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IN THIS ISSUE:

IEA HEAT PUMP CENTRE

NEWSLETTER
VOL. 32
NO. 3/2014

Market and Policy

Heat Pumps - A key technology for the future

IEA **Heat Pump** CENTRE
NEWSLETTER

Volume 32 - No. 3/2014

In this issue

Heat Pump Centre Newsletter, 3/2014
The heat pump market is significantly influenced by policy decisions, and vice versa. At the 11th IEA Heat Pump Conference, held in Montreal on May 12-16, a number of presentations were given on the topics market or policy. A few of these have been selected for this Newsletter issue. The Proceedings from the Conference may be purchased from the *HPC website*.

Recent European policy measures are outlined in the Foreword, and, together with their influence on markets, further discussed in one of the topical articles. Other topical articles describe heat pump markets in the US, New Zealand, and China. The Column summarises the Montreal Heat Pump Conference.

Enjoy your reading!

Johan Berg, Editor

Heat pump news

Regulars

Topical articles

COLOPHON

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EPEE (European Partnership for Energy and the Environment)

What's happening in Europe? Ecodesign and F-Gas rules continue to top the agenda

EPEE (European Partnership for Energy and the Environment), the European association of the refrigeration, air-conditioning and heat pump industry (RAC&HP), is experiencing yet another busy year. Ecodesign measures setting requirements for product energy efficiency and the new F-Gas rules are just two of the many challenges our industry is facing, and it is more important than ever for all stakeholders to closely follow developments in Brussels.

With the Ukraine crisis, energy security and energy efficiency continue to top the EU agenda. Measures such as Ecodesign and Energy Labelling play a crucial role, and heat pumps offer great opportunities. Indeed, the ecodesign requirements for space heaters (EU 813/2013) were adopted about a year ago, alongside with the energy label (EU 811/2013). Its final version is a major opportunity for heat pumps, as it allows for direct comparison between different heating technologies - in particular, heat pumps and fossil fuel boilers - and steers consumers towards the most efficient solution. But Ecodesign does not stop there. The next big challenge is already looming: Ecodesign measures for large heating and cooling systems are currently being drafted, and are expected to come into force at the end of this year. Finally, the existing ecodesign measure on fans will soon be revised. Once again, much is at stake, as some stakeholders wish to extend the scope to include all fans that are incorporated in products.

In addition to complying with ecodesign requirements, the RAC&HP sector will have to adapt very rapidly to the new F-Gas Regulation (EU 517/2014), which will change forever how the industry operates. Its most important new requirement is the phase-down of HFCs, which means that the quantities of HFCs placed on the EU market will gradually be reduced through the allocation of quota by the European Commission to producers and importers of bulk HFCs. By doing so, HFC consumption will be reduced by 79 % (expressed as CO_2 equivalents) by 2030. This is unprecedented, and means that industry and users must rapidly change to refrigerants with a lower global warming potential – bearing in mind that many of these alternative gases are flammable. The whole chain will be affected, from the suppliers of refrigerants, to manufacturers of equipment, and to installers and users. Whilst only producers and importers of bulk refrigerants can apply for a quota allocation, manufacturers of pre-charged equipment will need to ensure that the HFCs contained in their equipment comply with the phase-down programme. Proof will be required, in the form of a "traceability system" based on reporting and declaration of conformity. In addition to the phase-down, the new F-Gas rules introduce bans on, for example, HFCs with a GWP above 2500 (with effect from 2020). Whilst the principle of the new provisions, including the phase-down, is fairly straightforward, the devil is in the detail. EPEE (www.epeeglobal.org) will continue to closely follow all Ecodesign and F-Gas measures, to ensure that the industry's input is taken into account and understood by decision makers.

Column

Reflections on the 11th IEA Heat Pump Conference

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

The 11th IEA Heat Pump Conference, held in Montréal on May 12-16, 2014, was an excellent opportunity for heat pump friends, colleagues and stakeholders from Canada and from all over the world to meet and discuss the current state of the heat pump industry. Research and development activities, policies and environmental issues were common themes which led to many discussions about the industry's future.

The conference attracted about 325 participants from thirty countries. Just before the event, eight IEA Heat Pump Programme (HPP) Annex workshops were held, including more than thirty oral presentations. The main conference itself proposed ninety-three oral presentations in addition to eighty-four posters. There were also five technical and site visits in and around Montréal, show-casing Canadian expertise and projects.

Two side events were also organized. A workshop of the NSERC Smart Net-Zero Energy Buildings Strategic Research Network was held in combination with the Annex 40 workshop, allowing graduate students to present their research. The Canadian GeoExchange Coalition also organized a side event on ground-source heat pumps, which included twenty-four speakers from nine countries.

Of course, these statistics do not reflect the quality of the presentations, debates and other networking opportunities offered by the full week of activities. Nevertheless, they do provide some benchmark figures as well as guidance for the future.

In the IEA HPP, the conference is the culmination of three years of hard work not only by all those presenting papers but also by executive committee members. This three-year cycle is rich in learning and networking opportunities. This is partly done via the various annexes ongoing work. But this is also achieved through regional workshops which are organized twice a year by host countries where the IEA HPP executive committee meets. These are great networking venues as many future conference participants either attend or present material at these workshops. In the years leading to the Montréal conference, we had the chance to meet future delegates in Atlanta, Stockholm, Oslo, London and Tokyo. The conference is thus part of a continuum of research, experience sharing and networking.

I would like to recognize the efforts of all authors who took the time to write a paper to share their research results and forward-thinking ideas on market shaping and policy making. Over the summer months, I took some free time to read about fifteen of the conference papers. All I can say is that I was impressed by the general quality of the research. From a Canadian perspective, conference papers are a gold mine of information for months and years to come, as we continue to lay the groundwork for a wider adoption of heat pumps in our cold climate.

Many thanks go to conference sponsors and exhibitors. Without their support, it would be impossible to organize such an event. A special thank you to all associations, groups and other stakeholders in Europe, Asia and North American who took the time to promote the conference via direct e-mails or through announcements on their websites.

General

Outstanding achievements recognized at ASHRAE's Annual Conference

Eighty-nine people were recognized by ASHRAE for their contributions to the Society and the built environment industry at the Society's 2014 Annual Conference. Notably, among the twenty-three Exceptional Service Award recipients were:

- Gerald Groff, Fellow ASHRAE, Life Member, principal, Groff Associates, Cazenovia, N.Y.
- Eckhard Groll, Ph.D., Fellow ASHRAE, Reilly Professor of mechanical engineering and director of the Office of Professional Practice, Purdue University, West Lafayette, Indiana.

Source: www.ashrae.org

War on product pirates

Bitzer company has decided to wage war on product piracy, which is on the rise. For some time now, there has been an increase in product piracy among the company's compressors, spare parts and pressure vessels. This development now has a negative impact on the entire industry and refrigerant manufacturers. This is unacceptable because, unlike with counterfeit watches or handbags, technical applications can be very dangerous when pirated products of poor technical quality are used. Aside from safety, the issue of performance clearly takes center stage. In the long run, supposedly cheaper copies are much more expensive than the originals. It is not advisable to accept unusually cheap offers for compressors, spare parts or refrigerants.

Sources: www.pressebox.com

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IEA finds energy efficiency is fuel for economic growth

The EU does not do enough to conserve energy, endangering security of supply and the global climate, says a new study conducted by the International Energy Agency (IEA), citing enormous growth potential in energy efficiency. "Under existing policies, two-thirds of economically viable energy efficiency potential available between now and 2035 will remain unrealised", according to Maria van der Hoeven, Executive Director of the IEA. Often, energy efficiency is only on the periphery of the debate over climate protection, which instead focuses on issues like CO_2 reduction, increasing renewable sources and decreasing fossil fuel consumption. When energy efficiency, such as the utilisation of heat pumps, is discussed, many countries hesitate to adequately invest in energy-saving measures. But according to an IEA study released on 9 September, energy efficiency has long ceased to be a "hidden fuel" that only relates to energy saving among consumers. On the contrary, energy efficiency leads to macro-economic growth, long-term climate protection and greater energy security, the authors argue. The IEA study provides reliable numbers to back up this argument for the first time.

Source: www.euractiv.com

AC control over the internet

New York City residents now can remotely control their air conditioners via the Internet for free. As part of the "CoolNYC" program from local utility Con Edison, customers can request a free device, called a "modlet", that acts as an intermediary between air-conditioning units and electric outlets. The device is connected to the Internet and enables control of the AC unit through a smart phone app and website.

Source: www.businessinsider.com.au

UK: water source heat map published by DECC

The Department of Energy and Climate Change (DECC) has published a map of the rivers and estuaries across England that could provide heating to thousands of homes and businesses.

The map shows that there are around 40 urban rivers and estuaries that could provide large-scale renewable heating supplies to local communities through water source heat pumps, instead of traditional gas-fired or electric domestic heating. The map is designed to help local authorities, private developers and community groups to identify prime locations to install large water source heat pumps.

Source: www.acr-heat-pumps-today.co.uk

Policy

Key achievements of US-China Climate Change Cooperation

The USA and China have taken important steps to advance their cooperation to combat global climate change and work towards the common goal of low carbon economic growth. On July 9, at the U.S.-China Strategic and Economic Dialogue in Beijing, U.S. Secretary of State John Kerry, U.S. Treasury Secretary Jacob J. Lew, and their Chinese counterparts State Councilor Yang Jiechi and Vice Premier Wang Yang chaired a special Joint Session on Climate Change.

Recognizing the need to cooperate to decrease carbon pollution and protect carbon sinks, Secretary Kerry and State Councilor Yang Jiechi announced progress made through the U.S.-China Climate Change Working Group, in particular the launching of eight demonstration projects – four on carbon capture, utilization, and storage, and four on smart grids.

They also held a special event to celebrate the achievements of private sector partnerships to advance carbon capture and reduce HFC's from refrigeration and air conditioning, among other issues. This underscores the critical role of the private sector to deploy new solutions to climate change.

U.S. Special Envoy for Climate Change Todd Stern and National Development and Reform Commission Vice Chairman Xie Zhenhua also chaired a policy dialogue aiming to reach an ambitious global climate change agreement in 2015. Further, they reaffirmed their commitment to implement President Obama's and President Xi's agreement to phase down the production and consumption of HFC's.

Source: www.state.gov

Working fluids

New EPA proposals for refrigerants

In early July, the US Environmental Protection Agency (EPA) published a proposed rule to add a range of lower GWP alternative refrigerants to its Significant New Alternatives Policy (SNAP) list *http://www.gpo.gov/fdsys/pkg/FR-2014-07-09/pdf/2014-15889.pdf*. These include several hydrocarbons as well as HFC-32. EPA is proposing to approve these for use in a range of applications including air conditioners, heat pumps, refrigeration systems, freezers and vending machines.

In August, EPA proposed the next step, limiting use of higher GWP HFCs based on the availability of these new lower GWP options and other low GWP alternatives already on the SNAP list *http://www.gpo.gov/fdsys/pkg/FR-2014-08-06/pdf/2014-18494.pdf*. EPA estimates the climate benefits of the proposed changes are equivalent to reducing 31 to 42 million metric tons of carbon dioxide in 2020 or the annual emissions of between six and a half million to nearly nine million cars. The new EPA proposal limits HFC use in car air conditioners, commercial refrigeration, foam blowing and certain consumer aerosols.

3 million vehicles will use HFO-1234yf by end of year

Du Pont has announced that it estimates nearly 3 million vehicles worldwide will use HFO-1234yf as a refrigerant by the end of 2014.

HFO-1234yf was specifically developed to enable automakers to comply with the EU MAC Directive, which requires that all new model type cars sold in EU Member States use an automotive refrigerant that has a global warming potential (GWP) of less than 150. By 2017, all new cars sold in EU Member States must meet this requirement.

However, Mercedes has rejected a switch to the R1234yf alternative which has been brought in under the EU's MAC Directive, which it claims is potentially flammable – a position denied by the refrigerant producers.

Source: www.racplus.com

Source: www.racplus.com

Technology

Heat recovery industry in Germany

Heat recovery was a built-in feature in around 23,000 new ventilation and air conditioning systems installed in Germany in 2013, saving an estimated 1,900 GWh of thermal energy for an input of 103 GWh of electricity used to drive the equipment. Looked at as a form of heat pump, this is an energy efficiency ratio of 18.3. An analysis of developments since 2006 shows a steady increase in the use of heat recovery systems in AHU's from 32 % to 79 % in 2013 - although the number of AHUs being produced has fallen from 32,000 units in 2006 to 23,000 units in 2013.
Source: www.ejarn.com

Water chiller with all-aluminum micro-channel coil

Ciat's eco-designed PowerCiat2 water chiller is now available in a high energy efficiency (HEE) version. This is due, in particular, to the integration of a microchannel coil and a new high efficiency evaporator, which makes it 10 % more energy efficient than the standard model.
Source: www.ejarn.com

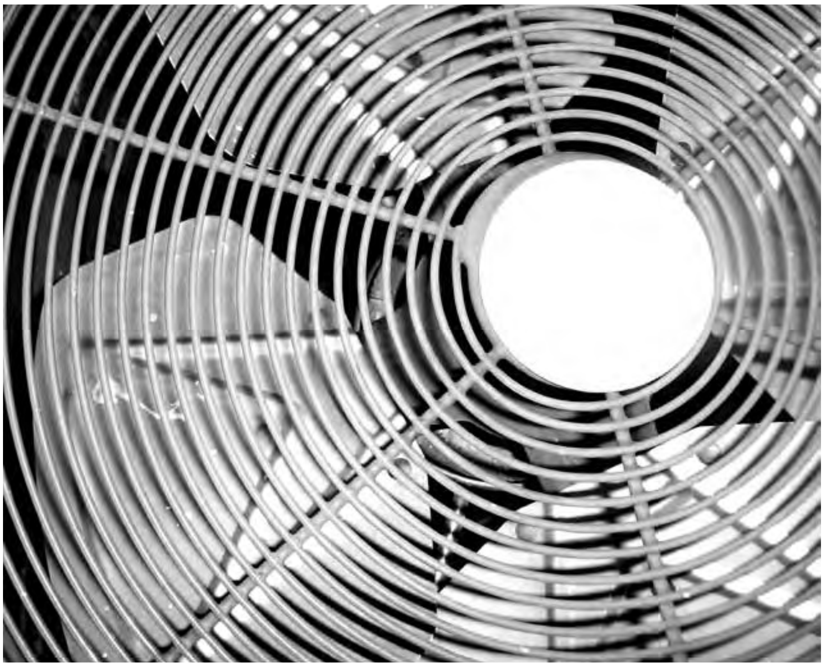
Markets

China's central AC market is growing

The China AC market still possesses huge growth potential driven by following factors:

1. **Urbanisation**:Urbanisation brings huge demands for housing and urban infrastructure. Heavy promotion of a new type of urban development is set to drive a new wave of central air conditioning market growth.
2. The **building energy-saving market**: Retrofit of the central air conditioning systems of large public buildings, which make up 5 % of China's total building area, would boost the development of the central air conditioning industry.
3. Remodelling of the **centralised heating market**: Coal remains the key heat source in North China's urban and rural areas, which causes significant air pollution and wastes huge amounts of energy. Energy consumed by centralised urban heating reaches as high as 160 million tons of standard coal.
4. **Wide spread of green building**: According to the twelfth Five-year Green Building and Green Ecocity Development Plan released by the Ministry of Housing and Urban/Rural Development, 100 green eco-cities, government investment projects, 50 % of new real estate projects located in the eastern coastal municipalities, and old building retrofit projects in the Northern heating area would be subject to green building standards by the end of 2015. During this 5-year period, a total of 1 billion m2 of new green buildings will be completed. By the end of 2015, 20 % of urban new constructions will meet the green building standard.

An increasing number of chiller makers have been involved in designing the most energy-saving, healthy and comfortable central air conditioning system solutions focusing on different requirements of individual environment. It is expected that central air conditioning enterprises will fiercely compete for the gigantic green building market in the future.
Source: JARN, July 25, 2014



USA market for VRF AC's

U.S. VRF AC demand in 2013 was 28,000 units, a 22 % increase compared with 2012. Nonetheless, this is a small share of the market compared with unitary systems and chillers, but there is potential for a larger portion of the U.S. unitary market to convert to mini VRFs, VRFs, and ductless PACs in the coming years.
Source: www.ejarn.com

ATW market accelerated by policies and standards in China

Among the air-to-water (ATW) heat pump water heater industry development, 2012 and 2013 were the two years with great significance in China. In 2012, ATW heat pump water heater was included by the state energy saving subsidy for the first time in the country; in 2013, energy saving subsidy came to an end and new energy efficiency standard was enforced, leading the development of ATW heat pump products to a higher level. The government also delivered stronger assistance to ATW products.
Source: www.ejarn.com

French trends in ATA Heat Pumps

In a relatively stable overall market in France for air-to-air (ATA) heat pumps, sales of small units (less than 5 kW) are becoming a significant growth sector. The main reason, according to Jean-Philippe Fondeville of Hitachi, is the reduced energy demand of new residential buildings - a consequence of the much higher standards of insulation and air tightness.
Source: www.ejarn.com

Large heat pumps in Europe

Large heat pumps can provide heating, cooling and hot water for factories and large service areas. The heat pump units are integrated into industrial or commercial processes for waste heat recovery. In terms of thermal output, large heat pumps can provide an amount greater than 100 kW.

This type of heat pumps has been overlooked the past years even though its potential can change the arena of renewable heating & cooling. EHPA together with a number of manufacturers have decided to join forces and set up a working group so as to discuss the opportunities and challenges of large applications as well as what needs to be done in order to achieve a bigger deployment in Europe.
Source: www.ehpa.org

Emerging refrigeration markets spur the global demand

Currently, the United States, Europe, and Japan account for a large share of the global refrigeration market. However, the standard of living in developing markets such as China, Southeast Asia, India, and Latin America has risen markedly over the last 20 years and with it, demand for food preservation through refrigeration and freezing has also risen. Along with this market shift, established European refrigeration manufacturers are beefing up their production and sales operations in countries such as China, India, and Brazil. Second-hand products from these manufacturers are also popular in emerging markets.

India's refrigerated logistics industry has long been considered an obstacle to growth, but now appears on the verge of sharp expansion. The country's cold chain market scale is forecast to hit US$ 8 billion in 2015, more than 2.5 times larger than the current scale of US$ 3 billion. The government has taken some moves to reform the economy, including significantly relaxing restrictions on foreign companies operating in the retail sector. This is expected to increase foreign private investment in the cold chain market. Thus, the market is forecast to grow at an average annual rate of 16 % over the next several years.

It is said that 20-40 % of fresh food in India is thrown out while in transport, so developing cold chain infrastructure as a way to reduce the amount of food waste is an important issue for the government as well. The Indian Ministry of Food Processing Industries is providing subsidies of up to Rs 100 million (about US$ 1.6 million) for construction of storage facilities. In addition, renovations and improvements to existing facilities are being done, and an increasing number of public-private projects in the cold chain industry are expected.
Source: JARN, August 25, 2014

Ongoing Annexes

IEA HPP Annex 36 Quality Installation / Quality Maintenance Sensitivity Studies

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

The focus and work undertaken by each participating country is presented in the table below.

The intended audience for the Annex 36 output includes:

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

The three-year effort is essentially complete with results presented at the Annex 36 workshop held in conjunction with the 11th IEA Heat Pump Conference (Montreal, Quebec, Canada; 12 – 16 May 2014).

The Annex 36 final report is being finalized with expected submission to the IEA HPC by July 2014.

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

ACCA → Air Conditioning Contractors of America
DECC → Department of Energy and Climate Change (UK)
EdF → Electricité de France
KTH → Royal Institute of Technology (Sweden)
NIST → National Institute of Standards and Technology (US)
ORNL → Oak Ridge National Laboratory (US)
SP → Technical Research Institute of Sweden
SVEP → Swedish Heat Pump Association

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

Annex 40 workshop held at the IEA Heat Pump Conference in Montréal, Canada

IEA HPP Annex 40 is to investigate and improve heat pump systems applied in Nearly or Net Zero Energy Buildings (nZEB). Germany has joined the Annex 40 in June 2014, so currently the nine countries CA, CH, DE, FI, JP, NL, NO, SE and US are collaborating in Annex 40.

In the frame of the 11th IEA Heat Pump Conference in Montreal in May 2014, a joint workshop with the Canadian Smart Net Zero Energy Strategic Research Network (NSERC) has been organised. In the morning session, the NSERC Network presented network projects. Among others several presentations was dedicated to building integrated PV/T hybrid collector systems, which are often operated with air in Canada for direct space heating purpose, or as heat source for a heat pump. In the afternoon session, the participants of IEA HPP Annex 40 presented interim results on the national contributions on the state-of-the-art, as well as on system comparison and technology developments. In Sweden, for instance, system comparison proved that ground-coupled heat pumps are economically feasible for the application in nZEB. The USA presented different variants of the highly integrated heat pump (IHP) development of Oak Ridge National Laboratory (ORNL) including field monitoring results. A new development is dedicated to a gas-engine driven IHP. At the US National Institute of Standards and Technology (NIST), the Net Zero Energy Residential Testing Facility (NZERTF) has been operated for the first year. The NZERTF is an nZEB building with a variety of tuneable loads in order to simulate real user behaviour in a reproducible way, which is used for in-field nZEB equipment testing. With favourable summer insulation, the net zero balance is reached in the first year. The Swiss project is dedicated to the integration of heat pumps and solar components for office buildings including the space heating, DHW and space cooling operation. Besides the presentations on the workshop Annex 40, interim results were also presented in a low energy building session in the frame of the conference. In addition, the 4th Annex 40 working meeting was held in Montreal after the conference.

All workshop presentations are available for download on the Annex 40 website at http://www.annex40.net.

The next Annex 40 working meeting is scheduled for 10-11 November 2014 in Nagoya, Japan.

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IEA HPP Annex 41 Cold Climate Heat Pumps

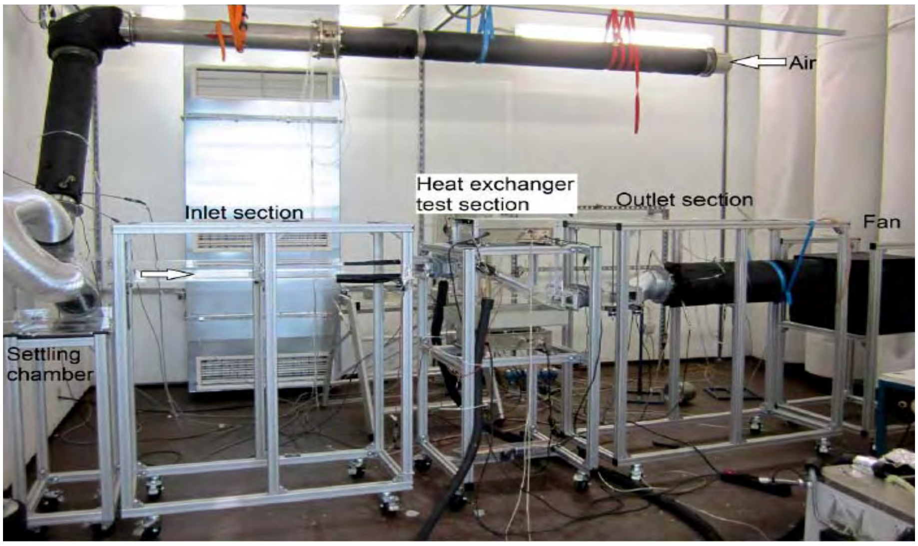
Annex 41 began in July 2012 to revisit research and development work in different countries to examine technology improvements leading to successful heat pump experience in cold regions. The primary focus is on electrically driven air-source heat pumps (ASHP) with air (air-to-air HP) or hydronic (air-to-water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

In the past quarter the Austrian team submitted a draft of their Task 1 report. Work is underway to draft the overall Annex interim report (including Task 1 and 2 works to date). A workshop and brief business meeting were held at the 11th International Heat Pump Conference in Montreal with representatives from all participating countries (Austria, Canada, Japan, and the US) making presentations.

