IEA OECD heat pump centre

IEA HEAT PUMP CENTRE

NEWSLETTER
VOL. 29
NO. 2/2011

Energy Efficient Buildings: Heating and Cooling Technology Roadmap

A key technology for the future

Roadmap: General and regional overviews

Market report: Sweden

IEA **Heat Pump** CENTRE
NEWSLETTER

Volume 29 - No. 2/2011

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Heat Pump Centre Newsletter, 2/2011

This issue is about the IEA Heating and Cooling Technology Roadmap. Thus, complementing the Roadmap, you can read regional overviews and accounts of policies for the different regions of the world.

This issue also includes a market overview for Sweden, as well as a report from a refrigerant symposium at Chillventa 2010.

Enjoy your reading!

Johan Berg
Editor

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COLOPHON

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10th IEA Heat Pump Conference forced to be held as a virtual conference

On behalf of the IEA Heat Pump Programme, I wish to extend to all Japanese our deepest sympathy following the major catastrophe that hit their country. We wish to express our moral support. We are convinced that the strength of the Japanese people will overcome the present difficulties and that we will be able again to hold events in Japan in the not too distant future.
Sophie Hosatte
Chairman of the IEA Heat Pump Programme

Dear heat pump friends,
When writing my introductory remarks for the Program Booklet of the 10th International IEA Heat Pump Conference in early March 2011, I couldn't know that all our planning for the conference would have to be changed. The tragic earthquake and the tsunami of March 11 affected and saddened all of us. Uncertainty about the possible effects on our conference site and the risk of further earthquakes forced both organizing committees, the National Organizing Committee of Japan and the International Organizing Committee, to cancel the meetings in Tokyo and to hold a virtual conference instead.

I wish to express my deepest sympathy to all those who are suffering from this catastrophe and I wish the Japanese people strength and courage to deal with the results of the disaster. The earthquake and tsunami show that nature can, at a stroke, outwit the best of human planning.

I feel that, as a mark of our respect, and to reduce the burden on our Japanese hosts who now have more than enough to deal with, it is only proper that the physical conference should be cancelled. I know that the conference would have been impeccably planned and organised, as I have had the chance closely to follow the organisation and preparation work performed by the National Organizing Committee of Japan under the leadership of Mr Momoki Katakura, the International Organizing Committee, and the Regional Coordinators Dr Monica Axell, Gerald Groff and Makoto Tono.

I invite you to attend the virtual conference on the website www.hpc2011.org and to download and study all the interesting papers. The Heat Pump Centre has decided to publish selected papers of the conference in the next Newsletter, which will be dedicated to the 10th International Heat Pump Conference.

Although I have not the chance to meet you for this conference in May, I do hope that you benefit from the virtual conference, and I look forward to meeting you at the next International Heat Pump Conference, hopefully in three years.
Prof. Dr. Thomas Kopp, Switzerland
Chairman, International Organizing Committee

The International Energy Agency's Technology Roadmaps

Energy Efficient Buildings: Heating and Cooling Systems

Dr. Peter Taylor
Head of Energy Technology Policy Division
International Energy Agency

For several years, the International Energy Agency (IEA) has been presenting the case that an energy revolution, based on widespread deployment of low-carbon technologies, is needed to tackle the climate change challenge. Energy Technology Perspectives 2010 (ETP 2010) demonstrates that a low-carbon future is also a powerful tool for enhancing energy security and economic development.

The IEA has established that there is a pressing need to accelerate the development and deployment of low-carbon energy technologies in order to achieve this technology revolution and address the global challenges of energy security, climate change and economic growth. One way to help achieve these goals is through the use of energy technology roadmaps. The role of roadmaps in meeting the challenge was acknowledged by Ministers from G8 countries at their meeting in June 2008 in Aomori, Japan. They charged the IEA with preparing energy technology roadmaps to advance innovative energy technologies, and this request was endorsed by IEA member countries.

The Energy Efficient Buildings: Heating and Cooling Systems roadmap is the first roadmap for the buildings sector. The overall aim of the roadmap is to advance global development and uptake of energy efficient and low/zero carbon heating and cooling systems so that the buildings sector plays its part in the global 50% reduction in total energy-related CO_2 emissions by 2050 identified in the Energy Technology Perspectives 2010 BLUE Map scenario.

Low/zero-carbon and energy efficient heating and cooling technologies for buildings—including heat pumps—will deliver up to 2 Gt CO_2 reductions, with 710 Mtoe of energy savings. Most of the technologies needed are commercially available today. However, due to cost, lack of information, institutional and other barriers, they require strong policy initiatives to promote deployment to the levels seen in the IEA's roadmap.

Achieving the goals of the BLUE Map scenario will require action by all stakeholders and a systematic approach to buildings as unique, integrated systems. The key will be to transform the market for heating and cooling technologies, by changing consumers' investment decisions and at the same time creating a framework within which industry (manufacturers, architects, installers, etc) has the confidence to develop the capacity to meet consumers' needs and the deployment goals.

Heat pumps will have an important role to play in the transformation of the buildings sector outlined in the roadmap. The deployment of more efficient cooling systems will be critical to reducing the rate of growth in CO_2 emissions from cooling in developing countries and, in conjunction with thermal energy storage, in helping to reduce the cost of decarbonising the electricity generation sector. Similarly, the deployment of heat pumps for space and water heating applications could also result in significant energy and CO_2 savings. However, although heat pumps are a mature technology for many applications/market segments, further R&D is required to reduce costs, improve performance and develop new products that are optimised for a wider range of applications.

The IEA's Multilateral Technology Initiatives (MTIs), including the Heat Pump programme, can make an important contribution in the transition to a low-carbon energy system in the buildings sector. For this roadmap, the IEA Secretariat worked closely with many contributors from the MTIs. The very close working relationship the IEA has with the Heat Pump Programme is highly valued and this roadmap has benefited significantly from their cooperation. The buildings roadmap for heating and cooling systems highlights the importance of heat pumps in achieving the goals of a more secure, low-carbon energy future and I am delighted that the Heat Pump Centre is highlighting the important messages of the IEA's roadmap in this newsletter.

Column

Heat pumps in the new millennium – Road maps give advice for development of technology and markets

Dr. Monica Axell, General Manager, HPC

Dr. Roger Nordman, Technical Editor, HPC Newsletter

Heat pumps have a wide range of applications, including refrigeration and cooling, air conditioning and heating. Technical solutions range from simple units serving single needs to complex systems comprising multiple heat pumps connected to solar thermal panels and storage systems in order fully to exploit the heat sources and serve multiple needs (e.g. cooling, heating and hot water production). The potential applications are limited only by imagination. This complex reality makes it sometimes hard to quantify the full potential that heat pumps can offer for the supply of renewable energy to energy systems.

In response to the ministerial meeting in Aomori in 2008, the IEA has acknowledged the role of road maps in meeting the challenge of the BLUE map scenario. A set of road maps has therefore been published for different technologies, outlining the potential of the technology, together with research and policy actions needed to realise the potential. The time has now come to technologies that are used for heating and cooling in buildings. The IEA has identified four major technologies; solar thermal, small-scale CHP, biomass and heat pumps. Worldwide, the number of installed heat pumps in the residential sector in 2010 is estimated to be around 800 million, which the BLUE map scenario foresees as growing to 3 500 million. Considering the demands for domestic hot water and cooling, heat pumps is the only technology that can supply both and, in addition, all year round.

Regardless of how each technology may evolve technically, there is a need to see the overall system effects and cost efficiency for society. We believe that heat pumps are well matched to meet these challenges as well, since they generally do not emit any pollutants locally, and they have proven to be cost-efficient in many countries when the investment is evaluated with an LCC perspective. The ability of heat pumps also to utilise a surplus of intermittent electricity produced from RES sources (PV, Wind, Wave), also makes the heat pump suitable for use in future smart integrated cities.

The Energy-Efficient Buildings: Heating and cooling Technology Road Map is a very welcome publication from the IEA. The Heat Pump Programme is looking forward to more road maps where the benefits of heat pumps can be exemplified and quantified for other sectors, such as industry.

The road map for Energy-Efficient Buildings shows in broad views the way that policy and technology should evolve in order to meet the challenges of combating climate change. However, the road map is not in itself the final solution: now, the hard work begins to monitor and follow up on this important road map. Improved statistics will then play a vital part, as well as the ability to adjust policies to steer towards the targets.
The heat pump industry therefore faces much work in the future in order to respond to new policies. New and existing research ideas must be turned into products, and the systems approach must be embraced. We believe that research and the industry are well prepared, and look forward to future developments.

General

The State of Renewable Energies in Europe

EurObserv'ER has released its annual publication 'The State of Renewable Energies in Europe', a synthesis of the Technology Barometers published during 2010 (with data up to and including 2009). The publication gives detailed capacity and energy performance data for all renewable energy technologies for all 27 member states of the European Union.
http://www.ehpa.org/news/article/the-state-of-renewable-energies-in-europe/

New EU brochure: "Renewables make the difference"

DG Energy has published a new brochure "Renewables make the difference", which acknowledges the huge potential of renewable energy for heating and cooling. However, as renewable energy sources account for only 12 % of total heating and cooling, this is far from being realised. Heat pumps are reported to contribute 2.2 Mtoe to total heat needs in the EU-27 - i.e. about 0.4 %.
http://www.ehpa.org/news/article/eu-new-brochure-renewables-make-the-difference/

EcoCute use during rolling blackouts

Since the earthquake and tsunami on 11 March 2011, and the resulting power shortage due to a number of power plants being offline, prefectures around Tokyo and in the north-east that were the hardest hit by the disaster have to deal with imposed power outages. In consequence, industry, commercial sectors and households need to deal with three hours per day without either electricity or, in most cases, hot water.
However, households at least are not entirely cut off from hot water supply. Six major EcoCute manufacturers have published information on their websites, about which features of their CO_2 heat pumps work without electricity.
http://www.r744.com/articles/138120110406.php

Policy

EU '2050 strategy'published, builds on energy savings

Europe must invest heavily in efficiency to limit spiralling energy costs and beat its own target for cutting greenhouse gas emissions, the European Commission said on March 8, unveiling plans to move to a competitive low-carbon economy by 2050. Much or all of the extra investment would be recovered from savings on oil imports, the Commission said in its 'Roadmap for moving to a competitive low-carbon economy in 2050'.

Europe needs to invest an extra 1.5 % of its economic output each year to rein in energy costs, the Commission's report said. Most controversially, the roadmap said that meeting efficiency goals would also help the bloc to beat existing targets for cutting greenhouse gas emissions by the end of the decade.
http://www.euractiv.com/en/climate-environment/2050-strategy-builds-energy-savings-news-502895

Experts question viability of 'Timid' EU energy plan

The European Commission finally launched its calculations on how to achieve a 20 % increase in energy efficiency by 2020 on March 8, but as it did so, senior policy figures were questioning the maths.
Stefan Scheuer, Managing Director of the SPRL environmental consultancy and former policy director at the European Environmental Bureau, predicted that the plan would fail "for the simple reason that it does not set itself specific sectoral or member state-relevant targets".

The Commission's low-carbon roadmap for 2050 says that emissions reductions of 25 % can be reached by 2020 – a much-needed 5 % increase on the EU's official target – but only if the energy savings goal are met.
http://www.euractiv.com/en/energy-efficiency/experts-question-viability-timid-eu-energy-plan-news-502916

New US portal for retailers: regulatory obligations and beyond

The US EPA has launched a portal that provides a one-stop shop for retailers to access resources on their current environmental regulatory obligations regarding refrigeration, in addition to information on other sustainability issues going beyond legal requirements. The latest webinar organised by the GreenChill Partnership explored the portal's basic structure and added value. The new Retail Industry Portal addresses the fact that a lot of content on the various EPA websites is scattered and hard to find by retailers.
http://www.r744.com/articles/2011-01-25-new-us-portal-for-retailers-regulatory-obligations-and-beyond.php

UK launches renewable heat incentive

The UK Government has launched an £860 million renewable heat incentive (RHI) making payments to household available from October 2012. The Department of Energy and Climate Change (DECC) says the scheme is expected to increase green capital investment by £4.5 billion up to 2020 and increase the number of industrial, commercial and public sector renewable heat installations sevenfold to 2020. The renewable heat incentive aims to encourage the installation of equipment such as renewable heat pumps, biomass boilers and solar thermal panels.
http://www.renewableenergyfocus.com/view/16523/uk-launches-renewable-heat-incentive/

Britain's renewable heat support: air-source heat pumps left out

The British government has announced details of its Renewable Heat Incentive policy that will encourage the uptake of renewable heat, including heat pumps. Only ground-source and water-source heat pumps for the non-domestic sector will be eligible from the outset of the scheme, but with the cooling function of heat pumps and exhaust air heat pumps not being eligible. Air-source heat pumps will be considered for

eligibility from 2012, when the second phase of the scheme will be introduced and will also cover long-term tariff support for the domestic sector.
http://www.r744.com/articles/136820110314.php

France considers ban on pre-charged split systems

The French government is considering banning sales of pre-charged split-system air conditioning units to the general public. According to AREA, the European contractors association, the French Ministry of Environment and Sustainable Development is considering modifying the distribution system of these pre-charged systems by applying the same restrictions as with fluorinated gas in cylinders.
http://www.acr-news.com/news/news.asp?id=2395

Germany revises funding scheme for heat pumps

In March 2011, the German government revised its incentive scheme for renewable energies, including heat pumps. Large heat pumps for industrial use are now also eligible for support. The market stimulus programme, by the German Federal Environment Ministry, supports the use of renewable energy sources to a total amount of €500 million per year in the period from 2009 to 2012. Installations eligible for support include those using aerothermal, hydrothermal and geothermal energy sources in existing buildings, as well as other types.
http://www.hydrocarbons21.com/content/articles/112920110408.php

Working Fluids

US: soon an end to HFC134a in motor vehicles

The US EPA will initiate notice and comment rulemaking in response to a petition asking the Agency to remove HFC134a from the list of acceptable refrigerants for cooling new passenger cars and light-duty vehicles. Currently acceptable alternatives include CO_2, HFC152a and HFC1234yf.

In response to a petition from three environmental NGOs, EPA has initialised the process of removing HFC134a from the list of acceptable refrigerants used for new motor vehicle air-conditioning (MVAC) under its Significant New Alternatives Program (SNAP). It is therefore expected that there will be consultations with carmakers and other stakeholders before a proposal is issued.
http://www.hydrocarbons21.com/content/articles/112720110331.php

R290 demonstration project in China

A United Nations Montreal Protocol Multilateral Fund (MLF) funded project in China for the conversion of a compressor production line to R290 has successfully passed a first technical evaluation. The project aims to enhance the global availability of R290 compressors. The project is scheduled for completion at the end of 2012.
http://www.acr-news.com/news/news.asp?id=2408&title=R290+demonstration+project+in+China+paves+the+way+for+hydrocarbon+technology

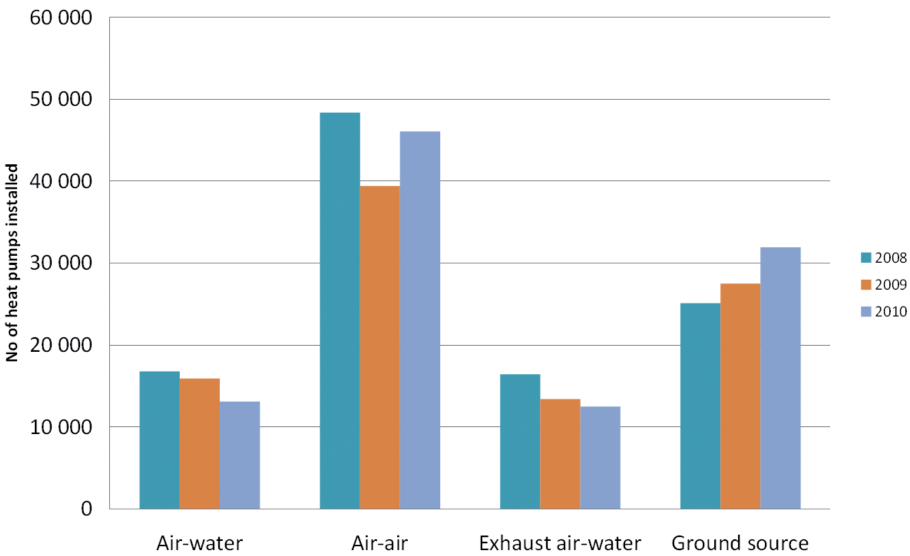
AHRI Announces Low-GWP Alternative Refrigerant Evaluation Program

The US Air-Conditioning, Heating, and Refrigeration Institute (AHRI) has announced an industry-wide cooperative research programme to identify and evaluate promising low-GWP refrigerants, including natural refrigerants, for major product categories. Solicitation for project participation will be open to both US and foreign manufacturers, before laboratory testing begins in July 2011.
http://www.hydrocarbons21.com/content/articles/112420110325.php

The Swedish people confirms its love for heat pumps

Martin Forsén, President Swedish Heat Pump Association (SVEP)

As the economy slowly recovers from the recent recession the heat pump industry strengthens its position as the number one heating technology in Sweden. 2010 resulted in yet another year with over 100 000 heat pumps sold. The value of the heat pump market is estimated as somewhere in the range of 980 million Euro 2010 (+21 %), excluding service and maintenance. There are now over one million heat pumps in operation in Sweden and there are no signs of a weakening market. The most significant changes on the market are the increased interest in ground source heat pumps and larger applications for multi-family houses and commercial buildings. According to estimates by the Swedish Heat Pump Association (SVEP), multi-family houses and commercial buildings now account for as much as 15 % of total heat pump market sales. Its turnover and market share seem to show continuous growth.



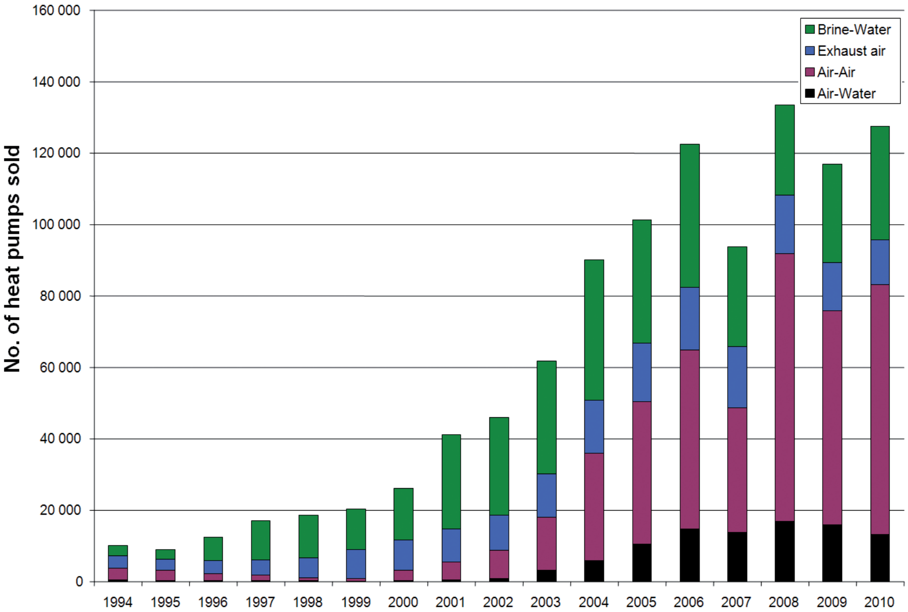
Recent policy changes influencing the heating market

The European Parliament and the Council adopted the revised Energy Performance of Buildings Directive on May 19, 2010. The new directive will enforce very strict building regulations for new buildings as well as all buildings undertaking major renovations from 2021 (for public buildings, 2018). Even though there are still several years until we see the full impact of this directive, we already see signs of a "fast-track" approach. The city of Stockholm has already taken a decision that all new construction on city land needs to meet very strict building codes, much higher than the existing building regulations prescribe. Given the decision taken in Stockholm, it is quite likely that several cities will adopt the fast-track approach. The fact that a growing number of policy-makers and decision-makers wish to distinguish themselves as forerunners in energy conservation can be seen as a sign that serious attention is now being paid to energy. Sweden has adopted a national commitment to reduce its energy use in buildings by 50 % by 2050. We believe that the revised Energy Performance of Buildings Directive will serve as the most important tool to realise this ambitious commitment. The heat pump industry is bound to develop and demonstrate cost-effective solutions for the building industry as quickly as possible.

Market trends

For more than a decade, the market for domestic heat pumps in Sweden has shown strong growth, with the country being one of the most developed heat pump markets in Europe. With rising prices of oil and electricity, together with increasing energy-related taxes, the competitiveness of heat pumps has improved significantly. The technology is by now fully recognised by the general public and consumers. For many years, it has been the number one choice for retrofitting, as well as for new construction of single-family houses. The rapid market growth for heat pumps is one of the most important reasons behind the fact that Sweden has reduced its use of heating oil by more than 75 % over the last 20 years. Today, heat pumps are in use in more than 50 % of single-family houses in Sweden. The last two winters, with very cold weather, have kept interest in energy conservation measures at a high level. The heat pump market is still prosperous, and continues to benefit from the economic recovery and the existing tax reduction scheme for renovation and extension work. This tax reduction scheme, which was introduced during the recession, enables private homeowners to deduct 50 % of the labour costs, up to a maximum of EUR 5500 per registered owner, for renovation and extension works. One of the effects of the scheme is that labour-intensive ground-source heat pump installations have gained market share at the expense of falling sales of air/water heat pumps. Sales of ground-source heat pumps increased by 16 % in 2010, while sales of air/water heat pumps fell by 18 %. Sales of exhaust air heat pumps still suffer from the low construction rate, and fell by 7 %. Sales of air/air heat pumps are a little uncertain, but are estimated to have increased by about 17 %.

As general awareness of heat pump technology has reached a high level in Sweden, customers have become more sensitive in their choice of a heat pump. Features such as remote control, capacity control and online connections through the internet are gaining popularity. Competition between brand names and installers is fierce, and advertisements for heat pumps are seen everywhere. Over the years, the best known manufacturers active on the Swedish market have developed strong sales channels and networks of installers. With its flourishing market, Sweden is seen as an attractive market for new entrants. Several manufacturers have made efforts to enter the Swedish market in recent years, but very few have been successful. The entry barriers are high, and most of the experienced installers have long ago been contracted by the existing actors. However, as the European and worldwide markets for heat pumps are picking up, we are bound to face a consolidation phase dominated by large multinational companies. When and how major changes will take place is hard to predict, but one thing is certain; that the future for heat pump technology is bright. The world cannot afford to miss out on the benefits of extensive use of heat pumps.



