

IEA Heat Pump CENTRE NEWSLETTER

Volume 22
No. 2/2004



Residential Heat Pump Systems

Field Analysis of Heat Pump Installations

Competitive Strength of Heat Pump in the Netherlands

Magnetic Cooling

In this issue

Residential Heat Pump Systems

The market for heat pumps and air conditioning units is growing in many parts of the world. We reported increasing sales in China and the USA in Newsletter no. 1, and in this issue we report on increasing sales in Norway, Sweden and Germany, together with expected substantial growth in India. In all these markets, it is residential heat pump systems that account for the major share.

This issue of the Newsletter presents two important subjects related to residential heat pump systems: operating experience after installation, and competitiveness of heat pumps with other forms of heating.

COLOPHON

Copyright:
Any part of this publication may be reproduced, with acknowledgement to the IEA Heat Pump Centre, Borås, Sweden.

Disclaimer IEA HPC
Neither the IEA Heat Pump Centre, nor any person acting on its behalf:

- makes any warranty or representation, express or implied, with respect to the accuracy of the information, opinion or statement contained here in;
- assumes any responsibility or liability with respect to the use of, or damages resulting from, the use of this information;

All information produced by IEA Heat Pump Centre falls under the jurisdiction of Swedish law.

Publisher:
IEA Heat Pump Centre
PO Box 857, S-501 15 BORAS
SWEDEN
Tel: +46-33-16 50 00, Fax: +46-33-13 19 79
E-mail: hpc@heatpumpcentre.org
Internet: <http://www.heatpumpcentre.org>

Editor in chief: Monica Axell
Technical editing: Fredrik Karlsson,
Ulf Mårtensson - IEA Heat Pump Centre
Language editing: Neil Muir, Angloscan Ltd
Illustration, page 1: With approval from Carrier AB
Frequency: quarterly

Heat pump news

General..... 6

Technology & Applications 9

Markets..... 10

Working fluids 12

IEA Heat Pump Programme 13

Features

Foreword 3

Columnist 4

Books & Software 30

Events 31

National Team Contacts 32

Topical article

Field Analysis of Heat Pump Installations 15

Competitive Strength of Heat Pumps in the Netherlands 19

Non-topical article

eff-Sys – a Swedish research programme for heat-pumping technologies 23

Performance Comparison of R-22 and R-410A..... 25

Magnetic Cooling..... 27





*Mats Fehrm
NIBE Export R&D*

There has been a major expansion of the Swedish heat pump market over the last few years, probably because the Swedish market has reached a high degree of maturity. The first alternative considered by those wondering whether to improve or replace their heating systems is to check whether a heat pump could be suitable. If a neighbour already has a heat pump, it is easy to find a reference. With high prices for oil, gas and district heating, and a low interest rate, investment in a heat pump system can give a positive cash flow already during the first year.

In 2003, about 31 500 ground source heat pumps, 12 000 exhaust air heat pumps and 3 100 ambient air to water heat pumps were installed in Sweden: a country with fewer than nine million inhabitants. From a Swedish perspective, it is easy to imagine that there must be a huge world market potential for heat pumps. Unfortunately, conditions for heat pumps differ widely from country to country. Cost savings are not always the main issue for the decision to install a heat pump. A Swiss investigation found that about 60 % of heat pump installations have been decided on the basis of their positive impact on the environment. We have reason to believe that this is the main reason for many installations in mid-Europe.

This alone will not build a substantial heat pump market. Many purchasers choose a heat pump for its cost savings, comparing the total cost of a heat pump with the total cost of the alternatives. A high-COP heat pump will have an advantage, as will a multifunctional heat pump, i.e. one that can provide heating, domestic hot water production and cooling in one package, keeping down the total cost for installation and equipment. A heat pump that meets more or less all service heat demands will use the minimum amount of electricity and needs no connection to the gas supply or to an oil boiler with tank and chimney.

Although no pattern is yet emerging, we can see that the heat pump market is developing very differently in different parts of the world. Most countries are showing a small increase, although some have a rapidly growing market. France, a country with considerable experience of heat pumps, has now overtaken Germany to have the second largest number of heat pumps in use. The types of heat pumps are also developing in different ways. In Europe, HFCs are the main refrigerants, though HCs are struggling against proposed new safety standards, while CO₂ has just lifted its nose above the horizon. Japan seems to be in the lead for domestic hot water heat pumps using CO₂, although HFCs are still the mostly commonly used refrigerants. The tremendous increase in world oil prices during the last few weeks might favour heat pumps due to shorter payback times when comparing heat pumps with oil heating.

My believe is that heat pumps are here to stay. More and more of the big heating equipment suppliers are moving into the heat pump business. This will force today's manufacturers and installers to improve products, systems and installations, and to offer cost-efficient heat pumps to a market that will be increasingly aware of the existence of the heat pump.

*Mats Fehrm
NIBE Export R&D*

Residential Heat Pump Technology in the United States



Steven R. Szymurski
Director of Research

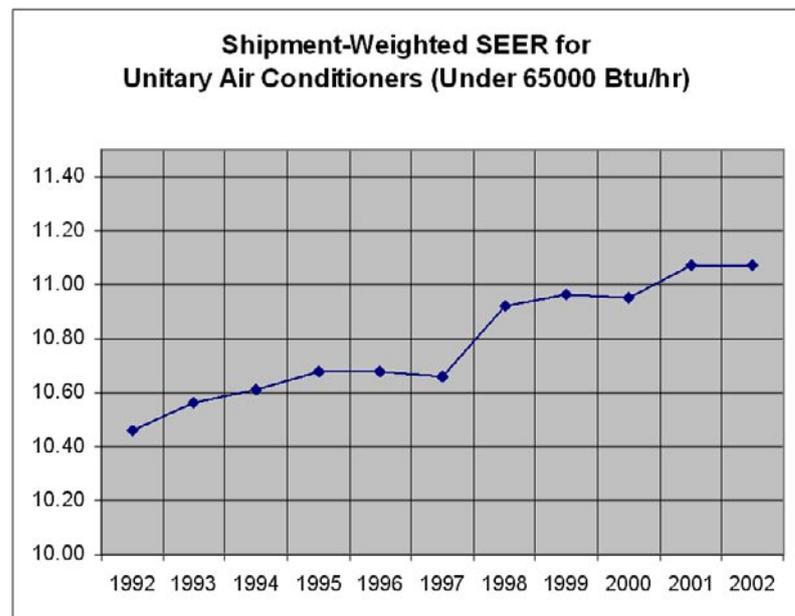


Arlington, Virginia, US

Heat pump technology for residential cooling and heating have gained wide acceptance in America. Approximately 87% of new homes in the U.S. are built with central air conditioning systems. Shipments of U.S. central air conditioners and air-source heat pumps hit an all time record last year with 6,746,326 units shipped. Air-source reversible heat pumps also hit a new record in 2003 with 1,626,365 units shipped. Residential air-conditioners for cooling only outweighed reversible heat pumps for cooling and heating by 3 to 1. Ground- and water-source heat pumps are gaining acceptance in the U.S. market and ductless mini-split air conditioners and heat pumps, which are popular in Asia, are also making their way into the U.S. market. Heat pump water heaters on the other hand have not made much headway in the residential market. This is primarily due to the significantly lower first cost of electric resistance water heaters and the relatively cheaper cost of gas for gas water heaters. The current U.S. market for heat pump water heaters is estimated at only 1000 to 2000 units per year. While the markets for completing electric resistance water heaters and the gas water heaters are both at about 3 million per year.¹

Steady Improvements in Energy Efficiency

U.S. manufacturers have steadily enhanced their product lines with more efficient residential systems. The current U.S. federal minimum efficiency for residential systems is a Seasonal Energy Efficiency Ratio (SEER) of 10. Although first cost for models meeting the minimum energy efficiency has been the leading driver for the residential air conditioner and heat pump market, there has been a steady increase in the sale of more efficient units as indicated by the increasing shipment-weighted SEER of unitary air conditioners over the last ten years.



Source: ARI Statistical Profile

In 2006 the federal minimum efficiency standard for residential split-systems will be raised to 13 SEER. Manufacturers are getting ready to meet this new requirement. They are investing heavily in new manufacturing lines and marketing support. Many of them already

have products that exceed 13 SEER; some in the 18 to 19 SEER range. HVAC&R manufacturers will face and respond to new challenges and changing market forces at home and overseas. Assisting manufacturers in this effort are a number of research programs. In addition to proprietary research conducted independently by each manufacturer, there are several organizations that sponsor publicly disseminated research programs. Among these are research programs sponsored by the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), research conducted in U.S. Department of Energy national laboratories, and private-public cooperative research programs initiated by the Air-Conditioning and Refrigeration Institute (ARI).

U.S. HVAC&R Industry Cooperative Research

For the past 15 years, U.S. manufacturers have participated in several cooperative pre-competitive research programs organized by ARI. The Materials Compatibility and Lubricant Research (MCLR) program - completed in 2001 - conducted fundamental research that assisted U.S. manufacturers in phasing out CFC refrigerants and transitioning to HFC refrigerants. The R-22 Alternative Refrigerant Evaluation Program (AREP) - completed in 1997 - was an international program for HVAC&R equipment manufacturers to cooperatively test and share results of comparative cooling capacity and energy efficiency performance of R-22 and R-502 replacements.



The U.S. manufacturer's current cooperative research effort is *HVAC&R Research for the 21st Century*, also referred to as the "21st Century Research" (21CR). This program began in 1999 and addresses fundamental research for improving the integration of HVAC&R technology into buildings to provide more energy efficient structures with improved indoor environments. More detailed information on the 21CR program and its many research projects can be found at the program's website (www.arti-21cr.org).

The IEA Heat Pump Center and its Heat Pump Newsletter play an important role in disseminating information on new advances in heat pump technology. I look forward to working with the Heat Pump Center in this effort.

My best wishes for the continued success of the Heat Pump Center,

Steven R. Szymurski

¹ Toward Market Transformation: Commercial Heat Pump Water Heaters for the New York Energy Smart (SM) Region, ACEEE report to NYSERDA, October 2002.

General

Coalition for Promotion of Earth Energy Heat Pumps Formed

Canada - Five electric utilities in Canada have formed a coalition to promote earth energy heat pumps. The Canadian GeoExchange Coalition includes BC Hydro, Hydro-Québec, Manitoba Hydro, SaskPower and Yukon Energy in an effort to "significantly increase" the number of annual installations for ground-coupled heat pumps. Funding comes from Natural Resources Canada under its 'Renewable Energy Deployment Initiative,' with additional support from the Washington-based Geothermal Heat Pump Consortium and the Earth Energy Society of Canada. A formal announcement of the launch is expected later in 2004.

Information:
www.Geo-Exchange.ca
Contact: Roy Staveley,
staveley@canelect.ca

European Certified Heat Pump Installer

The European Commission approved this project in December 2003, and a kick-off meeting took place on March 18, 2004. The "European Certified Heat Pump Installer" was initiated by the European Heat Pump Association (EHPA), and is a European project within SAVE.

The project was initiated for the following reasons:

- A significant market barrier for heat pumps is the fact that these systems are more complicated than traditional heating systems. A mixture of skills is needed that are normally covered by different professions (electricians, plumbers, refrigeration engineers).
- The efficiency and quality of the

heating system is not dependent on the heat pump alone, but is also very dependent on the design and installation of the whole system.

- At present, the market is growing more quickly than the number of qualified installers. This can lead to poorly installed systems, which can affect the development of the heat pump market.
- There are organised training courses for heat pump installers in many European countries, but they vary in standard and content.

This project was therefore initiated for these reasons, and because it was felt that a common European effort will be more effective than separate national actions. Among the expected benefits are:

- Collation of national experiences of training courses
- Transfer of knowledge and know-how within Europe.
- Common training targets for heat pump installers
- European curricula for the training courses
- Development of a European Certificate and the Accreditation and Certification Programme

This project will have the positive effect of providing a growing number of well-trained heat pump installers, thus also making the European Certified Heat Pump Installer a perfect marketing instrument.

Source and more info: www.fiz-karlsruhe.de/hpn/html/Proposal.html

Success for Clear Skies

UK – The Clear Skies scheme, which was started a year ago, provides capital grants to encourage homeowners and community groups to invest in renewable energy sources. 120 grants of GBP 1,200 have been made during the year to homeowners for installa-

tion of ground source heat pumps. Community projects are considered by an independent panel every three months, with grants of up to 50 % of the costs (maximum GBP 100,000) available. In the three rounds completed so far, 20 projects have been supported with grants totalling GBP 411,000.

