IEA Heat Pump CENTRE NEWSLETTER

Volume 28
No. 2/2010

Retrofit heat pumps for buildings

Report from Annex 30

Retrofitting for emissions savings in Canada

Market report: Finland

heat pump centre

IEA Heat Pump CENTRE
NEWSLETTER
Volume 28 - No. 2/2010

In this issue

Retrofit heat pumps for buildings

The topic of this issue, Retrofit heat pumps for buildings, is ever-important, because of the large market potential, and the special needs that apply to existing buildings. In the light of the recent economic crisis, leading to a decrease in new construction, the importance of heat pumps in retrofit situations has increased even further. In addition, several countries have subsidy schemes to promote home renovation, especially for energy savings. Finally, due to new regional legislation, certain types of heat pumps may not be suited for new construction, but may be installed without problems as retrofit installations.

Enjoy your reading!
Johan Berg
Editor

COLOPHON

Copyright:
© IEA Heat Pump Centre

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior permission of the IEA Heat Pump Centre, Borås, Sweden.

Published by IEA Heat Pump Centre
Box 857, SE-501 15 Borås,Sweden
Phone: +46 10 516 55 12
Fax: +46 33 13 19 79

Disclaimer IEA HPC
Neither the IEA Heat Pump Centre, nor any person acting on its behalf:

- makes any warranty or representation, express or implied, with respect to the accuracy of the information, opinion or statement contained herein;
- assumes any responsibility or liability with respect to the use of, or damages resulting from, the use of this information

All information produced by IEA Heat Pump Centre falls under the jurisdiction of Swedish law.
Publisher:
IEA Heat Pump Centre
PO Box 857, S-501 15 BORAS
SWEDEN
Tel: +46-10-516 50 00, Fax: +46-33-13 19 79
E-mail: hpc@heatpumpcentre.org
Internet: http://www.heatpumpcentre.org

Editor in chief: Monica Axell
Technical editing: Johan Berg, Åsa Jardeby, Roger Nordman, Ulf Mårtensson - IEA Heat Pump Centre
Language editing: Angloscan Ltd.

heat pump centre

Future building codes provide the key for the retrofit market

Martin Forsén,
President, Swedish Heat Pump Association

Opportunities for heat pumps are expanding as energy efficiency and the use of renewables are given high priority. New energy policies are being adopted as the world urgently needs to find ways to tackle climate change and reduce dependency on energy imports. In Europe, the EU's 20-20-20 targets[1] are demanding, and put considerable pressure on national decision-makers to initiate energy conservation measures at a pace the world has never seen before. Heat pump technology occupies a unique position, in the sense that it has the potential to increase energy efficiency, to make use of renewable energy, and to reduce greenhouse gas emissions. As recognition of particular benefits of heat pumps has grown, sales have steadily increased. However, the ongoing global economic crisis has not left the heat pump market untouched. After several years of continuous growth, the European heat pump market showed a 10 % drop in sales in 2009. The economic crisis has led to more cost-conscious buying decisions and a reduced rate of building construction. Even though new construction provides a welcome demand for heat pumps in several countries, it is the retrofit market that presents the greatest potential and, at the same time, the greatest challenge.

The retrofit market challenges the heat pump industry to offer cost-competitive and reliable installations. The industry cannot afford to overlook the challenges and potentials associated with the retrofit market. Poorly performing installations could give the industry a bad reputation that would take decades to overcome. Systems have evolved over the last few decades, and lessons have been learned. Nevertheless, the industry needs to put considerable effort into ensuring high-quality products and improving the level of competence of installers.

The high temperature levels that are commonly associated with classic radiator systems reduce the performance of heat pump systems and are one of the largest challenges facing the industry. However, conditions for the retrofit market will gradually improve. In Europe, the updated Energy Performance of Buildings Directive will force member states to implement strict building codes that apply to new construction and to all major renovation work. In this way, legislation will provide an important key to reducing the water supply temperatures required for heating systems.

[1] Renewable Energy Road Map, Renewable energies in the 21st century: building a more sustainable future, COM(2006) 848 final

Column

EU Policy for energy savings and environmental improvement in buildings

Fabrizio Barbaso, Deputy Director-General, DG ENER

European energy policy has developed significantly over the last years, and energy efficiency has become a crucial aspect of all our actions in this field. In 2007 and 2009, EU Heads of States and Governments endorsed ambitious energy and climate policy targets of 20 % reduction of greenhouse gas emissions, 20 % primary energy savings and 20 % share of energy from renewable sources by 2020, and also keeping the global warming below 2 °C, which corresponds to a greenhouse gas reduction of 80 to 95 % by 2050 within the EU (compared to 1990 emissions). All key energy-consuming sectors must contribute to these targets: commerce and industry, transport and buildings, with the latter having to contribute disproportionately to achieving the target (i.e. requiring more than 80- 95 % reduction within the sector!) as a result of its high cost-effective savings potential.