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Annexes, ongoing

IEA Annex 34: Thermally Driven Heat Pumps for Heating and Cooling

Most heat pumps and chillers, providing the building sector with heat or cold, are electrically driven. However, substitution of the electrically driven compressor by a thermally driven one could lead to significant primary energy savings, especially if the thermal energy is provided from solar or waste heat.
The objective of this Annex is therefore to reduce the environmental impact of heating and cooling by the use of thermally driven heat pumps (e.g. absorption and adsorption machines). It is based on the results of Annex 24, "Absorption Machines for Heating and Cooling in Future Energy Systems", and cooperates with Task 38, "Solar Air-Conditioning and Refrigeration" of the IEA "Solar Heating and Cooling" (SHC) Implementing Agreement. Annex 34 is concerned with the development of performance evaluation standards and with further development of thermally driven heat pumps with higher efficiencies.

While an experimental set-up to demonstrate sorptive heat pumping in general has been discussed in Newsletter no. 4/2010 (Volume 28) the evolution of highly efficient adsorbers as heat pumping force or visualised as vacuum pump respectively is presented here. Remember, the adsorber withdraws water molecules from the evaporator and thus reduces the pressure and temperature there (cold production). In turn, it must dispose of the heat released when water vapour is adsorbed on its surface (e.g. heat rejection to cooling tower (in cooling case only) or floor heating (in heat pump operation mode).

Figure 1 illustrates the performance enhancement of the adsorber heat exchanger in several development

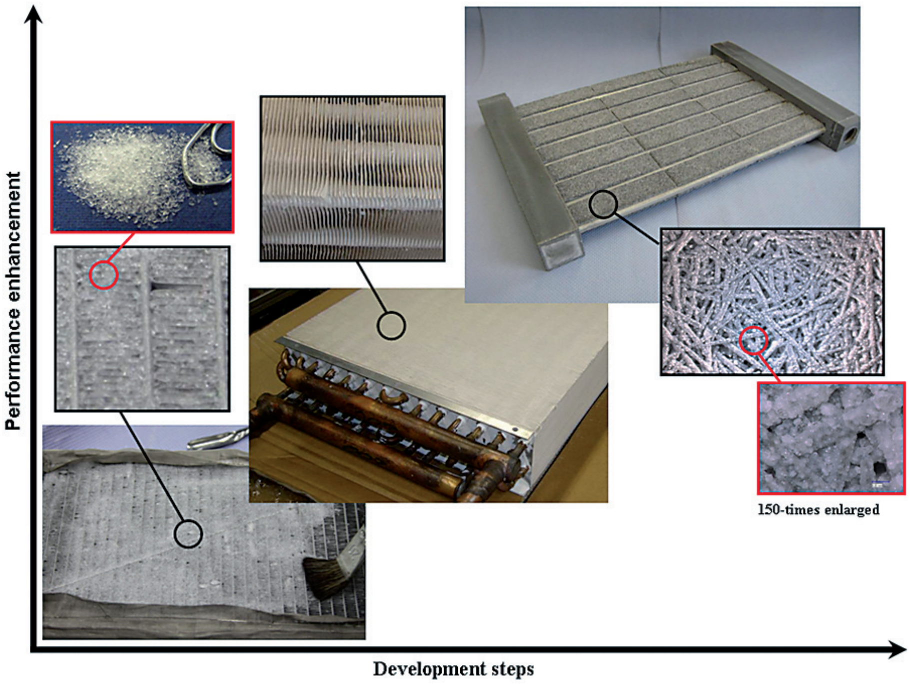


Figure 1: Different evolution steps of the performance enhancement in adsorber development: Packed-bed heat exchanger (left), binder based dip-coated lamella heat exchanger (middle) and direct crystallisation connection of the sorbent (right) on 3D-metal structure heat exchanger.

steps. The left-hand photo shows an automotive cooling unit used to create a packed bed adsorber where the sorbent is prevented from falling out at the bottom by a wire mesh, and a brush helps to fill in the sorbent very closely. Although the volume specific density (sorbent per volume) is very high in this case, the thermal connection between the sorbent and the heat exchanger fin is fairly poor, hindering the released heat (arising by adsorption of the water molecules on the adsorber) to flow from the granules to the heat transfer fluid. The reason is that there exists 'at most' two point contacts per sphere only between the sorbent (sphere) and the heat exchanger fin (the fin gap is greater than sphere's diameter) and the remaining surface area of the sphere has to face a higher thermal resistance (air gap) while transporting the released heat to the fins. To overcome this, for example a binder based dip coating of the lamella heat exchanger can be applied as next step (middle). Here, a uniform connection is realised all over the heat exchanger and only small air gaps (if any) exist between sorbent and fin. Finally, a direct crystallisation connection, as can be seen in the right hand photograph (150 times enlarged), can be done on top of a metallic short fibre structure (sinter-fused structure), giving an enormous increase of surface area (3-D). This combination provides both good thermal conductivity in the metal and an excellent sorption-material-to-metal-mass ratio.

The following Task description summarises the current work in 2010:

Task A Market overview and state-of-the-art – More Country Reports were collected and a first summary will be presented at the 10th IEA Heat Pump Conference 2011. Much work has been carried out to rebuild the web page fundamentally (www.annex34.org) in order to simplify the teamwork of the contributing participants. Unfortunately, an application for EU funding, aiming to ensure the co-operation of the participants beyond the project duration failed, but will be resubmitted.

Task B Performance evaluation – The database of existing standards was updated with new and revised documents currently under revision or development (e.g. EN14825, EN12309) and is accessible on the internal webpages. The German directive (VDI-Richtlinie) has already been published. A final proposal for the definition of performance figures was presented and agreed upon. The outcome - i.e. a proposal for a description of a standard to determine COP values and other energy performance figures of TDHPs and of systems using TDHPs - has been divided into four technical reports.

Task C Apparatus technology – The sorption material database has been expanded on the internal web pages with further material data according to the proposed measurement procedures. This includes mainly new promising commercially available silica gels and zeolites.

A technical report on the different technologies, their potentials and limits and a description of standards to determine sorption material properties will be provided soon. Work on continuous extension of the database, material sources and experimental expertise is also being carried out.

Task D System technology – A template to summarise data from existing plants has been developed. First results were already gained, providing information on system understanding, i.e. how does the TDHP work (proper functioning), how it is integrated (system components) and how does it operate within the whole system (control strategies). This included calculation of the system performance by analysing the monitoring data. In addition, available tools for the design of TDHP systems and for calculating their energy and economic performances were summarised.

Task E Implementation – A number of useful demonstration projects have been collected. Authors as well as responsible authors for most chapters of the planned handbook have already been decided upon. It is planned to finish the first chapters, i.e. an overview of standards as the outcome of Task B, at the beginning of 2011.

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

While the residential heat pump market has been already satisfied with standardised products and installations, most industrial heat pump applications need to be adapted to unique conditions. In addition a high level of expertise is crucial.

Industrial heat pumps are defined here as heat pumps in the medium and high power ranges which can be used for heat recovery and heat upgrading in industrial processes, but also for heating, cooling and air-conditioning in industrial, commercial and multi-family residential buildings as well as district heating.

The main market barriers for the introduction of industrial heat pumps are expected to be lack of experience and thus lack of acceptance in market with operators, industrial partners and its supply and consulting chains.

It was therefore agreed to start an new Annex entitled "Application of industrial Heat Pumps" as a joint venture of the IEA Implementing Agreements "Industrial Energy Technologies and Systems" (IETS) and "Heat Pump Programme" (HPP).

The Annex 35/13 officially started on the 1. April 2010 with 16 participating organisations from 10 member countries of IETS and HPP.

The annex will focus on the

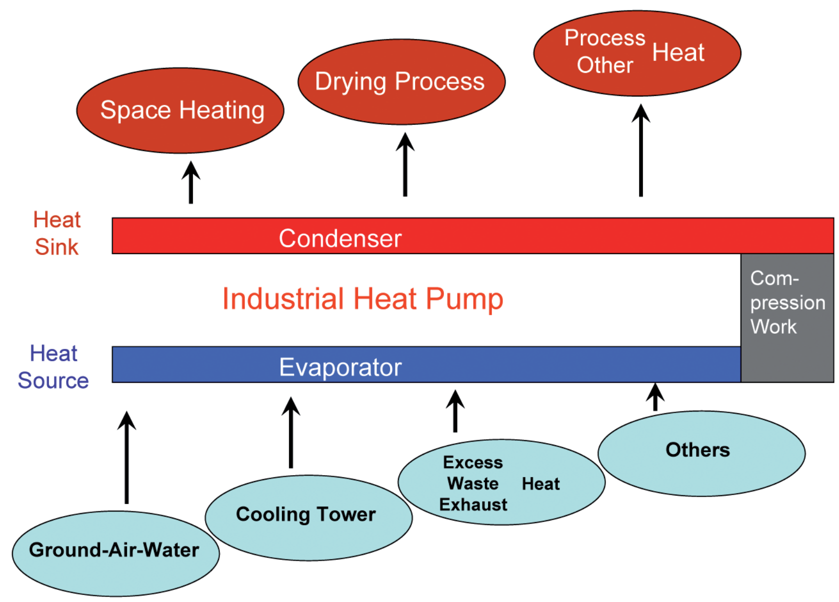
- reduction of energy costs, fossil energy consumption and CO_2-emissions in industrial and commercial heat generation
- constraints related to medium and high temperature refrigerants with low GWP
- adapted compressors for high temperature
- Process methodology for integration of HPs

A first kick-off meeting took place on 26. April 2010 at the European Academy of Refrigeration and AC in Maintal/Germany with 14 participants from 8 countries. The meeting discussed and decided on the following topics:

- Role and objectives of the Annex
- Expected contribution of the participants
- Detailed work plan
- Main tasks and time schedule
- Number of meetings

It was agreed that the following tasks

1. Market overview, barriers for application
2. Modelling calculation and economic models
3. Technology
4. Application and monitoring
5. Communication



should form the frame of the work programme and each task should have a task leader with specific competence for the individual task.

The first annex meeting took place on the 11.October 2010 in connection with Chillventa 2010, Nürnberg/Germany with 19 participants from 10 countries.

The Annex Coordinator IZW e.V. presented the present status of contracting parties / participants, specific obligations and responsibilities of the participants and the status of work.

The main topic of the meeting was the presentation related to Task 1 with an overview of the energy situation and the overview of energy use in segments of industries of the participating countries and a detailed discussion on the work programme.

Further information is available from the Operating Agent:
The Information Centre on Heat Pumps and Refrigeration - IZW e.V., Germany (Informationszentrum Wärmepumpen und Kältetechnik - IZW e.V.), in collaboration with Laurent Levacher, EDF-R&D-ECLEER (European Centre & Laboratories of Energy Efficiency Research), France.

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New IEA Annex 36: Quality Installation / Quality Maintenance Sensitivity Studies

(Avoiding Efficiency Degradation due to Poor Installations and Maintenance)

It is widely recognized that residential and commercial heat pump equipment suffer significant performance loss (i.e., capacity and efficiency) depending on how the components are sized, matched, installed, and subsequently field-maintained. Annex 36 will evaluate how installation and/or maintenance deficiencies cause heat pumps to perform inefficiently and waste energy. Specifically to be investigated is 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 larger impacts than others.
Objectives

Confirmed / Pending Participants for Annex 36	
Confirmed Parties	France Sweden United Kingdom USA *(Annex Operating Agent)*
Interested / Pending Parties	Canada Germany Japan South Korea Switzerland

Co-Operating Agents for IEA Annex 36
Glenn C. Hourahan, P.E. Air Conditioning Contractors of America (ACCA)
Piotr A. Domanski, P.E., PhD National Institute of Standards and Technology (NIST)
Van D. Baxter, P.E. Oak Ridge National Laboratory (ORNL)

- Develop information for use by industry stakeholders, policy makers, and owners/operators
- Each Participant to evaluate heat pump equipment types and applications that are:
  - germane to their country's general equipment applications
  - for residential and commercial buildings
- Lead to more efficient heat pump operation
  - Reduced energy utilization
  - Reduced greenhouse gas emissions
  - Provide for enhanced penetration of heat pumps

In undertaking the sensitivity analyses, each individual Annex partner will be seeking to quantify impacts on system performance (e.g., capacity, energy utilization, etc.) related to varying QI and QM practices /attributes for their varied equipment applications of interest.

Target Audience

- HVAC practitioners responsible for designing, selecting, installing, and maintaining heat pump systems in varied applications.
- Building owner/operators interested in achieving improved comfort conditioning and efficiency performance from their HVACR equipment.
- Entities charged with minimizing energy utilization (i.e., utilities, utility commissions, energy agencies, legislative bodies, etc.) in varied heat pump applications and geographic conditions.

Anticipated Meetings
Jun 2012: meeting (in conjunction with ASHRAE or Purdue Conferences) in the U.S.
mid-2013: face-to-face meeting at a venue still to be confirmed
Web Conferences to be scheduled on an as-needed basis.

Contact:
Glenn C. Hourahan, Glenn.Hourahan@acca.org

Annex Time Schedule

Start Date	End Date	Activity
November 2010	April 2011	Task 1 – Critical literature survey
May 2011	October 2011	Task 2 – Identify sensitivity parameters
November 2011	July 2012	Task 3 – Modelling and/or lab-controlled measurements
August 2012	April 2012	Task 4 – Simulations on seasonal impacts
May 2013	November 2013	Task 5 – Report and information dissemination

IEA HPP Annex 37: Demonstration of field measurements on heat pump systems in buildings - Good examples with modern technology

Annex 37 aims to expand acceptance of heat pumping technology and to increase take-up in new markets. The intention is to demonstrate energy and environmental potentials of heat pumping technology, using existing field performance measurements, and with the emphasis on best available technology. It should be possible to predict the most suitable heat source and heat pump system for particular applications.

In order to ensure reliable results, it is most important that the quality of the measurements should be assured, and so the criteria for good and assured quality will be defined in the Annex. As the results will also be used to compare given heat pump systems with alternative heating systems, it is therefore important to define measuring conditions such as measuring points and system boundaries that influence energy savings and CO_2 reduction.

An important outcome of Annex 37 will be a data base of existing field measurements, using a common method to express performance values such as seasonal efficiency and energy savings. The data base will be linked to the IEA Heat Pump Centre's website.

The work of Annex 37 started with an initial meeting on February 24th 2011 in Sweden. Annex 37 is an "Annex lite", which implies limitations in time and meetings. Confirmed participants of the Annex are Austria, Switzerland, the United Kingdom and Sweden (Operating Agent). Other countries are invited to join the Annex.

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IEA HPP Annex 38: Solar and Heat Pump Systems

The combined SHC Task 44 and HPP Annex 38, under the name of "Solar and Heat Pump Systems", is a joint effort of the SHC and the HPP bodies, and will be led by a single operating agent (JC Hadorn of Switzerland) from 2010 to 2013.

The objective of the work is to analyse and compare the most common combinations of solar heating and heat pumps for a single-family house.

The Task is organised into four subtasks:

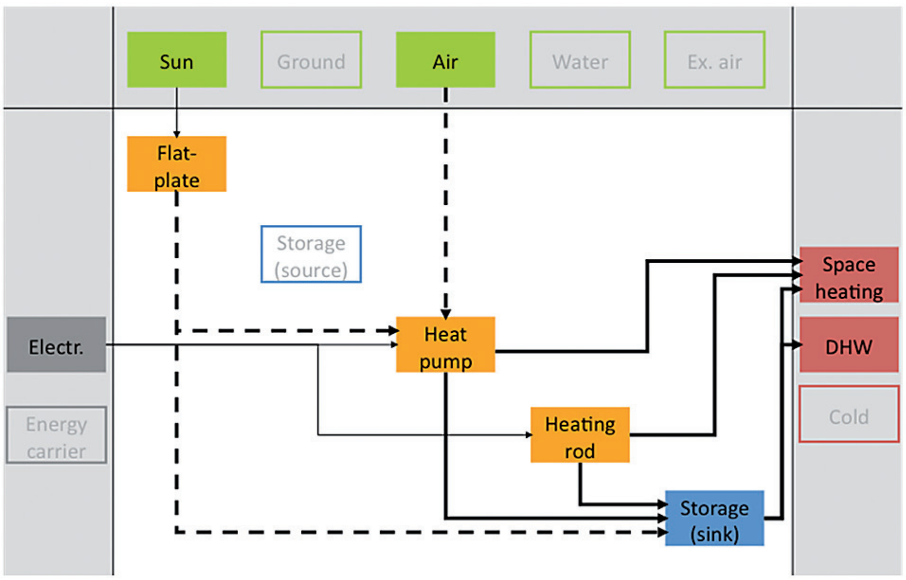
Sub-task A: Solutions and generic systems, led by Germany (Fraunhofer ISE, Sebastian Herkel)
Sub-task B: Performance assessment, led by Austria (AIT, Ivan Malenkovic)
Sub-task C: Modelling and simulation led by Switzerland (SPF, Michel Haller)
Sub-task D: Dissemination and market support, led by Italy (EURAC, Wolfram Sparber).

From the Solar Heating and Cooling Programme, participating countries are Austria, Belgium, Canada, Denmark, France, Germany, Italy, Spain and Switzerland. From the Heat Pump Programme, they are Finland, Germany, the UK and Switzerland.

One achievement of 2010 was in Sub-task A, to develop a new way of describing a system combining solar heating and a heat pump. Such a combination can be complex, and it is not always easy quickly to grasp the features and functions of the system from a system diagram. It was therefore decided in Annex 38 that a new way to represent a system should be set up. This new way should provide a rapid understanding of the global system in order to ease comparisons. After some discussions and many alternatives, the group ended up with what has been given the name of the "square layout" of a system, which makes it possible to see all the functional connections in a solar and heat pump system at once. (In fact, this presentation format is not restricted to this particular combination, but can be applied to any heating system).

Link to Task 44 / Annex 38 technical website: http://www.iea-shc.org/task44

For more information on this work contact the Operating Agent, Jean-Christophe Hadorn, jchadorn@base-consultants.com from Switzerland



The square layout: a new Task 44 / Annex 38 way of describing the sources, the sinks, the inputs and outputs, and the links in a solar and heat pump system.

IEA Annex 39: A common method for testing and rating of residential HP and AC annual/seasonal performance

Participating countries: Austria, Finland, France, Germany, Japan, The Netherlands, South Korea, Sweden (Operating Agent), Switzerland and the United States

To achieve a properly working heat pump system, the right type of heat pump must be chosen and installed with a matching heat distribution system. For this reason, it is important to have reliable information on both the heat pump itself and on how it is influenced by the surrounding system.

A common SPF method would be important for fair comparison between different types of heat pump systems as well as fair comparison with other competing technologies using fossil fuels. A common SPF method can later be incorporated in different labelling, rating and certification schemes.

There is therefore a need for an improved transparent and harmonised method for calculation of heat pump system SPF, based on repeatability and reliable test data from laboratory measurements.

There are many national standards for both testing and calculation of SPF. Manufacturers have made it clear that they would like to see common testing methods and common SPF calculation methods, since this would make it simpler for them to export heat pumps to different countries. The question has been highlighted in the European countries after the RES Directive was approved. In Japan, too, existing standards need to be updated, and a common methodology is desired.

The outcome from the project will be a proposal for a common transparent SPF calculation method for domestic heat pumps, including heating, cooling and domestic hot water production.

The idea is to conduct prenormative research, which later can be incorporated in standardisation (ISO and CEN) in the same way as Annex 28. The Annex builds on such material as experience and findings from Annex 28, "Test procedure and seasonal performance calculation for residential heat pumps with combined space and domestic hot water heating".

In order to achieve the objectives of the Annex, the following task-sharing activities have been planned:

Task 1 Review and evaluation of existing test methods and calculation methods for SPF
Task 2 Matrix definition of needs for testing and calculation methods
Task 3 New calculation method for SPF/Commonly accepted definitions on how SPF is calculated
Task 4 Identify improvements to existing test procedures
Task 5 Validation of SPF method
Task 6 Development of an alternative method to evaluate heat pump performance
Task 7 Communication to stakeholders

A project kick-off meeting was held at the ASHRAE Annual Meeting in Albuquerque in June 2010. At this meeting, participants from six countries contributed to the development of the final draft of the legal text. However, the start of the Annex has been delayed, due to the fact that some countries did not have the financial contribution settled. The Annex legal text was finally approved at the ExCo meeting in Vienna, Austria in November 2010, and in December 2010, most countries have established supporting national projects for input to the Annex. Because of this, the launch of the Annex work has been postponed until the beginning of February 2011.

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Ongoing Annexes

Bold text indicates Operating Agent. * Participation not finally confirmed, ** Participant of IEA IETS or IEA SHC

Annex 34 Thermally Driven Heat Pumps for Heating and Cooling	34	AT, CA, CH, **DE**, FR, IT, NL, NO, 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, CH*
Annex 36 Quality installation and maintenance	36	CA*, CH*, DE*, FR, JP*, KR*, SE, UK, **US**
Annex 37 Demonstration of field measurements of heat pump systems in buildings – Good examples with modern technology	37	AT, CH, **SE**, UK
Annex 38 Systems using solar thermal energy in combination with heat pumps	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, JP, NL, 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 International Energy Agency's Roadmap for Energy Efficient Heating and Cooling Systems in Buildings: The Role of Heat Pumps

Michael Taylor, International Energy Agency, France

The International Energy Agency's (IEAs) Energy Efficient Buildings: Heating and Cooling Systems roadmap lays out the "big picture" vision for stakeholders in the buildings sector of the goals for heating and cooling equipment if the world is to achieve a 50% reduction in energy related CO_2 emissions by 2050. It provides concrete advice on how to achieve the savings in the BLUE Map scenario, highlights the key technology options, the barriers they face and the policy options to address these barriers. Heat pumps are a particularly important abatement option and are a key part of the solution for buildings in this roadmap.

Energy Technology Roadmaps at the IEA

We are facing challenging economic times, with a range of events yet again highlighting the vulnerability of the global economy to high energy prices. At the same time, all nations share a responsibility to ensure their energy sectors become more sustainable and more secure to manage the risks and impacts of climate change. The need for action is urgent, but drastically changing energy infrastructure and end-use equipment on a national scale is a complex and expensive undertaking. Careful planning is required to ensure that limited resources are devoted to the highest-priority, highest-impact actions in the near term while laying the groundwork for longer-term improvements.

