IEA Heat Pump CENTRE
NEWSLETTER
Volume 23
No. 3/2005

The 8th IEA Heat Pump Conference

- Global Advances in Heat Pump Technology, Applications and Markets

IEA heat pump centre

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In this issue

8th IEA Heat Pump Conference

This issue of the HPC Newsletter features the 8th IEA Heat Pump Conference, held in Las Vegas on May 30 – June 2. Read the overview article and the eleven session/workshop articles for a good view of what is going on worldwide in heat pumping technologies.

COLOPHON

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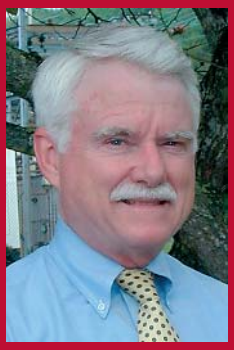
Illustration, page 1: Heat Pump Centre

heat pump centre

A successful IEA heat pump conference



John J. Tomlinson
Conference Chairman
Oak Ridge National Laboratories
USA

The 8th International Heat Pump Conference held in Las Vegas May 31 through June 2 is history, but the information distributed and discussed at the Conference on technical advances, growing markets and applications for heat pumping technologies presented there is lasting. From all accounts, the conference was a tremendous success with the participation of 225 people from 21 countries, 128 oral and poster papers presented in nine sessions, two technical tours, meetings of IEA Annexes that are underway as well as ones in the planning stage, and all-important times for one-on-one discussions among individual researchers from participating countries.

I want to congratulate recipients of the Peter Ritter von Rittinger Award – the first of its kind given to individuals or groups that have made outstanding contributions to the advancement of international collaboration in research, policy development, market development and applications for energy-efficient heat pumping technologies. Award recipients were Dr. Bernard Spinner (deceased, France), Dr. Katsuhiko Narita (Japan), Mr. Nance Lovvorn (USA), Mr. Wayne Reedy (USA), and the Research Team GEMINI (Norway). Peter Ritter von Rittinger, an Austrian engineer, designed and installed the first known heat pump in 1855. I also want to congratulate Dr. Eckhard Groll (USA) as recipient of the USNC IIR award.

I want to thank all of our sponsors - country as well as corporate and institutional - for the financial and administrative support to the Conference. Special thanks too go to the hosts for the technical tours provided for the Conference attendees.

Finally, I want to express my gratitude for all of the effort put forth by many people from Europe, North America and Asia that made this conference a success. The National Organizing Committee comprised principally of the U.S. National Team and their assistants assumed the responsibility for planning, organizing and running the conference with utmost attention and efficiency.

Growing energy consumption is an international issue that therefore requires an international solution. We hope that the 8th International Heat Pump Conference with your input, will continue to provide information to help reach that solution. Thank you all for making the Conference a success.

John J. Tomlinson

Personal remarks from the IOC chairman

Peter Rohlin
IOC Chairman
Swedish Energy Agency

The 8th IEA Heat Pump Conference 2005 is now history. As Chairman of the International Organizing Committee, I would like to make some personal remarks.

At the Executive Committee meeting in Trondheim in May 2003, we delegates had two important decisions to make. First, we had to decide who should run the Heat Pump Centre for the next term? Second, who should host the upcoming 8th Heat pump conference in 2005, and where should it be held? The first decision was difficult, and the Executive Committee had a comprehensive evaluation made by external experts of all applicants for the 'new' Heat Pump Centre. The second decision was much easier. When Mr. John Ryan presented the ideas put forward by the US National Team, and particularly the time and location – springtime in Las Vegas – the decision was easy.

I was appointed Chairman of the International Organizing Committee, and the journey could begin. The journey has been tough, with three comprehensive IOC meetings and innumerable e-mails and phone calls, but now we can put all that behind us.

The purpose of a conference is not primarily the presentations, and certainly not the paper publications: for that we have journals and newspapers. The main purpose is to provide an arena where people with common interests can meet and discuss and present ideas and contribute to the creative thinking. Papers and presentation are just some of the tools of that process.

In my personal summary of the conference, I will start with the two workshops on Monday before the conference. Both had over 100 participants, discussing the work of Annexes 28 and 29. Several proposals for new annexes are under consideration, and were also one of the subjects at the National Team Meeting on Friday, the day after the conference. Participation in annex work is a very cost-effective way of performing tasks of common interest for several countries and of establishing networks for fruitful collaboration. Although the conference is now over, I know that the formal and informal meetings will not stop. Please keep up the good work in establishing new and interesting annexes – for mutual benefits.

I would like to thank the National Organizing Committee, led by Mr. John Tomlinson, for an excellent proposal and well organised conference. Special thanks, too, to Mr. John Ryan for his mentorship as former IOC Chairman. I would also like to express my sincere appreciation to the Conference Secretariat and Ms. Melissa Voss Lapsa. Without professional administrative support, we front-line persons are nothing. I would also like to thank my committee members in the IOC. My second special thanks go to the regional coordinators; Mr. Gerald Groff, Mr. Takeshi Yoshii and Mrs. Monica Axell, for their tremendous work with all proposals for presentation, program coordination and much more. As Chairman I can just – from the depth of my heart – say *Thank you for all your dedication and all your excellent work.* Last, but not least, thank you all participants for a conference I will remember.

Peter Rohlin

General

News from the IIR

A directory of research organisations is now available for members of the International Institute of Refrigeration (IIR) via the web site. The directory contains information on 200 laboratories world-wide which are specialised in one or more of the fields in refrigeration technologies.

IIR has also made a list of research priorities for the future, and hopes that it will be a valuable tool for decision-makers in funding and promoting relevant technology. The research priorities are divided into seven key themes, as follows:

- Understanding, improvement and optimisation of present equipment and systems
- Performance of new energy systems
- Optimisation of the whole chain, including ancillary installations
- Behaviour of refrigerated and frozen live products
- Performance of refrigerants
- Improvement of the environment
- New uses of refrigeration

Finally, the venue for the International Congress of Refrigeration (ICR) in 2011 has been decided. It will be held in Prague, the capital of the Czech Republic. But before that, you are all welcome to the ICR in 2007 in Beijing, China.

Source: IIR Newsletter nos. 22 and 23

New president of ASHRAE

Lee Burgett is the new president of ASHRAE. He took over from Ron Vallort at ASHRAE's Annual Meeting held on June 25-29, 2005. Mr Burgett is a consultant to Trane and other companies.

Source: IIR Newsletter no. 23, July 2005

Better knowledge of heating systems required

Germany – The Deutsche Bundesstiftung Umwelt asked an interdisciplinary expert team to investigate what energy saving and CO2 saving potential there is in retrofit heating system optimisation. The intention is not to make major changes to systems, but to optimise control and system integration. The answer was that energy use may be reduced by 20 kWh per square meter annually in German buildings, equivalent to approximately 25 % of total energy use. The project investigated the current status of 100 apartment buildings, and applied optimisation strategies in 35 of them. It was concluded that the heating systems did not operate optimally, due to improper system integration and operation. Increasing the efficiency of individual components did not pay off. The problems seem to be due to training of operators, who are not given proper knowledge of the system.

Source: CCI Print, no. 9 2005

Asia-Pacific partnership

The United States, Australia, China, India, Japan and South Korea have joined to create a new Asia-Pacific partnership in order to approach issues on clean development, energy security and climate change. The partnership will focus on new investment opportunities, building local capacity and removing barriers to the introduction of cleaner and more efficient technologies.

Areas that will be treated within this framework are:

- Energy efficiency
- Clean coal
- Liquefied natural gas
- Bio-energy
- Power/solar power
- Methane capture and use
- Civil nuclear power
- Geothermal energy
- Agriculture/forestry
- Rural/village energy systems
- Advanced transportation
- Building and home construction/operation
- Hydropower/wind power

Source: www.whitehouse.gov

IIR Conference in Vicenza – "Thermophysical Properties and Transfer Processes of Refrigerants" and "Commercial Refrigeration"

Italy - Two conferences arranged by the International Institute of Refrigeration - Thermophysical Properties and Transfer Processes of Refrigerants (TP) and Commercial Refrigeration (CR) - were this year held with one day overlap at the same venue, at the Vicenza Campus of the Padua University School of Engineering in north-east Italy. The CR conference was held on 30 – 31 August, for the second time, while the TP conference ran from 31 August to 2 September, which was the third time for this conference.

The two conferences had three different keynote speakers. The first was Professor Horst Kruse, who talked about "Commercial Refrigeration – on the Way to Sustainability". In his speech, he addressed the developments concerning refrigerant substitution and emission reduction from the original single-stage R 502 systems, via intermediate solutions up to recently developed direct-expansion carbon dioxide systems.

The keynote speaker for the second day was Professor John R. Thome. He presented a comprehensive review with the title "State-of –the-Art of Two-Phase Flow and Flow Boiling Heat Transfer and Pressure Drop of CO_2 in Macro- and Micro-Channels.

The third day started with Mr. Mark O. McLinden as the keynote speaker, who presented "The Thermodynamic Properties of Propane: From p-ρ-T to the Equation of State".

A total of 29 technical sessions was held, two or three in parallel, during which approximately 140 papers were presented. As far as commercial refrigeration was concerned, there were three sessions devoted to display cabinets, dealing with experimental investigations, modelling, design optimisation etc. Other sessions during this conference (CR) covered topics such as environmental impact, modelling and simulation, control, direct and indirect working fluids and different components.

Papers dealing with CO2 as refrigerant were presented during six of the technical sessions during the overlap day and the TP conference. Studies of transcritical systems, cascade systems and more detailed studies of heat transfer in tubes and microchannels etc, were presented. Three sessions were devoted to absorption and adsorption refrigeration systems and heat pumps; two sessions to thermophysical properties of refrigerants; and two sessions to heat exchangers.

During two of the sessions of the TP conference, young researchers from the European Research Training Network presented their research results of heat and mass transfer in microchannels. Topics such as hydrocarbons and ammonia as refrigerants and two-phase flow models were also presented during the conference.

Over 200 delegates from many parts of the world, including both researchers and industry representatives, were registered for one or both of the conferences. The social events included a concert of classical baroque Venetian music at the 16th century Teatro Olimpico, and a gala dinner at Basilica Palladiana. Excellent food was served during the daytime and at the evening events, and both the technical and the social parts of the conferences were very well organised.

Source: Caroline Haglund Stignor
Heat Pump Centre
c/o Swedish National Testing and Research Institute

2005 China–Japan joint meeting/exhibition on heat pump and thermal energy storage

China - The China–Japan Joint Meeting/Exhibition on Heat Pump and Thermal Energy Storage was held on August 3 and 4, 2005, in Beijing, at Beijing International Convention Center, and attended by over 200 delegates from China and nearly 80 from Japan. The participants were policy-makers, researchers, engineers, marketing staffs from government, universities and relevant industries such as electric utilities, building and HVAC system design companies, contractors, and equipment manufacturers of heat pump and thermal energy storage systems. The meeting was organised and sponsored jointly by the China Academy of Building Research (CABR) and the Heat Pump & Thermal Storage Technology Center of Japan (HPTCJ), marking the inception of mutual exchange eleven years ago, by HPTCJ sending a small mission team to China in 1994.

This meeting was planned as a two-day event, in the form of one and a half days' meeting/exhibition and a half-day technical site visits. The meeting and exhibition was primarily intended to exchange information on markets and technologies for heat pump and thermal energy storage system, and to promote the use of advanced technologies to achieve energy saving, power load levelling and global warming mitigation. The main topics of the meeting were markets, system design, optimised operation, maintenance, advanced products/systems and application. Of the thirteen invited presentations at the meeting, seven were from Japan and six presentations were from China. Of specific concern for both sides were advanced energy-efficient technologies of thermal energy storage equipment and systems, ground source heat pump systems and district cooling systems.

On the second day, at the end of the 1½-day meeting, an open panel discussion session was held with six panel speakers and two moderators from both sides. The panel discussions covered a wide range of topics, from issues related to market promotion and advanced technology developments to expectations for future collaboration between China and Japan.

The exhibition consisted of fifteen exhibitors, nine from Japan and six from China, from manufacturers and installers of heat pumps and thermal storage systems.

Two technical site visits were arranged in and around Beijing city in the afternoon of the second day. One was a large-scale ground source heat pump project with 700 borehole heat exchangers for heating and cooling of a resort convention centre building at Jiuhuashanzhuang in the northern outskirts of Beijing. The other was a district cooling project with ice thermal storage at Beijing Zhongguangcun Plaza, a newly developed high-tech science park in central Beijing.

This joint meeting/exhibition was a great success for both sides, and far exceeded the initial expectation. It was confirmed that both countries have a similar climate in common, necessitating energy-efficient cooling and power demand control by thermal energy storage in summer, and energy-efficient heating by heat pumps in winter. It was also highly expected that activities for information exchange and collaboration between the two countries be strengthened in the coming years.

Source: Takeshi Yoshii (HPTCJ-Japan) / Wei Xu (CABR-China)

Denmark still an IIR member

Denmark - As reported previously in the HPC Newsletter, the Danish Government does not want to pay for Danish membership of the IIR, which has upset the Danish refrigeration industry, since it would lose a valuable source of international research and development information. This has now been solved, since the Danish Government has appointed the Danish Refrigeration Association as the official member, and the annual fee is paid by York Refrigeration and Danfoss.

Source: Scandinavian Refrigeration, no. 3, June 2005

IKK, with focus on heat pumps

Germany – The world's most important trade fair for the refrigeration industry, IKK, will be held this year in Hanover, Germany, on November 2-4. There will be a special focus on energy savings and heat pumps. Last year, the fair was attended by 27 700 visitors and 881 exhibitors, increases of 18 % and 10 % respectively. The day before the opening of IKK, there will be a symposium on the topic of innovations in the cooling, air-conditioning and heat pumping technologies for reduced CO2-emissions. The symposium is arranged by IZW, the German representative in the IEA Heat Pump Programme.

Source: Kulde Skandinavia (in Norwegian), no. 3 2005

Qualified installers in France

France – Heat pump sales in France continue to increase: in 2004, the increase was approximately 19 %. The greatest increase is for ground-source heat pump systems. In order ensure good quality of heat pump installation work, the French heat pump association, AFPAC, is developing a training and certification program for installers, with the preliminary name of Qualipac. The aim of this certification program is to increase customers' confidence in the technology and to assure them that the installer fulfils several basic criteria.

Source: die Kälte & Klimatechnik, no. 8, 2005

Higher temperatures to save energy

Greece, China and Canada – The need for cooling puts heavy demands on the electricity supply grid in many countries all over the world. This summer it has meant that authorities and utilities have recommended building owners to accept higher indoor temperatures in order to assure the power supply. Authorities in the city of Shenzhen in China released a guideline advising building management companies to set the temperature of central air-conditioning systems above 24 °C.

