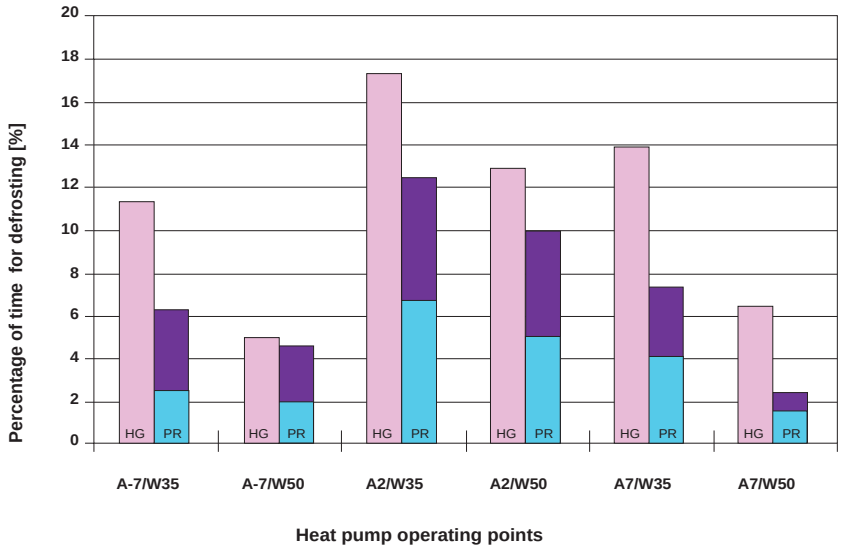


Figure 2: Percentage of total effective heat pump operating hours used for defrosting (mean values for the heat pumps measured; HG = hot-gas defrosting, PR = defrosting using cycle reversal; for PR: bottom part is for actual defrosting process, and upper part is for heating up the heating system again).

Further investigations are necessary before more general statements on the influence of natural defrosting can be made.

Less conventional options

The following less conventional defrosting solutions were also considered during the study:

- with the help of a heat transfer fluid, using heat from the heat distribution system, as in, for example, the Swiss Retrofit Heat Pump (The Swiss Retrofit Heat Pump Programme Preprints, 7th International Energy Agency Heat Pump Conference, Beijing, 19-22 May 2002, China Academy of Building Research, Vol. 1, pp. 208/218, www.waermepumpe.ch/fe in Publikationen); unfortunately, the only data available for the Swiss Retrofit Heat Pump are field measurements, which makes it impossible to compare the results with the laboratory based data presented in this report;
- 'air-defrosting' using on-site room air for heat pumps with small thermal capacities.

Air-defrosting is an interesting option if the considerable impact on climatic conditions in the room where the heat pump is installed is not a factor. The useful concept of applying heat on the air supply side can be further improved by using forced circulation of ambient air for defrosting at temperatures above 0 °C.

The study also considers other novel suggestions that have not yet been implemented for defrosting, such as using the thermal capacity of refrigerants. The prevention of ice formation by absorbing air humidity using lithium chloride is also discussed.

Economic efficiency

The economic efficiencies of the various defrosting processes are also examined in the report. Surprisingly enough, hot-gas defrosting exhibits

approximately the same total costs over 15 years of operation as does cycle reversal defrosting. Air-defrosting comes out as a very efficient option, although at the cost of considerably impacting room climate. Finally, the report compares operational advantages and disadvantages of the various means of defrosting.

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Full final report for this SFOE research project (in German):

S.Bertsch, M. Ehrbar, P.Hubacher: Verbesserung des Abtauens bei luftbeaufschlagten Verdampfern, Phase 2: Bewertung der Abtauprozesses, final report, Swiss Federal Office of Energy 2002.

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Reducing noise from air/water heat pump installations

Dr. Martin Zogg, Switzerland

Small air/water heat pumps are noisy, but little is known about the exact origin of the noise, let alone what to do about it. A Swiss study sheds new light on this problem. The main source of noise emission turns out to be the fan, while refrigerant compressor and piping also contribute. A range of noise reduction measures is suggested.

More then half of all new small heat pumps - with thermal capacities up to 25 kW - use ambient air as a heat source. Especially in heavily built-up areas, these air/water heat pumps have led to complaints about noise emissions. A study was therefore carried out to analyze the source of these emissions. The analysis led to the formulation of guidelines for designers and manufacturers in constructing low-noise installations, as well as a range of specific noise reduction measures that can be taken .

Acoustic measurements - theory and practice

In order to evaluate the possibilities for reducing the noise generated by heat pump installations, one can make use of acoustic theory and measurements. First, basic guidelines and criteria must be agreed upon for measuring sound emissions and judging noise levels.