The International Energy Agency's (IEAs) energy efficient and low-carbon technology roadmaps are strategic plans that help to outline activities, policies and organisation to transform the market for a given technology or grouping of technologies. The roadmaps are designed to identify, and provide solutions to overcome, all of the technical, market, R&D, regulatory, consumer acceptance, legal, etc. barriers to the uptake of these technologies as well as lay out specific goals and outcomes for technology R&D, development, costs and performance and deployment.

The Buildings Sector in Context: The IEAs Energy Technology Perspectives Scenarios

In the Baseline scenario, carbon dioxide (CO_2) emissions from the buildings sector, including those associated with electricity use, nearly double from 8.1 gigatonnes (Gt) of CO_2 to 15.2 Gt CO_2 until 2050. In the BLUE Map scenario CO_2 emissions are reduced by 12.6 Gt CO_2 from the Baseline scenario level in 2050, with 6.8 Gt CO_2 of this reduction being attributable to the decarbonisation of the electricity and heat sectors. This reduces the direct and indirect CO_2 emissions attributable to the buildings sector to 2.6 Gt CO_2 in 2050, one-third of the 2007 level.

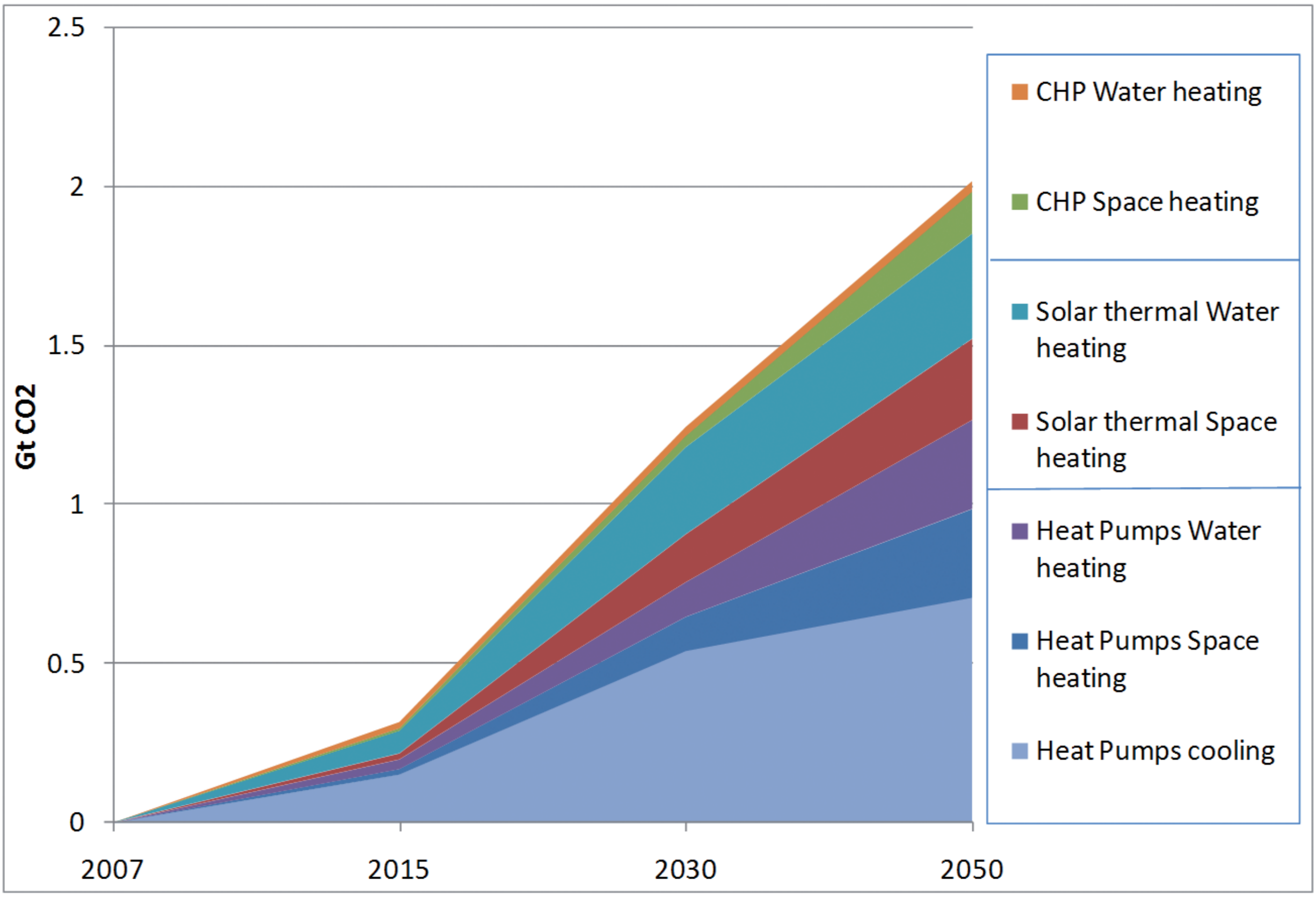
The heating and cooling technology solutions that will allow the buildings sector to shift to a more sustainable energy and environmental future contribute 2 Gt CO_2 of the total savings. The increased deployment of heat pumps for space and water heating, as well as the deployment of more efficient heat pumps for cooling account for 63% of the heating and cooling technology savings.

The Heating and Cooling Systems for Buildings Roadmap

The roadmap establishes a "big picture" vision for stakeholders in the buildings sector of the goals for heating and cooling equipment, and provides concrete advice on how to achieve the savings in the BLUE Map scenario. It highlights the key technology options, the barriers they face and the policy options to address these barriers.

The roadmap lays out a well structured and comprehensive vision of the appropriate and feasible long-term goals for the sector, as well as identifying specific milestones and packages of policies to achieve these goals. An integral part of the roadmap is the identification of the role and contribution of different stakeholders in this process and how they will need work together to reach the common objectives outlined in the BLUE Map scenario. The key areas

Figure 1: CO_2 emissions reductions in buildings from heating and cooling systems in the BLUE Map scenario (reduction below the Baseline)



Key point: Heat pumps play a critical role in reducing CO_2 emissions from heating and cooling equipment in the buildings sector

addressed in this roadmap are:

- The status, costs and future developments in selected heating and cooling technologies;
- The areas where specific R&D needs have been identified, as well as future technology development goals and milestones
- Specific deployment goals for heating and cooling technologies in the buildings sector
- Policy recommendations, to overcome existing and future barriers to heating and cooling technologies, and their timing to ensure achievement of the BLUE Map scenario results.

The key technology options for heating and cooling in buildings have been narrowed down to those with the greatest long-term potential for CO_2 emissions reductions, or facilitating them. This roadmap covers the following technologies for space and water heating, heat storage, cooling and dehumidification:

- Active solar thermal
- Combined heat and power (CHP)
- Heat pumps for cooling and space and water heating
- Thermal storage

The increased deployment of heat pumps for space and water heating, as well as the deployment of more efficient heat pumps for cooling account for 23% of the savings. Solar thermal systems for space and water heating account for around 12% of the savings. CHP plays a small but important role in reducing CO_2 emissions, as well as assisting in the balancing of the renewables-dominated electricity system in the BLUE Map scenario.

Heat Pumps in Buildings in the BLUE Map Scenario

The potential energy and CO_2 savings from the wider use of heat pumps are substantial, given their high efficiency and relatively low market penetration for space and water heating. The efficiency of today's BAT for air-conditioners is considerably higher than average installed efficiencies, offering further scope for CO_2 emission savings. When combined with thermal storage, to enable load to be shifted out of peak periods, heat pumps could also help reduce the costs in the BLUE Map scenario of integrating a high share of intermittent renewables into the grid.

The BLUE Map scenario will require nothing short of a complete transformation of the way space and water heating is provided, while the global average efficiency of cooling systems will have to more than double by 2050. Highlights for space and water heating include:

- The share of useful space and water heating demand met by fossil fuels will drop to between 5-15% (depending on region) from today's position of dominance.
- Installed solar thermal capacity will increase by more than 25 times today's level to reach 3 743 GW_{th} by 2050.
- The installed capacity of distributed CHP in buildings will be 50 times greater than today's level, reaching 489 GW_e in 2050.
- Heat pumps will dramatically increase their share of space and water heating, with total installed units for heating and cooling reaching almost 3.5 billion by 2050.
- Thermal energy storage will be associated with half of all space and water heating systems by 2050.

The deployment of today's heat pumps systems will give way in the BLUE Map scenarios over time to integrated systems providing space heating, water heating and cooling, and hybrid heat pumps systems (i.e. combined with solar thermal systems) for improved efficiency. Although heat pumps are often competitive today, the large-scale global deployment of heat pumps for heating and higher efficiency air-conditioning devices will require additional R&D, demonstration programmes and support policies to help transform the market for heating and cooling.

Worldwide, around 800 million heat pumps are estimated to be installed in the residential sector in 2010 and this will grow to 3 500 million in the BLUE Map scenario. Three-quarters of today's heat pumps are small air conditioning or reversible units with an average capacity of 2.5 kW. Their contribution to space and water heating at a global level is modest. The estimated total installed capacity of heat pumps for space and water heating needs to grow to 6.6 times today's level, critically, with installed capacity for water heating going from virtually nothing today to 1 300 GW_{th} by 2050.

The roadmap sets goals for a 20% improvement in COPs by 2020 and 50% by 2030, at the same time as reducing costs by 15% in 2020 and by 25% in 2030. Further R&D, as well as wider deployment will help to achieve these goals, while at the same time heat pumps systems capable of providing simultaneous space and water heating, and cooling for all market segments need to be developed, as well as hybrid systems (e.g. heat pump/active solar thermal systems) to achieve very high efficiencies and CO_2 emissions reductions.

To achieve the level of deployment envisaged in the roadmap, and hence the energy and CO_2 emissions reductions, will require strong, consistent, stable and balanced policy support. The roadmap recommends the policy focus should be in the following four main areas:

- Increased technology R&D, significant demonstration programmes and the development of beyond BAT technologies.
- Improved information for consumers and agreed, robust metrics for analysing the energy and CO_2 savings of heating and cooling technologies, as well as their life-cycle financial benefits.
- Market transformation (deployment) policies, which are ideally technology neutral, to overcome the current low-uptake of the many energy efficient and low/zero carbon heating and cooling technologies.
- International collaboration to foster greater collaboration in R&D, best-practice policy packages and deployment programmes to maximise the benefits of policy intervention, as well as the transfer of technical knowledge between countries and regions.

The market transformation policies need to focus on addressing current and future market barriers (lack of prioritisation of energy efficiency, capital market barriers, absence of external costs) and address market failures (lack of adequate number of market participants, lack of perfect information, principal-agent problems, transactions costs and delays, inadequate financial mechanisms etc). The roadmap recommends specific policies to:

- Improve information availability and relevance for decision makers.
- Improve heating and cooling system actors (architects, engineers, installers, etc) knowledge and competence with energy efficient and low-carbon heating and cooling technologies
- Implement deployment policies to accelerate uptake and reduce costs through economies of scale.
- Expand quality assurance schemes to encompass the entire sector and provide consumers with the confidence to invest.
- Remove regulatory, policy, fiscal and other barriers.

Achieving complete market transformation in the building sector is an extremely challenging policy goal, due to the large number of individual decision-makers and the fact that the buildings sector is large, diverse and fragmented. A clear message from the roadmap is that policies need to be "broad", to tackle the range of barriers, and "deep" to ensure the barriers faced by all those in the decision-making chain are addressed. Another clear message is the important role heat pumps play in achieving CO_2 emissions reductions in the buildings sector, in the OECD for space and water heating and in non-OECD countries for water heating and cooling.

Source: Energy Efficient Buildings: Heating and Cooling Systems 2011

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IEA Energy-Efficient Buildings: Heating and Cooling Systems road map. Focus on Japan and Asia region

Shogo TOKURA, Heat Pump & Thermal Storage Technology Center of Japan

Introduction

Heat pumps have been identified as most efficient technology for energy-efficient buildings in the IEA 'Energy Technology Perspective' (ETP) 2010. To show further concrete steps of the Blue Map Scenario towards the goal of ETP 2010, the "Energy-Efficient Buildings: Heating and Cooling Systems" road map has just been launched. The road map also points out the importance of collaborative work, to include non-OECD economies, as their growth of energy consumption will be dominant in coming decades. In this article, discussion addresses the Japanese and Asian region, specifically China and Vietnam, with regard to heat pump technology deployment.

Recent serious damage to Japanese people and nuclear power stations in Japan, hit by a huge earthquake and tsunami, is a real tragedy, but it is certain that energy efficiency is becoming a more essential issue. Among energy efficiency technologies, heat pumps must be strongly promoted throughout the world.

Background

ETP 2010 raises the following three points as key messages.

- It is possible to reduce CO_2 emissions by half by 2050, utilising existing and new technology in the energy field.
- The biggest contribution to CO_2 emission reduction will be by energy efficiency improvements and by reducing carbon emissions from electricity production
- World-wide promotion of heat pumps and electric vehicles is the key.

The Blue Map scenario targets a 50 % reduction of CO_2 emissions by 2050. To make this scenario happen, road maps have been proposed by IEA for some of key areas to provide concrete steps to be taken by stakeholders in three categories of end-use sectors, i.e., Building, Industry, and Transportation.

Water heating and space heating and cooling together account for about half of the global energy consumption of buildings. Heat pumps are the most promising measure to achieve the road map's vision.

This report will highlight policy action in Asia and Japan, and international collaboration as well, in order to improve energy efficiency in buildings discussed in the road map.

Outline of the road map

Three fundamental issues shape future energy consumption in the buildings sector and therefore dominate the policy challenges facing the sector. They are:

- Population, household numbers and service sector activity will grow significantly more quickly in developing countries by 2050 than in the OECD and EIT countries.
- Residential buildings, particularly in the OECD, are very long-lived and have significant space heating loads.
- Cooling loads are much more important in developing countries.

The increased deployment of heat pumps for water heating, space heating and cooling account for 22 % of the CO_2 emission savings. Solar thermal systems for space and water heating account for around 12 % of the savings. CHP plays a small role in reducing CO_2 emissions.

In the ROAD MAP, the following points are raised as key points for achieving the goal of the Blue Map scenario,

- Increase R&D efforts
- Implement new polices to transform the market for heating and cooling technologies
- Improve information availability, standardisation of presentation and quality using standardised information packages
- Improve standard education of key professionals.
- Develop policy packages to support the deployment of energy-efficient and low/zero-carbon heating and cooling technologies (minimum energy performance standards, utility programmes, financial incentives, etc).

Policy support in Japan

In Japan, METI announced a new road map in 2010, for further promotion of innovative energy technology development, taking into consideration Japan's advantage in technology and messages from international agencies, i.e. IEA's ETP 2010. The "Cool Earth- Innovative Energy Technology Plan" was announced, and similar scenarios have been adopted.

Japan's Top Runner programme helped to raise COPs. The COP of heat pump air conditioners in Japan increased from around 4.3 in 1997 to around 6.6 in 2008. Improvement in heat pump efficiency has also been supported by tax incentives and subsidies.

Figure 1 shows the improvement of efficiency of major heat pump types. Competition to achieve higher efficiency due to the effect of the Top Runner system introduced by the Revised Law Concerning the Rational Use of Energy in April 1999 has improved the average cooling and heating efficiency of household air conditioners (RAC) two-fold, to COPs of 6.7, over the past ten years or so. In addition to the equipment covered in the Top Runner system, centrifugal chillers for commercial and industrial uses have also improved their efficiency by about 40 % and achieved COPs of 7.0. In addition, EcoCute, the CO_2 refrigerant heat pump water heating system (HPWH) that was the first commercialised model in Japan and introduced in 2001, also improved the mid-term unit efficiency of heat source equipment and achieved a COP of 5.1.

Heat pump water heating systems with significant CO_2 reduction effects are rapidly spreading due to increasing awareness of the need to reduce global warming in recent years. Figure 2 shows the growth in numbers of EcoCute units sold for residential use (JRAIA 2010). Sales have rapidly increased, reaching 2.5 million units at the end of September 2010.

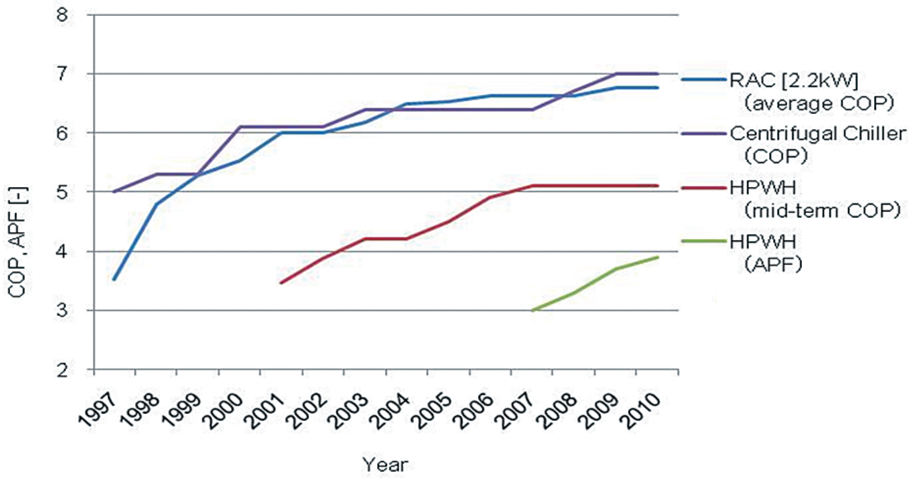

Figure 1. The development of efficiency of major heat pump types

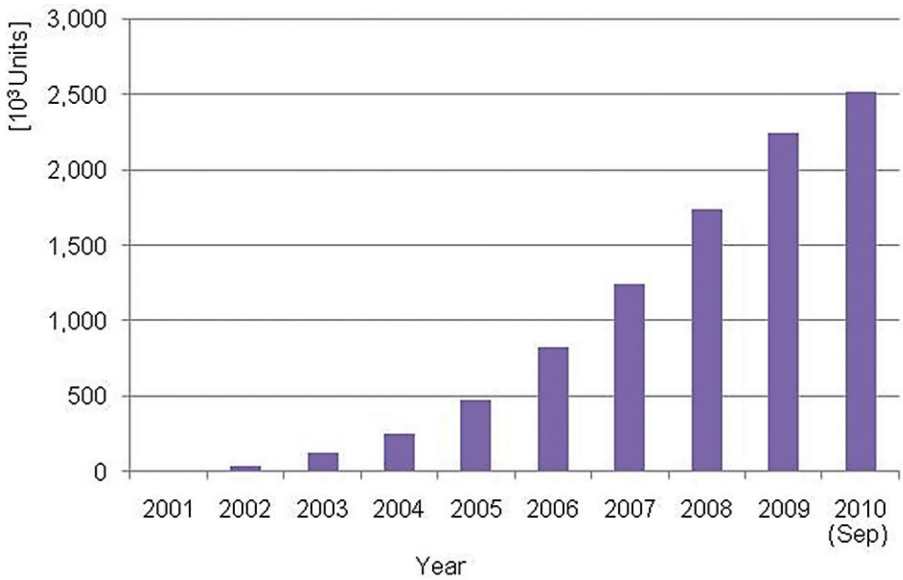

Figure 2. Cumulative numbers of EcoCute for residential uses

Japan's New Growth Strategy proposes policies to promote zero emissions through the use of heat pumps, increase the use of air thermal and geothermal heat sources, and expand the renewable energy market.

R&D

The main R&D priorities for the future are:

- Components:
- Systems/applications:
- Control and operation:
- Integrated and hybrid systems:

Among the above, variable-speed control by inverter technology has contributed substantially to dramatically improved efficiency . Continued deployment of inverter technology and application will be key to achieve the Blue Map Scenario target.

The other promising area of development for ultra-high performance of heat pump technology will be integrated heat pump systems that combine multiple functions (e.g. space conditioning and water heating) and hybrid heat pump systems that are paired with other energy technologies. (e.g. storage, solar thermal or other energy sources)

Integrated systems, such as those that integrate solar thermal technologies and heat pumps, have significant potential and would result in very high efficiency/low-carbon hybrid systems.

Particularly, as the Asian region has a large area of tropical climate, a method for simultaneous usage of waste heat from air conditioners for water heating should be developed.

The Japanese government is pursuing breakthrough technologies, including expansion dynamics recovery technology, super-high-efficient heat exchange, next-generation refrigerant, operation in extremely cold climates, heat recovery and utilisation of waste heat.

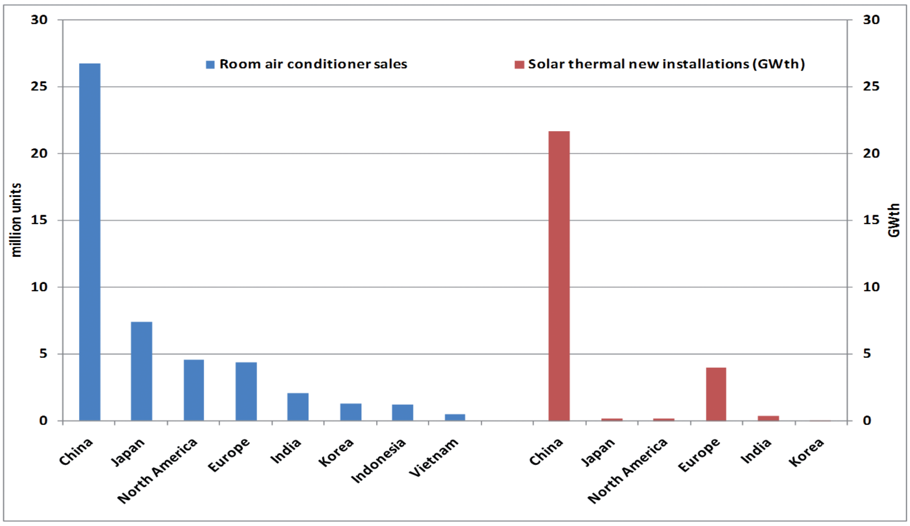

Figure 3. Sales volumes during 2009. Source: IEA Heat Pump Programme and Weiss, 2010

Asia

China has provided continuous and strong policy support for energy efficiency in buildings as described in the box below.

Chinese sales volumes of air conditioners was estimated at 27 million units in 2009, which is a 35 % increase over 2005 sales. China has already become the largest market for heat pump products in the world.

In many Asian economies such as Thailand, Vietnam, Malaysia etc., including China, governments are keen to promote energy efficiency, and are introducing labelling system as well as Minimum Energy Performance Systems (MEPS), similar to the Japanese Top Runner system.