In Athens, Greece, the power company PPT advised householders to limit the use of air-conditioning during peak temperatures in order to avoid power shortages. City authorities provided 25 air-conditioned areas where the public could take refuge from the heat. In Toronto, Canada, too, authorities advised limited use of comfort cooling. Many city centre shops had their double doors wide open, allowing the cool air to float out and cool the streets. A journalist writing for the Globe and Mail asked the rhetorical question: "Are we Ontarians stupid or just incapable of the smallest self-sacrifice?"

Source: RAC, August 2005 and www.chinaview.cn

Food uses increasingly more energy

The ever-increasing processing and transport of food causes the food industry to use more and more energy every year. This trend may lead to a substantial increase in food prices. The US food system alone uses over 10.55 EJ (10.55x10^18 J) per year, which is about the same amount as France's total annual energy use. The major part of this energy is used in US homes, by refrigerators and for food preparation (32 %). The rest is divided up between agricultural production (21 %), transport (14 %), processing (16 %), packaging (7 %), retailing (4 %) and restaurants (7 %). Measures are being taken to reduce this energy use, but a growing sector is that of refrigerated jumbo jets using 60 times more energy than sea transport in supplying fresh products to the northern hemisphere from South Africa, New Zealand and South America.

Source: IIR Newsletter no. 23, July 2005

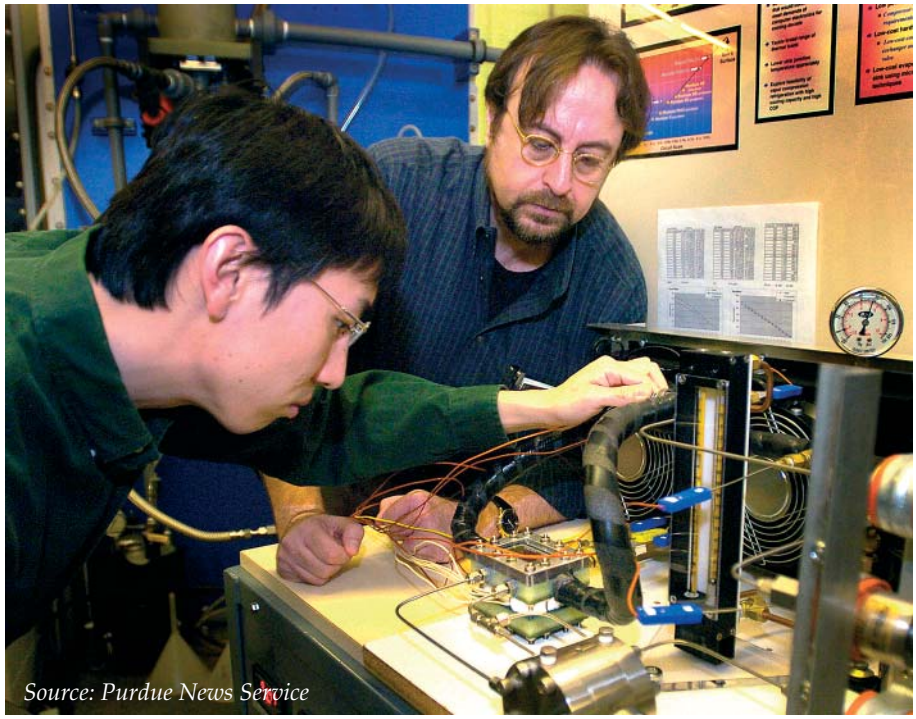
Source: www.ikk-online.com

Technology & Applications

Micro refrigeration

USA – Researchers at Purdue University are developing new micro-channel heat exchangers for cooling appliances. The heat exchangers consist of a copper plate containing numerous channels, only 231 microns wide (approximately three times as wide as a human hair) and 713 microns deep. This micro-channel heat sink has been successfully incorporated into an ordinary refrigerator using R134a. The 1 inch square micro-channel heat exchanger replaced the conventional evaporator, which is well over one meter long. The challenge is, according to the researchers, to unplug the large evaporator and replace it by a tiny heat sink and make the whole system work. The heat exchanger can also be attached directly to electronic components in military lasers, microwave radar systems and in computers, thus being able to cool these systems better than conventional technology.

Source: RAC, June, 2005



Source: Purdue News Service

Mixed mode climate control

As mentioned in the original article, it is hard to ignore the fact that an air conditioning use least energy when it is switched off. In order to take advantage of this, Mitsubishi Electric and the natural ventilation experts at Passivent have jointly developed a mixed mode air conditioning system. The system uses as much natural ventilation as possible, and automatically starts the inverter-driven air conditioning system only when the load is too high for the passive system. Natural ventilation has substantial energy-saving benefits, but has its limitations in that its performance is less predictable. An air conditioning system, on the other hand, is more predictable but not as efficient. By combining the two techniques it is possible to produce a reliable but still very energy-efficient comfort cooling system. Much of the energy saving is due to night cooling by the natural ventilation system. During a typical mid-July day, it is claimed that this system reduces energy use by 57 %, of which 39 % is attributed to night cooling.

Source: RAC, August 2005

The world's largest brazed plate heat exchanger

Sweden – In May SWEP, a large Swedish heat exchanger manufacturer, launched the B800 series, which is claimed to be the world's largest compact brazed plate heat exchanger. The B862, which is the first heat exchanger of the new series, has a 200 mm port for high flows, and measures 620 mm in width and 1550 mm in height. It offers capacities in the range of 400 kW – 1000 kW. The series is developed for meeting very high capacity requirements in district heating, district cooling and geothermal applications.

Source: JARN, July 2005

Source: SWEP

Unique technique for ice rinks

Sweden – IUC is currently running a project to investigate a new approach to ice rink construction, which has led to some unique technical solutions. Opportunity was taken, when a new ice rink was to be built in Katrineholm, Sweden, to investigate various new methods of construction.

Preliminary results indicated three system configurations as interesting: a conventional refrigeration machine with carbon dioxide as the secondary refrigerant; a conventional refrigeration machine with ice-slurry as the secondary refrigerant; or an ammonia system with calcium chloride as the secondary refrigerant. In many ways, the carbon dioxide system seemed to be the best choice. The pumping energy for the CO2 system would theoretically be 90 % less than for the calcium chloride system. The phase change process reduces the mass flow, which means smaller pipes and reduced material costs. However, in ice rinks that have previously been built using a CO2-based process, the pipes beneath the rink were of steel. This involves expensive installation, due to the high number of welds, each of which must be made by licensed welders, to join as-delivered 10-12 meter lengths of steel piping into a total length of 19 km. Instead, IUC decided to try the unique combination of CO2 and copper tubes, which can be rolled out in much longer lengths. This has not been tried before.

The two major concerns were whether the copper could be used together with concrete, and if the thermally induced stresses in the copper tubes would be too high. Investigations showed that these should not be problems. A miniature test rink has now been built, and the first tests are being run in order to try out the technique and to verify calculation models.

The estimated payback time for this kind of system, compared to a conventional secondary system, is five years.

Source: Kyla (in Swedish), no. 3, 2005

Markets

EHPA heat pump statistic for 2004

Europe – The European Heat Pump Association (EHPA) has released sales statistics for the European heat pump market in 2004, pointing out that the statistics from the seven countries that can present reliable statistics represent approximately 80 % of the total market. The total sales of space heating heat pumps amounts to approximately 208 000 units (this does not include approximately three million air-conditioners with a heat pump function). The total market has increased by 30 % since 2003. Sweden is the clearly dominating market, with over 100 000 units sold in 2004, and countries such as Austria and Germany showing remarkable increases during the last five years, of 136 % and 120 % respectively.

Source: www.ehpa.org

Swedish heat pump manufacturer acquired by Danfoss

Sweden – Thermia, the third largest heat pump manufacturer in Sweden, has been bought by Danfoss. Thermia will be a self-contained unit within Danfoss' Heating Division. Thermia, situated in Arvika, Sweden, will be the centre for development of heat pumps within Danfoss. Danfoss already manufactures many of the components for heat pumps, but now also enters the expanding heat pump market.

Source: www.thermia.se

York International sold

Equipment supplier York International has been sold to Johnson Controls for GBP 1.8 billion. "Bringing together our two organisations will also create the largest building services force in the world, strongly positioning us to capture an increased share of the fragmented USD 130 billion global services market for commercial buildings", said John M. Barth, Chairman and CEO of Johnson Controls. The joint company can combine York's experience in the manufacturing and service of heating and cooling equipment with Johnson Control's expertise in the control equipment.

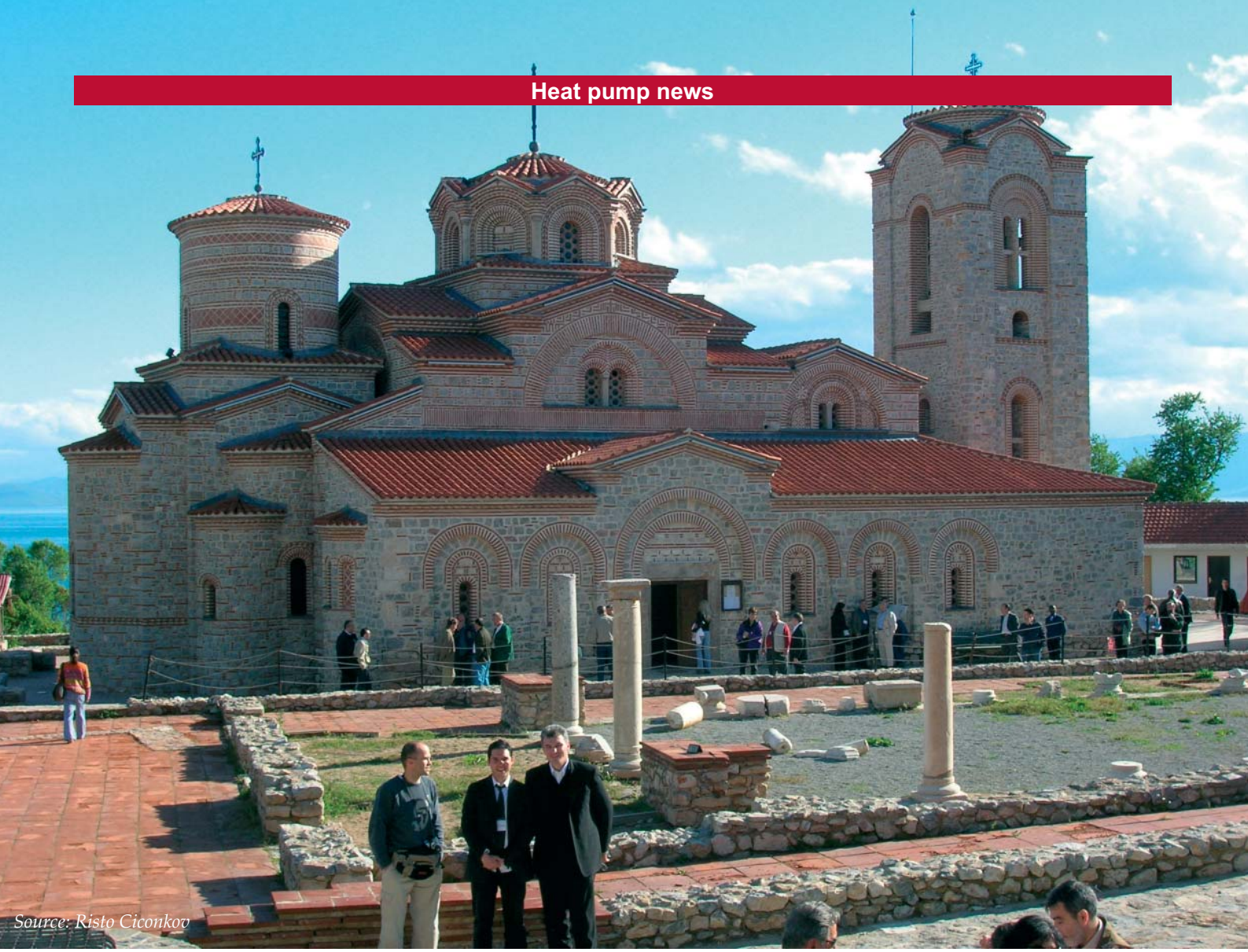
Source: RAC News Alert, August 30, 2005

World market for air conditioners, 2004

The market for room air conditioners and packaged air conditioners is estimated at 59 million units in 2004. The majority of them, approximately 20 million units, were sold in China. Other major markets are USA (13 million), Japan (7.7 million), Europe (5.3 million), Asia & Oceania (excluding Japan and China) (7.5 million), Central & South America (2.3 million) and Middle East and Africa (3.2 million).

Total sales of central air conditioners and air source heat pumps increased by 9 % in 2004, to 7.4 million units. Europe is considered as the best and most profitable market. The success in 2003 continued during the first months in 2004, but the market then slowed due to the cool summer. The market reached over 5 million units in 2004, and is estimated to increase to 6 million units in 2005. Western Europe is more concerned with environmental issues and regulations, and is thus more inclined to purchase value-added products such as DC inverter split systems with R410A. As for the Japanese market, it is too mature to grow much in volume, which mainly leaves it to the replacement market.

Source: JARN special edition, May 2005



Source: Risto Ciconkov

Working Fluids

IIR conference on ammonia systems

Macedonia – The IIR "Ammonia Refrigeration Systems, Renewal and Improvements" conference was organised by Professor Risto Ciconkov of the University of Skopje, Macedonia. The conference was held in Ohrid, a 6000-year-old town, and was attended by delegates from 28 different countries. Presentations dealt with low charge systems, plate heat exchangers, direct expansion systems, ammonia and CO2 as a secondary refrigerant, cold stores, supermarkets, heat pumps and air-conditioning. One very interesting part of this conference was a panel discussion with prepared questions to representatives from south-east European countries with transitioning economies, i.e. Bulgaria, Macedonia, Turkey, Romania and Serbia Montenegro. The questions were:

- What is the current situation?
- What are the economic obstacles?
- What is the level of present knowledge? Demands for education and training?
- What kinds of codes and standards are in force?

The answer from Serbia Montenegro is representative:

- Ammonia refrigeration systems are in bad condition and need to be rebuilt
- Due to high costs, economic help is needed
- Expert groups are needed to assess the current situation
- A strategy should be formulated for building new refrigeration systems with ammonia and natural refrigerants in applications where HFCs are used today
- Expertise is needed for choosing and purchasing new refrigeration systems
- Training of consultants and technicians is needed
- Must change to new European safety codes and directives
- Accidents with ammonia systems are rare, but there is still a need to improve the security level and quality of these systems.

Source: Press release and Scandinavian Refrigeration (in Swedish) no. 3, 2005

DuPont buys Rhodia's Isceon refrigerant business

UK – DuPont will purchase Rhodia's Isceon HFC refrigerant business. "This acquisition will enlarge our HFC product portfolio, and enable us to offer customers additional sustainable refrigerant solutions" said Mark Baunchalk, global business manager at DuPont. However, Rhodia will continue to manufacture and sell R22 from its Avonmouth facility.