These targets necessitate immediate and drastic change in the building sector. All new buildings must nowadays meet the "nearly-zero energy" standard as prescribed by the new version of the Energy Performance of Buildings Directive, with very energy-efficient buildings where nearly zero or only a very low amount of energy is required – with a significant quantity of energy being supplied from renewable sources, including heat pumps. In addition, as about 50 to 60 % of the EU 2050's building stock already exists today, the majority of these buildings will have to be upgraded into nearly-zero energy buildings in coming years and decades in order to meet the overall target by 2050.

Technical and economic restrictions make this a challenge in practice. This is why all planned renovations and investments must be decided with care and with a clear strategy in order not to miss any chance for mid- to long-term cost-effective saving solutions, and to avoid the need for other costly measures later on. Many of the energy-saving investments in buildings are just cost-effective when performed in combination with renovation that is needed anyway, so that doing the two together causes only very limited extra costs. This applies, for example, when a boiler breaks down, and thus provides an opportunity to upgrade the heating system, or the façade needs renovation which could therefore be combined with applying additional isolation. Public funding and other support initiatives will often be needed to realise this potential, which might be cost-effective from a macro-economic perspective (bearing in mind the macro-economic costs of combating climate change) but not from an individual's perspective (i.e. from an investor's perspective).

The relevant EU legislation in this field – the aforementioned Buildings and Renewables Directives plus the EcoDesign Directive– provides the means to stimulate the realisation of the EU energy efficiency and renewables targets. But another aspect might even be more important: that of getting our societies to recognise the inconvenient truth of the drastic changes that need to be made to our buildings if we seriously want to combat climate change by 2050. Current renovation rates and energy-saving investments are nowhere near sufficient to get there. Forthcoming EU energy policy, such as the new Energy Efficiency Strategy, will try to respond to this challenge.

The 10th IEA Heat Pump Conference

Early Notice – Call for Papers
May 16 – 19, 2011, Tokyo, Japan

The Conference program will cover the following topics:

- **Environment-friendly Technology**
  Advances in equipment design and development
- **Systems and Components**
  Advanced electrically and thermally operated systems, and ground source systems
- **Applications**
  Demonstrated energy efficiency and environmental advantages
- **Research and Development**
  New developments and new refrigerants in heat pumping technologies
- **Policy, Standards, and Market Strategies**
  Government, utility and professional society activities related to heat pumps
- **Markets**
  Market status, trends and future opportunities
- **International Activities**
  Discussion of actions in response to climate change initiatives

Papers: Papers will be presented both orally and as posters. Abstracts (200 - 300 words) should be submitted through our website, www.hpc2011.org by 30 June 2010.

The abstracts will be screened by an appropriate Regional Coordinator, authors will then be advised of acceptance by 31 August 2010. Full papers will be required by 31 January 2011.

Workshops: There will be opportunities for organization of workshops during the Conference. Interested organizations should contact one of the Regional Coordinators.

Exhibition: There will be an exhibition in connection with the Conference. For those interested in exhibiting, please contact your Regional Coordinator.

Web: For more information, please log on to the Conference website at: www.hpc2011.org

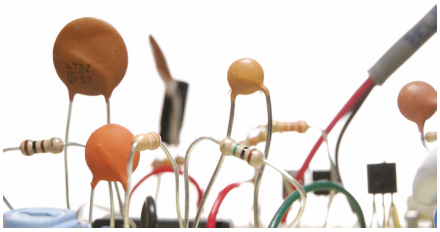
Regional Coordinators
For information on papers and workshops, conference program, etc., please contact the Regional Coordinator for your area:

- Asia and Oceania: Mr. Makoto Tono, tono.makoto@hptcj.or.jp
- North and South America: Mr. Gerald Groff, ggroff2@twcny.rr.com
- Europe and Africa: Mrs. Monica Axell, monica.axell@sp.se

General

Data centre industry agrees on energy efficiency

Industry groups and government agencies from the U.S., Europe and Japan have reached a basic agreement on how to measure the energy efficiency of data centres. The agreement establishes a common metric that different types of data centres, in different parts of the world, can use to report their level of energy efficiency. It can be used by companies to measure the efficiency of their own data centres, and also to see the effectiveness of energy-saving techniques employed by other facilities.



The agreement is unusual for its level of international cooperation and, according to a statement from the Green Grid, an industry consortium in the U.S., is backed by the U.S. Department of Energy, the U.S. Environmental Protection Agency, the European Union Code of Conduct and the Japan Ministry of Economy
Source: http://www.reuters.com/article/idUS176365990720100403

GreenBuilding EU awards: winners save over 80 % of their energy consumption

The award, launched by the European Commission in 2000 and 2005, promote the reduction of energy consumption by public and private organisations on a voluntary basis. Managed by the European Commission's Joint Research Centre (JRC), the GreenBuilding programme comprises voluntary schemes that invite private and public organisations to reduce energy consumption in their premises by promoting improved energy efficiency in buildings through several measures, such as thermal insulation, efficient heating and cooling, intelligent control systems, PV panels etc. Two of the best refurbishment projects, an office building in Austria and a secondary school in Germany, have achieved over 80 % of energy savings.
Source: http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/424&format=HTML&aged=0&language=EN&guiLanguage=en