Theoretical knowledge combined with proper measurements enables the calculation of sound propagation in the open air and allows one to predict the effectiveness of specific and combined measures for reducing noise emissions. **Figure 1** shows some examples of the measurements taken during the practical study of noise emissions from air/water heat pumps.

Results

Primary noise sources: About 90% of the noise emission is caused by the fans used for the circulation of ambient air. The following measures are proposed as the most important ones for reducing fan noise;

* Choose the fan carefully: choose a model with the lowest possible circumferential speed; operating point at the minimum noise-production; special blade forms for low sound power level (- not yet available, unfortunately);

* Improve airflow guidance in the fan's proximity: use inlet funnels, minimize obstacles to airflow, use sufficiently large radii of curvature for the ducting - especially on the fan input side, observe manufacturer's installation instructions;

* Aim for lower pressure drops in the air ducts: at an air velocity of 3 - 4 m/s, after axial-flow fans, use guiding baffles instead of the usual ducting diffusers (these baffles, however, cause additional noise); make sure that the cross-sectional area of the air vents for inflow and outflow > 140% of the free channel cross-sectional area; use airflow optimised grilles;

* Use the sound-absorbing effects of 90° bends, ventilation shafts (especially effective with horizontal

partition walls) and large changes in cross-sectional area;

* If specific noise frequencies are encountered (noise with an audible single note as caused by fans), resonance mufflers should be mounted;

* Insulate the air ducts with at least 50 mm of sound-absorbing materials.

Secondary noise sources: The refrigerant compressor is the second most important noise source. The following measures for reducing compressor noise are described in more detail in the final report:

* Acoustic containment: sound absorption by lining the inside of the soundproofing hoods with sound-absorbing material while making them as airtight as possible;

* Good, one- or two-stage mechanical vibration insulation.

Finally, the refrigerant piping is also a source of noise emissions. Therefore, these pipes should be equipped with mechanical vibration insulation.

In the final report, the various measures proposed are illustrated in detail with the help of numerous sketches and measurements.

Further information:
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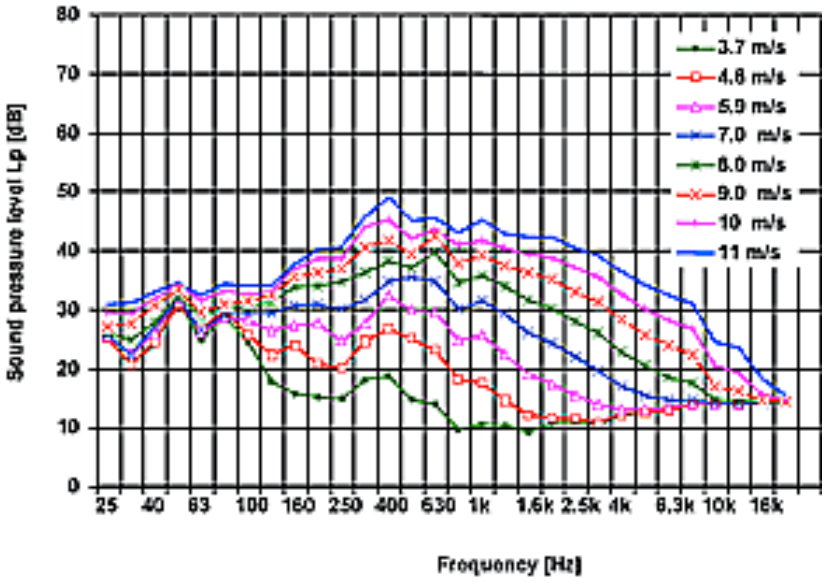

***Figure 1**: Acoustics lab measurements of the airflow noise produced by weather protection grilles.*
Above: test configuration.
Below: effective sound pressure levels at various frequencies at one metre distance plotted against airflow velocity in the free cross-section.

Full final report for this SFOE research project (in German):

H.R.Graf: Lärmreduktion bei Luft/Wasser- Wärmepumpenanlagen - Grundlagen und, final report, Swiss Federal Office of Energy 2002.

Downloadable from www.waermepumpe.ch/fe under "Berichte/Wärmequellen"

Order the printed version using ENET number 220193 from ENET, Egnacherstrasse 69, CH-9320 Arbon, +41 (0)71 440 02 55, enet@temas.ch

Books and software

Cool appliances: Policy strategies for energy-efficient homes

In IEA Member countries, electrical appliances are the fastest growing energy users after automobiles. Cost-effective technology exists that could improve the energy efficiency of appliances by more than one-third in ten years. Through application of such technology, the greenhouse gases emitted as a result of the use of appliances in IEA Member countries alone could be slashed by the equivalent of 322 million tonnes of CO_2 per year by 2010.