Source: RAC News Alert, June 27, 2005

Experiences from using R723

Denmark – R 723 is a mixture of ammonia (60 %) and dimethyl ether (DME) (40 %) which, due to the DME, has a good miscibility with oil. Miscibility is better than for a pure ammonia system and allows conventional oil return. The compressor discharge temperature is lower for R723 than for ammonia systems, which is also an effect of the DME, and allows a larger operating range for the compressor and reduces the need for compressor cooling. The DME content increases the heat transfer in evaporators compared to that of ammonia systems. R723 is also environmental friendly due to no ODP and a very low global warming potential (GWP = 8). The major drawback is that it is more flammable than ammonia and requires more security equipment. The materials used for ammonia systems can also be used for R723 systems.

Positive experience with this new refrigerant has been reported from large facilities in Austria and Switzerland; one air conditioning system and one indirect refrigeration system for a diary plant. However, some problems have been reported from an EU project, in which six demonstration plants with R723 were constructed and evaluated. The project, under the name of OSCAR (Innovation in low-capacity ammonia refrigeration plants) was operated in Denmark and Germany. As its name indicates, the aim was to develop the use of ammonia and R723 for use in small systems where HFCs are used today. The Danish projects consisted of a 3 kW ice making machine, a 10 kW marine chiller for use in a smaller fishing boat, and a 17-18 kW cooling capacity heat pump system for milk cooling and simultaneous domestic hot water production and space heating. As the intention was to make these relatively small systems competitive, hermetic compressors were used in the ice making machine and in the dairy heat pump. Due to the lack of hermetic compressors developed for R723, conventional HFC compressors were used, but they malfunctioned after just a few hours because the plastic parts and the varnish of the motor windings deteriorated. After having installed semi-hermetic compressors instead, the systems worked properly, although there were some problems with oil return for the heat pump system.

The conclusions from the OSCAR project report state that there clearly is a need for product development before secure and economically practical R723-based systems can be put on the market.

Source: Scandinavian Refrigeration (in Danish and English) no. 3, 2005

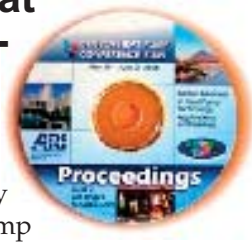
Australia introduces refrigerant licensing scheme

Australia – A new national licensing scheme for technicians and businesses in the refrigeration and air-conditioning industry came into force in Australia on 1 July. The scheme introduces national standards with the aim of reducing emissions of environmentally harmful refrigerant gases. Anyone handling refrigerant gases where there is a risk for leakage must have a refrigerant handling license. Authorisation is required for selling or buying these gases.

Source: RAC, July 2005

IEA Heat Pump Programme

Proceedings from the IEA heat pump conference



The Proceedings of the International Energy Agency's heat pump conference held in Las Vegas, USA, May 30 – June 2, 2005, can now be ordered from the Heat Pump Centre. They contain 128 papers on various topics related to heat pumping technologies, such as regional reports about market development in Asia, Europe and North America, environmental issues, ground-source heat pump systems, heat pumps in cooling, heating and power systems, refrigerants, advanced systems and components and much more. The Proceedings can be ordered from the Heat Pump Centre at www.heatpumpcentre.org

Source: Heat Pump Centre

National Teams meeting

USA – A Heat Pump Programme National Teams meeting was held in conjunction with the conference in Las Vegas. The well-attended meeting focused on new research areas and new joint research projects – Annexes. The following project ideas were discussed:

1. Field-proven best practice of combined heat pump systems
2. Advanced modelling and tools for analysis of energy use in supermarket systems
3. Air conditioning systems for large commercial buildings
4. Heat pumps in houses without traditional heating and cooling systems
5. Heat pumps in low and ultra-low energy houses
6. Economical heating and cooling systems for low energy houses
7. Compact heat exchangers

It was suggested that proposals 4, 5 and 6 should be merged into one. More information on the projects and contact persons can be found on the Heat Pump Centre web site at www.heatpumpcentre.org. Click on Projects and then on Proposals.

Source: Heat Pump Centre

Ongoing Annexes

Bold text indicates Operating Agent.

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
Annex 30 Retrofit heat pumps for buildings	**30**	**GE**, FR

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.

An overview of the 8th IEA Heat Pump Conference

Fredrik Karlsson, Caroline Haglund Stignor, Heat Pump Centre
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Introduction

The 8th IEA Heat Pump Conference was held in Las Vegas, USA, during May 30 – June 2. Walking around in this large desert city shows very clearly how reliable heat pumping technologies are of vital importance for comfort and health. In addition, all the lighting and the large air-conditioned hotels underline the importance of energy efficiency. Investigations and research related to these and other issues were presented and discussed during this successful conference, attended by 223 delegates from 20 countries. This article provides an overview of the conference, focusing on highlights and some of the material presented. More detailed articles on each conference session and workshop can be found elsewhere in this Newsletter.

Annex workshops

Held the day before the opening session, the conference program included workshops for two of the ongoing annexes within the IEA Heat Pump Programme. This was a new arrangement for the IEA heat pump conferences, showing itself to be successful with approximately 100 attendees at each workshop.

The day started with a presentation of the results of the work of Annex 28 "Test procedure and seasonal performance calculation for residential heat pumps with combined space and domestic hot water heating". The participants in the Annex have investigated test procedures for the most common combined heat pump systems, whether heating domestic hot water by desuperheating, subcooling of the condensate, cascade hot water heat pump, or using the heat from the supply line of the space heating system. The aim of the testing is to obtain the necessary data in order to calculate the overall seasonal performance factor of such heat pump systems. For further information on this workshop, please refer to the article written by the Operating Agent for this Annex.

Figure 1. The workshops for the ongoing Annexes were well attended.

The afternoon workshop presented the results from the first study performed in Annex 29 "Ground-Source Heat Pumps; Overcoming Market and Technical Barriers". This annex will investigate ideas and, depending on climate and application, identify systems that could improve the performance and market attractiveness of ground-source heat pump systems. Further information on this workshop can be found in the article written by the Operating Agent for this Annex.

Opening the conference

Mr. John Ryan of the U.S. DOE opened the conference and the plenary session. He was followed by Mr. John Tomlinson, Chairman of the U.S National Organizing Committee, who introduced Mr. Jim Gibson, Mayor of the city of Henderson (adjoining Las Vegas). Henderson has experienced a staggering 335 % growth rate over the past fifteen years, and by 2010 its population is projected to exceed 300 000. The Mayor remarked that, with 294 days of bright sunshine, 4 inches of average annual rainfall, average daily temperatures of 100 °F (38 °C) and growing demand for cooling and air-conditioning, Las Vegas served as an appropriate venue for a conference on air-conditioning technology. The Mayor urged conference attendees to apply the best science and talents to address the requirements of climates such as that of Las Vegas. He said that new requirements for buildings should address heating and cooling issues. His light-hearted concluding remarks were, "We want to move more heat out of the buildings as we watch the gamblers sweat at the poker table".

The next speaker, Antonio Pflüger, Head of the IEA Energy Technology Collaboration Division, said that the IEA agreements are the backbone of the energy-related issues of interest to public policy makers. Twenty-six countries are current members of the IEA. Energy security, environmental protection and economic growth are the guiding principles behind IEA activities. The IEA operates as a think tank to participating governments. It compiles energy statistics, convenes and mobilises experts and reviews member countries' policies. Strategic challenges facing the IEA are, (a) secure energy supplies, (b) reduce growing energy-related greenhouse gas emissions, and (c) overcoming lack of access to energy for more than one-quarter of the world's population. The IEA forecasts expect primary energy demand to increase by 60 % over current levels from 2000-2030. The foreseeable world energy investment between 2001-2030 is categorised as follows: oil (19 %), gas (19 %), coal (2 %) and electricity (60 %). Developed countries' share of CO_2 emissions is expected to grow from 36 % (current levels) to 49 % by 2030. Clearly, this trend is not sustainable. The need for a sustainable energy policy could not be greater. Dr. Pflüger said that although efficiency gains have slowed since the mid 1980s, stronger policies could reverse that trend. Mitigating dependence on energy through renewable sources and conservation are key elements for a sustainable society.

Jeff Littleton, Executive Vice-President and Secretary of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), heads ASHRAE's 106-person staff supporting chapter and member services. ASHRAE currently has 53 000 members, of whom 7 000 are students. Of the 53 000 members, 11 000 are outside the U.S. and Canada, spread among 132 countries. The largest membership outside the U.S. and Canada are in Hong Kong, followed by the United Kingdom and India. Mr. Littleton touted several 30 % Energy Savings Guides that ASHRAE will publish in the future because of the popularity and success of their first guide entitled 'Advanced Energy Design Guide for Small Office Buildings'. Other 30 % energy savings guides are for the retail, lodging and healthcare sectors of the economy. In his concluding remarks, Mr. Littleton said that sustainability and environmental stewardship resonates with young people, and that creates an opportunity to move ahead.

International heat pump status

The status of heat pumps in different regions was the next topic on the conference agenda. The presentations were made by Mark Menzer from the ARI (North America), Monica Axell from the IEA Heat Pump Centre (Europe) and Takeshi Yoshii from the Heat Pump and Thermal Storage Technology Centre of Japan (Asia and the Pacific). A summary of these reports is available in the article by John Ryan.

Technological developments

More detailed reports on the content of each session can be found in the other articles in this Newsletter. The summary below therefore concentrates not on the session topics but on more different applications and issues that were discussed at several sessions.

Ground-source heat pump systems

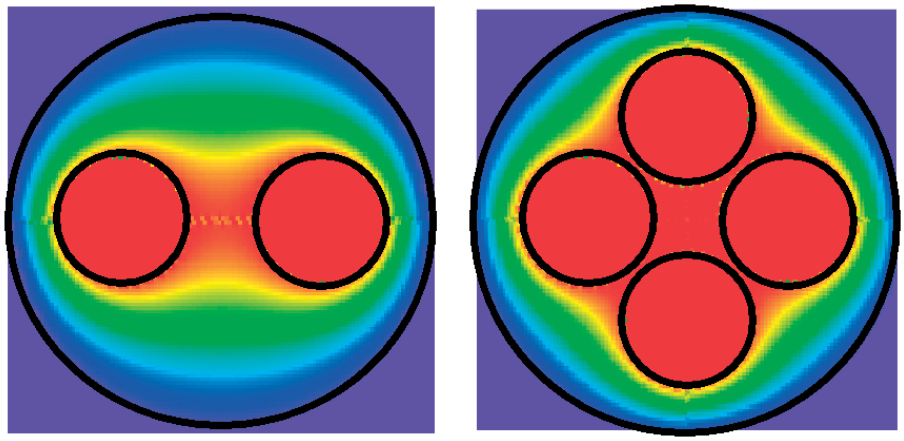
Many presentations and posters dealt with ground-source heat pump systems in one way or another. In his keynote speech in Session 4, Professor James Bose highlighted the issue of load networking for increased energy efficiency and economic competitiveness. A thorough system analysis must be made in order to determine:

- Thermal loads and internal gains
- Energy rates and costs
- HVAC equipment type and efficiency
- Geographic location of thermal components in relationship to each other
- Available space for construction of new thermal loads and/or businesses

Professor Bose exemplified this by describing an existing system where a ground-source system has been installed. The facility includes a grocery store, a casino and a headquarters building. The energy study showed that the heat rejected from the grocery store's air-conditioning and refrigeration system could be used for heating the store, the casino and the administrative building. At times when the heat is not needed by the buildings it is rejected by evaporative condensers or to a pond that is being constructed, and which will act as thermal storage. The added pond is critical to ensure that enough heat rejection capacity is available when all three buildings are being cooled. By adding this thermal storage, the ground heat exchanger can be made smaller and thus reduce the first cost of the system.

Design tools and simulations were discussed in several presentations. A design tool for use by installers has been developed in Sweden. The tool is called Prestige and currently has 600 registered users. It has a common basis for calculations in a dll-file, and allows users to use data from different manufacturers. More complex design tools for borehole systems which require more knowledge on the part of the user are Earth Energy Designer (EED) and Superposition Borehole Model. EED accommodates up to 307 pre-defined borehole configurations, and relies on a database of 2500 pre-calculated response functions.

The first design and performance prediction tool for the Japanese market has been developed at Hokkaido University, and can handle multiple boreholes for simulating large systems. Since not only energy savings and reduced environmental impact are of great importance in Japan but also (as always) cost factors, the tool include functions for calculating both the Life Cycle Assessment and the Life Cycle Cost.



Single U-tube *Double U-tube*

Figure 2. Calculation results for the borehole heat exchanger (source: Katsunori Nagano, Hokkaido University, Japan)

To reduce first cost for large ground-source heat pump systems, the pile foundations of building may be used for installing the ground source heat exchanger at the time of erecting the building, so that there will be no additional costs for drilling the boreholes. Two papers from Japan dealt with this issue, one using concrete piles and the other using steel piles. As shown in Figure 3, the U-tubes were arranged around the surface of the concrete piles, with eight pipes per pile. The system was used for heating in the winter and cooling during the summer. The average cooling COP for the system was 4.9 and thus claimed to be 1.4 times more efficient than a conventional air-source heat pump system. The first cost for this system, expressed in terms of heat extraction and heat rejection power, is USD 0.79/W, which can be compared with the cost of a conventional ground-source system at about USD 3/W.

Two other papers, both from Sweden, dealt with the combination of air and ground as heat source. The first paper described a new compact heat exchanger that has been developed and is used for domestic heat pump systems using both exhaust air and the ground as heat sources. The other paper dealt with a heat-only heat pump system using the ground and the outdoor air as heat sources. The benefits compared to a ground-source only system are that the evaporating temperature can be kept higher during the warm parts of the year, and the investment for heat capacity is lower for an outdoor air heat exchanger than for drilling more boreholes. This kind of a dual source system has been built for an 82 terrace house residential association area in the south-west of Sweden. The system consists of 17 boreholes, each 200 m deep, equipped with double U-pipes, and a conventional dry cooler. The dry cooler is used as the primary heat source when the ambient air temperature is above +3 °C: below this temperature, the ground heat exchanger is the main source for heating. The system utilises the short-term advantages of the ground and the long-term advantages of the air as heat sources. When comparing the dual-source system to the two single-source systems (air or ground), the performance for the dual system is greater than for both these systems after 15 years in operation (calculated results). The dual-source system is better than the air-source system from the beginning. However, the ground-only system is more efficient during the first year but, due to a reduced ground temperature caused by continuous heat extraction, the dual system will be more efficient in the long term.