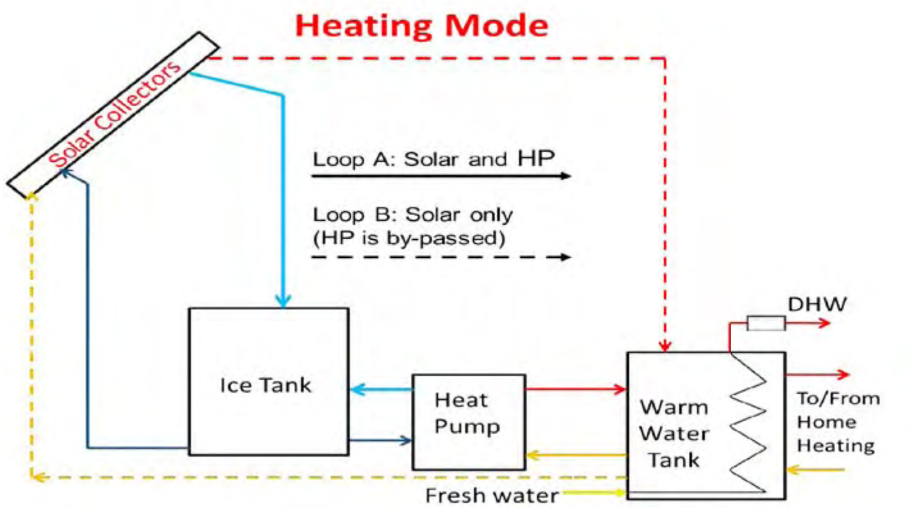
The participants also agreed to an extension of the Annex work period by 6-12 months to allow all participants time to complete their planned contributions. A proposal to this effect will be submitted to the Executive Committee for approval at the fall 2014 meeting in Germany.

A working meeting is being planned for May 2015 in Vienna at the Austrian Institute of Technology. The final Annex meeting and workshop are planned for August 2015 in Yokohama, Japan during the 2015 International Congress of Refrigeration.

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



Annex 41: Small scale wind tunnel for experimental analysis of air-side condensation and icing on outdoor heat exchangers and fin surfaces – photo courtesy Austrian Institute of Technology.



Annex 41: Schematic of integrated solar heat pump system under experimental and analytical investigation in Canada – schematic courtesy of CanmetÉNERGIE, Natural Resources Canada.

has been updated to include all reports submitted to date as well as the presentations from the Montreal workshop.

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IEA HPP Annex 42 Heat Pumps in Smart Grids

Work on this annex has effectively come up to speed during 2014.

During the tri-annual heat pump conference in Montreal in May, we successfully organised a regular Annex 42 project meeting, an Annex 42 workshop open for all visitors to the congress, and also a presentation in the main program accompanied by a scientific paper.

As Operating Agent we also organised a workshop for a future annex in hybrid heat pumps, which is expected to start in Q2 of 2015.

Flexibility and heat storage are key elements related to heat pumps in smart grids, and consequently were the main topics as discussed during the Annex 42 project meeting. An indicator such as a 'flexibility index' – a figure to rate the grade of flexibility of a dwelling - is recognised as of potential interest for further investigation. Task leadership fulfilment, task description, expected output, planning and table of contents of the task reports were updated during further discussions. A firm action list was compiled and agreed upon. Task #1, the country report, was finalised directly after the summer holidays.

Confirmed participants up to now are the United Kingdom, The Netherlands, South Korea, USA, Switzerland, Denmark and France. Sweden, Austria and Germany are in the process of arranging the procedure to become full participants in Q4 of 2014.

Switzerland's confirmation of participation was received during a presentation by the OA for Annex 42, during the annual Swiss heat pump conference in Burgdorf, Switzerland

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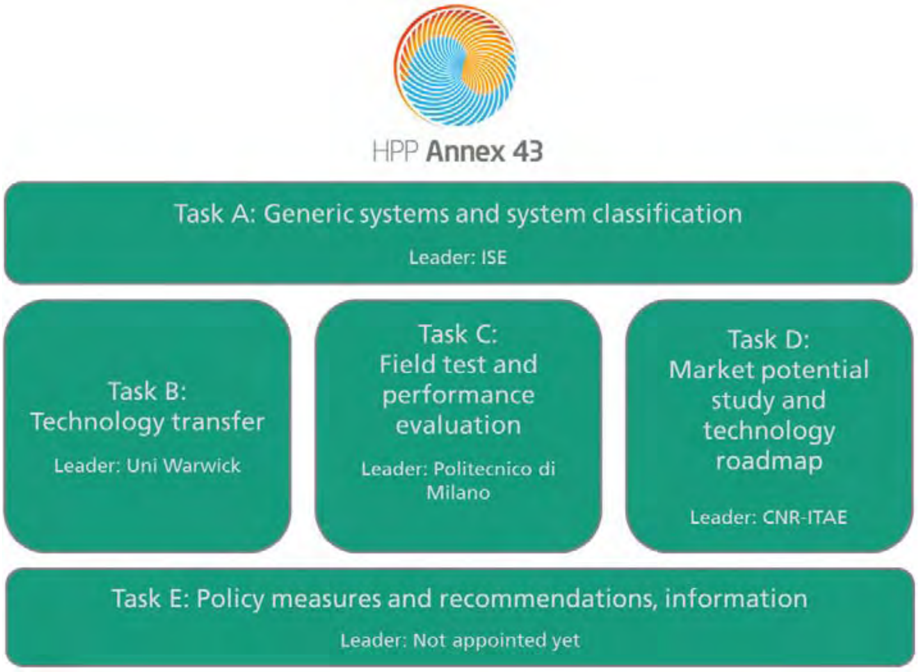
IEA HPP Annex 43 Fuel-driven sorption heat pumps

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

Objectives

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



Annex 43: Annex structure

Annex 43: Group picture of the second Annex meeting held in Paris, France, June 2014.

The Annex structure

The tasks are further specified as follows.

Task A: Generic Systems and System Classification

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

Task B: Technology Transfer

- Link research to industrial development for faster market penetration of new technologies
- Novel materials (e.g. MOFs for adsorption heat pumps)
- Novel components (integrated evaporators/condensers, compact heat exchangers)
- System designs (e.g. façade collector as heat source)

Task C: Field test and performance evaluation

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

Task D: Market potential study and technology roadmap

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

Task E: Policy measures and recommendations, information

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

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

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

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

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

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

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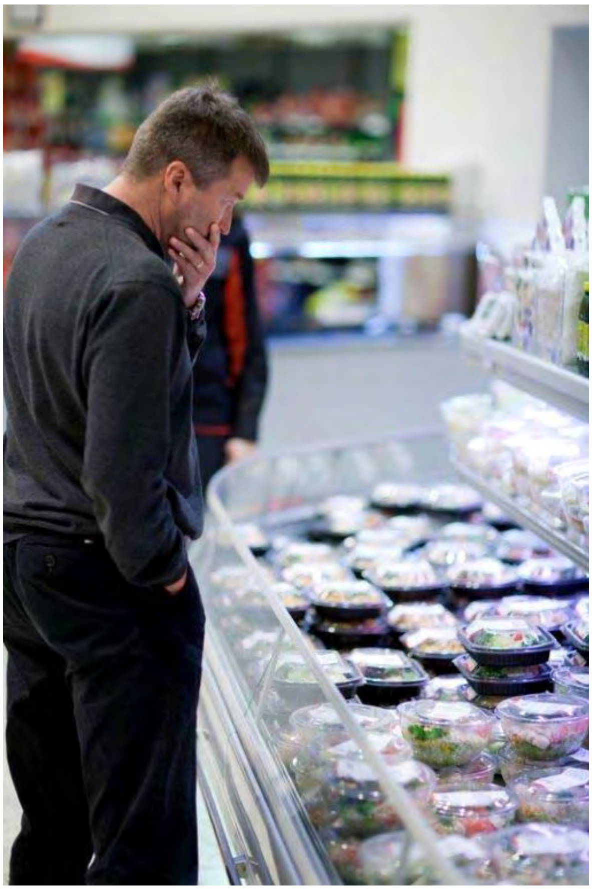
IEA HPP Annex 44 Performance indicators for energy efficient supermarket buildings

An Annex 44 meeting, open to all interested parties, was held on June 24th alongside the International Conference on Sustainability & the Cold Chain on June 24th in London.

The Operating Agent of Annex 44 opened the meeting with a presentation concerning the IEA Heat Pump Centre and Annex 44. The presentation showed the Annex objectives, tasks and progress, and also general information on participation in an IEA HPC Annex.

The activities of the Swedish team were presented. This work is closely supported by a reference group in which supermarkets, related organisations and suppliers participate. The basis is to make the work and results closely aligned with the requirements “from the field”.



Also, an idea was presented to let supermarket owners submit energy consumption data online. Such an approach has proven successful in the European “ICE-E” project concerning cold store energy consumption. The work by the Dutch team was presented. This has focused on making an inventory of supermarket chains. A group of students from the Leiden University have analysed data from a specific supermarket location. Temperature measurements in cabinets are under way.

The discussion with meeting participants focused on participation in the Annex 44. There is interest to participate from Norway, Denmark and Italy.
At the meeting, a representative from the Australian branch of a USA cabinet manufacturer also indicated an interest to participate in the Annex.

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Ongoing Annexes

Bold text indicates Operating Agent.

Annex 36 Quality Installation/Quality Maintenance Sensitivity Studies	36	FR, SE, UK, US
Annex 37 Demonstration of Field measurements of Heat Pump Systems in Buildings – Good examples with modern technology	37	CH, NO, SE, UK
Annex 39 A common method for testing and rating of residential HP and AC annual/seasonal performance	39	AT, CH, DE, FI, FR, JP, KR, NL, SE, US
Annex 40 Heat Pump Concepts for Nearly Zero-Energy Buildings	40	CA, CH, DE, FI, JP, NL, NO, SE, US
Annex 41 Cold Climate Heat Pumps (Improving Low Ambient Temperature Performance of Air-Source Heat Pumps)	41	AT, CA, JP, US
Annex 42 Heat Pump in Smart Grids	42	CH, DK, FR, KR, NL, UK, US
Annex 43 Fuel Driven Sorption Heat Pumps	43	AT, DE, FR, IT, UK, US
Annex 44 Performance Indicators for Energy Efficient Supermarket Buildings	44	NL, SE

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

Action behind the words: Are legislators doing enough to address Europe's heating challenge?

Thomas Nowak, Germany

The political framework in Europe is beginning to recognize heat pump technology as part of the solution towards the Union's triple goal of GHG emission reduction, increased energy efficiency, and the use of renewable energy sources. However, political will to directly support the technology is limited, and so is the impact of policy on market growth. More action is needed to reap the full benefit of the technology.

Introduction[1]

European policy makers have recently reconfirmed their commitment to reduce the demand for non-renewable energy sources, to improve energy efficiency, and to cut down greenhouse gas (GHG) emissions (Euractiv 2014a). Climate and energy policy should also result in reduced import dependency for energy, improved security of supply, affordability of energy and local employment.

For an impact in the market place, actions must follow words. Many stakeholders, among them the European Heat Pump Association, have called for truly ambitious, mandatory targets resulting in higher target values (30 % renewable energy, 35 to 40 % energy efficiency improvements), and an implementation trajectory that leaves no room for manoeuvre when working towards achieving them. This applies in particular to member states, as they are the key implementing actors.

Experience from the legislation set up around the currently active 202020 targets generates room for concern. Even though Commission representatives repeatedly stress that Europe is on track at least for the GHG and the RES targets for 2020 (Euractiv 2014b), EHPA's own analysis shows that both the renewables target and the energy efficiency target may be missed (Nowak 2013). This is particularly unnecessary, as heat pump technology would help to achieve all the goals mentioned in a cost-efficient manner. Providing direct support for heat pump technology as a matter of policy, by giving it "preferred technology" status, would make achieving the 2020, 2030 and 2050 targets much easier.

This article provides a condensed overview of the most important legislative acts (RES, EE, Ecodesign, the EPBD Directive and the F-Gas Regulation) affecting heat pump technology. It presents a brief analysis of the ways in which legislation both helps and hinders, and gives an overview of their effects on development of the heat pump markets in Europe. Finally, it discusses the status of the European heat pump market and the expected development of heat pump sales as a result of legislation.

Heat pump-related legislation in Europe

As a consequence of the 202020 targets, a number of legal instruments have been passed to contribute to target achievement. They address one or more target areas, and apply to a range of system boundaries - from the product level, to member states, to Europe as a whole (see Table 1).

The Directive on promotion of the use of energy from renewable sources

The Directive on promotion of the use of energy from renewable sources (2009/28/EC) requires EU member states to significantly increase the contribution of renewable energies in their energy mix. Using a burden-sharing mechanism, all 28 member states shall collectively provide 20 % of the Union's final energy demand in 2020 from renewable energy sources (European Commission, 2009a).

While member states are free to choose the means to achieve their individual targets, the Directive sets up a common framework of mechanisms and guidelines that member states have to integrate into their legislation to ensure fulfilment of the obligation. This includes eligibility of measures, statistical transfers, joint projects, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable energy sources.

With regards to heat pump technology this legislation was a milestone, as it not only **augmented the definition of renewable energy sources** (which previously only included geothermal energy) **by aerothermal and hydrothermal energy**, but also **officially recognised heat pumps as a technology to use these sources**.

At the start of the implementation phase, member states (MS) reported the expected contribution of heat pumps as part of their National

1 This article is based on previous work presented at the 2014 IEA HPP international heat pump conference in Montréal, Canada. Thanks for original support goes to Pieter-Jan Cluyse and Pascal Westring.

Year	Name	Target area	System boundary
2009	Renewable Energy Sources Directive (RES Directive)	RES	European Union / member state
2010	Energy Performance of Buildings Directive (EPBD)	Energy efficiency RES	Building
2009	Ecodesign for Energy related Products - Framework Directive (ErP)	Energy efficiency	Product/system
2009	Energy Labelling Directive	Energy efficiency	Product/System
2010	Energy Efficiency Directive (EED)	Energy efficiency	European Union / member state
2013	Regulation on Ecodesign for Heaters and Water Heaters	Energy efficiency	Product/System
2013	Regulation on energy labels for heaters and water heaters	Energy efficiency	Product/System
2014	F-Gas Regulation (review of 2006 regulation)	GHG emission	European Union / member state
2014	Ecolabel Framework Directive: Ecolabels for heat pumps, hydronic heating systems and office buildings	Energy efficiency Renewable energy GHG emission	Product/System
2014	Green Public Procurement	Energy efficiency Renewable energy GHG emission	Product/System

Table 1: Most important legislative instruments influencing the uptake of heat pump technology in Europe [Source: own]

Renewable Energy Action Plans (NREAPs). The accumulated MS targets for the contribution of air-, water- and ground-coupled heat pumps amounts to 141 TWh of renewable energy. However, this is barely 10 % of the overall reduction target. Clearly, the potential of heat pumps was not recognised to the full extent in most countries.

While the 2013 update of the renewable energy action plan shows compliance with the development trajectory (European Commission, 2010a), a forecast of the European heat pump industry based on current sales numbers questions the possibility of achieving the 2020 target: sales and growth rates have been insufficient over the past three years and an annual growth rate considerably more than 10 % p.a. over the next six years would be necessary to achieve the fairly unambitious heat pump targets. In consequence, policy makers must be more actively supportive of heat pumps to realise heat pumps' contribution potential towards the use of renewables for heating and cooling.

The recast of the Energy Performance of Buildings Directive

The recast of the Energy Performance of Buildings Directive (2010/31/EU | EPBD) came into force in July 2010 (European Commission 2010c). It addresses the impact of buildings on Europe's energy demand and in particular requires improvement of the energy performance of **new and existing buildings** within the European Union. The Directive sets minimum requirements on a framework for calculating the energy performance of buildings. The resulting method should be used to calculate the energy demand of buildings, building elements and technical building systems. It also requires an increase in the proportion of nearly Zero-Energy Buildings (nZEBs). Starting in 2021, all new buildings must be NZEBs, and energy renovation of existing buildings must be addressed by the member states.

A market drive is expected by making energy certification of buildings (including an inspection system for certification) mandatory, augmented by regular inspection of heating and air conditioning systems in buildings.

While heat pumps are barely mentioned in the Directive, they are major beneficiaries of its implementation. A much-increased energy standard, as currently observable in many member states, can quite often only be fulfilled with the installation of heat pumps. The concept of nearly zero-energy, using significant amounts of renewables produced on-site or nearby, can be seen as a requirement directly fulfilled by heat pumps connected to local photovoltaic systems.

Even though implementation of the EPBD was due by July 2012, the majority of member states has yet failed to implement it, with the Commission currently executing several infringement procedures.

The Ecodesign for Energy-related Products Framework Directive and the Energy Labelling Directive

The Ecodesign Directive establishes a framework for the setting of requirements for products with a major impact on energy consumption (European Commission 2009b). The requirements must meaningfully reduce the energy demand of each identified product group, and are minimum requirements that must be fulfilled in order to be able to bring the product to market.

The Energy Labelling Directive aims at the provision of end user-orientated information for different product categories. It is connected to the respective Ecodesign implementing act in those cases where the product covered is sold to end users. It consists of requirements for the product label as well as for the technical information to be supplied with the product (European Commission, 2010b).

Implementing Measure on Ecodesign Requirements for Heaters and Combi-Heaters and Hot Water Heaters (ErP Lot 1 and Lot 2)

The regulations on the minimum Ecodesign requirements for heaters, combi-systems and hot water heaters apply to products and packages using gas, oil, solar thermal, aerothermal, hydrothermal or geothermal energy to provide heating, and/or hot water (European Commission 2009b). They include products with a thermal output of up to 400 kW capacity. They set minimum efficiency requirements based on primary energy efficiency (η_s). The η_s for heat pumps (with a PEF[2] of 2.5) will be calculated for a low- (35°C) and a high-temperature (55°C) heat delivery system. Efficiency of hot water production will be calculated based on a standard tapping cycle. The measure enables comparison of functionally equivalent products – heaters – based on primary energy efficiency as a single criterion. Once in place, a major effect towards products with higher efficiency - such as heat pumps - is expected.

The Energy Labelling regulation governs the information to be provided to end users as well as responsibilities of suppliers and dealers for the proper preparation and display thereof. The label should enable consumers to choose the more energy-efficient products. The energy label for heat pumps is mandatory for products with a thermal capacity of up to 70 kW. It will show the primary energy efficiency in a range from A++ to G from 2015, and in a range from A+++ to D from 2019 onwards, with A+++ being reserved for the most energy-efficient products. The package label will show the A+++-class from the beginning: it will also show the thermal capacity per climate zone as well as information on the sound power. For Lot 2, the range will start with A+ to G (for heat pumps), and A+++ to G (for solar thermal water heaters), in 2015. In the case of combi-systems providing heating and hot water, a single unit will have two labels, indicating its heating and hot water production efficiency respectively (European Commission, 2013a; 2013b).

The Energy Efficiency Directive

The Energy Efficiency Directive (2012/27/EU | EED) aims at improving energy efficiency at member state level in order to achieve the non-binding EU-target of 20 % primary energy demand reduction by 2020 (European Commission 2012). Member states have to report their national energy efficiency targets and the measures to achieve them to the European Commission. The Directive encompasses a number of targets that have to be achieved at the national level, such as:

» a renovation rate of 3 % per annum of all buildings (by floor area) owned and occupied by the central government;
» establishing national energy efficiency obligation schemes to achieve a reduction in energy demand of 1.5 % per year;
» adoption of policies which encourage the use of efficient heating and cooling systems (this is mainly aimed at co-generation, but does not exclude other technologies, such as heat pumps);
» encouraging the introduction of energy services;
» strategies to overcome the low renovation rate of residential and commercial buildings

The Directive is a compromise between member states, and it is estimated that its implementation will result in an approximate reduction of energy demand by 16 to 17 %. This means that it falls short of achieving the 20 % target. Member states have by now declared their energy savings targets and have handed in National Energy Efficiency Action Plans (NEEAPs) to the Commission. A first evaluation of the planned measures and their impact reveals that it will be a challenge to achieve even the 16 – 17 %. If the full assessment of the plans confirms this, mandatory energy efficiency targets will be discussed in 2014 and most likely such a shortcoming would increase the likelihood of adding a mandatory energy efficiency target for 2030, alongside a GHG reduction and renewables target.

F-gas Regulation

The Regulation on Fluorinated Gases ('F-gases' | 2014/517/EU) aims at reducing the amount of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) placed on the internal market of the European Union. It is based on the general principle of avoiding the use of fluorinated gases in all cases where cost-effective and environmentally superior alternatives are available. If alternatives are not (yet) available, the Regulation aims at minimising losses in production, operation and at end-of-life of a product. Measures address leak-tightness and maintenance of equipment, labelling as well as training and certification of personnel.

The recast of the 2006 regulation came into force in May 2014. Its main element is a phase-down mechanism that reduces the amount of F-gases that can be placed on the EU market in 2030 by 79 % compared to the average emissions from 2009 to 2012 (European Commission 2014b). Consequently, refrigerants with a high Global Warming Potential (GWP), such as R404a, will most likely disappear from the market. However, R407a and R410 will be available and will be used due to their benefits of being energy-efficient, non-toxic and non-flammable. It will be a major task

2 *PEF = Primary Energy Factor: accounts for the energy losses of electricity generation and transport when comparing electricity use with other types of energy use in the building.*
A value of 2.5 has been agreed upon as a European average. It will be used for the first five years of the regulation being in force.

for the industry to develop efficient systems using alternative refrigerants by 2030. This applies in particular to the development of necessary components. This development will have to include the training of professionals as well as an adjustment of building codes and standards. EHPA is calling on the Commission and member states to support the phase-down with additional funds for research and development in the area of low-GWP refrigerant heat pumps.

Ecolabel and Green Public Procurement

In order to support decision-makers on the private as well as on the administrative level, the EU uses the Ecolabel and Rules on Green Public Procurement. The latter are based on EU legislation on product policy (European Commission 2004a, 2004b).

The requirements for both the Ecolabel and GPP for hydronic heaters exceed the minimum requirements of Ecodesign and the Energy Label, and enhance them by additional criteria. The Ecolabel exists for different product groups. It has been introduced for heat pumps in 2007, and is currently valid until 30.10.2014 (European Commission 2007). An updated version applicable to all heaters using hydronic heat distribution systems has come into force in 2014 (European Commission 2014c). The Ecolabel takes a lifecycle perspective to calculate the weighted emissions per kWh of thermal energy and augments this value by additional requirements to prove the superior environmental performance of labelled products. Most heat pumps that are currently available fulfil the requirement of the Ecolabel, which proves their positive contribution to energy efficiency and the environment. However, due to the differing requirements for quality by different governments, the Ecolabel often fails to qualify for financial support. As such, its penetration in the market is still low.