Heat pumps are the key to make Sweden fossil fuel-free

The Royal Swedish Academy of Science has presented its final report on how to make Sweden fossil fuel-free by 2050. The Academy highlights heat pumps as a key technology. Professor Harry Frank, of the Academy's Energy Committee, says that electrically driven heat pumps in houses and shopping centres could meet 25 % of Sweden's total heat demand in 40 years. He states that it is expected that electrical heat pumps should contribute 30 TWh by 2050, as against 10 TWh today. In addition, he said that everyone who installs an electrical heat pump ought to receive a letter from the Swedish government thanking them for contributing to the increased share of renewable energy in Sweden. Today, heat pumps in Sweden provide five times more renewable energy than Sweden's total wind power.
Source: http://www.heatpumpcentre.org/en/aboutHPP/news/Sidor/Sweden-fossilfuelfree.aspx

ASHRAE and JSRAE advance mutual interests

Illustrating that concerns about the built environment are shared worldwide, ASHRAE and JSRAE recently made a commitment to collaborate by signing a memorandum of understanding. "Working with JSRAE allows ASHRAE to expand its reach into countries that can contribute to and benefit from the technology and information sharing in the Society," said Gordon Holness, ASHRAE president. "This will help in creating a worldwide best practices databank of innovative and successful technologies that can serve the HVAC&R community. "
"It brings me much pleasure that ASHRAE and JSRAE have reached an agreement to explore collaboration on advanced refrigerant management along with other important HVAC&R issues," Momoki Katakura, JSRAE president, said.
Source: http://www.refrige.com/industry-news/ashrae-and-jsrae-advance-mutual-interests/menu-id-658.html

Cooperative venture for net-zero-energy office building

Daikin Europe N.V. announces its intent to join forces with major research institutions to develop economically feasible net-zero-energy building (nZEB) concepts based on heat pumps. The project should be to construct a typical office that will have a net-zero-energy use, utilising heat pumps and solar cells as renewable energy sources.
Source: www.daikin.eu

Denmark's first house with an energy surplus delivers the results

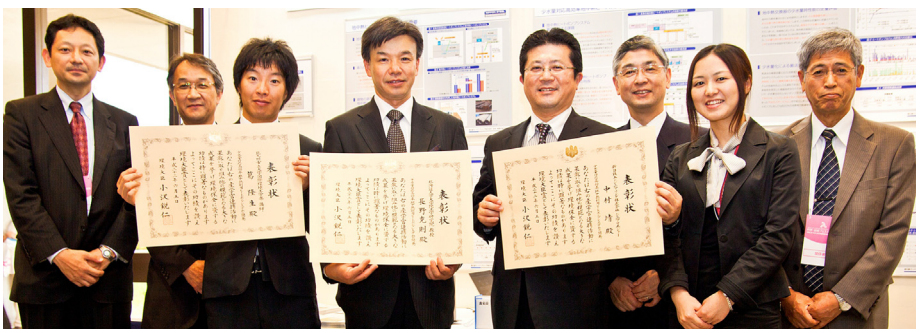
Denmark's first plus-energy house, a 200 m^2 dwelling in Sønderborg, has completed its first year of operation as an actual family home, and has recorded an energy surplus despite the protracted winter. The plus-energy house features built-in solar panels on the roof and extra-thick wall insulation. It is heated by special heat recovery equipment and heat pumps, while allowing 50 % air replacement per hour on a 24/7 basis. Over twelve months, the plus-energy house produced 5160 kWh – 27 kWh more than

the consumption figure, despite the exceptionally long and cold winter and heavy snowfall that frequently covered the solar panels on the roof.
Source: http://www.denmark.dk/en/servicemenu/news/environment-energy-climate-news/denmarksfirstenergyhousedeliverstheresults.htm

Merit award for development of ground-source heat pump system

Each year, the Japanese Ministry of the Environment awards a prize for the most successful environmental protection project that has brought together industry, academia and government. This year, the award has been won by Mr. Yasushi Nakamura, Nippon Steel Engineering Co., Professor Katsunori Nagano, Hokkaido University, and Dr. Takao Katsura, The University of Kitakyushu, for their project "Development of an innovative high-efficiency ground-source heat pump system employing low circulation flow rate control on the heat source side".

The use of low-flow circulation pumps has greatly improved system performance, while utilization of the foundation piles of buildings has reduced the initial cost of system. Also, by developing design methods for GSHP systems affected by groundwater flow, in combination with a cooling tower, the system can operate even if the cooling load is larger than the heating load. It is expected that this development will contribute to an expansion of the market of ground-source thermal energy systems.



The picture is from the award ceremony at Kyoto International Conference Hall. The awardees, holding up their awards, from the left: Dr. Takao Katsura, Prof. Katsunori Nagano and Mr. Yasushi Nakamura.