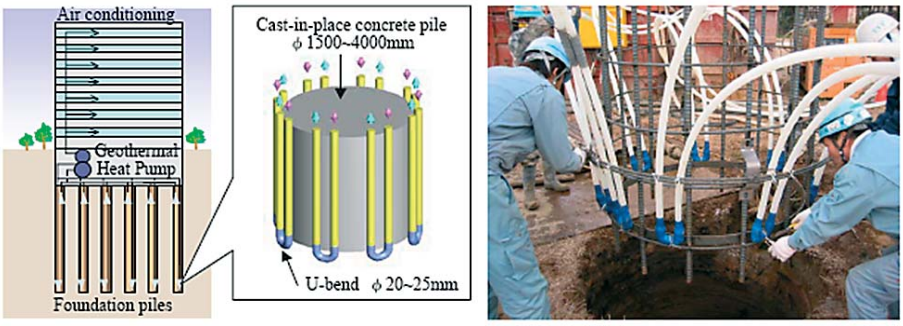


Figure 3. Outline of the heat exchange system using cast-in-place concrete piles (source: Ryozo Ooka, University of Tokyo, Japan)

Carbon dioxide heat pipes

Instead of using direct-expansion systems or indirect systems with glycol-solutions to extract energy from the ground for use in ground-source heat pump systems, a heat pipe can be used. If carbon dioxide is used in the pipe there are no risks related to leakage, apart from for low or no performance of the heat pump. Indirect glycol fluid systems can be difficult to use if they are located close to a water source, since the water may be contaminated if a leak occurs. Compared to a DX system, the refrigerant charge can be kept much lower. In addition, the heat pipe works by self-circulation and so there is no pumping energy requirement for heat extraction from the ground.

Ground-source heat pump systems with carbon dioxide heat probes have been in operation in Austria since 1999. The system was originally developed by an Austrian inventor, and has subsequently been improved in cooperation with the technical university in Graz. The market development of these systems has been good and no major technical problems have occurred. The price of the system is about the same as for a glycol-based system, and it has gained interest from the Austrian authorities due to its environmentally friendly profile.

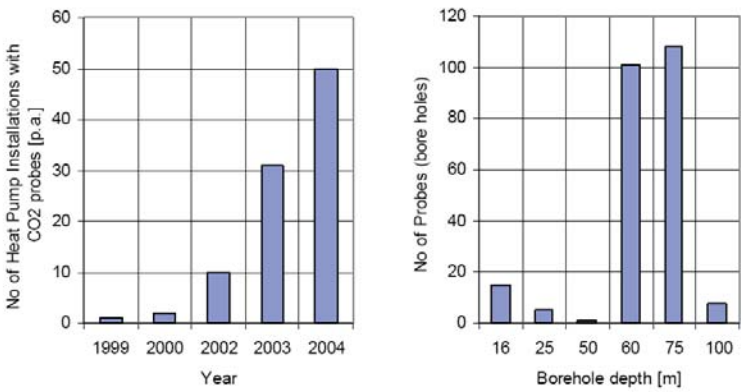


Figure 4. Development of heat pump systems using CO2 heat pipes and the probe length. (Source: Karl Mittermayer, m-tec, Austria)

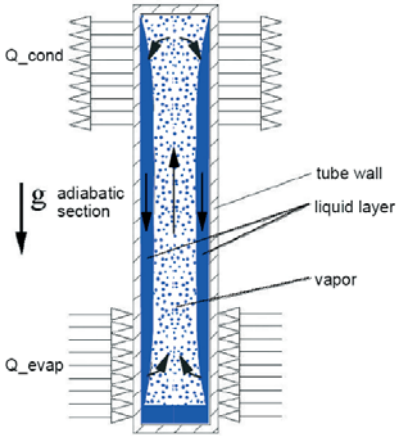


Figure 5. The working principle for a heat pipe is that the CO2 evaporates at the bottom and condenses at the top. The liquid CO2 falls back to the bottom along the pipe walls. (source: Karl Mittermayer, m-tec, Austria)

Theoretical and experimental investigations regarding this kind of heat pipes were also presented by researchers from Germany and the USA.

Micro-channel heat exchangers

One way of increasing the refrigerant side heat transfer in heat exchangers is to increase the number of parallel channels, and thus increase the surface area. When these tubes or channels are made very small, with a large number of parallel circuits, the heat exchangers tend to be called micro-channel heat exchangers. They also allow a reduction of the refrigerant charge, which is a benefit for security reasons if hydrocarbons are considered as the refrigerant.

In a study performed in France, the evaporator of a conventional air-to-water heat pump working with R410A was replaced by a micro-channel heat exchanger (MCHX). The goals for the investigation were to fit a MCHX into a standard cabinet, to match the face area of the MCHX and the standard round tubeplate and fin coil, to reduce the overall refrigerant charge, to increase system efficiency and to investigate refrigerant distribution and frosting issues. The heat pump was operated in both heating and cooling mode, and so the MCHX acted as both condenser and evaporator. The results showed that the refrigerant charge could be reduced by 50 % when operating the MCHX as the evaporator and by 40 % when operating it as the condenser. Water drainage and frosting/defrosting behaviour were similar to the standard round tubeplate fin coils. When operating the MCHX as the condenser, system efficiency increased by 15 % while the cooling capacity increased by 10 %.

Figure 6. Micro-channel heat exchanger pipe compared to a conventional pipe. (Source: Modine, USA)

The target of a Swedish project is to reduce the refrigerant charge of propane down to 150 grams in a liquid-to-liquid heat pump, still having a heat power of 5 kW. To do this, MCHX are used. At present, the system runs on 200 grams of propane, but development is continuing. If the target is achieved, it may open up the use of flammable refrigerants.

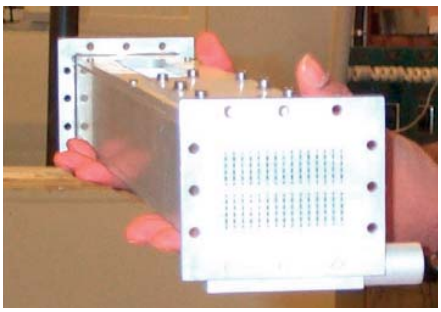


Figure 7 Micro-channel heat exchanger used in brine-to-water heat pump (source: Björn Palm, Royal Institute of Technology, Sweden)

Integrated heat pumps

Integrated heat pumps refer to heat pumps providing a combination of ventilation, space heating, domestic hot water (DHW) heating, cooling and dehumidification. The solutions vary, depending on the climate and building design in different countries and regions. In Sweden, one of the

most common heat pump types is the exhaust air heat pump (EAHP), which emerged during the oil crisis in the 1970s, when buildings became more airtight in order to reduce energy losses. However, simply improving the airtightness alone was a precursor for sick building syndrome, which caused many health problems due to unhealthy air and mould build-up. The response was to recommend an air change rate of half the building volume per hour, but this was not easily accomplished in existing buildings. Ventilation losses from kitchen, utility room and WC could lose as much as 25 % of the thermal energy. In low-energy houses, ventilation is responsible for the major part of the energy losses, which makes exhaust air the main heat source. Both requirements - ventilation and energy conservation - could be satisfied with the exhaust air heat pump. The disadvantage is that the supply air is normally not controlled. The EAHP is so popular that more than 90 % of new single-family houses in Sweden are equipped with them. One reason for their popularity is system integration because ventilation, heat recovery, DHW, full heating and controls comes in one convenient package. Sales of EAHPs in new single-family homes in Sweden have increased from 5 000 units in 1998 to about 15 000 units in 2004.

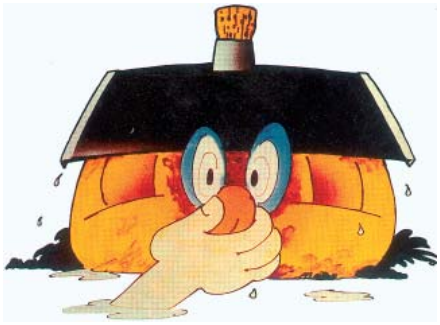


Figure 8 Sick building syndrome (source: Mats Fehrm, Nibe, Sweden)

Developments of integrated heat pump concepts for low-energy buildings have also started in Germany and Switzerland. In the USA, too, attention is being paid to these integrated solutions. The Department of Energy (DOE) supports manufacturers and organisations to develop efficient systems providing space conditioning and DHW. This is considered as one part of the development of Zero Energy Housing. Several combinations for domestic use are being investigated. For example, water-heating refrigerator, heat pump water heater, water-heating dehumidifier (WHD) and multifunction, integrated heat pump (IHP).

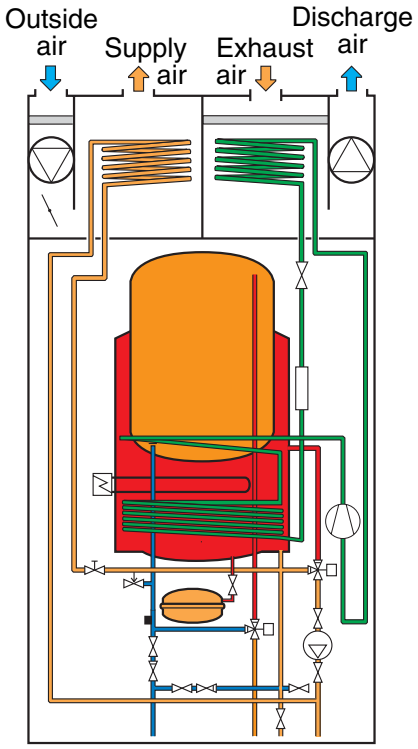


Figure 9 Exhaust air heat pump (source: Mats Fehrm, Nibe, Sweden

Heat pump water heaters

The energy used for DHW heating has steadily increased in Japan over the last 30 years, and now accounts for 1/3 of the energy used in the residential sector. To reduce the energy used, an air-source heat pump water heater (HPWH) with CO2 as its refrigerant was developed in 2001. These systems, called ECO-CUTE, have been subsidised by the Government since 2002 and are now sold and manufactured by 17 companies in Japan. Sales were projected to reach 120 000 units in 2004.

The situation for HPWH is not as favourable in the US as it is in Japan. Market penetration is still low, mainly because of a high first cost compared to electric water heaters, and a bad reputation for durability which was gained by the first units sold twenty years ago. Approximately 30-60 % energy could be saved if HPWH was used instead of electric water heaters. Suggestions for improving the perception and increase the use of HPWH in the US include:

Peter Ritter von Rittinger international heat pump medal

During the conference banquet, the organising committee announced the winners of this award, which was presented for the first time. The award recognizes outstanding contributions to the advancement of international collaboration in research, policy development, market development and applications for energy-efficient heat pumping technologies. In the IEA definition, heat pumping includes air conditioning, heat pump and related refrigeration technologies. The awardees were selected from nominations submitted by IEA member countries and by interested individuals.

The awardees were:

- Dr. Katsuhiko Narita, Japan
- Mr. Nance Lovvorn, USA
- Mr. Wayne Reedy, USA
- Dr. Bernard Spinner, France
- Research team GEMINI – Centre for Applied Refrigeration, Norway

Mr Wayne Reedy receives the heat pump medal from the chairman of the Heat Pump Programme, Dr Sophie Hosatte

The award is named for Peter Ritter von Rittinger, an Austrian engineer who designed and installed the first known heat pump, in 1855, for a salt works in the village of Ebensee in Upper Austria.

Technical tours

During the conference, the delegates could join one of two technical tours; Lake Las Vegas, which is a newly built community located 28 km outside Las Vegas; and Rocky Research, which is a research and development organisation in nearby Boulder City.

Lake Las Vegas

The Lake Las Vegas community comprises luxury residential villas, yacht and beach clubs, golf courses, restaurants and hotels. It surrounds a large 1.4 sq. km artificial lake. The tour included a boat trip on the lake. During the trip, refreshments were served and the guide Mike Kapps from Climate Master described the development. The lake project started in 1987, and the first buildings were built ten years later. The water of the lake comes via an underground pipe from Lake Mead. The air temperature swing ranges from -4 °C in wintertime to 52 °C during the warmest summer days. However, the water temperature of the lake seldom exceeds 20 °C, due to the fact that cold ground water compensate for the loss caused by evaporation.

Lake Las Vegas

One of the objectives for Lake Las Vegas was to reduce use of energy by application of heat pumping technologies. Space conditioning (heating and cooling) for the Lake Las Vegas buildings is therefore provided by water-source heat pumps with loops that are submerged in the lake. The depth of the lake is 18 – 36 m and the coils are placed approximately 15 m below the surface. By placing the condensers in the lake, energy efficiency is improved and the size of the coils is reduced. In addition the noise level is considerably reduced. The tour was very scenic as well as informative.

Rocky Research

Rocky Research is most recognised for its development of solid-gas sorption technologies that can be used in thermally activated heat pump systems. However, the company is also working on electronics cooling, HVAC&R fluid analysis and refrigerant flow control, as well as on prototyping and testing other thermal components and systems in the HVAC&R field. During the tour, we saw the laboratory facilities and some of the products that were developed and tested. Among the more special products were what are known as "Hot Biscuits™" – a product for keeping golf balls warm and thus make them travel further. More information about Rocky Research can be found at their web site www.rockyresearch.com

The entrance to Rocky Research

- Engage electric utilities in the most energy-using areas to market HPWH
- Include home builders in this area by including HPWH as part of an energy-efficiency package
- Engage large do-it-yourself retailers

Supermarket refrigeration

Issues related to supermarket refrigeration were dealt with at several different sessions during the conference. In one presentation, Donald Bivens from DuPont described the work performed when developing the IPCC/TEAP report "Safeguarding the Ozone Layer and the Global Climate System; Issues related to HFCs and PFCs". The results related to supermarket refrigeration showed that measures must be taken. The worldwide mean annual loss of refrigerant in these systems is approximately 30 % of the charge, although the variations between different countries are large. The problems with leakages can be reduced by increased attention to installation and maintenance procedures, refrigerant record keeping, leak detection, and designing systems to achieve a low refrigerant charge.

The results from the IEA Heat Pump Programme Annex 26 were summarized in a poster presentation. The combined efforts taken by the participating countries - Canada, Denmark, Sweden, United Kingdom and the US - show that there is considerable potential for both energy and environmental savings. By using low-charge refrigeration systems, energy savings of more than 10 % and TEWI reductions of 60 % could be achieved, compared to the prevalent baseline system – a multiplex DX system with air-cooled condensers. Savings are possible with distributed compressors, secondary-loop systems (which were the most investigated solution in the Annex work), and low-charge multiplex systems.

In a Canadian project, the refrigeration system is based on secondary loops which are also integrated with the building's heating and ventilation system. Greenhouse gas emissions can be reduced through this approach by 75 %, and energy consumption reduced by 25 % compared to a conventional Canadian supermarket. In their conclusions, the authors state that these reductions should be achievable without any extra cost. The extra investment at the first stage will be paid back by the reduced energy use.

Conclusion

To conclude, the conference was successful with many interesting presentations and discussions on the latest developments in both technology and markets. The IEA Heat Pump Conference is an important event, as it brings together people from industry and research organisations and thus provides a platform for exchanging experience and for networking. The articles in this Newsletter give an overview: for more detailed information, the conference Proceedings can be ordered from the Heat Pump Centre at www.heatpumpcentre.org.

