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IEA HEAT PUMP CENTRE

NEWSLETTER
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Heat Pumps - A key technology for the future

Heat pumps in smart grids and smart cities

IEA **Heat Pump** CENTRE
NEWSLETTER

Volume 30 - No. 2/2012

In this issue

Heat Pump Centre Newsletter, 2/2012
The topic of this issue is **The role of heat pumps in smart grids and cities.** The Foreword and Column set the background, while the topical articles cover capacity control as an enabling technology, and the role of heat pumps in district heating and cooling. The topic of this issue will also likely be the subject of other articles in later Newsletter issues during 2012.

A market overview for Germany is also provided.

With this issue, we are introducing a new type of article, the Strategic outlook. As for the Market reports, we plan to include one Strategic outlook in each issue. These will be national overviews, with UK as the first one.

We also want to remind you of, and highly recommend, the Heat Pump Programme Symposium (previously: Open Conference), which will take place in conjunction with the Chillventa, on Monday October 8, in Nürnberg, Germany. Read more about this on page 5.

Enjoy your reading!

Johan Berg, Editor

Heat pump news

Regulars

Topical articles

COLOPHON

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Foreword

The role of heat pumps in smart grids and cities

Heinrich Huber
Deputy Head of Sustainable Thermal Energy Systems,
Austrian Institute of Technology (AIT)

Against the background of global climate change, the European Union has set itself the target of making the transition to a competitive low-carbon economy within the next 40 years. This means that the EU needs to reduce its domestic emissions by at least 80 % by 2050 compared to 1990. With the urban proportion of the world's population forecast to increase to 70 % by 2050, cities will have to make a substantial contribution to achieving this ambitious goal. With this in mind, the Austrian Institute of Technology (AIT) last year initiated the EERA Joint Programme on Smart Cities with the aim of developing new methods and tools to pave the way for the smart low-emission cities of the future.

The main hopes in this context rest on a substantial increase in energy efficiency and the consistent use of renewable energy sources. However, the intermittent and fluctuating nature of electricity generated by wind or solar power presents entirely new challenges. The key to solving these problems is the use of "smart grids"; a new generation of intelligent networks based on real-time bi-directional communication between generators, consumers and storage facilities. Urban smart grids will, in the future, include both electrical and thermal networks and incorporate heat pumps as interfaces between these networks.

Heat pumps are considered a key energy technology for tomorrow's sustainable cities, as they collect heat from renewable, locally available energy sources such as air, water, ground or waste heat, and produce no direct local emissions. Their ability to couple electrical and thermal energy makes them key components in tomorrow's integrated energy strategies and ideal "partners" in smart energy storage, supply and demand side management, grid balancing and load shifting. This has been demonstrated in the Ecogrid project on the Danish island of Bornholm, where intelligent heat pumps are successfully being used as a support technology for large wind power integration.

Heat pumps can extract heat from a low-temperature source and raise it to a higher temperature level, suitable for space and water heating. They are thus expected to play an essential part in low-temperature district heating networks supplied by a wide range of as-yet-unused urban heat sources: from building-integrated solar collectors to excess heat from industrial facilities or even from public infrastructure, such as subway tunnels or sewage systems. Heat pumps are able to link such local thermal microgrids, via the electricity grid, to create a virtual district heating network that can be centrally controlled to respond to supply and demand.

This means that, in the future, it will not be sufficient to think exclusively in terms of individual technologies, buildings or components. Instead, the city must be viewed as a "system of systems" with complex interdependencies, in order to be able to develop integrated smart urban energy systems – and heat pumps are set to play an important role in this scenario.

Column

The role of heat pumps in smart grids/cities

Thomas Nowak
Secretary General
European Heat Pump Association

Industrial heat pumps can upgrade excess (waste) heat to useful heat and today's heat pumps are reliable and efficient. They comfortably provide the user with heating, cooling and sanitary hot water; using locally available, renewable energy sources (air, water and ground). As such, this off-the-shelf technology can provide solutions to an increasing number of residential, commercial and industrial application requirements.

But there's more . . .

In the average city, there are temporal and spatial differences in supply and demand of energy that cannot easily be overcome, with the result that energy is wasted. If we are aiming for a sustainable energy future, smart cities can make a valuable contribution to solving this dilemma.

The concept of smart cities is based on the vision of a networked infrastructure which, in an energy perspective, means **electric and thermal grids**
- that interconnect, and thus integrate, supply and demand,
- that are able to accommodate differences in temperature levels
- that integrate storage facilities, and
- that accumulate knowledge of energy usage patterns.

Properly designed and managed grids will help to avoid, and eventually overcome, inefficient use of energy and energy waste. Most, if not all, heat pump systems include thermal storage, and all of them have **a control unit**. If properly designed and connected, these two components make heat pumps the perfect enabler for future smart cities. **Heat pumps can store superfluous surplus electricity in the form of thermal energy.** Depending on their design, heat/cold is stored in tanks, in the ground, in floor/wall heating systems or in concrete cores using the mass of the building. **Smart heat pump systems** are distinguished from their standard variants by the ability to incorporate user behaviour, climate data and pricing signals into their control systems. Operating them when (cheap) surplus electricity is available will avoid this electricity being wasted. Operating them in off-peak hours will reduce peak-load demand. Over time, they build up a picture of energy supply and demand patterns inside and outside their own building boundary. Adding all this information together contributes to an improved overall system understanding. If grid operators knew when and where storage facility is available, it would be possible to integrate much larger shares of wind and solar electricity. While 'the advantage of smart' has been demonstrated in several studies, the majority of today's heat pumps cannot properly communicate with their surroundings. This lack of understanding goes both ways: most grids do not provide pricing signals and are not equipped to receive and analyse information from heat pumps.

In other words, **heat pumps and grids are not smart enough (yet).** Research and development is needed on algorithms, protocols, interfaces and an optimised design of systems. This technical perspective needs to be complemented by socio-economic factors such as privacy protection, setting of incentives and contractual issues. Once all these issues are resolved, cities will be ready to become smart heat pump cities, with all their benefits: comfort, efficiency and the use of renewable sources.

IEA Heat Pump Programme News

HPP Symposium

In conjunction with the Chillventa, October 8, Nürnberg, Germany

In order to promote the Heat Pump Programme, we will hold a Heat Pump Symposium. The Symposium will be open for all visitors of the Chillventa Congressing day (October 8).

During this Symposium, work and visions of ongoing and planned HPP Annexes will be presented. There will also be invited speakers, with presentations on hot subjects, such as the ETP 2012 (by its coordinator at the IEA), heat pumps in smart cities, heat pumps and energy storage, heat pump research in the US, and others. The schedule for the Symposium is close to finalized, and has been posted on the Heat Pump Centre website (http://www.heatpumpcentre.org). Please reserve the day, and let us know your interest by sending an e-mail to johan.berg@sp.se .

Other symposia at the Chillventa Congressing include reports on research, as well as information on current political parameters in Europe and worldwide. Speakers from ASERCOM, EPEE and EHPA will give presentations on current standards, smart cities, and the Ecodesign Directive. With the symposium Nearly Zero Energy Buildings, the ZVKKW addresses an ongoing trend, with ASHRAE also offering a practice-oriented workshop. Another workshop, on the theme Energy Reduction in Data Centers, builds on the results of the previous event at the last Chillventa.

More information in general regarding the Chillventa can be found at http://www.chillventa.de/en/

IEA Heat Pump Conference 2014 – A brief update from the National Organizing Committee

The International Energy Agency Heat Pump Conference 2014 will be held in downtown Montréal (Québec, Canada) on May 13-15, 2014 at the Fairmont Hotel – The Queen Elizabeth.

This Conference will be an excellent opportunity for heat pump stakeholders from all over the world to meet and discuss the current state of the heat pump industry. Research and development activities, policies, environmental issues are commons themes which will also lead to many discussions about the industry's future.

In addition to the conference program, participants will have the opportunity to attend a number of optional workshops and side events which are scheduled for May 12 and May 16. Further details will be provided in the coming months. The National Organizing Committee (NOC) is also putting together a series of site visits where heat pump applications in the Canadian context will be showcased.

The conference set-up is designed to maximize the discussions between participants. To facilitate interaction between participants, an extensive exhibition area has been planned with a potential of up to 50 booths. All the conference social functions (in addition to the poster sessions) will be held in the trade show area. If you are interested in booking a space for the exhibition, or if you wish to become a conference/event sponsor, please contact the NOC via e-mail at denis@geoexchange.ca.

11TH IEA HEAT PUMP CONFERENCE 2014 MONTRÉAL

The NOC is currently putting the final touch to the conference website which should be released in August 2012. Additional Conference information and sponsorship opportunities will be posted at that time.

As the Chairman of the NOC for the IEA Heat Pump Conference 2014, I invite you to put these dates down in your agenda today. It will be my pleasure to welcome you in Montréal in May 2014.

Denis Tanguay
Chairman
National Organizing Committee,
11th IEA Heat Pump Conference
Montréal 2014

General

Chillventa 2012 set to exceed expectations

Chillventa 2012, the international exhibition for refrigeration, air conditioning, ventilation and heat pumps, looks set to exceed the success of previous events. According to the organisers, the amount of space allocated to exhibitors for the 2012 event already exceeds the last show in 2010.

"The current level of registrations gives us every reason to be confident," says Gabriele Hannwacker, the events manager at organisers NürnbergMesse. "Far more people have registered with us today than at the same time in advance of the last fair.

Source: http://www.acr-news.com

ASHRAE launches new terminology site

Common definitions for terms found in ASHRAE standards and other publications can now be found at a new website from the Society. The free ASHRAEwiki is located at www.ashraewiki.org and contains over 6,000 terms related to buildings with a particular focus on mechanical, envelope, electrical, lighting, load calculations, design, water design/conservation and energy use and measurement metrics.

"Common terminology in communications and particularly in standards helps users in their understanding, thus encouraging adoption and use," Art Hallstrom, a member of ASHRAE Technical Committee 1.6, Terminology, said. "The ASHRAEwiki goal is to improve communication by encouraging the use of consistent terminology definitions within ASHRAE and the industry, worldwide."

Source: http://www.ashrae.org

Eurovent to merge activities with CERTITA

Eurovent has announced that it is to merge some of its activities with French heating product certification body CERTITA. A statement from Eurovent says that the intention of the signatories is to develop the proposed certifications, in line with the services already provided, with the marks NF, CSTBat and Eurovent certification, while enlarging the scope of products dealt with and increasingly operating at an international level. A full service would be proposed, expected to be better suited to the specific background of each country regarding voluntary certification of performance for HVACR products.

Source: http://www.acr-news.com

Policy

China to subsidize energy efficient home appliances

The Executive Meeting of the State Council has promulgated a series of policies and initiatives aimed to stimulate consumption of energy-saving home appliances in the domestic market. Encouraging the consumption of energy-saving products not only stimulates the domestic consumption, but also adjusts the industrial structure, and helps conserve energy and reduce the CO_2 emissions.

Source: http://www.ejarn.com

UK government announces biggest energy reforms in 20 years

The biggest reforms to the UK energy sector in two decades were set out on 22 May, prompting warnings from consumer groups and green campaigners that they would raise bills and penalise renewable energy while boosting nuclear power.

