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Space cooling

Heat Pumps - A key technology for the future

IEA **Heat Pump** CENTRE
NEWSLETTER

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In this issue

Heat Pump Centre Newsletter, 2/2015
The Heat Pump Programme, which we will now begin to call by its more official name Heat Pumping Technologies (HPT), has a long tradition of promoting heat pumps for heating. Common applications may be space heating and hot water production, for domestic or commercial buildings, or industrial processes. This has been reflected by the contents of the Newsletter. However, it is becoming clear that there is one heat pumping technology with a very large number of users, both in HPT present member countries and in other (future member?) countries, which we have traditionally not focused so much on in the Newsletter or the HPT. This heat pumping technology is space cooling.

In this issue, we get extensive snapshots and trends from the space cooling markets in North America and from Europe (France). We also get advice on detection and leakage prevention of refrigerants. Further, the Foreword presents the total management system in Japan, while the Column gives an account of the heat pump situation in South Korea. Also, the next IEA Heat Pump Conference is announced.

Enjoy your reading!
Johan Berg, Editor

Heat pump news

Regulars

Topical articles

Non-topical articles

COLOPHON

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Foreword

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Senior Manager
The Japan Refrigeration and Air Conditioning Industry Association (JRAIA)
Japan

Total management systems for the HVAC & R market in Japan to combat global environmental issues

In Japan, after the experiences of two oil crises in 1973 and 1978, the Energy Conservation Law which aims at promoting effective use of fuel resources was established in 1979. The law takes necessary measures in order to comprehensively promote the rational use of energy in factories and buildings as well as energy for plants and machinery, equipment and other items. In 1998, Japan revised the Energy Conservation Law with the goal of strengthening various energy conservation measures. As a leading energy conservation measure for residential and commercial sectors and transportation sector, the Top Runner Program was introduced to establish energy consumption efficiency standards for machinery, equipment and other items. The Top Runner Program uses, as a base value, the value of each product with the highest energy consumption efficiency on the market at the time when the standard is established and sets standard values with considering the potential of technological improvement as efficiency improvement. Currently, the Top Runner Program has 26 product categories regarding refrigeration and air-conditioning equipment, including air conditioners (household use and commercial use), refrigerators and freezers, heat pump water heaters (excluding those for heating use and commercial use).

When considering environmental issues, from the viewpoint of promoting recycling of useful resources and decreasing wastes, handling used products would be one of the big challenges. Thus, the Home Appliance Recycling Law was enforced in 2001. This is the law that promotes efficient use of resources, leads to decrease in wastes, and recycles useful parts and materials from home appliances including air conditioners, TV sets, refrigerators and freezers, clothes washers and dryers. Approximately three million units of air conditioners are recycled every year and their recycling rate becomes about 90 %. Although the recovery rate of refrigerant of air conditioners for residential use and commercial use is 30 %, that of automobile air conditioners is relatively higher and has reached 60 %, thanks to the car registration and registry management of owners.

The "Act on Rational Use & Proper Management of Fluorocarbons," which focuses on all aspects of the life cycle from manufacturing and use to reuse and abolishment of refrigerant used in refrigeration and air-conditioning equipment, has started from April 2015. It was formulated to further enforce control over refrigerant management.

A brief outline of the law is as follows:

1. Require manufacturers and importers of fluorocarbons to formulate initiatives for production volume of low GWP refrigerants.
2. Require equipment manufacturers to set target values and target year for each main product, in order to encourage development of refrigeration and air-conditioning equipment using low GWP refrigerants.
3. Require users of refrigeration and air-conditioning equipment for commercial use to periodically check whether the power output of compressors in such equipment exceeds a certain standard or not for prevention of refrigerant leakage in use and to make a report in case that refrigerant leakage exceeds a specific amount.
4. Require to issue the mandatory certificates of the amounts of refrigerant charged and recovered for commercial refrigeration and air-conditioning equipment.

In Japanese HVAC & R market, comprehensive management systems to cope with environmental issues are just about to get started by incorporating the "Act on Rational Use & Proper Management of Fluorocarbons" into the present laws such as the Energy Conservation Law, JRAIA Certification program and Recycle Law and so on.

Column

Actions to encourage the take-up of heat pumps in Korea

Minsung Kim
Associate Professor
Chung-Ang University
South Korea

Bong-Joo Shin
Alternate Delegate for South Korea in ExCo
Korea Institute of Energy Technology Evaluation and Planning
South Korea

Global efforts on energy saving include encouragement of heat pumping technology. The Korean government acknowledged the importance and potential of heat pump technology for energy saving a decade ago. Korea joined the Heat Pump Programme in 2008 and has supported the take-up of heat pump systems. The application of heat pumps in Korea is divided into three sectors: commercial, residential, and industrial. The heat pump market is significantly different in each of the three sectors, depending on climate, energy prices, lifestyle, and technology.

The Korean climate is characterised by hot humid summers and cold dry winters, which means that heat pumps for indoor climate control must be capable of cooling as well as heating. In the 1990s, commercial heat pumps in Korea failed to take off because they operated poorly in extreme winter weather below –20 °C. Later on, the heat pump technology to overcome such cold weather was developed, and heat pumps are now gradually replacing boilers in the commercial and non-residential market.

However, heat pumps could not expand in the same way in the residential market. Since residential properties require heat during the night as well as during the day, the heating load during the winter is much greater in residential buildings than in commercial and non-residential buildings. Thus the cheaper gas boilers, which can supply greater heat loads, are preferred in residential buildings in Korea. A residential cooling system is regarded as an add-on option, and can be achieved simply by installing a unitary or split air conditioner. In addition, an extensive gas network in urban areas makes the marketing of residential heat pumps much more difficult. For example, in Seoul, more than 90 % area of the whole city is covered by the gas network.

The industrial sector is seen as the most promising target for the take-up of heat pump technology. Industrial heat pumps have better economic performance than residential or commercial heat pumps, as they frequently operate throughout the year. A number of factories have already replaced conventional hot water boilers with hot water heat pumps to save energy. For an advanced application, we expect steam boilers to be partially replaced by innovative steam heat pumps, as a large portion of industrial heat demand is accounted for by steam generation. Since the Korean government regards the industrial sector as a primary market for heat pumps in the future, it is supporting R&D of advanced technology and market development.

Heat pumps are one of the heating alternatives that should compete with conventional boilers or electric heating, which supply a great portion of the Korean heating market. Since the conventional devices have better cost competitiveness, it will take some time before they are replaced by heat pumps. Furthermore, the difficult conditions of the residential Korean market have an adverse effect on the public understanding of heat pump technology. Nevertheless, the relatively low electricity price compared to the price of gas in Korea shows a positive effect on a long-term market for heat pumps. Once the Korean government considers heat pump systems as the most promising technology for a green energy society, it will spare no efforts in supporting the innovative heat pump technology.

IEA HPT News

Welcome to the 12th IEA Heat Pump Conference, Rotterdam, the Netherlands!

The 12th IEA Heat Pump Conference will be held from 15th to 18th May 2017, at the World Trade Centre in Rotterdam. The Conference will begin with a series of workshops on 15th May and a welcoming reception on the evening of 15th May.

The goal of the conference is to promote heat pumping technologies through discussions, networking, and information exchange.

The conference will pay attention to heat pumps, air conditioning and refrigeration equipment and systems for residential, commercial and industrial applications.

Conference Structure

- Plenary opening session with high level speakers Oral presentations in different sessions. Invited keynote speakers will lead each major topic session
- Poster presentation of papers after each session
- Exhibition of equipment and information kiosks
- Technical visits
- Social and sight-seeing program
- Workshops on international collaborative projects (Annexes in the IEA Heat Pumping Technologies implementing agreement and other collaborations)

Papers for oral and poster presentations will be solicited with a general call for papers in 2015 and 2016. Submitted abstracts will be screened by an International Organizing Committee to ensure a balanced conference with a high quality structure, where presentations complement the invited papers. All papers will be published in the formal Conference Proceedings.

Sessions will cover the following topics:

- Technology – Advances in equipment design and development
- Systems – Advanced electrically and thermally operated systems, and ground source systems
- Applications – Demonstrated energy efficiency and environmental advantages
- Research and Development – New developments in Heat Pumping Technology
- Policy, Standards, Market Strategies, Market status, trends and future opportunities

Participation

Those wishing to attend the conference, should visit the conference website *www.hpc2017.org*. Detailed information, including registration and hotel accommodation forms will be available with a first announcement in Fall 2015 together with a second announcement in Spring 2016.

Organisations

In association with the Executive Committee of the IEA Heat Pumping Technologies, the conference is organized by the International Organizing Committee (IOC) and the National Organizing Committee (NOC).

- Per Jonasson
  Chairman IOC, Sweden
- Sophie Hosatte
  Vice Chair IOC, Canada
- Takeshi Hikawa
  Vice Chair IOC, Japan
- Onno Kleefkens
  Chairman NOC, The Netherlands
- Raymond Beuken
  Vice Chair NOC, The Netherlands
- Ronald van de Steek
  Conference Secretariat, The Netherlands

General

Japan: new NPO, 'Environment and Energy Network 21'

A new Non-Profit Organization (NPO), 'Environment and Energy Network 21' (ENET21), has been initiated by Tetsuro Kishimoto, former president of the Japan Refrigeration and Air Conditioning Industry Association (JRAIA); presently senior advisor to JRAIA.

In ENET21, with Mr. Kishimoto as president, an expert group from the fields of environment and energy is working toward a solution for global environment issues, especially related to energy consumption. ENET21 investigates and studies environment and energy and establishes evaluation standards based on objective scientific facts, which it then makes public through lectures and seminars. In this way, ENET21 aims to contribute to improving the global environment by cooperating with the organs concerned in conducting surveillance studies or environmental energy valuation. ENET21 also aims at implementing realizable policy recommendations. ENET21 achieves the cooperation between authorities, industries, and academia, with its officers coming from those areas.

Source: JARN, March 25, 2015

New Legionnaires' disease risk assessment guide

BSRIA has recently revised its publications concerning legionella control and has launched Legionnaires' Disease – Risk Assessment (BG57/2015). The new guide has been written to provide a structured framework for a legionella risk assessment that may be carried out by a building manager, competent in-house staff or specialist consultants. It replaces BSRIA guide AG20/2000 and has been updated to take account of later standards and guidance documents.

Sources: www.acr-news.com

Searching for refrigerant traces in the atmosphere

The Swiss Federal Laboratories for Materials Science and Technology (Empa) researchers have now published first measurements on the atmospheric distribution and abundance of the 4th generation halogenated coolants and foaming agents.

Fluoroolefins, such as R1234yf, R1234ze(E) and R1233zd(E), decay more quickly in the atmosphere hence their lifetimes are considerably shorter. That is why they do not add nearly as much to the greenhouse gas effect as their stable predecessors. These new substances are now more frequently used, as evidenced by the first measurements made by Empa.

Source: www.iifiir.org

Policy

China's HCFC qouta cut by 10 %

China's Ministry of Environmental protection has announced that the 2015 annual consumption quota of HCFC was down by 10 %, compared to last year. This amount of HCFC is allocated to 82 enterprises. According to the Montreal Protocol, China should eliminate both production and consumption of HCFC by the end of 2030. The milestones include 10 % cut by 2015, 67.5 % cut by 2025, and entire phase-out of HCFC from 2030 to 2040, except small amounts left for maintenance.