Policy

EPA and DOE lift the moratorium on new applications for Energy Star® qualification

After meetings with AHRI and other affected industries, the U.S. Environmental Protection Agency and the Department of Energy has lifted the moratorium on new applications for Energy Star® qualification. They made the following changes to the program:
Manufacturers wishing to qualify new products as Energy Star compliant can now submit test reports from their own laboratory for review and approval by EPA prior to labelling. All new qualification applications will be reviewed and approved individually by EPA. By the end of the year, all products qualifying for Energy Star labelling would be subject to qualification testing in an EPA-approved accredited laboratory. Test reports from tests performed under the AHRI Certification Program will be sufficient for submission of products for Energy Star testing.
Source: http://www.ahrinet.org/Pages/ShowMeMore.aspx?src=single&lpk=1260

New efficiency standards for water heaters, direct heating equipment and pool heaters

The U.S. Department of Energy's Final Rule for revising the Federal Minimum Efficiency Standards for residential water heaters, direct heating equipment and pool heaters will be published in the Federal Register shortly. It should be noted that, compared to the proposed levels that have been presented earlier, the new minimum standards for lower-volume gas storage units are a little lower than what was originally proposed, while the new minimum standards for higher-volume electric and gas storage water heaters are appreciably higher than the original proposed level. In the case of higher-volume electric storage units, for example, the final rule sets a minimum efficiency level more than twice as high as that which was originally proposed and will, de facto, require heat pump technology.
Source: http://www.ahrinet.org/Pages/ShowMeMore.aspx?src=single&lpk=1257

European Council adopts position on the labelling of energy-related products

On 14 April 2010, the European Council adopted a position at first reading of the Directive on the Indication by Labelling and Standard Product Information of the Consumption of Energy and Other Resources by Energy-Related Products (5247/10 REV 1). The main aim of this recast directive is to extend the scope of the current Directive, 92/75/EEC, restricted to household appliances, to allow for the labelling of all energy-related products including the household, commercial and industrial sectors and some non-energy using products. The basis of the label will continue to be the scale A–G, with the corresponding colour scale going from dark green (the most energy-efficient) to red, which is well

understood by consumers, but allowing for three additional classes, with the total number being limited to seven. Advertising should also indicate, as appropriate, the energy efficiency class, where energy-related or price information is disclosed.
Source: http://europa.eu/rapid/pressReleasesAction.do?reference=PRES/10/84&format=HTML&aged=0&language=EN&guiLanguage=en

European Council adopts position on the Energy Performance of Buildings Directive

On 14 April 2010, the European Council adopted a position at first reading of the Energy Performance of Buildings Directive (5386/10) which aims to clarify, strengthen and extend the scope of the current Directive, 2002/91/EC, and to reduce the large differences between Member states' practices in this sector. Its provisions address different regulatory and information-based instruments and cover energy needs for space heating and hot water heating, cooling, ventilation and lighting for new and existing residential and non-residential buildings. It prescribes that all new buildings must be nearly zero-energy buildings by 31 December 2020, that Member States should set intermediate targets for 2015, and that new buildings occupied and owned by public authorities have to be nearly zero-energy buildings after 31 December 2018.
Source: http://europa.eu/rapid/pressReleasesAction.do?reference=PRES/10/83&format=HTML&aged=0&language=EN&guiLanguage=en

UN may complete review of HFC credits by August

By August, said a UN official, the United Nations may complete its review of the awarding of carbon credits for the emission of greenhouse gases that are more damaging than carbon dioxide.

A UN panel will present its findings on the methodology for issuance of carbon credits for hydro-fluorocarbon (HFC) combustion plants when the UN Clean Development Mechanism (CDM) board meets in Bonn at the end of July, Clifford Mahlung, Chairman of the UN CDM Executive Board, said in an interview today. HFC credits make up about half of the total CDM supply since 2005.
Source: http://www.businessweek.com/news/2010-06-22/un-may-complete-review-of-hfc-23-credits-by-august-update1-.html

Finland ramps up heat pump and other renewable technologies

The Finnish Government's ministerial working group for climate and energy policy has agreed on the contents of an extensive package of obligations concerning renewable energy, with the aim of increasing energy production based on renewable forms of energy by a total of 38 TWh of final energy consumption by 2020. This package will promote the use of forest chips and other wood-based energy in particular, alongside wind power, the use of transport bio-fuels, and increasing utilisation of heat pumps. In doing so, it will enable Finland to meet its obligations set by the European Union, to increase the share of renewable energy to 38 % of final energy consumption in 2020.
Source: http://valtioneuvosto.fi/ajankohtaista/tiedotteet/tiedote/fi.jsp?oid=293158

Working Fluids

Multilateral Fund supports low-GWP technologies in developing countries

Policies to enable developing countries eventually to eliminate HCFCs in cooling and heating equipment, and to prioritise low-GWP technologies such as hydrocarbon refrigerants, were agreed in April in Montreal at the 60th Meeting of the Executive Committee of the Multilateral Fund for the implementation of the Montreal Protocol.
Source: http://www.hydrocarbons21.com/content/articles/2010-04-26-multilateral-fund-supports-low-gwp-technologies-in-developing-countries.php

European Business Award goes to a merchandiser using natural refrigerants

A commercial ice cold merchandiser that uses hydrocarbon R290, R600a and R744 as refrigerants has been awarded with the second place of the European Business Award for Environment 2010. The use of natural refrigerants as well as the use of natural substances in the insulation process render the coolers completely HFC-free.