Heat pumps in China

The Ministry of Finance and the Ministry of Housing and Urban-Rural Construction of China have released an “Implementation Opinion about Promoting the Renewable Energy Utilisation in Building Application and Temporary Management Measures with Special Funds for Renewable Energy”. The following areas are strongly supported by the government:

- Heating and cooling using water-source heat pumps in surface water and groundwater-rich areas,
- Heating and cooling with seawater source heat pumps in coastal areas,
- Heating and cooling using ground-coupled heat pumps (geothermal heat pumps), and
- Heating and cooling using sewage source heat pumps.

In response to the country’s initiative, several ministries, commissions and local authorities have formulated corresponding policies for energy conservation and building energy efficiency. Many cities have also provided special subsidies to encourage the application of ground-source heat pump systems.

Over the last three years, the Central Government of China has promulgated a series of policies and regulations on energy conservation and environmental protection, so that local authorities and the whole nation will be more aware of the importance of energy efficiency and renewable energy utilisation. Heat pumping technologies, providing both heating and cooling for buildings, are becoming increasingly attractive, resulting in a rapidly growing market.

The Chinese state encourages the use of solar energy and geothermal energy in new and retrofit buildings. Geothermal energy is considered a renewable energy according to the Chinese Renewable Energy law. Geothermal pilot projects are given special subsidies. The rapid development of real estate construction, economic growth, and increasing living standards will inevitably make China the world’s largest heat pump market.

Standard methodology for energy efficiency

Standardised methodologies for evaluating the energy and CO_2 emissions reduction potentials of technologies need to be developed. To do this, information sharing and collaboration including research programmes, market deployment programmes, performance and test standards, and setting of energy and CO_2 emissions reductions targets/standards are important. It will also be important to track progress and keep stakeholders in all regions up to date.

Engage in international collaboration efforts

It is extremely important to harmonise all countries’ efforts to establish standardised methodologies and reduce market barriers.

Coordinated market development and certification/training schemes: there are a number of key areas for information-sharing and collaboration:

- Research programmes.
- Codes and standards.
- Setting of market development targets, such as market penetration.
- Alignment of heating and cooling system infrastructure.
- Policy development and experience in implementing different approaches.

Collaboration between Japan and Vietnam

Over the last decade, energy consumption in the residential sector in Vietnam has been increasing at an average growth rate of 8 % every year. This is caused by a modernised life style, particularly in urban areas, where rapid growth in the numbers of home electrical appliances such as refrigerators, electric water heaters and air conditioners can be seen. In 2006, the Vietnamese government endorsed the Vietnam National Energy Efficiency Program (VEEP) to promote energy-efficiency technologies and management, thus contributing to a saving in investment in the power sector. The VEEP targets are a reduction of 3-5 % of energy consumption between 2006-2010, and 5-8 % energy consumption reduction between 2011-2015, as compared with the corresponding business-as-usual scenarios.

Recent surveys in Hanoi indicated that energy consumption for air conditioning normally accounts for 30 % to 60 % of total electricity use in most residential buildings. Introduction of high-energy-efficiency air conditioning is therefore very important for energy reduction in all types of buildings in the region.

Simple Comparison Method to evaluate Energy Efficiency

Japan started collaboration with Vietnam by conducting cooperative experimental work under the METI program. As the counterpart on the Vietnamese side, Hanoi University of Science and Technology (HUST) has been leading the development of unique test facilities for improving energy efficiency. On the Japanese side, work is being led by the Heat Pump and Thermal Storage Technology Center of Japan (HPTCJ).

This work aims at making the efficiency differential between inverter and non-inverter drives visible. Standard laboratory systems, such as recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), commonly require artificial control of both indoor and outdoor environmental conditions to provide highly accurate evaluation of the energy performance of electric appliances. Such comprehensive systems are unaffordable in most developing countries. The study focuses on development of a least cost and yet simple method of investigating the energy performance of non-inverter and inverter air conditioners.

The simple method, using two identical rooms, in which the non-inverter unit and the inverter unit are installed respectively, was developed. The difference can be easily detected, for least cost. This method has great potential for use in regions where the demand for air conditioning is expected to grow.

Details will be reported at the 10th IEA Heat Pump Conference 2011 by Dr. Hoang-Luong Pham, Associate Professor, Hanoi Advanced School of Technology, Hanoi University of Science and Technology.

Conclusions

International collaboration, multi-stakeholder workshops – among governments, utilities, manufacturers and others – are also important for improving collaboration and sharing best practices in areas such as standardisation, system integration, innovation applications and consumer behaviour. Collaborative work, such as the joint study between Japan and Vietnam, will assist this framework.

Early involvement of developing countries in international collaboration and information sharing should be ensured.

While the IEA proposes to develop a Road Map Implementation and Monitoring Committee that would work together in an ongoing fashion, it will be essential to include Asian economies, as their emerging demand for cooling and heating in the building sector will constitute a major load which will require comprehensive countermeasures if the goal of the Blue Map scenario is to be achieved.

Source: Energy Efficient Buildings: Heating and Cooling Systems 2011 © OECD/IEA, 2011

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Improving the energy efficiency of buildings in China

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Improving the efficiency of energy use in buildings is an important way of reducing emissions and helping to combat climate change. Nearly 2 billion square meters of new buildings are constructed every year in China, accounting for 40 % of total world construction, and expected to continue at this rate for the next 25-30 years. At this critical stage, there are six main areas that influence the efficiency of energy use in building. This paper describes some general background information and related policy actions.

Heat metering and energy efficiency in North China.

The State Council requires that "metering and energy efficiency improvements in existing heating systems shall be started with 150 million square meters of residential buildings in North China". The Ministry of Construction (now called the Ministry of Housing and Urban-Rural Development, MOHURD) has broken down the target to 15 provinces and cities in the north. The Ministry of Finance, together with the Ministry of Construction, has put forward a fiscal policy of using central budget funding as incentives for such renovations. A total of RMB 900 million was earmarked for subsidising installation of heat metering devices in 2007. From 2006 to 2008, the number of buildings in which heat was metered doubled every year. By 2009, the total number of buildings with heat meters was three times as great as in 2008.

Increase of new buildings conforming to the energy standards.

As long ago as 1986, the central government required that all the new buildings should comply with the energy efficiency codes, which means 50 % or 65 % energy efficiency (depending on where in the country that the province or city was) in comparison with the same type of building and type of construction in the 1980s. Statistics collected from different localities show that 99 % of all the urban new-builds across the country in 2009 conform to energy efficiency codes in terms of their design, and 90 % of them in terms of their construction stage; improvements of respectively 46 and 69 percentage points over 2005.

In the future, the government will regard energy efficiency as one of the most important requirements to be met before acceptance of designs etc., and will extend the energy efficiency codes and green building standards to small cities and rural areas as well.

Energy-saving regulatory system for public buildings.

The State Council proposes that "demonstration projects shall be initiated for energy-efficient operation, management and transformation of large public buildings, with experiments to be made in 25 demonstration provinces or cities to put large public buildings under the control of an energy consumption monitoring and energy auditing scheme, with public notification of energy efficiency and energy consumption quota system". In the energy consumption quota system, the owner of a building pays a higher price for energy above a certain threshold of energy consumption . The Ministry of Construction and the Ministry of Finance has identified 24 provinces and cities for the first group of demonstration localities where action plans have been developed for establishment of an energy-saving regulatory system for state office buildings and large public buildings, and investigations made into the basic conditions and energy consumption data of such buildings. Energy auditing of state office buildings and large public buildings has been started in some provinces and cities. So far, energy use has been measured in over 30 000 buildings, with continuous measurements being made in 700 buildings. The on-line building energy monitoring system has been established in Beijing, Tianjin and Shenzhen.

Promotion of overall decorated house and fabricated constructions

It is estimated that compared with the traditional construction method, green construction methods can reduce energy consumption by about 20 % per square meter, water consumption by 63 %, timber formwork consumption by 87 %, and general construction waste can be reduced by 91 %. This means that if we are greatly to reduce energy consumption in the construction stage, the only way is to include overall fitting-out, in combination with pre fabricated construction. In this context, the term 'fitting-out' refers to most interior necessities of a house, which are not normally provided with new houses in China.

China will adopt three main counter-measures. Firstly, implement residential prefabricated fitted-out house-building by a group of large enterprises, in turn influencing small and medium-sized enterprises. For example, large enterprises such as Vanke have announced that they will deliver overall fitted-out houses and pre-fabricated buildings in all the real estate projects in which they are involved throughout the country. Second, provide incentives. Beijing has encouraged developers to choose overall fitted-out houses and prefabricated construction by volume bonuses and partial refund policies for municipal construction. Third, accelerate the publication of standards; make more new materials, new technology and new construction methods, all of which can be adopted by the vast number of small and medium-sized enterprises.

Renewable energy application in buildings

China has published regulations and announced incentives for renewable energy use in buildings. According to (incomplete) statistics, total world solar collector area for water heating amounts to nearly 150 million m2, of which China accounts for about 60-70 %, with an annual growth rate of about 30 % for solar water heater applications for buildings.
The next major work area includes acceleration of publication of regulations and standards, aiming for issue of the relevant standards in the next two years, and raising the profile of demonstration of renewable energy application in buildings, aiming to choose 20 cities as renewable energy demonstration cities each year, with the central government giving 60-80 million RMB (about USD 10-12 million) subsidies to the selected cities. The demonstration cities for renewable energy demonstration must deliver 3 million m2, and have established renewable energy utilisation policies for construction etc. In addition, input is needed in such areas as tax reduction, partial refunds for municipal construction etc., and we need also to speed up the promotion of renewable energy applications in rural housing.

Demonstration and promotion of green building

The Green Building Initiative in China started in 2008. By the end of 2009, 56 buildings had achieved the China Green Building Evaluation Label. In 2010, 200-300 large buildings will achieve the China Green Building Evaluation Label. Green building is of great significance, as it can make a valuable contribution to energy conservation, water conservation and material conservation in buildings, while also improving efficient land use. It can also improve indoor environmental quality and reduce external environmental impact, and is an important measure for fighting climate change. Green building must be combined with green design and construction. At present, the China Green Building Evaluation Label is achieved mainly by public buildings, as there is increasing awareness of energy consumption in public buildings, which should be a model of energy efficiency.
In view of the above difficulties, there are four measures to be implemented. First of all, perfect the relevant incentives policy. All buildings fulfilling green building star standards should receive preferential policy treatment. Second, accelerate publication of green building standards, matching the standards to the requirements of all climate zones and different types of buildings and residences. Third, promote integrated innovation of materials and systems. Fourth, strengthen the training of assessors, and extend training to architects.

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North American Overview - Heat Pumps' Role in Buildings Energy Efficiency Improvement

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Daniel Giguère and Sophie Hosatte, Canada

A brief overview of the situation in North America regarding buildings energy use and the current and projected heat pump market is presented. R&D and deployment strategies for heat pumps, and the impacts of the housing market and efficiency regulations on the heating and cooling equipment market are summarized as well.

Introduction

The Energy Technology Perspectives was introduced in 2006 as a response to the G8 meeting request for analysis of technology options and their potential to meet energy efficiency, security, and climate change policy goals. Energy Technology Perspectives 2010 [1] builds on the analysis in ETP 2006 and ETP 2008 to provide this kind of information. The most aggressive scenario examined in ETP 2010 (BLUE) sets the goal of halving global energy-related CO_2 emissions by 2050 (compared to 2005 levels). The Energy Efficiency in Buildings – Heating and Cooling Technologies Roadmap (EEB/HCT) [2] outlines a vision and strategies to help achieve the ETP 2010 Blue Map goals. Buildings heating and cooling technology solutions are estimated to contribute 2 Gt of the total CO_2 emission savings. Increased efficiency and deployment of heat pumps for space and water heating and space cooling are envisioned to account for almost two-thirds of these savings [2]. This article describes North American Strategic energy savings goals in relation to the EEB/HCT roadmap and summarizes the current buildings energy consumption and heat pump market situations.

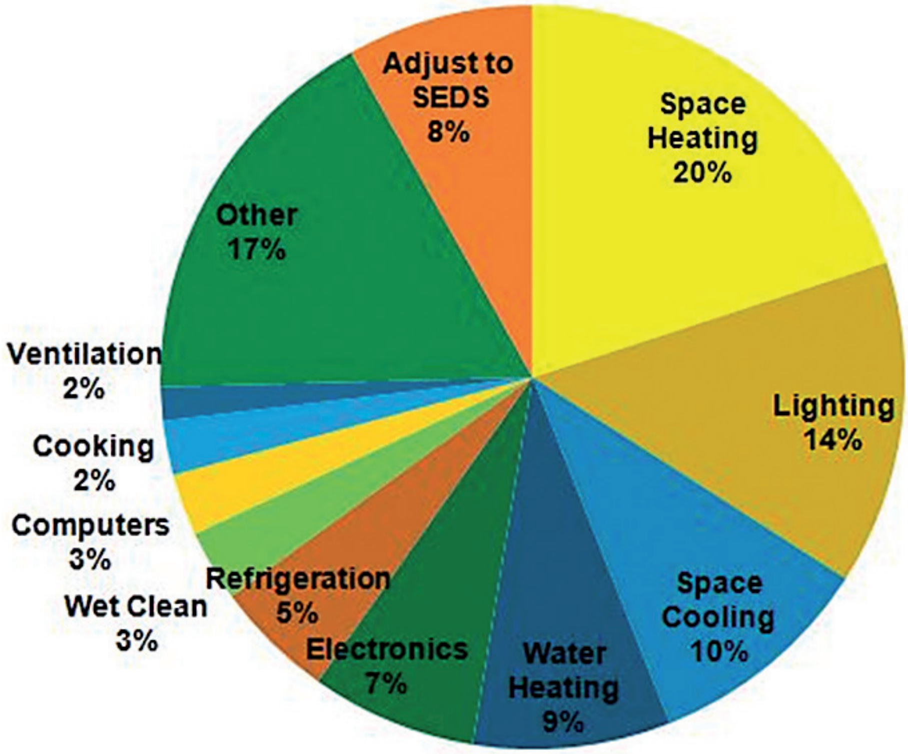

Figure 1. US Buildings Energy Use Profile (2010)

Strategic Direction

US. In the United States, buildings consume approximately 40% of all energy, including 72% of electricity, and account for 38% of greenhouse gas emissions. Residences totalled about 130 million units in 2009 (single and multi family), growing at 0.9%/year and average about 158 m^2 in floor space, growing at 0.7% per year. Commercial buildings totalled about 75 billion m^2 in 2010, growing at 1.3% per year. In a business-as-usual case, buildings end-use (not including electricity transmission and distribution losses) energy demand will grow from about 20.0 EJ currently to about 26.3 EJ in 2050 and CO_2 emissions would grow by 26%. HVAC, water heating, and refrigeration energy uses combined consume 53% of total US buildings energy use (59% in residences and 44% in commercial buildings) (Figure 1).

The overarching strategic vision of the US Department of Energy's Building Technologies Program (DOE/BT) is to minimize US buildings sector energy use (i. e., maximize buildings energy efficiency) to the maximum economically feasible extent. The goal of the BTP is to create marketable technologies and design approaches that address energy consumption in existing and new buildings. For existing buildings, BTP is currently analyzing which retrofit measures are cost-effective and have the largest impact on energy use. For new construction, the ultimate residential goal is to produce homes on a community scale that use on average 40% to 100% less source energy. For commercial buildings, the goal is to achieve 50% to 70% whole building energy improvements, relative to ASHRAE Standard 90.1-2004. [3]

Canada. In Canada, the energy consumption of commercial buildings and housing represents approximately 29% (16% commercial/institutional and 13% residential) of all secondary or on site energy (Total 8.9 EJ in 2007) (Figure 2), and 28% (13% commercial/institutional and 15% residential) of greenhouse gas emissions (Total 501.6 Mt in 2007). The total energy use of the country grew by 28% between 1990 and 2007. During the same period the GDP increased by 58% and the population by 19% while the energy intensity improved by 19% (energy used/GDP) and the energy efficiency improved by 16%. Energy efficiency gains in the building and housing sector are mainly due to thermal envelopes (insulation, windows) and increased efficiency of equipment (e.g. furnaces, auxiliary equipment, and lighting) [4]. Several energy efficiency incentive programs across the country, regulations and labelling of equipment performance (e.g. EnerGuide and ENERGY STAR® programs) helped reach this performance [5].

Commercial/Institutional buildings grew from approximately 450 million m2 in 1990 to 700 million m2 in 2007 (37% increase). Natural gas and electricity accounted for 86% of energy use in 2007. Offices (41%), retail trade (16%) and educational services (13%) represented 70% of the total floor space in 2007. Space heating represents the largest share (approximately 50%) of energy consumption due to the cold climate and increased by 21% from 1990 to 2007. Space cooling represents only about 5% of the energy use but is increasing significantly. (Figures 3 and 4)

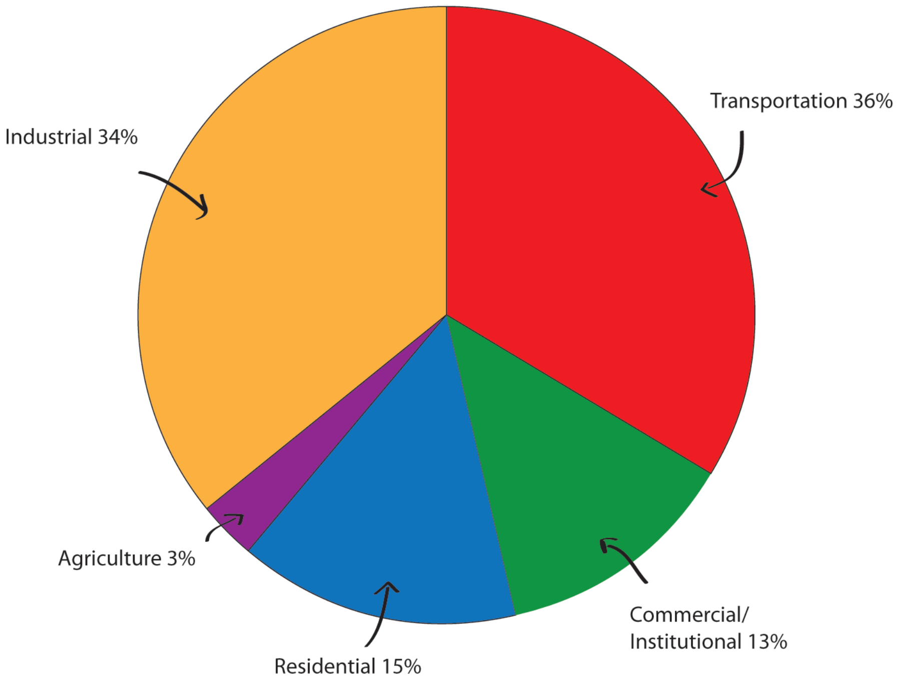

Figure 2: Secondary energy use by sector, 2007 (percent) in Canada

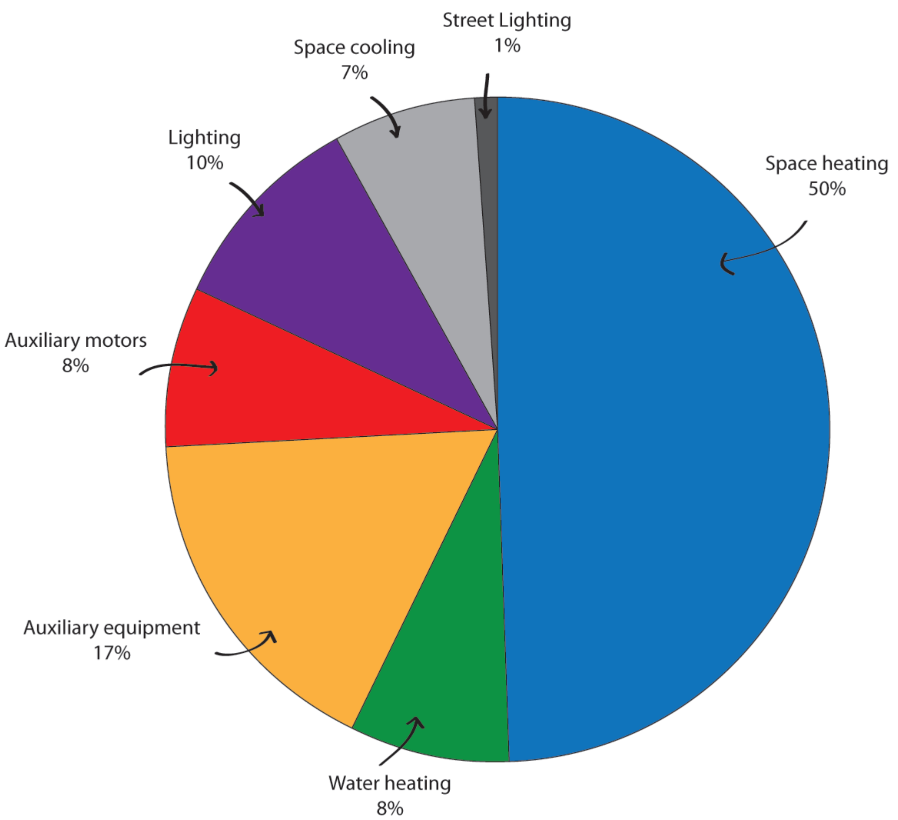

Figure 3: Commercial/Institutional energy use by end-use, 2007 (percent) in Canada

The total number of housing units (single-family and multi-family) was about 13.5 million in 2007, growing at 1.5% on average per year between 1990 and 2007. The average area was about 128 m^2 in floor space growing at 0.5% on average per year on the same period. Natural gas and electricity accounted for 86% of all residential energy use in 2007. 81% of all residential energy use was for space (63%) and water (18%) heating, and only 2% for space cooling (Figures 5 and 6). Between 1990 and 2007, natural gas and electricity became more dominant while heating oil use declined. This change in mix is mainly due to relative energy prices. Over the same period energy use for space heating decreased from 0.66 to 0.52 GJ/m^2, air conditioning penetration increased significantly, the energy use for space cooling growing by 167%

despite the use of more efficient systems (Figure 7)