Source: UK Heat Pump Network Newsletter, issue 8, March 2004

The 13 SEER standard to go into effect

USA – The Second Circuit Court in New York finally ruled that the 13 SEER standard as originally promulgated by the Department of Energy in 2001 should go into effect in January 2006 for new central air conditioners and heat pumps. This will reduce the energy use by new air conditioners by 23 % from the current standard (SEER 10). According to ACEEE (American Council for an Energy-Efficient Economy), this will reduce the peak demand for electric power by 41 500 MW by 2020.

Source: IIR Newsletter, no. 18, 2004

Trading in Energy Efficiency

Trading with green certificates (the renewable energy trading scheme) has already started. There are now plans to introduce a trading scheme for energy efficiency (called 'white certificates') by the European Union, which should be a valuable tool in showing the value of energy conservation measures.

The Demand Side Management (DSM) Implementing Agreement within the IEA is planning an international project to investigate the potential for these white certificates. White certificate trading schemes



are already operating on a trials basis in the UK, Italy and New South Wales in Australia. France is planning a scheme, while a mandatory Energy Efficiency Programme has been established in Belgium. Other countries are showing interest in a trading scheme of this kind, including Sweden and Norway.

The DSM project aims to address the following issues:

- Whether, and how, a scheme involving white certificates provides an effective means of attaining targets of reduced:
 - primary energy consumption
 - carbon dioxide emissions
- What is the most suitable format for such a scheme?
- What implementation problems are involved at national and international levels?
- How can it interact with other schemes?

Source: IEA OPEN Technology Bulletin, issue 17.

IEA DSM Draft Work Plan "Market Mechanisms for White Certificates Trading".

Ny Teknik no.18, 28 April 2004 (in Swedish)

Working Party on Refrigerant System Safety

This working party was established by the science and technology committee during ICR 2003 in Washington. The vision for this working party is to document existing experience regarding refrigerant system safety. The lack of documentation has become evident when drafting new safety standards. Accidents involving injuries to persons and/or damage of USD 0.1 million or more should be put in a database, and the accidents should then be analysed in order to find the real cause for them.

Anyone interested in participating in this work is welcome to contact the Chairman, Lennart Rolfsman from York EMEA, at lerolfsman@yorkref.com.

Source: Cdig Newsletter, no.2, February 2004

IIR Working Parties

The list below shows the currently active IIR working parties. Six of them are new (marked *). Anyone interested in participating in the activities of these working parties is welcome to contact the IIR or the chairman of the

working party concerned. E-mail addresses to the chairmen are available on the IIR web site, www.iifir.org.

Source: IIR Newsletter, no. 18, 2004

Name	Chairman	IIR Commissions involved
Data and models for refrigeration and freezing foods *	Bart Nicolai	C2, with D1, D2
Mitigation of emissions of greenhouse gases in refrigeration *	-	B1, B2, D1, D2, E1, E2
Magnetic cooling *	Peter Egolf	B2, with A1
Refrigerant system safety *	Lennart Rolfsman	B2, with B1, E1, E2
Cold chain optimization *	Nevin Amos	D1, D2
Cold chain in warm countries *	-	D1, D2
Ice slurries	Michael Kauffeld	B2, D1
Mobile air conditioning	Gabriel Haller	E1, with E2, B1, B2, D2

Workshop on Heat Pumps Held in Madrid

Spain - The Second International Workshop on Heat Pumps organized by the Spanish National Team on Heat Pumps (ENEBC) took place at the Spanish Ministry of Economy on 30th March.

The latest breakthroughs in heat pump applications reached by different national research groups were presented at the workshop. High-efficiency absorption heat pumps, their combination with residual geothermal energy or fuel cells and a comparison of them with traditional heating systems were some of the issues covered during the conference.

Other initiatives that are being carried out, such as installers' training, destruction and recycling of working fluids and coordination of different research groups into an R&D thematic network, were also announced.

An international presence was provided by a representative of the new Heat Pump Centre, which has been coordinated by SP in Sweden since January 2004. The intention of the Heat Pump Centre during this new stage is to increase the number of projects and member countries, encouraging

cooperation among national teams of member countries and also with other entities and international associations.

The closing session was presented by Mr. Luis Mas, Assistant Director-General of Technology Application and Development, on behalf of Mr. Arturo González, Director-General of Technology Policy at the Ministry of Science and Technology.

The workshop was attended by about 50 participants from different sectors related to heat pumps (manufacturers, installers, researchers and technicians), who saw the workshop as a useful discussion forum for the exchange of information in the sector. Several conclusions were reached during the workshop and the closing session: important examples include the institutional support that this clean and efficient technology has received, and the need for closer involvement by manufacturers in research and innovation activities that would promote the development of national technology.

Source: Spanish National Team



Earth Energy Heat Pumps as a Component of Green Heat

Canada - Ground-coupled heat pumps are positioned to lead a campaign to promote the use of renewable energy for low-grade thermal applications.

The Green Heat Partnership was created by the Earth Energy Society of Canada (EESC) and the Canadian Association for Renewable Energies (we c.a.r.e.), with support from members of the Canadian Solar Industries Association (CanSIA) and Canadian Bioenergy Association (CANBIO). The goal is to explain how earth energy systems, solar thermal collectors and biomass combustion units provide green heat for space conditioning, and complement the growing appreciation for green power and green fuel technologies.

Canada's residential sector consumed 1,328 PJ of energy in 1999, according to government data, of which 80% was for space heating, space cooling and water heating. In the commercial sector, 65% of the 984 PJ consumption is for space and water conditioning.

Both sectors rely heavily on natural gas and oil as the source of this energy, so the increased use of green heat technologies will lead to significant reductions in the emission of greenhouse gases. The Earth Energy Society estimates that its 30,000 systems in Canada already reduce GHG emissions by 0.5 MT a year.

Earth energy is the only technology among the green heat options that provides space cooling, so its role as a potential solution will be higher than solar collectors or wood stoves. EESC is developing a number of internet domains to reinforce the positive message on green heat, including 'In My Back Yard' to promote the invisibility of ground-coupled heat pumps, and an 'Off Carbon Campaign' to mimic the former 'off oil'



A ground loop is installed at a new high school in Nova Scotia, on Canada's east coast. The earth energy contractor laid the pipe on the sports field before landscaping, thereby drastically reducing the cost of installation.

efforts that followed the OPEC oil shocks of 30 years ago.

For the past year, the Green Heat Partnership has been lobbying for a 20 % green heat procurement by federal and provincial governments. Years ago, the federal government committed to purchase 20 % of electricity in its buildings from green power facilities, and this market guarantee has been credited by the domestic wind energy sector for kick-starting the growth of its industry. Similar targets are being set for the purchase of green fuels for government fleets, and the Green Heat Partnership is detailing the economic benefits and GHG reductions that would accrue from a similar commitment to green heat.

The next stage will be to ride the coat-tails of the growing understanding of renewable portfolio standards (RPS), by developing a campaign for a 20 % negatherms target. A RPS requires utilities to source a percentage of their electricity supply from wind-farms and other green power facilities, and the negatherms goal is to encourage gas and oil suppliers to diversify into green heat technologies.

To date, the greatest barrier has been the obsession with electricity and the lack of knowledge of how renewables can be used for heating, but the rising price of natural gas is helping to focus public and political attention on the applications for low-grade thermal demand that can be met by green heat technologies such as earth energy.

Further information:

Earth Energy Society of Canada
www.EarthEnergy.ca
 Green Heat Partnership
www.GreenHeat.org
 In My Back Yard
www.IMBY.org
 Negatherms Standard
www.negatherms.com
 Off-Carbon Campaign
www.off-carbon.com
 Canadian Association for Renewable Energies
www.renewables.ca
 Renewables for Residences
www.Green-Homes.org

Contact: Bill Eggertson,
Eggertson@EarthEnergy.ca

Technology & Applications

Chilled Beam with Integrated Lighting Awarded

Sweden – Architect Moon, a chilled beam with integrated lighting by the Lindab Group, has been awarded the Comfort & Design Award at the Mostra Convegno Expocomfort 2004 in Milan. Over the last two years, Lindab has been concentrating on aesthetic design when developing new products, in order to make them fit easily into the indoor environment.

Source: KYLA, no.2, 2004 (in Swedish)



Design Prize Awarded to Insulin Refrigerator

New Zealand – Second prize was awarded to a tiny insulin refrigerator at a gala reception during the United States National Manufacturing Week in Chicago. The Emhart 'Create the Future' contest, a prestigious international design contest, attracted more than 1000 entries from engineers, students and others across the world.

The mini refrigerator, claimed to be the world's smallest, was developed

by Olaf Diegel, a lecturer in product development. Mr Diegel developed the refrigerator as he saw a need for diabetics to have a portable, cool, storage carrier for the insulin they must carry with them. Today, ice packs are used in order to keep insulin cool when travelling.

The refrigerator uses the Peltier effect for cooling, and thus does not require a fan or other moving parts. It is powered with rechargeable batteries and fits into a jacket pocket.

Source: Massey News, Massey University, New Zealand



Compression/Absorption Heat Pump for High Temperatures

Norway – A compression/absorption heat pump using water/ammonia as its working fluid was installed in a dairy plant in Norway in 2003. It has now been in steady operation for 4000 hours, supplying heat for pasteurization, hot water for the dairy and heat to a district heating system (70-95 °C). The heat pump, with the nominal thermal power output of 300 kW, has been developed by the Institute for Energy Technology (IFE) in Oslo, with funding from the Research Council of Norway, York Refrigeration, Alfa Laval, Mobil and Statoil.

The compression/absorption cycle opens new possibilities for a flexible plant. Process characteristics can be changed by varying the ratio between the mass flow of water/ammonia solution and ammonia mass flow through the compressors. In addition, accumulating working fluid in different parts of the process will also affect the solution ratio between water and ammonia, thus changing the process characteristics.

Source: Kulde Skandinavia, no.1, 2004 (in Norwegian)

Markets

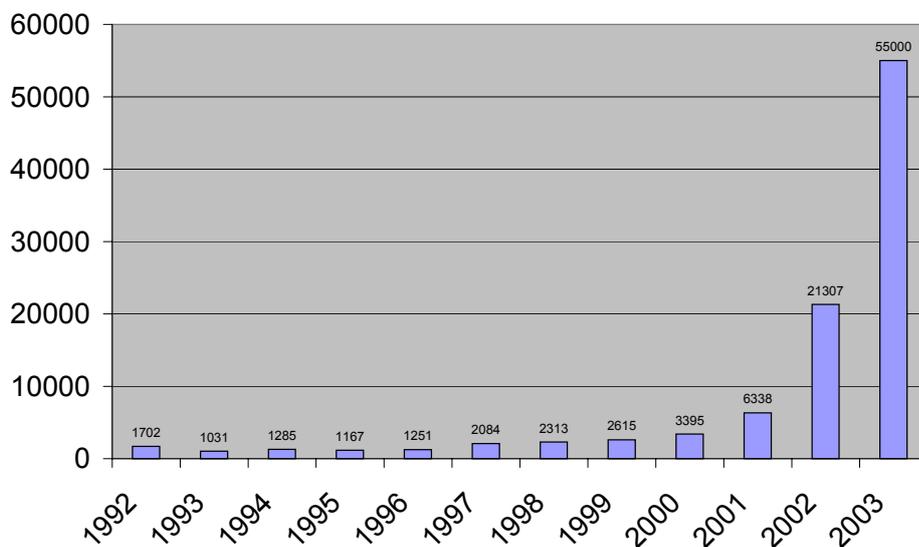
Current Status of the Norwegian Heat Pump Market

All-time high for heat pump sales in Norway

Norway - Heat pump sales in Norway in 2003 amounted to approximately 55 000 units, more than double the 2002 sales of 21 300 units. Growth rate has been high for a couple of years: in 2001, the market amounted to only 6300 units.

The market is dominated by outside air split units, but there has also been an increase in sales of ground source and sea water heat pumps. Although outside air units dominate, the other types of heat pumps are larger systems and generally give larger energy savings per unit. There is increased interest in systems that combine heating and cooling.

The leading Japanese manufacturers have dominated the Norwegian market for outside air split units, with high-efficiency inverter R-410a models, but are now facing increased competition from Chinese manufacturers. The Swedish manufacturers IVT, Thermia and Nibe dominate the market for ground source heat pumps.



Public subsidy for investment in heat pumps

Due to high energy prices, the Ministry of Petroleum and Energy announced a 20 % investment cost subsidy for heat pumps, wood pellets burning stoves and energy-saving control units for electric heating. Over 50 000 households applied for the subsidy, and over 17 000 invested in a heat pump system. This was a two-stage process: application for the subsidy, followed by a decision to continue. Heat pumps were by far the most popular investment for energy saving, constituting approximately 90 % of the investments.