The sweeping reforms grant the government powers to intervene in the market on a scale not seen since the industry was privatised. Under the changes, low-carbon generators, including nuclear companies, will receive a fixed price for their energy that should be higher than they can sell it for on the open market, and ministers will create a "capacity market" to ensure a reliable supply of power and prevent blackouts. There will be a minimum price for carbon dioxide emissions, and an emissions performance standard that will in effect stop any coal-fired power stations being built without technology to capture carbon.

Source: http://www.euractiv.com

New ASHP water heater subsidies stimulate HP market in China

China has unveiled a series of policy incentives and subsidies to stimulate purchases of energy-efficient appliances. According to the Chinese Ministry of Finance, RMB 26.5 billion (EUR 3.3 billion) will be allocated to subsidise energy-saving household appliances including televisions, washing machines, air conditioners, refrigerators, water heaters and so on. Under the policy, consumers who purchase air source heat pump water heaters that meet energy-saving criteria can receive a subsidy of up to RMB 600 (EUR 76), around a 10 % discount in the sale price per unit.
Source: http://www.r744.com

Maryland governor signs landmark geothermal heat pump bill

In the USA, Maryland Governor Martin O'Malley has signed the Renewable Energy Portfolio Standard - Geothermal Heating and Cooling bill into law, making Maryland the first state in the nation to allow utilities to claim credits for the installation of geothermal heat pumps. The legislation makes GHPs an accepted technology for utilities to use toward earning Renewable Energy Credits under the state's Renewable Portfolio Standard.
Geothermal heat pumps address one of the biggest consumers of U.S. energy – buildings. Buildings account for more than 70 % of the nation's electricity usage, and geothermal heat pumps have the potential to reduce energy use by as much as 40 % to 70 % in a typical building.
Source: http://www.nationaldriller.com

Investment in building renovations is a priority in the EU

The European Union's next budget should focus more on the energy-efficient renovation of buildings, European Commissioner for Energy Günther Oettinger said after member states officially agreed on the EU's intensely negotiated Energy Efficiency Directive. Speaking after the 16 June meeting of energy ministers in Luxembourg, which marked the official deal on the Energy Efficiency Directive, Oettinger warned member states that there will be no ways of getting around the new compulsory measures. To top this measure, member states agreed, as a compromise, to also commit to 2050 roadmaps for the energy-efficient renovation of almost the entire building stock.
Source: http://www.euractiv.com

Wake the sleeping giant of heating and cooling, says EHPA

The European Heat Pump Association (EHPA) has accused the European Commission of missing the chance to "wake up the sleeping giant of heating and cooling" in its recent communication to the European parliament on the current 2020 policy framework.
The EHPA argues that while the Renewable Energy Directive (2009/28/EC) fully recognizes heat pumps as a renewable technology, the communication fails to give due prominence to the product in its communication. This is despite the fact that heating and cooling represents the single largest demand segment and the National Renewable Energy Action Plans calls for a doubling of the share of heat pumps.
Sources: http://www.acr-news.com
http://www.ehpa.org

EPEE calls for effective policing of new Ecodesign regulations

EPEE, the European Partnership for Energy and the Environment, has welcomed the European Commission's publication of the Ecodesign requirements for air conditioners and comfort fans but has called for effective policing of non-compliance and urged the Commission to swiftly conclude and adopt other Ecodesign rules for critical products, such as boilers and water heaters.
Sources: http://www.acr-news.com
http://www.euractiv.com

EU efficiency law could 'triple' energy services market

The EU's upcoming energy efficiency directive could send strong enough signals to jump-start the market in energy services for commercial buildings, according to industry experts. The draft bill contains the strongest incentives to date for triggering a boom in the market for energy efficiency services, according to a number of experts working in the field.

In its current form, the draft directive requires central governments to achieve a 3 % renovation rate for the buildings they occupy, on a yearly basis. It also imposes an obligation on power utilities to achieve 1.5 % annual energy savings among their final customers - including large commercial and public building owners.
Source: http://www.euractiv.com

EHPA comment to the EU Energy Efficiency Directive

The European Commission, the European Parliament and the Members States have reached an agreement on the Energy Efficiency Directive (EED), part of the EU's effort to reach a target of 20 % of primary energy savings by 2020. Although a deal on the Directive is positive, its ambition and proposed measures are underwhelming. "A broader and more technology-neutral approach would have made it easier for Member States to reach more ambitious targets in a way that is appropriate to their particular national and geographical circumstances", says Thomas Nowak, Secretary General of EHPA. Thus, rather than focusing primarily on large-scale heating and cooling applications, EHPA would have liked to see reference to small-scale solutions also, such as heat pumps.
Source: http://www.ehpa.org

Danish government to phase out/ban gas- and oil-fired boilers

In March 2012, the Danish Ministry of Climate, Energy and Building announced that a political agreement was reached on an Energy Agreement, with a large majority in the Parliament. The Energy Agreement includes initiatives that will speed up the process of using renewable energies. One of the measures is to reduce the use of oil and gas in buildings for individual heating.

In more concrete terms, the Energy Agreement wants:
- to halt the installation of oil- and gas-fired boilers in new buildings as from 2013
- to halt the installation of oil-fired boilers in existing buildings in areas with district heating or natural gas as from 2016.

Source: http://www.ehpa.org

Working fluids

Stakeholders call for changes to the F-gas regulations

The vast majority of respondents to the EC's consultation on the review of the F-gas regulations have agreed that the existing law is not sufficient, but are divided on the appropriate action to take.

Between September and December 2011, the Commission held an online public consultation on actions to address emissions of fluorinated gases. The consultation was designed to gather input for a review of the F-gas regulations. An impact assessment is currently in preparation in view of a proposal to be presented in the autumn. Of those who responded in the consultation, 84 % found that the current status quo of implementing the existing regulation was not sufficient. While some stakeholders believed that better implementation would suffice, others wanted to see further legal action.
The summary can be downloaded here: http://ec.europa.eu
Source: http://www.acr-news.com

Harmonized standard for compressors and compressor units

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) today announced the publication of standards 570 (I-P)-2012 and 571 (SI)-2012, Performance Rating of Positive Displacement Carbon Dioxide Refrigerant Compressors and Compressor Units, providing for the first time a rating method for compressors and compressor units that use CO_2 as a refrigerant. These standards were developed by AHRI, in cooperation with the Association of European Refrigeration Component Manufacturers (ASERCOM) and the China Refrigeration and Air-Conditioning Industry Association (CRAA), as a way to harmonize the rating conditions with CO_2 standards under development in Europe and China.
Source: http://www.ahrinet.org

Combined HFO, HC and CO_2 training available

UK: WR Refrigeration in the UK has established what it claims is the world's first HFO, HC and CO_2 refrigeration training facility. The company's European Refrigeration Training Academy now includes a working HFO water chiller linked to an integral HC refrigerated cabinet alongside its existing CO_2 systems, enabling engineers to be trained in the new generation of low global warming refrigerants and hydrocarbons.
Source: http://www.acr-news.com

Japan, EU and US in coalition for HFC alternatives

At the end of April 2012, Colombia, Japan, Nigeria, Norway and the European Commission, along with the World Bank, joined the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants such as hydrofluorocarbons (HFCs), bringing the members to 13. Subsequently, during the May 2012 G8 meeting, those G8 countries that had not yet joined the Coalition, namely Germany, Italy, France, Russia and the United Kingdom agreed to also sign up to it. Already at the first meeting of the Coalition on 23-24 April 2012 in Stockholm, Sweden, ministers gave their go-ahead to five transformational initiatives including an initiative to accelerate the transition towards HFC alternatives. The coalition was launched back in February 2012, with the initial membership including Bangladesh, Canada, Ghana, Mexico, Sweden, the United States and the UN Environment Programme (UNEP).
Source: http://www.r744.com

Technology

ICA claims MicroGroove copper advantages

The International Copper Association (ICA) recently announced the advantages of MicroGroove technology compared to microchannel aluminum in air conditioning and refrigeration (ACR) applications. According to the ICA, MicroGroove technology consists of smaller diameter copper tubes with enhanced surfaces. Both features contribute to improved rates of heat transfer between the refrigerant and the tube walls, making it possible to use less material in smaller, lighter evaporators and condenser coils.
Source: http://www.ejarn.com

Markets

China now largest HVAC market

In addition to being the largest producer of heating, ventilating and air conditioning products in the world, China is now also the largest market for HVAC, a new report claims.
The top three Chinese manufacturers, Haier, Midea and Gree, can supply 50 % of the world's demand for HVAC products, according to the report by Frost & Sullivan.
Source: http://www.acr-news.com

World market for AC up 13 %

While the Euro crisis continues to affect the air conditioning market in Europe, worldwide sales were up 13 % last year, according to a new report from BSRIA. The world market for air conditioning increased from $78 billion in 2010 to $88.2 billion in 2011. Asia Pacific is still the largest world region in terms of air conditioning sales with $48.2 billion or close to 55 % of the world market in 2011. Within the region, China and Japan represent the biggest markets, with 83 % by value of the market. Apart from the sales, Asia represents the major production hub with around 70 % of the world's air conditioners were produced in China in 2011.

More information on the World Market for Air Conditioning can be found at http://www.bsria.co.uk .
Source: http://www.acr-news.com

NGWA will develop guidelines for large-scale HP installations

The US National Ground Water Association (NGWA) is in the beginning stages of developing a document entitled NGWA Hydrogeologic Guidelines for Large-Scale Ground-source Heat Pump Installations. NGWA member Nina Baird, a doctoral candidate at Carnegie Mellon University, volunteered to put together an initial draft document which will be fully developed by a volunteer work group. The group's first work session was held April 3rd.
More info: kmccray@ngwa.org, Chief Executive Officer, NGWA, USA

The German market: upwards again

Gregor Dilger, Bundesverband Wärmepumpe, Germany

The German heat pump market is characterised by keen competition and discerning consumers looking for products which are both efficient and economic. After two years of consolidation, sales volumes are rising again, especially because of the increasingly popular air-to-water heat pumps. Recent drilling incidents have led to higher quality assurance of the drilling procedure in the federal state of Baden-Württemberg – maybe a model for other federal states as well. The German heat pump market is in motion – with an upward trend.