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Annex 28 - Comprehensive and uniform testing and calculation for heat pump systems

Carsten Wemhoener, Thomas Afjei, Switzerland, Operating Agent of Annex 28

Annex 28 of the IEA Heat Pump Program (HPP) was started in January 2003, with the aim of developing comprehensive test procedures and calculation methods for the seasonal performance factor (SPF) of heat pumps for combined space heating and domestic hot water (DHW) production. The final results were presented as the opening session of the 8th International Heat Pump Conference in Las Vegas in May 2005. The final report is scheduled for the end of 2005.

Introduction

An audience of more than 90 people demonstrates the strong interest in innovative multi-functional heat pump systems, as well as in standardisation and labelling issues. This co-operative research project, managed by the Institute of Energy (IfE) of the University of Applied Sciences in Basel, is motivated by the following situation: With an increasing number of different heating systems on the market, consumers need clear indication of performance by energy- or eco-labelling at the point of sale to make rational purchase decisions. Thus, manufacturers need guidelines defining which values of their components must be shown in order to calculate the seasonal performance factor (SPF) which is the basic information on a label. Designers also need these data to make a fair comparison of different system solutions. In the end, uniform test procedures and calculation methods are required as the basis for effective labelling to promote energy efficiency.

Results

Currently, innovative heat pump systems are not covered by existing testing and calculation procedures. Newly developed systems are therefore at a particular disadvantage on the market, even though their performance is promising. Based on a survey of state-of-the-art systems on the market and standardisation, the participants in IEA HPP Annex 28 agreed on extending existing standards to include combined operation. The objective of the test procedure is to provide enough data on the component characteristics to enable seasonal performance to be calculated.

A black-box approach is applied for the testing, measuring only the values at the system boundary, so that different internal system configurations are taken into account only with regard to the energy input and output. The system boundary includes the heat pump itself, the domestic hot water storage and any back-up heaters. The system boundary is shown in Fig. 2.

Alternate combined operation, i.e. switching the heat pump to either space heating or domestic hot water operation, can be covered by the existing single mode test procedures, e.g. based on EN 14511 and EN 255-3

Fig. 1: C. Haglund-Stignor of SP presenting the results of the Swedish national team

for Europe. However, for simultaneous operating systems, i.e. systems which simultaneously supply energy to the heating and DHW systems, e.g. by desuperheating the refrigerant, the heat pump characteristic changes significantly between the single and the combined operation modes, and so

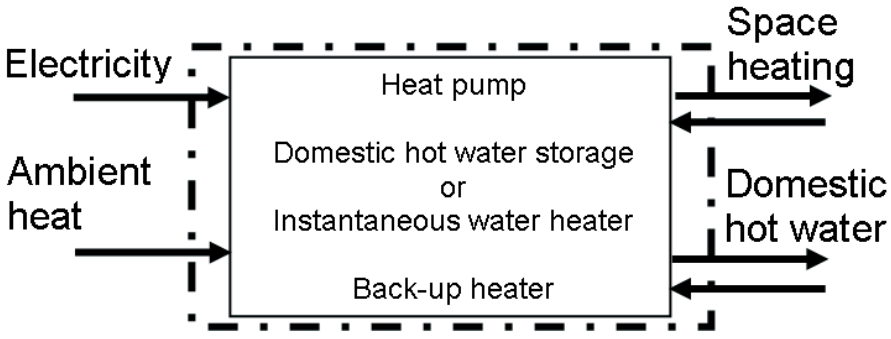

Fig. 2: Black box system boundary for the testing

testing has to be extended to a combined measurement. Combined testing must be performed by using the hot water draw-off cycle, as used in single testing, during the heating test. Testing for simultaneous operating systems thus delivers three characteristics: one for heating alone, one for DHW production, and one for combined operation.

For calculation of the seasonal performance factor based on standard testing, the participants agreed to build on the bin methodology which is already included in different national calculation standards for heat pumps. Calculation is performed by temperature ranges (bins), related to the duration of the outdoor air temperature. The performance factors at the centre of the bins, which are based on the test results and additional system energies, e.g. storage losses or auxiliary energy that are not considered during testing, are weighted with the respective energy amount which is represented by the ratio of the bin area to the total area. Subsequently, the single bins are summed up to the seasonal performance factor. Fig. 3 shows the principle of the bin methodology. For combined operation, this bin-method is extended to a third operation mode. The fraction of each operation mode is evaluated by the running time which is calculated by the energy requirements divided by the respective output capacity in each bin. The three seasonal performance factors are combined to an overall seasonal performance factor by weighting them with the energy fraction in each operation mode.

Due to the high number of nine participating countries - AT, CA, CH, DE, FR, JP, NO, SE and US - a wide range of different systems could be covered in the IEA HPP Annex 28, including CO2 systems, direct expansion systems and compact units for low-energy houses. Table 1 gives an overview of the national contributions to IEA HPP Annex 28.
In addition to the test-rig testing and calculation, the national projects in IEA HPP Annex 28 also included field testing, to prove the developed methods and evaluate the real-world

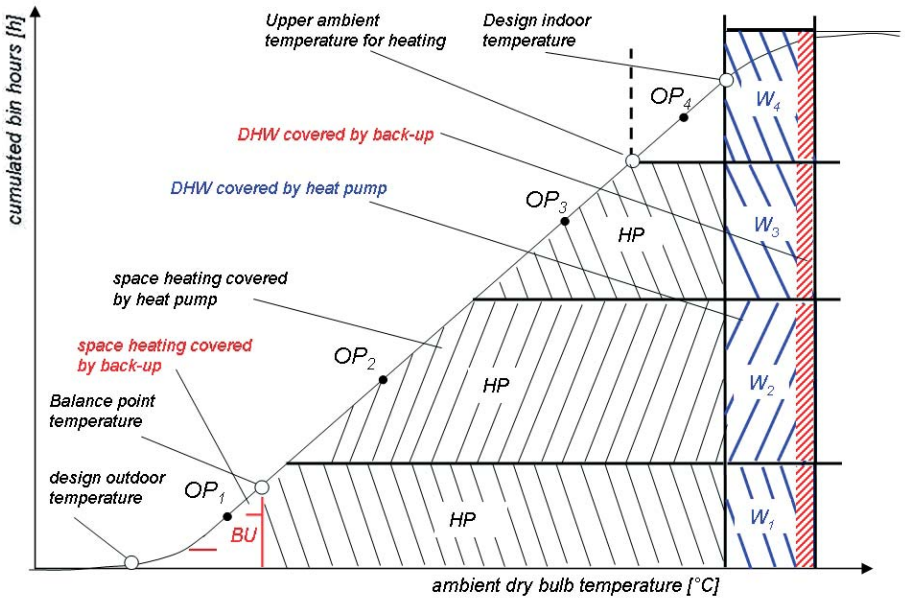

Fig. 3: Principle of the bin calculation

Table 1: National contribution to IEA HPP Annex 28

	Air source	Ground source	desuperheating	condensate subcooling	remark
AT		X	X		Direct expansion systems
CA		X	X		System incl. cooling operation
CH	X	X		X	Retrofit heat pump, extension to compact units, ventilation
DE	X				compact units, ventilation
FR		X	X		Part load operation
JP	X				CO_2
NO		X	X	X	CO_2, propane systems
SE	X	X			Test acc. to available standards
US	X		X		Experiences with ASHRAE standards

performance of innovative system layouts.

In order to integrate more complete results of this field monitoring, the date of the final report has been postponed to the end of 2005.

Conclusion

Parts of the results are already implemented in standards. The calculation approach has been adapted for the European prEN 14335 standard in the framework of the Directive on the Energy Performance of Buildings (EPBD) and the German national standardisation committee, DIN, has implemented it in its national standard. The product working groups of the European CEN standardisation committee will start work soon, so that the results of the testing will be implemented as well. This will provide coherent testing and calculation as a basis for further labelling, and contribute to environmentally sound technologies in the building sector.

The workshop presentations, and information on IEA HPP Annex 28, can be downloaded from the website http://www.annex28.net

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Ground Source Heat Pumps - Overcoming Market and Technical Barriers

Hermann Halozan, Austria, Operating Agent of Annex 29

On Monday, May 30, 2005, a workshop on the first results of Annex 29 "Ground Source Heat Pumps - Overcoming Market and Technical Barriers" took place in the conference facilities of the Caesars Palace Hotel in Las Vegas. 95 people attended this event, which offered more or less the results of the country reports of the participating countries Canada, Japan, Norway, Sweden, the USA and Austria (Operating Agent).

The fourth annex on ground source heat pump system

Annex 29 is the fourth IEA HPP annex on ground source heat pumps, after Annex 2: Vertical Earth Heat Pump Systems, Annex 8: Advanced in-ground Heat Exchange Technology for Heat Pump Systems, and Annex 15: Heat Pump Systems with Direct Expansion Ground Coils. In addition, the Energy Conservation through Energy Storage Implementing Agreement has carried out its Annex 13: Design, Construction and Maintenance of UTES Wells and Boreholes. This shows the importance of this project.

The tasks planned for this annex are State of the Art, a Market Analysis, the development of a Matrix of Ground Source Heat Pumps, Improvement of Components and Systems, identifying ways for Overcoming Legal Barriers, Overcoming Economic Barriers and, as the main topic, Increasing the Acceptance of Ground Source Heat Pumps.

State of the Art of Ground Source Heat Pump Systems and Market Analysis are almost finished, and the presentations in this workshop gave an overview of the situation in the participating countries.

The state of the art includes the climatic conditions (cold, moderate, hot, hot and humid), the ground conditions (soil, rock), different applications (single-family houses, multi-family houses, commercial buildings), operation modes (heating-only, heating and cooling, cooling-only, depending on the climatic conditions), heat source/heat sink systems, heat stores, heat distribution systems (air-based systems, hydronic systems), design conditions of the heat pump unit, design conditions of the heat source/heat sink system and control strategies.

Market Analysis covers the number of installed systems in the different sectors such as single-family and multi-family houses as well as commercial buildings, including data on operation modes such as heating-only, heating and cooling and cooling only, as well as the utilisation of the ground as heat source, heat sink, heat source/heat sink and as a store. This working area also includes the design conditions of the building, the capacity of the (reversible) heat pump unit(s), and the system used for heat extraction from and heat delivery to the ground.

Country presentations

The largest sales figures are in the USA, as presented by Arun Vohra.

Hermann Halozan, Operating Agent of Annex 29

The majority of the systems are secondary loop systems suitable for both heating and cooling. In addition to small systems for single-family houses, a lot of large systems are in operation, using the ground as a store. Due to climatic conditions, additional cooling of the store by air coils is sometimes required to keep the ground temperature at an acceptable level.

The greatest market penetration with ground source heat pumps has been achieved in Sweden, as Martin Forsen showed in his presentation. The majority of the systems is used for single-family houses, generally with a single borehole in the bedrock as the heat source for the house, cov-

ering about 70 % of the heat load and about 90 % of the heating demand. But Sweden has also large systems using the ground as a store with the capability of direct cooling, at least at the beginning of the cooling season and favourable heating conditions at the beginning of the heating season.

In Canada, a variety of systems, large and small, with different types of ground coils, are in operation, the market is growing and great efforts are made to improve the situation of ground-coupled heat pumps, as Vasile Minea has shown in his interesting presentations.

Several interesting large systems are in operation in Norway, as presented by Jorn Stene. Ground source systems have become interesting for single-family houses due to the fact that the electricity price has doubled during the last few years: before this happened, direct electric heating was the most common heating system in Norway in this sector. Now considerable efforts are being made to improve the situation of ground-coupled heat pumps.

Japan is just carrying out developments in the direction of heating and cooling larger buildings in the north of Japan – the northern part of Honshu and Sapporo – with the aim of improving the situation of heat pumps in this region, which can become pretty cold during the winter. Takao Katsura presented such a project with several new design and modelling tools for such systems.

In Austria, as in Canada, a variety of systems are in operation, as Hermann Halozan described in his presentation. Many direct-expansion systems are in use in single-family houses, where the majority of heat pumps are installed, in addition to secondary loop systems. A newly developed system uses a heat pipe thermo-siphon, using CO2 as the heat carrier, as the heat source for a conventional heat pump. In addition to these small systems, ground source installations are also in operation for large buildings, with the interface to the ground being the pile foundations of the buildings, incorporating coils.

Conclusions

Matrix of Ground Source Heat Pumps will be developed, identifying possible system designs for different building types, climatic conditions, soil temperatures and soil properties.

The main influencing factor on the design of a ground source system is the building. Building characteristics have changed significantly over the last few decades. The thermal insulation of buildings has been considerably improved which, in the case of single-family houses, means that internal gains will have a proportionately greater effect in reducing heating demand. At the same time, cooling demand has increased, so that a balance sheet would show a tendency to more cooling and less heating. This change is even more marked in the case of commercial buildings, due to the fact that the ratio of volume to surface is rising. An additional influence comes from architecture, with more and more glazed facades being used. Although there is good awareness of solar gains and day-lighting during the winter, there is little consideration of solar loads in the summer, which increase the temperature significantly. This is not a problem that can be properly solved by an air conditioning system.

Climatic conditions and with the characteristics of the buildings determine the ratio of heat extraction/heat removal, which should be balanced to keep the average temperature of the ground near the undisturbed ground temperature. Although ground temperatures and soil properties are no longer a problem for single-family houses, they need to be considered very carefully for large systems, and the thermal response test is an important tool for properly sizing large systems.

As can be seen, ground source systems offer high energy efficiency, and using LCA or LCCA, even high economic efficiency. The problems of ground source systems are very often a high first cost and a lack of knowledge of the benefits of these systems. We hope that this project can contribute to solve at least some of the problems of broader application of ground source heat pump systems.

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Session 1 – Heat pumps - status and trends

John Ryan, USA, chairman session 1

Introduction

Regional reports for North America, Europe and Asia/Oceania, summarizing market and technology status and trends for heat pumps, have been a traditional feature of the triennial IEA Heat Pump Conferences. These reports are an excellent resource for understanding the similarities and differences in heat pumping technologies in the major world regions. This article is based on the regional reports, discussions with the authors and other sources. The focus here is on space heating applications, although air-conditioning, refrigeration and process heating are also important uses for heat pumps.

Common trends in all regions

All three regions contain a wide range of climatic zones: from areas that are dominated by space heating to those which are cooling-dominated. Large commercial buildings with high internal loads have similar needs for air-conditioning in most areas. This results in significant similarities in systems and applications among regions.

Electrically-driven, split system, air-source units are commonly used in small buildings in all regions, with a significant market share in parts of Europe and a dominant share in North America and Asia/Pacific. Examples of emerging and niche markets include heat pump water heaters and gas-driven heat pumps.

Ground source heat pumps continue to be of interest in all regions, although market development varies considerably.

All regions have experienced very significant market growth in the last several years, although the factors driving growth vary considerably among countries. The drivers include consumer demands for increased comfort, rising economic levels, energy supply factors, technical developments and promotion programmes.