The prizes are awarded by the European Commission every two years and single out European companies that have made outstanding contributions to sustainable development in four categories - management, products, processes, and international cooperation. Greek-based company, Frigoglass, has designed, produced and marketed natural refrigerant coolers. As the main reason for the award, the jury stated that the units use natural refrigerants that significantly reduce the impact on the environment both in terms of greenhouse gas emissions and in terms of energy consumption.
Source: http://www.hydrocarbons21.com/content/articles/2010-06-10-european-business-award-goes-to-natural-refrigerants.php

F-gas data published by the European Commission

The European Commission recently published data on fluorinated gases (F-gases) obtained from the reports submitted by EU producers, importers and exporters, pursuant to F-gas Regulation commitments. EU production of F-gases was 41 647 tonnes in 2008 (vs 58 037 tonnes in 2007). EU

sales – i.e. the amounts of F-gases placed on the EU market for the first time – were 94 043 tonnes in 2008 (250.41 Mt CO_2-eq) vs 93 126 tonnes in 2007. EU sales in the refrigeration and air-conditioning sector were 64 176 tonnes (144.57 Mt CO_2-eq) in 2008 vs 64 600 tonnes in 2007.
More: http://ec.europa.eu/environment/climat/fluor/pdf/statistics.pdf

Novel injection system for CO_2 evaporators

Danfoss is introducing its new generation of injection systems for CO_2 evaporators. The new injection system makes it easier to design and commission CO_2 systems, thus bringing CO_2 to the market more quickly.
http://www.r744.com/articles/2010-04-19-new-generation-of-danfoss-adap-kool-injection-system-for-co2-evaporators.php

Technology

California begins 53 MW ice energy storage experiment to reduce peak electricity demand

The Southern California Public Power Authority (SCPPA) and Ice Energy, a provider of advanced energy storage solutions, today announced an agreement to undertake the nation's first cost-effective, utility-scale, distributed energy storage project.

The 53 MW project, to be implemented by SCPPA member utilities throughout Southern California, will permanently reduce California's peak electrical demand by shifting as much as 64 GWh of on-peak electrical consumption to off-peak periods every year, reducing exposure to costly peak power and improving the reliability of the electrical grid.
Source: http://www.scppa.org/Downloads/Press%20Releases/IceEnergy_01_27_10.pdf

Looking into the future: smart refrigerator and heat pump trials

Three hundred smart refrigerators will be delivered across the UK in the coming months in order to carry out what will be Europe's first residential trial of smart grid technology. A similar trial, this time with heat pumps "talking" to the grid, is set to take place in 2011 in Denmark. Allowing for electricity demand-side management, the technology has the potential to realise sizeable CO_2 emissions reductions.

Smart energy houses of the future will use intelligent appliances such as smart refrigerators or heat pumps that can respond to signals from the electricity grid system. Electric utilities, manufacturers of appliances and companies developing smart grid technologies are now trialing the technology within the residential environment using refrigerators and heat pumps, appliances that may also incorporate hydrocarbon refrigerants.
Source: http://www.hydrocarbons21.com/content/articles/2010-05-31-looking-into-the-future--smart-fridge-and-heat-pump-trials.php

Largest ground source heating system underway in Denmark

The construction of Denmark's largest ground source heating system, to meet the needs of a 28 000 m^2 office building is underway. The propane-based system will be able to deliver a cooling capacity of 1200 kW and 750 kW heating simultaneously, while also allowing the owner to realise significant energy cost savings.
Source: http://www.hydrocarbons21.com/content/articles/2010-05-19-largest-ground-source-heating-system-underway-in-denmark.php

Marks & Spencer cuts fridge emissions by 18 % in three years

Marks & Spencer reports that it has made an 18 % reduction in refrigeration emissions when compared to 2006/07.
Source: http://www.acr-news.com/news/news.asp?id=2129

Markets

Global air conditioning feels the world recession in 2009

After a volatile year around the world, the market contracted by 11 % compared to 2008, and reached to $63.2 billion in 2009. The market is expected to see a slow recovery in 2010, with an expected growth rate of around 5 % by value.
Source: http://www.bsria.co.uk/news/global-air-conditioning-feels-the-world-recession-in-2009/

Global AC market to hit 78.8 million units by 2015

The global market for air conditioning systems is expected to recover from the recession and a fall in growth, and to reach 78.8 million units in volume sales by 2015.
According to the report "Air Conditioning Systems: A Global Strategic Business Report", growth in the short to medium term period will be driven by factors such as focus on energy-efficient air conditioners, grow-

ing replacement needs and rising demand from developing markets.
Source: http://www.acr-news.com/news/news.asp?id=2126