This book assesses the potential energy savings and carbon reductions to be achieved through technical improvements to appliances. It analyses the policy options available to stimulate the manufacture and use of more efficient appliances. It suggests ways to strengthen existing appliance-efficiency programmes, and it demonstrates how international collaboration can enhance those programmes.

Published: April 2003
ISBN: 92-64-19661-7
Paper price: USD 85
Pdf price USD 68
30% discount for non profit organisations

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Eurovent Certification Programmes

The importance and reliability of the European Air Conditioning Industry are clearly demonstrated by the very existence of the voluntary certification programmes established and administrated by Eurovent. Comparison of product performance by third party testing based on well-defined procedures ensures healthy, solid competition within a market that is open to all manufacturers. This brochure outlines the purpose, essential features and benefits of the certification programmes and highlights the fact that the Eurovent Directories of Certified Products are becoming the reference handbook for consultants, specifiers and users for product selection.

Published: March 2003, cd-rom
For more information:
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62, boulevard de Sébastopol
75003 Paris
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Tel: +33 (0) 1 49 96 69 80
Fax: +33 (0) 1 49 96 45 10
E-mail: info@eurovent-certification.com
www.eurovent-certification.com

Proceedings of the Eurotherm Seminar No. 72: Thermodynamics, Heat and Mass Transfer of Refrigeration Machines and Heat Pumps

The seminar was held at Valencia, Spain on March 31st – April 2nd, 2003. Contributions on any fundamental or applied topic concerned with the main subject of the seminar were requested. Close to 90 abstracts were submitted to the seminar. Finally, 70 peer reviewed papers were accepted and included in the book of proceedings, which is also published in CD format. They provide an excellent overview of the state of the art of the field in general and good examples of new advances and recent developments.

The final programme, list of participants, instructions to order the book of proceedings, and a gallery of photographs taken during the event can be found at the following website: http://www.imst.upv.es/en//eu_ seminar.htm

Published: April 2003, a book of proceedings and the proceedings in CD format.

Source: J.M. Corberán and R. Royo
Institute of Energy Engineering
Universidad Politécnica de Valencia
P.O. Box 22012-45071 Valencia, Spain.
Tel: +34-96-3877323
Fax: +34-96-3877329

Heat Pumps

If you are interested in how exactly a heat pump works, which buildings they are suitable for, what operating cost savings they can bring or how to proceed when selecting a specific heating system, this new publication is recommended. The book provides a summary of heat pumps already installed in the Czech Republic and gives information on economic aspects of their operation. It also describes particular types of pumps, heating systems and forms of heat consumption in households. The publication also offers a number of contacts from which more specific data can be obtained.

Author: Ladislav Tintera
More information: contact publishing house ABF, a.s.:
http://www.eprodejna.cz/kniha.asp?id=617

Source: News at SEVEn, Volume 11, Number 1, March 2003

Refrigeration A/C Heat Pumps' TOC Report: 2002 Assessment of the Refrigeration, Air Conditioning and Heat Pumps Options Committee

In the last decade, the refrigerant, air conditioning and heat pump industry made tremendous technical progress and complied with the Montreal Protocol by phasing out CFCs and, in several applications, HCFCs as well. The mobile air conditioning and the domestic refrigeration industries have shifted rapidly from CFC-12 to non-ODS refrigerants. Other applications, such as chillers and commercial refrigeration, have shifted from CFCs to HCFCs and HFCs or other fluids.
The requirement to phase out CFCs and eventually other ODS, along with the motivation to reduce global warming impacts, has spurred unprecedented transitions. Differences in timing and in the choice of options between different countries have been influenced by regional and national regulations.

ISBN: 92-807-2288-3
www.unep.org/ozone (go to English, go to The 2002 Assessments Reports).

Source: Secretariat for the Vienna Convention and the Montreal Protocol

Tel: (254-20) 62-3850 or 62-1234
Fax: (254-20) 62-3601 or 62-3913

Standard 117-2002- Method of testing closed refrigerators

The standard establishes uniform methods of testing closed refrigerators for rating so that comparative evaluations can be made of energy consumption, product temperature performance, refrigeration load, required suction pressures and other performance factors. This standard, along with Standard 72-1998- Method of Testing Open Refrigerators (Code 86192), will aid design engineers in comparatively rating refrigerators.