Expanding environmental awareness is taking hold in all areas, considering the direct impacts of heat pumps and their global benefits. Issues include peak load impacts, product recycling, equipment efficiency and refrigerants. The transition to environmentally benign refrigerants is accelerating in all regions. The global benefits of heat pumps are being increasingly recognized.

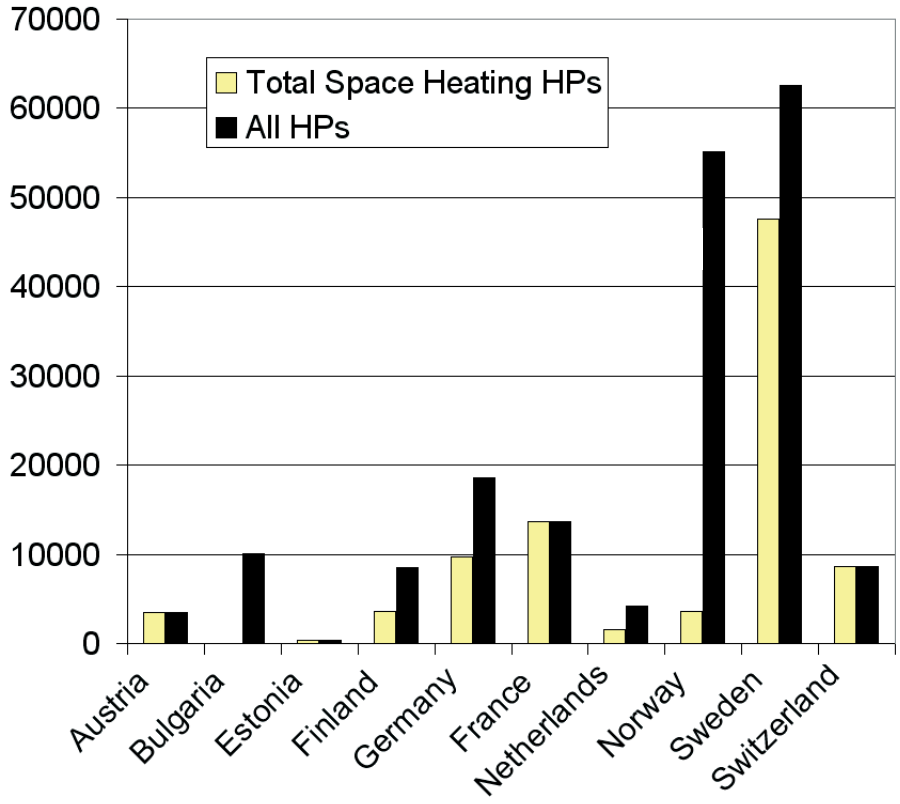
Efficiencies will be trending sharply upward with minimum efficiency requirements, whole building performance standards and promotion programmes in all regions.

North America

Reversible, air-source split system heat pumps with forced air (ducted) distribution dominate the market for small buildings. Single-package, air source heat pump units are widely used in medium-sized commercial buildings. Ground-source heat pumps continue to have a small market niche, nowadays primarily in the commercial sector. Sales of heat pumps have had a sustained annual growth rate of 10% for over ten years (growth driven largely by replacement of older units). However, heat pumps are used in only 10% of homes because natural gas predominates as a heating fuel, especially in colder areas and in cities. New U.S. Department of Energy regulations dictate a 30% increase in the minimum efficiency of small air source heat pumps, effective in January 2006 - the first increase since 1992. Refrigerant transition from CFCs to HFCs is being guided by government regulation and industry standards. Refrigerant containment and installation quality is being enhanced by industry technician training and certification programmes.

Europe

There is significant variety in European applications. Region-wide, most heat pumps are installed in new buildings with low-temperature hydronic heating systems. However, exhaust air heat pumps (Sweden), retrofits (Norway) and other types are important nationally. Heat pump sales levels have risen rapidly and significantly across the region in the last few years. Sustained annual growth rates of 15 to 25% are common in several countries, even those with well-established markets. (Such growth has been achieved in Switzerland through a comprehensive programme of technical support and market development). Sweden appears to have by far the largest per



The European heat pump market in 2003 (source: EHPA)

capita market penetration of heat pumps, based on available data. Regulations on refrigerants and on building energy performance will directly affect heat pump design and installation in the future.

Asia

Reversible, air-source, ductless, split-system heat pumps dominate the residential and commercial markets in the Asia/Pacific region. Explosive market growth in China (to about 12 million heat pumps in 2003) dominates the regional market trend. Reversible, air-source chillers are an important niche product for medium sized buildings. Concern about the peak load impacts of air-conditioning has driven governments across the region to set up mandates, subsides, tariff structures and promotion programmes to stimulate use of integrated thermal storage systems and natural gas driven heat pumps and cooling equipment. These efforts have helped establish a modest market in Japan for small gas engine-driven heat pumps and a major market for gas absorption chillers for larger buildings across the entire region. Water heating heat pumps also appear to have some market traction. A recently-introduced Japanese heat pump water heater using CO2 as the refrigerant has attained strong initial sales, boosted by government subsidies. A solar heat pump water heater is now on the market in Australia. Japan's "Top Runner" program will boost efficiency of small air-source equipment by 60% over 2000 levels.

Conclusion

Similarities and differences among regions have always stimulated interesting discussions on heat pump technologies and markets. The 8th IEA Heat Pump Conference provided a unique forum for participants to update their awareness of the worldwide situation. The Conference showed that the sector is changing perhaps more rapidly than ever. Dramatic market expansion, the emergence of new technologies and new policy initiatives characterize today's situation.

References:

1) Heat Pump Status and Trends: North America, Mr. Mark Menzer (Air Conditioning and Refrigeration Institute), 8th IEA Heat Pump Conference, Las Vegas, Nevada, USA, May 30 - June 2, 2005

2) North American Market Overview, John Ryan (U.S. Department of Energy) and Gerald Groff (Groff Associates), 7th IEA Heat Pump Conference, Beijing, China, May 19 - 22, 2002

3) Europe Heat Pumps - Status and Trends, Dr. Monica Axell, Mr. Fredrik Karlsson (IEA Heat Pump Centre), 8th IEA Heat Pump Conference, Las Vegas, Nevada, USA, May 30 - June 2, 2005

4) Heat Pumping Technologies in Asia & Pacific - An Overview, Mr. T. Yoshii (Heat Pump Technology Center of Japan) and Mr. Wei Xu (China Academy of Building Research), 8th IEA Heat Pump Conference, Las Vegas, Nevada, USA, May 30 - June 2, 2005

Session 2 – Energy and Environment

Sophie Hosatte, Canada, chairman of session 2

Professor Halozan opened the session with a keynote paper, presenting a comprehensive review of the history of heat pumps and concentrating on the evolution of, and recent changes in the use of, refrigerants. Principles, definitions, and types of heat pumps were covered, and the importance of performance factors for electricity generation described. World markets were described: almost saturated in Japan; increasing numbers of heat pumps being installed in China, which has now the world's largest air conditioner manufacturing industry; limitations of the market in North-America due to cold climatic conditions; programs in preparation in Europe to increase the market breakthrough of this technology, facilitated by the deregulation of electricity tariffs. Professor Halozan concluded that heat pumps have a high potential for GHG emission reduction, as one of the largest contributions to CO_2 reduction that a single technology available on the market can offer.

The German context of the heat pump market in the residential sector was the topic of the first presentation. Although manufacturers and associations are very active in promoting heat pumps, the market is less than in other European countries. Initial costs remain the major barrier. The important criteria for heat pump acceptance in the residential sector were detailed. The cost structures of heat pump system, as well as of the heat pump units themselves, were described, together with ways in which these costs could be reduced. It was also shown that decreasing the capacity of the heat pump and using an auxiliary heating source during peak periods is an interesting option.

The second presentation described the geothermal project at the Richard Stockton College of New Jersey (US). This installation has one of the largest single BTES (u-tube closed-loop) well fields. The project was aimed at thermally balancing the field over a year's period of time. This was arranged by using a cooling tower during the winter. The methodology for calculating the CO2 emission reduction resulting from this project and the results were presented, and the benefits demonstrated. Emission savings range from 17 % to 50 % per building. These findings can be applied to other regions and climates in the US, with the possible exceptions of cold climates and large heating demands that utilizing coal-generated electricity.

Water heating status and future views of CO_2 refrigerant for water heating in the residential sector were covered in the third presentation. In Japan, 34 % of energy use is for water heating in the residential sector. CO_2 heat pumps were reported to provide 30 % energy savings and 50 % CO_2 emission reduction compared to conventional combustion-type water heaters. The new product has been on market for four years, and is sold by 17 manufacturers in Japan. A Government subsidy system has been available since 2002. 120 000 units were sold in 2004 alone, and the total number of units in operation now exceeds 250 000. Various types of system that accommodate different user needs (e.g. for connection to bathtubs, for floor heating, different control strategies etc.) are now available on the market.

The fourth presentation was described development of a heat pump for the French retrofit market. The constraints were as follows: complete autonomy; ability to provide all the heating needs, even at the lowest temperatures in France (-20 °C); use of the current radiator hydronic circuit (55 to 75 °C); cooling provided in summer. The challenges were the variation of the heating capacity depending on the outdoor temperature and the variation of energy efficiency depending on the temperature difference between the sink and the source. The solution presented was a versatile two-stage/single-stage system to meet 100 % of the demand, with water delivery temperature varying with outdoor temperature.

The final presentation of the session provided a progress report on supermarket refrigerant emission reduction programs, including system design options for reduced Life Cycle Climate Performance (LCCP). Refrigerant emission rates from a limited number of supermarket organisations in the United States and Europe are now in the range of 3 % - 22 % of refrigerant system inventory on an annualised basis, compared with a worldwide estimate of 30 % for commercial refrigeration systems. These improvements are the result of different strategies: better installations, regulations, maintenance, record keeping and reporting, concentration on leak detection, indirect cooling systems (secondary loop heat transfer fluids). LCCP calculations show the importance of energy efficiency, refrigerant charge size and refrigerant emissions in reducing the climate change impact of supermarket refrigeration systems, with potential for reducing climate change impact by over 60 %.

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Session 3 - Heat Pump Applications

Peter Rohlin, Sweden, chairman session 3

Session 3 consisted of six oral presentations and eleven poster presentations. The subject was Heat Pump Applications, and the presentations concentrated on the benefits of heat pumps, market situations and some successful applications.

Gerald Groff opened the oral presentation with the question - Heat Pumps—Who Uses Them and Why? Heat pumps have been used in industry and for space-conditioning systems in buildings since the latter part of the 19th century. Today, more than 130 million heat pumps are installed worldwide, with more than 15 million new heat pump systems being installed each year. The presentation was a review of the historical development of heat pump applications over more than 150 years and, through this historical overview, attempted to answer the question: "Who uses heat pumps, and why?" Mr. Groff concluded that governments, utilities and conservationists who wish to accelerate heat pump market growth must provide educational programs and initiatives to overcome the problem of lack of familiarity of most people and other long-standing market barriers.

The second presentation, by Nance Lovvorn, picked up the subject of familiarity by addressing Increasing Consumer Confidence in Heat Pumps. Over 50 years ago, an electric utility company in the southern part of the United States had the vision of promoting electric heat pumps as a load management tool. Various programs and incentives have been utilised to do this in a manner that would be mutually beneficial to the company and its customers. The presentation discussed some of the initiatives that have led to increasing consumer confidence in heat pumps. In the end - has consumer confidence in heat pumps changed? Mr. Lovvorn's answer is Yes! And in a very positive way. The initiatives addressing reliability concerns from 25-30 years ago were significant, and heat pumps have proven to be viable and marketable when installed and serviced properly.

Rune Aarlien presented the Unprecedented Heat Pump Market Development in Norway: What Happened, and Will It Last? The Norwegian heat pump market 'exploded' in 2003, and sales reached an all-time high of 55 100 units (compared to the normal figure during the 1990s of between 1000 and 2000 units annually). Several factors seem to explain the peak behind the unprecedented market development; introduction of an investment grant scheme, extreme peaks in electricity prices, cumulative market efforts over years undertaken by different parties, the massive media attention, the increased market competition yielding lower equipment prices, and improved product quality over time. With expected sales of between 20-25,000 units in 2004 (comparable to 2002), the market is still relatively hot.

The heat pump market in Switzerland, too, has experienced continuous growth in the last decade, as described in the final oral presentation Heat Pumps in Switzerland—A Success Story, by Stephan Peterhans. On average, sales increased by 15 %. Heat pumps play an important role particularly in the new building market, with a market share of about 20 %. Quality assurance and operational reliability have been set as a precondition for an active market development.

Akira Okagaki presented a Successful Application of Heat Pumps to a DHC System in the Tokyo Bay Area. The Harumi Island District Heating & Cooling (DHC) scheme, which is located in the Tokyo Bay area, introduced the heat pump and thermal storage system with the aim of achieving minimum energy consumption, minimum environmental load and maximum economical efficiency. It started operating in 2001.

Experience indicates that the real-world efficiency of a heat pump system often is considerably below the theoretical potential. Per Fahlén pointed out, in his presentation Performance Audits of Heat Pumps — Procedures and Uncertainties, that performance audits can detect deviations and indicate ways of upgrading the performance. A survey indicates a shortage of proven, cost-effective methods, but a Nordic project has resulted in two in-situ test methods. One is based on traditional external measurements of energy inputs and outputs, while the other relies on internal measurements of temperatures and pressures in the refrigerant system. Both methods include requirements on accuracy and stability and methods of comparing stated performance with measured data. One particular advantage of the internal principle is its ability to detect deviation from expected performance and simultaneously provide information regarding the cause.

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Session 4 - Ground and Water Source Heat Pump Systems - Design and Application Tools

Hermann Halozan, Austria, chairman session 4

Session 4 of the Conference, "Ground and Water Source Heat Pump Systems - Design and Application Tools", was chaired by H. Halozan, Graz University of Technology, Austria, and Steven R. Szymurski, Air-Conditioning and Refrigeration Institute, Arlington, VA, USA. The session consisted of one keynote speech, five oral presentations and 13 poster presentations on the topic of ground and water source heat pump systems.

In his keynote speech, "Ground source heat pumps: meeting global challenges through load networking", James E. Bose - who has been working in this field for many years - discussed the increased benefits of networking by combining or adding thermal loads (buildings, processes, etc.) to a system for the purpose of increasing overall system energy efficiency.

In "A joint western and eastern culture procedure for cost-estimating geothermal heat pump systems", William S. Fleming presented an overview of his experiences in the cooperation with China in the field of ground source heat pump systems, which was a great success. He believes that GHP technology and service is beneficial to Western and Eastern governments, businesses and users. There is also a need for information on items to understand, factors to consider, and how properly to estimate GHP systems for commercial buildings throughout the world.