Global compressor sales

JARN has published an extensive overview of compressor markets in 2009. On the whole, the compressor market has suffered from the decrease in the air-conditioning market (down 2.9 % compared with 2008).
Source: https://www.iifiir.org/en/news.php?rub=2&page=2&id=2107 (Refrigeration sector news, trends: compressors, May 27, 2010)

Survey of availability of heat pumps in the food and beverage fields

A survey has been published, estimating CO_2 reduction potential by introducing modern-technology heat pumps into the food and beverage fields. The report covers France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, UK, USA and China.
http://www.hptcj.or.jp/e/publication/pdf/survey.pdf

IEA Heat Pump Programme

Call for Rittinger Award candidatures

The Heat Pump Programme seeks candidates for the Rittinger Award which recognizes deserving individuals or teams that have distinguished themselves in the advancement of heat pumping technologies applications, market development and/or related dissemination activities with lasting international impact.

Sophie Hosatte, Chairperson for the IEA Heat Pumping Technologies Programme, has announced that nominations are being sought for the Peter Ritter von Rittinger Award 2011. The award was presented for the first time at the IEA International Heat Pump Conference in 2005. It is named for Peter Ritter von Rittinger, an Austrian engineer who is credited with the design and installation of the first practical heat pump system at a salt works in Upper Austria in 1856.

The awards will be presented at the International Heat Pump Conference 2011, which will be held in Tokyo, Japan in June, 2011.

Information on the award selection guidelines and nomination applications are available on the Heat Pump Centre website, which also contains information on the previous recipients in 2005 and 2008. *http://www.heatpumpcentre.org/en/aboutHPP/news/Sidor/Rittingercandidatures.aspx*

Welcome to the new HPC website! www.heatpumpcentre.org

We have launched a new version of the HPC website. We hope you like it and find everything you are looking for!

Heat pumps in Finland: market report

Jussi Hirvonen, Finland

This article presents an overview of the heat pump market in Finland, a relatively new member of the IEA HPP. The present situation is described, together with a prognosis until 2020. The market is dominated by air/air heat pumps (by numbers) and by ground-source heat pumps (by revenue). It is expected that the market for both of these will continue to grow, while that for exhaust air heat pumps may decrease, due to new legislation. If the prognosis for 2020 holds, heat pumps can be expected to contribute significantly to Finland's target for renewable energy.

Introduction

Finland is a relatively new member of the Heat Pump Programme, joining in 2009. Heat pump technology is gradually gaining increased recognition and acceptance among the general public. Sales are growing in most market segments, and there is a considerable potential for continued growth.

Country:	Finland
Population:	5.3 million
Area:	338 000 km^2
Capital:	Helsinki
Number of single/two-family houses:	1 100 000
Average heat demand per single/two family house:	20-25 MWh/year
Share of energy from renewable sources in final consumption 2005:	28.5 %
Binding target for the use of renewable sources by 2020:	38 %
Rate of new construction of single/two family houses 2009:	8 000

This article presents a brief overview of the Finnish heat pump market and market potential.

The Finnish heat pump market, by heat pump type

Since the turn of the millennium, heat pump sales in Finland have taken off, see Figure 1. In terms of sales numbers, air/air heat pumps have dominated. Traditionally, they have been the most cost-effective way of retrofitting electrically heated houses: more recently, they have also been installed in a large number of summer cottages, where they provide a complement to electric heating. It should be noted that air/air heat pumps are sold through a number of channels: builders merchants, mail-order firms, and web stores. Since there are no sales statistics for these channels, the sales numbers for air/air heat pumps can only be estimated.