Source: JARN, April 25, 2015

EU looks to phase down HFCs under Montreal Protocol

The European Union (EU) has submitted a proposal to amend the Montreal Protocol to control HFCs, in refrigeration, air-conditioning, fire protection, aerosols and foams. This move by the EU follows similar proposals submitted since 2009 by the USA, Canada, Mexico and Micronesia, and would significantly reduce HFCs in developed countries by following a phase-down schedule closely matching the EU F-Gas Regulation, groundbreaking legislation adopted by the European Parliament and the Council in 2014. Head of climate at the Environmental Investigation Agency (EIA) Clare Perry said: 'The EU clearly expects developed countries to lead by example. The EU is now calling on other developed countries to match it.'

In developing countries, the EU proposes a new approach, aimed at initially limiting the growth of HFCs, followed by an agreement to negotiate a phase-down schedule by 2020.

Ms Perry continued: 'The EU proposal is trying to be sensitive to the fact that HFCs are generally used to replace ozone-depleting HCFCs, which developing countries have only just begun to phase-out under the Montreal Protocol. For this reason, HFCs cannot be considered in isolation and this is the first proposal to try and address that specifically within an HFC amendment proposal – as such, it has the potential to unlock negotiations'.

Source: www.acr-news.com

Working fluids

EPA approves new climate-friendly refrigerants

The U.S. Environmental Protection Agency (EPA) has issued a final action that increases the options for refrigerants used in various kinds of refrigeration and air-conditioning equipment that offer better climate protection without harming the ozone layer. The final action addresses refrigerants under the Climate Action Plan that calls on EPA's

Significant New Alternatives Policy (SNAP) Program to identify and approve additional climate-friendly chemicals.

Under the authority of the Clean Air Act, EPA's SNAP Program evaluates substitute chemicals and technologies that are safe for the ozone layer. The final rule expands the list of SNAP-approved substitutes to include more low-global warming potential (GWP) alternatives that can replace both ozone-depleting substances and high-GWP hydrofluorocarbons (HFCs).

Among the refrigerants and applications EPA is approving are ethane in very low temperature refrigeration and in nonmechanical heat transfer; isobutane in retail food refrigeration and in vending machines; propane in household refrigerators and freezers, vending machines, and in room air-conditioning units; and HFC-32 (difluoromethane) in room air-conditioning units.

Source: www.yosemite.epa.gov

China: new environmental label of RACs released

A new Environmental Protection and Low-GWP Label for room air conditioners (RACs) and air-to-water (ATW) heat pump water heaters was released in Shanghai in March. Addressing the the growing global concern about the environment, China's RAC industry is switching to next generation refrigerants to meet the challenges of ozone layer protection and global warming. The Label features 'one vision, two types of products, three standards, and five sponsors'. The five sponsors are China's Foreign Economic Cooperation Office of the Ministry of Environmental Protection, China Household Electrical Appliances Association, United Nations Environmental Programme, United Nations Industrial Development Organization, and Germany's Gesellschaft für Internationale Zusammenarbeit.

Source: JARN, April 25, 2015

New HCFC phase-out guides by UNEP

UNEP has produced two guides to assist developing countries in their phase-out of HCFC.

According to the Montreal Protocol, Article 5, countries were obliged to freeze baseline consumptions (average of 2009-2010 HCFC consumption) by 1 January 2013 and achieve a 10 % reduction in consumption by 1 January 2015.

The first guide "*Good Servicing Practices: Phasing out HCFCs in the Refrigeration and Air-Conditioning Servicing Sector*", was developed to help National Ozone Units and training institutions create HCFC phase-out training sessions for refrigeration servicing technicians.

The second guide "*Phasing-out HCFCs in Small and Medium-sized Foam Enterprises*" is aimed at manufacturers currently using HCFCs in the refrigeration, air-conditioning and other foam sectors.

Source: www.iifiir.org

A new angle on beating the R22 ban

Labelling cardboard cartons of refrigerant cylinders as R134a was not a clever idea. When customs opened the cartons, they found that the cylinders themselves were clearly stamped R22. The total consignment of some 20 tons was impounded by officials in Vyborg, Russia. Although R22 is still available in Russia, its price is high, encouraging the demand for cheap illegal import. Similar seizures of mislabeled refrigerants have been reported over the last twelve months, so it seems that the contraband market is still flourishing in Europe.

Source: JARN, April 25, 2015 and www.coolingpost.com

IIR Conference on ammonia and CO_2 refrigeration technologies

The 6th IIR Conference on ammonia and CO_2 refrigeration technologies was held in Ohrid, Republic of Macedonia, April 16-18, 2015. This was the first to be officially named NH_3/CO_2 Conference, and its success was very likely because CO_2 was added to the NH_3 tree.

In the Plenary Papers the following topics were discussed:

1. NH_3, Dr Andy Pearson.
2. CO_2 , Dr Armin Hafner/ Professor Pega Hrnjak.
3. Regulation, Mr Maurice Young/Mr Eric Smith.

A total of 12 pure NH_3 papers, 15 CO_2 papers and 4 Absorption papers were presented. There were 18 posters dealing with NH_3, CO_2, cascade systems, alternative improved materials, energy efficiency and oils. The phase down of HFC refrigerants was also discussed.
140 delegates registered for this meeting, which is nearly a 40 % increase over the previous ones.
Delegates came from about 35 countries including speakers and presenters from 23 countries. This was a unique IIR conference, where approximately 40 % participants are coming from developing countries which is a chance for exchange of experience and transfer of new technologies.
The remarkable advances in the number of CO_2 refrigeration applications were presented, both cascade and transcritical, and the application of ejectors in various ways. It would appear that the ejectors are much favoured over expanders, no doubt because of their simplicity, reasonably good performance and moderate cost.

The key message of the President of Organising Committee, Risto Ciconkov is:

"Instead to be occupied with a phase-down of HFC gases, drop-in refrigerants, retrofit of systems, environmental taxes, restrictions etc., let's start with a new approach: PHASE-IN of natural refrigerants."

Source: Klaas Visser, KAV Consulting Pty Ltd, Australia; Risto Ciconkov, Organising Committee

Technology

Technical trend of large compressors

The recent technical trend of large compressors, such as centrifugal and screw, is the use of variable speed motor control systems. Variable Frequency Drives (VFDs) have become a major part of the market, offering improved seasonal energy efficiency when compared to fixed speed applications. The Permanent Magnet (PM) motors for large capacity have also been developed after the rotary and scroll compressor PM motors, which improved their performance over wide operating load conditions. Another trend is that the oil-free centrifugal compressors combined with PM motors are now available over a wide capacity range. New compressors incorporating advanced technology started from small centrifugal compressors, and have now extended the chiller capacity up to 5 MW within the past five years.

Source: www.ejarn.com

New milk refrigeration system in rural India

In rural India, the dairy industry is very vulnerable to spoilage because of the poorly developed cold-supply chain. Farmers, often far away from central collection centers can use specialized bulk milk chillers. But, these systems don't allow for long enough cooling and depend on unreliable energy sources. Sometimes, up to 30 % of the production can be lost.

Sorin Grama and Sam White, founders of Promethean Power Systems developed a refrigeration system to help villagers. They designed a rapid milk chiller (RMC) using a thermal battery which cools a fluid, including phase-change materials inside a tank. The heat is evacuated by a compressor like a traditional heat-pump process. The RMC system cools the milk to 4 °C in a matter of seconds and allows for milk storage until pick up by a dairy plant. Installed for a village-level collection center, the system reduces transportation costs and improves milk quality, as a battery provides back up during power cuts. Engineers hope to apply this technology to perishable foodstuffs.

Source: www.iifiir.org

Markets

Ducted or ductless? That is the question

At the 2015 AHR Expo, it was clear that ductless air conditioning is attracting attention in the United States. It is interesting to compare the air conditioning markets of the US and Japan. For doing that, it is helpful to look at the factors that have led to the differences in their air conditioning cultures using the examples of room air conditioners (RACs) and packaged air conditioners (PACs). For small- and medium-capacity air conditioner units, ductless systems clearly dominate the Japanese market, while ducted systems are the mainstream in the US. See further the source.

Source: JARN, April 25, 2015

VRF market in China

China's GDP growth rate slowed to 7.5 % in 2014, putting some pressure on development in the central air conditioner industry. However, the domestic central air conditioner market bucked the trend with growth much higher than the overall economic growth. In China, central air conditioners include chillers, VRF, water- and ground-source heat pumps, unitary systems, and terminal systems.
According to marketing data from All View Consulting, total shipments of central air conditioners in China came to RMB 64.4 billion (US$ 10.3 billion) in 2014, up more than 12 % from 2013. Although the market growth rate was lower than in 2010 and 2012, when shipments reached record highs, double digit growth was maintained.

Source: JARN, March 25, 2015

New York moves to make utilities distributors of energy

The New York Public Service Commission (PSC) has issued an order largely barring utilities from owning distributed energy resources (DERs). DERs are small, decentralized grid-connected systems that distribute energy, often from renewable sources.

The state PSC issued a 133-page order establishing a "policy framework" for the development of markets for DERs and changes the role of traditional utilities in a move that fundamentally reshapes how core electric and natural gas utilities have always conducted business as the central mover behind the grid. In most cases, utilities will be barred from owning DERs, including demand response, distributed generation, and distributed storage. The directive envisions thousands of small power sources joining to replace baseload power.

Source: www.rtoinsider.com

Ongoing Annexes

IEA HPT Annex 40 Heat pump concepts for Nearly Zero Energy Buildings

Next Annex 40 working meeting in Helsinki, Finland

The objective of the work of IEA HPT Annex 40 is to investigate and improve heat pump systems applied in Nearly or Net Zero Energy Buildings (nZEB). Currently, nine countries - CA, CH, DE, FI, JP, NL, NO, SE and US - are collaborating in Annex 40.

The 5th Annex 40 working meeting was held in Nagoya, Japan, on 10/11 Nov. 2014. In the frame of the meeting, interim results of the national contributions were presented.

Task 2, which involves simulation studies of different system configurations, deals with system comparison and improvement concerning performance and cost. The different simulation studies confirm that heat pumps are very well suited as a system technology for nZEB. For instance, a feasibility study in Japan confirmed that medium-sized office buildings equipped with PV and efficient heat pumps can reach nZEB balance. In addition, design tools for heat pumps for use in nZEB are under development in Norway and the US.

Task 3 is dedicated to technology developments and field monitoring. The USA is running field tests of a residential testing facility for nZEB system technology (NZERTF) and for various highly integrated heat pumps. Larger field tests are ongoing in both the Netherlands and Germany. The work in the Netherlands is concerned with field tests in residential buildings, and goes under the name of the "Energy Leap" field tests. Germany is performing long-term monitoring of nZEB office buildings with heat pumps and thermally-activated building systems (TABS). The first Scandinavian nZEBs are being field-monitored as part of the work of the Annex.

Task 4 investigates options for local load management with respect to self-consumption of on-site PV electricity, and evaluates the load-matching characteristic of different technologies.