A competitive market

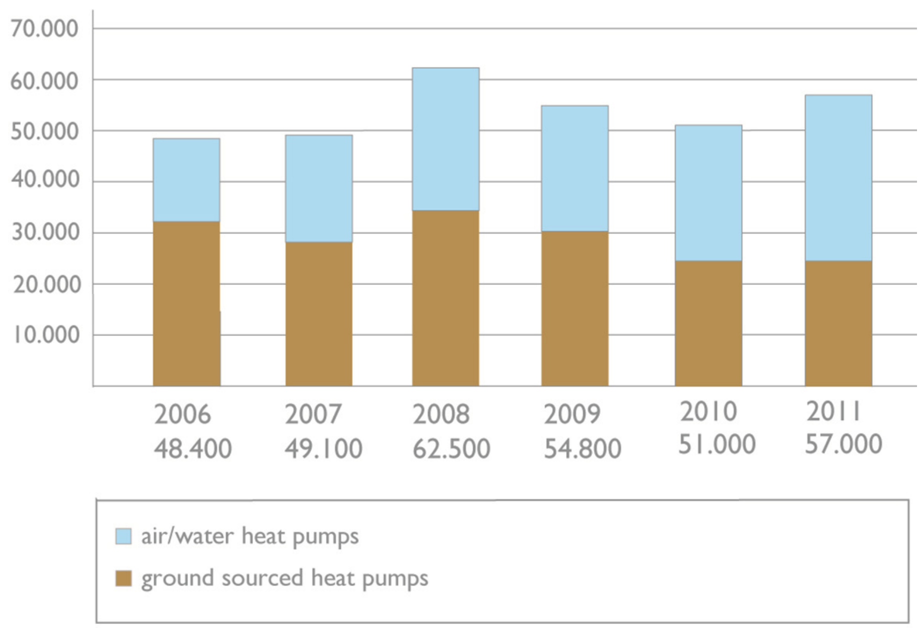
In Germany, over 50 different companies provide heat pumps. The heat pump market includes companies from the traditional heating market as well as companies with an electricity market background. Most of the German-based enterprises have their origin in the HVAC market and sell gas and oil boilers as well (e.g. August Brötje, Buderus, Junkers, MHG, Roth Werke, Vaillant, Viessmann, Weishaupt, Wolf Heiztechnik). Stiebel Eltron, one of the major manufacturers, has expanded from the market for electric sink heaters. Another example with a comparable origin is that of the Swedish company NIBE. ELCO is a traditional heating company from Switzerland. Most companies that are specialised in heat pumps only are either German-based (Glen Dimplex [former KKW], Alpha Innotec, Waterkotte), or rooted in other German-speaking countries (Austria: Heliotherm, IDM, Ochsner). In addition, some companies originally providing heat pump components have expanded to the heat pump market (geothermal collectors: IWS, Rehau; compressors: Sanyo). There are also examples of solar industry companies that have built up modest ranges of heat pumps (e.g. Solvis). With the rapid rise of air-to-water heat pumps over the last few years, Asian manufacturers have gained importance in the German market (e.g. Daikin, Fujitsu General, LG, Mitsubishi Electric, Panasonic, ROTEX, Sanyo). In addition to these mass production corporations, several medium-size or small companies build custom heat pumps to meet specific customer requirements (e.g. BARTL, Voß, ITEC, TRANE, Smartheat).

Steady growth of sales figures since 1990

Sales figures of heat pumps have risen steadily since 1990. Over the last two decades, the number of heat pumps sold has centupled (risen a hundred-fold). But in 2009 and 2010, sales numbers declined by around 10 % each. The reasons can therefore be presumed to be the coincidence of the worldwide economic crisis and withdrawal of the German Industry Subsidy policy. The economic crisis, on the one hand, led to a fall in oil and gas prices, which reduced the attractiveness of alternative heating systems such as heat pumps. On the other hand, 2010 saw withdrawal of the main incentive program for two months, caused by the budget cutbacks of the German government. This led to a wait-and-see position for potential customers. Nevertheless, with 57 000 heat pumps sold, the sales figures for 2011 almost matched those of 2008.

Sales figures: Air-to-water rapidly growing, GSHP stagnating

In 2011, sales of heat pumps grew by 11.8 per cent. This increase was generated by a rapidly increasing demand for air-to-water heat pumps, which grew by 21.6 per cent. On the other hand, ground-source heat pump sales stagnated with an increase of only 0.8 per cent. The national heat pump association (BWP) sees the tightened approval procedures for drilling as one of the main reasons for the difficult market development. Recent drilling incidents in Baden-Württemberg have led to growing scepticism there, as well as in some other federal states. The incidents led to some changes in the approval procedures in Baden-Württemberg: higher standards of qualification for drilling company employees, new guid-



Sales of space heating heat pumps in Germany from 2006 to 2011 ance for quality assurance of the drilling and grouting procedure, and a special drilling insurance required to be held by the building owner. There are no comparable developments in other federal states at present, but some authorities in other states recommend some parts, such as the drilling insurance.

Market focus: today and tomorrow

The heat pump market is mainly concentrated on that for single or two-family houses. 80-90 per cent of heat pump sales are for such buildings. The energy efficiency policy, mainly resulting from the Energy Saving Regulation (Energieeinsparverordnung - EnEV), the national implementation of EPBD, leads to a constantly falling energy demand of new buildings. This means that an increasing number of heat pumps with heating capacities of less than 6 kW are required. It can be seen that manufacturers are starting to produce small-capacity models to meet this demand. At the same time, the increasing energy efficiency of buildings is creating a growth in the demand for air conditioning. Because of the ability to heat and cool with the same machine, this is seen as an advantage for heat pumps compared with other heating systems.

The German heat pump industry is also trying to conquer new markets, which means that the market share of larger heat pumps is presumed to be growing as well. In 2011, only 0.7 per cent of installed heat pumps had a heating capacity of more than 50 kW. But, although the market for ground-coupled heat pumps in general was stagnating, the market for high-capacity ground-coupled heat pumps has grown by 12.9 per cent.

As far as heat sources are concerned, the importance of geothermal energy as the most traditional German energy source for heat pumps is diminishing. In 2010, for the first time, more air-to-water heat pumps than brine-to-water and water-to-water were sold. Increasing attention is being paid to energy efficiency and the use of waste heat, particularly in the industrial sector.

Support schemes

The main Support program for renewable heating systems is the Marktanreizprogramm (MAP), which has included heat pumps since 2008, providing grants to subsidise the investment costs. Air-to-water heat pumps up to 20 kW receive EUR 900, while larger heat pumps qualify for a subsidy of EUR 1200. Ground-source heat pumps get: <=10 kW: 2400 €; 10-20 kW: 2400 € + 120 € per kW; 20-100 kW: 2400 € + 100 € per kW. Performance is also a qualifying factor: air-to-water heat pumps must have an SPF of 3.5 or higher, while ground-source heat pumps must have an SPF of 3.8 or higher. These SPFs must be calculated in accordance with VDI 4650. Since 2010, the COP values must be measured by an independent test centre. From January 2012, heat pumps must meet at least the minimum requirements of Ecolabel or EHPA Quality Label V 1.4, which are:

- Air-to-water: 3.1
- Water-to-water: 5.1
- Brine-to-water: 4.3

Higher grants are available for combining heat pumps with solar heat and further investment in energy efficiency.

The EEWärmeG requires house builders to use renewable heating for at least 50 % of demand, and of which solar energy must supply at least 15 %. In addition to this requirement, heat pumps must have a minimum SPF of between 3.3 and 4.0, calculated in accordance with VDI 4650. Alternatively, house builders can invest in energy efficiency. A similar regional law came into force in the previous year in Baden-Württemberg: it additionally requires renewable heating systems to be included in existing building stock where heating systems are being replaced. Other federal states plan to introduce similar laws.

EnEV is the German implementation of the European Building Directive (EPBD), which regulates the maximum permissible value of primary energy consumption (including losses from the heating system and heat demand) in new buildings. The required values can be achieved by means of adequate insulation or by environmentally friendly technologies such as heat pumps. The regulation was launched in 2001, and has since been modified several times.

Brand names

The following brands distribute heat pumps in Germany:
Airwell, Alpha InnoTec, August Brötje, Bartl, Buderus, Carrier, Cofely, DAIKIN, ELCO, ENERTECH, Fujitsu General, Glen Dimplex, Hautec, Heliotherm, Hoval, IDM, Immosolar, ITEC, IWS, Junkers, LG, Max Weishaupt, MHG, Mitsubishi Electric, Neura, NIBE, Novelan, Ochsner, Panasonic, Rehau, Remko, Rotex, Roth, Smartheat, SANYO, Schüco, SOLVIS, Stiebel Eltron, Tecalor, Termo-Technika, TRANE, Vaillant, Viessmann, Voß, Waterkotte, Wolf.

Distribution channels

Different distribution channels are used in the German market, depending on each company's strategy. Common approaches are distribution via wholesalers (and then on to retailers and through them to the final consumers), or via dedicated retail networks.

Industry infrastructure

The German Heat Pump Association e.V. (BWP) is an industry organisation based in Berlin, promoting the use of efficient heat pumps and covering the entire product chain. Its members comprise approximately 700 craftsmen, architects and designers, as well as drilling companies, heat pump and component manufacturers, and energy providers. It organises the "Zeichen setzen – Wärme pumpen" marketing campaign, and hosts the "Forum Wärmepumpe" – the annual conference of the German heat pump market. It is a member of the German Renewable Energy Federation BEE (Bundesverband Erneuerbare Energie e.V.). Its members employ approximately 5.000 persons in the heat pump sector, with a turnover of more than EUR 1.5 billion. The BWP represents 95 per cent of the German heat pump industry.

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Strategic outlook for the UK

Penny Dunbabin, Department of Energy & Climate Change, UK

This article presents the strategic outlook for heat pumps in the UK up until 2030. It presents the principal Government policies designed to increase the uptake of heat pumps, both in the domestic and the non-domestic sectors. Ensuring that UK installers have the necessary skills to install heat pumps is another key element, and Government has worked closely with industry to develop new installation standards, which are now in force. Finally, the article summarises some of the research projects undertaken by DECC to improve integration of heat pumps in heating systems.

Introduction

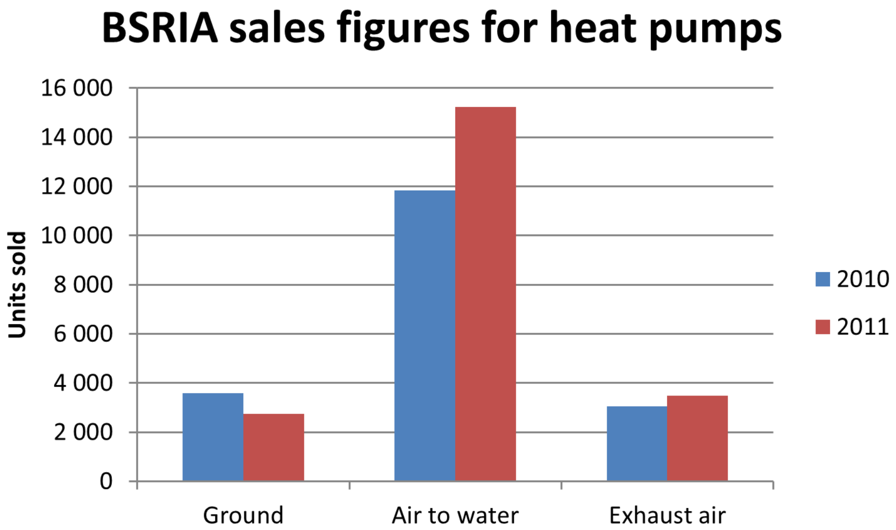
The United Kingdom is going through a transformation to achieve its ambition of reducing greenhouse gas emissions by at least 80 % (relative to 1990 levels) by 2050.