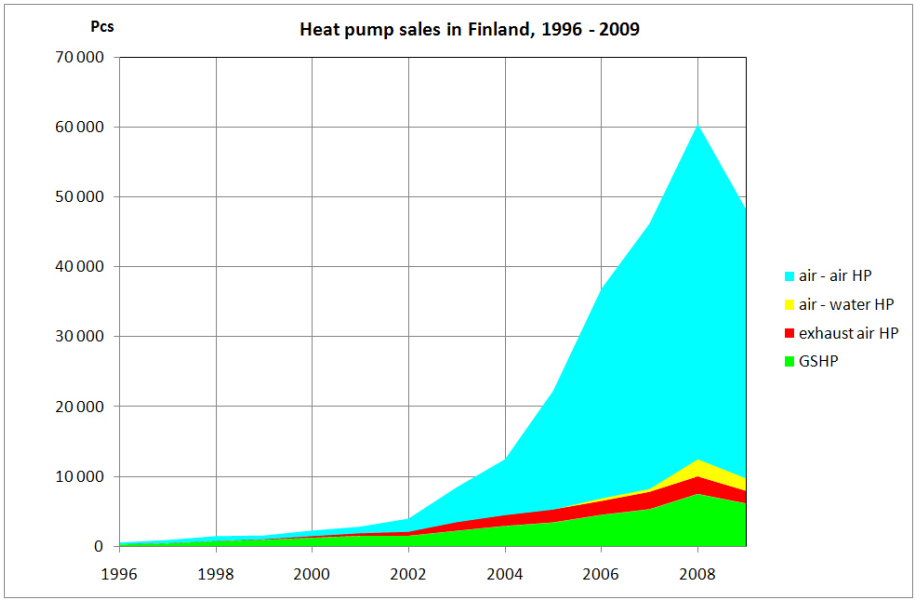


Figure 1

Although air/air heat pumps dominate by number, ground-source heat pumps show the greatest volume by installed value. They are installed in reasonable numbers, but are considerably more costly than air/air heat pumps (about EUR 11000 – 20000, compared to EUR 1500 – 2500 for air/air, all including VAT). The vast majority of ground-source heat pumps in Finland are vertical indirect systems. Vertical systems are favoured by the relatively low cost of drilling (due to the presence of crystalline bedrock of high thermal conductivity) and relatively liberal legislation regarding drilling.

This article is based on a presentation given by Mr. Hirvonen at the Workshop prior to the meeting of the HPP Executive Committee in June 2010, as well as on the material for Finland in "EHPA Outlook 2009". This article is edited by the Heat Pump Centre.

Exhaust air heat pumps have a moderate market share, but one which will probably decrease in the future. They have been installed in some new-building construction. However, the standard type of these heat pumps does not comply with the new, more stringent building regulations. They may be used in the most well-insulated new buildings, or may replace old exhaust air heat pumps. Recently, air/water heat pumps have been introduced on the Finnish retrofit market. For climate reasons, they are more common in the southern parts of Finland.

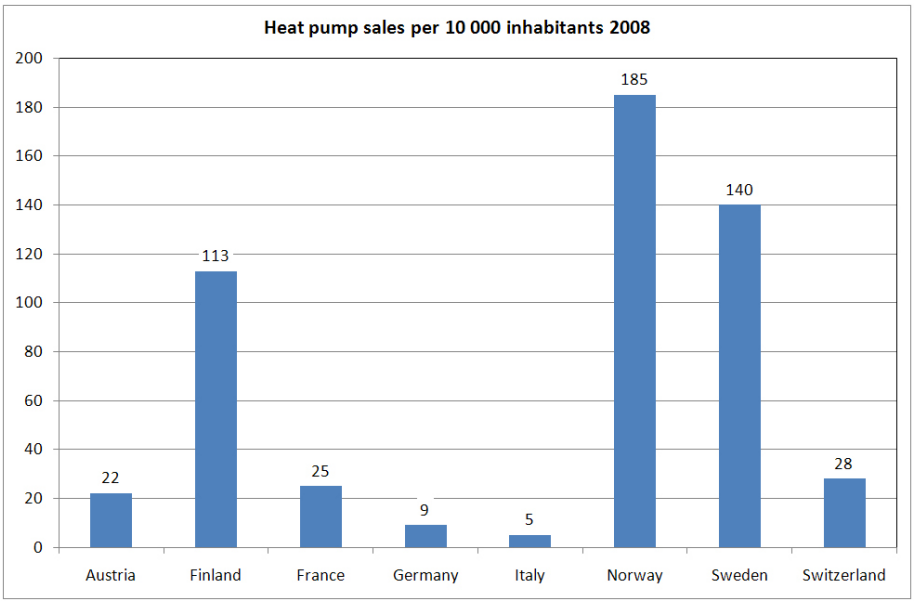


Figure 3

Market potential

The development of the heating system market (% revenues) for new construction is shown in Figure 2. The numbers for 2011 are a prognosis. As can be seen, the trend from previous years, of increasing green/effective energy (ground source heat pumps, district heating and bio), is expected to continue. This is in line with the more stringent building legislation mentioned above.

For the retrofit market, there are some interesting numbers to take into consideration. There are:

- 250 000 houses heated by oil
- 150 000 houses heated by electricity, with hydronic heat distribution
- 500 000 houses heated by direct electricity
- 500 000 summer cottages (mostly heated by direct electricity)
- 100 000 large estates not having district heating

If these numbers are summed up, the resulting number, 1 500 000 houses, gives the potential for retrofitting for instance heat pumps, bio/pellets, district heating, or possibly solar heating.

It is worth noting that the retrofit market has gained importance in comparison with the new construction market due to the recent economic crisis. In addition, Finnish homeowners are eligible for tax reductions for heat pump installations (as well as for other renovation and extension work). Up to 60 % of the labour cost may be deducted, with a maximum limit of EUR 3000.