The next Annex 40 working meeting will be held in Helsinki, Finland, on June 15-17, 2015. As part of the meeting, a workshop with Finnish manufacturers and stakeholders will take place in the Finlandia Hall. The focus of the Annex working meeting is the discussion of the national project contributions and the preparation of deliverables. In addition, a technical tour to the largest ground-coupled heat pump in Finland is included. Annex 40 publications can be found on the Annex 40 website at http://www.annex40.net.

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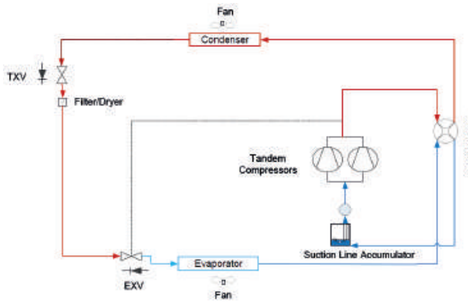
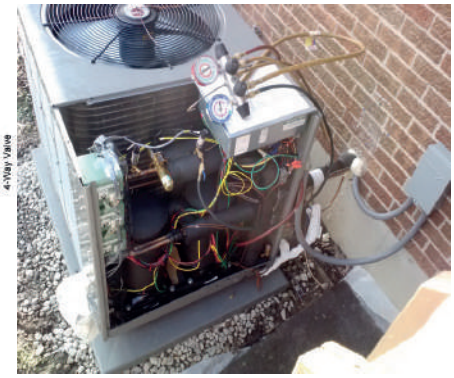
IEA HPT Annex 41 Cold Climate Heat Pumps (CCHP)

Annex 41 began in July 2012 to revisit research and development work in different countries to examine technology improvements leading to successful heat pump experience in cold regions. The primary focus is on electrically driven air-source heat pumps (ASHP) with air (air-to-air HP) or hydronic (air-to-water HP) heating systems, since these products suffer severe loss of heating capacity and efficiency at lower outdoor temperatures. The main outcome of this Annex is expected to be information-sharing on viable means to improve ASHP performance under cold (≤ -7 °C) ambient temperatures.

In the past quarter the Annex 41 summary interim report was posted to the Annex web site. The HPT Executive Committee approved an extension of the Annex through July 2016 at its Nov. 2014 meeting. The 3rd working meeting of the Annex was held on May 8, 2015 in Vienna at the Austrian Institute of Technology (AIT). AIT was also hosting a forum the day before the Annex 41 meeting, May 7 "Air Source Heat Pumps in Retrofitting Applications." The Annex 41 Operating Agent was one of the presenters; the presentation will include discussion of CCHP R&D activities within the Annex. The 2nd Annex 41 workshop is to be held in





Annex 41: 2015 CCHP field test; single-stage vapor compression cycle with dual single-speed compressors – schematic (left image) and field test prototype system installed in late January at residence in Ohio. [Source: Oak Ridge National Laboratory and Copeland Compressor]

August 2015 in Yokohama, Japan during the 24th International Congress of Refrigeration (ICR). A program for the workshop is posted on the ICR web site (*www.icr2015.org*). The program was discussed and finalized at the May 8 working meeting.

The Annex web site is http://web.ornl.gov/sci/ees/etsd/btric/usnt/QiQmAnnex/indexAnnex41.shtml

Contact: Van D. Baxter, baxtervd@ornl.gov

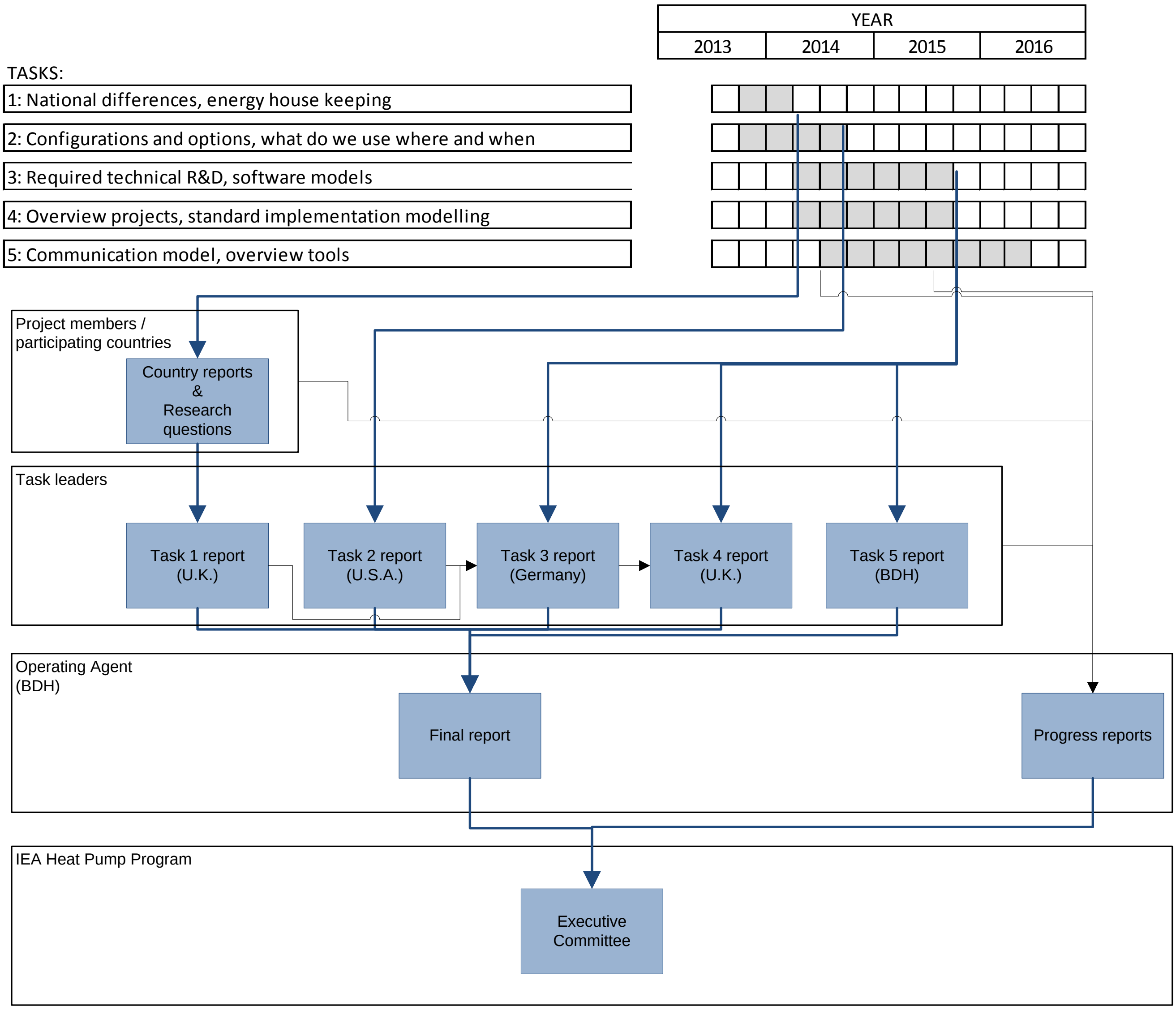
IEA HPT Annex 42 Heat Pumps in Smart Grids

Started in Summer 2013, Annex 42 is at full speed with the following participants:

1. United Kingdom (Department of Energy and Climate Change, Delta-ee)
2. The Netherlands (RVO, DHPA, Berenschot E & S, Alliander, TNO Innovatie)
3. South Korea (Korean Institute for Energy Research (KIER)
4. USA (Oakridge Laboratory, Electric Power Research Institute (EPRI)
5. Switzerland (Hochschule from Luzern)
6. Denmark (Danish Technology Institute (DTI)
7. France (Electricité de France (EDF)
8. Germany (Fraunhofer ISE)
9. Austria (Austrian Institute for Technology (AIT) and University of Graz).

The execution of the Annex 42 is based on a project breakdown as shown in Table 1.

Table 1: Annex 42 Project break down

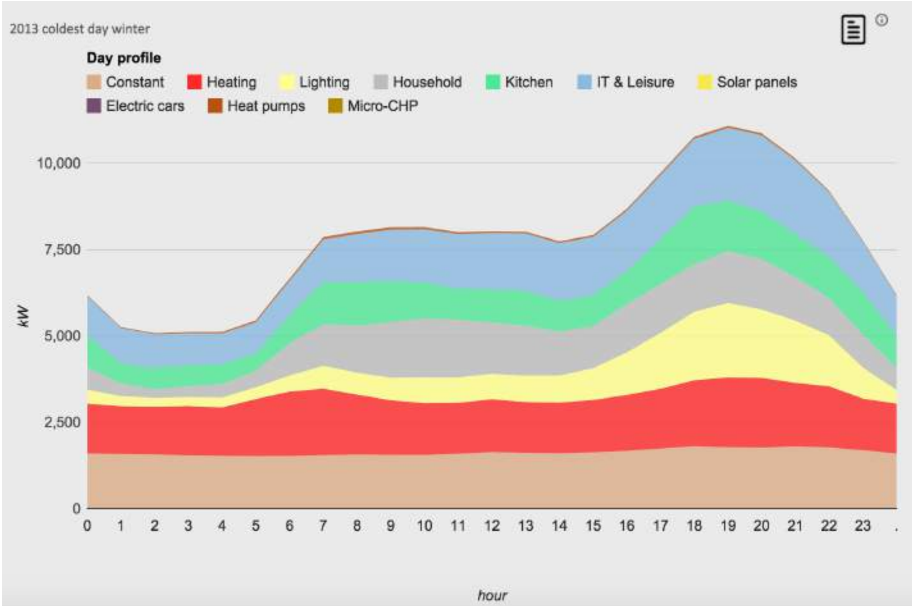


Flexibility and storage are the essential elements for successful implementation of heat pumps in smart grids, and consequently these have been the main topics for several meetings within the Annex.