Heating accounts for 47 % of total UK final energy consumption and more than three-quarters (77 %) of energy use across all non-transport sectors. In terms of carbon emissions, heating accounts for 46 %. In 2008, approximately 69 % of heat in the UK was produced from gas. Oil and electricity accounted for 10 % and 14 % respectively, followed by solid fuel (3 %) and renewables (1.5 %).
Heat pumps are a key technology that can be used to decarbonise heating and cooling in buildings. In the United Kingdom, low-carbon technologies are forecasted to replace the existing heat that is being provided by natural gas. Looking to the future, between 21 % and 45 % of heat supply to buildings will need to be low carbon by 2030; and will therefore need between 1.6 million and 8.6 million building-level low-carbon heat installations by 2030.

At present, the market for air to water and ground to water heat pumps is small, although there are many air to air heat pumps in the commercial sector, used primarily for air conditioning.

BSRIA's estimates for UK sales of heat pumps.

2010	Volume
Ground/Water to water	3,590
Air to Water (Split and monoblock)	11,840
Exhaust Air	3,050
2011	
Ground/Water to water	2,736
Air to Water (Split and monoblock)	15,228
Exhaust Air	3,478



These figures are broken down as shown below:

2010	Ground	Air	Exhaust Air
Small Domestic (up to 10kW)	2,010	8,608	3,050
Large Domestic (10.01-20kW)	1,077	3,161	0
Commercial (above 20kW)	503	71	0
2011			
Small Domestic (up to 10kW)	1,301	10,363	3,399
Large Domestic (10.01-20kW)	1,054	4,363	79
Commercial (above 20kW)	381	502	0

A range of Government policies influence the uptake of heat pumps. These include: the Carbon Emission Reduction Target (CERT), the Renewable Heat Incentive, the Renewable Heat Premium Payment (which includes a social housing and communities competition), and the Green Deal.
To ensure good performance, new standards have been developed for the installation of air and ground source heat pumps.
Finally, the Department is conducting a range of research projects, to further develop installation guidance for the use of buffer tanks.

Carbon Emission Reduction Target

The Carbon Emission Reduction Target (CERT) requires all domestic energy suppliers with a customer base in excess of 250,000 customers to make savings in the amount of CO_2 emitted by householders. Suppliers meet this target by promoting the uptake of low carbon energy solutions to household energy consumers, thereby assisting them to reduce the carbon footprint of their homes.
On 30th July 2010, CERT was extended from March 2011 to December 2012. Energy suppliers are now required to deliver measures that will provide overall lifetime carbon dioxide savings of 293 $MtCO_2$ by December 2012, superseding the original target of 185 $MtCO_2$ lifetime savings from measures installed by March 2011.
The CERT scheme is regulated by OFGEM (Office of the Gas and Electricity Markets) who report supplier progress on a quarterly and annual basis. The CERT scheme focus has always been on delivering technology with low marginal abatement costs, typically insulation and lighting. In December 2011 the total lifetime CO_2 savings of the measures installed to date was estimated at 218.7 Mt CO_2, of which insulation and lighting accounted for 62.0 % and 23.7 % respectively, with Microgen & CHP accounting for 0.8 %. The number of heat pumps that have been installed under the CERT scheme is 6,576; however, OFGEM does not collect the data on air and ground source heat pumps separately

Renewable Heat Incentive

On 10 March 2011, the Government announced the details of the Renewable Heat Incentive (RHI) policy to revolutionise the way heat is generated and used. Increasing renewable heat is key to the UK meeting its renewable energy targets, reducing carbon emissions, ensuring energy security and helping to build a low carbon economy. The RHI will help accelerate deployment by providing a financial incentive to install renewable heating in place of fossil fuels.
The scheme is being introduced in two phases. In the first phase, long term tariff support is targeted at the non-domestic sectors. The measures eligible for this policy include:

- Biomass boilers
- Biogas (including injection of biomethane to the gas grid)
- Energy from waste
- Ground and water source heat pumps
- Deep geothermal heat extraction
- Solar thermal panels.

Monitoring is an integral part of the RHI. In September 2012, the Government will hold a consultation on expanding the list of technologies eligible for the RHI, in particular, on whether to include air to air and air to water source heat pumps.

Renewable Heat Premium Payment Scheme

Before the RHI starts, there is also support of around £15 million for households through the Renewable Heat Premium Payment scheme. This scheme will be run in Great Britain and will focus on houses not heated by mains gas. Those homes will be able to apply for grants for air source and ground source heat pumps, biomass boilers and solar thermal (see table). There are minimum energy efficiency criteria, and householders must agree to monitor the performance of their heating system through a survey.

Support through the Renewable Heat Premium Payment Scheme

ALL HOUSES	HOUSES NOT HEATED BY GAS FROM THE GRID
£300 – solar thermal	£950 – biomass boiler
	£850 – air source heat pump
	£1250 – ground source heat pump

DECC will also be carrying out detailed monitoring of the seasonal performance factor for a sample of measures. For heat pumps, this monitoring will take into account all the electricity used (circulation pumps, electric cassette, domestic hot water immersion, and the heat pump itself).
As part of the scheme, DECC and the Energy Saving Trust (EST) have run a competition for social housing providers to part-fund projects to install renewable heating. Twenty-four social housing providers have been awarded a share of the £4 million fund. The £4 million is part of the £15 million Renewable Heat Premium Payment budget.
Figures for the end of February indicate that 1,090 heat pumps have been installed in the domestic sector via the RHPP. The first phase of the RHPP will finish on 31st March 2012, and will be replaced by a second phase, with £25m funding, of which £8m will be reserved for community projects.

The Green Deal

One of the major barriers to the installation of energy efficiency measures is the upfront cost. The Green Deal is the Coalition Government's flagship policy for addressing this barrier in both the domestic and non-domestic sectors. Under this policy, an energy advisor will carry out a survey of the building, and recommend a range of energy efficiency measures (for example, insulation or heat pumps), suitable to the property. The estimated fuel bill savings will be calculated for that property, taking into account usage patterns.
The customer can then take out a long term loan with approved Green Deal financiers, to be paid back by the fuel bill savings. If the customer moves house, the loan is transferred to the next occupier.
The qualifications for energy advisors have now been finalised, and in March 2012, Minister Greg Barker announced a £1m training package.
One sub-component of the Green Deal will be the Energy Companies' Obligation (ECO), an energy saving policy focussed on low income households.

Microgeneration Certification Scheme
DECC carried out a detailed analysis of the performance of the domestic air to

water and ground to water heat pumps in the Energy Saving Trust's heat pump field trial. Several heat pumps showed poor performance, due to:

- Undersizing – with the result that the electric cassette was used too frequently
- Poor design of the borehole/ground loop
- Poor choice of emitters (with high flow temperatures)
- Undersized hot water tanks (which meant that the water was stored at very high temperatures)
- Over-use of circulation pumps
- Inadequate insulation of pipes and tanks.

As a result of this analysis, DECC and the Energy Saving Trust convened a subgroup of heat pump experts to develop more robust guidance for installation. Following a number of meetings, the MIS 3005 standard (Requirements for contractors undertaking the supply, design, installation, set to work commissioning and handover of microgeneration heat pump systems, Issue 2.0) has been updated to Issue 3.1. The principal changes that have been made are:

- heat pump sizing
- ground loop sizing
- selection of emitters.

A number of more minor changes have also been made.

MIS 3005 Issue 3.1 can be downloaded from:
http://www.microgenerationcertification.org/installers/installers

The new standards came into operation on 01/03/2012. DECC has funded a series of roadshows and a webinar to inform installers about the new standards and their implications.

Other Research Programmes

The EST domestic field trials have been extended for a further year, and a final report is expected by the end of 2012.
Last year, DECC published a short report on the acoustic emissions of domestic air-source heat pumps in situ.
DECC is also carrying out research into the effect of cycling on the efficiency of heat pumps, and into the most efficient way of providing domestic hot water for various usage patterns. Finally, DECC is investigating the relative merits of underfloor heating and oversized radiators, and the best way to incorporate buffer tanks in heating circuits.

Conclusions

Despite difficult economic circumstances, the UK Government has put in place a number of policies to encourage the uptake of heat pumps, in all sectors of the economy (domestic, commercial, public, industrial and commercial). These policies include CERT (a domestic energy efficiency policy, scheduled to finish at the end of 2012), the Renewable Heat Premium Payment scheme (which subsidises heat generated by renewables in the domestic sector) and the Renewable Heat Incentive (which subsidises heat generated by renewables in the non-domestic sector, and which will be expanded to include the domestic sector when the Renewable Heat Premium Payment scheme finishes). As part of the Renewable Heat Premium Payment Scheme, the Government has subsidised many programmes in the social housing sector.
The Green Deal will provide low cost finance to both businesses and householders to help with the installation of energy efficiency measures, including heat pumps.

It is vitally important that consumers can be confident that their heat pumps work correctly. DECC has undertaken detailed analysis of the data from the first year of the EST field trials, and, as a result, has worked with the industry to develop new standards for heat pump installation.
Finally, DECC is carrying out a number of research projects which will help to provide further guidance on the most efficient ways to incorporate heat pumps in domestic heating circuits.

References

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Green Deal
http://www.decc.gov.uk/en/content/cms/tackling/green_deal/green_deal.aspx
RHI
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Correct sizing and installation of heat pumps are essential to ensure good performance.

Annexes, ongoing

IEA HPP Annex 35 / IETS Annex 13 Application of Industrial Heat Pumps

In Annex 35, the work on the SWOT analysis of software and user needs are in preparation. Collecting of the relevant data for assessing industrial heat pumps is also ongoing, through a study of available technology. This will be reported in the form of a database that will be made available.

Good examples of installations of industrial heat pumps are also collected and analysed. If you know of a specific installation that you would like to tip us about, please contact roger.nordman@sp.se. Please attach some information about the installation, e.g., a web link or a paper describing it.

In the communication of the project, a workshop entitled "Application of industrial heat pumps" was recently arranged at the ACHEMA congress, 21 June 2012 in Frankfurt, Germany. The presentations, that were highly appreciated, are available through the HPC website.

IEA Annex 36 Quality Installation / Quality Maintenance Sensitivity Analysis

Annex 36 is evaluating how installation and/or maintenance deficiencies cause heat pumps to perform inefficiently (i.e., decreased efficiency and/or capacity). Also under investigation are the extent that operational deviations are significant, whether the deviations (when combined) have an additive effect on heat pump performance, and whether some deviations (among various country-specific equipment types and locations) have greater impact than others. The focus and work to be undertaken by each participating country is given in the table below.

The Annex is scheduled to run through November 2013 with future working meetings planned for September 2012 (in the U.S.) and the fall 2013 (in France).