Price: USD 20.00 (Member: USD 16.00)
Code: 86353 (ISSN: 1041-2336)

Source: ASHRAE Journal, Feb. 2003

Standard 147-2002- Reducing the release of halogenated refrigerants from refrigerating and air-conditioning equipment and systems

Halogenated refrigerants, when released into the atmosphere, deplete the ozone layer and contribute to global warming. This standard establishes practices and procedures that will help air-conditioning equipment designers, installers and operators reduce the inadvertent release of halogenated refrigerants. The standard helps reduce refrigerant release during equipment manufacture, testing, installation, operation, maintenance, repair and disposal.

Price: USD 31.00 (Member: USD 25.00)
Code: 86481 (ISSN: 1041-2336)

Source: ASHRAE Journal, Feb. 2003

Standard 151-2002- Practices for Measuring, Testing, Adjusting, and Balancing Shipboard HVAC&R Systems.

This standard provides uniform and systematic practices for making measurements in testing, analyzing, balancing and reporting the performance of the HVAC&R systems onboard ships. It describes methods for measuring temperature, humidity, enthalpy, current, wattage, voltage, rotation, fluid flow, heat flow, pressure, sound, and vibration levels in shipboard HVAC&R systems. Field test results are essential to operators, design engineers, manufacturers, and installers, enabling them to evaluate the results of system performance and installation techniques under actual operating condition. This standard provides designers, installers and operators with the proper guidelines to conduct these valuable field tests.

Price: USD 29.00 (Member: USD 24.00)
Code: 86490 (ISSN: 1041-2336)

Source: ASHRAE Journal, Feb. 2003

Commissioning, preventive maintenance, and troubleshooting guide for commercial ground-source heat pump systems

This book covers the project implementation stage and reviews the necessary technical information for geo-thermal or geo-exchange heat pump systems. Commissioning, maintenance requirements, and troubleshooting for these energy-efficient systems are covered in detail. This guide is a valuable reference for those involved in the design, installation, operation, and maintenance of commercial building ground-source heat pump systems.

Price: USD 69.00 (Member: USD 55.00)
Code: 90302 (ISBN 1-931862-09-5)

Source: ASHRAE Journal, Feb. 2003

Geology and drilling methods for ground-source heat pump installations - an introduction for engineers

Because of low operating and maintenance costs, ground-source heat pump systems are becoming increasingly popular for commercial HVAC systems in offices, schools, health care facilities, stores and factories. Design and installation of ground-source and groundwater-source heat pumps are straightforward engineering exercises. This manual is intended to help the designer understand the driller's tools, techniques and the ground they penetrate. It includes an introduction to geology, hydro-geology, soil development, and other conditions that impact the feasibility and economics of ground-source heat pump system installation.

Price: USD 87.00 (Member USD 69.00)
Code: 90423 (ISBN 1-931862-02-8)

Source: ASHRAE Journal, Feb. 2003

Standard 40-2002- Methods of testing for rating heat-operated unitary air-conditioning and heat pump equipment

This standard replaces Standard 40-1980 (RA 1992), and provides test methods for determining heating and cooling output capacities and energy inputs of unitary air-conditioning and heat pump equipment that is heat-operated. These test methods may be used as a basis for rating such equipment. Improvements from the previous version include the addition of environmental chamber design considerations, as well as changes to the air-enthalpy, external resistance and heat balance sections. In addition, chapters on the coolant heat-transfer fluid and refrigerant enthalpy methods have been added. The standard applies to heat-operated unitary air conditioners and heat pump consisting of one or more assemblies, including engine-driven systems

Price: USD 19.00 (Member USD 15.00)
Code: 86097 (ISSN: 1041-2336)

Source: ASHRAE Journal, Feb. 2003

Events 2003

21st IIR/IIF International Congress of Refrigeration, 'Serving the Needs of Mankind'
17-22 August 2003 / Washington DC, USA
Contact: ICR 2003 Conference Manager, Nadine George
Hachero Hill, 6220 Montrose Road
Rockville, MD 20852
Tel.: +1-301-984-9450 x11
Fax: +1-301-984-9441
http://www.icr2003.org

2nd International Conference on Modern Problems of Refrigerating Engineering and Technology
17-19 September 2003/ Odessa, Ukraine
Contact: Organizing Committee MPRET
Tel: +38 (0482) 23-62-89
Fax: +38 (0482) 23-89-31
E-mail: admin@osar.odessa.ua

11th International Stirling Engine Conference (ISEC)
19-21 November 2003 / Rome, Italy
Contact: Conference Katiuscia Cipri
E-mail: katiuscia.cipri@uniroma1.it
Fax: +39 06 4881 759
http://dma.ing.uniroma1.it/isec2003