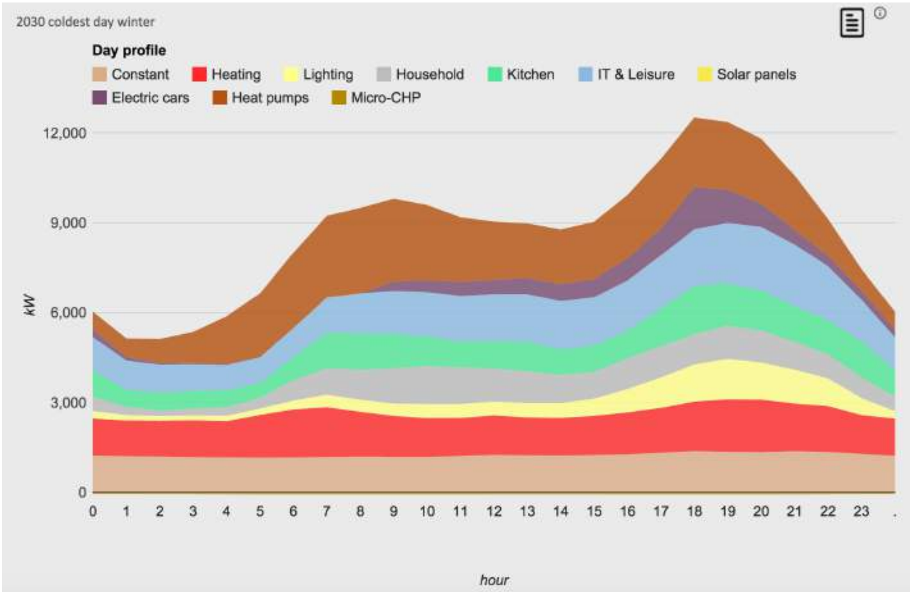
Each country identified four case scenarios consisting of its housing stock, for a typical heat pump application combined with a specific housing type.
With these case scenarios, now defined simulations will be made of the flexibility and storage potential these cases offer in a smart grid context. Aggregated projections will then be available for estimating the true potential of heat pumps in smart grids in domestic housing in the nine countries in this Annex.
Due to the variation in energy systems, building stock, heating habits and energy costs, a wide variety of case scenarios is identified in the various countries. This variety will offer a wealth of insights and knowledge during the second half of this project, January 2015 until September 2016.
A visualization on the necessity on smart grids technology for heat pumps, by means of developing flexibility and suitable storage options, can be found in the graphs below, which show a typical urban area's power consumption on a coldest winter day, when heat pumps run at full load, in 2013 and 2030.

Figure 1 shows a typical 24 hour load profile for the electricity grid in an urban area, in 2013 with negligible loads from heat pumps.

Figure 2 shows significant increases in grid load even at a modest penetration of heat pumps in the same area. This emphasizes the necessity of smart grids, by means of flexibility and storage, and at the same time it indicates the huge potential for handling electricity from renewable, intermittent production by means of heat pumps.



Annex 42: Figure 1. Coldest day in winter 2013 [Source: BDH, Scenario tool domestic energy consumption]



Annex 42: Figure 2. Coldest day in winter 2030 [Source: BDH, Scenario tool domestic energy consumption]

Task # 1, Country report has been finalized.
Task # 2 and 3 are on track. The task will be finalized during summer 2015.
Task # 4 and 5 will start in the course of 2015, as parallel activities.
Delivery of the summary report is foreseen for Q3/Q4 – 2016.

Next Annex 42 meetings will be in June 2015, at Department of Energy and Climate Change (DECC) in London-UK, and in November 2015 at Austrian Institute Technology, Vienna-Austria.

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IEA HPT Annex 43 Fuel-driven sorption heat pumps

During the period while work was in progress on Annex 34 “Thermally Driven Heat Pumps for Heating and Cooling”, there was a growing interest in the area of fuel-driven sorption heat pumps, with more and more products approaching market release. A new Annex, “Fuel-driven sorption heat pumps”, was therefore proposed to the ExCo in March 2012. After an Annex definition meeting, a legal text was compiled and accepted as a draft by the ExCo. The new annex, Annex 43, started officially in July 2013, with a planned duration of four years. A kick-off meeting was held on October 9-10 2013 in Freiburg, with participants from six countries. The main topics were finalisation of the legal text and the work plan, and the setting up of the organisational framework.

Objectives

The scope of the work under this Annex will be the usage of fuel-driven sorption heat pumps in domestic and small commercial or industrial buildings or applications. If applicable, the additional possibility of supplying cold will also be considered. The main goal is to widen the use of fuel-driven heat pumps by accelerating technical development and market readiness of the technology, as well as to identify market barriers and supporting measures.

The Annex structure

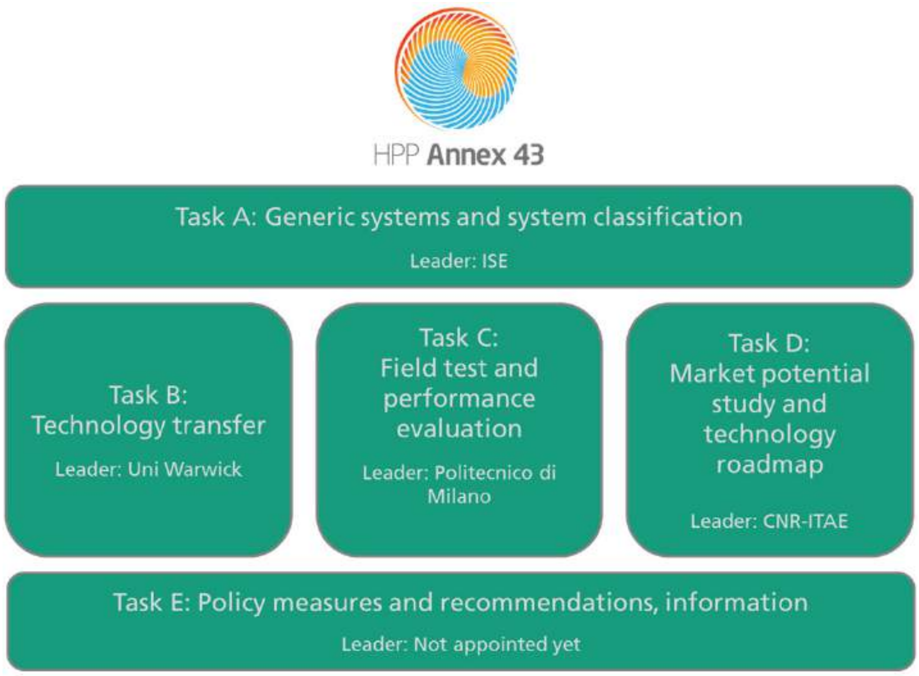
The tasks are further specified as follows.

Task A: Generic Systems and System Classification

- Available sources and heating systems
- Existing market and regulatory boundary conditions

Task B: Technology Transfer

- Link research to industrial development for faster market penetration of new technologies



Annex 43: Annex structure

Annex 43: Field test of a new prototype of an absorption heat pump.

- Novel materials (e.g. Metal-Organic Frameworks for adsorption heat pumps)
- Novel components (integrated evaporators/condensers, compact heat exchangers)
- System designs (e.g. façade collector as heat source)

Task C: Field test and performance evaluation

- Measurement/monitoring procedure standardisation (e.g. how to cope with different fuel quality, system boundaries, auxiliary energy, etc.)
- Extend standards to seasonal

performance factors at the system level

Task D: Market potential study and technology roadmap

- Simulation study to evaluate different technologies in different climate zones, different building types and building standards
- Combine with market data and actual building stock for technology roadmap

Task E: Policy measures and recommendations, information

- Dissemination
- Workshops for planners, installers and decision makers
- Develop recommendations for policies, e.g. building codes and funding schemes

Within Task A, a template for the country report was prepared by ISE and sent out to the participants.
A presentation on the annex was given at the Heat Pump Summit 2013 in October 2013 in Nuremberg, Germany, and at several more local events.

So far, six countries have confirmed joining the annex (AT, DE, FR, IT, UK, USA). Further countries have expressed their interest (Korea, China), but of course more participants are welcome.

The second meeting was held on June 4-5 2014 in Paris, with about 19 participants from seven countries. Participants agreed on the work plan for the next six months, and exchanged information on earlier work. The next meeting will be held on 6/7 November 2015 in Freiburg, Germany

More fuel-driven sorption heat pumps entered the market in summer 2014, and more field trials are in progress.

More information about the annex can be found at:
https://www.annex43.org/

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IEA HPT Annex 44 Performance indicators for energy efficient supermarket buildings

During the most recent working meeting of Annex 44 "Performance Indicators for Energy-Efficient Supermarket Buildings" in Stockholm on February 27th, 2015, a representative from Danfoss was present to discuss the possible participation of Denmark in this annex. There is a strong shared interest in using the large amount of available measurement data, and trying to find ways of extracting useful information from it, related to energy efficiency. Participation from Denmark now still depends on acquiring funding for the work on the Danish side.

Based on the data collected in the Netherlands, a scientific paper has been drawn up to be presented at an international refrigeration conference this summer. The paper goes into detail on analysis of the electricity consumption data. This analysis shows that the conventional technical performance indicators (such as sales area, opening times and installed energy-saving options) are not sufficient by themselves to explain differences in energy efficiency of supermarkets. The (preliminary) conclusion is that non-technical issues, such as personnel training, maintenance and management focus, also contribute to the overall energy efficiency. Furthermore, unconventional technical parameters, such as system dynamics, may play a role in the overall energy efficiency. The focus of the Annex will shift towards these issues in the coming months.

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Ongoing Annexes

Bold text indicates Operating Agent.

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 39 A common method for testing and rating of residential HP and AC annual/seasonal performance	39	AT, CH, DE, FI, FR, JP, KR, NL, **SE**, US
Annex 40 Heat Pump Concepts for Nearly Zero-Energy Buildings	40	CA, **CH**, DE, FI, JP, NL, NO, SE, US
Annex 41 Cold Climate Heat Pumps (Improving Low Ambient Temperature Performance of Air-Source Heat Pumps)	41	AT, CA, JP, **US**
Annex 42 Heat Pumps in Smart Grids	42	AT, CH, DE, DK, FR, KR, **NL**, UK, US
Annex 43 Fuel Driven Sorption Heat Pumps	43	AT, **DE**, FR, IT, UK, US
Annex 44 Performance Indicators for Energy Efficient Supermarket Buildings	44	**NL**, SE
Annex 45 Hybrid Heat Pumps	45	**NL**
Annex 46 Heat Pumps for Domestic Hot Water	46	**NL**
Annex 47 Heat pumps in District Heating and Cooling systems	47	**DK**

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

Space cooling in North America: Market overview and future impacts

Van D. Baxter, Gannate Khowailed, Karen Sikes, and Tyler Grubbs, USA

The North American space cooling market, particularly in the United States, is experiencing shifts in regulatory regimes, population patterns, economic conditions, and consumer preferences - all catalyzed further by rapid technological innovation. Taken together these factors may result in a slight reduction in air conditioning shipments in the short term, however the longer term trends indicate a continuing increase in the number of air conditioning systems in the U.S. markets. These increases will be greatest in the warmer and more humid (e.g. higher load demand) regions. This will result in increasing pressure on the U.S. electricity supply system to meet the energy peak and consumption demands for building space cooling.

Introduction

An air conditioning (AC) system is a type of heat pump system that only provides space cooling. In the U.S. most ACs are sold together with some type of space heating system – generally a central air distribution gas, oil, or electric warm air furnace or as part of a reversible central whole house heat pump (HP) system. ACs provide both sensible space cooling (air temperature control) and latent cooling (space humidity reduction) but in most cases are controlled only by a simple thermostat responding to the indoor space temperature.

Several elements that appreciably influence the air conditioning (AC) manufacturing industry in North America are identified and discussed in this article, including new energy efficiency mandates, population growth in and migration towards warmer climates, the now universal preference for space cooling in new building construction, and the aging stock of existing AC equipment.