New skills necessary

The Norwegian Heat Pump Association (NOVAP) is somewhat concerned over the quality of installers in the Norwegian market. There is no legal requirement for qualifications for installers of heat pump systems from the Government in Norway. Because of this, NOVAP has established a voluntary certification scheme for installers. In addition, a number of four-day courses have been run, providing a mix of teaching and practical training in small groups.

Source: Norwegian National Team

Toshiba Carrier and Midea Establish Joint Venture

China – On 8 April, Toshiba Carrier and Guangdong Midea Group announced that they had agreed on establishing a joint-venture company to produce compressors. The company will be established in Fushan City in Guangdong province in China. Midea will provide 60 % of the total cost and Toshiba Carrier 40 %. It is

intended to build a factory capable of producing three million units/year in 2008, enabling the companies to increase their world market share by 20 %.

Source: JARN, no. 4, 2004

Vaillant Enters the Heat Pump Market

Germany – Vaillant, the large German heating equipment supplier, now enters the heat pump market. In March, the company announced a product program consisting of four split units, three multi-split units and one mobile unit. The range covers domestic appliances and small offices. The heat pumps provide both heating (3.0 – 7.9 kW) and cooling (2.6 – 6.5 kW).

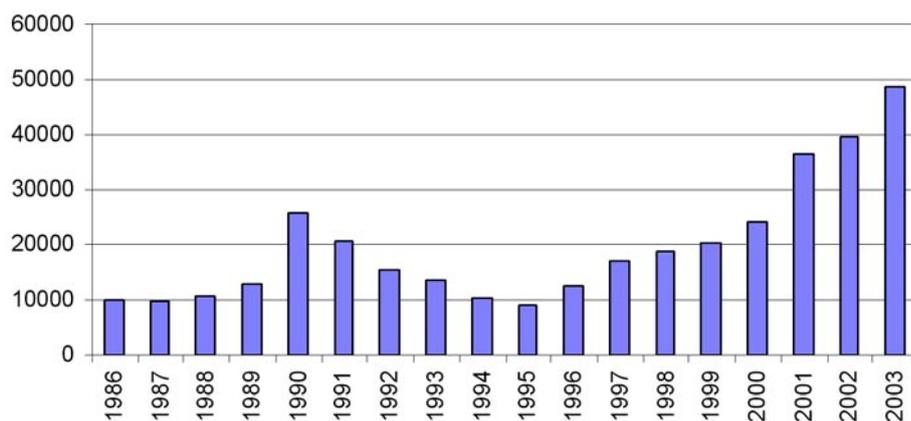
Source: CCI Print, no. 3, 2004



Increased Sales in the Swedish Heat Pump Market in 2003

Sweden - The official sales statistics collected by the Swedish Heat Pump Association reveal yet another sales record, with 48 806 heat pumps sold in 2003. As the statistics do not include a large number of air/air units (approximately 20-25000), the official figure underestimates total sales for the year. The reason why the official statistics do not include air/air units is that several importers of these units do not report their sales to the Swedish Heat Pump Association.

Ground source heat pump sales increased by 15 %, reaching a total of 31 586 units. Exhaust air heat pumps increased by no less than 42 %, reaching a total of 17 220 units. The reason



for this increase of exhaust air heat pumps is that such heat pumps are by far the most favourable choice for new construction and, in addition, the replacement market for exhaust air heat pumps has started to take off. The Swedish market has been very concentrated on the market for single-family houses, and we expect

this market to start to slow down soon. The major potential for growth now lies in the market for apartment buildings.

Source: Martin Forsén, Swedish Heat Pump Association (SVEP), Tel: +46 8 762 75 11

Indian Air-Conditioning Market Expected to Increase Rapidly

India - Currently only 1.2 % of Indian households have an air conditioner, which means that there is a huge market potential in the second most populated country in the world. This market is now expected to increase rapidly, by approximately 25 %/year over the next three years, according to LG Electronics. The forecast for 2004 is that 1 million air-conditioners will be sold, up from 800,000 in 2003. The increase is expected due to the strong demand and rising incomes.

Source: Reuters / ASHRAE e-Industry, vol. 3, issue 12

Carrier Acquires Europe's Largest Refrigeration Company

USA/Germany - Carrier acquires Linde AG's refrigeration division, the European leader in commercial refrigeration. Products include industrial and commercial refrigeration systems, display cases and subsystems. The headquarters of the Linde refrigeration division is located in Cologne, Germany, with manufacturing facilities in Europe, South America and Asia.

Source: ASHRAE e-Industry, vol. 3, issue 13

The German Heat Pump Market Continues to Grow

Germany - The market for heating only heat pumps in Germany increased by 17 % from 2002 to 2003. 9745 space heating heat pumps and 3776 domestic hot water heat pumps were sold. The greatest increase was noted for air-to-water heat pumps, which increased by 57 %.

Source: Wärmepumpe aktuell, no. 1, May 2004

Working Fluids

DuPont Forms Joint Venture with Chinese Company

China – In March 2004, DuPont and Zhonghao New Materials Company, Ltd. formed a joint venture for producing HFC refrigerants. The new company, named DuPont 3F Fluorchemicals Changshu Company Ltd., will have its headquarters in Changshu, Jiangshu province, in China, and has been established to meet the demands from the fast growing air-conditioning and refrigeration market in China. The main products will be R404A, R407C and R410A.

Source: Die Kälte und Klimatechnik, no.4, 2004

European F-Gas Regulation

EU – The European Parliament voted on the F-gas proposal (Proposal for an European Parliament and Council regulation on certain fluorinated greenhouse gases) on March 31st. The main decisions were:

- Regulation based on the internal market EC Treaty
- A ban on fluorinated gases with a GWP higher than 50 (will affect R134a and R152a) on all new car air-conditioning systems as of 2014, with a phase-out period starting in 2011.
- The frequency of equipment inspections will be based on the condition of the equipment. Inspections will become more frequent if a leak is detected, and less frequent if no leaks are detected.
- Details provided on training and certification programmes are needed for service personnel etc., who will handle F-gases.

A ban on fluorinated gases in a wider range of applications, such as domestic refrigerators, was rejected. But

Member States are required to promote the use of gases with a GWP lower than 150. The next phase in the adoption procedure will be a meeting of the Environment Council in June. The regulation is not expected to come into force before autumn 2005.

Source: IIR Newsletter, no. 18, April 2004

R410A Shows Lower Environmental Impact than Propane for Medium-Temperature Refrigeration

USA – In a Life Cycle Climate Performance (LCCP) analysis, medium temperature commercial refrigeration equipment designed to use R410A performs better than equipment designed to use propane. The LCCP take into account the environmental impact of the fluid and the equipment, including energy use, during the entire life cycle of the fluid and equipment. The analysis was carried out on an equal first cost basis, i.e. if the propane system involved an extra cost of, for example, 10 % for added safety features, then this extra cost could be used for a larger condenser for the HFC system. On this basis, the LCCP-value was 4.2 % lower for R410A than for propane. On the other hand R404A, which was also included in the analysis, returned an LCCP value 1.8 % higher than that of propane.

The study was released in March by the Centre for Environmental Energy Engineering (CEEE) at the University of Maryland. The report entitled "Comparison of hydrocarbon R-290 and two HFC blends (R404A and R410A) for medium-temperature refrigeration applications" can be downloaded from www.ari.org. The study is part of the Global Refrigerant Environmental Evaluation Network (GREEN), a network set up to test HFCs and other refrigerants such

as ammonia, propane and butane in air-conditioning and refrigeration equipment. The GREEN program is under the auspices of ICARMA (International Council of Air Conditioning and Refrigeration Manufacturers' Association).

Source: Koldfax, April 2004

Regulations and Use of HFCs in the US

USA – On March 12, the Environmental Protection Agency (EPA) published a rule clarifying that it is illegal to vent HFCs. They should instead be recovered in the same way as CFCs and HCFCs. However, this is not enough, according to the Air Conditioning Contractors of America (ACCA), which wants all current regulations on CFCs and HCFCs to be applied to HFCs as well. This means that HFCs would be required to meet the same requirements for leak-rate prohibitions, evacuation levels, leak repairs, record keeping, refrigerant recovery equipment certification, contractor licensing, and refrigerant sales restriction. This is in order to preserve the future use of HFCs by applying good refrigerant use practices today. Currently, the situation is that a small subset of the HVAC&R community ignores responsible refrigerant use practices, thus putting those who want to use proper practices in an unfair competitive situation. Therefore "ACCA members strongly encourage EPA to restore a level marketplace by vigorously enforcing current CFC and HCFC regulations and by extending the same regulations onto HFCs. With HFC-410A widely recognized as the replacement for HCFC-22, extension of current regulations to HFCs is critical for responsibly safeguarding the natural environment in the future" said Glenn Hourahan, ACCA Vice President.

Source: Air Conditioning, Heating, Refrigeration News, 12 April 2004



IEA Heat Pump Programme



National Teams Meeting held in Borås

The National Teams meeting held in Borås on 19-20th April was very successful. Ten out of twelve countries were represented, several by more than one delegate. The first day was devoted mainly to country presentations. The situation in each member country was described, i.e. market trends, policies, research and work within the Heat Pump Programme (HPP). In addition, the new Heat Pump Centre (HPC) was introduced to the delegates. In the evening, everyone gathered for a very pleasant dinner with exotic Swedish dishes.

Day two was devoted to discussing the activities within HPP and HPC. A number of suggestions for new Annexes (see list below) were discussed, as were the topics and sessions for the 8th Heat Pump Conference in Las

- Retrofit Heat Pumps for Buildings
- Development of a Performance Analysis and Optimization Tool for HVAC&R Systems in Supermarkets
- The Role of Heat Pump Energy Systems for a Sustainable Society
- Long Term Performance of Heat Pump Systems

Vegas, 2005. The National Teams also gave their opinions on the work of HPC. New activities and changes to the current activities were suggested.

Altogether the meeting was a success, providing the HPC with a valuable information and closer contacts with the National Teams.

Source: Heat Pump Centre

The 2003 Annual Report of the Heat Pump Programme Now Available

The promotional Annual Report of the Heat Pump Programme, describing the activities of the program in 2003, is now available and can be downloaded or ordered from the web site, www.heatpumpcentre.org.

Events of interest in 2003 include the transfer of the Heat Pump Centre from Novem to SP Swedish National Testing and Research Institute, and the establishment of formal links between the HPP and the European Heat Pump Association. In addition, Annex 26, Advanced Supermarket Refrigeration/Heat Recovery Systems, was finalised and a new annex (Annex 29),

dealing with the issue of market and technical barriers to ground source heat pumps, was established.

Source: Heat Pump Centre

Annex 28 Web Site Launched

The web site for Annex 28, 'Test procedures and seasonal performance calculations of residential heat pumps with combined space heating and domestic hot water production', was launched in March. It provides information about the project, project participants and the publications available from the annex. For more information, visit www.annex28.net.

Source: Heat Pump Centre

Annex 28 Workshop held in Japan

Japan - A workshop was held in conjunction with the expert meeting of Annex 28, in Yokohama, Japan, on June 4. The workshop saw presentations from researchers participating in the annex work, as well as from Japanese researchers and companies on various heat pump technologies.

The presentations from the Annex 28 participants described the annex work and also the new Heat Pump Centre secretariat.

Carbon dioxide as working fluid is very much in focus now in Japan, and several companies are developing components and systems for it. The workshop saw two presentations on this subject; one describing carbon dioxide compressors, and one describing heat pump water heaters. Several companies in Japan are now developing and producing heat pump water heaters with carbon dioxide as the working fluid.

The workshop programme was as follows:

- IEA HPP Annex 28 – goals and actual project state
Carsten Wemhöner, Institute of Energy, University of Applied Sciences, Basel, Switzerland

- Development of multi-function CO2 heat pump water heaters
Hidemine Murahashi, Denso Corporation, Japan
- Test procedure and experimental results of a multi-function heat pump unit
Thomas Afjei, Institute of Energy, University of Applied Sciences, Basel, Switzerland
- Heat Pump Centre
Monica Axell, SP Swedish National Testing and Research Institute, Sweden
- Development of a high-efficiency carbon dioxide hermetic scroll compressor
Akira Hiwata, Matsushita Home Appliances Company, Matsushita Electric Industrial Co., Japan
- Research on annual energy consumption of packaged air-conditioning units
Jianfeng Wang, University of Tokyo, Japan

Source: Heat Pump Centre

Workshop – Canadian Activities in Heat Pumping and Refrigeration Technologies

Canada - The Canadian National Team arranged a workshop on 10th May in connection with the IEA HPP Executive Committee and the IEA ECES Executive Committee meetings. The workshop presented work in the IEA Heat Pump Programme and in the IEA Energy Conservation and Storage Programme. Manufacturers, policy-makers and researchers working in fields related to energy technology attended the workshop.