In parallel with the Ecolabel, a set of guidelines on green public procurement (GPP) was developed for heating systems. It aims at helping public authorities to make purchasing decisions for products with a reduced lifecycle environmental impact. GPP rules on heaters could play an important role in implementing the Energy Efficiency Directive on the administrative level.

However the voluntary nature of both measures, and the limited acceptance with regards to government support programmes, as well as the fact that many of the additional requirements are covered by other legislation, may hinder their positive impact on the development of the heat pump market.

New framework conditions: The 2030 Climate and Energy Package

EU decision-makers are currently discussing a follow-up of the 2020 targets. The new framework maintains the overarching aim of a secure, affordable and independent sustainable energy system providing local employment and mitigating climate change. After intense negotiation, stakeholders have agreed on the continuation of three mutually reinforcing targets for energy savings (via increased energy efficiency), more renewables and, in consequence, reduced GHG emissions.

At their autumn meeting, European heads of state will have to decide on the proposal made by the European Commission (European Commission 2014a) earlier this year. This means that Europe will aim to achieve a GHG reduction of 40 % by 2030 (based on 1990 levels), a 27 % share of renewable energy (based on the 2030 share of final energy) and at least a 30 % improvement in energy efficiency. Discussions are still in progress on how to implement targets that are mandatory at EU level in each member state: in particular under which governance mechanism non-compliance could be identified and resolved.

From a heat pump perspective, three mandatory targets will support the technology's market development, as heat pumps are beneficial to achieving these targets and would thus be at the centre of fulfilling the requirements of related legislation.

Impact of legislation on the market

Market status

EHPA records HP sales data and market information since 1996. The number of countries covered has reached 21 in 2013.

A total of 771 245 heat pump units was sold in 2013 (+3 %). When integrating data since 1989, the aggregated sales number of heat pumps in Europe is close to 6.85 million units. Assuming a useful life of 20 years, the stock of units in operation is around 6.8 million units (see Table 2 and Figure 1).

Year	Total EU-14	Total EU-21	Cumulative total 1989-2013
2005	446 037		1 015 607
2006	509 794		1 525 401
2007	589 118		2 114 519
2008	804 457		2 918 976
2009	734 282		3 653 258
2010	800 388	800 388	4 453 647
2011	808 591	808 591	5 262 238
2012	750 436	750 463	6 012 674
2013	771245	771 245	6 783 919

Table 2: Heat pump sales in Europe, 2005 - 2013 [Source: EHPA]

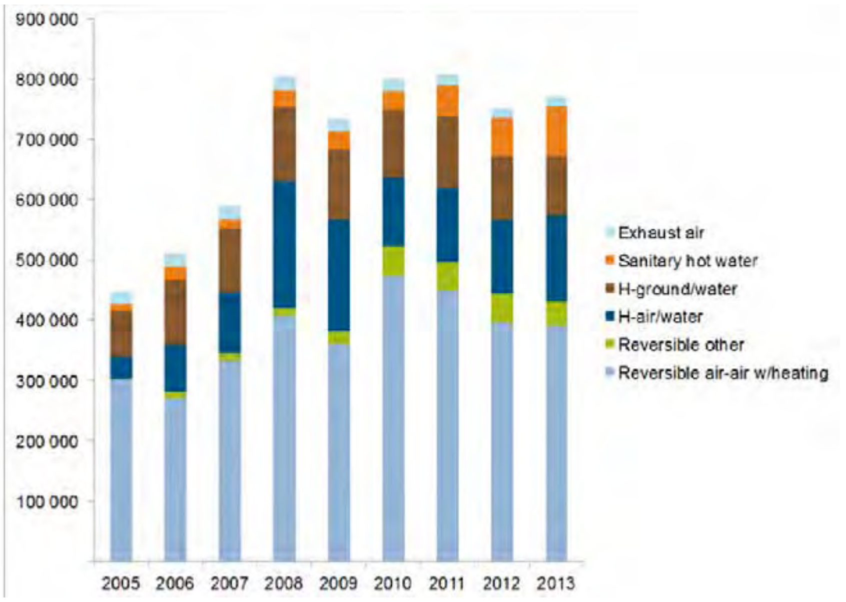

Figure 1: Development of heat pumps sales in Europe, 2005-2012, by category. Countries covered: 2005-2008: 14; 2009: 19; 2010-2012: 21

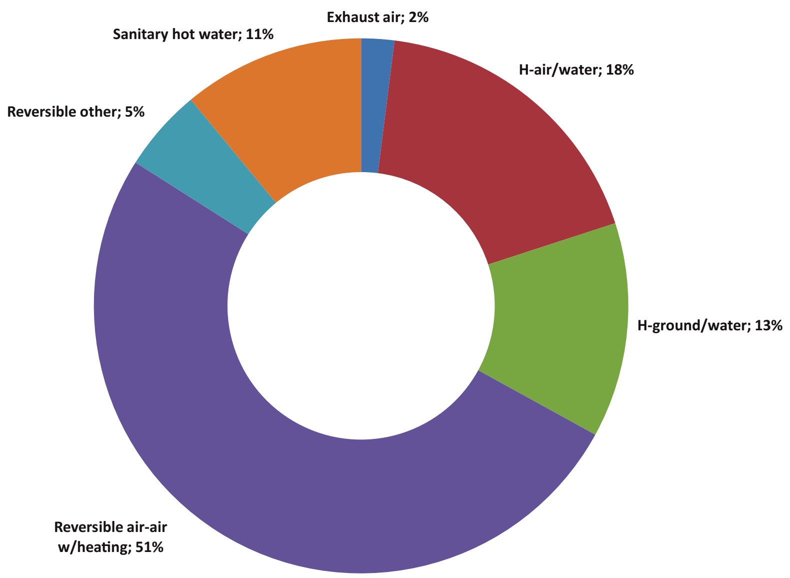

Figure 2: Heat pump sales in Europe, 2012, shares by type of heat pump

Based on the 2013 data, the following trends can be observed:

Air is the dominant energy source for heat pumps. The majority of heat pumps sold are reversible air-air systems (51 %) followed by air-water (18 %) and ground-coupled units (geothermal energy, 13 %), Exhaust air heat pumps are a small but growing segment (2 %). The greatest growth is recorded for sanitary hot water units, with an increase of 29 % from 2012 to 2013 and a share in total sales (2013) of 11 % (see Figure 2).

Expected advancements in technology will make the already easy-to-install units more efficient and compact, integrating most of the necessary components. As well, new products are introduced in the market, providing efficient heat pump solutions for an increasing number of demand scenarios, namely the **renovation segment** and **large building** solutions, where a parallel demand for heating and cooling makes heat pumps particularly suitable. Air source units are cost-competitive in an investment perspective, and even more in an operations perspective. As such, they are preferred solutions for the performance and cost-aware consumer.

Sanitary hot water systems, which also use air as energy source, are the fastest growing sales segment. Their easy integration with existing heating system makes them an "entry-level heat pump". They enable the use of a minimum share of renewables (around 15 %), as often requested by legislation.

The **geothermal and hydrothermal installations** segment shows a split picture. The number of large installations for commercial buildings, building blocks and district heating is increasing, with the latter often connected to bodies of water. The market for residential geothermal application sees a constant number of approx. 100 000 units. This is not expected to change, unless the cost of drilling can be reduced and the necessary administrative procedures to obtain a drilling permit are simplified.

Large heat pumps for commercial, industrial and district heating applications are becoming more popular, but not enough data exists for this important market segment.

The slight increase of 2 % in the European market is spread unevenly across countries. In 2012, approx. half of the 21 observed markets grew, while the other half shrank. In 2013, 10 out of 13 markets that have reported data show positive growth, most of them stronger than reported, from 2011 to 2012 (see figure 3).

The number of markets showing double-digit growth has decreased from 2012 to 2013, but some of the large markets, such as Germany, France and Sweden, have returned to the group of growth markets.

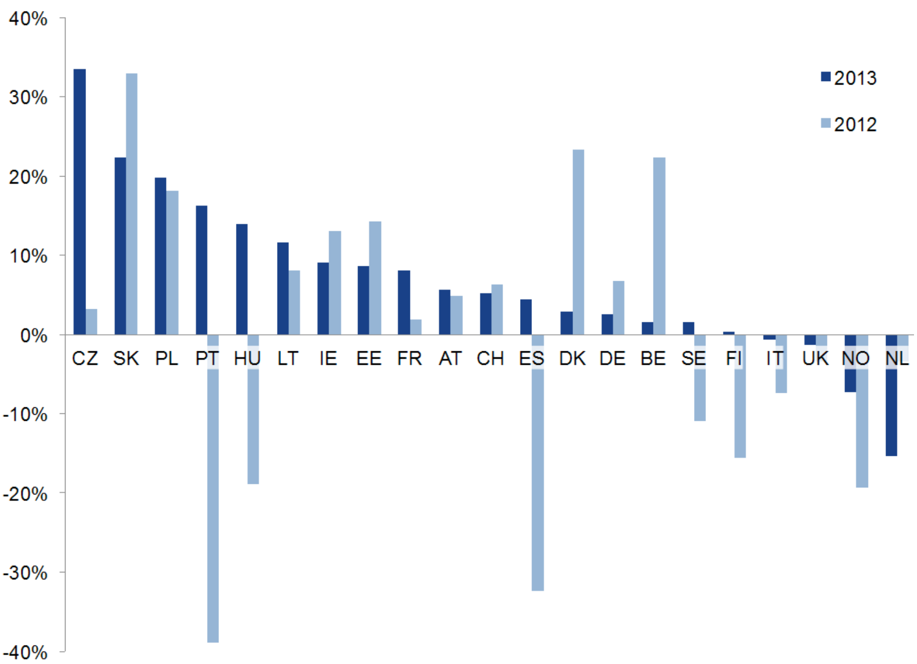

Figure 3: Growth rate of heat pumps sales in 21 European countries (in per cent), 2011-2012 and 2012-2013 [Source: EHPA]

Looking at the available data for 2013 reveals that the Slovak Republic is leading the growth countries for a second time in a row followed by Poland, a market quickly becoming one of the major drivers of heat pump growth in Europe. In absolute terms, France is the growth leader with an additional 11 400 units, followed by Poland (+2 493) and Spain (+ 2 233).

As far as the benefits of the technologies towards achievement of the EU's climate and energy targets are concerned, heat pumps continue to deliver the expected triple dividend in the form of also providing local employment as well as security and affordability of energy supply. As the market is growing, a slightly higher contribution to the different targets can be expected from sales in 2013.

The 771 245 units sold in 2013 added 20 GW of capacity to the market. They produced approx. 13 TWh of useful energy, and integrated 8.26 TWh of renewables in heating and cooling, at the same time avoiding 2.12 Mt of CO_2-equivalent emissions. An additional 4.83 TWh of primary energy was saved, resulting in a reduced final energy demand of 10.56 TWh, thus saving the end consumer money and making financial means available for other purposes.

In order to produce the 2013 sales volume and to maintain the installed stock, a total of 41 600 man-years were necessary. Obviously, real employment related to the heat pump market is larger, as not every employee works full-time on heat pumps only.

Impact of current legislation on markets

Current European legislation shows a clear focus on more energy efficiency, renewables and less GHG emissions. Overall guidance is provided by the RES-Directive and the EED, both being connected to a relevant 2020 target. GHG emission reduction is governed mainly by the EU Emission Trading System (EU-ETS), which covers 45 % of all emissions. It is augmented by individual legislation such as the F-Gas Regulation, which addresses areas of high concern.

Heat pumps are part of the climate and energy legislation. The start can be seen in the recognition of heat pumps as an environmentally friendly technology by the **Ecolabel** for heat pumps in 2007. An enhanced definition of renewable energy in the RES Directive in 2009 changed the landscape for heat pumps, introducing air and water as renewable sources, and recognising heat pumps as a technology to use them.

The **Energy Performance of Buildings Directive** has probably had the greatest impact on market development of heat pumps up to today. Although the directive rarely mentions the technology, its impact on the selection of a building's heating solution is huge. Stricter energy demand requirements lead to buildings with a lower relative energy footprint, a development that favours heat pumps for the equipment of the building - both new and renovated.

It is too early to determine the impact of the **Ecodesign** measure and the related energy label on heaters and hot water heaters, but industry is positive that the clear labelling of **heat pumps as best-in-class technology** will have a major impact in the market place. Due to the transition period, this effect will only become visible in the market from 2015 onwards. It is quite obvious, however, that manufacturers are currently using the transition period to align their product ranges to the requirements. While not yet visible, efficiency will be optimised.

Tools to guide and encourage customer demand, such as the Energy Label, the Ecolabel, and the Green Public Procurement rules are assisting the positive recognition of heat pump technology. All these instruments (should) have a positive effect on the further development and uptake of heat pumps in the European Union.

The implementation of the F-Gas phase-down, as agreed to in the F-Gas Regulation, will be a major challenge to the industry, as the search for, and development of, low-GWP alternatives and components for heat pump systems will impose considerable work on the industry's research and development capacity.

A greater challenge may be presented by the different approaches towards heat pump support taken by the different member states. Instead of basing their **incentive schemes** for the technology on European legislation, such as the energy label, member states often opt for national, sometimes stricter, requirements for financial support. This interferes with the advantage of a single market, as it creates a more complex landscape of requirements, necessary tests and certificates. The approach rarely makes the final product or installed system any better, but renders its placing on the market more difficult, time-consuming and expensive.

The fact that incentives most often depend on government budgets makes them random, as they are stopped when budgets are used up. It can be argued that such schemes cannot only develop but also slow down and even destroy market development if not applied in a consistent, transparent and foreseeable manner.

Is current legislation enough?

Today's legislation has been shaped around the 2020 targets. With only six years left until then, reaching the targets makes a sheer necessity of fast and comprehensive implementation of all EU legislation at member state level. Even this cannot be taken for granted, considering the fact that the Commission has issued notifications of non-implementation to a number of member states, both with regards to the EPBD and -most recently - with regard to the Energy Efficiency Directive.

Nevertheless, proper implementation would make achieving the current goals (and much more) easy, and this possibility makes opting for more ambitious targets on the EU and the member state level not a threat but an opportunity. Heat pumps are a key to open the door for governments to move towards a low-carbon economy in general and a low-carbon heating sector in particular.

Convincing decision-makers, in turn, is the key towards heat pump market growth. The purchase decision for a heating / hot water system depends largely on the relative price of the different alternatives. Unfortunately, decision-makers tend to focus on a comparison of the upfront investment cost, and rarely take the total lifetime cost of ownership of a product into consideration. This applies a disadvantage to heat pump technology, as the first costs are higher than those of comparable fossil alternatives.

Member states wanting to overcome this challenge can either help to reduce the cost for heat pump-based systems, or implement measures that increase the cost for the fossil fuel alternatives. In the first case, this would mean institutional or financial incentives for heat pumps, and the second would result in a burden on fossil fuels, for example via the introduction of a CO_2 tax or the integration of the heating sector into the emissions trading scheme.

Providing more support for heat pumps would speed up the decarbonisation of the heating sector. The comparison between heat pumps and the best available fossil fuel technology, a gas condensing boiler, reveals at least a 50 % savings potential in heat pump emissions; and this saving is even higher when replacing oil or coal-fired systems.

In other words: governments that really want to address the heating sector can do so by giving a preference to heat pump-based systems. However, this requires much clearer decisions towards renewables and heat pumps for heating. The current business-as-usual approach will not be sufficient.

Conclusion

The current legal framework governing climate and energy explicitly and implicitly includes heat pumps as helping to achieve the targets.

Due to the long implementation cycles of legislation, the impact of the different legal measures on the markets is only partly beginning to show. The biggest impact currently observable results from the **Energy Performance of Buildings Directive**.

The **Ecodesign** regulation and the related energy label are too new to show any meaningful impact in the market place. They will influence sales from 2015 onwards.

The **Energy Efficiency Directive** is a strong tool, but it needs to be used. Once properly implemented in all member states, a strong impact on heat pump markets is expected.

The implementation of the **F-Gas Regulation** is critical. With its effect on the availability of F-gases, it is a major threat to the manufacturers of heat pumps, who now have to continue their normal development cycles in terms of unit design, functionality and efficiency (etc.), while at the same time having to integrate measures to reduce GHG emissions from refrigerants.

In **conclusion**: the foundation for a heat pump-friendly policy framework has been laid. Member states must now implement it swiftly and decisively in order to unleash heat pump technologies' potential in achieving the climate and energy targets. A real policy change towards a low-carbon, energy-efficient heating (and cooling) sector requires more decisive action, addressing in particular the relative cost situation.

If such action is not taken, heat pump market development will have to continue largely on its own. This would be the slower development path. It would deprive Europe of an available solution towards many pressing issues when it comes to renewables, energy efficiency and greenhouse gas emission, let alone the issue of affordability and security of energy supply.

The heat pump industry stands to support policy makers in their challenge towards a sustainable European energy system.

It is easy to like heat pump technology, but now we need action behind words.

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Recent Progress in the Residential U.S. Heat Pump Market

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Abstract: 13.5 million homes in the United States rely on heat pumps (HPs) for their primary heating equipment, about 80% of which are concentrated in the Southern United States. HPs are a technology of choice in the South not only due to the relatively moderate winter weather, but also because of the relatively greater affordability of electricity compared to natural gas in that region. Historical data analysis showed a strong correlation between growth in HP shipments and a drop in electricity prices relative to natural gas. HPs also showed growth in the new housing market: 38% of homes completed in 2012 included a HP, up from 25% in 1978. However, more than 74% of HP shipments are absorbed by the replacement and add-on markets. Even though HP technology experienced growth in the last decades, the future may be even more promising. The market transformation and research societies are working toward validating HPs in the cold climate region. This, together with other potential favorable market conditions, could even exceed the 2014 Annual Energy Outlook (AEO) estimates of tripling HP stock by 2040.

Key Words: heat pump, U.S. market, efficiency, residential

1 THE EXISTING RESIDENTIAL BUILDING STOCK

HP technology is increasing in popularity in the U.S. residential sector. As of 2011, 13.5 million, or 12%, of homes occupied in the United States relied on HPs for their primary heating needs (American Housing Survey (AHS) for the United States: 2011 (Table C-03-AH)). About 13% of single-family homes and 10% of multifamily units use HPs for their primary heating equipment. However, HP deployment in the United States is very concentrated in warmer climate zones. For example, 11 million, or 80%, of all homes relying on HPs are located in the Southern United States, and about 11% of homes using HPs are in the West. HPs are popular in the South due to the moderate winter weather, making HPs a great candidate to satisfy households cooling and heating needs. The South is also the most populous region in the United States with 37% of households concentrated in that region as of 2009. Between 2005 and 2010, the South was the only region to report a significant population net gain of 1.1 million (Faber, 2012). This seems to be a historical trend. Since the 1980s the South has shown a positive population net gain of more than 1.4 million every 5 years. The Northeast and the Midwest have consistently shown a population net loss since 1965. The West has experienced only minor net gains for the last 15 years. In the 2005 to 2010 timeframe, the West experienced a net gain of only 71,000 residents.

Figure 1 indicates that in 2009 the total heating load of all occupied housing units in the United States was 4.226 quadrillion BTUs or Quads (4.46 EJ). Due to the cold weather, the Northeast and the Midwest have the highest average site energy consumption for heating, close to 60 Mbtu (63.3 GJ) per household. The average in the South stands at 22 Mbtu (23.2 GJ), while the average in the West is 27 Mbtu (28.5 GJ) (2009 RECS Survey Data (table

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CE3.1)). Even though 37% of the occupied housing units are located in the South they only represent 21% of the total U.S. residential buildings heating load. The HP deployment trends throughout the United States have had a major impact on HP's share of the national heating load. Because HPs are mainly prevalent in moderate climate conditions with low per household heating loads, they are only responsible for only 0.3 Quads (0.32 EJ) or 8.2% of total heating load.

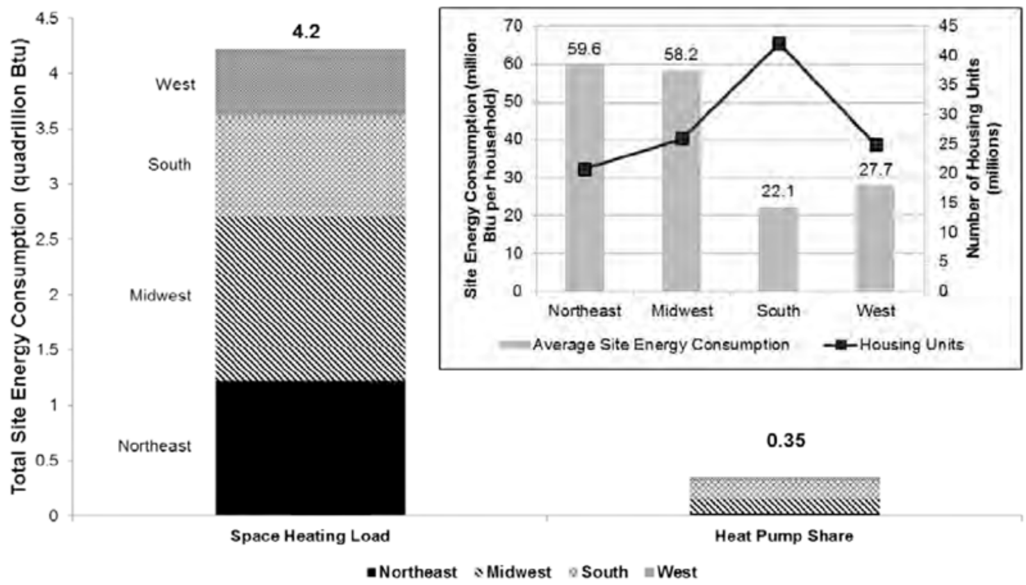

Figure 1: U. S. Residential Heating Load Characteristics; total and per household

2 NEW HOUSING MARKET

It takes decades of sustained growth in HP shipments to affect the existing housing stock, but the impact is more easily noticed in the new housing market. Figure 2 highlights the continuous growth in HP installations in new homes. In 1979, 17% of completed multifamily units included a HP. By 2011 this had reached a historic high of 58% and stabilized back to 49% in 2012. Similarly, 25% of new, completed single-family homes included a HP in 1978, but grew to 38% in 2012.