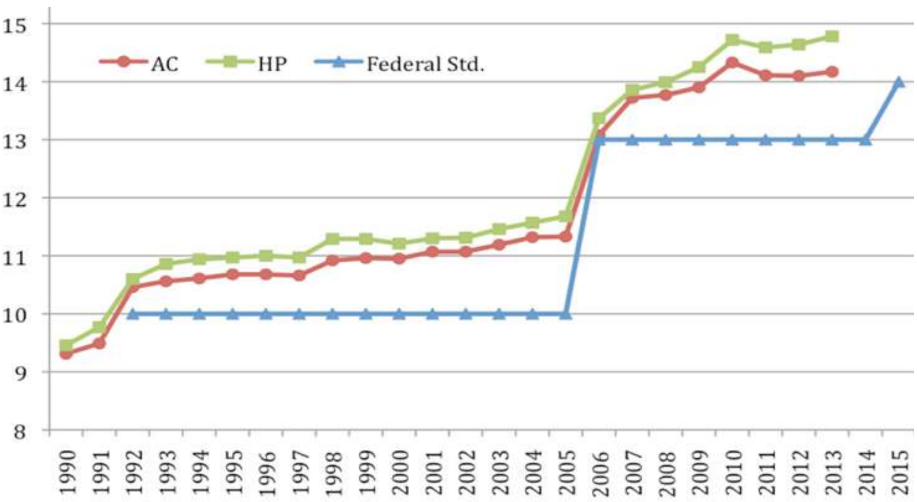

Figure 1. U.S. shipment-weighted average seasonal efficiency (SEER) for central ACs and HPs. Source: AHRI [1]

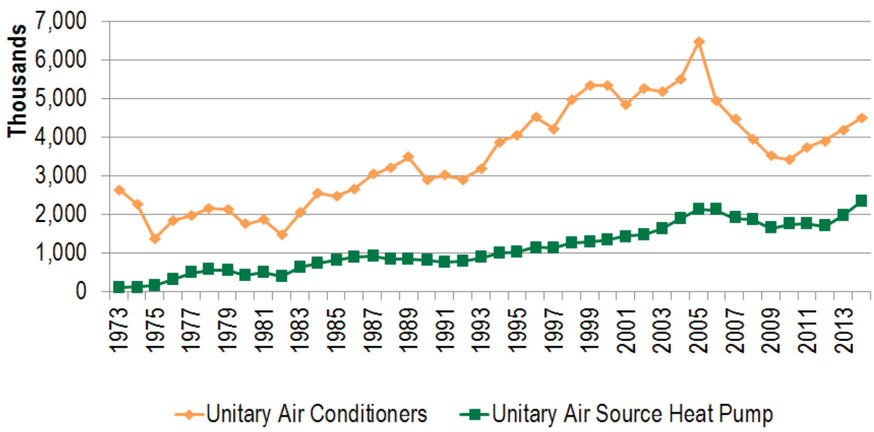

Figure 2. U.S. central AC and HP shipments 1973-2014. Source: AHRI Annual Shipment Data [1]

Market impact of regulatory changes

On January 1, 2015 the U.S. Department of Energy commenced enforcement of more stringent efficiency standards as measured by the cooling seasonal energy efficiency ratio (SEER). These standards vary by region (North, South, and Southwest). Single package systems in the North, as well as single package and split systems in the South and Southwest, are now required to have a minimum SEER of 14 Btu/Wh (COP_c of 4.1). Split system units in the North are required to have a new minimum SEER of 13 Btu/Wh (COP_c of 3.8). Meeting the new efficiency standards should not be a problem for manufacturers. Shipment-weighted average SEERs for split HPs and split ACs already exceeded the new minimum by 2009 and 2010, respectively, potentially indicating a smoother adoption curve for the majority of manufacturers (Figure 1).

A similar, though more dramatic, escalation of minimum SEER from 10 to 13 Btu/Wh (COP 2.9 to 3.8) took effect in 2006. In 2005, unit shipments increased by about 20 % compared to the previous average annual shipments for 2002-2004 as manufacturers aggressively moved non-compliant inventory before the approaching enforcement date (Figure 2). For 2006 shipments dropped below the 2002-2004 average by almost 10 %. This may be attributed at least in part to diminished production capacity as manufacturers were unable to produce at full capacity while retooling to produce equipment compliant with the 2006 regulations.

How might this latest round of regulatory changes impact aggregate HP and AC shipments? In an attempt to gain insight, Figure 3 shows monthly changes in AC shipments compared to previous year data for December 2013 through February 2015. Using this methodology, growth trends can be observed absent any normal seasonal variations. Shipments in December 2014 for instance were 50 % higher than in December 2013. This is consistent with the 2006 vs. 2005 observations, again indicating that the increased efficiency mandates may have led to aggressive movement of older, non-compliant units into the market. The January and February 2015 shipment increases over the 2014 levels and remain high but appear to taper, possibly as the last inventory of the pre-2015 units are shipped. We would expect HP and AC shipments to continue to taper down for the remainder of 2015 but to a lesser extent than seen in 2006, as the mandated SEER increases are only a third of what they were at that time.

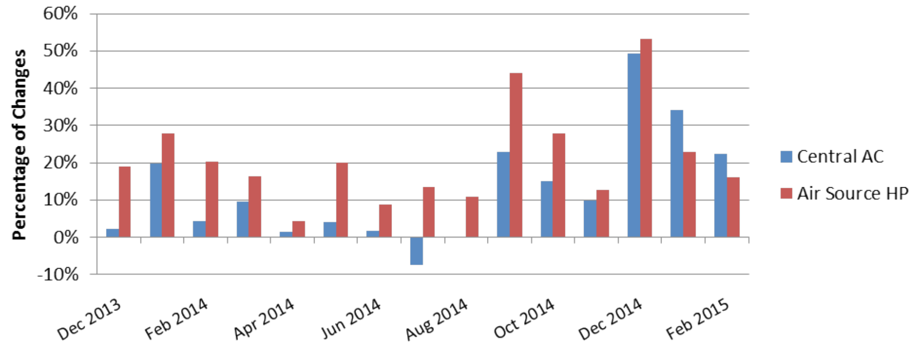

Figure 3. Monthly U.S. shipments for central ACs and HPs, change vs. previous year. Source: AHRI [1]

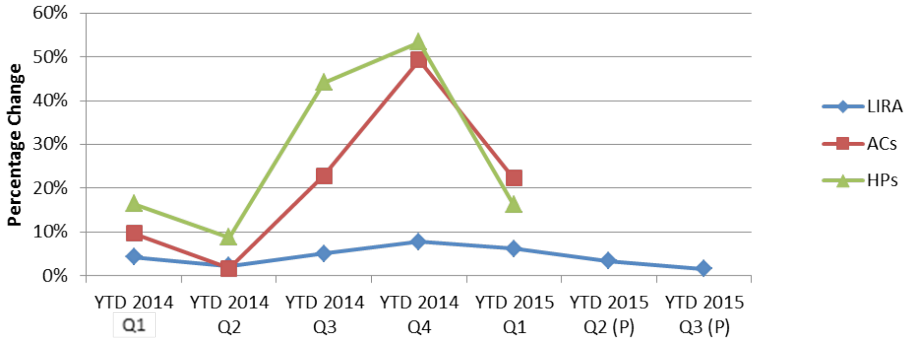

Figure 4. Year to date change by quarter of AC and HP shipments and the LIRA vs. previous year [4]

Economic outlook

As 74 % of HP shipments are absorbed by the replacement and add-on markets [2], the Leading Indicator of Remodeling Activity (LIRA) published by the Joint Center of Housing Studies of Harvard Universities (JCHSH) [3] may be a good indicator of broader economic conditions applicable to HP and AC shipment expectations. The LIRA tracks home improvement spending for the current quarter and estimates it for the subsequent three quarters. Measured as an annual rate-of-change of its components, the LIRA offers short-term guidance on homeowner remodeling activity and may help identify future inflection points in the home improvement market.

Figure 4 shows the year to date change per quarter for HP and AC shipments and the LIRA indicator. A regression analysis yielded a coefficient correlation of 0.94 between AC shipments and the LIRA. A slightly weaker, though still statistically relevant, value of 0.71 was associated with HP shipments and the LIRA. Therefore, the LIRA appears to be a valid indicator of economic conditions vis-à-vis growth in the space cooling market as measured by shipments.

Due to the projected slight drop in the LIRA for the second and third quarter of 2015 and the impact of efficiency regulation discussed earlier, U. S. AC shipments may suffer slightly, or at least not increase greatly over 2014 levels, during the next two quarters of 2015.

Space cooling current inventory and shipments

As of 2009, 99 million or 83 % of U.S. residences use some kind of AC equipment, either a cooling only AC or a heat pump AC, and this number continues to grow [4]. The remainder of U.S. housing units in 2009 either had an AC unit but did not use it (4 %) or did not own an AC unit (13 %). Of the housing units that used an AC unit, the majority used central ACs or HPs (80 %) as opposed to wall or window ACs. The use of AC varies significantly across

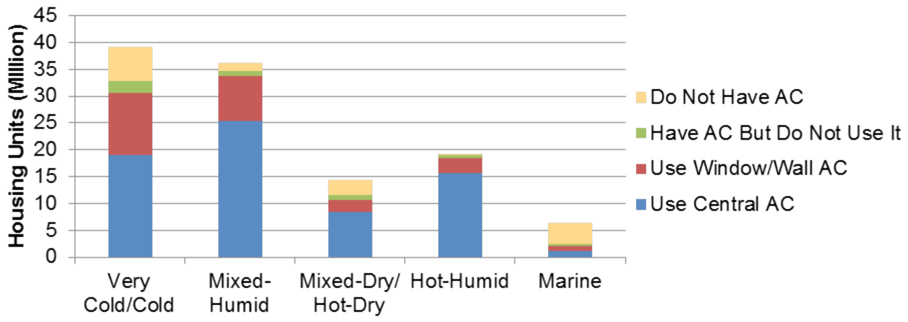

Figure 5. AC penetration in U.S. housing stock [4, Table HC7.6 Air Conditioning in U.S. Homes, by Climate Region]

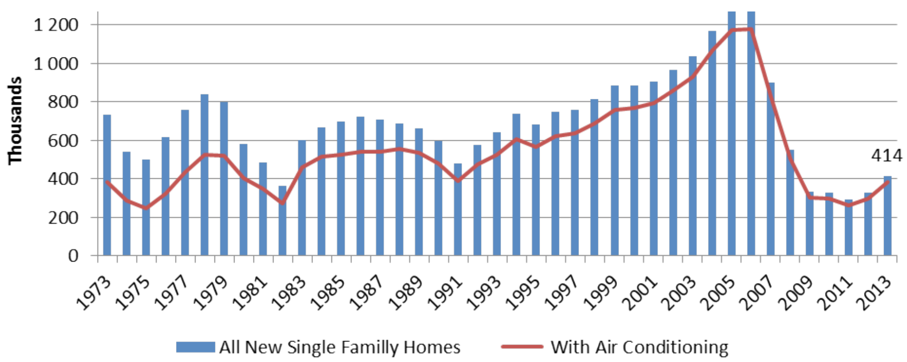

Figure 6. AC penetration overlaid with single family home construction [5]

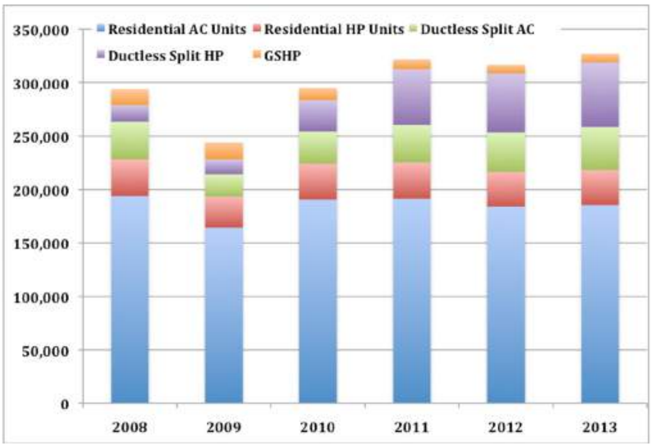

Figure 7. Canadian heat pump and AC sales, 2008-2013 [7]

climate regions, as shown in Figure 5. The housing stock using AC in the combined Mixed-humid and Hot-humid climate represents about 55 % of all AC units used in the United States [4].