Canada is a large producer of electricity, with 65 % from hydro power, 15 % from nuclear power and 19 % from coal. Climate change has emerged as the central challenge for energy policy in Canada. Roughly 85 % of greenhouse gas emissions are energy-related, and Canada's efforts on climate change are significant (spending almost \$ 4000 million).

The main objective of a national 'Energy Innovators' Initiative (EII)' programme is to reduce greenhouse gas emissions from existing buildings. The programme use financial incentives and information dissemination to improve energy efficiency, decrease cost and improve productivity.

The New Buildings Program / Energy Code is another national programme, working with compliance tools and financial incentives to decrease greenhouse gas emissions and increase energy savings. The programme is aimed mainly at commercial and industrial buildings. 2,2 million m² of buildings have been constructed under the programme, achieving a reduction of 92 000 tonnes of CO₂.

CANMET Energy Technology Centre - Varennes is working on programs for industry, renewable energy and buildings. Supermarkets, ice rinks and curling rinks are interesting areas for research in the field of refrigeration technology in Canada. One problem is that the refrigeration technology is not adapted to Canadian climatic conditions. The objective of research is to achieve greenhouse gas emission reductions in the building sector through energy savings and reduction of synthetic refrigerant leaks. The potential for supermarkets, ice rinks and curling rinks is estimated as 4.0 Mt-eq. CO₂/year.

One presentation dealt with a pre-feasibility study software tool, RET-Screen, which includes models for wind, small hydro power production, photovoltaics, solar and biomass firing. Models for ground source heat pumps, CHP and refrigeration will be included in the software during 2004/2005. The aim is to use RET-Screen as a decision-making tool to reduce the cost of pre-feasibility studies.

Hydro Quebec is carrying out research in the field of heat pump and refrigeration technology. At the workshop, the company gave a presentation from a research project entitled 'An Electrical School with GSHP in Quebec'. A school has been built as a demonstration project with no fossil-fired heat sources. The aim is to promote efficient GSHP heating and cooling systems in cold climates. The school, with 200 students, employs a combination of solar energy and a geothermal heating system with heat pumps. The preliminary results show an annual specific energy consumption of 0.21 GJ/m²/year, which is 72 % lower than the Quebec average for school buildings.

Source: Heat Pump Centre

Ongoing Annexes

Bold text indicates Operating Agent.

Annex 25 Year-round residential space conditioning and comfort control using heat pumps	25	FR , NL, UK, SE, 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
Annex 29 Ground-Source Heat Pumps - Overcoming Market and Technical Barriers	29	AT , CA, JP, NL, NO, ES, SE, CH, UK, US

IEA Heat Pump Programme participating countries: Austria (AT), Canada (CA), France (FR), Germany (DE), Japan (JP), 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). Sweden is Operating Agent of the HPC.



Field Analysis of Heat Pump Installations - the FAWA Project

Peter Hubacher, Project Manager, FAWA, Switzerland

FAWA aims to employ statistical methods to document the energy efficiency and operational data of small heat pumps up to 20 kW heating capacity in operation, typically installed in single-family-houses or small condominiums, and to point out improvement potentials. The project was started in 1996 by the Swiss Federal Office of Energy SFOE, with the long-term view of assisting heat pump promotion strategy. FAWA has shown that the collected data enabled more in-depth analysis of plant behaviour over time, and recommendations could be made on plant installations. FAWA thus describes and analyses today's reality in the field and provides guides for planning. However, due to the statistical nature of the data, the results derived from it cannot be seen as general planning rules.

Method

Since the project started, statistics for 30 new plants have been added to FAWA each year by the designated ARGE (working cooperative). In addition, data for installations from 1994/95 have been added later. By the end of 2003, a total of 237 plants had been registered in the FAWA project. To ensure that the installations chosen remained representative, manufacturers, plant salesmen, electricity suppliers and installers were contacted and requested to suggest suitable installations. The measured data were read off by the owners of the plant at suitable intervals (at first weekly, and after one to two years every 2-3 weeks) and noted in a list. This record was called in regularly (1x per quarter) by the ARGE. A faults list, with data on system disturbances (type of disturbance, duration of the failure, rectification of the failure by the owners of the service/plant) was compiled at the same time.

To date, seasonal performance factors (SPF) are available from 221 plants. Approximately 45 % of them are air/water or brine/water plants. Water/water and ground-coupled heat pumps with horizontally installed coils form the remainder, but statistically reliable data for them is not available. To date, data for 1.3 million operation hours, and 740 op-

erational years, has been captured, making FAWA the largest and best documented quality test of a heating system in the world.

The SPF computations are based on readings by the plant owners of the installed electricity and heat meters. In addition to the energy quantities, half of the monitored plants also provided information on system temperatures. From this data, it has been possible to monitor the differences in efficiency and heat capacity between results from EN 255 tests (heat pump test centre WPZ Töss, since 2004 WPZ Buchs) and from the calculated manufacturers' data.

The criteria for choice were co-ordinated with the corresponding market conditions (number and geographical distribution). Care was also taken to ensure that data included results from new buildings and refurbished buildings, with corresponding differences in system types (with/without domestic hot water production; with/without parallel boilers). Only private buildings were included, with well-known standard installations. We deliberately left out exotic and 'non-standard' installations. The results were discussed in detail with a team made up from specialists and an expert. It was shown that the heat pumps achieve an extremely high level of reliability, but that improvements in planning are still possible.

Results and conclusions

The most important results and conclusions are presented below. Further information can be obtained from the full report, which will be available from ENET at the end of April 2004.

Seasonal performance factor (SPF = annual average of COP)

The brine/water plants (B/W) have an average SPF value of 3.4, which is about 25 % better than the value of air/water plants (A/W) at 2.6. It was stated also that probably because of the very different efficiency of the earth heat probes, the SPF for B/W heat pumps exhibit a much wider spread of data than that for the A/W plants.

Between 1995 and 2003, the SPF improved by approximately 20 % for both groups. Since the start of the project, the SPF data for 59 % A/W and 41 % B/W heat pumps, plotted against the total installed Swiss heat pump capacity, show an increase of around 23 % (from 2.5 to 3.1). This corresponds very well with the results from the WPZ Töss heat pump test centre. The FAWA result showing that the SPF figures have hardly changed since 1999 corresponds to the WPZ results, Fig. 1 and 2.



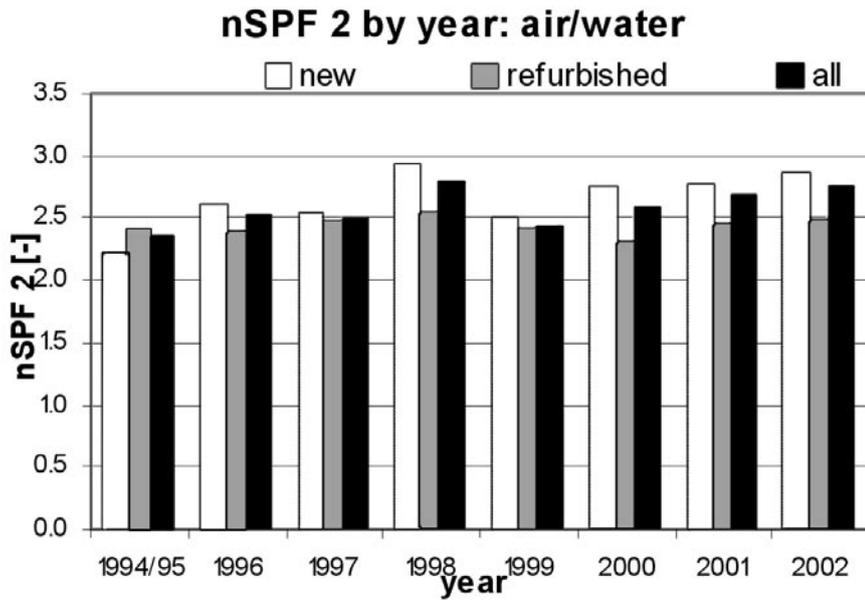


Figure 1: Average nSPF2 (seasonal performance factor including heat pump and accumulator and normalized source and sink temperature) for A/W plants, by year and building type. Linear regression shows an average annual improvement of 1.7%.

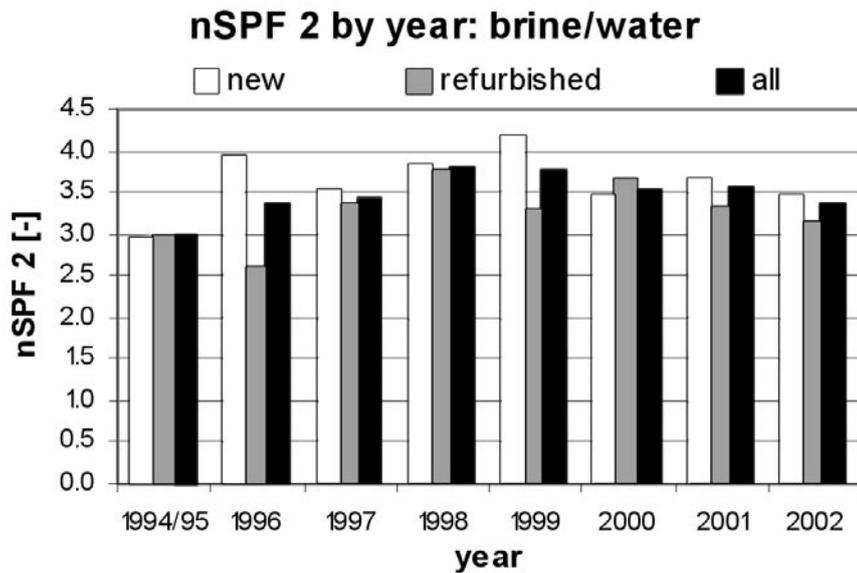


Figure 2: Average nSPF2 for B/W plants, by year and building type. Linear regression shows an average annual improvement of 1.5%.

Customer satisfaction

A 1997 survey found that 78 % of the heat pump owners in the survey were very satisfied: a further 17 % were fairly satisfied. Only 3% had reservations and 2% were not at all satisfied with their heat pumps. This essentially positive result has also probably to do with the high availability of 99.5% for heat pump systems, as determined in FAWA, Fig. 3

Customer satisfaction heat pump owners representative survey 1997

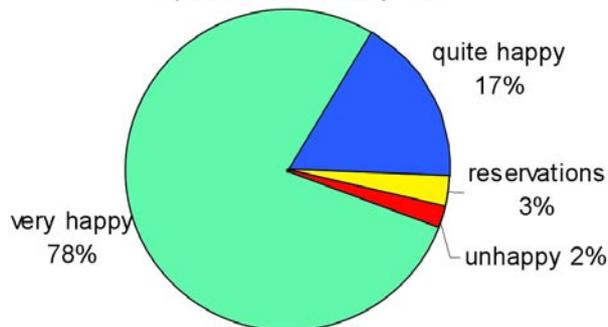


Figure 3: A user survey showed that 95% of HP-owners are happy to very happy.



Availability

The plants examined in FAWA exhibit an accumulated running time of approximately 1.3 million hours up to the middle of 2003. During this time, 8500 hours of faults occurred. From this we can calculate an average availability of all plant of 99.5%. Importantly, over 70 % of the plants operated without faults. The average duration of the fault (time from notice to rectification) was six hours. Depending on the type of fault, out-of-service times ranged from about two hours to more than three days. Fig. 4

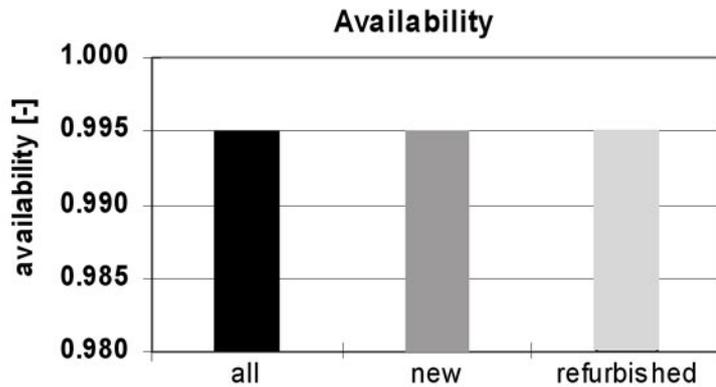


Figure 4: The reliability of new installations is no better than in refurbished cases.