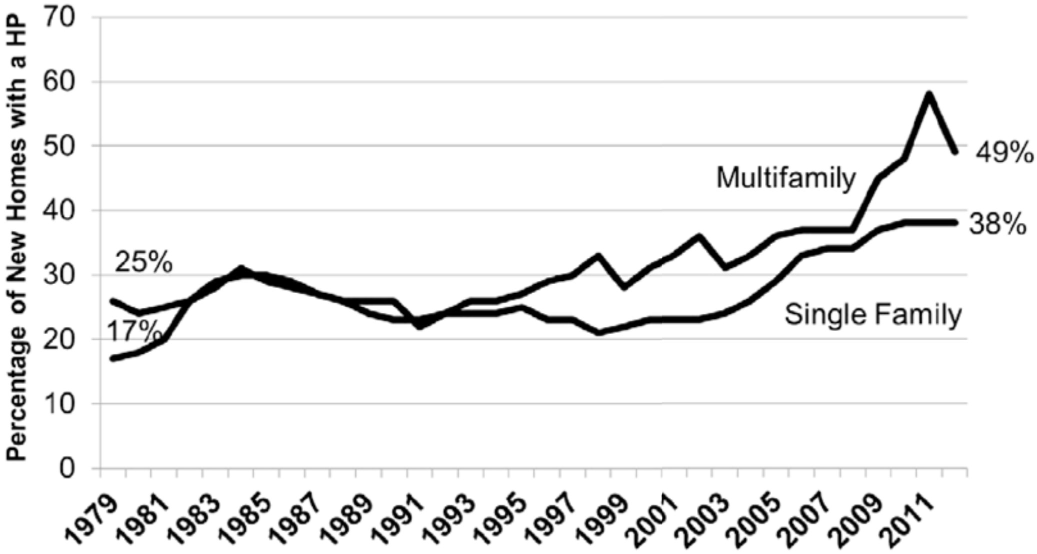

Figure 2: Percentage of New U.S. Homes with a HP

Figure 3 shows the total annual HP shipments trend since 1979 (AHRI, 2014) for the replacement and add-on markets, new single-family market (Census.gov (Type of Heating System)), and multifamily market (Census.gov (Presence of Heat Pump)). The replacement market absorbed between 74% (assuming two HPs per single-family unit) and 85% (assuming one HP per housing unit) of total HP units shipped in 2012. As is evident in the figure, the U.S. new housing market is still struggling to recover from the housing crisis that began in 2007, halting many new home construction plans. In 2012 almost 500,000 new single-family homes were completed—down from the 1.6 million homes completed in 2006. However, total HP shipments remained relatively high and have begun to increase somewhat in response to demand from the replacement and the add-on markets. Before 2006 the replacement market was only responsible for 51% (assuming two HPs per housing unit) to 73% (assuming one HP per single-family unit) of total units shipped. The replacement market role will likely continue to grow as the new housing market recovers.

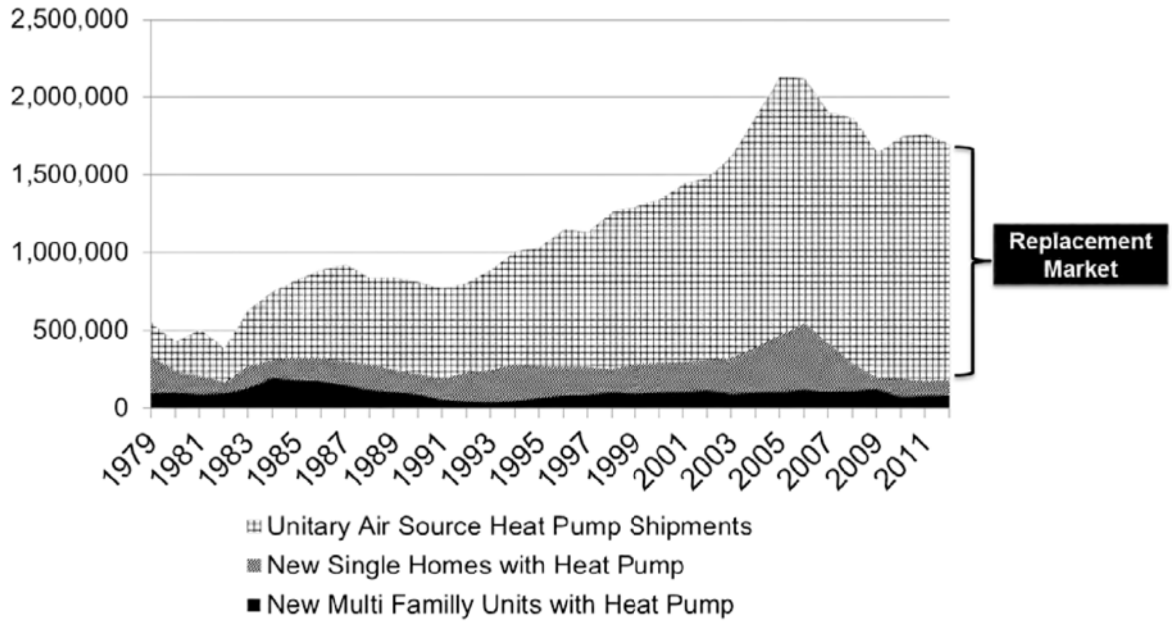

Figure 3: Total U.S. HP Shipments for Replacement and New Construction Markets

Figure 4 shows the number of new homes completed with air-conditioning (AC) systems, HPs, and warm-air furnaces (Census.gov (Type of Heating System)), (Census.gov (Presence of Central Air-Conditioning)). Note the sharp decline in new housing starts accompanying the economic recession that began in 2007 and how HPs gained market share during this time at the expense of furnaces. From the late 1970s through about 2006, homes completed with HPs represented only 25-30% of total homes completed while homes completed with a furnace represented 50-60% of total homes completed. In 2012, furnaces maintained a steady market share at ~58% of new homes completed while the share of new homes with a HP rose to 38%.

The HP market share increase has been due mainly to phasing out of hot water, steam, electric baseboard, panel, radiant heat, space heater, floor or wall furnace, and other heating equipment types because of the superior efficiency and lower cost of HPs relative to other legacy technologies. This is promising for the future of HP technologies. The increase can also be explained in part by the population migration shift toward warmer climates where HPs are more prevalent. About 53% of newer homes are in the more temperate South, compared with only 35% of older homes (Energy Information Administration, 2013). It is also interesting to note that 89% of homes completed in 2012 are equipped with ACs, because it symbolizes the potential market for HP technologies. That is, as technological advances are made in cold climate HP technology, allowing for increased efficiency, HPs will become strong candidates to potentially replace ACs to meet the cooling and heating needs of households in these regions. This is especially true for air-source HPs (ASHP), the most prevalent type sold in the United States.

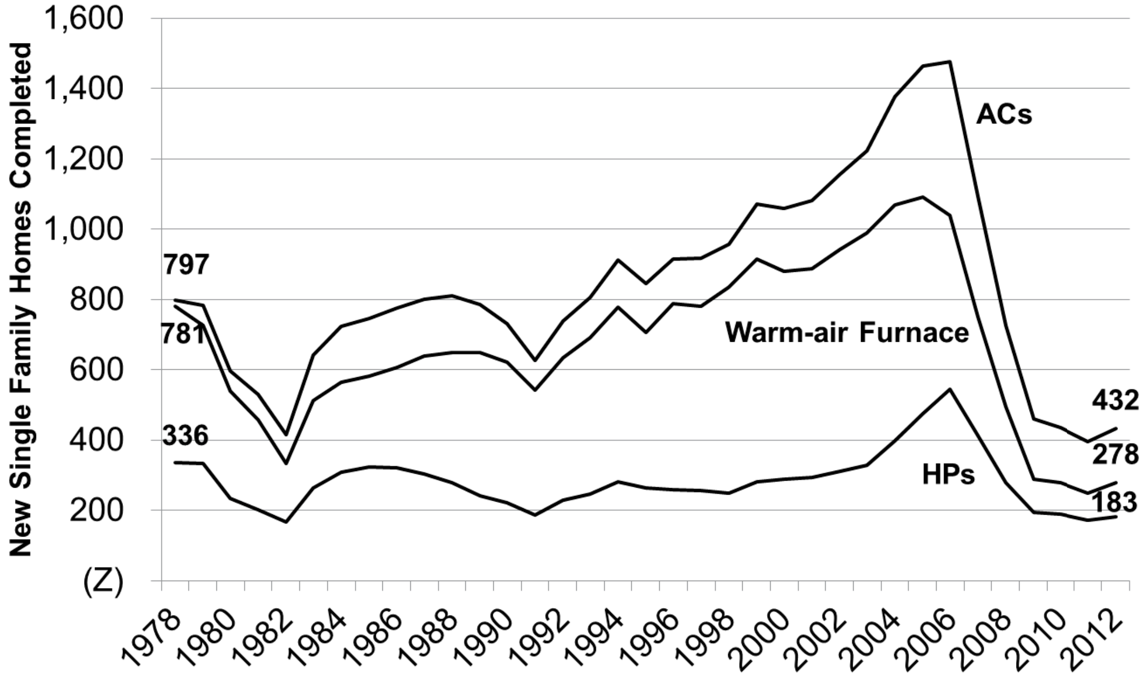

Figure 4: New Homes Completed with AC Systems, Warm Air Furnaces, and HPs

Not only are HPs more popular in the Southern United States, they are also substantially more popular outside metropolitan statistical areas (MSAs) (Census.gov (Presence of Heat Pump)). 51% of new homes built outside MSAs have a HP, relative to only 36% of new homes completed inside MSAs. That probably is due to the fact that HPs are more readily available to residential customers outside MSAs. About 99.8% of homes outside MSAs have electricity available, relative to only 43% that have access to and use natural gas (American Housing Survey (AHS) for the United States: 2011 (Table C-03-AH)), which gives HP technologies a competitive edge over furnaces in these areas.

3 HEATING EQUIPMENT SHIPMENTS

The HP market is recovering from the economic crisis that began in 2006 faster than other heating technologies as seen Figure 5, which shows unit shipments for the most popular heating equipment: ASHPs, gas furnaces, and oil furnaces (AHRI, 2014). The 1.7 million HP units shipped in 2012 is equal to ~80% of HP shipments made in 2005, while the 2.2 million gas furnace units shipped in 2012 is equal to only ~63% of gas furnace shipments made in 2005.

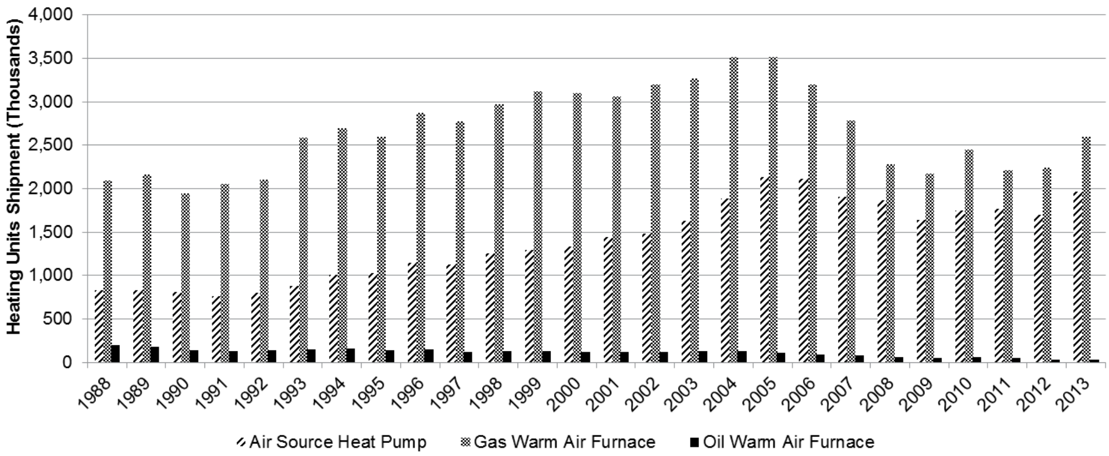

Figure 5: ASHP, Gas Warm Air Furnace, and Oil Warm Air Furnace Historical Shipments

HP efficiency has also increased substantially over the last two decades. In 1990, prior to the initiation of federal minimum energy efficiency standards, the average shipment-weighted cooling seasonal energy efficiency ratio (SEER) was less than 10 Btu/Wh (2.93 W/W). The federal standards and associated technological advancements effectively led to steady increases in shipment-weighted SEER. In 2005, the average HP and AC SEERs were 11.3 and 11.6 Btu/Wh (3.3 and 3.4 W/W), respectively. In January 2006, the minimum required SEER for new ACs and HPs was increased to 13 Btu/Wh (3.8 W/W). In January 2015, new federal minimums standards for SEER and Heating Seasonal Performance Factor (HSPF) will be required to be at least 14 and 8.3 Btu/Wh (4.1 and 2.4 W/W) for HPs and ACs respectively, and space-constrained HPs will be required to meet a minimum efficiency of 12 SEER (3.5 W/W). The shipment-weighted average SEERs for split HPs and split ACs in 2013 (through November) already exceed the new 2015 minimum requirement - 14.78 (4.3 W/W) and 14.17 (4.2 W/W), respectively.

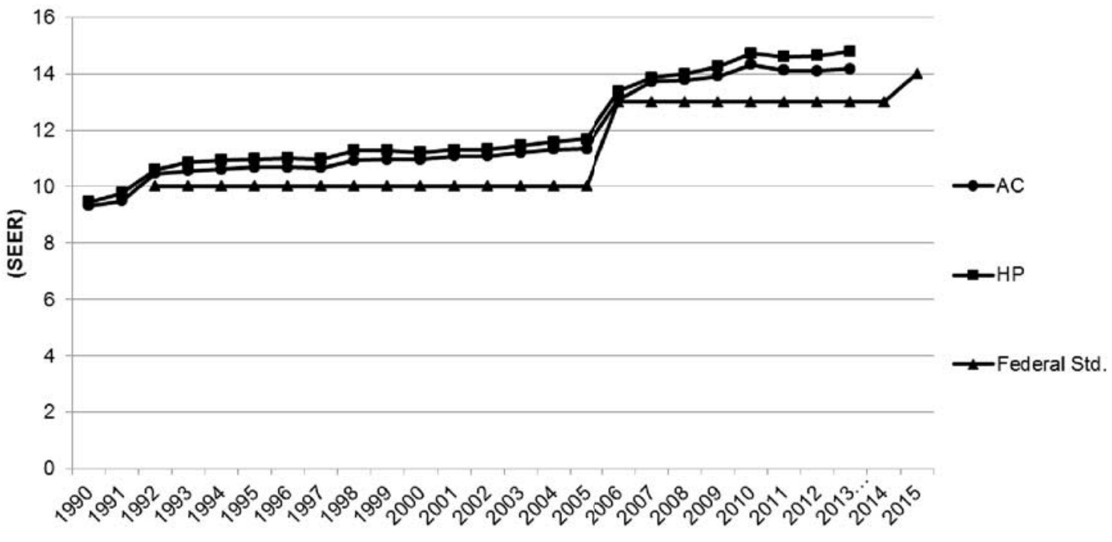

Figure 6: AC and ASHP Shipment-Weighted Average Seasonal Energy Efficiency Ratio (NOTE SEER in units of Btu/Wh; divide by 3.412 to get SEER in W/W units)

4 FUEL PRICES

4.1 State Level Analysis

Figure 7 shows state-level data for the percentage of homes using HP (right axis of the chart) with only the publicly available data for 29 states shown (2009 RECS (tables HC3.8, HC 3.9, HC 3.10, HC 3.11)). As discussed earlier, HPs are more popular and prevail in the South; on average almost 20% of homes in the Southern United States rely on HPs as their primary heating equipment. Some Southern states, however, have a much higher penetration of HPs than some of their neighboring states. In Virginia (VA), for example, 37% of homes rely on HPs for their primary heating needs. In an attempt to better understand market drivers for HP penetration (besides moderate climate), the relationship between electricity ((Energy Information Administration (Average Retail Price of Electricity to Residential Sector)) and natural gas (EIA (Natural Gas Residential Prices)) residential prices per state were investigated. The left axis of Figure 7 displays the cost ratio between electricity and natural gas. For the state of VA, the cost ratio for 10^6 Btus (1.06 x 10^6 Joules) from natural gas to that from electricity is 1.7. That is, the price of electric energy to a residence is 1.7 times that of natural gas energy, which is relatively low compared to other states. In Alaska (AK), for instance, this cost ratio of 6, referring to the fact that an electric MMBtu is six times the price of a natural gas MMBtu. Figure 7 shows 12 states where more than 14% of homes use HPs as their primary heating equipment. In most of these states the electricity-to-gas fuel price ratio is less than 2.1. To conclude, the relative moderate climate and the relatively lower price of electricity compared to natural gas in these 12 states created a favorable market condition for HP technologies to penetrate the southern region of the United States.

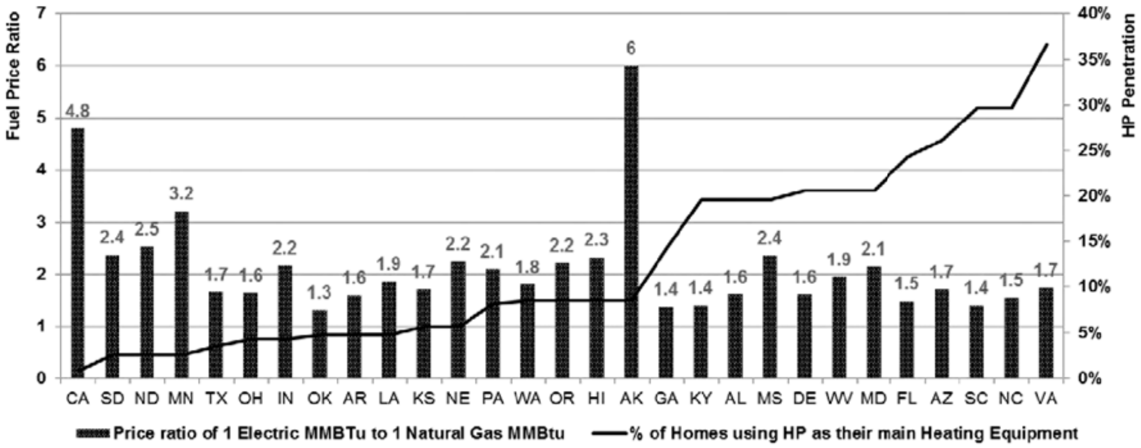

Figure 7: State Level Data on Relative Fuel Prices and Percentage of Homes Using HPs as Their Main Heating Equipment

4.2 Regional and Historical Analysis

Figure 8 shows the historical relationship between HP shipments (AHRI, 2014) and the national average residential gas-to-electricity price ratio (EIA (U.S. Price of Natural Gas to Residential Customers), 2014) and (EIA (Average retail price of electricity to ultimate customers by state, by provider, annual back) to 1990, 2013). Note that in Figure 8 the fuel price ratio is inverted relative to Figure 7. The inverted fuel ratio is intended to ensure that the visual correlation between the two factors could be easily seen. The national average gas-to-electricity price ratio stands at about 0.3 for 2012, referring to the fact that 1 natural gas MMBtu is a third of the price of 1 electric MMBtu. The ratio has fluctuated between 0.25 and 0.45 between 1990 and 2012. HP shipment variations over the same period generally mirror the price ratio fluctuations with a correlation coefficient of 0.917. From 1990 to 2003 natural gas prices surged relative to electricity prices, giving an opportunity to the HP shipments to flourish. That trend broke in 2005, where HP shipments experienced a dropping trend partly driven by a surge in electricity prices relative to a more stable natural gas prices.

Figure 8 also shows a snapshot of the regional gas-to-electricity fuel price ratio for 2012 (EIA (Table 7c : U.S. Regional Electricity Prices)) and (EIA (Table 5b : U.S. Regional Natural Gas Prices)). Only four EIA regions have fuel price ratios higher than the average, that is, where natural gas is relatively more expensive than electricity. Three of these EIA regions (South Atlantic, East South Central, and West South Central) are located in the Southern United States, indicating that the South is generally characterized by lower electricity prices relative to natural gas prices. This trend highlights the role that relatively lower electricity prices play in promoting HP technologies and the role lower natural gas prices play as a barrier to HP penetration.

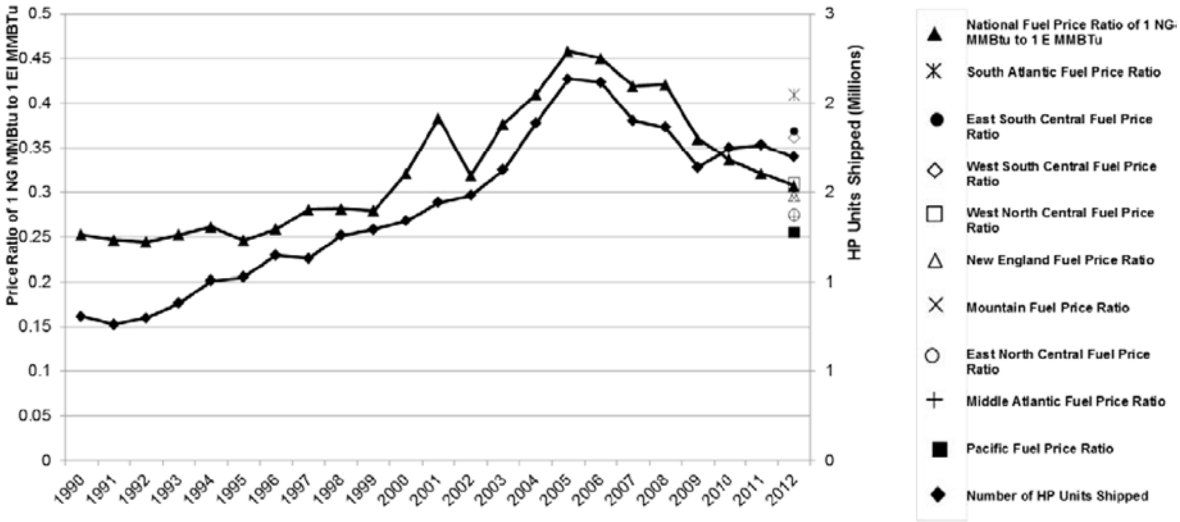

Figure 8: Relative Fuel Prices and the Number of HP Units Shipped

5 FUTURE OUTLOOK

Figure 9 shows a forecast of the anticipated growth in residential heating equipment stocks from 2012 to 2040 (EIA (Annual Energy Outlook 2014 Early Release Overview)). The forecast takes into consideration electricity and natural gas prices and the important role they play in supporting or hindering the penetration of these heating technologies. An average growth rate for all electric HPs of 3.1% annually throughout the period is anticipated with stocks of geothermal heat pumps (GHP) projected to increase by 3.8% on average. In comparison, growth in natural gas heating equipment stock is projected at only 0.9% per year.

According to the AEO, 9.8 million homes were estimated to be using HPs as their main heating equipment in 2011 based on the latest data from the Residential Energy Consumption Survey (RECS). However, this number is believed to be underestimated since RECS respondents often have trouble identifying HPs. The general impression is that the number of electric central furnaces is overstated, and the number of HPs is understated. Comparing the HP numbers for heating versus AC seems to indicate this. Also, the RECS data indicate that 13.5 million households use HPs for space cooling while only 9.8 million use HPs for space heating. Another issue is that the RECS data is based on asking respondents to self-identify their main heating equipment. As HPs go into more and more homes, especially in warmer climates, respondents may think that other heating sources, such as space heaters, are their primary heating equipment because they do not use much heat. The number homes listing HPs as a secondary heating source did grow slightly from 1.2 million in 2005 to 1.3 million in 2009. Finally, RECS data only asked about homes that actually used heat in 2009. 2.4 million homes have heating equipment and did not use it. Since HPs are more common in warmer climates, it is possible that there are a significant number of homes with HPs that did not use heating at all.