In "Simulation and optimisation of ground source heat pump systems", J.D. Spitler explained methods for modelling of components, simulation for the design of vertical ground loop heat exchangers, design of GSHP systems and optimisation. Göran Hellström presented the "Status of design tools for ground-source heat-pump systems". The knowledge of system components and in-situ techniques to obtain necessary ground properties makes it possible to perform reliable simulations of GSHP system performance for both domestic and commercial applications. The future challenge for GSHP designers is to use these tools to find the optimum system configuration and control in different situations. K. Nagano described the "Development of a design and performance prediction tool for ground source heat pump systems", containing a user-friendly interface for input data and showing the calculation results graphically assist understanding. Martin Forsén presented "A novel design tool for heat pump systems", developed in co-operation with parties active on the Swedish heat pump market. The tool has been developed in order to perform system performance analysis and to assist the design of vertical boreholes.

The poster session covered many aspects of ground source heat pumps such as "An integrated geothermal ice-storage system" for peak load operation, a "Thermal and cost benefit analysis of a geothermal pilot project at northwest Tennessee correctional facility", an investigation of "Comparing new control concepts for heat pump heating systems on a test bench with the capability of house and earth probe emulation", "Design and optimum control of a Swedish dual-source (air and ground) heat pump system", an overview of "Ground source heat pumps – overcoming market and technical barriers (IEA Heat Pump Programme Annex 29)", "Performance of ground source residential heat pumps", "A ground source heat pump with a new compact collector", "Analysis of a ground-coupled heat pump heating and cooling system for a multi-storey office building", "Development of a ground source heat pump system with ground heat exchanger utilizing the cast-in-place concrete pile foundations of a building", "Development of a high-performance water-to-water heat pump for ground-source application", "Development of an autonomous performance-testing system of water-source heat pumps and actual performances of Japanese small water-source heat pump units", "Optimum running of heat pumps under low-load conditions", and "Development and application of an innovative shallow groundwater heat pump system".

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Session 5 - Integration of Heat Pumps in Cooling, Heating and Power (CHP) Systems

Caroline Haglund Stignor, Heat Pump Centre

The fifth session of the Conference dealt with integration of heat pumps in cooling, heating and power systems. The session was chaired by Mr. Ron Fiskum, U.S. Department of Energy, and Mr. John Tomlinson, Oak Ridge National Laboratory.

The keynote speaker, Mr. Robert DeVault, of Oak Ridge National Laboratory, introduced the session by showing a graph illustrating how important energy is to quality of life. There is a clear relation between use of energy and income in the world. Therefore, thermally activated heating and cooling systems are an interesting alternative to electrically driven technologies, since they offer many benefits such as energy efficiency and the potential for reducing peak electric demand. Since 2001, the United States Department of Energy (DOE) has made a significant shift in focus for development and use of thermally activated heat pumping technologies. DOE is working with partners from the heating and cooling industry and the power generation industry to develop Integrated Energy Systems (IES) using advanced thermally driven heat pump technologies for building heating and cooling by recycling otherwise wasted heat from electric generating equipment. Robert DeVault presented different key activities within the programme; lithium-bromide water absorption chillers matched with power generation to make Integrated Energy Systems (IES); ammonia-based residential and light commercial absorption technology for refrigeration, heat pumps and chillers; and advanced "hi-cool" heat pumping technology.

The first paper presented in this session, written by John Ward, Don Chase, Rob Hellstrom and Stephen White, described the performance of Australia's first demonstration of trigeneration with desiccant cooling, which had been installed in Hornsby Library. The project goal was a substantial cut in CO2 emissions, and trigeneration was selected as the best way of achieving this goal. Initial performance shows approximately a 20 % reduction in CO2 emissions. However,

substantial improvements are expected with an improved control strategy that is currently being installed.

Thereafter, Lennart Vamling, Chalmers University of Technology in Sweden, discussed the future role of heat pumps in Swedish district heating systems and their competition with refuse incineration and combined heat and power generation as ways of reducing greenhouse gas emissions. The situation in Sweden today is that 11 – 15 % of the heat supplied by district heating systems is produced by heat pumps. However, conditions are changing, due to integration on the European electricity market, with new policy instruments, prohibition of landfill disposal of combustible waste and the fact that the existing heat pumps are ageing and beginning to require renovation. Different scenarios were explained, and the conclusion from the study was that reinvestment in a new heat pump, when its life had come to its end, was only a really good alternative if neither natural gas or waste was available.

The following three presentations dealt with absorption chillers. Chaobin Dang from AIST, Japan, presented an R&D project dealing with small-capacity absorption chillers using waste heat from distributed power generation. The aim of the project was to reduce the size of the absorber and increase the COP. The results showed that by using a mixing-type absorber, the COP was improved by 10 % to 15 % in comparison with a conventional absorption cycle. Further, the volume of the mixing-type absorber is reduced by about 50 % in comparison with a conventional falling film type absorber.

Tom Rosfjord from United Technologies Research Center in the USA talked about integration of an absorption chiller system in a supermarket heating, cooling and power system. The objective of the investigation was to integrate a pre-engineered Combined Cooling, Heating and Power (CCHP) system into a supermarket application. Results from an energy analysis indicated that the CCHP system would provide a 65 % reduction in grid power demand. The system was commissioned in January 2005 and had, up to the time of the presentation, been successfully operating for four months, with energy savings exceeding expectations.

The final presentation of this session, given by Richard Sweetzer, Exergy Partners Corp. on behalf of Zhang Yue, CEO Broad Air Conditioning Co., Ltd., described development of the world's first small-scale two-stage absorption chiller/heater/hot-water system. In addition to the complete product design, an automated manufacturing process and facility has also been created, resulting in current production levels of 100 systems per day.

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Session 6 - Advanced Concepts - Components

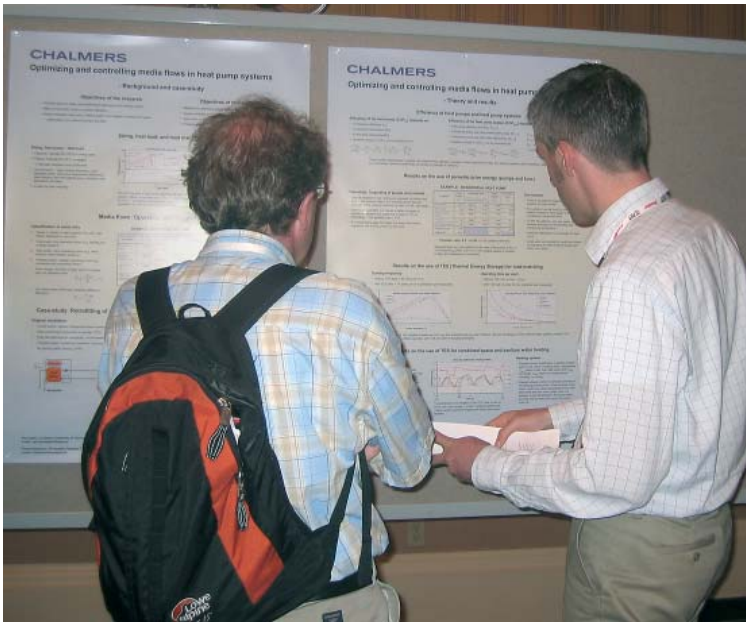
Thomas Kopp, Switzerland, Chairman Session 6

The need to improve components has to be a continuing process, since no concept can work without components such as compressors, heat exchangers, piping and control equipment.

In his keynote presentation, Prof. Clark Bullard, ACRC, University of Illinois, USA, gave an interesting overview on technical evolution of heat pumping technologies which started with custom-built systems and arrived at mass production as in its present state. The challenge must be computer-assisted manufacturing, increased adaptability and better integration with buildings. The focus on advanced components was devoted to the critical charge and the mass flow rate of refrigerant, and also to the flow of the outside air. Heat exchangers have seen a dramatic evolution in the form of micro-channel types that achieve a significant increase in heat transfer coefficient. In addition to the common reciprocating and scroll compressors, a compressor with variable displacement for automotive applications was presented. After having discussed various improved circuits, Professor Bullard concluded with his visions of the future, such as the integration of heat pumps in pre-fabricated wall panels.

Dominique Hantz, from CETIAT France, demonstrated the operation of a microchannel heat exchanger in a reversible air to water heat pump using R410A and providing 8 kW of heating and 6 kW of cooling capacity. Compared to the OEM round tube-plate finned coil heat exchanger, the microchannel exchanger permitted a remarkable charge reduction of 50 %, better condensation drainage, 15 % improved heat pump efficiency and 10 % increased cooling capacity.

Robert Uselton, Lennox Industries Inc. US, focused on a split-system residential heat pump with separate dehumidification operating mode. In addition to heating and cooling, there is an increased need for dehumidification in certain climates e.g. in Texas. Dust mites, too, can be desiccated at average humidities below 55 % RH.



An analytical model was used to compare different technologies in terms of indoor temperature and humidity. The variable condenser reheating system can be enhanced to a conventional system without undue complexity or cost.

Wayne Reedy, Carrier US, awarded with the Ritter von Rittinger award at the conference banquet, explained the influence of product design and air flow rates on sensible heat ratio (SHR) in unitary A/C equipment. SHR is the rate of the sensible cooling capacity compared to the total cooling capacity. It was shown that the SHR value is very little dependent on a higher SEER design, but it is extremely important that evaporator airflow rates do not exceed 450 scfm/ton, which is also the ARI limit.

Professor Guo-yuan Ma from Beijing University of Technology reported on an experimental study of heat pump cycle of a flash-tank economizer with a scroll compressor. Flash-tank systems have better heating performance than sub-cooler systems, and are particularly suitable for use in cold regions. The prototype, with a 5 HP compressor, provided a heating capacity of 8.15 kW when evaporating at 25 °C and condensing at 45 °C.

The last speech was given by Karl Mittermayr, M-Tec Austria, and described the market experience of four years of CO_2 thermosyphon heat source for heat pumps. In Austria, heat pumps are mainly used for heating. Vertical CO_2 earth probes operate on the thermosyphon principle, and need no pumping energy. In 2002, a prototype was built with four coated copper tubes with a length of 65 meters each. 50 heat pumps with CO_2 probes were installed in 2004, and have operated well. Other ideas using the thermosyphon principle were also presented, such as an energy-free footpath heating system.

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Session 7 - Advanced Systems and Equipment

Rune Aarlien, Norway, chairman session 7

In his keynote address, Professor Emeritus Eric Granryd (Sweden) discussed various challenges in heat pumping technologies. He pointed to the many different types of applications, and to the fact that the working fluid predicament has also created interest in alternative cycles. As building design becomes more advanced, demand for heat will be reduced and cooling and tap water heating will become more important. He stressed that different climatic conditions will give priority to different system choices. Granryd underlined the need to reduce energy consumption and peak power. Heat pumping systems in general have a poor thermodynamic efficiency, with room for substantial improvements. He foresees a future with many surprises.

Yoshinori Shirakata (Japan) presented results from the development of a high-performance turbo chiller, for large-capacity air conditioning. The chiller uses HFC-134a as refrigerant, and is reported to have achieved significant performance enhancements through improvements in the refrigeration cycle, aerodynamic performance of the compressor, the heat exchangers and in the design of the control system. The system is equipped with an inverter for optimum variable control.

Mats Fehrm (Sweden) discussed the exhaust air heat pump as a rational way of heating low-energy houses. He pointed to the fact that the low-energy housing industry is constantly searching for compact solutions for heating, ventilation, hot water production, heat recovery and controls. He said that the exhaust air heat pump is particularly suitable for this application. Common practice is now to combine space heating and domestic hot water systems with the ventilation function. In 2004, roughly 15 000 exhaust air heat pumps were installed in Sweden.

Andreas Bühring (Germany) presented results from a development and monitoring project. Several thousand passive houses, with annual heating demands as low as 15 kWh/m2 and thermal peak load of 10 W/m2, have been erected in Europe. The paper describes compact ventilation and heating devices with an integrated exhaust air heat pump, which is used for space heating, domestic water heating and ventilation. Units have been monitored in more than 30 single family houses, with high efficiency and low operating costs. For passive houses in Europe, this new kind of heating system has reached a market share of 30-50%.

John Tomlinson (USA) addressed the subject of integrated heat pumps for combined space conditioning and water heating in the US. He reported on activities, results and findings of sponsored US research to develop an advanced integrated heat pump for space heating, cooling, dedicated dehumidification and water heating, and a water-heating dehumidifier for retrofit applications. One of the messages from the presentation was that the integrated approach to heat pump water heating is important as a means of reducing first costs and improving performance of air conditioning and water heating systems.

KA Jahangeer (Singapore) presented results from a study on an innovative multi-function solar heat pump system with HFC-134a as working fluid, which can provide space heating and cooling, water heating and dehumidification simultaneously or independently. The system was designed and tested in Singapore. Results indicate that the system can meet domestic and industrial requirements and save considerable amounts of energy compared with conventional systems.

Poster presentations

This session included twelve very interesting poster presentations. The titles of the papers were: Hermetic gas-fired residential heat pump; A heat pump for automotive applications; Residential heat pump water heater development status - USA; Summary of advanced supermarket R&D activities conducted under IEA Annex 26; Non-reversing, 100%-outside-air heat pump for heating and cooling; Low-energy cooling technologies; Performance measurement and modelling of air-source heat pumps; A generic calculation scheme to estimate seasonal performance of combined systems and experimental results; IEA HPP Annex 28 – a uniform energy-related characterization of heat pump systems; Heat pump with high outlet temperatures; Development of a two-circuit heat pump for heating and domestic hot water supply; and Airflow in multi-air ducts of semi-conductive thermoelectric heat pumps.

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Session 8 - Experiences with Alternate Refrigerants

Caroline Haglund Stignor, Heat Pump Centre

The eighth session of the Conference was devoted to presentation of different experiences of alternate refrigerants. The session was chaired by Dr. Ranier Jakobs, IZW e.V. and Dr. Donald Bivens, Dupont. Three of the six oral presentations dealt with CO_2, two with refrigerant blends, and one with hydrocarbons.

The first paper was presented by Michio Moriwaki and described development of a two-phase flow expander for CO_2 heat pumps and air conditioners. According to him, CO_2 heat pumps have generally lower COPs than those using HFC in normal vapour compression cycle conditions. On the other hand, operation with CO_2 enables production of higher discharge air temperatures. If the COP for a CO_2 heat pump could be raised to a value at least equivalent to that of HFC heat pumps, conditions for using them in cold regions, where they are not widely used today, improve. Replacing the throttle valve with an expander makes it possible to recover energy and reduce the use of electric power for a refrigerating cycle. A two-stage swing expander was selected, and the process taking place in the expander was shown in an illustrational animation. Test results with the expander were applied to a simulation of heat pump performance, and the results showed that a COP of 3.7 is obtained under the Japanese standard heating condition (outdoor temperature 7°C). The primary energy efficiency during the heating season in Japanese cold regions is then 107% which, according to the presenter, reduces energy consumption by 24% compared to traditional combustion type heaters.