Heat pump market overview

US. The U.S. heating and cooling market has gone through major changes in the last decade. Figure 8 shows annual shipments for the major types of residential heating and cooling equipment from 1990 to 2010 and forecasted through 2012 along with annual completed housing through 2009. The share of equipment going to new construction is a minority (22% for heat pumps in 2009). The spike in 2005 shipments followed by the drop in 2006 compared to 2004 can be explained in part by new minimum efficiency regulations that went into effect January 1, 2006. Figure 9 illustrates the impact of the regulation for heat pumps and air-conditioners. Manufacturers were attempting to clear out inventory before the new regulations became effective and some could not produce the new higher efficiency systems at full capacity in 2006. The sharp fall in total shipments starting in 2007 and continuing through 2009 is due to the housing market drop. Early 2010 data indicates that the housing market is slowly beginning to recover. Consequently forecasts indicate shipments for 2010-2012 growing slightly in part due to expected increase in housing starts but mostly to sales for the replacement and add-on markets. Recent trends show that heat pumps share of the heating equipment sales is increasing – 42% of total sales in 2008 vs. 27% in 1999. [6]

Figure 10 shows the total stock of US residential units (single-family and multi-family) and the share of various main heating equipment types for 1999-2009. Heat pumps' share of the total heating equipment stock increased from 10.9% in 1999 to 12.3% (16 million residences) in 2009. Note that the actual number of heat pumps is larger because many larger homes have two or more heat pumps. [6]

Figure 11 compares 1999-2009 trends for heat pumps' share as the main residential heating source and heating energy use along with heating degree days and CO_2 emissions. The number of homes using gas furnaces is also

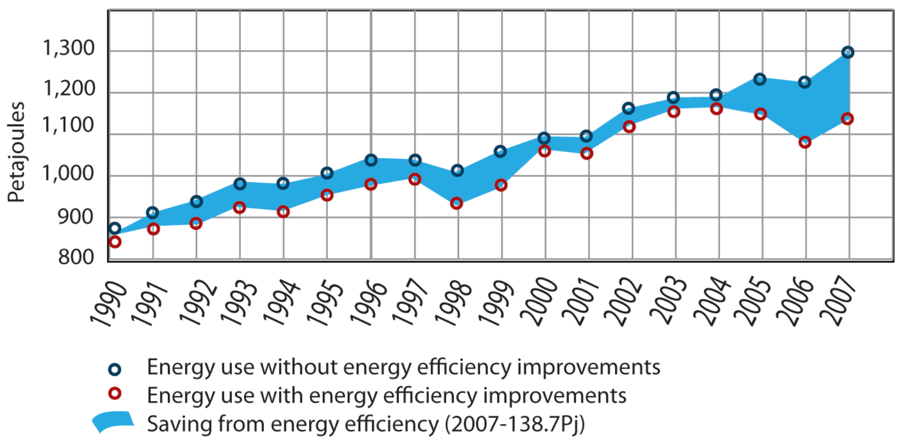

Figure 4: Commercial/Institutional energy use, with and without energy efficiency improvements, 1990–2007 in Canada

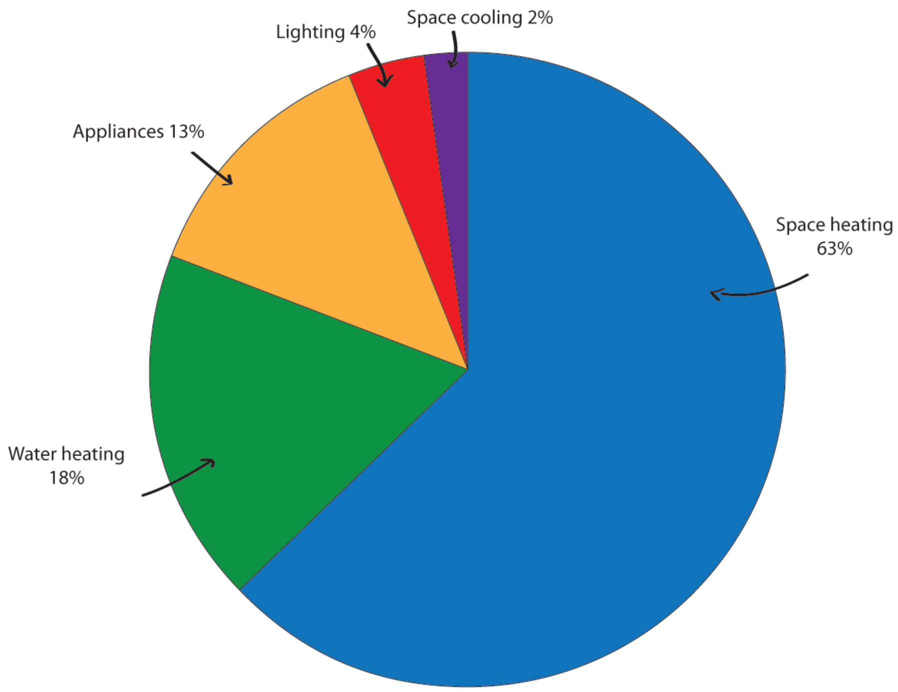

Figure 5: Distribution of residential energy use by end-use, 2007 (percent) in Canada

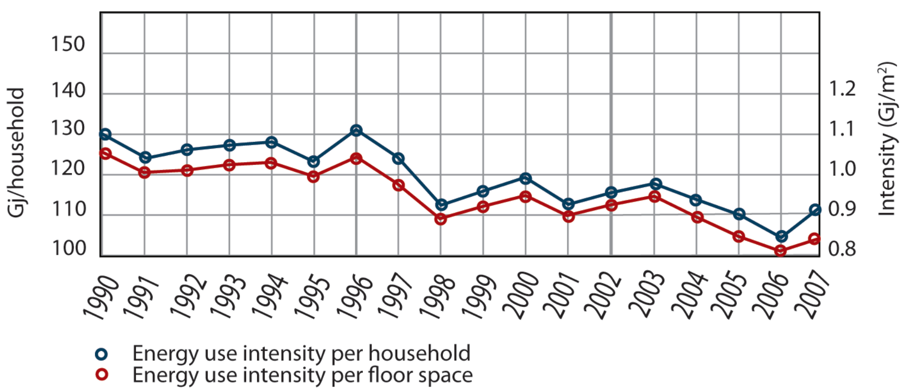

Figure 6: Residential energy intensity per household and floor space, 1990–2007 in Canada

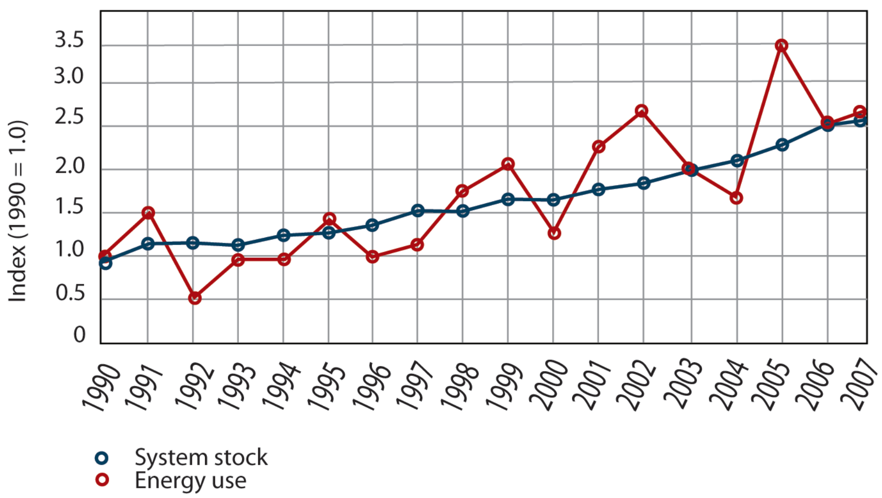

Figure 7: Space cooling stock and energy use, residential sector, 1990–2007 in Canada

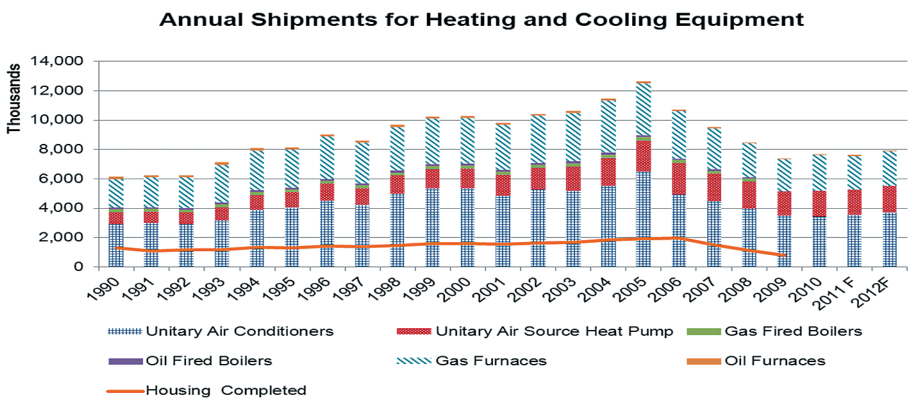

Figure 8: 1990-2010 U. S. Annual Equipment Shipments and Housing Completions and Forecast Equipment Shipments 2011-2012. [6]

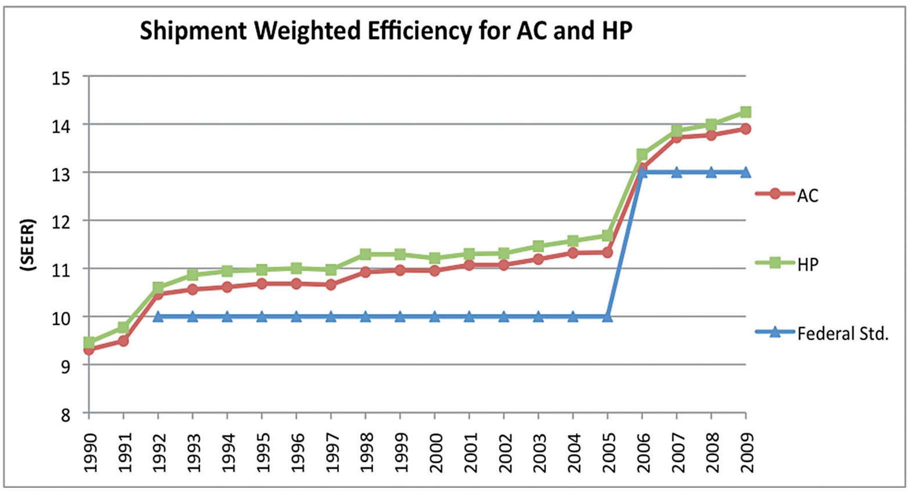

Figure 9: U. S. Shipment Weighted Efficiency for Air-Conditioners and Heat Pumps [6]

added for comparison. Forecasted residential heating energy use to 2020 from the US Energy Information Administration (EIA) [7] and three scenarios (based on 10% growth in annual heat pump sales, 3% growth, and 2% decline) for future heat pump stock are included as well [6]. A common scale (1999 value = 1) is used to display the information. It is reasonable to assume that the increasing number of homes using heat pumps along with the increase in heat pump efficiency has significantly contributed to lowering residential heating energy use through 2008. Continued activities are needed to improve heat pumps efficiency and increase their deployment in order to achieve the projections for future energy use and concomitant CO_2 emission reductions.

Canada. In 2007, in the residential sector the number of installed heat pumps was approximately 235 000, compared to almost 8.2 million furnaces and boilers, and 3.2 million electric baseboards. This low share of heat pumps results from their high capital costs and low performance at cold temperatures. In 2007, the air conditioning market was 6.7 million units (62% central units, 38% window/room units). This market is increasing, in the province of Ontario 80% of housing units are now equipped with air conditioning [8].

The ground source heat market has grown significantly in recent years: by more than 40% between 2004 and 2005, and more than 6% annually from 2006 to 2008. In 2009, 57% of all residential installations were done in existing buildings while the share of ground source heat pumps installed in new homes declined from 45% in 2005 to 30% in 2009. The retrofit market was characterized by 64% replacement of oil and other fossil fuel switching and 36% replacement of electric heating systems, electric baseboards, and existing ground source heat pump systems. This growth is probably attributable to a combination of phenomena: the increase in oil prices that induced fuel switching, financial assistance programs (e.g. ecoENERGY for retrofits, tax rebates in the province of Ontario, loan program in the province of Manitoba, and direct grants in the provinces of Quebec and Saskatchewan), and the role of the Canadian GeoExchange Coalition. Started in 2003, the Coalition engaged in a market transformation initiative, partnering with government, utilities, and industries (manufacturers, assemblers, and installers) [9].

The heat pump market is still low in Canada, due to cold climate and an energy context not favourable to high capital cost systems. The industry is dominated by US manufacturers. For a larger penetration of the technology it is important to work on both increasing performance at low temperatures - ground source heat pumps being one solution - and reducing capital investment. Natural Resources Canada is engaged in Building and Housing R&D programs to achieve net-zero energy targets using integrated systems combining renewable energy, heat pumps and thermal storage.

Conclusions

Heat pumps are growing in popularity and becoming an established economic technology, but further aggressive action in both the existing and new building markets is necessary to increase adoption in North America, and achieve the US EIA's projected decrease in residential energy use (~40% vs. 1999, Figure 11). In Canada, the severe climatic conditions and the energy context represent additional challenges.

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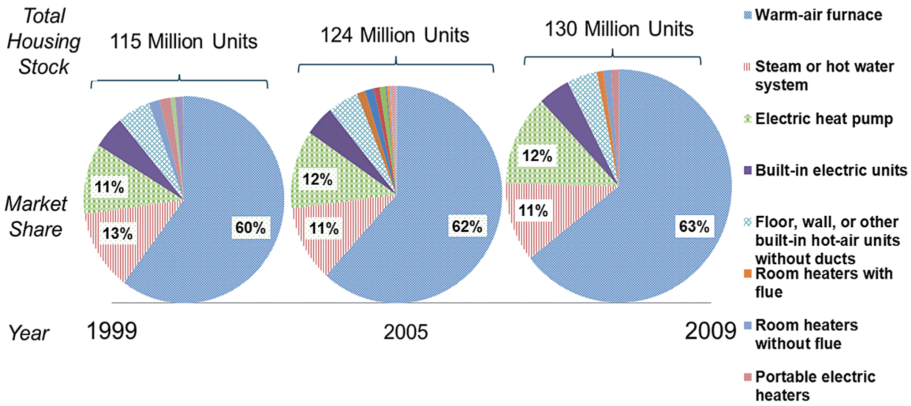

Figure 10: Total U. S. Residential Housing Stock and Primary Heating Equipment Types – 1999-2009 [6]

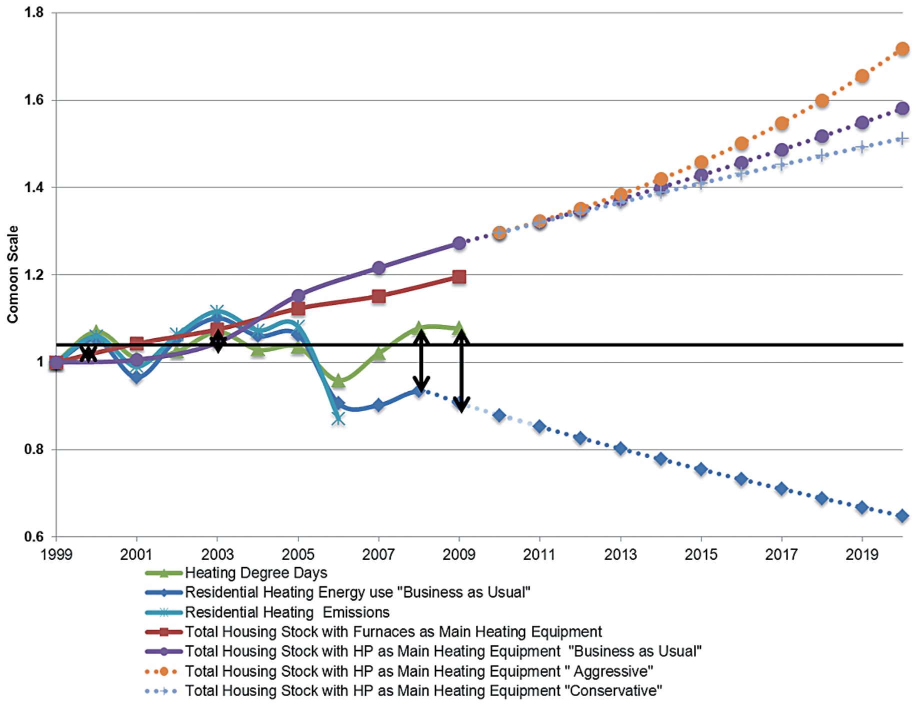

Figure 11: U. S. Trends for Share of Total Housing Stock for Heat Pumps and Warm-Air (Natural Gas) Furnaces, Heating Degree Days, Heating Energy Use, and CO_2 Emissions – with forecasts of heat pump share and heating energy use to 2020. [6]

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U. S. Building Equipment RD&D Strategy Approach and Technical Options

Antonio Bouza (DOE), Van Baxter, Melissa Lapsa, and Ed Vineyard (ORNL), USA

The goals established by the US Department of Energy's Building Technologies (DOE/BT) Program for deep reductions in energy demand of buildings sector are summarized. Plans for future Research, Development, and Deployment/Demonstration (RD&D) activities to achieve the extremely challenging goals are discussed.

Introduction

The overarching strategic vision of the U. S. Department of Energy's Building Technologies Program (DOE/BTP) is to minimize buildings energy use (i. e., maximize buildings energy efficiency) to the maximum economically feasible extent. BTP's goal is to create marketable technologies and design approaches that address energy consumption in existing and new buildings. For existing buildings, BTP is currently analyzing which retrofit measures are cost-effective and have the largest impact on energy use. For new construction, the ultimate residential goal is to produce homes on a community scale that use on average 40% to 100% less source energy. For commercial buildings, the goal is to achieve 50% to 70% whole building energy improvements, relative to ASHRAE Standard 90.1-2004. [1]

Aggressive pursuit of this goal will also be beneficial in reducing buildings CO_2 emissions and help achieve the vision of the IEA's Energy Efficiency in Buildings – Heating and Cooling Technology roadmap. [2] This will require development and implementation (deployment) of efficient thermal envelope systems and components as well as better building equipment of all types. Improved heat pump systems and components form an important part of this strategy. The priority focus of DOE/BTP's efforts is on technologies that can be applied on a large scale to retrofit of existing buildings as this will impact the largest share of the building stock in the shortest time frame. Technologies applicable to new buildings are also important but a lower priority.

This article attempts to briefly describe current efforts to develop technology road maps to guide DOE/BTP's future RD&D investments to put its strategic vision into effect.

RD&D Roadmaps

In January 2010, DOE and ORNL developed a preliminary strategic roadmap for HVAC, water heating (WH), and refrigeration technologies [3]. This initial document is being expanded to develop a series of more detailed roadmaps for space heating, cooling and refrigeration equipment (HVAC&R), WH, and new working fluids (alternatives to high-GWP refrigerants). The focus is on applications for both residential and commercial buildings with emphasis on technologies for retrofit and/or renovation of existing buildings. An additional roadmap specific to light commercial buildings is under development as well. A light commercial building is defined as a non-residential building six stories or lower with no specialized use (e.g., strip malls, malls, hotels and motels, offices, metal buildings, etc.). Of particular interest are multi-tenant light commercial (MTLC) buildings generally exemplified by office parks, strip malls, etc., that typically range between 100 and 500 kW demand usage.

The technology roadmaps are generally divided into near-term and long-term RD&D activities. Potential timelines for future DOE/BTP RD&D are illustrated in Figures 1 (HVAC&R) and 2 (WH).