3rd International conference on energy efficiency in domestic appliances and lighting (EEDAL '03)
1-3 October 2003 / Turin, Italy
Tel: +39 0332 78 9299
Fax: +39 0332 78 9992
E-mail: softech@softech-team.it
http://softech-team.it/EEDALweb/e-index.htm

IKK- International Trade Fair for Refrigeration, Air Conditioning and Ventilation
8-10 October 2003/ Hanover, Germany
Contact: NürnbergMesse Gmbh, Messezentrum
90471 Nuremberg, Germany
Tel: +49 (0) 911 8606 8110
Fax: +49 (0) 911 8606 8247
E-mail: ikk@nuernbergmesse.de
http://www.nuernbergmesse.de

4th International Symposium on Heating, Ventilation and Air Conditioning
9-11 October, 2003 / Beijing, China
Tel: +86 10 6278 1339
E-mail: ishvac@tsighua.edu.cn
http://www.ishvac2003.org

3rd International Symposium on Heat Transfer Enhancement and Energy Conservation (ISHTEEC 2003)
8-11 November, 2003 / Guanzhou, China
Contact: Prof. Dongsheng ZHU, ISHTEEC'03 Secretary General
Chemical Engineering Research Institute
South China University of Technology
Gangzhou, 510640, China
Tel & Fax: +86-20-8711 4568
E-mail: ishtee@scut.edu.cn
http:/www.ishtee.gd.edu.cn

Deutsche Kälte-Klima-Tagung 2003
19-21 November, 2003 / Bonn, Germany
Contact: Deutscher Kälte- und Klimatechnischer Verein – DKV e.V.
Pfaffenwaldring 10
70569 Stuttgart (D)
Fax: +49-(0)711-685 3242
E-mail: dkv@itw.uni-stuttgart.de

2004

ASHRAE winter meeting and AHR Expo
24-28 January, 2004 / Anaheim, California, USA
Contact: ASHRAE meetings section
Tel: +1 404 636 8400
E-mail: jyoung@ashrae.org
http://www.ashrae.org

Interclima
3-6 February, 2004 / Paris, France
Contact: Philippe Brocart
Tel: +33 1 4756 5088
E-mail: philippe_brocart@reedexpo.fr
http://www.interclima.com

Mostra Convegno Expocomfort
2-6 March, 2004 / Milan, Italy
Tel: +39 02 48555 01
Fax: +39 02 4800 5450
E-mail: mce@planet.it

ASHRAE Annual Meeting
26-30 June, 2004 / Nashville TN, USA
http://www.ashrae.org

Natural Working Fluids - 6th IIR Gustav Lorentzen Conference
29 August-1 September, 2004 / Glasgow, UK
Contact: Miriam Rodway, secretary
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Kelvin House, 76 Mill Lane
Carshalton, Surrey SM5 2JR
Tel: +44 (0)20 8647 7033
Fax: +44 (0)20 8773 0165
E-mail: oir@ior.org.uk
http://www.ior.org.uk/gl2004

5th International conference on compressors and coolants – Compressors 2004
29 September-1 October, 2004 / Nitra, Slovak Republic
Contact: Peter Tomlein
SZ CHKT, Hlavnà 325
900 41 Rovinka, Slovak Republic
Tel: +421 2 4564 6971
Fax: +421 2 4564 6971
E-mail: zvazchkt@isternet.sk
http://www.isternet.sk/szchkt

For further publications and events, visit the HPC Internet site at http://www.heatpumpcentre.org.

Next Issue
HP Systems in cold climates
Volume 21 - No. 3/2003

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among its participating countries, to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development.

IEA Heat Pump Programme

International collaboration for energy efficient heating, refrigeration and air-conditioning

Vision

The Programme is the foremost world-wide source of independent information & expertise on heat pump, refrigeration and air–conditioning systems for buildings, commerce and industry. Its international collaborative activities to improve energy efficiency and minimise adverse environmental impact are highly valued by stakeholders.

Mission

The Programme serves the needs of policy makers, national and international energy & environmental agencies, utilities, manufacturers, designers & 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 benefit through deployment of appropriate high quality heat pump, refrigeration & air-conditioning technologies.

IEA Heat Pump Centre

A central role within the programme is played by the IEA Heat Pump Centre (HPC). The HPC contributes to the general aim of the IEA Heat Pump Programme, through information exchange and promotion. In the member countries (see right), activities are coordinated by National Teams. For further information on HPC products and activities, or for general enquiries on heat pumps and the IEA Heat Pump Programme, contact your National Team or the address below.

The IEA Heat Pump Centre is operated by

Novem

Netherlands agency for energy and the environment

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