Ageing

Similarly, the plants fared unexpectedly well concerning ageing. During the eight operational years, neither A/W nor B/W plants showed any significant reduction of SPF. Fig. 5

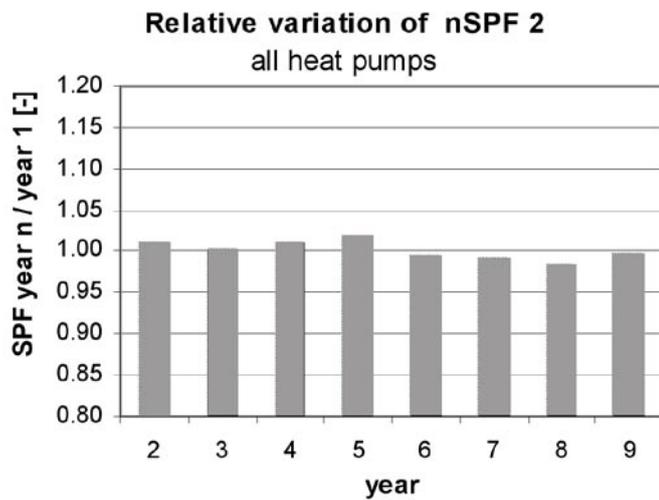


Figure 5: Relative variation of nSPF2 from first operational year for all installations. The 9th year is based on data from only four installations, and is therefore not yet statistically significant.

Control equipment

Plants with automatic control and room temperature compensation fared well on average. 50 % of the positive effect of over 8 % on the SPF can be explained by the compensation for external contributions (e.g. sunshine). It is inferred therefore that the automatic controller corrects primarily for heating curves that are set too high.

Auxiliary heating systems

The operation of A/W plants has shown that auxiliary electrical heating systems are not needed for normal heating purposes: at low outdoor temperatures, the entire heat requirement can be supplied by the heat pump. Additional electrical heating systems can nevertheless be useful for start-up and drying out the building. From the measured values of utilisation in normal operation it must be stated that the B/W units in particular are frequently oversized. This has primarily economically disadvantageous consequences.

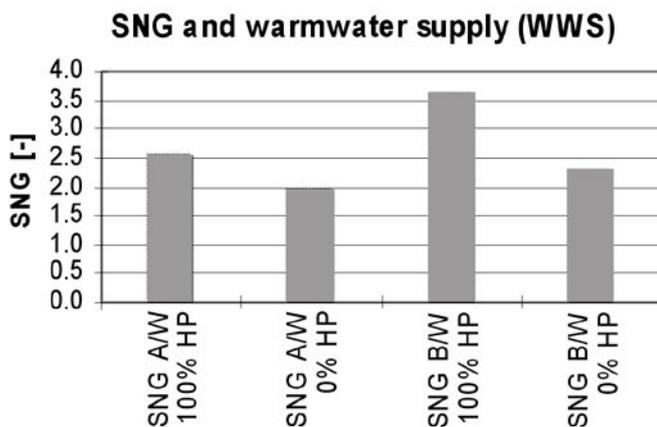


Figure 6: System efficiency (SNG=ratio of useable energy divided by the amount of electricity consumed) of A/W and B/W installations, supplying domestic hot water at 100% and at 0%

Domestic hot water

FAWA shows that the integration of domestic hot water heating has clear ecological and energy advantages over electrical heaters. Clear differences could also be seen in respect



of the different types of integration of water heating. As far as energy efficiency is concerned, adequately dimensioned heaters (i.e. for the daily requirement) with heat exchangers on the inside proved to be best. Fig. 6

Heat storage accumulators

Heat storage accumulators have hardly any positive effect on the SPF. However, they cost money, take up space and complicate the system, and should therefore be used only where they are really necessary.

Vertical earth probes

As mentioned earlier, B/W systems vary widely in their seasonal performance factors. The assumption that an important reason for this was to be found in widely varying characteristics of the ground heat collector subsystems was confirmed. Although the average measured brine temperature of 5 °C is quite high, there are very wide variations in the value. The measured brine temperatures could be only partly explained by the geological data. The present-day rule of thumb for a collector rating of 50 W/m could not be confirmed as a guarantor of a good result. A better estimate can be obtained from the annual energy absorbed per unit length of collector. A substantial optimisation potential, which can be implemented relatively simply, was found with the circulation pumps in the brine circuit. Clearly, the oversizing of the brine pumps adversely affects the SPF of the B/W plants.

Heat pump units

The result of the analysis of the energy efficiency of the actual heat pump units in the field was very satisfactory. A forecast of COPs for A/W machines, based on test rig data, was compared with the results from the field surveys. On average, the field results are 4 % lower than the test rig results, which indicate that the machines submitted for WPZ examination are typical of the manufacturers' series production units.

Summary and outlook

The experience gained has revealed new perspectives. The overall SPF does not depend on the heat pump alone: integration of the heat pump in the heating system is also important. This is a planning task. The planner/installer must define the inlet temperatures, the hydraulic concept of the heating system and specify the choice of heat source. It is clear that training requirements exist here. Unfortunately, it must be stated that the heat pump courses offered are not attended as well as they could be. The introduction of a formal "Certified Heat Pump Planner" qualification would create market pressure for planners to take the necessary further training. A further aspect concerns the information from planners, architects and owners about technical and economic performance data. Energy-efficient heating systems should not only be man-

ufactured, but should also be available at a reasonable price. It does not make sense to achieve extreme COPs at the expense of exaggerated costs. The principal purposes of the heat pump promotion were to create consumer confidence by achieving high reliability, to increase acceptance of heat pumps, to extend the knowledge of technical target groups and to improve both their quality and efficiency. Thus the objective was not a blanket promotion, but to ensure that the quality of systems was such that owners were satisfied with them. This work has taken a large step in this direction.

*Peter Hubacher
Hubacher Engineering
Tannenbergrasse 2
H-9032 Engelburg
Switzerland
Phone +41 71 260 27 27
Fax +41 71 260 27 28
E-Mail: he-ko@bluwin.ch*

Competitive Strength of Heat Pumps in the Netherlands

Peter Oostendorp, Hans van Wolferen, Netherlands

Development and application of sustainable energy is one of the objectives of the Dutch government in recent years, and heat pump systems for buildings are one of the spearheads in this policy. In 1999, an agreement was reached between about 60 participants (government, contractors, installers, producers, suppliers, property developers and research institutes) to coordinate and stimulate implementation of heat pumps. After four years, a study was carried out by TNO, KEMA and BMT of the competitive strength of heat pumps in The Netherlands [1]. The study was ordered by Novem, and interim results have been discussed with the parties. The main results and conclusions are presented below.

Heat pump system projects

An increasing number of heat pump projects have been performed in recent years. A quick inventory shows that at least 1800 dwellings have been equipped with heat pump systems, and over 700 are in progress. The following system arrangements are the most common. However, no system arrangement of the type shown at the bottom of the table has yet been installed, since individual gas-fired heat pumps are still under development.

Most heat pump systems are installed in new estates, and particularly in detached and semi-detached houses and expensive flats, although they are also installed in terraced houses. In most heat pump projects floor heating is applied, allowing free cooling in summer. Both floor heating and free cooling are appreciated by occupants for improved comfort.

Heat pump system energy performance

Performance of individual heat pump systems has improved rapidly over the last few years. Table 1 is an overview of annual COP and primary energy SPF for different levels of design temperature of the heating system. The first lines give the fixed

Concept	System functions ¹	Dwelling type	Ownership / operational structure (options)	Installed
Individual combi HP with individual heat source	H, DHW, C	Single-family dwelling (new estate)	Owner / user: occupant or lessor	Yes
Individual combi HP with collective heat source	H, DHW, C	Single-family dwelling or block of flats (new estate or renovation)	1. Owner of HP: occupant or lessor; owner of cold water system: energy service. 2. Owner of HP and cold water system: energy service – occupant pays his own power consumption.	Yes
Collective HP with additional heater and collective heat source	H, DHW, C	Single-family dwelling or block of flats (new estate or renovation)	Owner of HP and cold water system: energy service – occupant pays for heat and cold consumption.	Yes
Collective HP with additional heater and collective heat source (H, C) and individual heat pump boiler	H, C	Single-family dwelling or block of flats (renovation, possibly new estate)	Owner of HP and cold water system: energy service – occupant pays for heat and cold consumption.	Yes
	DHW		1. Owner of HP: occupant or lessor 2. Owner of HP: energy service – occupant pays his own power consumption.	
Various types of heating and individual heat pump boiler	DHW	Single-family dwelling or block of flats (renovation, possibly new estate)	1. Owner of HP: occupant or lessor 2. Owner of HP: energy service – occupant pays his own power consumption.	Yes
Individual gas fired heat pump and combination boiler	H, DHW	Single-family dwelling or block of flats (boiler replacement in existing dwellings)	1. Owner of HP: occupant or lessor 2. Owner of HP: energy service – occupant pays his own gas consumption.	No

¹System functions: Heating, Domestic Hot Water, Cooling.



values for heat pump performance in the Energy Performance Standard, EPN [2]. The other lines give higher performance values for heat pumps based on test results and described in product declarations of conformity. It is permitted to use these higher values in the EPN method, so better performance is rewarded. The performance figures for heat pumps are far better than the 97.5 % generator efficiency for the best condensing boilers applied with a low temperature distribution system.

Table 2 is an overview of annual COP and primary energy SPF for domestic hot water production for different levels of hot water demand. In some cases, higher ventilation rates and additional building ventilation losses are to be expected in comparison with traditional mechanical ventilation systems.

The effect of different heat pump systems on the energy performance of a typical Dutch dwelling is shown in Table 3. An energy reduction of 20 % or more can be achieved.

Heat pump system economy

An economic evaluation is carried out using the Net Present Value method. This includes all major factors, such as investment, gas and power costs, maintenance, interest, inflation and energy price. The results are shown in Figure 1.

Since heat pump systems with ground heat exchangers or aquifer source allow free cooling, a second calculation is done, on the basis that all other systems would need additional investment for cooling machines. The results are shown in Figure 2.

It is obvious that with the current energy performance requirements, and without cooling, heat pump systems are not economically competitive. Reduction of the Energy Performance Coefficient from 1.0 to 0.8, scheduled for 2006, will change this situation. The price of individual combination

Table 1. COP and SPF of heat pumps for heating (with declaration of equivalence).

Manufacturer / supplier	Type	Heat source	COP / SPF (for net primary energy)					
			Tsupply <= 35		35 < Tsupply <= 45		45 < Tsupply	
EPN (Standard)	Fixed, high level	soil	4,4	1,700	4,1	1,575	3,8	1,475
EPN (Standard)	Fixed, high level	groundwater	5,0	1,950	4,6	1,775	4,1	1,575
Nefit Buderus	Auris 11 / 19 / 24C	soil	1,250	1,250	1,225			
		outside air	1,200	1,200	1,175			
Itho	WPU-6	soil	5,85	2,275	5,70	2,200	5,40	2,100
		groundwater	6,00	2,325	5,85	2,275	5,55	2,150
Itho	WPU-8	soil	6,00	2,325	5,85	2,275	5,50	2,125
		groundwater	6,15	2,375	6,00	2,325	5,65	2,200
IVT / ES Techniek	Greenline C4 (C-W)	groundwater	5,65	2,200	5,15	2,000	4,65	1,800
IVT / ES Techniek	Greenline C4 (C-W)	groundwater	5,60	2,175	5,10	1,975	4,55	1,750
Redenko	Villa Classic 55	soil	4,70	1,825	4,25	1,650	3,80	1,475
		groundwater	6,25	2,425	5,55	2,150	4,85	1,875
Vaillant	VWS 6	soil	5,20	2,025	4,75	1,850	4,25	1,650
		groundwater	6,60	2,550	5,85	2,275	5,15	2,000
Vaillant	VWS 8	soil	5,20	2,025	4,65	1,800	4,10	1,575
		groundwater	6,35	2,475	5,50	2,125	4,55	1,750
Vaillant	VWS 10	soil	4,75	1,850	4,30	1,675	3,80	1,475

Table 2. COP of heat pumps for domestic hot water.

Manufacturer / supplier	Type	Annual hot water demand			
		Class 3 > 11500 MJ/year		Class 4 >= 14000 MJ/year	
		COP	SPF	COP	SPF
EPN (Standard)	Fixed	1,4	0,525	1,4	0,525
IVT / ES Techniek	550E WP-Boiler	---	---	2,37	0,900
Inventum	Ecolution Optima 120 WPBoiler	2,17	0,825	2,34	0,900
Itho	WPU-6 combi WP	2,38	0,925	2,54	0,975
Itho	WPU-8 combi WP	2,41	0,925	2,54	0,975
Kodi	Vesttherm BLW 304-20 DWTE WP-Boiler	---	---	2,59	1,000
Stiebel Eltron	LWA 252 WP-Boilker	---	---	3,69	1,425

heat pumps for economic equivalence, including the heat source, should be reduced to € 6,000 excl. VAT, without

cooling, or € 8,000 with cooling. At present, it is between € 7,500 and € 10,000 excl. VAT.