The primary short-term focus is on 1) development and/or improvement of technical solutions based primarily on existing technologies (e.g. HFC fluids, vapor compression, VC, cycle, currently used approaches for hot water distribution and space heating/cooling distribution, etc.) for rapid deployment in existing building retrofit and 2) development of more advanced technical solutions for new construction applications. Longer-term, the RD&D focus shifts more toward advanced technologies with maximum potential for reducing energy demand (and concomitantly, CO_2 emissions). These include advanced VC cycle-based systems, non traditional refrigeration cycles (aka non-VC cycle or not-in-kind (NIK) technologies), and low

ID	Task Name	Start	Finish	Priority level
1	**HFC – Vapor compression**	**1/1/2010**	**1/1/2015**	
2	Advance cycle	1/1/2010	12/31/2014	
3	Advance components: Linear compressors, carbon fiber HX	1/1/2010	12/31/2014	
4	Reduce refrigerant charge: secondary loops, Microchannel HXs	1/1/2010	12/31/2014	
5	Technology Review	1/1/2015	1/1/2015	
6	**Non HFC – Vapor compression**	**1/1/2010**	**12/31/2018**	
7	Alternative refrigerants: Low GWP	1/1/2010	12/31/2012	
8	Natural refrigerants: CO2	1/1/2010	12/15/2014	
9	Modified cycles	1/1/2013	12/31/2018	
10	Advanced components	1/1/2013	12/31/2018	
11	**Ground source**	**1/1/2010**	**12/31/2014**	
12	Improve effectiveness	1/1/2010	12/31/2012	
13	Reduce cost	1/3/2011	12/31/2014	
14	**Humidity control and IAQ**	**1/1/2010**	**12/30/2016**	
15	DOAS (sensors)	1/1/2010	12/31/2014	
16	Solid/Liquid Desicant	1/1/2010	12/31/2014	
17	Demand Driven based on IAQ (sensors)	1/1/2013	12/30/2016	
18	**Modeling**	**1/1/2010**	**12/31/2020**	
19	BIM	1/1/2010	12/31/2020	
20	Advanced technologies modeling in Energyplus	1/1/2010	12/31/2020	
21	Energy demand profiles	1/2/2012	12/31/2020	
22	Integration with Building Management Systems	1/1/2015	12/31/2020	
23	**Standards**	**1/1/2010**	**12/31/2020**	
24	Energy usage	1/1/2010	12/31/2020	
25	Comfort conditions	1/1/2015	12/30/2016	
26	Refrigerant characterization	1/1/2010	12/31/2012	
27	**Energy Storage**	**1/1/2010**	**12/31/2020**	
28	Phase Change Materials	1/1/2010	12/31/2014	
29	Multi-temperature level storage	1/1/2013	12/31/2020	
30	**Energy Recycling**	**1/1/2010**	**12/31/2020**	
31	Ventilation heat recovery	1/1/2010	12/31/2014	
32	Commercial integrated heat pump	1/2/2012	12/30/2016	
33	Cycle Cascading	1/1/2010	12/31/2020	
34	**CHP**	**1/1/2010**	**12/31/2018**	
35	GHP	1/1/2010	12/31/2014	
36	biofuels	1/2/2012	12/29/2016	
37	emissions	1/1/2014	12/31/2018	
38	**Onsite Renewables**	**1/1/2010**	**12/30/2022**	
39	Solar (PV and Thermal)	1/1/2010	12/31/2020	
40	Demand driven grid integration	1/2/2012	12/29/2016	
41	Energy conversion	1/2/2012	12/30/2022	
42	**Dirstibutions**	**1/1/2010**	**12/31/2014**	
43	Hydronic loops	1/1/2010	12/31/2014	
44	VRV systems	1/1/2010	12/31/2014	
45	Zoning	1/1/2010	12/31/2014	
46	Personal cooling	1/1/2010	12/31/2014	
47	Advanced air distribution systems (+ve displacement)	1/1/2010	12/31/2014	
48	**NIK**	**1/1/2010**	**12/31/2029**	
49	Magnetic refrigeration	1/1/2010	12/31/2014	5
50	Magnetic refrigeration technology review	1/1/2015	1/1/2015	
51	Thermotunneling	1/1/2015	1/2/2025	2.5
52	Magnetic Refrigeration commercialization	1/1/2015	1/2/2025	2.5
53	Not in Kind System market penetration	1/2/2023	12/28/2029	
54	New ideas	1/1/2010	12/31/2029	1.0
55	**Operations and Maintenance**	**1/1/2010**	**1/3/2030**	
56	Controls - Protocols	1/1/2010	12/31/2029	
57	FDD	1/1/2010	1/3/2030	
58	Preventive maintenance	1/1/2010	1/3/2030	
59	Continued commissioning	1/1/2010	1/3/2030	

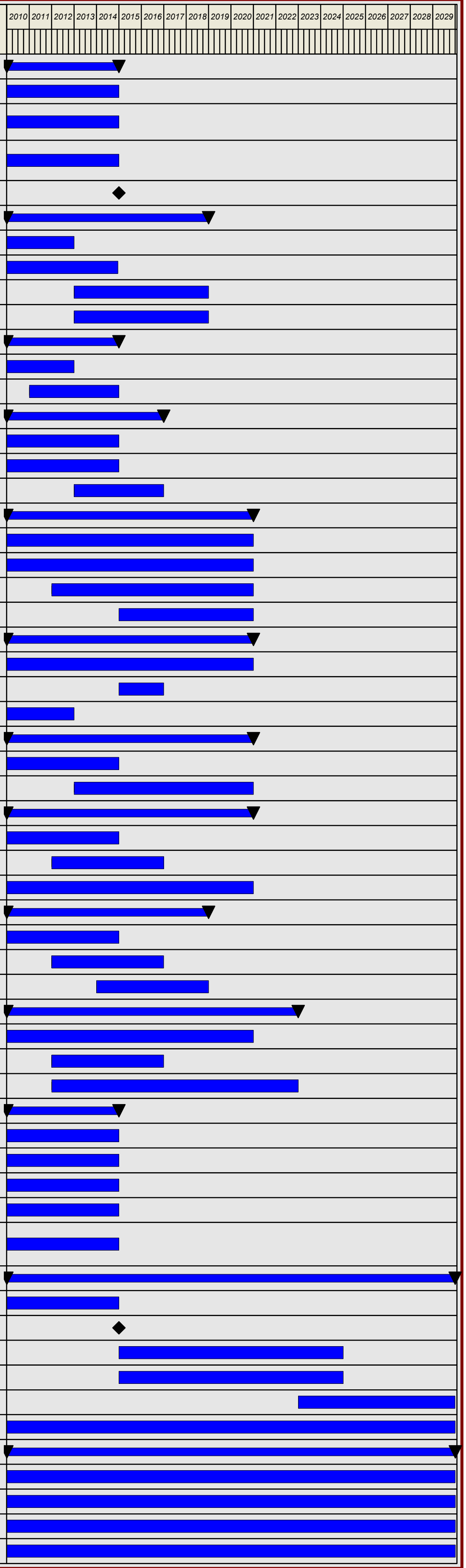

Figure 1. HVAC&R projects timeline.

ID	Task Name	Start	Finish
1	**WH equipment**	**10/3/2011**	**6/29/2027**
2	Solar (or other) WH systems w/>30% source savings vs GTWH	10/3/2011	9/29/2017
3	Non-HFC VC cycle HPWH	10/3/2011	9/29/2017
4	Gas-driven cycle HPWH	10/3/2011	9/29/2017
5	NIK cycle HPWH	10/3/2016	6/29/2027
6	**Combined systems/heat recovery**	**10/3/2011**	**9/29/2017**
7	Drain water heat recovery	10/3/2011	9/30/2014
8	Solar SH+WH systems	10/3/2011	9/29/2017
9	Integrated heat pump systems	10/3/2011	9/30/2013
10	**Distribution systems/WH use reduction**	**10/3/2011**	**9/30/2021**
11	Low-loss HW dist system/end use devices	10/3/2011	9/30/2014
12	Upgrade existing WH system models/add to bldg energy models	10/3/2011	9/30/2013
13	Optimized min loss dist/HW use/WH systems for range of bldgs/climates	10/1/2013	9/30/2021
14	**Market support activities**	**10/3/2011**	**9/30/2026**
15	Well instrumented HW field tests in range of bldgs/climates	10/1/2012	9/30/2014
16	Large-scale demonstrations in range of bldgs/climates	10/1/2013	9/30/2026
17	Support existing marketing & education efforts	10/3/2011	9/30/2026
18	Enhanced marketing strategies dev	10/3/2011	9/30/2014
19	**Standards**	**10/3/2011**	**9/30/2026**
20	Revise WH test procedures	10/3/2011	9/30/2016
21	Support to raise floor of DOE minimum energy use standards	10/3/2016	9/30/2026

Figure 2. Water Heating RD&D projects timeline

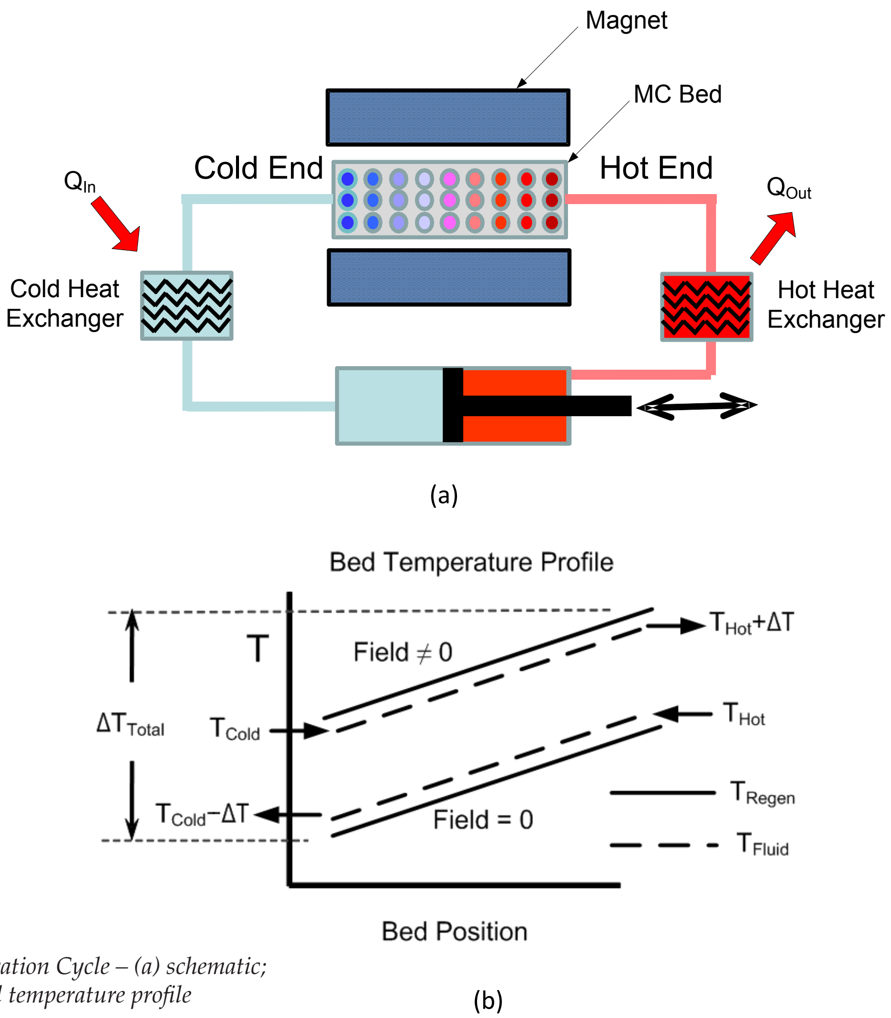

Figure 3. Magnetic Refrigeration Cycle – (a) schematic; (b) magnetocaloric (MC) bed temperature profile

GWP working fluids applications.

Technical and Market Challenges and Barriers.

The challenges to widespread implementation of high efficiency HVAC&R/WH equipment, systems, and thermal distribution networks are significant, particularly in existing buildings. High efficiency heat pump (geothermal and air-source) systems are commercially available today, but their market penetration is extremely limited due primarily to their high initial costs. High efficiency is typically not the main incentive for sales of such premium systems. In the case of water heating equipment and systems, there are few, if any, premium features (e.g. comfort, aesthetics, image, enhanced functionality) that can be combined with efficiency to promote high efficiency products. Furthermore, most residential WH replacements are emergency sales where immediate availability is essential, and upgrading to more energy-efficient units is generally not feasible – plus these more efficient WHs and systems carry high price premiums, limiting their sales. The relatively low annual energy costs to individual consumers and building owners make it difficult to justify more efficient systems.

For commercial buildings, equipment buyers are under pressure to keep upfront cost low, reliability high, and refrigerated space maximized (for food service/sales buildings). In many situations equipment is often specified and provided by entities other than the building owner/user. These third parties do not pay the energy bill and have little incentive to specify high efficiency equipment. In addition, across many segments, there is limited awareness of energy savings potential, although it is growing with the rising cost of energy and the introduction of ENERGY STAR qualified products.

Higher efficiency equipment and systems are available but at unacceptable costs. Affordable advanced technologies are critically needed, particularly for achieving any significant impact in the existing building stock. DOE/BTP's strategies and approach must, therefore, address technical solutions that reduce costs of advanced systems (particularly for retrofits) and focus efforts on more aggressive promotion and deployment of such systems. It cannot focus solely on improving equipment efficiency.

Candidate near term technology options under consideration.

For the near term, efforts to raise awareness among building owners about the benefits (energy efficiency, etc.,) of advanced HVAC&R and WH technologies could help raise adoption, especially for retrofit and replacement markets. Example projects may include:

- Demonstrate performance and cost savings benefits of high-efficiency products and systems via limited, but well instrumented, field tests in a range of building types and locations. Include evaluation of consumer/occupant behavior & reactions/attitudes to advanced systems.
- Large scale demonstration and/or mass buy projects of advanced technologies to increase production volumes, thereby lowering individual unit prices.
- Support existing efforts at market change (Energy Star, etc.).
- Develop enhanced market strategies to tout advanced HVAC&R and WH systems' benefits to home resale value, commercial building appeal/marketability, environmental stewardship/responsibilities, etc.
- Supporting R&D to enable raising minimum energy use standards for advanced equipment and systems.

Example specific near-term technology options follow.

1. Residential technical solutions that have long-term potential to reduce annual HVAC and WH energy consumption by 50% at neutral cost. Several different design approaches will be necessary for optimal performance in different climate zones and building types:

- Integrated heat pumps which combine heating, cooling, ventilation, humidity control, and water heating.
- Very high performance air conditioning (VHPAC) system: target is a 30% reduction in annual energy use with incremental installed price premium of $1000 relative to a current SEER 18/EER 13.4 (5.28 cooling SPF/3.93 rated cooling COP) system with tight ducts in conditioned space.
- Fuel-fired (natural gas or oil) multi-function heat pump and WH systems: targeting 50% reduction in annual energy consumption relative to today's standard systems.
- High performance cold climate heat pumps (air-source heat pumps of primary R&D interest): performance targets as shown in Table 1.
- Initiate analytical/lab projects to identify promising approaches for alternative (non-HFC VC cycle and/or gas-driven absorption cycle) heat pump water heaters (HPWH) – target minimum 50% energy savings vs. Conventional storage WHs.
- Develop advanced WH equipment with potential for 30% source energy savings vs. 0.8 energy factor (EF) gas tankless WH baseline.
- Develop low loss hot water distribution systems and low-cost,

Table 1. Advanced Cold Climate Air-Source Heat Pump – Preliminary Performance Targets

Ambient Temperature (ºC)	Minimum COP	Maximum % capacity degradation from nominal
8.3 (nominal rating point)	4	0
-8.3	3.5	10
-25	3	25

- easy-to-install integrated waste heat recovery – target 20% or more system energy savings relative to conventional distribution systems.
- Space conditioning distribution systems: target 3- to 5-fold reduction in total thermal losses under peak loading conditions (focus on duct systems and air handlers that cannot be moved into conditioned spaces).

2. Commercial building options that have the potential to reduce HVAC&R and WH energy consumption by 30–50%:

- Radiant cooling can significantly reduce energy consumption by reducing air moving power and enabling operation at higher evaporator temperatures. Systems are available but need further development and demonstration of feasibility and cost-effectiveness in various US climate zones - separate dehumidification system is necessary in humid climates.
- Fuel-fired or electric multi-function heat pumps and engine-driven combined heating and power (CHP) systems.
- Desiccant cooling and dehumidification systems, particularly those that can be powered by low grade heat (e.g., heat from CHP or distributed power systems, solar heat from low-cost flat plate collectors, etc.).
- Low loss commercial building hot water distribution networks.
- HPWHs for commercial building applications – particular focus to applications where space cooling output can be utilized.
- Near term efforts for refrigeration systems will concentrate on implementing technologies that are currently commercially available but not widely used. Among these are improved controls, high-efficiency components (compressors including variable-speed models, fan motors, improved fan designs, etc.), and advanced door technologies such as vinyl composite and low/no heat reach in doors. The key challenge will be to determine why these technologies are presently underutilized and develop pathways to more widespread adoption.

In addition, R&D is planned on low GWP refrigerant working fluids to identify candidates for a range of residential and commercial building HVAC, refrigeration, and WH applications.

Candidate longer term technology options under consideration.

For the longer term, DOE/BT's deployment/technology implementation efforts for all areas (HVAC&R and WH) will continue to promote cost-effective retrofit of as much of the existing building stock as feasible to minimize energy demand of this portion of the buildings sector. Efforts will also continue to support existing efforts at market change (Energy Star, etc.).
Longer term R&D efforts will shift toward the development of systems with maximum reasonably achievable efficiency for application to new buildings. The long term RD&D portfolio will also continue to address alternatives to HFC refrigerants and begin activities to develop and implement systems using candidate not-in-kind (NIK) technologies.

Not-In-Kind Technologies

Several screening efforts have been previously made to identify NIK technologies that can replace or be integrated with conventional VC cycle compression technologies to provide energy savings or other relevant environmental benefits. Among the NIK technologies evaluated, those that appear most interesting included Thermoelectric Cooling, Thermotunneling (Thermionic), Thermoacoustic Cooling, Magnetic Refrigeration, and Compressor-Driven Metal Hydride Heat Pumps. [4] Of these, the magnetic refrigeration cycle, Figure 3, appears to hold the most promise. Thus, initial NIK development efforts will focus funding on this technology. Other technologies will be evaluated if appropriate.

Conclusions

The DOE/BT Program's goals for improving the energy efficiency of the US buildings sector and its current strategy to achieve these goals have been presented.

Acknowledgement

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Development of heat pumps in Europe - Overview

Hermann Halozan, Austria

In Europe, installation of heat pumps started after the second oil price shock in 1979, since when market development has seen many ups and downs. Nowadays, stable and growing markets have been established, and the acceptance of heat pumps as RES devices by the EU has contributed to positive market development. The number of European countries in which heat pumps are the favourite heating system for new buildings is increasing, with heat pumps even dominating in retrofit applications in a few countries. Other countries are following this development, with the result that heat pumps in the building sector are becoming the key technology for achieving the 20/20/20 target of the EU, as well as for a possible realisation of the Blue Map scenario developed by the IEA for limiting global temperature rise to 2 K.

Introduction

In Europe, heat pump market development started after the second oil price shock in 1979, with groundwater heat pumps and low-temperature heat distribution systems, and ambient air heat pumps for retrofitting existing buildings. Where these buildings had high-temperature heat distribution systems, bivalent heat pump systems would be used, very often utilising the existing boiler. Countries have started heat pump subsidy programmes at various times, but the majority of these programmes failed. After the drop of oil prices in 1985, bivalent systems more or less disappeared from the market, with the remaining market concentrated on new buildings. By then, a new heat source had been recognised and developed; the ground. With almost the same availability as ambient air, ground heat sources delivered higher temperatures, without the wide temperature fluctuation of ambient air.

The first real heat pump market was established in Sweden, followed by Switzerland, which has started a successful program. Heat pumps are becoming increasingly popular in the Nordic countries, as well as in France and other countries, such as Austria. The main market is still that of new buildings – with much better thermal insulation than in the past and, in some applications, with controlled ventilation systems with heat recovery and additional preheating of air in a ground collector. The retrofit market is already very strong in the Nordic countries. Other countries will follow, as the retrofit market is much larger than that for new buildings. The construction rate of new buildings in Europe is about 1-2 % of the building stock per year.

This development is strongly supported by the European Union, which accepts heat pumps as devices utilising renewable energy. This acceptance makes heat pumps competitive with solar thermal energy, with geothermal energy (and shallow geothermal energy can be utilised only with heat pumps), and biomass. Another reason is that cooling is accepted, and the only competitors of heat pumps are solar thermal cooling – a solar-driven sorption heat pump – and cooling from renewable sources – sorption units driven by solar thermal, biomass and geothermal heat, and direct cooling [3].

IEA “Energy Efficiency in Buildings – Heating and Cooling” Roadmap

The International Energy Agency (IEA) has developed the “Energy Efficiency in Buildings – Heating and Cooling” Technology Road Map as a collaborative effort between the IEA, its member countries, various consultants and experts worldwide. It looks for energy-efficient and low-carbon heating and cooling systems between now and 2050 to achieve a global reduction in total energy-related CO_2 emissions to 50 % below today’s levels. Heating and cooling technology solutions that will allow the buildings sector to shift to a more sustainable energy and environmental future should contribute 2 Gt of CO_2 savings. Increased deployment of heat pumps for space and water heating, as well as for cooling, could account for 63 % of the heating and cooling technology savings [1].

The reason for this road map was that current trends in energy supply and use are unsustainable – economically, environmentally and socially. Without decisive action, energy-related greenhouse gas emissions will more than double by 2050, and increased oil demand will heighten concerns over security of supplies. In the buildings sector, the number of households will grow by 67 % and the floor area of service sector buildings by close to 300 %. We can and must change the energy/climate path that we are now on. Energy-efficient and low/zero-carbon energy technologies for heating and cooling in buildings will play a crucial role in the energy revolution that will be required in order to make this change happen. The Energy Efficiency in Buildings – Heating and Cooling Road Map sets out a detailed scenario for the evolution of the key underlying technologies and, just as importantly, their levels of deployment in the market place. It points out that urgent action is required if the building stock of the future is to consume less energy and result in lower CO_2 emissions.

Implications for Europe and heat pumps

The IEA road map focuses on four key technology options for heating and cooling in buildings. These are the technologies with the greatest long-term potential for reducing or facilitating CO_2 emission reductions. Low/zero-carbon and energy-efficient heating and cooling technologies for buildings—including solar thermal, CHP, heat pumps and energy storage—will deliver up to 2 Gt of CO_2 reductions, with 710 Mtoe of energy savings. Increased deployment of heat pumps for space and water heating, as well as deployment of more efficient heat pumps for cooling, account for 63 % of the heating and cooling technology savings [2].

Most of these technologies are commercially available today. However, due to cost, lack of information, institutional and other barriers, they require strong policy initiatives if they are to achieve deployment to the levels seen in this road map.

- Implement new polices to transform the market for heating and cooling technologies.
- Address policy and industry needs at national levels.
- Increase R&D efforts in key areas for energy-efficient and low/zero-carbon heating and cooling technology systems
- Improve data collection, metrics and standards
- Engage in international collaboration efforts

Buildings

In OECD Europe, the key abatement potential lies in space and water heating. In the residential sector, the very large existing building stock built before 1970, and the slow rate of replacement of this stock, means that addressing the existing building stock through retrofits is a priority.

Heat pumps

Heat pumps are technologies for providing space heating, water heating and cooling in buildings. They are highly efficient, although their overall primary energy efficiency depends on the efficiency of production of the electricity (or other energy source) that they use. They are proven, commercially available technologies that have been in use for the past 50 years. Annual sales of air conditioners were estimated to be worth more than USD 70 billion in 2008 (BSRIA, 2009), with sales of room air-conditioners in China alone estimated as 27 million units in 2009, which is a 35 % increase over 2005 sales. Globally, there are an estimated 800 million heat pump units installed. The full statistics for 2009 cover a total of 17 European countries, showing sales of 592 322 heat pump units [4].