To conclude, the combination of respondent misidentifications of heating equipment, respondent selection of main heating equipment type, and homes that do not use the heating equipment may have caused the 2012 value of HP equipment stock to be underestimated ((McNary) Personal Communication, 2014). In Figure 9, the dotted black line represents the estimated electric HP stock if the true HP equipment stock in 2012 was accounted for and assuming similar growth rate of 3.1%. The true HP equipment stock in 2011 is thus assumed to be 13.5 million. This number is consistent with the number estimated by the American Housing Survey (American Housing Survey (AHS) for the United States: 2011 (Table C-03-AH)) and by RECS for homes that use HPs for cooling purposes.

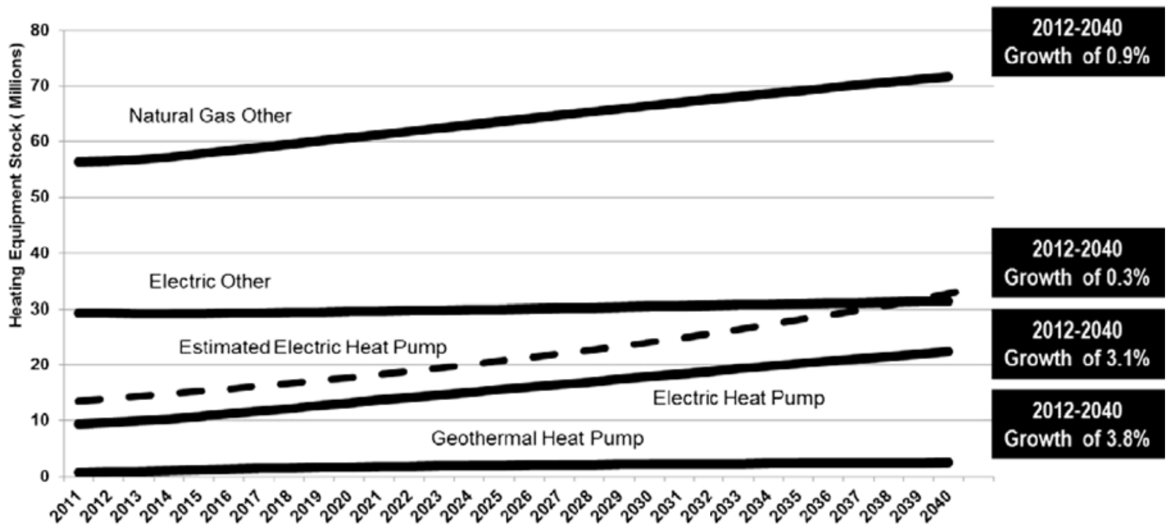

Figure 9: Forecast of Residential Heating Equipment Stock (2012-2040)

HP technologies have had a successful market penetration story to date. Their future potential continues to evolve as more stakeholders realize their unique applications and potential energy savings as improvements to efficiency continue to be made. The AEO has estimated that residential HP stock to more than triple by 2040. A few promising highlights listed below suggest that HP technologies may even exceed the AEO estimates.

- Expansion into colder climates. As discussed earlier, HPs have always been a popular choice in the Southern United States. However, in the future, HP popularity may expand to reach other climate zones. Research and market transformation efforts are underway to substantiate HPs (particularly ASHPs) as legitimate heating equipment in colder climate regions. In the Northeast and the Mid-Atlantic region, the Northeast Energy Efficiency Partnership (NEEP) is coordinating the market transformation efforts. In a recent publication (Northeast Energy Efficiency Partnerships, 2014), NEEP has identified strategies that have the potential of transforming the heating equipment market in their region. The strategies range from creating a consumer and contractor awareness campaign to developing accurate modeling software for estimating energy and cost savings in cold climate regions. The report also indicates that the existing target market for HPs in the Northeast region would include: 10 million homes constructed prior to 1980, 9.5 million homes without central AC, and 4 million homes that use oil for heating. These population numbers are not additive, and the overlap is not known, but it is believed to be substantial. An excellent HP candidate home would be an older home that is getting an energy retrofit including a smaller and more energy-efficient heating system. If the home previously used electric resistance or oil for heating, the electric HP would offer energy cost savings. If the home did not have central AC, the HP would also provide a significant comfort improvement in the summertime.

HP technology in the Northeast region has also had a few modest deployment success stories, especially in Connecticut, Maine, and Vermont. In the one-year period starting in August 2012, Efficiency Maine was able to deploy 1,350 ductless split HP units as part of its weatherization program. In 2011 Connecticut's Home Energy Solutions Income Eligible program installed 3,576 ductless split HPs. In parallel with NEEP's market transformation efforts, the U.S. Department of Energy (DOE) and the International Energy Agency are coordinating efforts to address the key technical challenges facing ASHP technology in cold climate conditions, namely the reduction in heating capacity at low outdoor temperature (OD) temperatures and resultant increased usage of back-up electric resistance heating. The true challenge is achieving the higher low OD temperature heating capacity and higher HSPF will incur an installed cost premiums (Baxter, Van et al., 2014). The broadening of a market for ASHP technologies beyond the Southern United States to reach cold climate regions has the potential of drastically reshaping the HP market. Market transformation efforts driven by the technical and the marketing society hold much promise for substantial growth in the HP market.

- Role of Relative Equipment Efficiency. Relative equipment efficiency is one of the important factors that affect technology market penetration decisions. Long-term HP efficiency technological improvement promises are higher than its competing gas furnace technology. In addition, HPs allow for an opportunity to capitalize on renewable energy produced on site. However, the current difference in the efficiency performance of these two technologies has usually been balanced with the price difference of different fuel heating: natural gas and electricity. If HP efficiency continues to improve and as long as fuel prices ratio stay almost constant, the market may tend to favor HP technologies.
- Potential New Markets for HPs. New end-use applications for HPs are gaining ground, particularly for water heating. For example, the stand-alone heat pump water heater (HPWH) is an exciting application with great potential. HPWHs experienced a significant boost in market presence in the United States beginning in 2009 when a number of manufacturers with considerable market presence and brand name awareness each introduced their HPWH models. However, HPWH (over 55 gallons) technologies will be challenged to grow from 1% of the market in 2012 to meet a federal standard that requires 100% penetration in April 16, 2015 (Northeast Energy Efficiency Partnerships, 2014). The efficiency requirement defined by the federal standard can today be only met by the HPWH technology. Multi-purpose heat pumps or integrated heat pumps (IHP) that combine space heating, space cooling, and water heating functions are another new HP technology with potential to achieve overall energy savings exceeding 50% compared to separate minimum efficiency systems (Baxter et al, 2013). Another promising technology, though not new, is the GHP. According to a new report from Pike Research (Navigant, 2011), GHP sales will experience strong growth rates in the next several years, with annual unit shipments in the United States increasing from just fewer than 150,000 in 2011 to more than 326,000 units in 2017. The potential for GHPs is high, but installations currently represent just 1% of the heating and cooling market. GHP and HPWH growth has the potential of educating consumers, contractors and cities in its entirety about HP technologies. This shared knowledge could set the stage for HPs to further penetrate the electric heating market.

In summary, the AEO projects the residential HP stock to more than triple by 2030. However, the applicability of newer ASHP technologies for cold climate regions, the potential of improved HPs efficiency relative to gas furnaces and increased application of HP technologies for domestic water heating (for water heating only or as part of an IHP system) could create a favorable environment for HP growth that may even exceed the AEO projections.

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HEAT PUMPS IN NORTH AMERICA 2014

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Abstract: This report provides a snapshot of the U.S. heat pump and air conditioning market in the context of a struggling economy and housing market, following a period of robust growth during the last decade. Heat pumps show continuing growth as an efficient electric heating alternative to fossil fuel heating systems, particularly in the warmer areas of North America where there is the highest population growth. Instabilities and higher prices for fossil fuels add impetus to the interest in heat pump systems. Statistical data is presented to illustrate the growing number of heat pump systems in the U.S. and Canada, A positive prognosis is offered for further penetration of heat pump systems for both residential and commercial building heating and cooling markets in North America, providing motivation for continued efforts to improve products and applications.

Key Words: heat pumps, building heating systems, efficiency

1 INTRODUCTION

The U.S.is slowly recovering from the worst housing market decline in decades, which began in 2006 as a result of the sub-prime mortgage and banking crisis that triggered a major economic recession in the U.S. As shown in Figure 1 (from National Association of Home Builders, NAHB 2014) the rate of new housing starts (seasonally-adjusted) dropped from 1.75 million in 2005 to approximately 500,000 in 2009. Although there has been an increase in building construction since 2010, new home sales have continued to languish despite low interest rates and government incentives for first-time home - buyers.

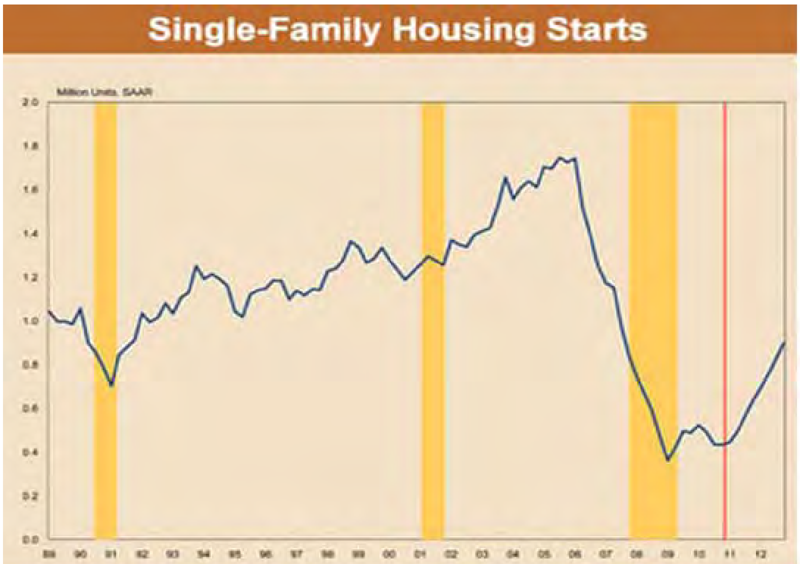

Figure 1 U.S. New Home Starts - Seasonally Adjusted (from NAHB 2014)

In Figure 2 the actual single- and multi-family home completions through 2014 (year to date – seasonally adjusted) are shown, along with new manufactured home completions. Housing permit activity is superimposed on this chart.

The Canadian housing market did not experience the dramatic changes seen in the U.S., likely due to the fact that Canadian banks refrained from broad participation in sub-prime mortgages and credit to homebuyers who were unable to pay their mortgages once banks raised interest rates to normal levels.

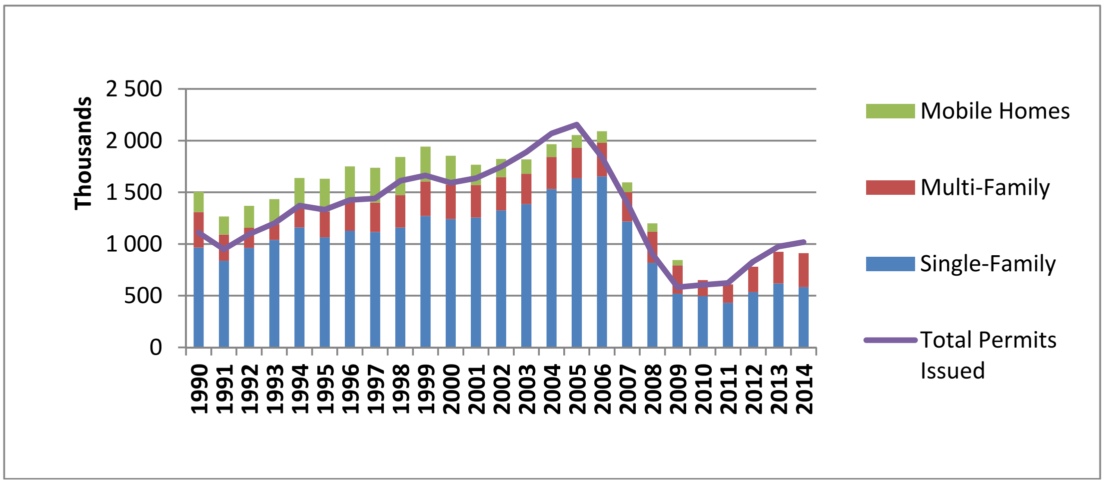

Figure 2 U.S. Home Completions 1990 – 2014 (NAHB, 2014)

The rapid changes in the U.S. housing market have resulted in some notable market changes for heating and cooling system sales. These changes are discussed in ensuing portions of this report.

2 BACKGROUND

The U.S. air conditioning and heat pump situation has been well documented in earlier presentations and this report will focus primarily on the changes that have occurred since 2008 when a similar report was presented at the 9th International Energy Agency Heat Pump Conference in Zurich, Switzerland (Groff, 2008). Heat pumps have been accepted as a viable option to fossil fuel furnaces and boilers or direct electric heating since the 1980s. Heat pumps have been popular in the southern and southwestern parts of the U.S. where the space-conditioning need is primarily for cooling but some heating is required. Heat pumps have been less popular in parts of the country where heating is the primary need, except in special situations where electricity rates are low or natural gas and fuel oil are not readily available and electric heat or propane are the main alternatives. When careful attention has been paid to the sizing of the units and to their installation, heat pump installations in colder parts of the U.S. have shown quite successful performance and reliability results. With greater new home construction rates in the south and southwest over the past twenty years annual heat pump sales in the U.S. grew to more than 2 million units. And with the installed heat pump stock accumulated over the past 30 years, significant portions of these sales have been for the add-on and replacement markets. Replacement sales have been stimulated by the increased efficiency of newer units as federal minimum efficiency requirements have driven air conditioner and heat pump efficiencies higher.

3 RESIDENTIAL HEAT PUMP SALES

3.1 UNITARY HEAT PUMP AND AIR CONDITIONER SHIPMENTS

Figure 3 presents the unitary air conditioner and heat pump shipment statistics since 1973 from AHRI (Air Conditioning, Heating and Refrigeration Institute). The drop in shipments starting in 2006 follows directly the housing market decline, but to some extent this impact has been moderated by increased add-on and replacement sales, which have grown to be nearly 80% of annual shipments of heat pumps. Homeowners trying to sell their homes and those adding-on to existing homes, rather than moving to new homes, have stimulated this sales growth. As can be seen in this graph, heat pump sales were not as adversely affected by the housing market decline, as were residential air conditioners. Annual heat pump sales are roughly one-third that of cooling-only units.

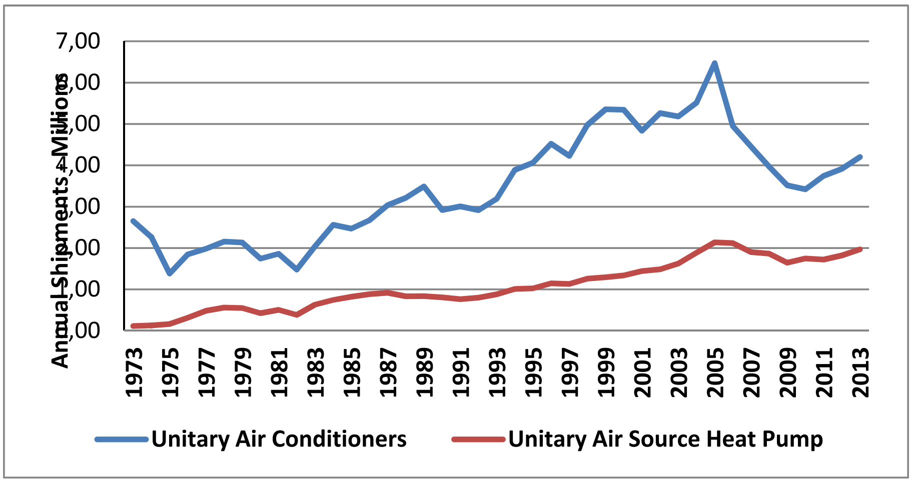

Figure 3 U.S. Annual Shipments of Heat Pumps and Air Conditioners

3.2 RESIDENTIAL FOSSIL FUEL FURNACE AND BOILER SHIPMENTS

It is of interest to examine the sales of competing residential heating products during this period of reduced market activity. In Figures 4 and 5 the annual shipments of natural gas and oil boilers and warm air furnaces are presented. As shown in Figure 4 total shipments of residential boilers are less than 300,000 units annually, with oil boiler shipments having declined noticeably. The graph of gas-fired warm air furnace shipments in Figure 5 shows clearly the effect of the housing market decline, with a drop in annual shipments from 3.5 million units in 2005 to slightly over 2 million in 2009. There has been an increase since 2010 but this increase is most likely due to sales for replacement of older units, as many first generation condensing furnaces are reaching the end of their life. Heat pump shipments are included in this chart to illustrate the increase in sales for these units in comparison to gas furnaces in recent years. Sales of heat pumps have been gaining on gas furnace sales.

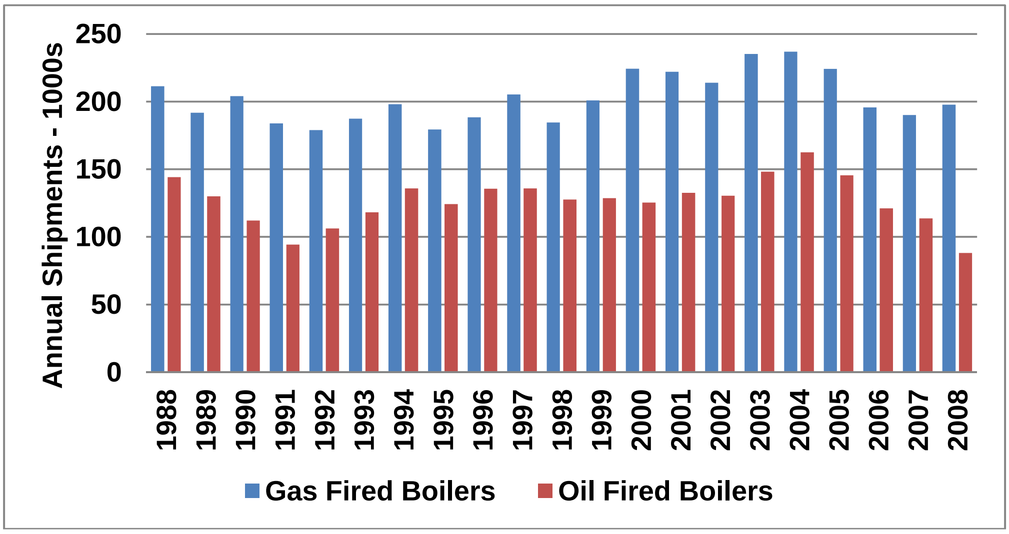

Figure 4 U.S. Annual Shipments of Residential Boilers

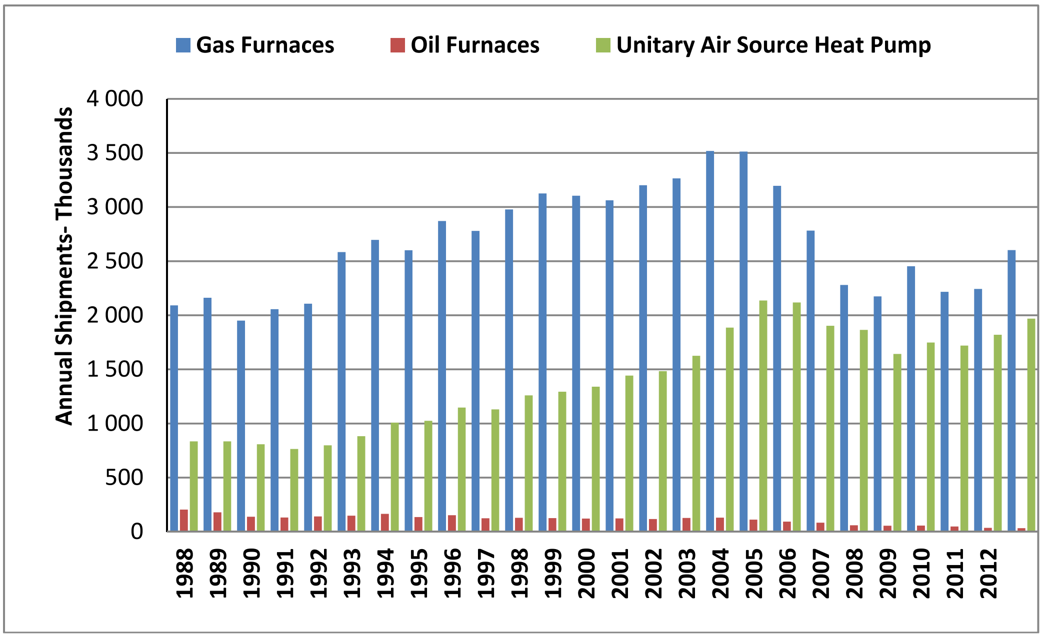

Figure 5 Annual Shipments of Residential Gas and Oil Furnaces and Heat Pumps

Figure 6 illustrates the changes that have occurred in the U.S. sales of heating equipment over the past decade. The recent changes result from both the lower rate of new home building and from increased home heating oil cost and, more importantly, in natural gas prices since 2005. Discussion with manufacturers suggests that the increased heat pump sales also represent increasing popularity for installation of dual systems (heat pump and gas furnace) as a hedge against high gas and oil prices relative to electricity. Over the past few years, residential electricity cost has risen more slowly than fossil fuel cost in the U.S. Increased availability of natural gas in the U.S. from hydro fracturing has not slowed the increased market share gains of heat pumps.

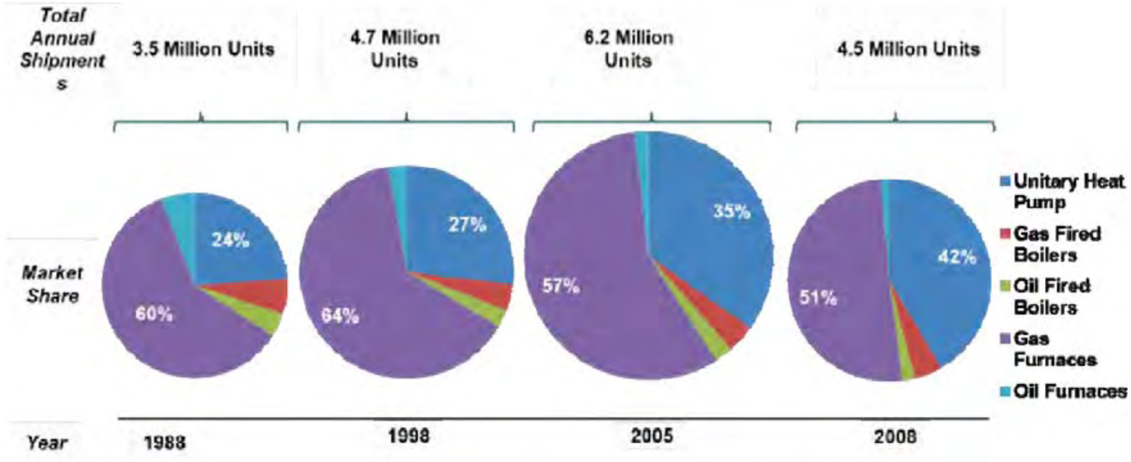

Figure 6 The Changing Heat Pump Share in Shipments of Heating Equipment in the U.S.

The increased share of heat pump sales is also reflected in a change in the share of residential home heating equipment in the total U.S. residential building stock. But changes in the existing building stock occur much slower, especially with decreased new home building, and heat pumps continue to represent approximately 12-14% of existing U.S. heating systems.