Table 3. Effect of heat pump on energy performance of a typical Dutch dwelling.

Status	State of the art EPC<1	EPC < 0.8	EPC < 0.7	EPC < 0.7	EPC < 0.7	EPC < 0.7
Heating	Best condensing combination boiler	Individual combination HP at fixed performance level with COP of 3.8	Individual combination HP at sub-peak performance level with COP of 5.0	Individual combination HP at peak performance level with COP of 5.5	Central heating with COP of 4.5 & additional boiler	Central heating with COP of 4.5
Domestic hot water	HR/CW	Individual combination HP with COP of 2.0	Individual combination HP with COP of 2.0	Individual combination HP with COP of 2.4	Central heating with COP of 4 (excl. storage and distribution losses) & additional boiler	Heat pump boiler with COP of 3.6
Ventilation system	Balanced ventilation with heat recovery	Mechanical ventilation				
EPC	0,83	0,73	0,69	0,62	0,65	0,66

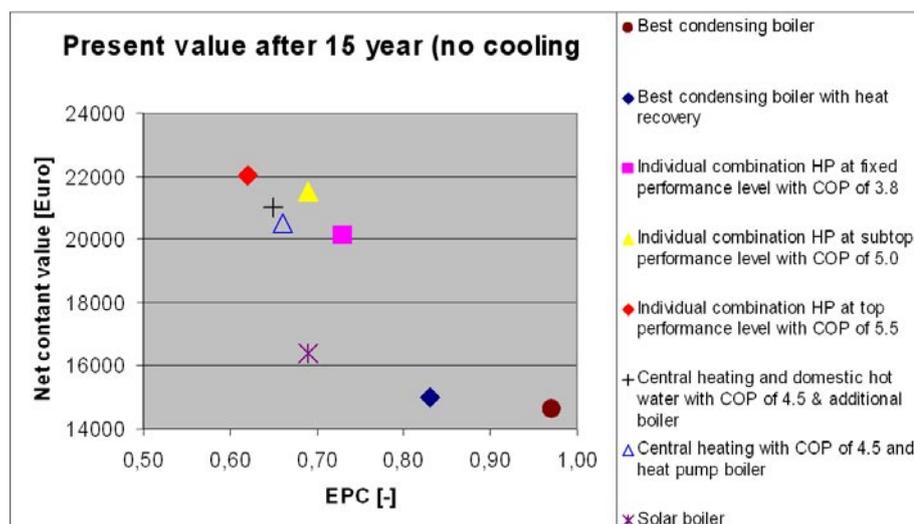


Figure 1. Present value for different heating systems in a typical Dutch dwelling.

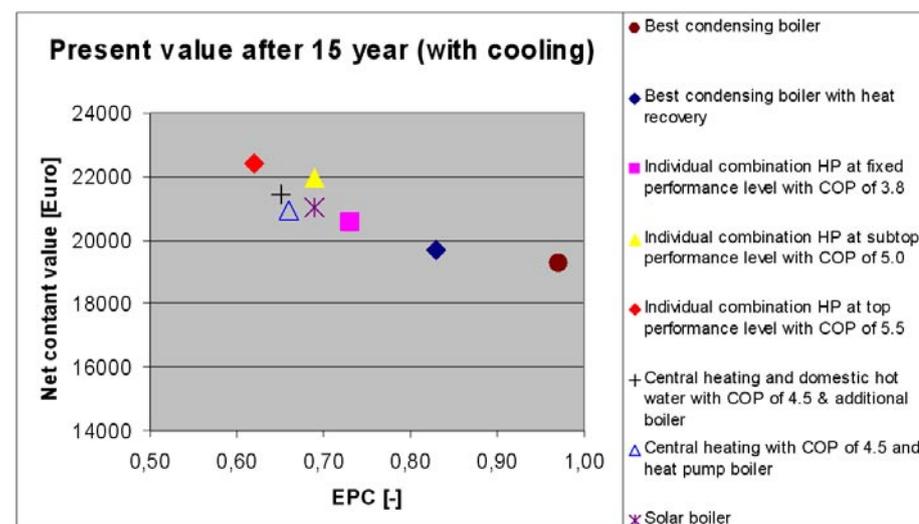


Figure 2. Present value for different heating systems in a typical Dutch dwelling, including the cost of cooling.

Dutch energy key figures for dwellings
 Total number of dwellings: 6,400,000 (2001)
 Single-family dwellings: 70%
 Apartments: 30%
 New dwellings: 66,000 a year (2002 – 2007)

Heating systems (1995):
 Individual boilers 76%
 Local heating 14%
 Central heating 7%
 District heating 3%

Natural gas is the dominating fuel for heating systems.

In The Netherlands, the Energy Performance Standard (EPN) sets out rules for calculation of the energy performance of a building, including the effect of heat generation and domestic hot water production. The result is expressed as the Energy Performance Coefficient (EPC); a dimensionless index with the calculated energy demand in the numerator and a normalised energy demand depending on surface area and heat loss area in the denominator. The EPC does not depend on the size of a building. A low energy demand is expressed by a low EPC value. For new dwellings the EPC must be below 1.0, which requires good insulation and condensing combination boilers as basic elements. Balanced ventilation with heat recovery and solar boilers are gaining market share. All efficiencies given in EPN and in this paper relate to gross calorific value. Net calorific value is 10 % lower for natural gas, so net efficiencies are about 10 % higher.

Conclusions

The main conclusions are:

- Suitable heat pump systems are available for new estates and renovation. No suitable heat pump systems are available for boiler replacement.
- Individual electric combination heat pump systems achieve high COP values for both heating and domestic hot water.
- Heat pumps can achieve a 20 % reduction in energy consumption, compared to the best condensing boiler systems.
- With an EPC-requirement of 0.8 and a requirement for cooling, heat pump systems are already economically competitive with all other systems. Without cooling, there needs to be a cost reduction of about € 3000 for economic equivalence.

The main recommendations are:

- Reduction of the EPC requirement from 1.0 to 0.8. This is scheduled for 2006.
- Concentrate product development of individual electric combination heat pump systems on cost reduction.
- Development of (gas-fired) heat pumps with outside air as the heat source is required for boiler replacement.

References

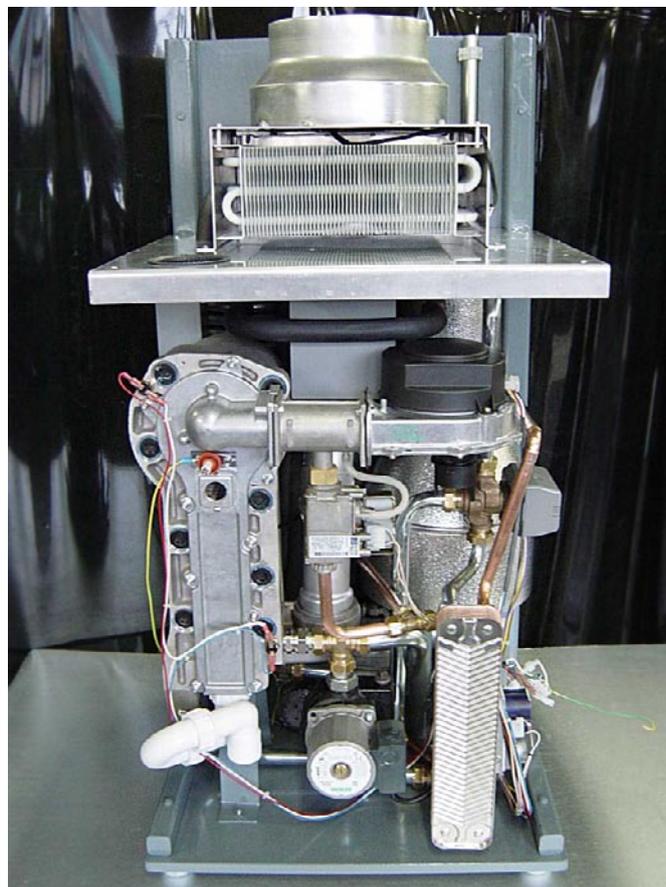
1. De concurrentiekracht van warmtepompen in Nederland – actualisering 2003 (R 2004/062) (the competitive strength of heat pumps in The Netherlands – 2003) TNO, Apeldoorn, 2003
2. NEN 5128 - Energy performance of residential functions and residential buildings – determination method NEN, Delft, 2001

Peter Oostendorp
TNO Environment, Energy and Process Innovation
P.O. Box 342
7300 AH Apeldoorn
The Netherlands
T + 31 55 549 37 71
F + 31 55 549 37 40
Peter.Oostendorp@mep.tno.nl

Hans van Wolferen
TNO Environment, Energy and Process Innovation
P.O. Box 342
7300 AH Apeldoorn
The Netherlands
T + 31 55 549 37 67
F + 31 55 549 37 40
Hans.vanWolferen@mep.tno.nl



Redenko - Thermia Villa classic



Prototype of gas-fired heat pump

eff-Sys – a Swedish Research Programme for Heat-Pumping Technologies

Johnny Andersson, Sweden
Chairman of the eff-Sys Programme Board

The Swedish Energy Agency (STEM), together with Swedish industries and organisations, has been financing a large number of research projects concentrating on heat pumping technologies. The work started as long ago as 1994 with the first program "Alternative refrigerants", followed by "Climate 21", which ran from 1998 to February 2001. The third programme, eff-Sys, has just finished. Preliminary work for a fourth programme has now started. A common feature of the programmes is that they stimulate the development of state-of-the-art technology for heat pumps and refrigerating systems that utilise energy very efficiently and are commercially and environmentally viable.

Introduction

The three research programmes have had a common objective – to strengthen Swedish industry on a long-term basis through co-operation between universities and industry, which leads to mutual exchange and transfer of knowledge. The emphasis has widened during the past nine years – from refrigerants via components to complete systems.

Four universities, a research institute (SP) and several partners from the industry form groups for each project and collaborate in the work. The financing is split, normally on a 40/60 percent basis, between STEM (through the programme board for eff-Sys) and industry.

eff-Sys

Starting and running a project

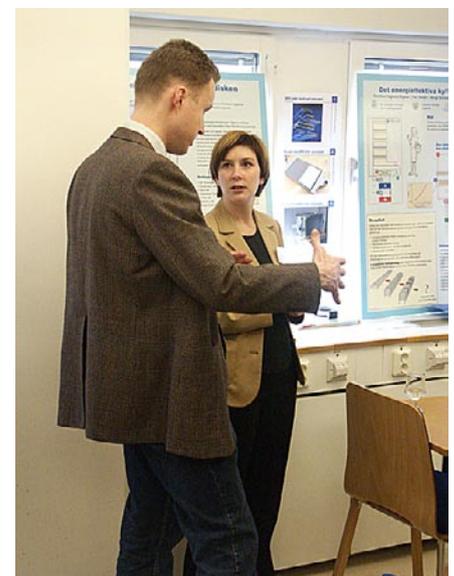
The way that the projects are started and run is unique. A prerequisite for a project to start is that there is interest both from industry in the future results and from universities to carry out the research. A large part of the projects are run as postgraduate studies, and should end with a thesis which requires both adequate theoretical value and sufficient time for the work, normally at least three years. Industry, on the other hand, must be willing to wait for the results (even though it is of course informed of



the interim results at frequent project meetings and by other ways of information), and also to finance its part of the costs. Financing is often based on the number of work hours, costs for test equipment and similar contributions. The grants from eff-Sys cover the salary for the postgraduate student and expenses. The program budget for the three-year period is SEK 54 million (approx. USD 7.2 million), of which a maximum of 50 % is financed by STEM. Each project is financed by a maximum of 40 % from STEM and the remainder from the industry partners.

Before a typical project is started, a project group with researchers from a technical university and members from the Swedish refrigeration and heat pump industry is organised. Common for most of the projects is that they stimulate the development of state of the art technology for heat pumps and refrigerating systems that utilize energy very efficiently and are commercially and environmentally viable.

The members work together during the project where the researchers, normally a PhD student and his instructor, are responsible for the research and the scientific quality, and the industrial members look after the practical relevance of the results and support the researchers with back-up facilities. Both parties gain from this





During the last eff-Sys meeting the outcomes of the different projects were reported both through oral presentations and poster sessions.

collaboration: the industries increase their theoretical knowledge and the scientists get an insight into how the industries work. Both sides get to know each other in an informal manner and have established good contacts for the future, which could be useful when the student has taken his/her doctor's degree and is looking for a position.