Heat pumps use renewable energy from their surroundings (ambient air, water or ground) and "high-grade" energy, e.g. electricity or gas, to raise the temperature for heating, or lower it for cooling. Point-of-use efficiencies exceed 100 %, i.e. they provide more useful cold or heat (in energy terms) than the energy input. The heat pump cycle can be used for space heating or cooling, with reversible systems and hybrid systems capable of providing alternately heating and cooling, and (depending on the system design) simultaneously providing heating and cooling. Heat pump technology, either simple air conditioners or reversible air conditioners, is the predominant technology used for space cooling. Heat pumps for space and water heating are also mature technologies, but their share of the global heating mar-

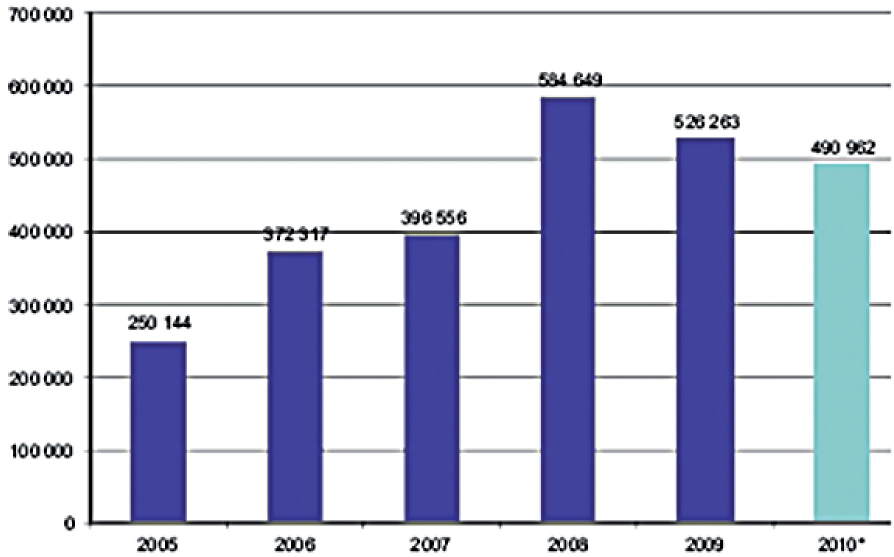

Fig. 1: Heat pump sales in 17 European countries

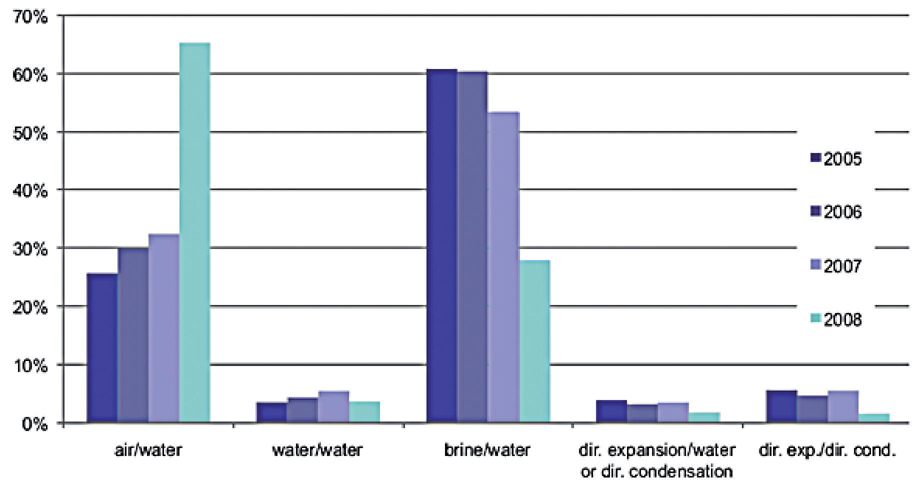

Fig. 2: Heat pump sales based on heat source/heat sink systems

ket is small.

Heat pumps for heating and cooling buildings can be described by the source of renewable energy they use (air, water or ground) and by the heat transport medium they use (air or water). Hybrid systems with higher efficiency are also possible, such as heat pumps coupled with conventional boilers or solar thermal collectors. Heat pumps can also be described by the service that they provide, i.e. cooling, or space and/or water heating. The European Union, depending on certain criteria being met, credits heat pumps as using renewable energy.

Significant improvements in the average efficiency of new air-conditioners have been achieved. The United States minimum energy performance standards and Energy Star programmes, the European labelling schemes, and Japan's Top Runner programme, have helped to raise COPs.

The Japanese programme has resulted in impressive improvements in COPs. The average COP of heat pump air-conditioners in Japan increased from around 4.3 in 1997 to around 6.6 in 2008.

In the United States, the minimum standard for new central air-conditioners in the residential sector is a seasonal COP of 3.8, while models with a COP greater than six are available.

In the BLUE Map scenario, the buildings sector deploys heat pumps widely for space and water heating and for cooling. This, together with decarbonisation of the electricity sector, results in very significant savings as against the Baseline scenario.

Research

Research is needed in the following technical areas:

- Components: More efficient components and systems for heating and cooling applications. Reduce costs and increase reliability and performance: the key technology component areas are heat exchangers, compressors, expansion devices, fans, circulation pumps and drives, heat pump cycles, variable-capacity compressors, defrosting strategies, advanced system design.
- Systems/applications: Optimise component integration and improve heat pump design and installations for specific applications to achieve higher seasonal efficiency in wider capacity ranges. Improve optimisation with ventilation systems in larger applications.
- Control and operation: Develop intelligent control strategies to adjust operation to variable loads and optimise annual performance. Develop automatic fault detection and diagnostic tools.
- Integrated and hybrid systems: Develop integrated heat pump systems that combine multiple functions (e.g. space conditioning and water heating), and hybrid heat pump systems that are combined with other energy technologies (e.g. storage, solar thermal and other energy sources) in order to achieve very high levels of performance.

Improving the efficiency of these components, developing more efficient heat pump cycles, and better integration and optimisation of these components at a system level, will lead to more efficient heat pump applications.

Policy measures

In terms of market transformation policies, the road map recommends specific policies to:

- Improve information availability and relevance for decision-makers
- Improve heating and cooling system actors' (architects, engineers, installers, etc) knowledge of, and competence with, energy-efficient and low-carbon heating and cooling technologies
- Implement deployment policies to accelerate uptake and reduce costs through economies of scale
- Expand quality assurance and certification schemes
- Expand or start education, training and certification programs for installers and manufacturers. Certification and labelling of equipment helps boost consumer confidence in a product and can improve competition and reliability of the systems .
- Remove existing regulatory, policy, fiscal and other barriers that are not technology-neutral, and also policies that do not aim to reduce the use of fossil fuels.

Conclusions

Heat pumps are playing an increasing role in meeting the heating needs of new residential buildings in OECD Europe, with some countries now routinely seeing a 30 % market share for new installations.

The number of European countries in which heat pumps are the favourite heating system for new buildings, is increasing. In a few countries, heat pumps for retrofit are already dominating, and other countries are following this development. Sweden and Switzerland exemplify what can be done with the right policies, as the market share of heat pumps for new buildings in these countries is around 75 % and 95 % respectively. This means that, in the building sector, heat pumps are the key technology for achieving the 20/20/20 EU target, and also for a possible realisation of the IEA Blue Map scenario for limiting global temperature rise to 2 K.

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A European View of Heat Pumps in the IEA's Roadmap for Energy Efficient Heating and Cooling Systems in Buildings

Michael Taylor, International Energy Agency, France

Europe has a number of examples of heating and cooling markets where heat pumps are the norm for heating, at least in new buildings. However, this transformation has touched just a small fraction of the buildings sector in Europe. The International Energy Agency's (IEAs) Energy Efficient Buildings: Heating and Cooling Systems roadmap lays out the "big picture" vision for stakeholders in the buildings sector of the goals for heating and cooling equipment if the world is to achieve a more complete transition by 2050. Although significant progress has been made on advancing policy in Europe, there remains a lot more to do. The roadmap recommends that policies need to be "broadened" to systematically address all market barriers and failures, as well as "deepened" to ensure that all of the very diverse decision-makers in the buildings sector are addressed.

The IEAs Energy Technology Roadmap for Heating and Cooling

The IEAs Energy Efficient Buildings: Heating and Cooling Systems roadmap looks at the vision for energy efficient and low-carbon heating and cooling systems between now and 2050 if we are to achieve a global reduction in total energy-related CO_2 emissions of 50% below today's levels. The heating and cooling technology solutions that will allow the buildings sector to shift to a more sustainable energy and environmental future contribute 2 Gt CO_2 of savings. The increased deployment of heat pumps for space and water heating, as well as the deployment of more efficient heat pumps for cooling account for 63% of the heating and cooling technology savings.

When shifting from a global to a regional perspective, three fundamental issues are shaping future energy consumption in the buildings sector and therefore dominate the policy challenges the sector faces. They are:

- That the OECD has significant space and water heating loads, while the stock of residential buildings is very long-lived and was built mainly before building codes included stringent requirements from an energy perspective (Figures 1 and 2).
- Population, household numbers and service sector activity will grow significantly faster in developing countries to 2050 than in the OECD and EITs.
- Cooling loads are much more important in developing countries, while water heating loads are modest.

These broad differences are just the tip of the iceberg in terms of the regional and country level differences that have important implications for what policies need to be prioritised in different countries. Achieving the goals of the roadmap will therefore require policy packages that are tailored to individual countries or regions in order to ensure that policy efforts address the unique challenges faced by different countries, as well as focussing on the areas with the most significant potential for energy and CO_2 emissions reductions.

The Buildings Sector in OECD Europe

In OECD Europe, the key abatement potential is for space and water heating (Figure 3). In the residential sector, the very large existing building stock built before 1970 and the slow rate of retirement of this stock means that addressing the existing building stock through retrofits is a priority (Figure 1 and Figure 2).

In 2010, the IEA estimated occupied residential dwellings to be around 220 to 230 million units, with average

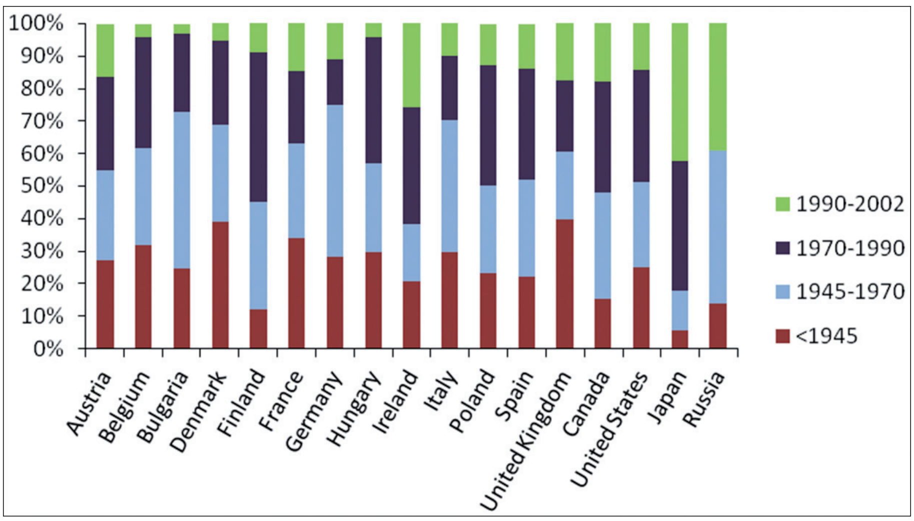

Figure 1: Age of the residential buildings stock for selected countries

floor area per dwelling of around 90 m2. Data for the service sector is less complete, but the floor area could have reached a figure of somewhere between 7 900 and 8 200 million m2 in 2010. Total energy consumption for space and water heating, and cooling was estimated to be around 220 to 240 Mtoe (10 EJ) in the residential sector and around 65 Mtoe (2.7 EJ) in the service sector.

Heat pumps are playing an increasing role in meeting the heating needs of new residential buildings in OECD Europe, with some countries now routinely seeing a 30% market share for new installations. Sweden and Switzerland exemplify what can be done with the right policies, as the market share of heat pumps for new buildings in these countries is around three-quarters and 95% respectively.[1] However, even if 100% share could be achieved for new buildings in OECD Europe by 2020, at most around a fifth of all residential dwellings in 2050 would have their heating needs met by heat pumps, and an even smaller percentage of actual energy consumption.

The Roadmap's Implications for OECD Europe and Heat Pumps

The IEA roadmap focuses on four key technology options for heating and cooling in buildings. They are the technologies with the greatest long-term potential for CO_2 emissions reductions, or facilitating them. They are:

- Active solar thermal
- Combined heat and power (CHP)
- Heat pumps for cooling and space and water heating
- Thermal storage

The increased deployment of heat pumps for space and water heating, as well as the deployment of more efficient heat pumps for cooling account for an important part of the

[1] See Nowak, T. (2010) in the IEA Heat Pump Newsletter, Vol. 28, No. 3/2010.

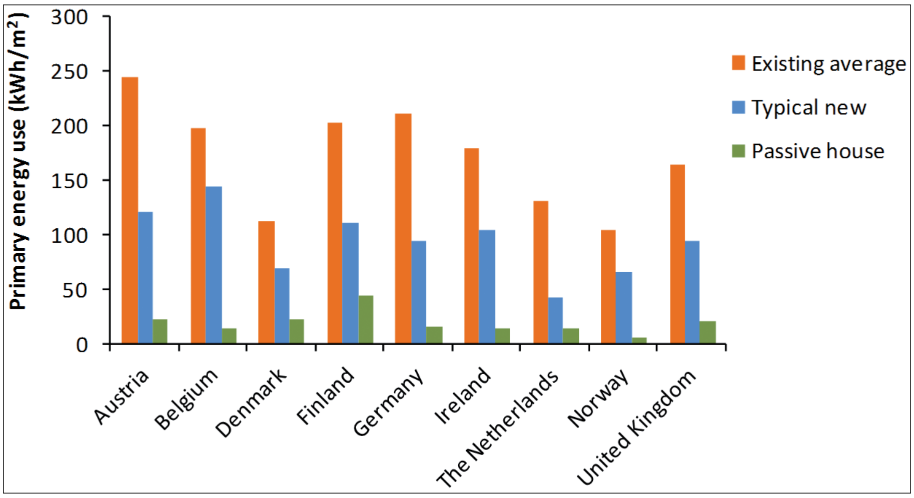

Figure 2: Yearly primary space heating use per residential dwelling in selected European countries

potential energy and CO_2 savings in buildings in OECD Europe. The current progress in raising the market share of heat pumps chosen as the heating and cooling option of choice in new buildings needs to be accelerated and complemented by efforts to address the existing building stock and retrofits of heat pumps in these buildings. Reducing the costs and improving the performance of heat pump systems for the retrofit market is a key goal of the roadmap.

In the BLUE Map scenario the evolution of energy efficient and low-carbon heating and cooling technologies is based on a portfolio approach, with heat pumps, solar heating and district heat and/or CHP dominating the useful energy demand for space and water heating by 2050 in OECD Europe. For example, by 2050 in the BLUE Map scenario coal, gas and oil account for just 8-20% of useful energy demand for water heating and space heating. This compares to today's dominance of fossil fuels meeting an estimated three-quarters today. This requires that heat pumps, solar thermal and CHP/district heating achieve market dominance (around 90% of combined sales) for all space and water heating installations in new buildings and for replacement boilers by around 2025. This is nothing short of the complete transformation of the space and water heating market in the next 15 years, at the latest!

In the BLUE Map scenario the number of installed heat pumps will grow from perhaps around 800 million today to 3.5 billion globally in 2050. In OECD Europe, this will represent a thirty-fold increase in the number of heat pumps installed to meet space and water heating in the residential sector. For water heating, the transformation is even more dramatic in the residential sector, with installed units to grow 70-fold by 2050. Total installed heat pump capacity for space and water heating in OECD Europe will have to grow to almost 800 GW_{th} by 2050 in the residential and service sectors.

These figures mask to some extent the growth in the contribution of heat pumps to meeting energy demand, because the deployment of today's heat pumps systems will give way in the BLUE Map scenarios over time to integrated systems that will be capable of providing space heating, water heating and cooling simultaneously. This means that to meet these three service demands, only one unit will be required, rather than two to three different ones that are required today. In addition, hybrid heat pumps systems (i.e. combined with solar thermal systems) for improved efficiency and CO_2 emissions reductions will play an increasing role.

R&D and Policy Implications for Europe

R&D Goals and Priorities

The roadmap sets goals for a 20% improvement in COP's by 2020 and 50% by 2030, at the same time as reducing

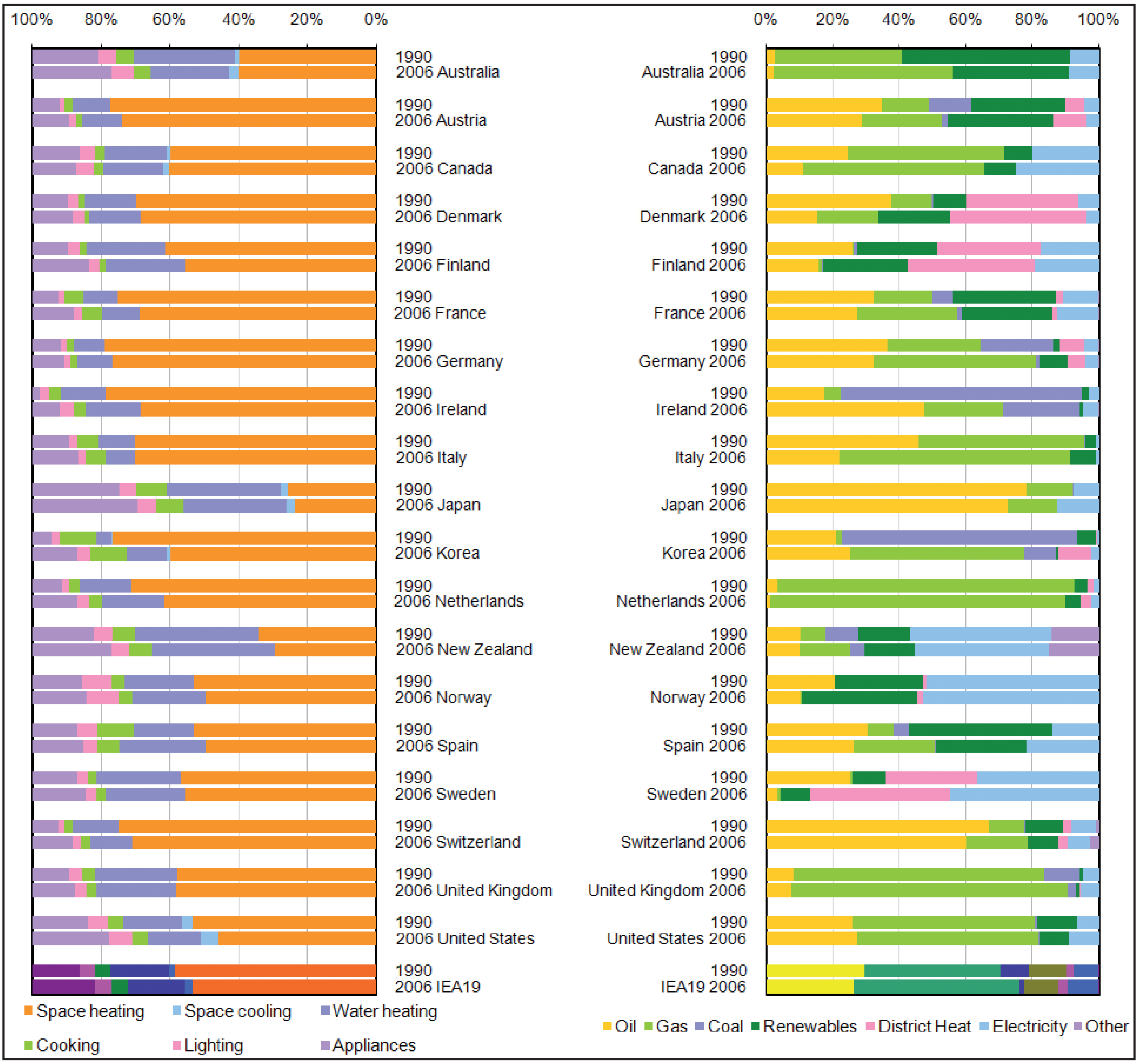

Figure 3: Residential energy consumption by end-use and fuel for selected IEA countries

costs by 15% in 2020 and by 25% in 2030. Further R&D, as well as wider deployment will help to achieve these goals, while at the same time heat pumps systems capable of providing simultaneous space and water heating, and cooling for all market segments need to be developed, as well as hybrid systems (e.g. heat pump/active solar thermal systems) to achieve very high efficiencies and CO_2 emissions reductions.

In terms of specific R&D goals, the technology roadmap identifies several areas for increased RD&D including more efficient components, cost reductions, and solar thermal integration, among other priorities. Specifically, research is needed on the following technical areas:

- Components: More efficient components and systems for heating and cooling applications, decrease costs and increase reliability and performance, the key technology component areas are:
  - Heat exchangers
  - Compressors
  - Expansion devices/valves
  - Fans, circulators and drives
  - Heat pump cycles
  - Variable speed compressors
  - Defrosting strategies
  - Advanced system design
- Systems/applications: Optimise component integration and improve heat pump design and installations for specific applications to achieve higher seasonal efficiency in wider capacity ranges. Improve optimisation with ventilation systems in larger applications.
- Control and operation: Develop

intelligent control strategies to adapt operation to variable loads and optimise annual performance. Develop automatic fault detection and diagnostic tools.
- Integrated and hybrid systems: Develop integrated heat pump systems that combine multiple functions (e.g. space-conditioning and water heating) and hybrid heat pump systems that are paired with other energy technologies (e.g. storage, solar thermal and other energy sources) in order to achieve very high levels of performance.

Improving the efficiency of these components, developing more efficient heat pump cycles, and better integration and optimisation of these components at a system level will lead to more efficient heat pump applications. In most cases this work is building on existing technologies, however in some cases they represent new approaches or technologies that could be integrated into heat pumps either now or in the future. In parallel, improvements in buildings design and operation that reduce the temperature lift performed by the heat pump will bring gains in the average efficiency achieved in operation (the seasonal or annual performance factor).

Policy Development

In many areas Europe has already started to address the policy needs to achieve the transformation of the heating and cooling market. However, much more needs to be done, particularly in addressing the barriers to the retrofit market where most of the savings potential exists. The key policy gap is that policies need to be "broadened" to tackle the full range of barriers for new and replacement markets, and "deepened" to ensure the barriers faced by all those in the fragmented decision-making chain of the buildings sector are addressed. The market transformation policies need to focus on overcoming the market barriers (lack of prioritisation of energy efficiency, capital market barriers, absence of external costs), at the same time as addressing the many market failures (lack of adequate number of market participants, lack of perfect information, principal-agent problems, transactions costs and delays, inadequate financial mechanisms etc) in the market for heating and cooling technologies.

Given the large number of policy areas and decision-makers in the very fragmented buildings sector, poor policy co-ordination is a real risk for the sector. The roadmap therefore recommends the formation of a policy co-ordination workgroup to develop regulatory and policy framework for heating and cooling systems in buildings. This group should include all regulatory and policy making bodies with an influence over the building sector at a national, regional and local level (e.g. Ministries of finance, energy, housing, environment/climate, urban planning, regional and local governments, etc.).

In terms of market transformation policies, the roadmap recommends specific policies to:
- Improve information availability and relevance for decision makers, including:
  - o Surveying decision makers to identify key drivers of their decisions.
  - o Tailoring information packages to consumers and professionals that take into account their different needs and understanding of the sector.