As mentioned earlier about 70 million U.S. homes, or 80 % of those using ACs, rely on central AC for their cooling needs. About 15 million U.S. homes are older than 15 years and another 16 million U.S. homes have AC units between 10 and 14 years old. It is anticipated that a large portion of these 31 million homeowners will be in the market for a replacement in the next few years assuming an average unit lifespan of 15-20 years [4].

Space cooling penetration in the new housing and population patterns

Figure 6 shows that AC presence in new U.S. single family homes grew from 52 % in 1973 to 92 % in 2013. This same degree of penetration can be seen in multifamily units, with 93 % using AC as of 2013 [5].

100 % of new homes built in the South have ACs due to the relatively hot climate and high cooling loads. The greater AC load in the South is demonstrated by its average site AC energy usage of 3 165.3 kWh/year in 2013, compared to 1 817 kWh/year in the West, the next most intensive energy-consuming region. The Mid-West and Northeast regions round out the group, with 879 and 674 kWh/year, respectively [6].

In 1973, the Southern U.S. Census region (hot-humid and mixed-humid climate zones primarily) accounted for 43 % of new home construction, and by 2013 this share had grown to 53 %. To lend some context to overall population trends: in 2013 the West, Mid-West, and Northeast Census regions combined saw 194 000 new single family homes constructed compared to 220 000 in the South region. Americans continue to move to the South and, to a much lesser degree, the West. Since these two regions have the highest AC loads and population, it appears certain that U.S. AC energy consumption will continue to increase. Demand pressure on the U.S. electric utility grid will continue growing for the same reason.

Canadian AC market

According to Figure 7, between 2008 and 2013 Canadian residential AC sales (central systems and ductless split ACs combined) remained relatively constant at ~ 220,000-230,000 units annually (apart from 2009) [7]. The cooling only (AC) share of sales dropped from ~80 % of the AC+HP total in 2008-2009 to ~70 % in 2012-2013. Overall residential AC and HP annual sales increased to roughly 320 000 units per year for the 2011-2013 timeframe due mainly to growth in the ductless split HP market. According to the most recent available data (HRAI 2015) AC shipments show a decline of 17 % and 20 % in 2014 vs. 2013 for commercial and residential air conditioning, respectively [8].

Concluding Observations

Due to current trends of continuing and accelerating population shifts towards warmer regions of the United States where cooling needs are greatest, it seems clear that AC (and HP) shipments will increase over the long term. The AC share of U. S. annual energy use will continue to increase as well (all other things being equal). This will result in continuing pressure on the U. S. energy supply infrastructure, primarily the electric energy grid to meeting the increasing power peak and annual energy demand. The U.S. is not an isolated case in this regard. Developing countries in warm regions of the world (SE Asia, India, South America, etc.) are experiencing significant economic growth and thus increasing demand for AC systems as well. Fortunately the trend in AC system efficiency is also increasing and this will help moderate the energy demand and consumption growth. Further efforts to increase the efficiency of AC systems as well as to reduce AC loads in buildings are needed to control AC energy demand long term.

A few "discussion starter" possibilities for future HPT Annex activities to address AC equipment and system efficiency improvement are offered:

- Investigate technology solutions to separate the latent (dehumidification) part of the AC load from the sensible (space temperature control) part of the load so each could be handled in the most efficient manner. A combined vapor compression (VC) system for sensible cooling with a desiccant or other system for latent cooling is one possibility – heat rejection from the VC cycle could help provide desiccant regeneration energy.

- Examine applications of thermal energy storage to AC and HP systems. Identify technical solutions to reduce electric grid power peak by shifting AC loads to off-peak times without increasing annual energy use. Collaboration with the Thermal storage IA might be fruitful here.

- Investigate the potential for alternative, non-vapor compression refrigeration cycles. Might there be a breakthrough solution there?

- Other ideas and approaches are welcome to this discussion.

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Reversible heat pumps for space cooling and air conditioning: French market and R&D needs

Michèle Mondot, France

This article presents market trends in France for space cooling and air conditioning systems. Due to European regulations and development of (very) low energy consumption buildings, reversible heat pumps will find an increasing interest for air conditioning and cooling of buildings. However, improvements on energy and comfort aspects are still needed for a wider and more efficient dissemination of the technology.

Other alternatives than mechanical cooling may also be envisaged. However, technologies such as passive cooling are neither mature enough, nor cost effective enough, in order to be widely used.
The article highlights different areas for R&D to be considered for improvement of heat pumping technologies applied to building cooling and air conditioning, which may be of interest for new IEA HPT Annexes.

Introduction

IEA Heat Pumping Technologies Implementing agreement (HPT IA) activities are mainly dedicated to the use of heat pumps for space heating or industrial applications. However the IEA HPT is interested in broadening its field of activities, to extend its contribution to the development of the heat pumping technology when used for cooling and air conditioning applications.

Market trends for air conditioning in France

When considering air conditioning (AC) products, two different markets can be identified. Residential buildings need air conditioning that is "weather dependent". This is mainly achieved by using reversible air-to-air heat pumps, and the range of capacity to be considered is up to 17.5 kW. In the commercial and service industry sectors, air conditioning is needed all year round due to constant heavy building internal loads. Chillers and fan coils, roof-tops or VRF (Variable Refrigerant Flow) systems are usually installed and the capacity range goes up to a few MW.

The following figures issued by PAC&Clim'Info [1] for France show the different product market shares. In residential applications about 350 000 outdoor units were sold in 2013 which is representative of a quite stable market since 2008. Units below 5 kW represent about 70 % of the monosplit units, while 70 % of multisplit systems have capacities between 2.7 and 7 kW.

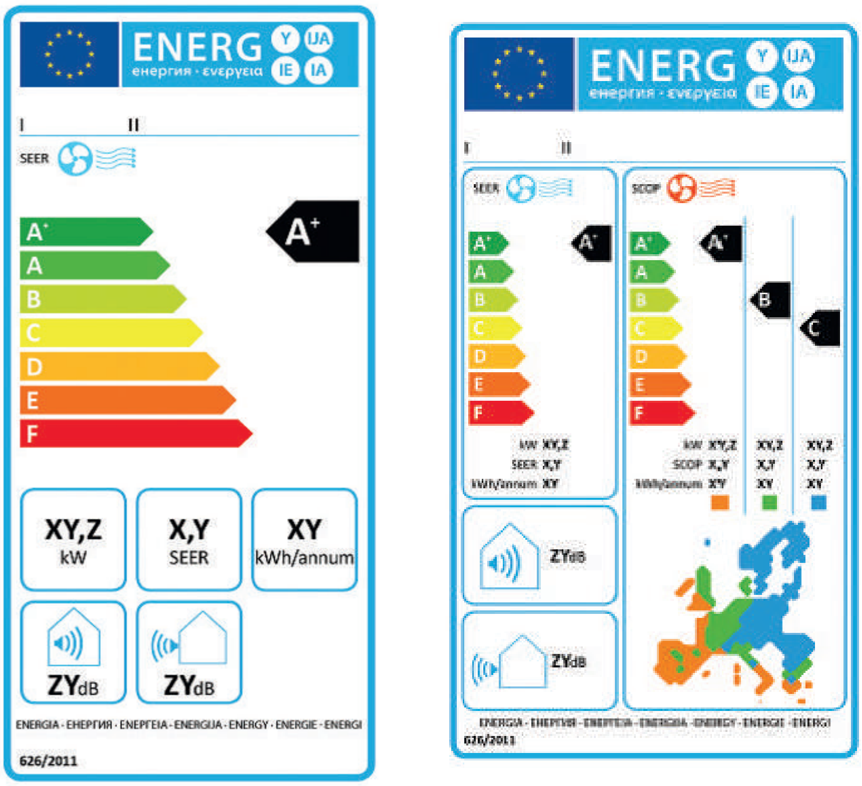

Figure 1. Energy labelling of air-to-air conditioners < 12 kW - Labels as applicable from 1st January 2015 (left hand side: cooling only units – right hand side: reversible units)

Air-to-air units above 17.5 kW represent a decreasing market, with more than 4 000 outdoor units sold in 2014, while the VRF market is more stable with 15 000 outdoor units and 125 000 indoor units.

Roof-top units constitute a very specific market as they are mainly used in large commercial buildings, theatres and sport halls, and also have a ventilation function. In a steady market of about 1 400 units, 90 % are reverse cycle units and provide both heating and cooling.

When considering chillers, the market in 2014 was 6 600 units, air-cooled or water-cooled systems.
60 % of the market is covered by units in the range of 17.5 to 200 kW. Larger capacity units represent 25 % and lower capacity units only 15 % of the market share.

Energy efficiency and environmental regulations

All AC products are or will be covered by Energy efficiency regulations with Minimum Energy Performance requirements (MEPs), linked to the European Directives on Ecodesign [2] and Energy Labelling [3].

Since January 2013, air-to-air units below 12 kW must comply with MEPs defined for cooling mode as seasonal energy efficiency ratio SEER [4]. The label to be used to show the energy efficiency class of a product from January 2015 is represented in Figure 1 [5], previous page.

MEPs became even more stringent in January 2014. SEER ranging from 3.87 to 4.6 - depending on the capacity range and the GWP of the refrigerant used - must be achieved for placing products on the European market.

For larger AC units, VRF systems and chillers, a draft regulation is under preparation with an expected entry into force by January 2017 [6].

The envisaged minimum seasonal space cooling energy efficiencies expressed in % correspond to SEER values ranging from 3.9 for air-cooled chillers to 6.4 for water-cooled chillers. For air-to-air conditioners, SEER of 4 to 4.5 may be required.

If these MEPs are maintained in the final regulation, a large range of products will have to be withdrawn from the market in 2017 if no efficiency improvement is achieved.

It is also to be noticed that these MEPs will have to be obtained with the use of low GWP refrigerants as the F-gas regulation [7] is planning a phase down of the refrigerants such as R410A, R407C or R134a used today in AC products. Furthermore, the use of HFCs with GWP > 750 in small AC units with less than 3 kg of refrigerant charge will be banned from January 2025.

The so-called EPBD, Energy Performance of Buildings Directive [8], also has an influence (although indirect) on the need for improvement of air conditioning systems.