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Annex 36 Participants	Focus Area	Work to be Undertaken
France	Space heating and water heating applications.	Field: Customer feedback survey on heat pump system installations, maintenance, and after-sales service. Lab: Water heating performance tests on sensitivity parameters and analysis.
Sweden	Large heat pumps for multi-family and commercial buildings Geothermal heat pumps	Field: Literature review of operation and maintenance for larger heat pumps. Investigations and statistical analysis of 22000 heat pump failures. Modeling/Lab: Determination of failure modes and analysis of found failures and failure statistics.
United Kingdom	Home heating with ground-to-water, water-to-water, air-to-water, and air-to-air systems.	Field: Replace and monitor five geothermal heating systems Lab: Investigate the impact of thermostatic radiator valves on heat pump system performance.
United States (Operating Agent)	Air-to-air residential heat pumps installed in residential applications (cooling and heating).	Modeling: Examine previous work and laboratory tests to assess the impact of ranges of selected faults covered augmented by seasonal analyses modeling to include effects of different building types (slab vs. basement foundations, etc.) and climates in the assessment of various faults on heat pump performance. Lab: Cooling and heating tests with imposed faults to correlate performance to the modeling results.

IEA HPP ANNEX 38 Solar and heat pump systems

The objective of Annex 38 of the Heat Pump Programme (which is also Task 44 of the IEA's Solar Heating and Cooling Programme) is assessment of the performance and relevance of combined systems using solar thermal collectors and heat pumps.

Participants are drawn from research institutions, engineering firms, HVAC industry and the solar industry. The 2012 meeting was attended by about 40 participants; from Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Portugal, Spain, Sweden and Switzerland.

Subtask A, Solutions and Generic Systems, led by Sebastian Herkel, Fraunhofer ISE, Germany, is active in gathering monitoring data from 20 different systems or combinations of solar and heat pumps. Results will be available in 2012 in a common format.

Subtask B, Performance Assessment, led by Ivan Malenkovic, AIT, Austria, has defined the performance criteria that the Annex should report for monitoring results or simulation results, concentrated on energy and ecological factors.

Subtask C, led by Michel Haller of SPF, Switzerland, is concerned with modelling and simulation. It has produced a report on the reference system and climates that the simulation teams should use to compare and optimise their solar and heat pump configurations. It has also issued a draft report on available models for solar collector, heat pump, heat storage and ground heat exchangers, and identified missing areas for which models need to be developed.

Subtask D, led by Wolfram Sparber of Eurac, Italy, deals with dissemination of all the material and ideas produced by the Annex. At the end of 2011, it produced a newsletter describing the status of the Annex subtasks, and is now working on a new method to derive all values and ratios from a simple square view (the method we introduced in 2011 to describe the power, heat and energy flows in a system) of a given configuration.
http://www.iea-shc.org/task44

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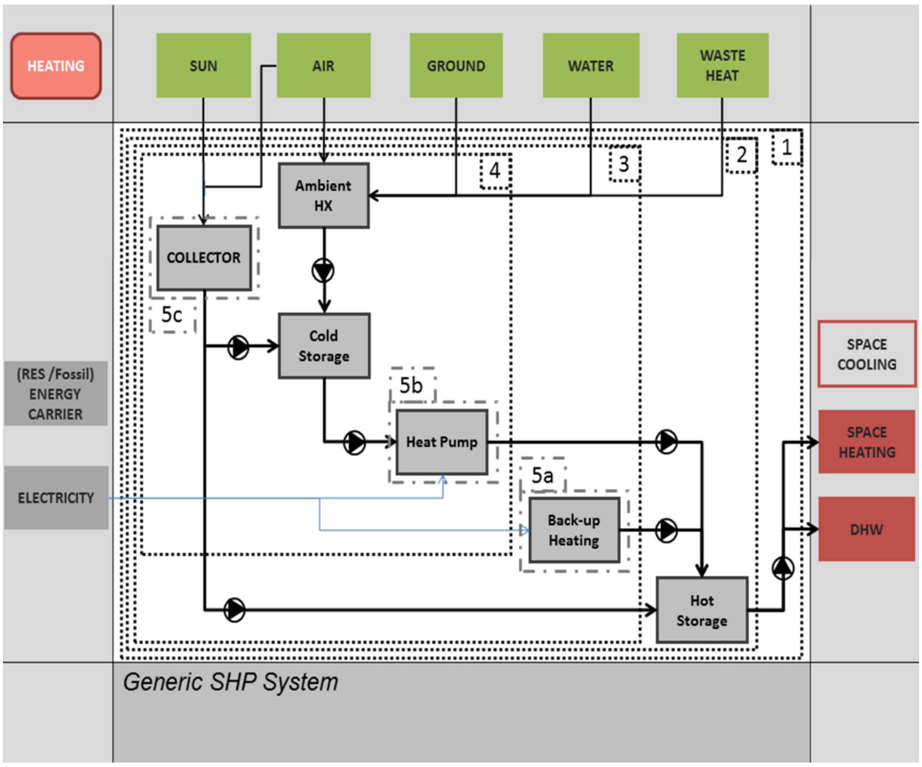

The different SPF limits (Seasonal Performance Factors) to consider in solar and heat pump combinations (source: AIT)

IEA HPP Annex 40 approved by HPP ExCo

Political targets for buildings both in Europe and in North-America focus on Nearly or Net Zero Energy Buildings (NZEB) to be introduced by 2020. While low energy and passive houses already show strong market growth, in particular in Germany, Austria and Switzerland, NZEB are mainly in the Pilot and Demonstration phase with about 300 NZEB realized world-wide.

In April 2012, the HPP ExCo approved the new IEA HPP Annex 40 entitled "Heat pump concepts for Nearly Zero Energy Buildings" which is to start in July 2012 and is dedicated to the development of concepts and technologies for NZEB incorporating heat pumps as central component of the building technology, since heat pumps are expected to play an important role in NZEB. Currently, the four countries CH (Operating Agent), JP, NL and NO are participating in the project, with the further countries AT, BE, DE, FI, FR, KR, SE, US interested to join the project.

Task 1 is dedicated to a state-of-the-art survey of building technology concepts installed in pilot plants of NZEB in order to derive a technology matrix of building envelope and HVAC technologies and to identify further development needs.

In Task 2, detailed analysis and optimization of promising concepts are performed by HVAC system comparison and simulations, considering the system performance and cost as well as design and control issues. In parallel, in Task 3, a further development of system technology and field trials of prototype technologies are accomplished.

Task 4 will derive recommendations and guidelines from Task 2 and Task 3 experiences. Moreover, Task 4 is also dedicated to storage options for electricity and heat, grid interaction and options for demand side management by enhanced ICT which will become important with a broad introduction of NZEB.

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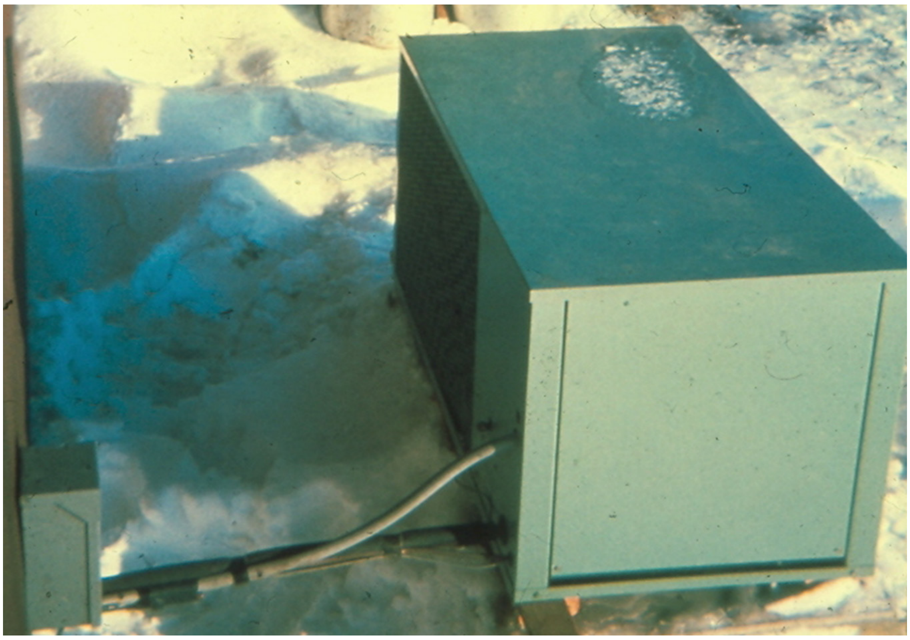

New IEA HPP Annex 41 - Cold Climate Heat Pumps

Heat pump technology provides a significant potential for CO_2 emissions reduction. This annex will revisit research and development work in different countries to examine technology improvements leading to successful heat pumps experience in cold regions.

The primary focus is on air-source heat pumps (ASHP), with air or hydronic heating systems, since these products suffer severe performance degradation at lower outdoor temperatures. Each participating Annex partner will focus on **ASHP types and applications of primary interest to their residential and commercial building sectors.** Electrically driven ASHPs systems are the main interest but thermally activated (engine-driven, absorption, etc.), and ground-source heat pumps (GSHP) may also be included in individual country contributions if desired. The main technical objective is to identify solutions leading to ASHPs with heating SPF ≥ 2.63 W/W, recognized as a renewable technology in the EU.

The main outcome of this Annex is information-sharing on viable means to improve ASHP performance under cold (≤ -7°C) ambient temperatures. This will lead to achievement of systems with reduced energy consumption (and related CO_2-emissions) while serving the needs of building owners and operators. Availability of cold climate ASHP systems would result in a stronger heat pump market presence in cold areas which currently rely predominantly on fossil fuel furnace heating systems.

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Ongoing Annexes

Bold text indicates Operating Agent. ** Participant of IEA IETS or IEA SHC

Annex 34 Thermally Driven Heat Pumps for Heating and Cooling	34	AT, CA, CH, **DE**, FR, IT, NO, UK US
Annex 35 Application of Industrial Heat Pumps (together with Task XIII of "Industrial Energy-Related Technologies and Systems" (IEA IETS))	35	AT, CA, DK**, FR, **DE**, JP, NL, KR, SE
Annex 36 Quality Installation/Quality Maintenance Sensitivity Studies	36	FR, SE, UK, **US**
Annex 37 Demonstration of field measurements of heat pump systems in buildings – Good examples with modern technology	37	CH, NO, **SE**, UK
Annex 38 Solar and Heat Pump Systems	38	AT**, BE**, CA**, **CH**, DE, DK**, ES**, FI, FR**, IT**, UK
Annex 39 A common method for testing and rating of residential HP and AC annual/seasonal performance	39	AT, CH, DE, FI, FR, KR, **SE**, US

IEA Heat Pump Programme participating countries: Austria (AT), Canada (CA), France (FR), Finland (FI) Germany (DE), Japan (JP), The Netherlands (NL), Italy (IT), Norway (NO), South Korea (KR), Sweden (SE), Switzerland (CH), United Kingdom (UK), United States (US). All countries are members of the IEA Heat Pump Centre (HPC). Sweden is Operating Agent of the HPC.

The Growing Role of Heat Pumps in a Smart Grid Era

Ron Domitrovic, K. R. Amarnath, Electric Power Research Institute, USA

Heat pumps based on the vapor compression platform are here to stay, as an entire new family of products are beginning to work their way into the market. Variable capacity advancements are enabling what was an inherently single-speed, single-capacity technology, to mature into an advancement better able to match capacity to load. This capacity flexibility can make advanced heat pumps an attractive tool for electric grid demand control. Unfortunately that flexibility is difficult to characterize through the established methods of rating, and likewise difficult to promote through existing channels. There is much work to be done in properly describing the potential of this technology family, in the laboratory, in the field and in modeling tools.