The second presentation was an informative overview of key developments of transcritical CO_2 heat pumping systems, mainly concentrating on projects where SINTEF and Shecco had been involved. The presentation was given by Arne Jacobsen, SINTEF, on behalf of the authors of the paper, Kjell Stenstadvold, Shecco Technology and Petter Nekså, SINTEF. The paper reviewed applications where transcritical CO_2 systems have been introduced on the market, and applications where developments are ongoing. The most important applications are heat pump water heaters, heat pumps for space heating and air conditioning, and mobile air conditioners and heat pumps.

The third presentation on CO_2 was given by Jørn Stene, describing a prototype 6.5 kW CO_2 brine-to-water heat pump for combined space heating and hot water heating, which he had extensively tested and analysed. He showed different interesting design alternatives of CO_2 heat pumps. Some of them had optimum performance for high hot water demands, but poorer performance in other respects. The tested prototype heat pump was equipped with a unique counter-flow tripartite gas cooler for preheating of domestic hot water (DHW), low-temperature space heating and reheating of DHW. The experimental results proved that a brine-to-water CO_2 heat pump system may achieve a higher seasonal performance factor than the most energy-efficient brine-to-water heat pump system on the market. However, this is provided that the heating demand for hot water production constitutes at least 25 % of the total annual heating demand, the return temperature for space heating is lower than 30 °C and that the thermodynamic losses in the DHW tank can be reduced to a low level.

Souhel Stanbouly from Lennox gave an overview of information in the search for a good replacement for the dominant refrigerant HCFC22. He pointed out HFC410A as the best alternative to HCFC22 in residential and light commercial products. Different alternatives, such as other hydrofluorocarbons, hydrocarbons, ammonia and CO_2, were compared. Since it is the indirect global warming effect that dominates, the efficiency of the refrigerant is important. According to his investigation, manufacturers see the efficiency of CO_2 as being too low, ammonia and propane as being too dangerous. and HFC410A as the best choice.

Michele Zehnder from Ecole Polytechnique Fédérale de Lausanne presented a screening for refrigerant blends in high-temperature rise heat pumps for retrofit in residential heating. The reason for the investigation was that only a small number of refrigerants are available, and that the blends are not optimised for high temperature rise applications. He explained the optimisation process and pointed out that it was a highly discontinuous process. The refrigerant mixture with the highest COP shows an improvement of 8 % over R-407C. If, instead, the specific heat rate is to be maximised, a gain of 83 % can be achieved. However, all the main solutions were composed of flammable mixtures.

Professor E. Wobst from ILK Dresden, Germany described operational experience with a heat pump using propane as refrigerant. Hydrocarbons are environmentally benign substances, well suited for use as refrigerants. Their disadvantage is their flammability, and so additional safety measures are required if the refrigerant charge exceeds 150 g. In addition, the availability of some components is limited. Professor Wobst concluded that heat pumps with hydrocarbons as refrigerant could be a good choice for reduction of environmental impact. Handling is not too difficult if their special properties are observed. Several practical problems seem to have been solved already, and so wider application is not so much a technical problem as a safety problem, which could be resolved only by legislative means. Manufacturers and users have to comply with standards and fulfil the requirements of product liability.

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Session 9 – Country research program overviews

Arun Vohra, USA, co-chairman session 9

Session 9 included presentations from representatives of several nations, each of whom described recent and ongoing heat pump R&D activities.

Steve Szymurski of the U.S. Air Conditioning & Refrigeration Institute (ARI) presented an overview of HVAC&R research programs in the United States. He outlined some of the driving factors for collaborative HVAC&R research. He also identified major government and private HVAC&R research funding organizations and their research programs. The paper contains a compilation of web links to several HVAC&R related research roadmaps, trade organizations and technical societies, federal and state agencies, and some of the leading U.S. HVAC&R related university research centers.

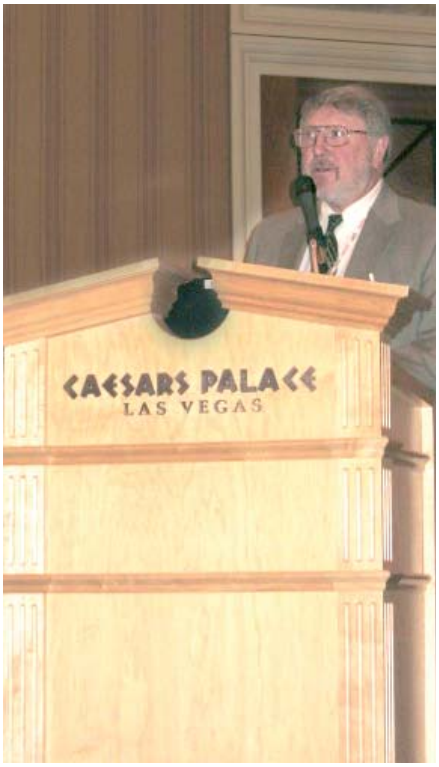
Sophie Hosatte of Natural Resources Canada reported that Canada has directed substantial resources towards heat pump R&D in recent years. Results have been documented in numerous publications, including refereed papers in technical journals, conference proceedings, and reports to collaborating partners. Over the past 20 years Canada has been involved in at least 15 Annexes covering a broad range of technical input, and has led three projects. Ongoing R&D focuses on areas particularly relevant to Canada, such as refrigeration and ground source heat pumps.

Xu Wei of the China Academy of Building Research presented a paper describing the large opportunities for heat pump development in China, the dramatic growth of the market in recent years, and the technical challenges associated with heat pump R&D efforts. He also described current research activities and typical heat pump applications, including air source heat pumps, water source heat pumps, ground-couple heat pumps and some specialized applications such as wastewater and sea water source heat pumps. He also described the current status of heat pump standards and regulations.

Shigeaki Tonomura of the Japan New Energy and Industrial Technology Development Organization explained that Japanese heat pump R&D began with the national "Moonlight Program" including the "Super Heat Pump Project." Recently, efforts have focused on reducing greenhouse gas emissions, with CO2 working fluids as a major R&D focus. During this project, various improvements have been implemented, enabling the researchers to demonstrate a very high COP. The remaining task is to improve the compression efficiency and the heat transfer performance of the heat exchanger.

Dr. Thomas Kopp of the Swiss Federal Office of Energy presented the Swiss research program. The program focuses on: heat pumps to replace oil and gas burners; air coolers, earth probes and waste water channels; natural working fluids such as ammonia and CO2, compressors, heat exchangers and other components; integration of heat pumps in buildings; control strategies; and methods to measure and calculate COPs and SPFs

Johnny Andersson of Ramboll AB described heat pump R&D efforts in Sweden. For the past 10 years, the Swedish Energy Agency, together with fifty Swedish companies and



organizations, has supported numerous heat pump related R&D projects. Research began in 1995 with the first program entitled, "Alternative Refrigerants", followed three years later by the, "Climate 21" program. The third program, focused on more efficient heat pump and refrigeration systems, has just been completed.

Arun Vohra
US Department of Energy
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8th IEA heat pump conference
The Proceedings of the International Energy Agency's heat pump conference held in Las Vegas, USA, May 30 – June 2, 2005, can now be ordered from the Heat Pump Centre. They contain 128 papers on various topics related to heat pumping technologies, such as regional reports about market development in Asia, Europe and North America, environmental issues, ground-source heat pump systems, heat pumps in cooling, heating and power systems, refrigerants, advanced systems and components and much more.

The Proceedings can be ordered from the Heat Pump Centre at ***www.heatpumpcentre.org***

Mobilising energy technology
This book describes the latest activities and achievements of the IEA Working Parties and Expert Groups. It also includes some key messages on optimising use of today's energy resources. The expert groups and working parties are the interface between the 40 implementing agreements within the IEA, and thus serve as the interface for channelling information between the different fields of technology. They provide platforms for analysis of current energy technology and policy issues.

The book can be ordered from the IEA bookshop at ***www.iea.org***

Design essentials for refrigerated storage facilities
This publication from ASHRAE provide designers, owners and operators of storage facilities for perishable food items with guidance on design details such as support structures, doors, docks, underfloor heating, insulation and vapour barriers, refrigeration system design and more. The authors are Professor Bryan Becker, and Assistant Professor Brian Fricke at the University of Missouri, Kansas City.

The book can be ordered from the ASHRAE bookshop at ***www.ashrae.org***

Ammonia refrigerating systems, renewal and improvement
The Proceedings of this conference held in Ohrid, Macedonia on May 6-8, 2005, are now available from the IIR. They contain 29 papers on a wide range of ammonia applications.

The Proceedings (CD-ROM) can be ordered from the IIR at ***www.iifiir.org***

Handbook on ice slurries – fundamentals and engineering
This book aims to contain everything anyone would like to know about ice slurries. Published by the IIR working party on ice slurries, it is the joint effort of 50 international experts. It summarises current knowledge of this field, with topics ranging from past use, modern applications and perspectives, through other phase-change slurries, flow and pressure drop to production methods, pumping, storage etc. It can be ordered as a book or as a CD-ROM.

The book can be ordered from the IIR at ***www.iifiir.org***

A numerical model of an active magnetic regenerator refrigeration system
This is the final report from an ARTI-funded project carried out at the University of Wisconsin-Madison, USA, which developed a model for predicting the energy efficiency and performance limits of a magnetic refrigeration system. The model will allow researchers analytically to determine the efficiency and performance limits of systems using recently developed magnetocaloric materials. The effect used in magnetic refrigeration systems is that some paramagnetic materials, such as gadolinium alloys, heat up when placed in a magnetic field and cool down when the field is removed. In a magnetic refrigeration system, this process replaces the compressor in a conventional vapour compression system. A refrigerator bed made of porous magnetocaloric material is used for transporting the heat to or from the heat exchangers. The development of new materials has also made this technique interesting for room air conditioning.

The report can be downloaded from the ARTI web site at ***www.arti-research.org/research/completed/finalreports/10075-final.pdf***

2005

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
Web: www.clima2005.ch/

3 Forum Wärmepumpe
13- 14 October 2005
Berlin, Germany
Contact: Tina Barosso
Tel: +49 (0)30 726 296 301
Fax +49 (0)30 726 296 309
E-mail: forum@solarpraxis.de
Web: www.solarpraxis.de

IKK Trade Fair
2 - 4 November 2005
Hanover, Germany
Tel: +49 (0)9 118 606 8109
Fax +49 (0)9 118 606 8246
Web: www.ikk-online.com

13th Annual Conference of the IoR: the Future of Cooling: Opportunities and Threats
10 November, 2005
London, United Kingdom
Contact: Miriam Rodway
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Tel: +44 (0)20 8647 7033
E-mail: miriam@ior.org.uk
Web: www.ior.org.uk

International Conference on Heating, Refrigerating and Air Conditioning
30 November – 2 December 2005
Belgrade, Serbia and Montenegro
Contact: Branislav Todorovic
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E-mail: smeits@eunet.yu
Web: www.kgh-hvac.org

2006

ASHRAE Winter Meeting
21 – 25 January, 2006
Chicago, USA
E-mail: jyoung@ashrae.org
Web: www.ashrae.org

Innovative Equipment and Systems for Comfort and Food Preservation
16 – 18 February, 2006
Auckland, New Zealand
Contact: Mike Leggett, Pradeep Bansal
Fax: +64 9262 1406
Tel: +64 9262 1405
E-mail: mike@irhace.org.nz and p.bansal@auckland.ac.nz
Web: www.iir-irhace2006.org.nz

17th Air-conditioning and Ventilation Conference 2006
17 - 19 May, 2006
Prague, Czech Republic
Contact: Milos Lain
Fax: +420 221 082 201
Tel: +420 221 082 353
E-mail: stp@stpcr.cz
Web: www.acv2006.cz

3rd Asian Conference on Refrigeration and Air Conditioning (ACRA2006)
21- 23 May, 2006
Gyeongju, South Korea
Contact: Min Soo Kim
Fax: +82 2 883 0179
Tel: +82 2 880 8362
E-mail: minskim@snu.ac.kr
Web: www.acra2006.org

5th International Conference on Cold Climate Heating, Ventilation and Air-Conditioning
21 – 24 May, 2006
Moscow, Russia
Contact: Andrey Golovin
Tel: +7 095 921 6031
E-mail: golovin@abok.ru
Web: www.abok.ru/CC2006

Ecostock – Tenth Triennial IEA Energy Conservation through Energy Storage Conference on Thermal Storage
31 May – 2 June, 2006
Stockton College, New Jersey, USA
Contact: Diane Hulse-Hiller
Tel: +1 609 652 4677
E-mail: ecostock@stockton.edu
Web: www2.stockton.edu/ecostock/

Natural Working Fluids 2006: 7th IIR-Gustav Lorentzen Conference
29 – 31 May, 2006
Trondheim, Norway
Contact: Trygve Eikevik
SINTEF Energy Research
Tel: +47 7359 3750
Fax: +47 7359 3950
E-mail: Trygve.M.Eikevik@sintef.no
Web: www.energy.sintef.no/arr/GL2006/

ASHRAE Annual Meeting
24 – 28 June, 2006
Quebec City, Canada
E-mail: jyoung@ashrae.org
Web: www.ashrae.org

18th International Compressor Engineering Conference and 11th International Refrigeration and Air Conditioning Conference at Purdue
17 – 20 July, 2006
Purdue University, West Lafayette, USA
Contact: Virginia Freeman
Tel: +1 765 494 6078
Fax: +1 765 494 0787
E-mail: herlconf@ecn.purdue.edu

Cryogenics 2006
17 – 21 July, 2006
Prague, Czech Repub.
Contact: Vaclav Chrz
Fax: +420 266312113
Tel: +420 284828481/284823250
E-mail: icaris@icaris.cz
Web: www.isibrno.cz/cryoprague2006

Solar Heating and Cooling: International Session to be held in conjunction with the 61st National Congress of the Italian Thermotechnical Association (ATI Conference)
14 September, 2006
Perugia, Italy
Contact: Francesco Asdrubali
Fax: +39 (0)75 585 3697
Tel: +39 (0)75 585 3716
E-mail: ati2006@unipg.it
Web: www.unipg.it/ati2006

6th International Conference on Compressors and Coolants – Compressors 2006
27 – 29 September, 2006
Casta Papiernicka, Slovak Republic
Contact: Peter Tomlein
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Fax: +421 2 4564 6971
E-mail: zvazchkt@isternet.sk
Web: www.isternet.sk/szchkt/

2007

22nd IIR International Congress of Refrigeration
21 – 26 August, 2007
Beijing, China
Contact: Qiu Zhongyue
Fax: +86 10 6843 4679
Tel: +86 10 6843 4683
E-mail: icr2007@car.org.cn
Web: www.icr2007.org

For further publications and events, visit the HPC internet site at www.heatpumpcentre.org.

In the next Issue

Ground-source heat pump systems

Volume 23 - No. 4/2005

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.

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IEA OECD heat pump centre

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