To fulfil Article 3 of the EPBD requiring the Member States to adopt a method for calculation of energy consumption of buildings, the French Building code RT2012 was developed. The building shall demonstrate annual energy consumption per m² lower than a threshold value. With the exception of some areas and buildings where air conditioning will be allowed

- due to noisy environment and/ or non-opening of windows for safety reasons
- the maximum allowable energy consumption does not include consumption from cooling equipment.

Installation of a cooling system will only be possible if all other equipment (ventilation, heating, domestic hot water production) is very energy efficient so that the total energy consumption of the building including cooling still not exceeds the maximum allowable energy consumption.

However, it is well known that although very low energy consumption buildings are well insulated for reducing heating loads, they may require cooling during summer in order to maintain comfort for the occupants.

Development of high efficient air conditioning systems can thus be foreseen in response to real cooling needs as well as to regulations.

Passive cooling

As an alternative to mechanical cooling by means of a heat pump cycle, free cooling and passive cooling can be envisaged.

Geothermal heat pumps may offer geo-cooling by means of a direct heat exchange between the ground and the cooling emission system in the building. The compressor is thus not running, and electrical consumption is due only to the circulation pump. By rejecting heat into the ground during summer, geo-cooling will provide a higher temperature of the ground heat source at the beginning of the heating season, thus improving the efficiency of the heat pump in heating mode.

Because of its low cost and effectiveness, evaporative cooling is an interesting alternative in hot and dry climate. Its main applications today are food storage and precooling. However, evaporative cooling can also be efficient for air conditioning of buildings.

In IEA "Energy Conservation in Buildings and Community Programme" (EBC) Annex 28 "Low energy cooling systems" in the late 1990s, a review of low energy cooling technologies was conducted, to assess the main type of applications for each technology.

Passive cooling systems are today rarely used in France, except in Research and Demonstration projects.

R&D needs for improvement of air conditioning

This overview of regulatory aspects has shown that achieving high MEPs, leading to competition between the manufacturers, will contribute to improvement of the energy efficiency of AC products. Improvement can be obtained by using more energy efficient components (e.g., motors), new but more complex thermodynamic cycles, or other concepts. Energy efficiency aspect will also be addressed when looking for low GWP alternative refrigerants for heat pumps in cooling mode.

In residential buildings where mainly reverse cycle heat pumps are used, reduced heating loads will require a new optimised design of the product for high performance in both heating and cooling modes.

Air conditioning under our European climate sometimes has a “bad image”: unnecessary energy consumption, hygienic and health considerations, discomfort aspects such as sound power level or cold air streams, etc. However, it is demonstrated that comfort temperature conditions in buildings during warm days will provide better wellness of the occupants and higher efficiency at work. Therefore it is important that cooling comfort becomes as “normal” as heating comfort.

Up to now, the IEA HPT has mainly considered heat pumps for heating purposes. The cooling function of heat pumps has been studied within the IEA EBC Annex 48 “Heat pumping and reversible air conditioning”. The aim of the Annex conducted between 2005 and 2011 was to promote the best heat pumping techniques applicable in air conditioning of commercial buildings. Focus was given to the integration of these techniques, providing information about the best use of currently available technologies.

Conclusions and recommendations from EBC Annex 48 could be considered as a starting point for defining new HPT annexes on cooling heat pumping.

Conclusions

Up to now, HPT annexes have mainly focused on the use of heat pumping technologies for heating purposes. However, market and regulation trends in France show that there is place for improvement of the technology for cooling applications. Several issues such as improvement of energy efficiency, use of new components or refrigerants, air quality and comfort are already identified, and may constitute first ideas for new international R&D projects within the IEA HPT.

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[7] Regulation (EU) No 517/2014 of 16 April 2014

[8] Directive 2010/31/EU on the energy performance of buildings

Safety and energy-saving resulting from early detection and prevention of leakage of low-flammable refrigerants

Masahide Sumi, Japan

Leakage of refrigerants represents a high cost in terms of the energy required in refrigeration and air conditioning devices. As it is expected that low-flammable refrigerants will be used in many devices in the future, this issue can be very important for the global environment, energy saving and safety. The following article describes detection systems which can easily detect and identify leakage at an early stage, and a method which can easily prevent leakage from plumbing and joints of air conditioning equipment.

Introduction

The HFC-32 refrigerant was launched to replace R410A in the refrigeration and air conditioning market. In the automotive air conditioning market, R134a is likely to be replaced by HFO-1234yf.

Leakage during operation from these devices has become a problem in Japan, and the "Act on Rational Use and Proper Management of Fluorocarbons" was promulgated as a countermeasure and was enforced from April 1, 2015. The important point is to prevent, detect and rectify refrigerant leakage at an early stage. However, different design and construction technologies, as well as leakage detection and prevention technologies, are necessary for the next-generation refrigerants that will be used from now on. Let us introduce some methods below.

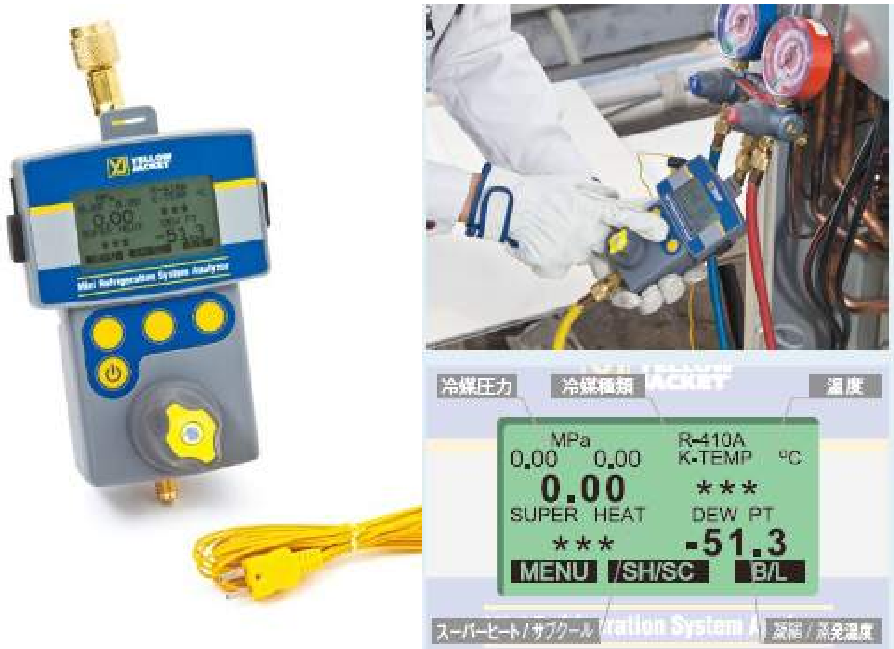

Figure 1. Refrigeration System Analyzer II

Current leakage detection

Various instrumentation systems use an indirect method to confirm abnormal conditions in air conditioning systems.

One indirect method uses a digital manifold to provide temperature and pressure monitoring. Some products on the market display superheat and subcooling temperatures that are calculated from the refrigerant data. Using these manifolds, possible problems or faults can be estimated by comparing these data with the actual temperature.

We are working on the introduction of a new technique that can become a powerful weapon in indirect method checks in the future. The Analyzer II instrument, shown in Figure 1, is preloaded with 97 items of refrigerant data (with capacity for more data to be added if required), from which it calculates and displays subcooling and superheat temperatures. Confirmation of abnormal refrigeration and air conditioning conditions is provided by comparing digital temperature and pressure measurements from thermocouples with these calculated temperatures. This is the most suitable digital indirect method for leakage detection. It is possible to perform a digital indirect inspection using only the Analyzer II. As a result, many measuring instruments can be replaced by this single instrument.

Leakage detection methods that are used in Japan are shown in Table 2. The detection methods that are most widely used are foam-

Table 1. Next-generation refrigerants

	HFC-32	HFO-1234yf
GWP	675	0
ASHRAE safety group	A2L	A2L
Flammability	Lower flammability	Lower flammability
Explosion limits	Max. 29.3 vol.% Min. 13.3 vol.%	Max. 12.3 vol.% Min. 6.2 vol.%

Table 2. Leak detection methods

Classification	Methods	Gas
Foaming liquid	Foam leak detection	All
Portable electronic detector	Corona[1]	CFC, HCFC
	Semiconductor[2]	CFC, HCFC
	Heating semiconductor[3]	HCFC, HFC
	NDIR[4]	HCFC, HFC, CO_2
Fixed electronic detector	Semiconductor[2]	CFC, HCFC, HFC
	NDIR[4]	HCFC, HFC, CO_2
Fluorescent	Fluorescent solutions and UV light	all

1) Watch voltage variation by corona discharge.
2) Watch the value of electric current flow to semiconductor.
3) Heat a semiconductor to achieve sensitivity.
4) Non-Dispersive Infra-Red (NDIR) detectors. Watch the absorption change of a specific infrared ray.

ing liquid and portable electronic detectors (leakage detector). In the portable electronic detector market, semiconductor methods and semiconductor temperature measurement methods account for a large percentage. Electronic detectors with Non-Dispersive Infra-Red (NDIR) detectors have come into use over the last several years.

The latest model of NDIR leakage detector has a high performance of detection sensitivity. It also includes a special function that can more easily identify the position of a leak, thanks to an infra-red absorption type sensor and various functions such as detection and indication of leakage with 36 levels of automatic sensitivity switching function and peak hold function.

Problems of low-flammable refrigerant detection

There are some points to keep in mind regarding the next-generation HFC-32 and HFO-1234yf refrigerants (Table 1).

1. It is desirable to detect leakage at an early stage in order not to exceed an upper safety limit to avoid an explosion risk. It is hard to find refrigerant leakage until leakage causes an abnormality in system operation. In addition, the fact that a leakage of less than 100-300 g/yr cannot be detected by using foaming liquid could become a problem.

2. HFO-1234yf does not have a flashpoint, but it is not desirable to expose it to a high temperature, because there is an ignition point. The problem is due to the corona discharge method and the heating semiconductor method of the portable electronic detector. The former usually discharges between electrodes, and the latter heats up to more than 400 °C (600 to 700 °C to achieve sensitivity). In our experiment, this neither led to flashing or ignition. How-ever, there is a question concerning the use of these methods for flammable refrigerants.

Safety detection

The following are the necessary performance targets for safe detection.

1. Early detection
2. No flashing or ignition
3. High sensitivity detection

One high-viscosity foaming liquid has a performance that can detect much lower leakage rates, 1 7-30 g/yr.

With an electronic detector, the semiconductor form that does not rely upon an electric discharge or heating is recommended. However, it is desirable to use an infrared absorption type (NDIR) detector because of its high sensitivity and reproducibility.

As for fluorescence methods, they can be regarded as an ultimate detection method that can pinpoint leakage by leaving a leakage trace,

Table 3. Merits and demerits of detection methods

Type	Method	Monitoring method	Advantage	Disadvantage
Bubble	Direct detection by spray	Operator can check when detecting and monitoring	Exact leak position can be found	Under some situation, leak detection is difficult
Electronic leak detection	Direct detection by leak detector			
Fluorescent scanner	Visual check by fluorescent and UV	Once leak is detected, fluorescent stain remains permanently		
Automatic monitoring system	Detect pre-set gas by sensor	External alarm and unmanned monitoring	Unmanned monitoring 24 hours	Wide leak area can be monitored

once leakage has occurred. But as a fluorescing agent has to be injected into an air-conditioning system, it is necessary to make sure that it does not affect the device.