Introduction

The Smart Grid has many evolving definitions, but they generally involve increasing flexibility and reliability of electricity transmission and distribution systems, seamlessly integrating distributed resources into the grid, and empowering end-use customers. Detailed attributes of a "smart-grid" are highly dependent on the specific needs of a region or a utility and in some cases may strictly focus on the transmission system, while another may incorporate end-use loads as a grid resource. Incorporating end-use loads as a resource to the grid, is a rapidly developing area where new adaptations of heat pumps can play an important role and find a new and expanding market.

Electrical system load demand profiles vary periodically on daily and seasonal time periods, forcing generation to continuously adjust to match load in a dance lasting into perpetuity. The adjustability of generation has limits depending on the type, availability and cost of the marginal generation unit. In times of high demand ("peak" conditions), it is often more cost effective to trim load than to add generation. Such demand response activities have been used for many years in certain utility regions in the form of relay or thermostat control on air conditioners and water heaters. The smart-grid era is expanding technologies used for load curtailment and maturing them to be flexible resources for additional purposes, including integration of renewables and grid voltage and frequency control—so called ancillary services.

Space conditioning (heating & cooling) consumes approximately 17 % & 24 % of delivered electrical power in the U.S residential & commercial sectors, respectively (Figure 1) making heat pumps and other components in the heating/cooling load category the primary candidate for advancement in technology as a grid resource. [1] Flexibility, built on variable components, is the key technological advancement that could enable heat pumps to become an even greater resource.

Variable Capacity Heat Pumps

There is a wave of new air conditioning and heat pump products that expand the capabilities of the tried-and-true vapor compression platform with the incorporation of variable capacity and distributed control (VCDC). The vapor compression system for air conditioning and heat pumping applications has proliferated around the world since its discovery and invention over the past century. Most of the installed unitary air conditioners and heat pumps in the US are centrally ducted, single speed,

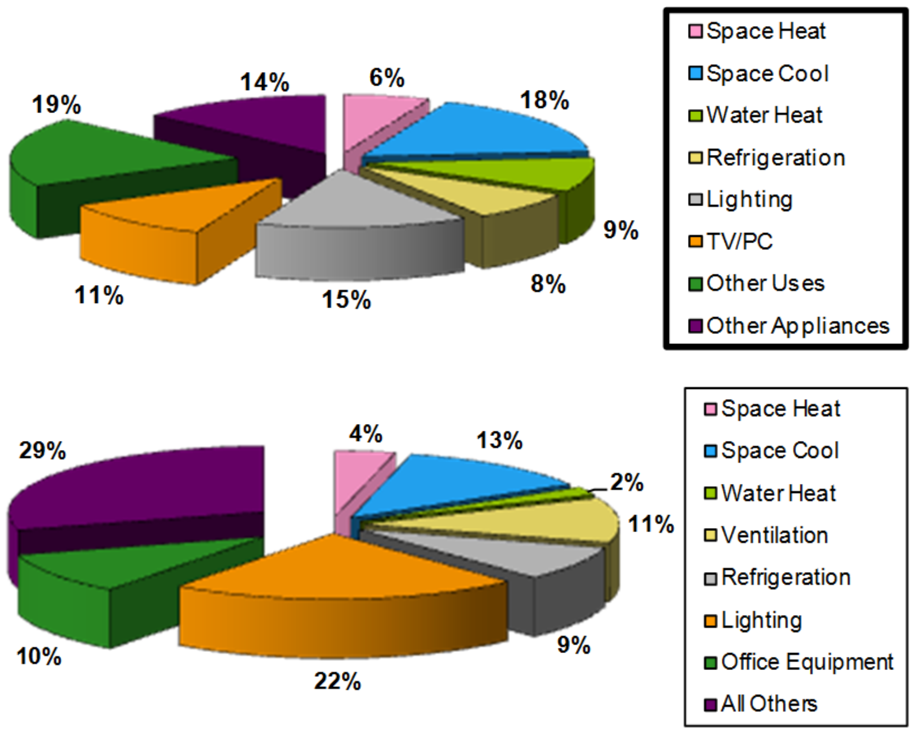

Figure 1 – End-Use Electricity Consumption in 2010 [4]

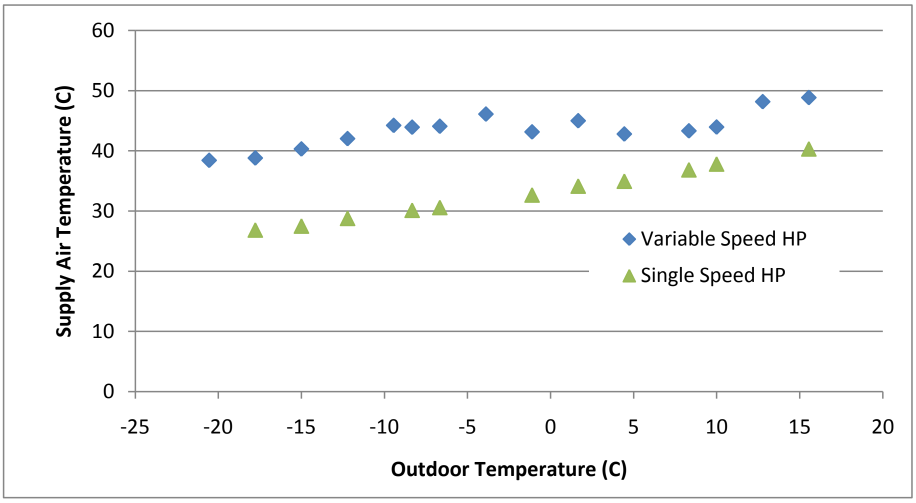

Figure 2--Supply air temperature as a function of outdoor temperature for a traditional single speed air-to-air heat pump with rated seasonal heating SPF of 2.26 W/W (US HSPF rating of 7.7) and a variable speed air-to-air heat pump [2]

air-to-air type systems. The historically wide acceptance of these relatively simple and reliable systems in the United States was in part due to an abundance of available and relatively inexpensive electric energy. In areas of the world with less abundant energy and higher cost, engineers have pushed the envelope of performance for direct expansion (DX), developing systems that, in the U.S. market, were less-cost effective. Newly invigorated drivers in the push for the efficient use of energy, particularly in devices that consume large amounts of it, are changing the American space conditioning landscape by creating markets for advances in variable capacity technology that, a short time ago, would have been considered unnecessary.

Though simple in concept, capacity variation in vapor compression is not simple to implement because of a variety of complicating factors including components that are not variable—like heat exchangers—and difficulties with refrigerant and oil flow management. Fixed capacity systems have the unfortunate behavior that capacity decreases in the direction of increasing load. Cooling capacity of an air conditioner decreases as the outdoor temperature rises (and the demand for cooling increases). Likewise heating capacity of an air-source heat pump decreases as outdoor temperature drops. Capacity variation allows nominally sized equipment to operate at excess compressor speeds and fan speeds and at appropriately altered expansion valve states to enable capacity increases beyond nominal rating. This is of particular value in heating mode where traditional single-speed heat pumps rely on electric resistance heat for low ambient conditions, which inhibits the proliferation of heat pumps into traditionally colder winter climates such as the Midwest and Northeast U.S. Development of heat pumps that can flexibly provide heating capacity, and high supply air temperature, at lower outdoor temperatures could expand the heat pump market into regions currently dominated by fossil fuels. Figure 2 shows test data of an example low temperature variable capacity heat pump, maintaining 38+°C (100+°F) supply air temperature at -21°C (-5°F) outdoor temperature. [2]

Advanced and highly efficient new products built on the established vapor compression base technology can act as effective resources for managing energy consumption while maintaining or improving indoor comfort. The American utility industry is on a constant search for tools to help manage electric load growth and temporal variation in the most efficient manner. Technologies like the compact fluorescent light bulb have been used extensively as an energy efficiency tool aimed mainly at controlling long term-load growth, while techniques such as relay-controlled air conditioner shedding have been used for real-time load management. The variable capacity, distributed control platform is seen as a next, comprehensive tool for managing both short-term electric load variations and long term load growth. The missing element is comprehensive documented understanding of what this technology set offers in terms of efficiency and load management capabilities.

There is a distinct need in the greater HVAC industry to characterize and quantify the differences in performance realized by variable capacity DX systems versus more conventional single speed unitary or other HVAC configurations, both as pieces of equipment and as integral parts of a building.

Currently Available System Types

Currently available variable capacity systems come in a variety of flavors:

- Small ductless single-split systems covering the range of ~ 3-7 kW (~3/4– 2 tons), commonly called ductless heat pumps (DHP) or mini-split heat pumps. Some manufacturers offer mini-ducted, or what is termed low-static ducted air handlers in this family of product.

- Intermediate multi-split heat pumps where 2 – 8 indoor units pipe directly to the outdoor unit, ranging from ~7-14 kW (~2-4 tons) total capacity.

- Unitary variable speed split systems with a traditional American style high-static residential air handler ranging from ~7-18 kW (~2-5 tons). This type is currently limited to one indoor unit per outdoor unit.

- Intermediate variable refrigerant flow (VRF) heat pumps where up to 8 indoor units connect to a common refrigerant line set and a single outdoor unit in the range of ~11-14 kW (~3-4 tons).

- Full size variable refrigerant flow (VRF) heat pumps where tens to hundreds of indoor units connect to a common refrigerant line set and an array of coupled outdoor units under a common control system.

- Full size heat recovery VRF systems, similar to above, but that can perform simultaneous heating and cooling among indoor units, while the outdoor unit operates in net cooling or net heating mode determined by the percentage of demand for each.

All the above systems share the common platform that primary transport of heat is via refrigerant. Transfer to or from the conditioned air is through a variety of indoor unit configurations including wall or floor mount fan coil units, ceiling cassettes, low static air handlers and traditional high static air handlers. The term "ductless heat pumps" has become somewhat of a catch-all term for many of the variable capacity systems, but it is a bit misassigned. Any system can be ductless and any can be ducted, and the intermediate to full size variable capacity systems often integrate both ducted and ductless indoor units into a coordinated design.

Variable capacity systems are readily available in the American market, mainly sold as advantageous from efficiency and comfort standpoints. But, such systems can be integrated as grid-interactive resources that act in concert with or awareness of the needs of the greater electrical system. This has the potential to be an area of growth in heat pump application in the coming years.

Heat Pump Water Heaters

A second major load category where advanced heat pumps have the potential to play a similar role is in domestic water heating. Over the past few years, heat pump water heaters (HPWHs) have gained a new foothold in the U.S., with major manufacturers like A.O Smith, General Electric, Rheem, Bosch, Vaughan and others introducing new products into the market. These systems are primarily single speed heat pumps and provide an energy efficiency advantage to the customer, but are not yet a grid interactive resource. Application of similar variable speed components and flexible control of HPWHs have the potential to become a grid resource as well.

Applications of HPWHs have focused on warmer climates and some questions remain about proper use in colder areas. Questions arise regarding evaporator coil frosting & defrosting and proper design of intake and discharge air such that the space cooling effect is optimized.