3.3 U.S. EXPORT SALES

Export sales from U.S. manufacturers represent about 8% of total manufactured quantity. Most of these units are shipped to Canada or South America.

3.4 THE CANADIAN HEAT PUMP MARKET

The building sector represents a large fraction (31% - 17% for residential and 14% for commercial/institutional) of Canada's secondary energy use, and 28% of GHG emissions. Heating is the major energy use in that sector; space heating and domestic water heating represent 81% of the residential energy use and 58% of commercial energy use. Air conditioning represents only 2% of the energy use but air conditioner energy use has been growing at a rate of 5% per year for the last 20 years.

Canadian shipments of unitary and ductless air conditioners and heat pumps are shown in Figure 7, based on data from HRAI (Canadian heating, Refrigeration and Air Conditioning Institute. The drop in shipments in 2009 is due more to the economic recession and not to the major housing credit crisis experienced in the U.S. Canadian residential construction dropped nearly 40% from 2004 to 2009 with the majority of this drop occurring in 2008 and 2009. Some recovery has occurred in 2010 and 2011. As seen in this figure annual shipment of unitary air conditioners and heat pumps is less than 300,000 units, or about half the value of U.S. exports (ground-source heat pumps are discussed separately in a subsequent section of this report). The Canadian air conditioner (including heat pumps) shipments are presented in Figure 7. Heat pumps represent approximately 30% of the total a.c. and heat pumps shipments in Canada, similar to the U.S. situation. A comparison of a.c. shipments with furnaces is shown in Figure 8

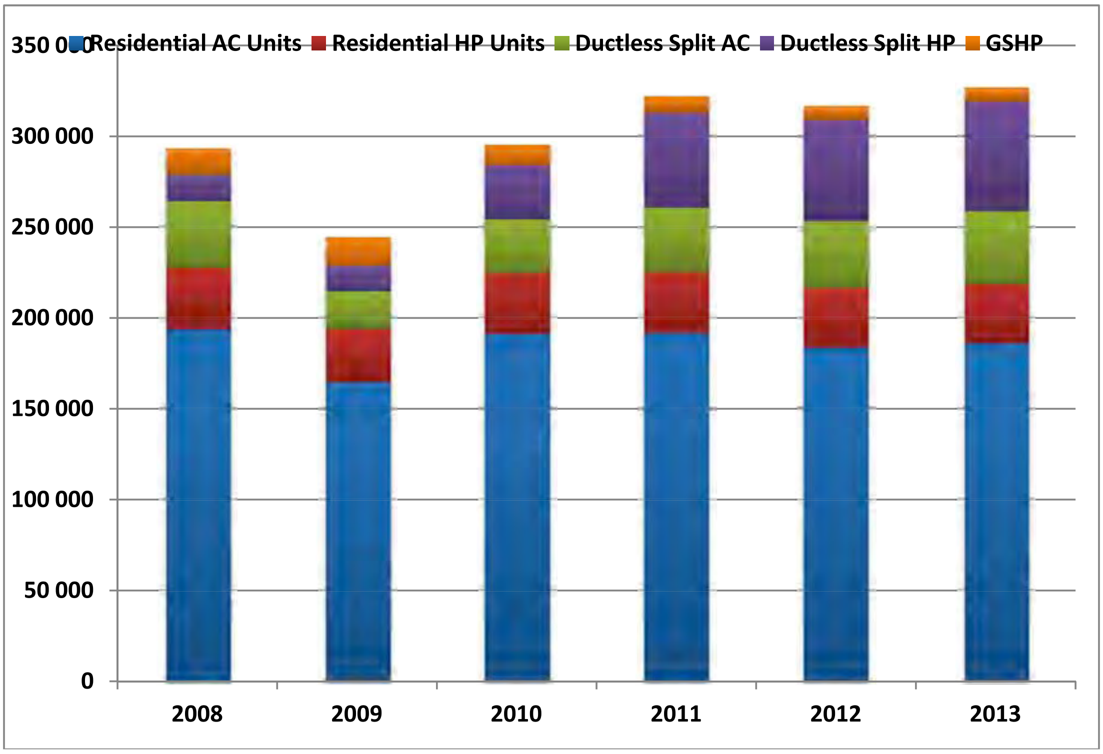

Figure 7 Canadian HP and AC Shipments

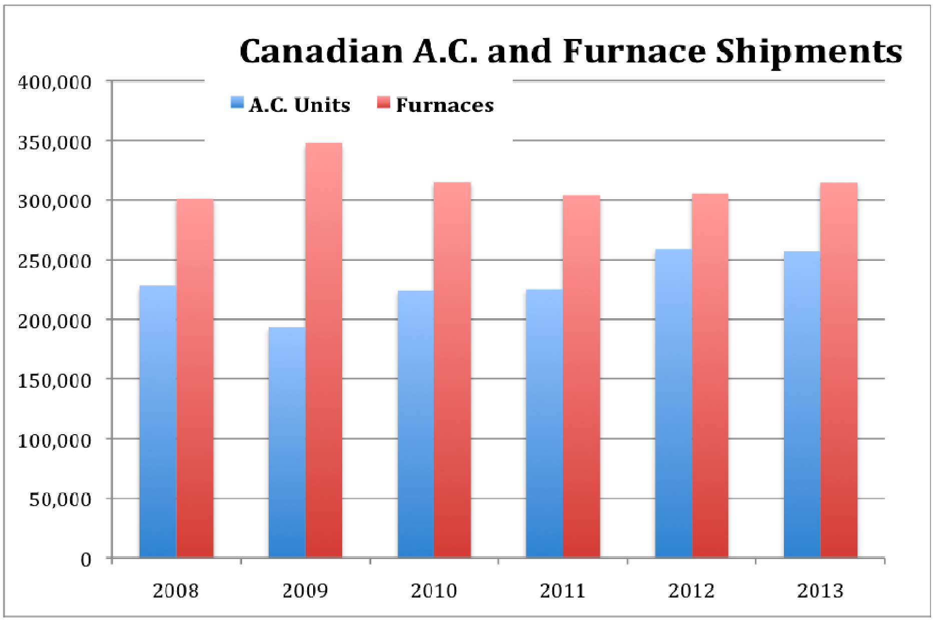

Figure 8 Canadian Residential Air Conditioner and Furnace Shipment History

3.5 GROUND-SOURCE HEAT PUMPS

Hughes, et al (2011) describes recent U.S. Government initiatives to advance technology and market development for ground-source heat pumps (including ground water source heat pumps). Sales of these systems have increased during the past decade without much assistance. In a report at the 9th International Heat Pump Conference in Zurich the author presented results of a private study showing the growth in ground-source heat pump shipments in the U.S. in the period 2001 to 2007 (Groff, 2008). This study showed an increase of 65% over this six-year period. The U.S. Department of Energy EIA (Energy Information Administration, 2011) website has provided market data on ground-source heat pump sales by AHRI product category (but data is provided only through 2009). In Figure 9 the residential and commercial unit shipments from the 2008 study were combined in order to compare with the EIA data. One of the difficulties in obtaining good comparative data for these products is that the equipment used in these systems are classified in several product areas by AHRI and some product types are not included in the classification areas. Thus it is necessary to separate out the products that are used in loop systems in commercial buildings from those used to extract heat from ground and ground water sources. Nevertheless the data from the two sources presented in Figure 9 gives clear indication that sales of ground-source systems are increasing. With efforts to improve the infrastructure for design and installation, it is expected that these systems will play an increasingly important role in the U.S. heating market in the future although incentives have been an important factor in generating sales of these systems in North America.

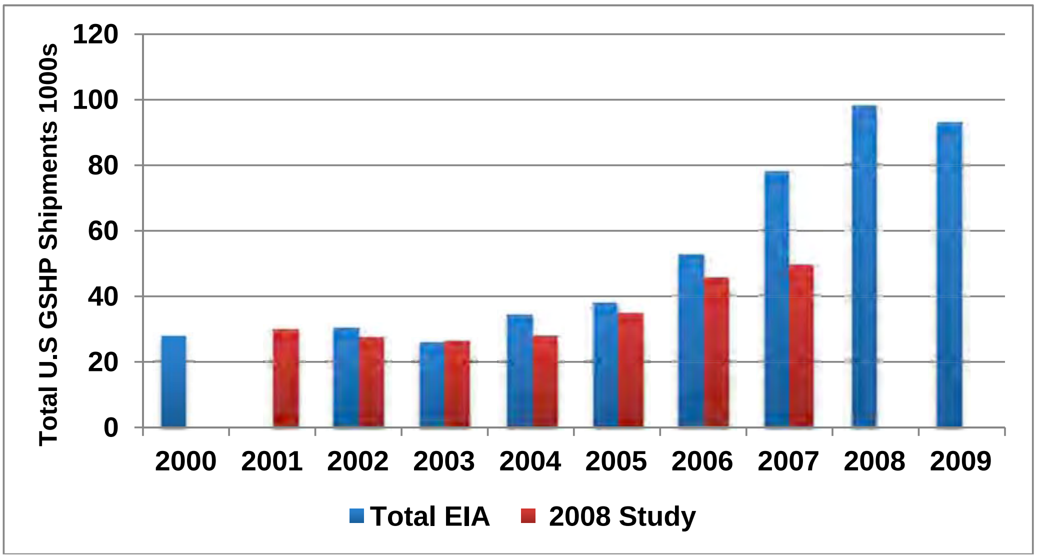

Figure 9 Annual U.S. Shipments of Ground-Source Heat Pumps

During the past 5 or 6 years ground-source heat pump system installations have grown rapidly in Canada, with impetus provided by Canadian GeoExchange Coalition initiatives. Installed systems have increased from approximately 2,400 in 2004 to nearly 16,000 in 2009, with approximately 55% of these for residential applications. Rising fuel oil prices in this period have stimulated growth in these systems, but the phenomenal growth also coincides with various grant and financial assistance programs deployed by utilities, provincial governments and the federal government (Canadian GeoExchange Coalition 2010 Market Survey). Similar incentives have generally not been available in the U.S. although in recent years a significant tax credit has been available. Canadian ground-source heat pump installations have fallen since 2009 as incentive programs concluded, but seem to have stabilized at approximately 8,000 installations per year. With a capital cost of between 6,000 and 8,000 Canadian dollars per ton, these systems are expensive and require a longer-term return on investment acceptance. The average size of the installed systems is 2 Tons.

3.6 HEAT PUMP WATER HEATERS

Electric heat pump water heaters (HPWH) have received a great deal of interest in North America, beginning in the late 1970s. First, small entrepreneurial companies and niche manufacturers introduced products. Later, major water heater makers and major air-conditioning manufacturers entered the market. By the mid-1980s, there were at least 15 manufacturers of such units for residential and small commercial buildings. This surge of interest in HPWHs quickly dissipated when consumer interest in energy efficiency was insufficient to overcome the HPWHs higher cost, reliability problems and institutional barriers.

Up until the mid-2000s there were only a few small manufacturers of residential electric HPWHs operating in the U.S. The market for these products was almost entirely driven by utility support programs in the Northeastern part of the U.S. In 2008 General Electric Corporation announced the introduction of a new HPWH product. Since that time several other manufacturers (including at least one EU - based company) introduced products to the market as well. As a result residential HPWH sales have skyrocketed from about 2,000 units in 2006 to more than 34,000 in 2012 -- a growth of 1600 percent (US DOE, 2010; US Energy Star Program, 2012). Today 7 manufacturers offer Energy Star qualified residential electric heat pump water heaters on the U.S. market under more than a dozen brand names (U. S. Energy Star Program 2014).

Electric heat pump water heaters for use in commercial buildings are also available from a few manufacturers, in sizes up to 220kW thermal output. Commercial units are being used in commercial laundries, hotels and restaurants – wherever there is a coincident need for hot water and space cooling. Commercial HPWHs (with their cooling benefits included) have about the same operating cost as gas water heating. Consequently, electric utilities have generally been more interested in promoting commercial HPWHs and less interested in residential HPWHs. There are no gas-driven HPWH products on the U. S. market to date. However there is a number of R&D activities focused on developing a gas HPWH (based on sorption heat pump cycles). At least one is in the field test stage and may be introduced to the market soon.

3.7 COMMERCIAL HEAT PUMP AND AIR CONDITIONING SALES

The unitary heat pump and air conditioner sales statistics presented previously in this report cover products up to approximately 5.4 tons (19kW) in capacity. Many of the residential units are also applied to commercial buildings, but larger capacity units, whose sales are not captured in the small unitary statistics, are also applied to large residences. Accordingly, it is of interest to review recent history in sales of the larger unitary products (19 to nearly 200 kW). Sales of products in this size range are largely in the smaller capacity range up to 100kW of cooling capacity. Figure 10 presents shipment data for these larger units. The individual heat pump and air conditioner statistics are not available but it is estimated that approximately one-third of these shipments are heat pumps.

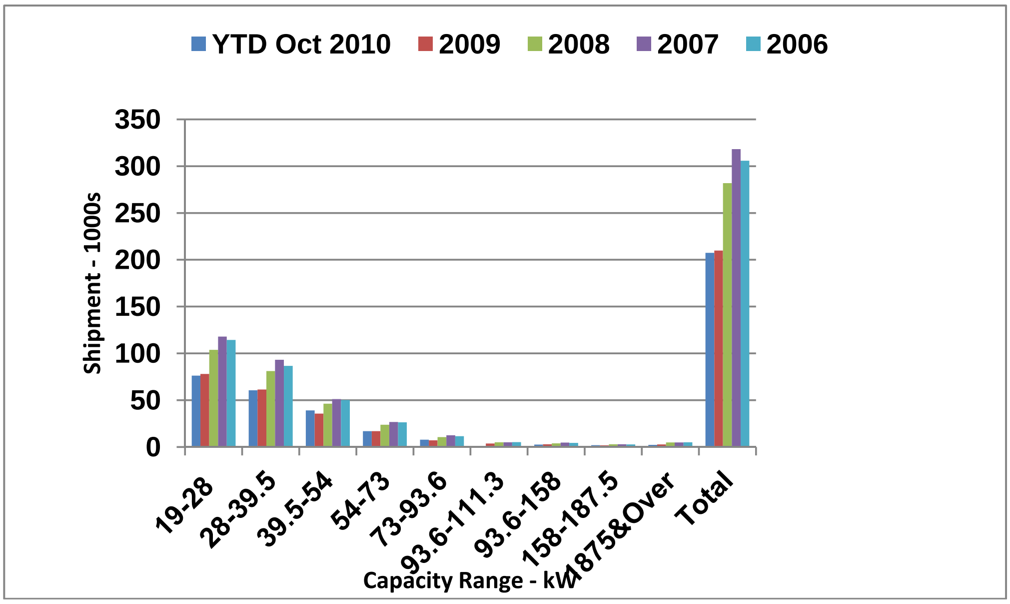

Figure 10 Annual Shipments of Larger Air Conditioners and Heat Pumps

3.8 HEAT PUMP EFFICIENCY STANDARDS

In the U.S. the energy difficulties of the 1970s gave impetus to a wave of government initiatives directed to energy conservation. In the U.S. this led to the promulgation of mandatory efficiency standards for household appliances. In 1992 federal mandatory standards for unitary air conditioners and heat pumps were instituted, utilizing new efficiency indicators: seasonal energy efficiency ratings (SEERs) for air conditioners and heat pumps in the cooling mode, and heating seasonal performance factors (HSPFs) for heating performance of heat pumps. Seasonal performance requirements were also issued for gas and oil warm air furnaces and boilers. All of these rating indicators are based on specific test procedures that involve cycling tests to capture the dynamic performance characteristics of the products. The resulting seasonal ratings may then be used to calculate annual operating costs for specific climatic regions that are used in labeling of the appliance.

Introduction of new minimum energy efficiencies presented significant challenges to manufacturers to achieve the technology improvements necessary to achieve the increased standards and to incorporate the more sophisticated testing regimens. The initial minimum performance standards for cooling efficiency requirement that began with the 1992 standard (10 SEER) has led to an increase of more than 50% in operating efficiency during the last 22 years. The data in Figure 11 are the seasonal efficiencies in cooling operation, for both cooling-only and heat pump units. Heating seasonal performance levels have shown a similar increase over the period. It is also to be noted that the SEER and HSPF values are expressed in Btu/Wh units. The equivalent seasonal coefficient of performance (COP) or seasonal performance values (heating) (SPF) may be obtained by dividing these by 3.412 (Btu/Wh). A new standard level became effective in January of 2006 standard (13 SEER). It is equivalent to a SCOP (dimensionless) of 3.8 and the next step in the minimum efficiency standards takes place in 2015 when the minimum SEER is raised to 14 (8.2 HSPF for heat pumps). Currently there are products in the AHRI Directory with SEER levels up to 23 (with variable speed compressors), and minimum efficiency standards are stimulating continuing increases in efficiency for U.S. manufacturers. The increased minimum efficiency standards taking effect in 2015 for residential air conditioners (and gas and oil furnaces) will have different levels for different climate regions of the country. The minimum performance standard for residential heat pumps will be the same for the entire U.S. The climate zones defined for air conditioners and furnaces are depicted in Figure 12.

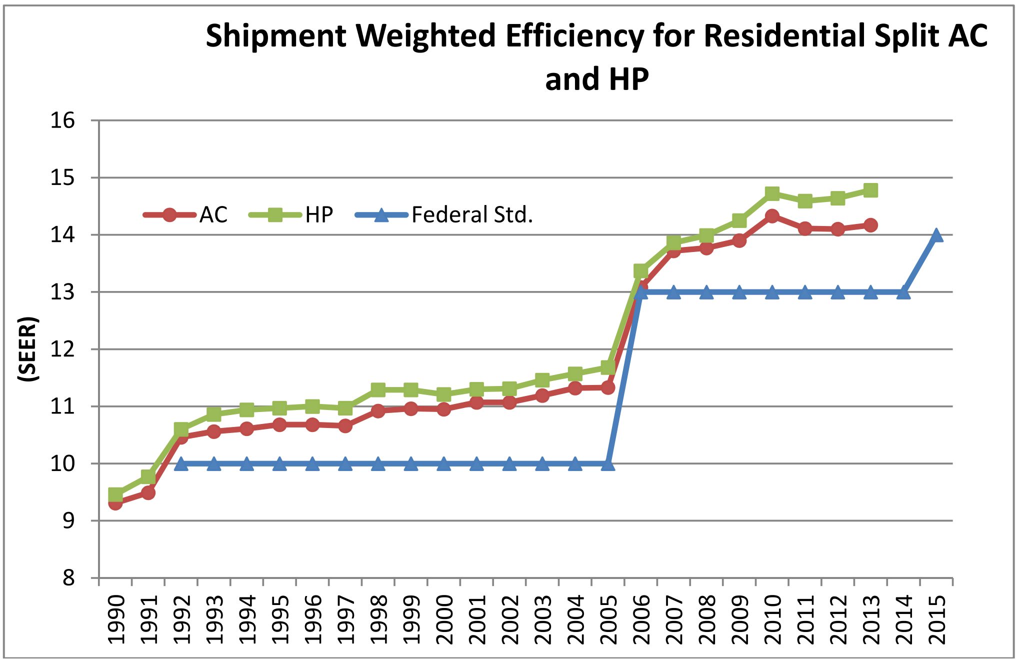

Figure 11 Unitary Equipment Shipment-weighted Seasonal Efficiency (Cooling) History

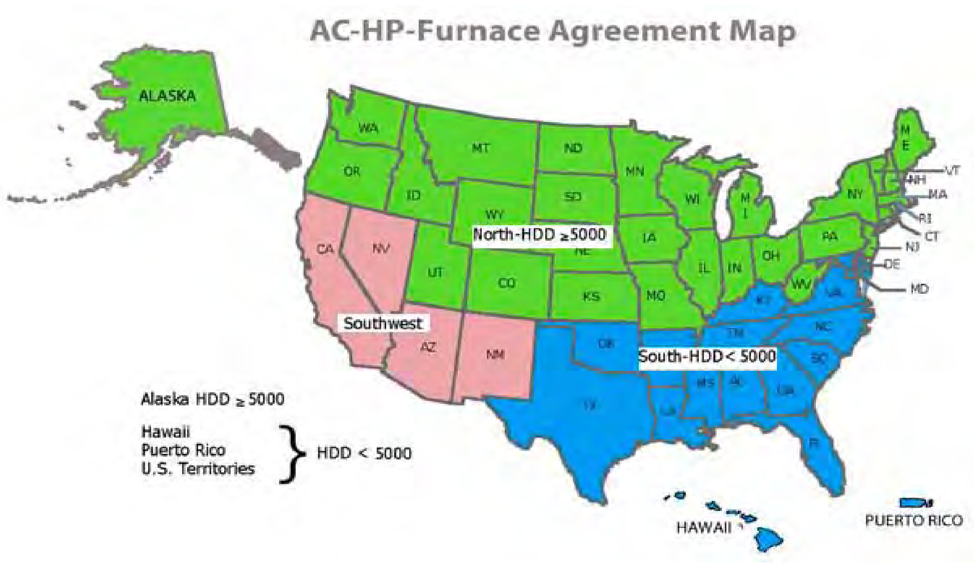

Figure 12 Climate Zones Used for Specification of 2015 Minimum Performance Standards for Residential Air Conditioners (Cooling) and Furnaces (Heating)

5 SUMMARY AND OUTLOOK

Despite the severe housing market recession of the past 3 or 4 years the popularity for heat pumps has shown notable strength and it is encouraging to see heat pumps gaining market share in annual shipments of residential heating equipment, and also in the existing building stock. The combination of concerns for energy security and increased price of fossil fuels for residential heating and water heating has given strong stimulus for interest in alternative heating systems. The long track record of reliable, energy efficient performance for contemporary heat pump products has provided end-users with confidence to move to heat pumps for primary or dual-system installations. The commensurate growth in ground-source heat pump systems, even without strong market promotion and incentives in the U.S., and for heat pump water heaters, gives further evidence of a bright future for heat pump systems. When the housing market recovers it is expected that sales of these systems will continue at even greater growth rates. Although heat pump sales in Canada are relatively smaller it is likely that robust market activity in the U.S., coupled with greater visibility of heat pumps as a result of the geothermal heat pump initiatives, will stimulate increased heat pump sales there as well. Continuing technological advances, such as the new integrated heat pumps now entering the market, and increased efficiency, will provide an even better market position for heat pumps against conventional fossil fuel heating systems. It should be an exciting time for heat pumps over the next decade.

6 ACKNOWLEDGEMENTS

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The geothermal heat pump opportunities in New Zealand

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Abstract: The New Zealand Geothermal Heat Pump (GHP) market is in its infancy compared to international trends, but recent developments seek to accelerate growth in this area.

A small research project, started in 2008, has grown into a consultative, multi-agency collaboration for research, advocacy and market development. In 2012, the Geothermal Heat-pump Association of New Zealand (GHANZ) was established. This group, comprising suppliers, installers, designers, government agencies and private organisations, is working together to encourage growth and quality in the New Zealand GHP market.

This paper will present an update on the market opportunities in New Zealand, identified barriers and initiatives underway to accelerate technology transfer. These include: modelling ground temperatures and shallow rock properties; understanding heating and cooling practices; consultation with architects and engineers; encouraging quality assurance; developing promotional and educational material; improving the regulatory regime; economic modelling; enabling sector collaboration and improving communication.