- Improve heating and cooling system actors (architects, engineers, installers, etc) knowledge and competence with energy efficient and low-carbon heating and cooling technologies by:
  - o Improving their initial training at university level, as well as through ongoing continuous learning programmes in the workplace.
  - o Working to standardise testing procedures internationally to provide consistent and comparable ones metrics.
- Implement deployment policies to accelerate uptake and reduce costs through economies of scale, including:
  - o Developing effective communication policies to target consumers and professionals.
  - o Labelling schemes to become mandatory for all heating and cooling systems by 2015 in OECD countries
  - o Introduce a portfolio of deployment policies that could include minimum energy performance standards (continuously tightened over time and transitioning to CO_2-based metrics), utility obligations, feed-in tariffs, fiscal and/or financial incentives etc.
- Expand quality assurance schemes to encompass the entire sector and provide consumers with the confidence to invest.
- Remove existing regulatory, policy, fiscal and other barriers.

The development of a stable long-term policy package that has for its overall goal the transformation of the heating and cooling end-uses in the buildings sector is crucial to unlocking the energy and CO_2 savings potential of the sector. Heat pumps will play an important role in achieving these savings. Europe has the policy capability to develop the "broad" and "deep" policy packages required to achieve this shift to a more sustainable energy future for buildings, but the time to act is now, the challenge faced is urgent and delays only serve to increase the long-term cost of the transformation of the sector.

Source: Energy Efficient Buildings: Heating and Cooling Systems 2011 © OECD/IEA, 2011

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Chillventa congressing 2010: Refrigerants for a Sustainable Future

Rainer Jakobs, Germany

As reported in the last IEA HEAT PUMP CENTRE NEWSLETTER, No. 1/2011, the Chillventa 2010 was a complete success, with 29 312 trade visitors from all over the world at the exhibition from 13–15 October 2010. Chillventa set a new record with a 10 % increase in exhibitor numbers to 881 companies. International attendance of 63 % is also excellent. Companies from 42 countries exhibited at the event.
The Newsletter included a report on the Industrial Heat Pumps workshop. Concerning the refrigerant issue, a symposium was held at Chillventa 2010, entitled Refrigerant Sustainable Future.

Introduction

Chillventa Congressing started on the day before the exhibition.
The "Institut für Energietechnik, Bitzer-Stiftungsprofessur für Kälte-Kryo- und Kompressorentechnik" from the Technical University of Dresden, in cooperation with the Information Centre on Heat pumps and Refrigeration e.V., organised the Refrigerants for a Sustainable Future symposium, with six presentations. Prof. Dr.-Ing. Ullrich Hesse was the Chair of this event.

Synthetic and Natural Refrigeration Fluids: Recent Developments
by Tim G.A. Vink and Paul Sanders, Honeywell Belgium.
Honeywell embarked on an extensive research program to identify fourth generation fluorocarbon chemistry that would incorporate the desired environmental properties, that is, low global warming potential (GWP) with respect to climate change, while maintaining desirable properties, avoiding toxicity, stability and compatibility issues, while at the same time having high performance characteristics.

A new low-GWP platform based on hydrofluoro-olefin (HFO) technology has been developed. Among the compounds developed by Honeywell, HFO-1234yf has emerged as a new low-global-warming refrigerant (GWP = 4) that is essentially a drop-in replacement for most systems currently designed for R134A. It has been selected as the refrigerant of choice for a sustainable and global solution for automotive air conditioning.

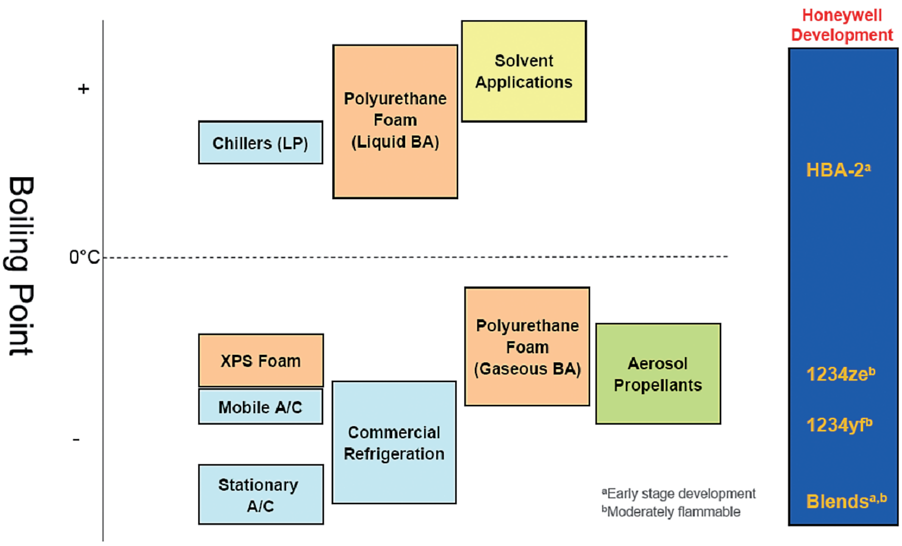


Figure 1: Low-GWP HFC Replacements

Another low-GWP molecule, HFO1234ze (E), has been identified and is currently commercialised by Honeywell as a blowing-agent for one-component foam and as an aerosol propellant. It has also potential for refrigeration applications. It is a highly energy-efficient HFO molecule, with a GWP of only 6. HFO technology offers significant promise as a result of its energy efficiency, environmental benefits, safety and overall effectiveness. HFO-1234yf and HFO-1234ze(E) may have potential in applications such as small commercial and residential refrigeration systems, where low-global-warming refrigerants are needed to meet current and future climate regulations.

This paper gave an overview of the legislative landscape for refrigerants, along with the technology progress and environmental considerations.
The summary was:
- Fluorinated refrigerants serve a wide range of applications,
- Shift from safety to environmental

performance,
- LGWP fluids and blends have reduced environmental footprints,
- Using mainstream technology
- Safety properly assessed through EN-378,
- Energy > 80% cost of ownership, and

There is no ideal fluid – energy efficiency and safety play key roles.

Demonstration project for R290 room air-conditioners at Gree Electric Appliances, Inc. by Jürgen Usinger, Consultant for GTZ Proklima.

Room air-conditioning systems in China contain hydrochlorofluorocarbons (HCFCs) as the refrigerant gas. This is the main source of ozone- and climate-damaging HCFC emissions in China, amounting to 260 million tonnes of CO_2-equivalent emissions per year. The air conditioning sector is a fast growing sector in China, and alternative, environment-friendly technologies are urgently needed to reduce negative climate impacts. Changing to the use of hydrocarbons as refrigerants would not only cut greenhouse gas emissions but also achieve energy savings compared with conventional technology. It is also intended to minimise the need to switch from HCFCs to HFCs (e.g. R-410A), which have an even higher climate impact than the currently used HCFCs.

GTZ-Proklima has implemented a pilot project funded by the German Environment Ministry within the framework of the International Climate Initiative. The project supports the introduction of production of room air-conditioning systems by the Chinese manufacturer Gree Electric Appliances Inc. using R290 as refrigerant instead of HCFCs, thereby establishing a best-practice model.

The production capacity of R290 air-conditioners at Gree is around 180 000 units per year. Replacement of the HCFC refrigerant will prevent 560 000 tonnes CO_2 equivalents of direct emissions during the life cycle of the units. Additionally, indirect emission of 320 000 tonnes CO_2 equivalents will be avoided through improved energy efficiency of the units.

The project elements encompass the
1. Optimization of technical design,
2. Installation of new production equipment,
3. Pilot production, and
4.Training of service technicians.

The project also includes comprehensive training for production and service technicians for responsible and safe handling of flammable refrigerants as well as maintenance of the equipment.

The presentation covered the following aspects:

Backgrounds to the International Climate Initiative and GTZ-Proklima's projects, the application of R290 in room air-conditioners and relevance for HCFC phase-out in "A 5" countries, details of the IKI project with Gree, and the overall outlook.

The summary of the current status was:
- Trials and technical optimisation: completed
- Development of safety standards: developed
- Installation of production line: completed
- Pilot production: beginning at the end of the third quarter of 2010
- Commercial production: beginning of 2011
- 2010 – First replication of projects under the Multilateral Fund based on GREE's first move.

Refrigerants for stationary air-conditioners and heat pumps by Shigeharu Taira, Tadafumi Mikoshi,. presented by Dr. Chun-Cheng Piao, Daikin Daikin Industries, Ltd.

In recent years, the world has been facing crucial environmental problems: ozone depletion, global warming and energy shortage are particularly seen as major problems. To cope with these problems, international bodies such as the Montreal Protocol and the Kyoto Protocol set targets to reduce the use of ODP and emissions of GHG (including HFCs) respectively. All stakeholders must take immediate actions to meet the targets to mitigate the environmental impact in the next two decades, which are crucial for human beings. Air conditioners and heat pumps are closely involved in all these issues. As a responsible stakeholder in the stationary air-conditioning industry, we would like to propose a balanced view on refrigerants as an immediate actions to be taken.

When looking at the refrigerants issue, it is necessary to consider overall aspects by taking into consideration the life cycle effect of refrigerant, from manufacturing to disposal. GWP is not the only criteria for choosing refrigerants. There are others arising from regional differences such as climate and the culture of air-conditioning. We should not forget the differences between developed and developing countries, since their social infrastructures would be different.

Safety: the result of the experimental analysis on flammability is described.

Energy efficiency: Comparison of energy efficiency, including peak load for air-conditioners and heat pumps.

Economic feasibility: Comparison of cost of products and investment for changing refrigerants, etc.

Serviceability: Comparison of availability of tools and skills for service.

Power supply infrastructure: Comparison of peak load.

Legal barriers to overcome

We obtained some candidate refrigerants, made a fair evaluation of them against the above criteria, and allocated applications using them to each region.

In addition, the balanced view on refrigerants includes refrigerant management. In this paper, we point out the importance of creating refrigerant management systems, such as leakage prevention, recovery, recycling, and destruction of refrigerants. Although such measures require a great deal of effort in society as a whole, it will play an indispensable role in reducing the environmental impact of refrigerants. We will touch upon the situation of refrigerant management measures in place in Japan and Europe, and discuss the possibility of other regions adopting the measures.

The summary was:

1. **Evaluate not only GWP but also the total GHG emissions (LCCP)**
   In the case of R32, higher efficiency and less refrigerant charge will lead to lower greenhouse gas emissions. Additional leakage prevention measures will contribute to further emissions reduction, as is the case for all refrigerants.
2. **Only minor modifications will be needed to allow A2L-class refrigerants to be used for all capacity ranges**
3. **Peak loads should be considered when choosing candidates.**
   Not only seasonal energy efficiency but also efficiency in extreme temperature conditions(peak load) should be taken into consideration. This is important for the power supply infrastructure capacity.
4. **Earn "Quick Gain" for lowering future global warming impact.**
   To address climate change issues, quick actions are required. We are confident that R32 technology is one of the solutions that could quickly reduce greenhouse gas emissions from refrigerants, also in developing countries.

Development and evaluation of high-performance, low-GWP refrigerants for AC and refrigeration by T. Leck, K. Kontomaris, and F. Rinne , DuPont de Nemours, presented by Frank Rinne.

In response to concerns about global climate change, and in consideration of probable legislation that may impact the production and use of refrigerants with high global warming potential, a group of new refrigerant candidates has been developed for evaluation. Some candidates are designed for stationary air conditioning in residential and light commercial end uses. Other refrigerant candidates were designed more specifically for use in medium-temperature refrigeration applications. These candidates all have GWP values that are reduced significantly in comparison with R-134a, R-410A and R-404A values, and have good predicted performance characteristics as determined by cycle modelling. Model results must always be validated by actual system tests, and this work has been under way for some time now. System tests are indeed showing that the predicted model results are achievable. This presentation will describe these candidates and show some results from evaluations of their cooling and heating performance properties and LCCP (Life Cycle Climate Performance) comparisons.

The paper gives an overview about the current state of technology in the supermarket sector, demonstration of optimisation potentials, obstacles and limits of current and alternative technologies as well as combinations of them, and the introduction of the Eco-Efficiency concept to compare and evaluate supermarket refrigeration performance from an environmental and economic point of view.

- There is no single perfect refrigerant for all applications
- Potential for significant reduction in CO_2 contribution by replacing R404A
- Today, R134a is part of the solution to replace R404A for medium-temperature applications
  - better efficiency and lower leakage rates
  - special optimised compressors are now available
  - REWE has already converted more than 2000 shops
- Today, increasing interest in hybrid systems with CO_2 LT cascaded to R134a MT
  - No negative impact for high ambient temperatures, and can be used globally
  - CO_2 equipment for low temperature works in similar pressure ranges with high efficiency
- European supermarkets have interest in XP10/CO_2 cascade systems which further reduces GWP and improves the TEWI
  - Non-flammable solution which can be used as a drop-in for R134a systems
  - There are trade-offs of GWP, Flammability, Performance, and Glide.
- Best Environmental Performance is not from the lowest GWP candidates
- The Higher GWP Fluid DR-5 shows superior energy and environmental performance versus HFO-1234yf and DR-4

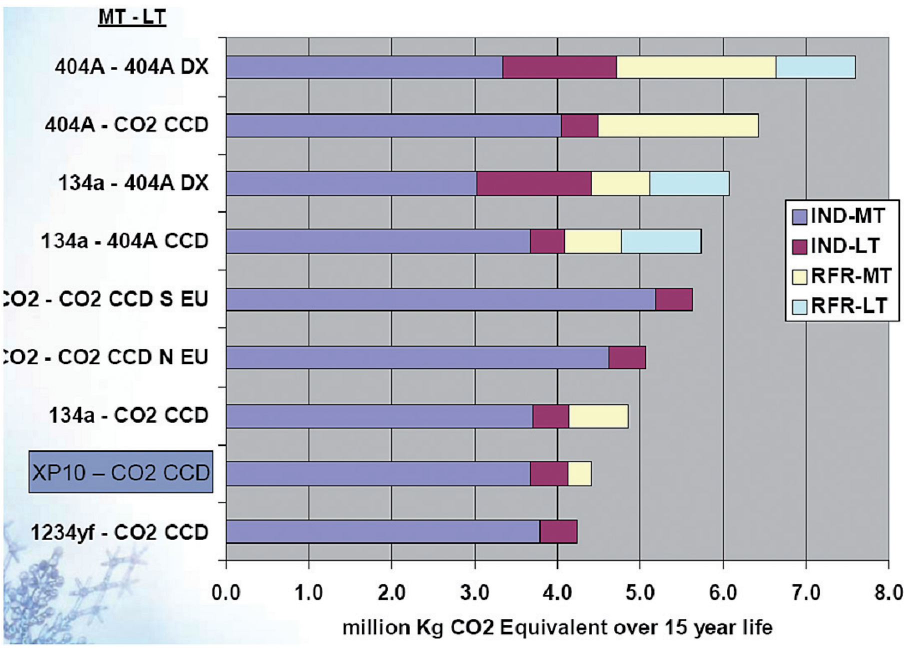
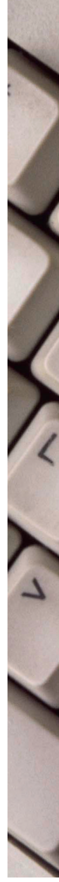


Figure 2: Europe TEWI results for low-GWP refrigeration options



- Flammability risk issues must be assessed for safety codes in residential and commercial buildings before this new generation of refrigerants can be fully implemented.

Safe & environmentally friendly refrigeration and refrigerants by Frédéric Gauvard and Christophe Maldémé, Arkema,

The sustainable development of HVAC & R will go together with the development of safe, economical, efficient and low-TEWI systems. New low-GWP refrigerants will play an important part in this.

The development of new low-GWP refrigerants is presented in the perspective of history and the main technical backgrounds of refrigerants and refrigerant management.

A specific focus is proposed on the main fields of applications - air conditioning, heat pumps and commercial refrigeration - with consideration of the safety, environmental, cost and efficiency balance that must be found in order to answer the growing environmental concerns.

Hydrofluoroolefins have been known in the chemical industry for a long time. L. Henne in 1946 reported the boiling point of a large number of fluoropropene molecules, and many studies of the preparation and global warming potential of fluoroolefins have been performed over the latest decades.

This paper introduces some new 1234yf blends and shows how they can be a part of global environment-friendly solutions. Some basic thermodynamic properties and other application characteristics, as well as calculated performances in typical refrigeration cycles, are discussed; we show that low-GWP blends with excellent performance can be proposed; the need to compromise between GWP and flammability is emphasised. However, it is known from the example of mobile air conditioning using 1234yf that a proper risk analysis can in some cases guarantee the safe use of moderately flammable blends ("A2L" according to ASHRAE classification).

The presentation concludes that HFO 1234yf blends under development have a high potential to be the best candidates for all types of synthetic and natural refrigerants. They are efficient, safe and environmentally friendly refrigerants, suitable for use in the lowest cost system solutions.

The summary:

- HFO-based blends allow the development of reduced GWP solutions for main market segments of HVAC & Refrigeration
- Blend compositions are tailored to suit environment conditions and system architectures
- Arkema has several HFO-based blends under development
- New technical challenges are coming for the next decades.

Prof. Hesse summarized the symposium **Refrigerant Sustainable Future:**

There are low GWP refrigerant options

- If low flammability can be accepted (A2L)

HC as R290 are only seen as an option

- if operated under controlled conditions
- or if fully self contained small charge systems

AC and HP:

- R32 to replace R410A
- R1234yf or R1234ze for chillers

Commercial (supermarket) TEWI:

- Low GWP /R744 cascade system

Mixtures extend the number of options

- Recycling needs attention

Source: Chillventa Congressing 2010 www.chillventa.de/congressing

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New ASHRAE guideline published: ASHRAE guideline addresses interactions affecting indoor environmental quality

ASHRAE has published a new guideline that provides guidance on achieving good indoor environments by considering the interactions of air quality and thermal conditions, as well as lighting and acoustics. Guideline 10 is especially important in the design of low-energy buildings in order to ensure full consideration of indoor environmental quality and its effects on occupants.

ASHRAE Guideline 10-2011, Interactions Affecting the Achievement of Acceptable Indoor Environments, calls attention to many interactions that designers might not have previously recognized or understood. The guideline contains an assembly of available knowledge on the complexity of the indoor environment and its impact on building occupants.

"The guideline summarizes what research and experience have taught us about the complex interplay of the wide range of factors that determine occupants' reactions to the buildings they inhabit," said Hal Levin, Chair of the committee writing the guideline.

Levin explains that the guideline is intended to help users understand and use existing documents that deal with indoor environments, including the ASHRAE standards relating to energy, ventilation, indoor air quality and thermal conditions, with a more complete understanding of their combined effects on occupants.
http://www.techstreet.com/cgi-bin/detail?product_id=1771697

IEA report published: Smart Grids Technology Roadmap
A new report from the International Energy Agency (IEA) says that the widespread deployment of "smart grids" – networks that monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users – is crucial to achieving a more secure and sustainable energy future.

With current trends in the supply and use of energy becoming increasingly untenable – economically, environmentally and socially, the IEA believes that smart grids can play a significant role in enabling the use of nearly all clean energy technologies, including renewables, electric vehicles and energy efficiency improvement.
The report, Smart Grids Technology Roadmap, provides a consensus view from more than 200 government, industry, academia and consumer representatives on the current status of smart grid technologies, and charts a course for expanding their use from today to 2050.
This report is the latest in the IEA's series of technology roadmaps to guide governments and industry on the actions and milestones needed to achieve the potential for the full range of clean energy technologies.
http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=409
http://www.iea.org/Papers/2011/Smart-Grids_roadmap.pdf

2011

22-25 May
World Geothermal Energy Policy Council's - International Symposium 2011
Minneapolis, USA
http://www.wgeopc.org/brochure/symposium_brochure.pdf

24 May
Europe's Renewable Energy Policy Conference
Brussels, Belgium
http://www.erec.org/erec2011

24-26 May
3rd International Concerence on Heating, Ventilating and Air Conditioning
Tehran, Iran
http://www.hvac-conference.ir/index_e.aspx

27-28 May
15th International Passive House Conference 2011
Innsbruck, Austria
http://www.passivhaustagung.de/fuenfzehnte/englisch/index_eng.html

1 June
4th European Heat Pump Forum
London, United Kingdom
http://www.ehpa.org/calendar/list-view/?tx_cal_controller%5Bgetdate%5D=20110309&tx_cal_controller%5Bcategory%5D=2&cHash=0f90784b5b

10-11 June
The latest technologies in air-conditioning and refrigeration, 14th European Conference
Milano, Italy
http://www.centrogalileo.it/milano/CONGRESSODI MILANO2011english.html

25-29 June
ASHRAE Annual Meeting
Montreal, Canada
http://www.ashrae.org/events/2011-montreal-conference

4-7 July
24th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems
Novi Sad, Serbia
http://www.ecos2011.com

6-8 July
International Conference on Air-Conditioning & Refrigeration (ICACR 2011)
Pyungchang-Gun, Gangwon-Do, Republic of Korea
http://www.sarek.or.kr/eng/

21-26 August
23rd IIR International Congress of Refrigeration: Refrigeration for Sustainable Development
Prague, Czech (Republic)
Contact: Ladislas Cervinka, icaris @ icaris.cz
http://www.icr2011.org

5-6 September
International Conference on Compressors and their systems
London, United Kingdom
http://www.city.ac.uk/events/2011/sep/international-conference-on-compressors-and-their-systems

12-15 September
8th Minsk International Seminar, Heat Pipes, Heat Pumps, Refrigerators, Power Sources
Minsk, Belarus
http://www.minskheatpipes.org/en/index.htm

21-23 September
3rd Conference on Smart Energy Strategies
Zurich, Switzerland
http://www.esc.ethz.ch/ses11

28-29 September
European Heat Pump Summit
Nuremberg, Germany
http://www.hp-summit.de/en

11-12 October
ATMOsphere
Brussels, Belgium
http://www.atmosphere2010.com/
[link for 2011 event not yet available]

6-9 November
ISHVAC 2011: 7th International Symposium on Heating, Ventilating and Air-Conditioning
Shanghai, China
Contact: Zhangxu-hvac @ mail.tongji.edu.cn
www.ishvac2011.org

7-9 November
China Mobile Air Conditioning Show 2011
Shanghai, China
http://www.autocoolexpo.com/en

17-19 November
HVACR Indonesia
Jakarta, Indonesia
http://hvacrseries.com/indonesia/

In the next Issue

10th IEA Heat Pump Conference 2011

Volume 29 - No. 3/2011

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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