Conclusions - Into the Future

A simple conclusion is that the vapor compression platform is here to stay, as an entire new family of products built on the nearly 100 year old technology is working its way into the American market. It is ancillary technology development, like inverter driven motors, electronically variable expansion valves, sensor and control algorithms and firm understanding of oil flow management, that allowed what was an inherently single-speed, single-capacity technology, to mature into an advancement that is better able to match capacity to load as it is demanded by conditioned space.

High variation of load profile, with time of day and with building floor plan, is well suited for zonal control and simultaneous heating and cooling. Systems with multiple indoor units and multiple separately controlled zones offer additional flexibility for real-time load management. Centralized control can temporarily override local control and curtail total system power draw according to a variety of algorithms. This might include selective zonal temperature setbacks, cycling indoor units off based on position within a building, hierarchy or according to occupancy sensing. The degree to which curtailment can be requested is flexible and can serve both the utility looking to shed load for system reasons and the customer looking to remain within the bounds of a demand category.

The U.S. Environmental Protection Agency (EPA) is in the process of defining "connected" appliances as a supplemental attribute to Energy Star qualified products. The designation of "smart-appliance", or something similar, will give additional credit against minimum Energy Star performance levels. The first appliances in the queue for this new category are thermostats, room air conditioners and refrigerator/freezers, with others to follow on an as yet undetermined schedule. [3]

Most of the variable capacity heat pumps currently available use manufacturer proprietary control communication, as opposed to the standard 24 Volt switching thermostat. By migrating to digital control and open standards based communication, future heat pump systems could very well have in-built ability to interface with and react to, utility signals or measurements of the grid state.

Flexibility is perhaps the primary attribute of variable capacity distributed control vapor compression systems, but it is that flexibility that makes them difficult to characterize through the established methods of rating, and likewise difficult to promote or provide incentives for through existing channels. There is much work to be done in properly describing the potential of this technology family, in the laboratory, in the field and in modeling tools. Reliable design tools remain somewhat sparse and un-unanimously approved for widespread use. There is great interest in closing these gaps across the spectrum of interested parties—manufacturers, design professionals, installers, utilities and end users.

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Heat pumps – A key technology in future district heating and district cooling systems

Jørn Stene, COWI AS and NTNU, Norway

Heat pumps represent an important technology for district heating and cooling systems, since they utilize renewable heat sources/sinks and so reduce primary energy consumption and greenhouse gas emissions in comparison with boiler systems. Current state-of-the-art technology has a maximum outlet water temperature of 90 °C, which means that heat pumps are applicable even in high-temperature systems. The most promising and environmentally benign working fluids for the future are ammonia (R717) and HFO1234ze, which will replace R134a. Carbon dioxide (CO_2) is also an interesting option in district heating systems with low return temperature.

District heating and cooling

A district heating system is a large-scale heating system for multiple residences and/or nonresidential buildings comprising a heating plant, a hydronic heat distribution system with supply water temperatures between 70 and 120 °C and heat exchanger substations in the different buildings.

During the last decade there has been considerable expansion of the Norwegian market for district heating. The annual heat supply increased from about 1.5 TWh to 4.3 TWh/year between 2000 and 2010, and in 2010 about 400 GWh (9 %) was supplied from large-capacity heat pump systems.

The positive market development for district heating is mainly due to stricter building regulations focusing on renewable energy and energy conservation (the RES and EPBD Directives), Governmental plans for phasing-out oil-fired heating systems and public subsidies. District heating represents an alternative to local oil- and gas-fired boilers, electro-boilers and electric base-board heaters. The main advantages for district heating systems include reduced primary energy demand, lower greenhouse gas emissions, greater energy flexibility, utilisation of local energy sources and more compact heating installations in buildings. The main disadvantages are high investment costs, practical challenges when installing pipeline systems, inevitable annual heat loss from the distribution system (8 to 30 %, grid-dependent), rigid distribution system that is not optimised for future buildings of passive house standard, and relatively high temperature levels in the distribution systems limiting the Seasonal Performance Factor (SPF) for heat pump systems.

A district cooling system is a large-scale cooling system for non-residential buildings. The principle is similar to that of a district heating system, and the supply water temperature range from 5 to 10 °C. District cooling can be provided by free cooling from seawater, groundwater, river water or bedrock, combined heat pump and chiller systems as well as absorption chillers operated with (for example) high-temperature waste heat. District cooling systems represent an alternative to local split-type air conditioners and water chiller systems in buildings.

Heat pumps and chillers

When designing large-scale heat pumps in district heating systems, it is crucial that there will be an abundant heat source and heat sink. In Norway, the most common sources are sea water, groundwater, bedrock (ground) and raw sewage. The installed capacity ranges from about 600 kW to 28 MW per installation. Due to the high specific investment costs (USD/kW) and the aim for high COP even at part-load operation, the heat pump is always designed for base load operation, with peak load being supplied by oil or gas-fired boilers, electro-boilers or high-temperature industrial waste heat. In district cooling systems, the heat pump and chiller system should cover 100 % of the maximum cooling load. During summer operation the heat pump units either provide simultaneous heating and cooling or are operated in cooling mode together with the chillers.

Large-capacity heat pumps for district heating systems use R134a or ammonia (R717) as the working fluid, always using a two-stage design in order to improve system performance and keep the exhaust gas and oil temperatures at acceptable levels. R134a heat pumps are normally equipped with centrifugal (turbo) compressors, either two single-stage 28 bar units in series or one integrated two-stage 40 bar unit. The evaporator and condenser are optimised shell-and-tube heat exchangers. The maximum outlet water temperatures for the 28 and 40 bar systems are 75 °C and 90 °C respectively. Due to the relatively low critical temperature of R134a, considerable sub-cooling is required at high outlet water temperatures in order to achieve the same COP as ammonia systems.

Ammonia heat pumps employ reciprocating, twin-screw or mono-screw compressors, with the design pressure for the second compressor stage being 40 or 50 bar for reciprocating and twin-screw compressors, and 75 bar for mono-screw compressors. Shell-and-tube heat exchangers are normally used as evaporator and condenser. The maximum outlet water temperature for high-pressure ammonia systems range from about 68 to 90 °C.

Working fluids

In order to ensure an environmentally benign and energy-efficient alternative in the future, it is crucial that large-capacity heat pumps and chillers for district heating and cooling systems should have a high COP under all operating conditions and use a low or zero GWP working fluid.

The GWP value of R134a is 1300. High-capacity R134a heat pump systems with turbo compressors have a typical leakage rate of 1 %. Due to the considerable working fluid charge, the annual emissions for a typical installation will be in the range of 50 to 100 tonnes CO_2 equivalents. In order to reduce the emissions from large R134a heat pump systems, HFO1234ze has been introduced as a low-GWP alternative. The GWP value of this fluid is only 5, but the cycle COP will fall by 2 to 5 % compared to an R134a system, while the volumetric refrigerating capacity (VRC) is about 25 % lower. However, despite the slightly inferior properties of HFO1234ze, it represents a promising replacement for R134a.

Ammonia is a zero-GWP natural working fluid. Over the last five years, there has been a considerable development of large-capacity high-temperature ammonia systems, with the maximum outlet water temperature having been raised from about 70 to 90 °C. The main reason is the development of high-pressure compressors. There has also been a focus on optimising the systems in terms of advanced heat exchanger design and maximum heat recovery. The main challenges with high-temperature ammonia heat pump systems have been excessive exhaust gas temperatures and high pressures leading to problems with sealing materials, lubrication and oil return.

Carbon dioxide (CO_2, R744) is another zero-GWP natural working fluid. A transcritical CO_2 heat pump cycle will achieve a very low COP in standard district heating systems with a return temperature between 50 to 60 °C. However, in systems with a low return temperature, CO_2 heat pumps will be competitive against R134a and ammonia systems. In Denmark two high-capacity CO_2 heat pump systems have been installed in district heating systems. The supply and return temperature are 80 °C and 30-35 °C respectively, and the COP range from about 2.8 to 3.4.

Installations

The first Norwegian heat pump plant supplying heat to a district heating system was installed at Skøyen Vest in Oslo in 1983. The 2.3 MW R12 heat pump utilised raw sewage as its heat source. Unfortunately, the plant experienced a number of operational problems, including compressor failure and severe fouling on the falling film plate heat exchangers. In 2006, the heat pump was replaced by an advanced 18.4 MW R134a heat pump unit with a 40 bar integrated two-stage turbo-compressor and a single-pass tube-and-shell evaporator. Rotating filters clean the sewage, and an OD 600 4-way valve changes the direction of the sewage flow once an hour in order to prevent fouling. The heat pump has a maximum outlet water temperature of 90 °C, with a COP (including input power to the sewage pumps) of about 2.8. The installation was so successful that the energy utility installed a similar 10 MW unit in 2008.

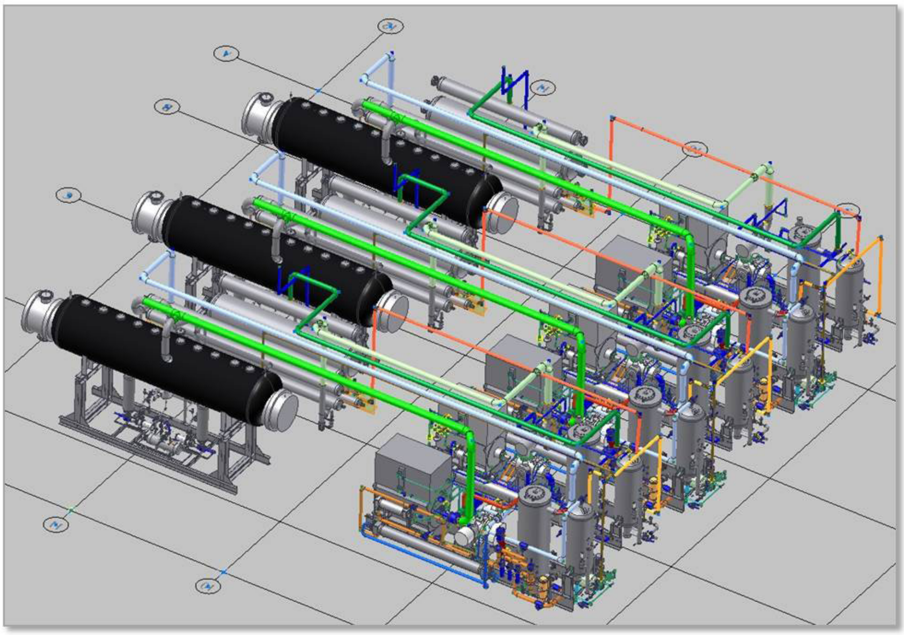
The first heat pump system for combined district heating and cooling was installed in Sandvika in 1989. This system also utilises raw sewage as its heat source and heat sink. The 13 MW heat pump comprises two two-stage R134a turbo compressor units with shell-and-tube evaporators and condensers, delivering a maximum outlet water temperature of 75 °C. The heat pump units are quite complex, since they have two evaporators in parallel: one abstracting heat from the sewage and one abstracting heat from the chilled water in the district cooling system.