Projects

The postgraduate students and senior researchers in the projects during the past three-year period of eff-Sys have come from the following technical universities: KTH (Stockholm), CTH (Gothenburg), LTU (Luleå) and LTH (Lund), and from SP (The Swedish National Testing and Research Institute, Borås).

Some of the projects in the program are/were:

- Optimisation of low temperature driven absorption chiller (KTH)
- The energy-efficient supermarket – a comprehensive view of energy use, economy and environmental consequences (KTH)
- The energy-efficient display cabinet (SP/CTH)

- The energy-efficient cooling coils of the display cabinet (SP/CTH/LTH)
- Integrated control of refrigeration and heat pump systems (SP/CTH)
- Simulation of heat pump systems' behaviour (KTH)
- Efficient plate heat exchangers as evaporators in heat pump systems (KTH)
- Lubrication of bearings in refrigerating machines (LTU)
- High-efficiency cooling systems for refrigerators and freezers (KTH)
- High-temperature heat pumps - A feasibility study
- Free cooling - Analysis of techniques and design
- Heat pumps in hydronic heating systems – efficient solutions for space heating and domestic hot water (CTH)

Information

Annual seminars

The researchers, industrial participants and other interested parties have met at the end of each year of the three-year programmes for presentations and discussions of the projects and the results. The last meeting of eff-Sys took place at STEM, Eskilstuna, March 3 – 4, 2004.

Future research

The seminar discussed the future needs of research and development for the following areas:

- Efficient systems for food refrigeration
- Components and media
- Heat pump systems
- Refrigeration system.

Project reports

The projects reports and other relevant material will be published on a common CD-ROM at the end of May 2004. The reports from the two previous programmes, "Alternative refrigerants" and "Climate 21" are also available on CD-ROM.

Web site

More information about the programme and the projects is available from the programme's web site <http://www.eff-sys.org>

International conferences and reviewed articles

Many of the projects have been published in scientific journals and presented at international conferences, e.g. at IIR, ASHRAE and Purdue.

Johnny Andersson
Ramböll
Box 4205
SE-102 65 Stockholm
Sweden
Phone: +46 8 615 62 15
E-mail: Johnny.andersson@ramboll.se

Performance Comparison of R-22 and R-410A

PhD Evelyn Baskin, USA

The Air-Conditioning and Refrigeration Technology Institute (ARTI) is a not-for-profit organization established in 1989 for the purposes of conducting pre-competitive research in the fields of HVAC&R. Under ARTI's 21 CR Program (HVAC&R Research for the 21st Century), research was recently completed on the performance of refrigerants under ambient temperatures such that the refrigerant operates close to its critical temperature. This research compared the performance of a conventional HCFC refrigerant to an HFC replacement under high condensing conditions.

Introduction

The project sponsored by ARTI was conducted jointly by The National Institute of Standards and Technology (NIST) and Oak Ridge National Laboratory (ORNL). The principal goal was to investigate and compare the performance of an R-410A air conditioner to that of an R-22 air conditioner, with specific interest in performance at high ambient temperatures at which the condenser of the R-410A system may actually be operating above the refrigerant's critical point.

Method

Part 1 of the study involved comprehensive measurements of the thermophysical properties for R-125 and refrigerant blends R-410A and R-507A and then developing new equations of state and mixture models for predicting the properties of the HFC refrigerant blends. Part 2 consisted of performance measurements of split-system, 10.6-kW (3-ton) R-22 and R-410A residential air conditioners in the 28 to 57°C (80 to 135°F) outdoor temperature range followed by development of a system performance model. The performance data was used in preparing a new beta version of EVAP-COND, a windows-based simulation model for predicting performance of finned-tube evaporators and condensers. The modeling

portion of this project also included the formulation of a model for an air-conditioner equipped with a thermostatic expansion valve (TXV).

Results

Capacity and energy efficiency ratio (EER) were measured and compared over the above temperature range. The project found that the R-410A system had greater throttling losses than the R-22 system, greater superheat losses than the R-22 system, and better heat transfer performance than R-22.

Results of the testing showed that both systems had similar capacity and EER performance at 27.8°C (82.0°F). Tests also showed that the capacity and EER degradation of both systems dropped in a linear fashion with rising outdoor ambient temperatures. The performance of R-410A at higher temperatures was slightly less than that of R-22. However, the R-22 and R-410A systems both operated normally during all tests. Visual observations of the R-410A system gave no indication of vibrations or TXV hunting at high ambient outdoor test conditions while the compressor was operating in the transcritical regime.

ORNL used data developed by NIST to refine and validate an ORNL system simulation model. The ORNL work also included modeling of different refrigerant flow devices. Results of that modeling indicated that:

- subcooling losses were more extreme for capillary tubes,
- subcooling was best maintained with fixed orifices,
- compressor power was smallest for thermostatic expansion valves.

The CR21 analysis provided a basis for other research on R-410A done in the U.S. An assessment of the Life Cycle Climate Potential (LCCP) of R-410A was performed by Honeywell International and was reported at the recent ASHRAE Meeting in Anaheim, California in January. Honeywell found that R-410A systems had better performance than R-22 at temperatures less than 36.4°C (97.5°F). Above this temperature, R-22 systems performed better. Further, Honeywell found that the R-410A system had a 1.4% lower environmental impact than R-22 for Phoenix and 2.5% lower environmental impact than R-22 for the average U.S. city.



Conclusions

Results from comparison evaluations of R-22 and R-410a show that:

- R-410A performance better than R-22 at temperature less than 36.4°C (97.5°F)
- R-410A system had 2.5% lower environmental impact than R-22 for the average U.S. city
- Modeling revealed that fixed orifices maintain subcooling and expansion valves use less compressor power
- Both R-22 and R-410A systems had similar capacity and EER and had normal performance

This information was extracted from the February 2004 Tech Update (Research and Technology News from ARTI) of the 21CR Program. Further details on these projects as well as results from other research sponsored by ARTI can be found at their website, www.arti-21cr.org.



Evelyn Baskin, Ph.D
Building Equipment Technology
Oak Ridge National Laboratory
Engineering Science and Technology
Division
PO Box 2008, MS-6070, Bldg 3147
Oak Ridge, TN 37831-6070
USA
Phone: (865) 574-2012
Fax: (865)574-9329
E-mail: baskine@ornl.gov

Magnetic Cooling

Lucienne Krosse, Netherlands

About a decade ago, a breakthrough in research into magnetic cooling made it possible to apply magnetic cooling at conventional cooling temperatures. Magnetic cooling is based on the reversible magneto-caloric effect (MCE). Cooling can be obtained by magnetising and demagnetising MCE-materials with permanent magnets, so very little electrical energy is needed. Furthermore, any fluid, such as water or air, can be used as the heat transfer medium.

Research is still going on in the universities, and new materials have been found. The technology is now sufficiently mature to consider actual applications, such as air conditioning, to become feasible.

Introduction

Over the years, several alternative technologies have been proposed to replace vapour compression based coolers or heat pumps. Until now, only absorption machines have had any significant success. However, this does not mean that vapour compression systems remain the best choice for the future. The demands imposed on cooling and heating systems are subject to change over time. The different techniques are developed and optimised further, and the environment changes constantly. For example, requirements such as sound level, the use of environmentally benign refrigerants, energy efficiency, etc. are becoming increasingly important. It therefore seems logical to monitor the feasibility of alterna-

tive techniques. A comparison at any given time might very well give different results from those of a comparison from some years previously.

One of the alternative techniques to vapour compression cooling is magnetic cooling. Magnetic cooling is based on the reversible magneto-caloric effect (MCE) of some materials.

Until about a decade ago, the application of magnetic cooling was limited to cryogenic applications. Applications close to room temperature were not possible. This was because, until then, only materials that showed a significant magneto-caloric effect at very low temperatures were known. The change was brought about in the 1990s by the discovery in the USA [1]

of the large magneto-caloric effect of materials close to room temperature. Since then, worldwide research for materials showing a similar large effect close to room temperature has started. The materials of the most interest are the Gd-based alloys [1] and the MnFe-alloys [2].

Among the advantages of magnetic cooling are: silent operation, application of environmentally benign heat transfer media and energy efficiency.

Magnetic cooling: the principle

Magnetic cooling is a reversible periodic process. The basic principle is shown schematically in Figure 1.

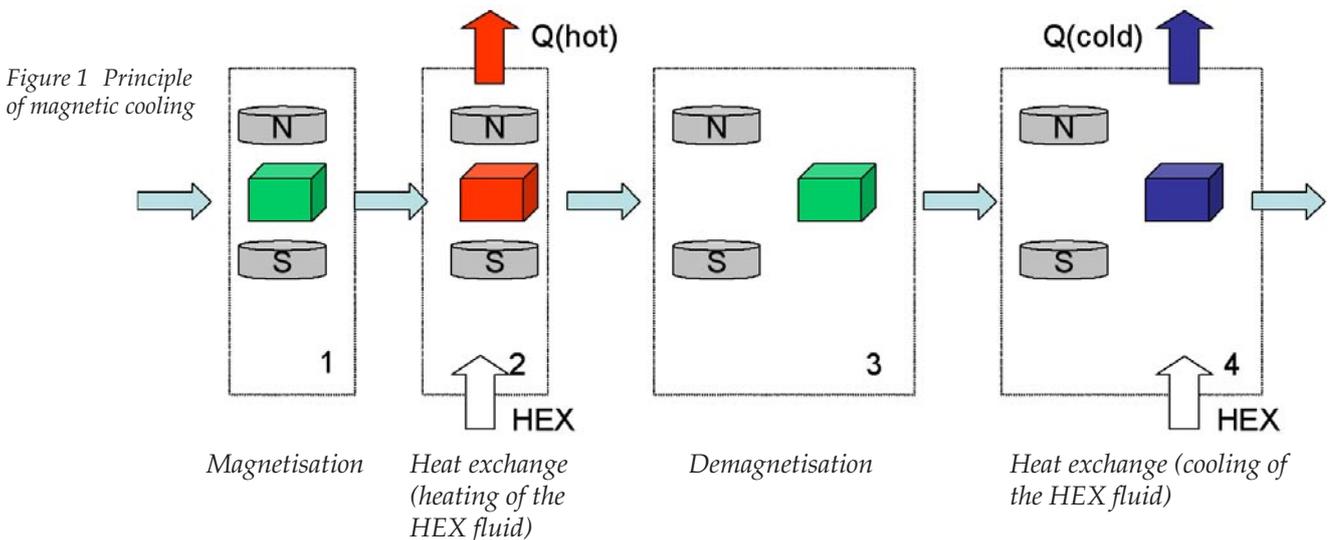


Figure 1 Principle of magnetic cooling

In the first phase, the magnetisation phase, a magneto-caloric material is placed in a magnetic field. The material is magnetised, the entropy changes and the material heats up. In phase II, the heat is removed by a heat exchanging fluid, cooling the magneto-caloric material. In phase III, the material is demagnetised by removing it from the magnetic field, causing the entropy to change again. This is accompanied by a further cooling of the material. Finally, in phase IV, the 'cold' is transferred to a heat exchanging fluid: the refrigeration effect of the magnetic cycle.

This is the basic cycle. Variants such as multi-stage systems are possible.

Important parameters

Among the important parameters that determine the refrigeration capacity of a magnetic cooler (or the heating capacity of a heat pump) are:

- i) The amount of magnetic material. The greater the magneto-caloric effect (MCE) of a material, the greater the cooling effect. Depending on the final application, MCE per unit of mass or per unit of volume is important.
- ii) Magnetic cycle frequency. The maximum cycle frequency is mainly determined by the heat transfer rate in the separate phases.
- iii) Maximum temperature difference between the 'cold' and the 'hot' temperature. The MCE is greatest close to the Curie temperature of the material. Further away from the Curie temperature, the MCE diminishes rapidly.
- iv) Magnitude of the magnetic field. The cooling capacity increases with increasing magnetic field strength. The strength of commercially available permanent magnets is limited to 1.5 Tesla.
- v) Heat losses due to the periodic character of the system. This is a common problem in periodic cycles. There are several ways to

limit these losses, such as by using an Active Magnetic Regenerator [3].

The total ΔT and refrigeration capacity can also be increased significantly by using (for example) composite¹ MCE-materials and multiple-stage systems.

Applications

The use of magnetic cooling is still mainly limited to cryogenic applications. Apart from a few experimental set-ups in laboratories, magnetic cooling has not yet been applied for conventional cooling applications such as air conditioning or refrigeration.