Key Words: Geothermal heat pumps, New Zealand, Australia, Barriers, Market, Opportunities

1 INTRODUCTION

Geothermal Heat Pumps (GHPs), also known as ground-source heat pumps or geo-exchange systems, harness the stored, renewable thermal energy at relatively shallow depths in soil, rock, surface water or groundwater. The GHP technology transfers the heat energy from lower-temperature sources to useable higher grade energy, by using a small amount of electrical energy, making it available for heating and cooling purposes.

Applications include space heating and cooling in buildings, heating swimming pools, heating domestic hot water systems and supporting some industrial heat use applications. The utilisation of GHPs is common place in the northern hemisphere; however in the southern hemisphere they are a comparatively under-utilised technology and there is an evident potential for their increased use.

2 NEW ZEALAND CLIMATE

New Zealand is located in the south Pacific and stretches 1600 km from top to bottom, crossing 13 lines of latitude. The New Zealand climate varies from warm subtropical in the north to cool temperate in the south. Average annual temperatures range from 16ºC in the northern regions to 8ºC in the southern, with some average alpine temperatures reaching as low as 2ºC (Figure 1; NIWA 2012). Ambient air temperatures can fluctuate up to 20ºC between seasons in many places around New Zealand.

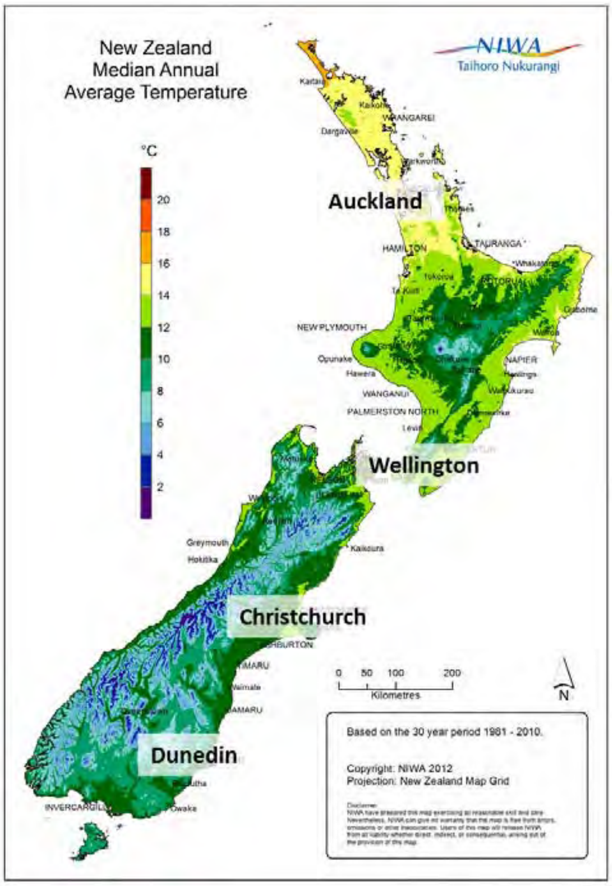

Figure 1: Mean annual ambient temperatures (NIWA 2003)

Ground temperatures remain relatively constant throughout the year. While they are site specific and best obtained from local water well logs or ground temperature surveys, New Zealand ground temperatures generally average between 12°C and 16°C, depending on location.

2.1 Monitoring of New Zealand soils temperatures

The National Institute for Water and Atmosphere (NIWA) monitors and maintains a network of climate stations around New Zealand. Many of these climate stations include shallow (1 m deep) boreholes measuring in-ground temperatures. GNS Science is co-locating deeper temperature monitoring boreholes (10 m) at several of these climate stations, to research the climatic effects on the thermal properties of differing soils types around New Zealand. Understanding the thermal properties of soils is a critical design consideration for GHP installations.

Variations in daily ambient temperatures generally affect ground/soil temperatures to depths of approx. 50 cm, while seasonal temperature variations can propagate to depths of 7 – 9 m

(Figure 2). Below about 10 m depth the ground temperature is fairly stable, and a temperature profile can be approximated by adding 2°C to the average annual air temperature for a specific location. Average ground temperatures recorded in some New Zealand locations are: Auckland 16.1°C; Wellington 14.3°C; Christchurch 13.2°C and Dunedin 12.2°C (from www.niwa.co.nz).

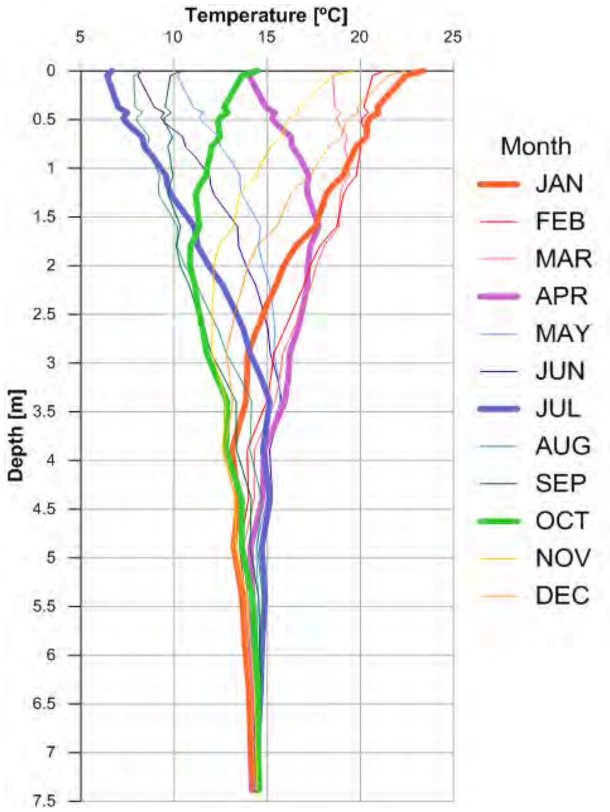

Figure 2: Annual ground temperatures measured at Wairakei, near Taupo, New Zealand (Seward *et al*, 2013).

By continuously monitoring *in-situ* ground temperatures, thermal properties such as thermal diffusivity, thermal conductivity and volumetric heat capacity can be determined. In the development of low enthalpy geothermal resources, these parameters are particularly important for efficient and cost-effective heat recovery using GHPs. The effects of rainfall and moisture content on the propagation of heat through varying soils can also be observed.

3 GEOTHERMAL HEAT PUMP INSTALLATIONS

Globally, GHPs have been gaining in popularity, with utilisation increasing over 2.5 times across ca. 30 countries between 2005 and 2010 (Lund et al 2010). In New Zealand, the GHP market is less developed with approximately 200 installations nationwide. The 2010 estimated net use from GHPs in New Zealand was ca. 11 GWh/yr (0.04 PJ) (Bromley and White 2010). The majority of installations are domestic, with several larger-scale commercial installations, including two airport terminals, public swimming pools, town-halls, library, conference facility and hotels. Domestic installations are predominately located in the South Island where the largest variations in seasonal temperatures occur.

Systematic tracking of new installations began in 2013, with the initiation of a New Zealand GHP database. This database collects information on locations, installers, installation type, loop type, configuration, distribution system, and capacity. An interactive web-based map is being developed to provide information on the uses of New Zealand's geothermal resources, including the GHP industry (http://data.gns.cri.nz/geothermal) (Figure 3).

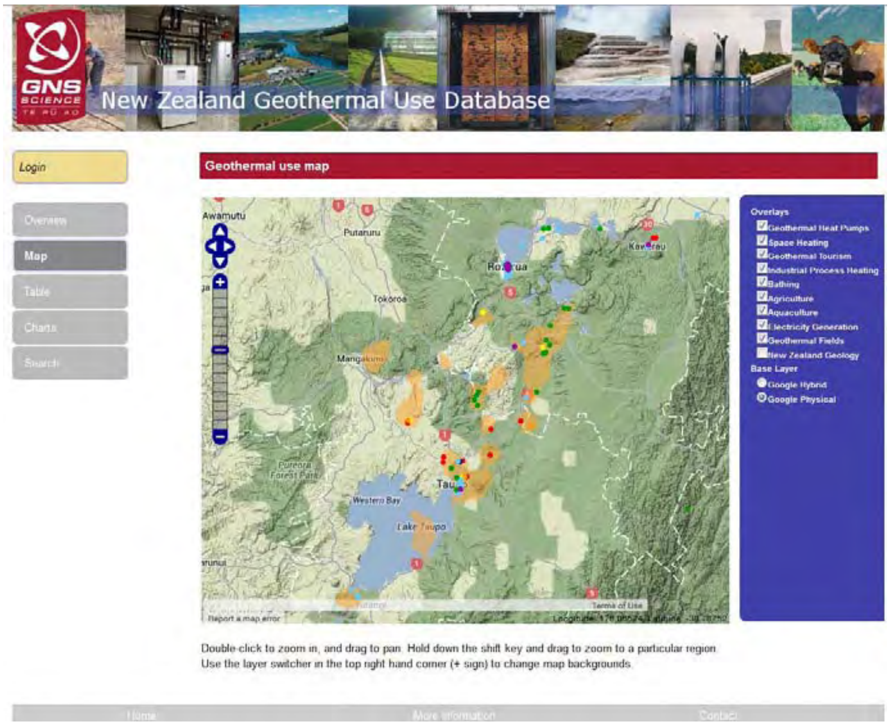

Figure 3: Example screen shot of GHP database web-based map.

3.1 Installation Case Studies

3.1.1 Christchurch International Airport

Figure 4: Aerial view of Christchurch International Airport.

Christchurch city airport (Figure 4) accommodates almost six million passengers a year and is forecast to increase to 1.5 million by 2020. In 2007, Christchurch airport commenced a Terminal Development Project, in which it aimed to achieve carbon neutral status. In 2008, Christchurch International Airport Limited became the first airport company in the Southern Hemisphere to achieve that goal.

The airport terminal building is heated and cooled via an open loop groundwater GHP system. Groundwater (12°C) is extracted from the underlying aquifer via a series of boreholes and is pumped to heat exchangers before being discharged back through soak pits to the ground.

The system is based on 3.6MW water-cooled chillers and variable speed pumps that direct thermal energy around the building. The chillers work in combination with the ground water. In summer the groundwater can be used for cooling directly, however when demand is high the groundwater can be further cooled using the chillers. By reversing the chillers (i.e. using them as heat pumps), groundwater becomes the source of heat and the buildings can be heated through 40°C heating loops.

3.1.2 Manuka Point Lodge

Figure 5: Manuka Point Lodge.

Located in the Rakaia Valley in the Southern Alps, Manuka Point Lodge (Figure 5) experiences some of the most extreme climatic conditions in New Zealand. Winter temperatures can reach as low as -15ºC and as warm as 40ºC in the summer. The lodge was built in 2008, with the owners keen to “create a premium trophy lodge that was sensitive to the environment, while ensuring that clients were warm and comfortable”. A horizontal ground loop coupled to a 19.9 kW heat pump provides water at 30 - 35ºC which is pumped through underfloor pipes to heat the lodge.

3.1.3 Queenstown Family Home

Figure 6: Queenstown family home

Queenstown is located in the central Southern Alps and is prone to cold temperatures (-5ºC) in winter and warm (~28ºC) temperatures in summer. In designing their family home (Figure 6), architect Ian Adamson considered comfort, sustainability and environmental considerations as key factors. The family home has been designed to be as energy efficient as possible and is heated / cooled through the use of two 120 m (vertical depth) boreholes, each encasing “U-shaped” ground exchangers and an 11 kW heat pump.

4 POTENTIAL FOR MARKET GROWTH

The New Zealand Government is committed to reducing fossil fuel consumption and increasing the nation's use of renewable energy. The Government has targeted 90% renewable electricity generation by 2025 and, of relevance to GHPs, an additional 9.5 PJ/year of direct-use geothermal or biomass over 2005 levels (MED 2007; MED 2011; NZEECS 2011).

As New Zealand's population grows and attitudes change, energy demand for space heating and cooling is predicted to increase. In the residential sector, New Zealand has a history of minimal investment in home heating, energy efficient design and construction techniques. Single room heating is common, and there are generally lower expectations of indoor comfort levels in winter compared with many other similar countries where central heating / air conditioning, double glazing and good insulation are the norm. This attitude is changing in New Zealand; adequate home heating is increasingly being seen as important for improved health. Energy demand modelling predicts an 11% increase in heating and cooling energy demand over 2007 levels (49.3 PJ/year) by 2025 (Rossouw and Lind 2010).

In the commercial sector (i.e. non-residential buildings such as schools, hospitals, office buildings, airports, factories and warehouses) with large facilities to heat or cool, energy consumption is greater, and small improvements in energy efficiency can achieve significant cost savings. Modelling (Rossouw and Lind 2010) predicts a 40% increase in heating and cooling energy demand over 2007 levels (24 PJ/year) by 2025 in the commercial sector.

4.1 Barriers and Success Factors

There are several barriers that need to be overcome for the industry to thrive, including:

(1) lack of consumer awareness,
(2) limited consumer confidence,
(3) high capital installation cost, and
(2) absence of market infrastructure.

Consumer awareness is a significant market barrier. A study of New Zealanders' perceptions of geothermal energy use showed that generating power was the most commonly understood use of geothermal resources, but less was known of the direct heat use or GHP opportunities (Doody and Becker 2011). Consequently, consumer confidence is difficult to gauge given the limited knowledge of the technology.

However, substantial information on the perceived barriers for GHPs has also been collected in a series of focus groups with architects, engineers and energy/facilities managers; those who advise the consumers in their decision making. This study aimed to gain an understanding of perceived risks and benefits of direct geothermal heat use and GHPs, and to identify the barriers that prevent the adoption of these technologies (Coyle 2014). Identified barriers include natural phenomena, such as seismicity and lack of extreme climate, as well as lack of awareness and a need for consumer confidence, and the culture of "living in a cold house.

Development and dissemination of educational, marketing and accurate technical information is required to address these issues of awareness and confidence, and to support informed decision making amongst consumers and those groups (e.g. engineers, architects) who advise consumers (Climo and Carey 2011).

At present, the capital installation costs of GHPs in New Zealand are relatively high, compared to more conventional heating options such as natural gas and electricity. Factors contributing to higher capital costs include:

- lack of sufficient experienced installers and designers;
- low volume of installations;
- current drilling practices;
- poor availability of materials;
- the need to import GHP systems; and
- the tendency to overdesign systems based on European or North American design standards.

These higher costs can mean longer pay back periods, and as such GHP's are generally utilised in the higher end residential market and in commercial buildings where energy savings can be more significant. Costs are expected to reduce as the market matures, opening up a wider market and higher uptake. Likewise, the market infrastructure (e.g. manufacturers, suppliers, installer training, industry regulation etc) will also develop as the market matures.

To assist in the development of the New Zealand GHP market and infrastructure, the Geothermal Heat-pump Association of New Zealand (GHANZ) was established in 2012. This industry group is working collaboratively to promote and monitor the development of the GHP market in New Zealand. Members include suppliers, installers, designers, government agencies and other private organisations. GHANZ seeks to develop this sector as a quality, renewable energy source for New Zealand homes, businesses and institutions, by:

- Expanding the market in New Zealand for GHP technologies and services;
- Promoting GHP technology to government / industry / consumers;
- Maintaining a website for information and promotional purposes (www.ghanz.org.nz);
- Providing a forum for members to collaborate and discuss common interests;
- Serving as a point of contact for anyone seeking advice and information about GHPs;
- Engaging with equivalent organisations overseas to share information and develop knowledge that will benefit the development of the New Zealand market;
- Working closely with industry to promote top quality products and professional standards of design and installation across the industry; and
- Facilitating the development of internationally recognised training and standards for installers and designers.

In 2013 the Australasian chapter of IGSHPA (International Ground Source Heat Pump Association) was also formed, in an effort to improve training, standards and collaboration opportunities in Australia and New Zealand.

5 THE AUSTRALIAN PERSPECTIVE

The first GHP systems were installed in Australia in the early 1990s. Over this twenty year period the industry has seen successful installations in landmark buildings as well as long periods of inactivity. Closed vertical loops have been the most common application across both the residential and commercial sectors.

Interest in the technology has increased over the past 8-10 years as a result of new companies in the market, increased power costs and a general trend towards energy efficiency in the building sector.

The industry is still in its nascent stage and has both great opportunity and great challenges ahead of it. The main challenge for the industry is to ensure its sustained growth through high quality installations that deliver on the expectations of the client and provide the predicted energy savings. The on-going development of industry training programmes and standards will contribute significantly towards achieving the desired sustainable uptake of the technology.

6 ONGOING RESEARCH AND WORK

There are numerous groups undertaking research into GHP technology and how the North American and European standards and designs can be utilised and applied to Southern Hemisphere conditions. Most research is focussed on reducing the upfront cost of installation, for example:

- by modelling effects of energy piles on the ground (Melbourne University (e.g. Johnston et al 2011, Johnston 2012, Bidarmaghz et al 2014); Monash University (http://www.eng.monash.edu.au/civil/research/centres/ggrg/));
- understanding local soils and effect of climate on ground thermal properties (Van Manen and Wallin 2012; Seward et al 2013); and
- retrofitting for resilient and sustainable buildings (Wollongong University (www.sbrc.uow.edu.au)).

Collaboration between the Australian and New Zealand industries and research groups will aid in developing GHP markets.

7 SUMMARY

Geothermal heat pumps offer a mature, proven, energy efficient technology using a renewable, nationally available resource. The utilisation of this technology is still in its infancy in New Zealand and Australia. Increased use of GHPs can contribute to meeting expected growth in heating and cooling demand.

On-going research in both Australia and New Zealand aims to increase our understanding of local conditions that are key to designing efficient ground loops and GHP systems in the southern hemisphere. The formation of the Australasian chapter of IGSHPA in 2013 endeavours to produce a common industry standard between Australia and New Zealand, as well as provide a means to share knowledge and training.

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LARGE SCALE AND CITY LEVEL GROUND SOURCE HEAT PUMP SYSTEM

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Abstract: A large number of ground-source heat pumps (GSHP) systems have been used in residential and commercial buildings in different climate zones in China because it was considered as an environmentally-friendly and cost-effective alternative with potential to replace fossil fuels and help mitigate global warming by the central government since 2006. The total floor area that uses this technology is nearly 10 times at the end of 2012 compared with 2006. Ground heat exchanger heat pump system in China are always used for large scale residential and commercial building with the floor area more than 20,000 m^2 and some surface water and sea water heat pump system could reach to city level, such as provide heating and cooling with several large GSHP energy station for an new district with the building floor area more than 5 million m^2. At the same time, how to planning, design and operation such large system correctly to achieve higher COP is still needed to be answered. With latest research and development information of large scale and city level GSHP collected from EU, USA and Japan, this paper raise a series of questions that needed to be solved in China in the future to keep promoting this technology, such as simultaneity usage coefficient of different buildings selection in one district, more accurate TRT and ground water flow consideration during the load calculation, heat extraction and rejection point selection and control strategy for hybrid system.

Key Words: large scale, city level, GSHP

1 INTRODUCTION

Since 2000, GSHP started to be used in few small pilot projects, the total floor area that uses this technology reach to 240 million m^2 at the end of 2012, which is nearly 10 times compared with 2006. Technical Code for Ground Source Heat Pump System GB50366-2005 made a clear definition of GSHP for China, which let the government much easier to provide policies and subsidies for this technology. But, due to the China's fast development in urbanization and its own building form, GSHP always use for large building more than 20,000 m^2 and even for district with total building floor area reach to 5 million m^2. As the system goes larger, the COP of the system couldn't reach the design requirement and some problems raise up. By latest research and development information collection of large scale and city level GSHP of EU, USA and Japan, the future research area that should be paid attention to in China are discussed.

2 RESEARCH AND DEMOSTRATION OF LARGE SCALE GSHP

Ground-source heat pumps (GSHP) systems have been used in residential, commercial and industry buildings throughout the world because of the highly energy saving and greenhouse gas emissions reduction potential. The GSHP technology can be used both in cold and hot weather areas and the energy saving potential is significant. During the past few decades, Due to the renewable energy policies and financial subsidy, GSHP systems have been applied in larger and larger scale around the world, some systems even reached community and city level. (Ioan, 2014).

2.1 EU large scale GSHP utilization

On 2008, the European Parliament adopted the Renewable Energy Directive, which establishes a common framework for the promotion of energy from renewable sources. This directive opens up a new opportunity for widely use of heat pumps for heating and cooling of new and existing buildings. Also, EU set up three key objectives for 2020, known as the "20-20-20" targets, which including Raising the share of EU energy consumption produced from renewable resources to 20%.

With the promotion from the EU and member countries, GSHP had been promoted by different programs, such as The GEO.POWER project etc. The GEO.POWER project (“Geothermal energy to address energy performance strategies in residential and industrial buildings”) (B.M.S. Giambastiani, 2014) was co-financed by the European Regional Development Fund in the frame of the INTERREG IVC Programme. The general project objective was to exchange the partners' own experiences on heating and cooling supply mainly through GSHP and from low enthalpy geothermal energy. After a SWOT technical and cost–benefit assessment, Participants evaluated the reproducibility and transferability of the best practices currently exists in Europe. It could find out that the most transferable example of technology is the TELENOR building in Hungary. The TELENOR building is a new industrial building with 180 Borehole Heat Exchangers (BHE) drilled 100m deep for cold and hot water, it also has 168 m^2 solar collectors to meet 60–70% of the hot water demand. The CO_2 emission saving could reach to 800–850t/year and the energy saving is 2.1 million kWh; the payback time is 8–10 years.

The core results achieved by the GEO.POWER project focused on the elaboration of action plans to encourage the GSHP market development and through the use of the EU Structural Funds in the current and in the future Programming Period 2014–2020. All documents contain a set of potential flanking measures to be implemented in the concerned areas to address strategies for GSHP large scale introduction and subsidy schemes to support geothermal energy investments.

Most large cities use tunnels to provide transportation and utility networks and some of the tunnels need to be cooled to meet operational requirements. Nicholson D. P. discusses the use of system-wide thermal tunnels with closed loops embedded in the tunnel segments to extract heat from the tunnel and then used with GSHP systems to heat adjacent buildings via a district heating system. After the detailed analysis of the system, Nicholson D. P. point out that this kind of large scale GSHP system requires a city scale investment in long term heat supply because the thermal tunnel system requires an early investment when the tunnels are being built to provide pipe work for heating adjacent buildings (Nicholson D. P.2013). The author carried out a preliminary study for the buildings in a corridor extending 100m beyond the tunnels for CROSSRAIL project, which including 34 hotels, large residential, hospitals, 4 schools, colleges, libraries, museums and 327 offices, leisure centers, retailers, with the conclusion that based on header pipe access points connecting to 500 m of twin tunnels, the heat output would be about 200 to 600 kW for 10 to 30 W/m^2 of tunnel surface heat extraction.