A unique district heating and cooling system was installed at the University of Bergen over the period 1996 to 2006. Two single-stage sea water heat pumps, with a total heating capacity of 3 MW, supply 25 °C heat to a low-temperature distribution system, with the water serving as the heat source for 14 single-stage R134a heat pumps installed in different buildings. The total heating capacity is about 4 MW. During the summer, the water in the distribution system is cooled by sea water and the chilled water is used for free cooling in the buildings. The local heat pumps are operated as chillers whenever required, and the excess condenser heat is removed by sea water. The cascade system design leads to reduced costs for the pipeline system, a higher total Seasonal Performance Factor (SPF) due to lower average supply temperature, excellent operating conditions for the heat pump units, and high flexibility with regard to future extension of the system. However, the design and operation is more complex than that of conventional large-capacity heat pump systems; the total investment and maintenance costs are higher, and peak load boilers must be installed in the individual buildings.

In 2006, a 14 MW sea water heat pump system with two-stage R134a turbo compressor units was installed in the Fornebu area outside Oslo. About 80 to 90 % of the annual cooling demand in the district cooling system is covered by free cooling from sea water. The planned heating and cooling capacity is about 25 MW.

One of the largest ground-source heat pump systems in Europe was started up at Akershus University Hospital in 2008. Four single-stage ammonia heat pump units, connected to 228 boreholes in bedrock, provide heating and cooling to a district heating and cooling network.

The most energy-efficient high-capacity heat pump system in Norway is in Drammen. This sea water heat pump plant from 2011 comprises three identical two-stage ammonia heat pump units, with a total heating capacity of 14.3 MW. Each heat pump unit incorporates 75 bar mono-screw compressors, a spray tube-and-shell evaporator with titanium tubes and a shell-and-tube intercooler, subcooler, condenser and desuperheater. Due to the advanced system design and high-efficiency components the plant achieves a COP above 3 at 8 °C inlet sea water temperature and 90 °C outlet water temperature.



Drammen - high-temperature ammonia mono-screw compressor units (district heating), overview

Drammen - high-temperature ammonia mono-screw compressor units (district heating)

Conclusions

Heat pumps represent an important technology for district heating and cooling systems since they utilise a renewable heat source/sink and so reduce primary energy consumption and greenhouse gas emissions in comparison with boiler systems. The state-of-the-art technology has a maximum outlet water temperature of 90 °C, which means that heat pumps are applicable even in high-temperature district heating systems. The most promising and environmentally benign working fluids for the future are ammonia (R717) and HFO1234ze, which will replace R134a. Carbon dioxide (CO_2) is also an interesting option in district heating systems with low return temperature.

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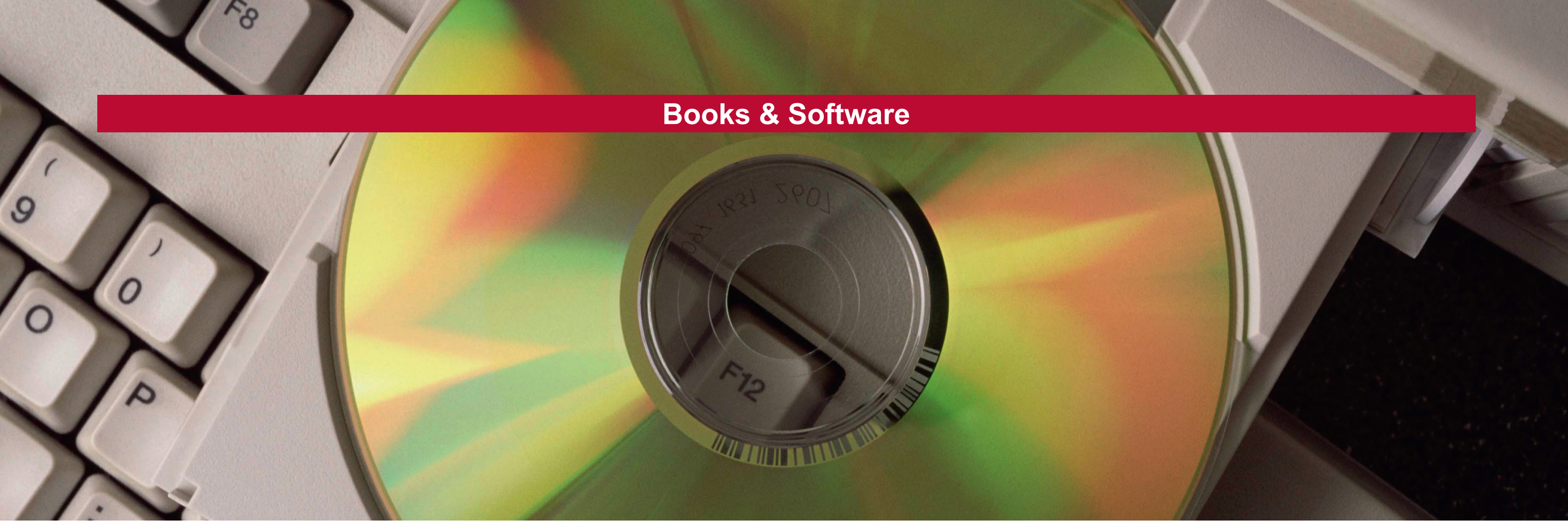

Energy Technology Perspectives 2012

Energy Technology Perspectives 2012 (ETP2012) is the International Energy Agency's most ambitious publication on new developments in energy technology. It demonstrates how technologies – from electric vehicles to smart grids – can make a decisive difference in achieving the objective of limiting the global temperature rise to 2°C and enhancing energy security. ETP2012 presents scenarios and strategies to 2050, with the aim of guiding decision makers on energy trends and what needs to be done to build a clean, secure and competitive energy future.

ETP2012 shows

- Current progress on clean energy deployment, and what can be done to accelerate it?
- How energy security and low carbon energy are linked?
- How energy systems will become more complex in the future? Why systems integration is beneficial and how it can be achieved?
- How demand for heating and cooling will evolve dramatically and which solutions will satisfy it?
- Why flexible electricity systems are increasingly important, and how a system with smarter grids, energy storage and flexible generation can work?
- Why hydrogen could play a big role in the energy system of the future?
- Why fossil fuels will not disappear but will see their roles change, and what it means for the energy system as a whole?
- What is needed to realise the potential of carbon capture and storage (CCS)?
- Whether available technologies can allow the world to have zero energy related emissions by 2075 – which seems a necessary condition for the world to meet the 2°C target?

Global scenarios to 2050 are the backbone of ETP, and the 2012 edition features detailed scenarios for nine world regions.
Source: http://www.iea.org/etp/
Note: the ETP 2012 will be the Topic of IEA HPC Newsletter 4/2012

VRF systems added to ASHRAE Handbook

VRF air conditioning systems, their components and applicable standards, are included within the new 2012 ASHRAE Handbook.
An industry "bible", the ASHRAE Handbook comprises 52 chapters and discusses systems and the equipment that comprises them, including features and differences. It is designed to help system designers and building operators select and use equipment.
In previous volumes, variable refrigerant flow was covered in the unitary products section. Now with its own chapter, VRF systems are described in detail: their components and applicable standards, a system design example and important guidance on costs, controls and safety.
"This new chapter covers the A to Z of variable refrigerant flow - from application of VRF to understanding how VRF works and from analyzing a building load in terms of VRF to zoning with VRF," Paul Doppel, chair of ASHRAE's technical committee on variable refrigerant flow that wrote the chapter, said. "The chapter offers an excellent overview of VRF technology, including discussion about 2-pipe and 3-pipe system performance during heating operations."
Source: http://www.acr-news.com

Events

This section lists exhibitions, workshops, conferences etc. related to heat pumping technologies.

2012

29 July - 1 August
10th IIR Conference on Phase Change Materials and Slurries for Refrigeration and Air-Conditioning
Kobe, Japan
http://www2.kobe-u.ac.jp/~komoda/pcms/

1-4 August
The Second International Conference on Building Energy and Environment
Boulder, Colorado, USA
http://www.colorado.edu/cobee2012/index.html

13-14 September
International Symposium on Advanced Waste Heat Valorisation Technologies
Kortrijk, Belgium
http://www.wasteheat.eu

25-26 September
Heat Pump China 2012 - The 2nd International Heat Pump Development Forum
Shanghai, China
http://www.heatpumpchina.cn/

1-3 October
Energy Modeling Conference: Tools for Designing High Performance Buildings
Atlanta, Georgia, USA
http://ashraem.confex.com/ashraem/emc12/cfp.cgi

8 October
Chillventa Congressing [including IEA Heat Pump Programme Symposium]
Nürnberg, Germany
Contact for the Symposium:
johan.berg@sp.se

9-11 October
Chillventa
Nürnberg, Germany
http://www.chillventa.de/en/

25-26 October
3rd IIR Workshop on Refrigerant Charge Reduction in Refrigerating Systems
Valencia, Spain
http://www.imst.upv.es/iir-rcr2012

29-30 October
2012 ASHRAE/NIST Refrigerants Conference: Moving Towards Sustainability
Gaithersburg, Maryland, USA
http://www.ashrae.org/membership--conferences/conferences/ashrae-conferences/ASHRAE-NIST-Refrigerants-Conference

31 October – 2 November
35th World Energy Engineering Congress
Atlanta, Georgia, USA
http://www.energycongress.com/

8-9 November
10th International symposium on new refrigerants and environmental technology
Kobe, Japan
http://www.jraia.or.jp/english/symposium/index.html

12-14 November
Cold Climate HVAC 2012
Calgary, Alberta, Canada
http://www.ashrae.org/membership--conferences/conferences/ashrae-conferences/Cold-Climate-HVAC-2012

3-7 December
Ecobuild America
Washington DC, USA
http://www.aececobuild.com/conference-schedule

2013

26-30 January
ASHRAE Winter Conference
Dallas, Texas, USA
http://www.ashrae.org/membership--conferences/conferences/dallas-conference

28-30 March
International Process Integration Jubilee Conference 2013
Gothenburg, Sweden
http://www.chalmers.se/en/areas-of-advance/energy/news/Pages/2012/International-Process-Integration-Jubilee-Conference-2013-.aspx

2-4 April
2nd IIR International Conference on Sustainability and the Cold Chain
Paris, France
http://www.iccc2013.com/

9-11 May
5th International Conference Ammonia Refrigeration Technology
Ohrid, Republic of Macedonia
http://www.mf.ukim.edu.mk/web_ohrid2013/ohrid-2013.html

7-8 June
Latest technologies in refrigeration and air conditioning
Milano, Italy
http://www.centrogalileo.it/milano/GRESSODIMILANO2013english.html

In the next Issue

The role of heat pumps in NZEB

Volume 30 - No. 3/2012

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 worldwide source of independent information and expertise on environmental and energy conservation benefits of heat pumping technologies (including refrigeration and air conditioning).

The Programme conducts high value international collaborative activities to improve energy efficiency and minimise adverse environmental impact.

Mission

The Programme strives to achieve widespread deployment of appropriate high quality heat pumping technologies to obtain energy conservation and environmental benefits from these technologies. It serves policy makers, national and international energy and environmental agencies, utilities, manufacturers, designers and researchers.

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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