For most cooling or heat pump applications, the following aspects are more or less important:

- Energy efficiency
- Costs
- Reliability
- Safety
- Environmentally benign refrigerants
- Silent, or very little sound production
- Good part-load behaviour
- Volume
- Weight
- Maintenance time and costs

Compared to vapour compression cooling, magnetic cooling is probably more energy-efficient (particularly when permanent magnets are used), quieter (no compressor), performs better at part load conditions (cycle frequency is easily altered), and almost any heat transfer medium can be used (such as air or water).

For a successful application of magnetic cooling in any application, it is not only the extent of compliance with the above aspects that is important. What is more important is whether, or to what extent, the conventional vapour compression system fails to answer to these aspects. Areas in which further work is re-

quired are the still limited ΔT and refrigeration capacity.

At TNO, the feasibility of magnetic cooling for several applications was roughly determined. In particular, a small-capacity magnetic air conditioner seemed very interesting, mainly for two reasons:

First of all, European regulations concerning refrigerants are becoming steadily more restrictive. Replacement of current refrigerants by, for example, propane is technologically feasible, and the environmental benefits are obvious. However, the flammability of propane has prevented wide public acceptance of its use in air conditioners so far. Magnetic cooling would not face this problem because any fluid, such as air or water, can be used as the heat transfer medium.

Secondly, an energy labelling system has been set up for air conditioners. Although an energy label merely states the energy efficiency and energy consumption, it is often regarded as a quality label by customers. So, for marketing reasons, it is very beneficial to have air conditioners in the highest energy class. This makes the energy efficiency of an appliance even more important.

Magnetic cooling seems to meet both the higher energy efficiency demand and the refrigerant issue.

Conclusion

Magnetic cooling is a technique with considerable potential, but is not yet mature. Worldwide, research at universities is concentrated mainly on a search for the material with the largest magneto-caloric effect. However, several MCE materials have already been found that can be used in a magnetic cooler to replace (for example) a conventional air conditioner. The research at TNO in the Netherlands is aimed at transforming the magnetic cycle into an actual cooler. The

¹ A composite MCE-material is a material composed of several materials with different Curie temperatures. In this way the MCE can be remained constant over a larger temperature range.

first feasibility studies show promising results. The main advantages of magnetic cooling are the freedom to use safe and environmentally friendly heat transfer media, low energy consumption, low noise level and good performance at part-load conditions.

The research for materials with better properties is very important. However, an efficient and effective design of the complete cycle (and thus appliance) is crucial. Attention needs particularly to be paid to fast and efficient heat transfer and efficient use of the magnetic field.

References

- [1] Pecharsky, V.K., Gschneider, K., 1997. "Tunable magnetic regenerator alloys with a giant magnetocaloric effect for magnetic refrigeration from ~20 to ~290 K". *Appl. Phys. Lett.*, vol. 70, pp. 3299-3301
- [2] Tegus, O., Buschow, K.H.J. Boer, F.R., 2002. "Transition-metal-based magnetic refrigerants for room-temperature applications". *Nature*, vol. 415, pp. 150-152
- [3] Yu, B.F., Gao, Q., Zhang, B., Meng, X.Z., 2003. "Review on research of room temperature magnetic refrigeration". *Int. J. Refr.*, vol. 26, pp. 622-636

Acknowledgement

The work described here was funded within the framework of the Reduction of Greenhouse Gases programme (ROB, Reductie Overige Broeikasgassen, programma), by the Dutch Energy Agency, NOVEM.

*Lucienne Krosse
TNO, Institute of Applied Scientific
Research,
Apeldoorn
The Netherlands
L.Krosse@mep.tno.nl*

Energy Policies of IEA Countries, 2003

This report contains an analysis of developments in energy policies in the IEA member countries. Major trends in the energy market, including the renewed interest in energy security, are also surveyed. Other interesting topics covered are: efforts by countries to meet the Kyoto Protocol, developments in energy security, and energy market reforms in major non-OECD countries.

The report is available from the IEA bookshop at:
<http://www.heatpumpcentre.org>
 Price: 96 € (pdf)
 120 € (paper)

ASHRAE Transactions. 2003 Annual Meeting

This CD-ROM includes all the 86 papers presented at the 2003 annual ASHRAE meeting, including symposia and technical papers. The technical papers are peer-reviewed. Among topics covered are:

- Energy efficiency opportunities in supermarket display cases
- Refrigerants and heat pumps
- Radiant cooling/heating
- Computer centre and telecommunication room cooling of high-density heat loads
- and more

Available from ASHRAE:
 Send e-mail to orders@ashrae.org
 Price: USD 211

Variable Primary Flow Chilled Water Systems: Potential Benefits and Application Issues

This report contains an extensive study comparing variable primary flow chilled water systems with other common systems, including: constant flow/primary-only chilled water systems, constant primary flow/variable secondary flow chilled water systems, and primary/secondary chilled water systems with a check valve installed in the decoupler. The comparison concerns energy use and economic benefits. The

results show that primary-only chilled water systems reduce the total annual plant energy by 3-8 % and life cycle cost by 3-5 % relative to conventional constant primary flow/variable secondary flow chilled water systems.

The report is available from ARTI at:
<http://www.arti-21cr.org>

Using Acid Number as a Leading Indicator of Refrigeration and Air Conditioning System Performance

This report is concerned with the issue of long-term reliable use of air conditioners and refrigeration equipment. Over long periods of time, deterioration of the refrigerant and/or the lubricant will occur which can cause changes in the system chemistry resulting in reduced efficiency and potentially to failure. The degradation processes form increasing amounts of acid over time. The Total Acid Number (TAN), which includes both mineral and organic acids, is therefore a useful indicator of the deterioration. If the TAN can be measured, it can be used for indicating when maintenance is required in order to prevent failures. A literature review was undertaken in order to assess acidity characteristics of both mineral oil and polyolester (POE), as well as to evaluate different acid measuring techniques. The results show that there is enough experience to determine a critical TAN value for the old systems' CFCs and mineral oil, but for systems with HFC and POE such experience is missing. Several techniques are available for measuring acids.

The report is available from ARTI at:
<http://www.arti-21cr.org>

EnergyPlus

EnergyPlus is a building energy simulation program for modelling of heating, cooling, lighting, ventilating and other energy flows. It is based upon features and capabilities of BLAST and DOE-2. The new version, 1.2.0, includes displacement ventilation,

dynamic shading controls and more new features. The program is available as a free download from the US Department of Energy.

Available from DOE at:
<http://www.eere.energy.gov/buildings/energyplus/>

2004

ASHRAE Annual Meeting

26 - 30 June 2004
Nashville TN, USA
Tel: +1 404 636 8400
E-mail: jyoung@ashrae.org
<http://www.ashrae.org>

17th International Compressor Engineering Conference at Purdue

12 - 15 July 2004
West Lafayette, USA
Tel: +1 765 494 6078
Fax: +1 765 494 0787
E-mail: herlconf@ecn.purdue.edu
<http://www.ecn.purdue.edu/Herrick/Events/Conference>

10th International Refrigeration and Air Conditioning Conference at Purdue

12 - 15 July 2004
West Lafayette, USA
Tel: +1 765 494 6078
Fax: +1 765 494 0787
E-mail: herlconf@ecn.purdue.edu
<http://www.ecn.purdue.edu/Herrick/Events/Conference>

World Renewable Energy Congress VIII

28 August - 3 September 2004
Denver, Colorado, USA
Tel: +1 303 275 3781
Fax: +1 303 275 4320
E-mail: ivilina_thornton@nrel.gov
<http://www.nrel.gov/wrec>

Natural Working Fluids - 6th IIR Gustav Lorentzen Conference

29 August-1 September 2004
Glasgow, UK
Contact: Miriam Rodway, secretary
Institute of Refrigeration
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>

SDHK Conference - Refrigeration and Air Conditioning
5 - 6 November 2004
Zdravilisce Lasko, Slovenia
Tel: +386 (0)1 4771 446
Fax: +386 (0)1 2518 567
E-mail: posvetovanje@drustvo-sdhk.si
<http://www.drustvo-sdhk.si/prijava2004>

2005

ASHRAE Winter Meeting

5 - 9 February 2005
Orlando, Florida, USA
Tel: +1 404 636 8400
E-mail: jyoung@ashrae.org
<http://www.ashrae.org>

Ammonia Refrigeration Systems, Renewal and Improvement

6-8 May, 2005
Ohrid, Republic of Macedonia
Contact: Prof. R Ciconkov
Box 464, 1000 Skopje, Macedonia
E-mail: ristoci@ukim.edu.mk
<http://www.mf.ukim.edu.mk>

8th IEA Heat Pump Conference 2005

30 May - 2 June 2005
Las Vegas, Nevada, USA
Contact: The Conference Secretariat
Oak Ridge National Laboratory (ORNL)
P.O.Box 2008, MS-6067
Oak Ridge, TN 37831
Tel: +1 865 576 8620
Fax: +1 865 574 9331
E-mail: hp2005@ornl.gov
<http://www.ornl.gov/hp2005>

Commercial Refrigeration

30 - 31 August 2005
Vicenza (Padua), Italy
Contact: Alberto Cavallini
Fax: +390 49 827 6896
Tel: +390 49 827 6890
E-mail: alcav@unipd.it

Thermophysical Properties and Transfer Processes of New Refrigerants

31 August - 2 September 2005
Vicenza (Padua), Italy
Contact: Alberto Cavallini
Fax: +390 49 827 6896
Tel: +390 49 827 6890
E-mail: alcav@unipd.it

Clima 2005

9- 12 October 2005
Lausanne, Switzerland
Tel: +41 (0)31 852 13 00
Fax +41 (0)31 852 13 01
E-mail: info@swki.ch
<http://www.clima2005.ch/>

2006

Natural Working Fluids 2006: 7th IIR-

Gustav Lorentzen Conference
E-mail: TrygvTe.M.Eikevik@sintef.no

2007

22nd IIR International Congress of

Refrigeration
21 - 26 August 2007
Beijing, China
<http://www.iifiir.org>

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

In the next Issue
Supermarket Refrigeration

Volume 22 - No. 3/2004



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



SP Swedish National Testing
and Research Institute

IEA Heat Pump Centre
SP Swedish National Testing
and Research Institute
P.O. Box 857
SE-501 15 Borås
Sweden
Tel: +46 33 16 50 00
Fax: +46 33 13 19 79
E-mail: hpc@heatpumpcentre.org
Internet: <http://www.heatpumpcentre.org>



National team contacts

AUSTRIA

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

CANADA

Mrs Sophie Hosatte
1615 Lionel-Boulet Blvd
Varenes (Quebec)
Canada J3X 1S6
Tel.: +1 450 652 5331
E-mail: sophie.hosatte@nrcan.gc.ca

FRANCE

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

GERMANY

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

JAPAN

Mr Takeshi Yoshii
HPTCJ
Kakigara-cho, F Building (6F)
1-28-5 Nihonbashi, Kakigara-cho
Chuo-ku, Tokyo 103-0014
Japan
Tel: +81-3-5643 2404
E-mail: yoshii@hptcj.or.jp

NETHERLANDS

Mr Onno Kleefkens
Novem
P.O. Box 8242
NL-3503 RE Utrecht
Tel.: +31 30 2393 449
E-mail: o.kleefkens@novem.nl

NORWAY

Mrs Trude Tokle
Enova SF
Abelsgatan 5
N-7030 Trondheim
Tel.: +47 73 19 04 54
Fax: +47 73 19 04 31
E-mail: trude.tokle@enova.no

SPAIN

Ms Marta Garcia
ENEBC
Po General Martinez Campos, 11 10
28010 - Madrid
Tel.: +34 914445904
E-mail: enebc@enebc.org

SWEDEN

Dr Björn Sellberg
FORMAS
PO Box 1206
S-11182 Stockholm
Tel.: +46-8-775 4028
E-mail: Bjorn.Sellberg@formas.se

Peter Rohlin
STEM
Buildings & Community Systems
PO Box 310
S-63104 Eskilstuna
Tel.: +46 16 544 2112
E-mail: Peter.rohlin@stem.se

SWITZERLAND

Dr Thomas Kopp,
Hochschule Rapperswil
On behalf of the Swiss Federal Office
of Energy, Energy Renewable
Division, CH-8640 Rapperswil
Tel: +41-55-222 4923
E-mail: tkopp@hsr.ch

UK

Mr Roger Hitchin
BRECSU, BRE
Energy Efficiency
Garston, Watford, WD25 9XX
Tel.: +44 1 923 664773
E-mail: HitchinR@bre.co.uk

USA

Mrs Melissa V. Lapsa
Oak Ridge National Laboratory
Building 4500 N, P.O. Box 2008
Oak Ridge, TN 37831-6183
USA
Tel.: 1 865 576 8620