A. Sciacovelli (A. Sciacovelli, 2013) investigated the impact of a ground source heat pump installation for a public building in Italy through a thermo-fluid dynamic model of the subsurface which considers fluid flow in the saturated unit and heat transfer in both the saturated and unsaturated units. The building is 160 m high and its volume is about 240,000 m^3. The groundwater flows in the south-east direction toward PO River, which is about 2 km far from the building. The groundwater system is composed of four wells, two for the water extraction and two for the re-injection. The distance between re-injection and extraction wells is 150 m, while the transversal distance between the wells is 80 m. The cooling season lasts for about 6000 h with a peak request of 7 MW and the heating period is of about 2800 h with a peak heating load of 2.5 MW for the building. The author made analysis of two possible scenarios, one is constant heat pump mass flow rate case and the other is variable heat pump mass flow rate case. The result shows that at 1.8 km downstream the wells the difference between the unperturbed temperature and thermal plume temperature is about 3 K when the heat pump operates with a variable mass flow rate and the wells thermal plume temperature is 5 K higher than the unperturbed one when the heat pump operates with a constant mass flow rate.

2.2 USA large scale GSHP utilization

Justin Mahlmann considered that the only way to achieve California's stringent policies and emission goals that set a minimum for emissions reductions is strategic planning of the energy system on the community scale. Technologies such as geothermal heat pump systems (GHPS) can be implemented to heat and cool an entire community, reducing energy consumption, emissions and water consumption, while also serving as a backbone for carbon neutrality and zero net energy. Justin Mahlmann introduced Ball State University GSHP system, which have a capacity of approximately 5000 tons, and will serve the heating and cooling purposes for 47 buildings over 731 acres. The underground heat exchanger consists of 3600 boreholes with depths ranging from 400-500 ft and diameters of 5-6 inches. Capital expenditures for the project cost upwards of $70 – 75 million, which is only $15 million more than that for a conventional HVAC, resulting in a payback period of 7.5 years. The system will reduce the campus's CO_2 an estimated 85,000 tons annually (Justin Mahlmann, 2012).
Alaska Sea Life Center demonstrates a seawater heat pump system with the funding from Denali Commission Emerging Energy Technology Grant (EETG) program. Two 90-ton heat pumps were installed to provide heating and hot water. Since February 2013 the project was successfully commission, over the course of three months of monitoring since that time (1,900 hours of system operation), the average COP was 2.90, displacing a total equivalent of 20,000 gallons of heating oil while consuming 300,000 kWh of electricity. Years to payback the investment is 8.5(ACEP, 2013).

2.3 Japan large scale GSHP utilization

Hikari Fujii developed a mass and heat transport model to simulate the long-term performance behavior of large-scale GSHP systems with the consideration of well-to-well interference in the presence of groundwater flow for a public building. The GSHP system was installed in the basement of a gymnasium of a public school in the central part of the Akita Plain with 75 cast-in-place, one-meter diameter and 50 m deep piles in the foundation of the building. All of the piles were equipped with two 2.5 cm i.d, 50 m long U-tubes to be used as GHEs. With the set up and analysis of the field wide numerical model of Akita Plain on the basis of groundwater levels and temperatures measured in the field. Groundwater velocity at the GCHP system location was estimated to be 1.4×10-4 m/day. Four simulation run cases all with 120 days of heat extraction and different heat storage periods (none, 30 days, 60days, 120 days) were carried out, the author find that more heat storage operations should be implemented in the downstream GHEs than in the upstream GHEs to maintain heat extraction rates and wider GHE spacing is preferable in cases without heat storage operations (Hikari, 2005).
Li Huai used both field data and a numerical simulation to examine the long term performance and environmental effects of a large GSHP (ground source heat pump) system installed in the city of Akabira in the north of Hokkaido, Japan. The heat exchange system of the GSHP consists of 78 boreholes, each with a depth of 85 m, that could provide a maximum capacity of 640 and 648 kW for heating and cooling for 12 greenhouses, each greenhouse comprises a total area of 450 m^2.The system was monitored and analyzed from Oct 2010 through May 2011. The system had a COP of 3.0 and the average heat extraction rate of the system was approximately 27.7 W/m. Six wells were drilled in the borehole field to monitor the soil temperature and groundwater level, the author found the ground temperature

at a depth of 40 m decreased from approximately 7.8°C to 0°C after 8 months of operation and the operation of system with unbalanced heating and cooling loads (less than two times) is available with an average groundwater flow velocity around 10-15 m/y (Huai, 2013).

Table 1 Typical large scale and city level GSHP projects

Country	Location	Building Type	Installed year	Collector Type	Collector Index	Load/Heat Pump(kW)	COP	Payback Period (years)	CO_2 reduction
Hungary	Torokbalint	industrial building	-	Vertical Borehole	180*100m		-	8 to 10	800–850 t/year
Italy	Turin	240,000 m^3	-	Underground Water	2 extraction wells, 2 injection wells	peak heating load=2.5MW	-	-	-
USA	Indiana	47 buildings	2012	Vertical Borehole	3600*120 m	5000 tons		7.5	85,000 t/year
USA	Alaska	-	2013	Seawater	-	2 90-ton heat pumps	2.9	8.5	-
Japan	Akita	public building	2003	Vertical Borehole	75*50m	-	-	-	-
Japan	Akabira	12 greenhouses	2010	Vertical Borehole	78*85m	640kW for heating;	3		291t/year

3 CURRENT STATUS OF GSHP IN CHINA

The last decade of the 20th century was the infant phase of GSHP application in China. During that period, policymakers and the real estate developers started to realize the advantages of GSHP through some pilot projects.

3.1 Technical Code

One technical code set the concrete foundation for the fast development of GSHP after 2005 because it gave the financial incentive mechanism from the central and local government a technical reference. The technical code is ‘‘Technical Code for Ground Source Heat Pump System (GB50366-2005)’’, which was promulgated and took effect on January 1, 2006. The code plays a significant role for the development of geothermal heat pump industry as it is first time made the clear definition of Ground-Source Heat Pump System of China, which including three major types, that are Ground Heat Exchanger Heat Pump System (same as ASHRAE ground-coupled heat pump (GCHP) systems), Groundwater Heat Pump System, Surface Water Heat Pump System (sea water, lake water, river water and sewage water). The code is composed of eight parts, including general principles, technical terms, engineering exploitation, buried pipeline heat exchange systems, groundwater heat exchange systems, surface water heat exchange systems, indoor systems, equipment operation and trial running, etc (CABR, 2005).

3.2 Government Policies and Subsidies

On September 2006, ‘‘Opinions on promoting application of renewable energy in buildings’’ and ‘‘A tentative management method of special funds for renewable energy development’’ were promulgated by the Ministry of Construction (now called Ministry of Housing and Urban-Rural Development, MOHURD) cooperating with the Ministry of Finance. In these two documents, 4 of the 8 technologies which are subsidies by the state are GSHP system:

Ground source heat pump system and shallow groundwater source heat pump system.

- Water source heat pump system.
- Seawater source heat pump system.
- Sewage source heat pump system.

After that, a series of policies came out to promote GSHP on the city level and town level, at the end of 2010, 47 cities and 98 towns got the funding from the central government to promote GSHP, each city got 50 to 80 million RMB and each town got 15 to 20 million RMB to promote this technology. Based on the information from The State Council Information Office of P.R.China, at the end of 2006, the total floor area of GSHP application is just 26.5 million m^2, by the end of 2007, the number reach to 80 million m^2, till the end of 2012, the total project number use GSHP is 23,000 with the floor area reach to 227 million m^2 and the number of GSHP system integration companies reach to 4,000. The increasing rate of GSHP in China from 2000 to 2012 could be found in Figure 1 (Xu, 2013).

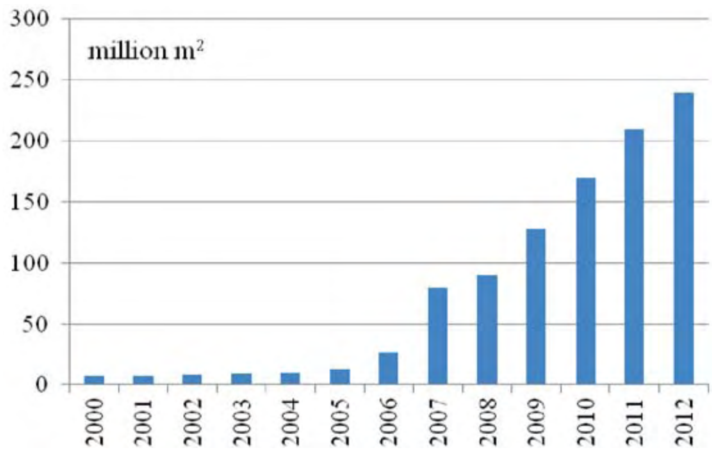

Figure 1 Increasing of GSHP in China

3.3 Project Type Distribution

Based on the analysis of 291 projects that funded by the Ministry of Construction and the Ministry of Finance, which the total floor area is about 32.72 million m^2, we could find out that: 259 projects use GHSP at the only heating and cooling source while 32 projects use hybrid system. In the GSHP only projects, 110 projects use Ground Heat Exchanger Heat Pump System with the total floor area of 11.19 million m^2 which accounts for 33.70% of all the projects, 78 projects use Groundwater Heat Pump System with the total floor area of 8.84 million m^2 which accounts for 26.63% of all the projects, 32 projects use Surface Water Heat Pump System (heat source are river and lake water) with the total floor area of 3.63 million m^2 which accounts for 10.92% of all the projects, 16 projects use Surface Water Heat Pump System (heat source is sea water) with the total floor area of 1.82 million m^2 which accounts for 5.46% of all the projects, 23 projects use Surface Water Heat Pump System (heat source are civil sewage water, cooling water in Refinery, coal mine tunnel water and circulating cooling water from thermal power plant)with the total floor area of 4.52 million m^2 which accounts for 13.61% of all the projects (Xu, 2013).

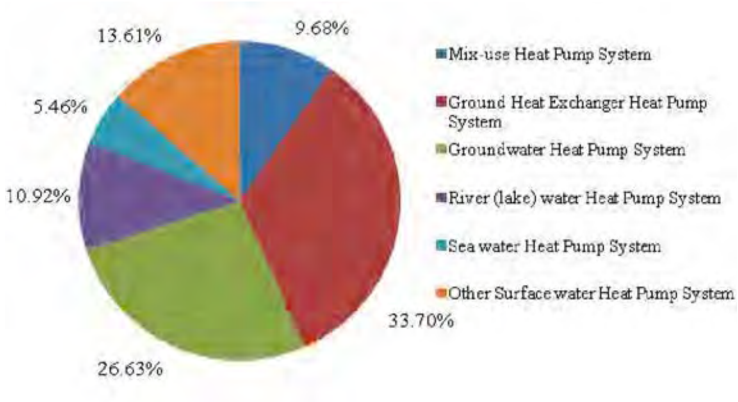

Figure 2 Percentage of different type GSHP system in China

4 LARGE SCALE AND CITY LEVEL GSHP APPLICATION IN CHINA

Due to China's different climatic zones, each type of GSHP have their own characteristics and suitable location, The Ground Heat Exchanger Heat Pump System are suggested to be mainly used in cold, cold winter & hot summer and temperate zones. In the southeast and coastal areas, where there is abundant groundwater and surface water resource, the Ground and Surface Water Heat Pump System are suggested to be used while in the cold and cold winter and hot summer zone. If the heat extraction and heat rejection cannot be balanced, the hybrid systems are suggested. Because the average single building in China is always bigger than the western style and with a much more quantity, the GSHP system is usually larger. Also, China now is going through a fast increasing period of urbanization, there are lots of new cities, new towns, new districts and new communities, from the beginning of the planning, GSHP was considered as the main heating and cooling source, that makes this technology goes to city-level in China recently. Following are some pilot projects in large-scale and city level.

4.1 Ground Heat Exchanger Heat Pump System Project

Beijing Zhongguancun International Mall is located in Beijing Zhongguancun Technology District, the total floor area is 1.56 million m^2. Based on the system simulation, the total cooling load is 17 MW, and the total heating load is 7.39 MW.

Figure 3 Beijing Zhongguancun International Mall

Table 2 Heating and Cooling load of the Mall

Building floor area (m^2)	Cooling Load Index (W/m^2)	Cooling Load (MW)	Heating Load Index (W/m^2)	Heating Load (kW)
156000	108.9	17	47.4	7.39

Based on the TRT, the geological condition is as follow:

Table 3 Geological condition of the Project

Depth（m）	thermal conductivity W/(m.K)
0~19 m	1.4
19~32 m	2.0
32~35 m	1.6
35~38 m	2.2
38~44 m	1.4
40~52 m	1.7
52~57 m	1.6
57~70 m	2.2
70~75 m	1.6
75~100 m	1.4

According to the on-site condition and the TRT result, 1,060 vertical boreholes with 123 m depth and distance as 4.5 are drilled under the parking lot. Double-U ground heat exchanger with diameter as DN32 is used.

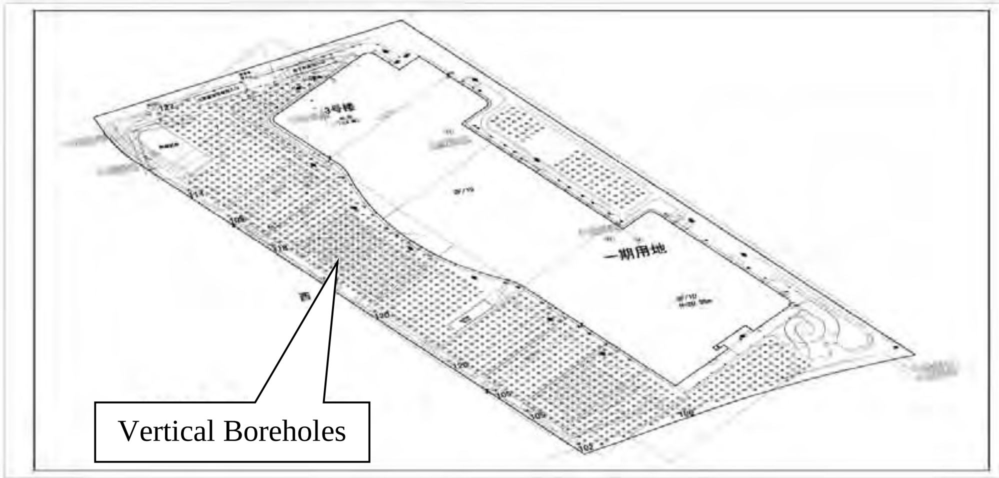

Figure 4 Vertical boreholes map of the projects

3 LSBLGR-M2800 heat pumps are selected, the heating capacity of single heat pump is 2.32 MW, and the cooling capacity is 2.28 MW. The system heating COP could reach 3.0 according to the system testing result during 120 days in the 2008 winter.

4.2 Groundwater Heat Pump System Project

Qindao Yinshengtai International Center and Business Center are two buildings in one district near each other. The total floor area of International Center is 58,000 m^2 and the total floor area of Business Center is 26,400 m^2. The water extracted from underground from one well is 80t/h and the rejection data is 67t/h.

According to the calculation, 464 tons of water per hour with the inlet/outlet temperature as 16°C/31°C in summer and 348 t/h tons of water per hour with the inlet/outlet temperature as 15°C /7°C in winter is needed. 14 wells with the minimum distance as 40 m are drilled; other 3 spare wells are also constructed. Cost of the GSHP system is 350 RMB/m^2.

4.3 Surface Water Heat Pump System Project

(1) Wuxi T-Park Energy Center

WUXI T-Park is a new district on the south of the urban area, the total construction floor area will be 8 million m^2, and the first phase is just finished with the total floor area of 4 million m^2. Across the district, there is a river with stable flow rate, the temperature is 6.8-12.4°C in winter and 23.6-32.4°C in summer, also there is a sewage plant, the temperature of the sewage is 9-14°C in winter and 25-28°C in summer. Two energy stations B and G that use the energy from the river water and sewage water are built to supply energy for the entire district.

4 water source heat pump with cooling (heating) capacity as 7.8 MW (9.2 MW) and 4 water source heat pump with cooling (heating) capacity as 5.9 MW (10.6 MW) are installed in the energy center B. 1 water source heat pump with cooling (heating) capacity as 6 MW(6.5 MW) and 1 water source heat pump with cooling (heating) capacity as 6 MW (6.4 MW) are installed in the energy center G. 860,000 MWh electricity and 900,000 tons of CO_2 will be saved each year after the whole district completed.

(2) Thaizhou Medical City Energy Center

Thaizhou is a city near Yangtse River, the water average temperature and the flow rate is suitable to use in a heat pump system to provide energy for the whole district. So the new core city areas with the total floor area of 5 million m^2 use the river water heat pump system for energy service. The total cost of the energy station in the first phase is 1.84 billion RMB with the cooling load of 55 MW and heating load of 38.5 MW. 3 water source heat pumps with cooling (heating) capacity as 7.9 MW (8.4 MW) and 3 water source heat pumps with cooling (heating) capacity as 6.0 MW (9.5 MW) were selected for the system.

Table 4 average water temperature and flow rate

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Auf	Sep	Oct	Nov	Dec
Ave Temp (°C)	9.2	10.6	13.1	17.9	22.3	25.5	28.1	29.1	26.2	22.4	17.4	12.6
Flow Rate (m^3/s)	6.5	8.3	9.4	15.0	22.2	24.1	18.4	19.4	18.9	22.4	13.7	6.7

4.4 Hybrid Heat Pump System Project

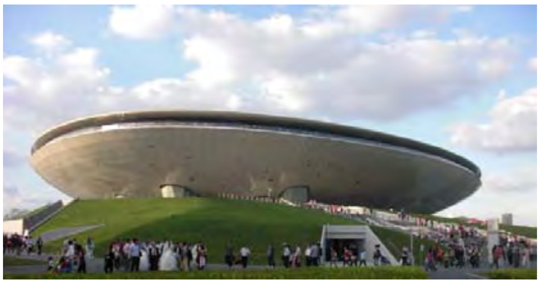

Figure 5 Shanghai World Expo Culture Center

Shanghai World Expo Culture Center is a mix-use building, above the ground is a theatre with 18,000 seats and the six floor building circulated the theatre, 2 floors are under the ground. Peak cooling load in summer is 14.95 MW and peaking heating load is 9.2 MW in winter. The center is very close to the Shanghai Huangpu River, the hydrological data shows that the water temperature is 26~32°C in the upper level and 15~22°C in the lower level in summer, in winter, the water temperature is 3~8°C in the upper level and 10~15°C in the lower level. As in the summer the river water temperature is relatively high and in winter cold, besides the heat pump system, ice storage system and boiler are also installed for summer and winter. According to the test, the river water heat pump system could cover 40% cooling load with COP 5.1 in summer and 55% heating load with COP 4.1 in winter.

5 FUTURE RESEARCH DIRECTION OF LARGE SCALE AND CITY LEVEL GSHP IN CHINA

From the general data of GSHP developments in China we could find that GSHP in China are always in a large scale and even reach to city level. According to the Ministry of Science and Technology of China, the total area adopting the GSHP systems will be up to 350 million square meters by the end of 2015. From the operation COP of the pilot projects, there are still big potential for the large scale and city-level GSHP system to enhance the energy efficiency in the future. Compare with the research of large GSHP system internationally, there are still several problems that needs to be resolved in China

5.1 Simultaneity usage coefficient

When use GSHP system to provide heating and cooling for a city level system, which including lots of residential buildings and commercial buildings, some of them are mix-use, the simultaneity usage coefficient between different function area in the same between and between different buildings should be considered, especially the coefficient between different buildings. Because for large central heating system with boilers in the northern part of China, this coefficient should be 1 to secure the heating supply. For the mix-use building, according to the China National Standard <Design code for heating ventilation and air conditioning of civil buildings> GB50736-2012, the coefficient could be 0.7-0.9. But In the GSHP system, heating and cooling are both supply within the GSHP system, usually, the GSHP provide cooling only for commercial buildings in summer but for heating for all the buildings, including residential buildings in winter, how to calculate the simultaneity usage coefficient of the large scale GSHP system is a key question.

5.2 TRT and ground water flow

For the Ground Heat Exchanger Heat Pump System, accuracy of the TRT result to calculate the thermal conductivity will contribute significantly to the total costs of system planning. The TRT equipment is commonly built in a few portable boxes or mounted on a car trailer for easy transportation to test sites. The mobile TRT method is becoming more and more important in the rapid spreading of Ground Heat Exchanger Heat Pump System. In the future, how to make the mobile TRT box smaller while more accurate will be put more effort. Groundwater flow is normally present and could enhance the heat exchanger rate and balance the heat extraction and injection to increase the COP of GSHP systems. But nowadays, the underground flow rate is not taking consideration during the design of Ground Heat Exchanger Heat Pump System; the engineer took it as a safety factor for the system. From the international experience, if the underground water flow is carefully calculated, the underground heat exchanger system could be 10-20% smaller to save cost; so the impact of groundwater flow on the performance of ground heat exchangers will be a future research area in China.

6 CONCLUSION

More and more large scale and city level GSHP system and GSHP energy station are used in China for buildings and districts, GSHP have a bright future in China as an environmentally-friendly and cost-effective technology to help mitigate global warming. As the system grow larger and hybrid, some technical problems that will not affect the COP of small GSHP system obviously became a hot topic to save cost for the large scale and city level project, such as more accurate TRT and ground water flow consideration during the system calculation, heat extraction and rejection point selection and control strategy for hybrid system and so on. Compare with the latest research and development information collection of large scale and city level GSHP of EU, USA and Japan, the future research area of GSHP in China are discussed.

7 ACKONWLEDGEMENTS

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Events

2014

2 – 3 October
International Conference on Efficient Building Design - Materials and HVAC Equipment Technologies
Beirut, Lebanon
https://www.ashrae.org/membership--conferences/conferences/2014-international-conference-on-efficient-building-design

14 – 16 October
Chillventa
Nuremberg, Germany
http://www.chillventa.de/en/

15 – 16 October
IGSHPA Technical Conference and Expo
Baltimore, USA
http://www.igshpa.okstate.edu/conf/

22 – 23 October
Heat Pump Centre National Teams' meeting 2014
Gothenburg, Sweden

3 – 5 November
Heat Pump Centre ExCo Fall meeting 2014
Freiburg, Germany

19 – 20 November
GeoEner 2014
Madrid, Spain
http://www.geoener.es/pages/geoener-english.html

20 – 21 November
The International Symposium on New Refrigerants and Environmental Technology 2014
Kobe, Japan
http://www.jraia.or.jp/english/symposium/

2015

24 – 28 January
ASHRAE Winter Conference
Chicago, USA
http://ashraem.confex.com/ashraem/w15/cfp.cgi

24 – 27 February
Climatizacion
Madrid, Spain
http://www.ifema.es/ferias/climatizacion/default_i.html

26 – 28 February
ACREX 2015
Bangalore, India
http://www.acrex.in/

10 – 14 March
ISH
Frankfurt, Germany
http://ish.messefrankfurt.com/frankfurt/en/aussteller/willkommen.html

16 – 18 April
6th IIR Ammonia and CO_2 Refrigeration Conference
Ohrid, Republic of Macedonia
http://www.r744.com/events/view/615

19 – 24 April
World Geothermal Congress
Melbourne, Australia
http://wgc2015.com.au/index.php

6 – 8 May
Advanced HVAC and Natural Gas Technologies 2015
Riga, Latvia
http://www.hvacriga2015.eu/

19 – 21 May
13th IEA Energy Conservation through Energy Storage Greenstock Conference 2015
Beijing, China
http://iea-eces.org/eces/event-calendar.html , scroll to May 2015

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

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

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

In the next Issue

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International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among its participating countries, to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development.

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International collaboration for energy efficient heating, refrigeration and air-conditioning

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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.

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