How to minimise leakage

There are two types of electronic detectors; portable and fixed. The weakness of a portable detector is that detection requires a human operator, and also takes a certain time before detecting leakage. This fact has led to the development of another effective refrigerant leakage detector; a fixed electronic analyser.

The analyser is already used in Europe and the U.S. and shows a significant effect. Not only does it detect leakage, but it can also use a range of sensors for detecting different gases and possibly identify future leakage.
In addition, it can be used in energy management systems for refrigeration and air conditioning by identifying systems that are using higher energy due to refrigerant leakage.

However, it has to be used with a portable detector, as it is intended for monitoring of large spaces and cannot identify an exact leakage position, as can be done by portable detectors. Of course, fixed detectors have many good points including fast leakage detection capability.

Merits and demerits of detective methods are shown in Table 3. As can be seen, there is no single superior method that can be used in any and all situations and environments.

It is important to use a number of detective methods together that perform detection work more safely than the present status, with reliable detection being ensured without depending on one detection method alone.

How to prevent leakage

So far, we have considered the detection of refrigerant leakage. The following text introduces the latest techniques of preventing refrigerant leakage as a fundamental counter-measure. The following is a method of preventing leakage by inserting special anti-leakage seals made of copper into flare connections and fittings.

The product Flaretite CU, is made of the same material as soft copper pipe. The special concentric sealing rings, an anti-leak feature, are the most suitable for sealing the fitting of equipment. Repeated use is possible. These concentric sealing rings prevent leakage from axial gaps or axial angular misalignment, which are often caused by thermal shock or vibration. In our confirmation experiment on the leakage prevention effect with helium gas, we used damaged parts in a flare joint and measured for leakage. Flaretite showed that it was very effective for preventing leakage.

Another effective product for leakage prevention is Nylog, a leakage inhibitor which increases the viscosity of refrigerator oil to the maximum. Packings, gaskets and valve cores are used in the charging port in refrigeration and air conditioning equipment, and are also a potential leakage point that cannot be ignored.

Leakage inhibitors which are refrigerator oil-based are widely used at various jointing positions, and have been well received by the market.

There are two types: POE oil-based and mineral oil-based. They are both made of refrigerator oil, with a very high viscosity. Therefore the system is not affected, even if the product becomes mixed with the refrigerator oil in the system. Moreover, the sealing effect lasts for a long time, and it is possible to use the system safely without affecting it.

It is also necessary to consider moisture problems in a system. Moisture in a system generates acid by hydrolysis and causes trouble if it freezes. This can eventually lead to refrigerant leakage.

The most important part of design and assembly is to prevent moisture from entering. Maintaining vacuum conditions is effective. However, we think that there are many workers who do not understand the importance of using vacuum pumps. The most important purpose is to reach a high vacuum level, but neither standard gauges nor analogue vacuum gauges can measure the vacuum level.

Many easily used vacuum gauges can be are commercially available. The use of digital vacuum gauges is expected to be common in refrigeration and air conditioning work in the future. In addition, a periodical test of the vacuum level is necessary to maintain the performance of the vacuum pump. Application of the following standards is recommended in performing a high vacuum pull:

1. The appropriate exhaust pressure is less than 2500 microns of Hg (333 Pa) [1].

2. ASHRAE recommends a pressure less than 1000 microns of Hg (133 Pa) for the stable vacuum condition after leaving the system under vacuum for several hours (ASHRAE Standard 147-2013) [2].

Attention should also be paid to moisture in refrigerating oil during maintenance work. Generally, moisture enters a system without being noticed, because the synthetic oil has a high moisture absorbance. Other reasons could be use of old oil or insufficient sealing oil. In addition, the composition of refrigerator oil that absorbs moisture is more likely to change, so this type of oil should not be used.

As a method of measuring moisture in a system, a simple moisture detector tube is commercially available.

It is easy to measure the moisture level (ppm) in a refrigerant by using a detector kit, and this can prevent trouble with moisture in the system during operation. In addition, acid detector tubes can measure the acid level resulting from hydrolysis at ppm levels of humidity. We can measure moisture and acid concentration by using these two kits and can guarantee refrigerant quality for leakage prevention in the future.

Conclusions

Leakage from refrigeration and air-conditioning systems must be tackled in an effective and immediate manner. In addition, in any and all companies engaged in refrigeration and air conditioning, measures should be carefully implemented.

It is important that everyone pays attention to leakage and constructs and assembles systems correctly.

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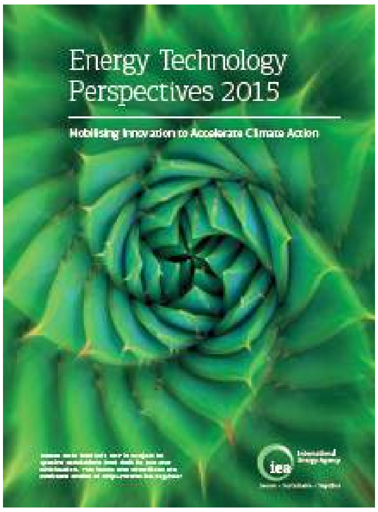
References

[1] ASHRAE Guideline 3-1996
[2] ASHRAE Standard 147-2013

New from the IEA: ETP 2015 - Mobilising Innovation to Accelerate Climate Action



As climate negotiators work towards a deal that would limit the increase in global temperatures, interest is growing in the essential role technology innovation can and must play in enabling the transition to a low-carbon energy system. Indeed, recent success stories clearly indicate that there is significant and untapped potential for accelerating innovation in clean technologies if proper policy frameworks are in place.

In an especially timely analysis, the 2015 edition of Energy Technology Perspectives (ETP 2015) examines innovation in the energy technology sector and seeks to increase confidence in the feasibility of achieving short- and long-term climate change mitigation targets through effective research, development, demonstration and deployment (RDD&D). ETP 2015 identifies regulatory strategies and co-operative frameworks to advance innovation in areas like variable renewables, carbon capture and storage, and energy-intensive industrial sectors. The report also shows how emerging economies, and China in particular, can foster a low-carbon transition through innovation in energy technologies and policy. Finally, ETP 2015 features the IEA annual Tracking Clean Energy Progress report, which this year shows that efforts to decarbonise the global energy sector are lagging further behind.

Source: www.iea.org/etp/etp2015/

ASHRAE publishes revision of Ground Source Heat Pump book

When ASHRAE's original book on ground source heat pumps was published 17 years ago, such systems were used mainly in residential settings and designers who used them were seen as risk takers.

Today, the technology is much more widely used having been recognized for its benefits. The lessons learned during that time are incorporated in a newly published book from ASHRAE, "Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (GSHP)." The publication is a complete revision of "Ground-Source Heat Pumps: Design of Geothermal Systems for commercial and Institutional Buildings," published in 1997 and recognized as the primary reference for non-residential GSHP installations.

The new book was written by Steve Kavanaugh, professor emeritus at the University of Alabama, and Kevin Rafferty, a consulting engineer, Klamath Falls, Ore. Both have spent the last 25 years focused on geothermal/GSHP work.

The book provides benchmarks, design strategies and information necessary for engineers to configure the most efficient and cost effective systems and avoid problems such as inefficient pumping, high cost ground loop designs, inadequate outside air provisions, unnecessarily complex control schemes and other common design errors.

In addition to cost and performance data, Kavanaugh provides building owners and their architects the information necessary to ask the right questions and accurately evaluate potential engineering consultants. The net effect is a more cost effective and efficient design and satisfied building owners.

As part of the revision, seven of the original eight chapters and appendices were completely rewritten and now include coverage of close-loop ground (ground-coupled), groundwater, surface water, GSHP equipment and GSHP piping. Additional information on site characterization has been added including a new hydro-geological chapter. The final chapter was replaced and the new section contains results of recent field studies, energy and demand characteristics and updated information to optimize GSHP system cost.

Source: www.ashrae.org/bookstore

Events

2015

1 – 6 June
eceee 2015 Summer Study on energy efficiency
Toulon/Hyères, France
http://www.eceee.org/summerstudy

17 June
Heat Pump Conference in Switzerland - *21. Tagung des Forschungsprogramms Wärmepumpen und Kälte des Bundesamts für Energie BFE* - 21st session of the research program Heat pumps and refrigeration of the Federal Office of Energy
Burgdorf, Switzerland
http://www.fws.ch/tl_files/download_d/Flyer%20WP-Tagung%202015.pdf (in German)
The flyer is also available in French.

25 – 26 June
ATMOsphere America 2015
Atlanta, USA
http://www.atmo.org/events.details.php?eventid=30

27 June – 1 July
ASHRAE Annual Conference
Atlanta, USA
https://www.ashrae.org/membership--conferences/conferences/ashrae-conferences/2015-ashrae-energy-modeling-conference

16 – 22 August
ICR 2015 – The 24th IIR International Congress of Refrigeration
Yokohama, Japan
http://www.icr2015.org/

30 September – 2 October
ASHRAE Energy Modeling Conference
Atlanta, USA
https://www.ashrae.org/membership--conferences/conferences/ashrae-conferences/2015-ashrae-energy-modeling-conference

19 October
HPT Annex meetings and Kick off Annex meetings
Nuremberg, Germany

20 – 21 October
Heat Pump Summit
Nuremberg, Germany
http://www.hp-summit.de/en/

22 October
HPT National Teams' meeting
Nuremberg, Germany

20 – 23 October
8th International Conference on Cold Climate-Heating, Ventilation and Air-Conditioning (Cold Climate HVAC 2015)
Dalian, China
http://www.coldclimate2015.org/

9 November
National workshop
Basel, Switzerland

10 November
HPT ExCo meeting (open meeting)
Basel, Switzerland

11 November
HPT ExCo meeting (closed meeting designated ExCo members)
Basel, Switzerland

2016

23 – 27 January
ASHRAE Winter Conference
Orlando, USA
https://www.ashrae.org/membership--conferences/conferences/ashrae-conferences

23 – 26 February
HVAC&R JAPAN 2016
Tokyo, Japan
http://www.hvacr.jp/en/index.html

7 – 9 April
4th IIR Conference on Sustainability and the Cold Chain
Auckland, New Zealand
http://www.iifiir.org/medias/medias.aspx?INSTANCE=exploitation&PORTAL_ID=general_portal.xml&SETLANGUAGE=EN

22 – 25 May
12th REHVA World Congress - CLIMA2016
Aalborg, Denmark
http://www.clima2016.org

25 – 29 June
ASHRAE Annual Conference
St. Louis, USA
https://www.ashrae.org/membership--conferences/conferences/ashrae-conferences

11 – 14 July
International Compressor Engineering, Refrigeration & Air-Conditioning, and High Performance Buildings Conferences
West Lafayette, USA
https://engineering.purdue.edu/Herrick/Events

21 – 24 August
Gustav Lorentzen Natural Working Fluids Conference
Edinburgh, Scotland
http://www.ior.org.uk/GL2016

11 – 13 October
Chillventa
Nuremberg, Germany
http://www.chillventa.de/en/

In the next Issue

Ground Source Heat Pumps

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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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