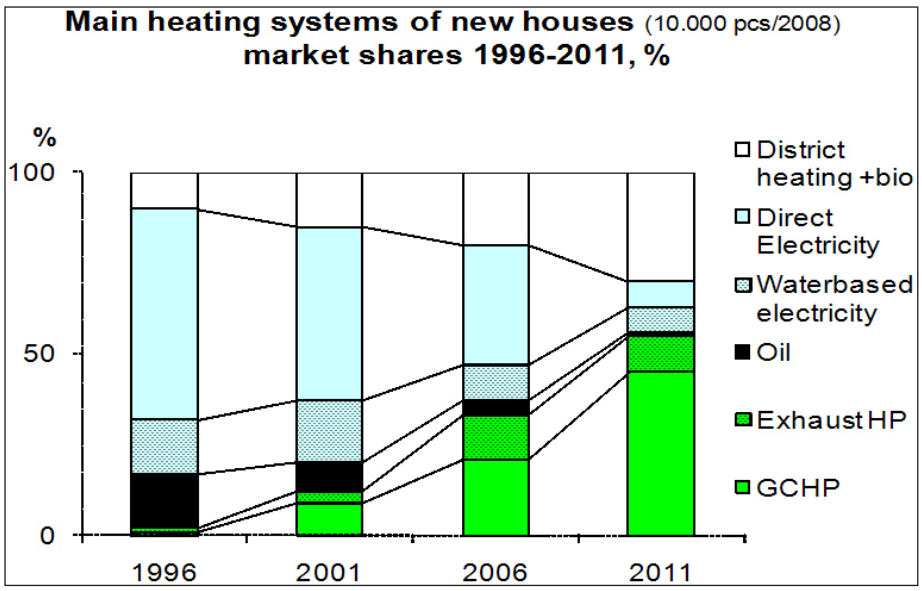


Figure 2

The Finnish heat pump market as a whole (not divided up by heat pump type or new construction/retrofit) is large, if judged relative to the population, see Figure 3. However, note that the numbers for the Scandinavian countries include reversible air/air heat pumps. In these countries, this type of heat pump is used almost exclusively for heating. As mentioned above, their sales numbers can only be estimated.

A prognosis of the total stock of heat pumps in Finland up to 2020, by type, is shown in Figure 4. Growth is expected for all four types of heat pump, with the possible exception of exhaust air heat pumps, as described above.

Heat pump industry association: SULPU

The Finnish Heat Pump Association, SULPU, was founded in 1999. At present, it has about 120 members: manufacturers, importers and installers of heat pumps, as well as other companies with interest in the

heat pump industry. Its role is to promote the heat pump industry and to improve both the operational conditions of the industry and the quality of installation work and equipment. SULPU also monitors the interests of contractors/installers in the field, and promotes the cooperation of its members. It is also the official voice of the industry at the national level.

SULPU has been active in promoting the implementation of the EUCERT certification system for heat pump installer training as well the EHPA Quality Label system in Finland.

In 2009, SULPU was awarded the Finnish Renewable Energy of the Year prize (see HPC Newsletter 2/2009).

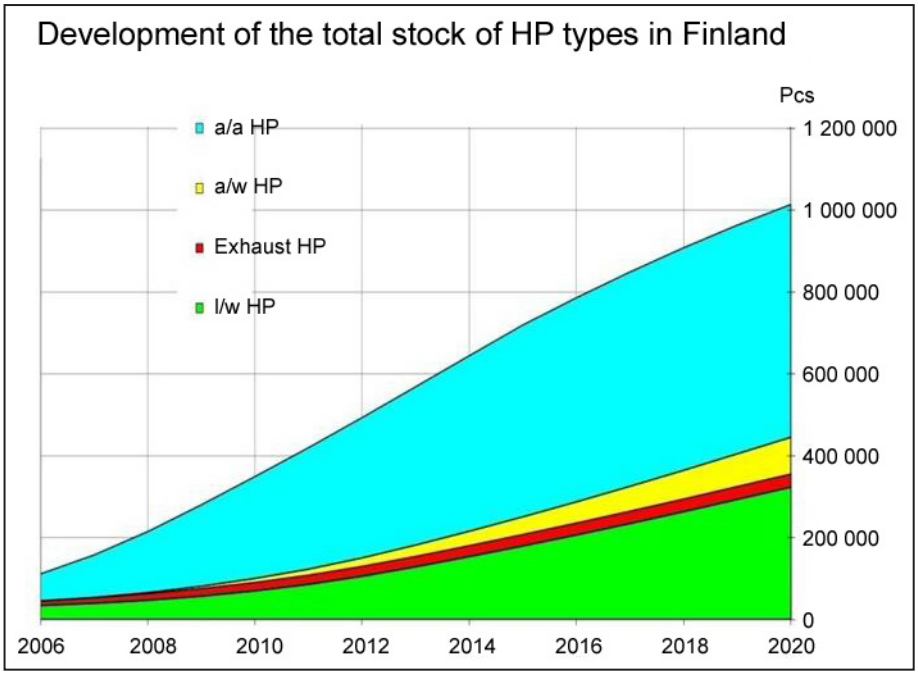


Figure 4

Final comments

It is clear that Finland has a strong heat pump market, with large potential. One of the key issues in energy discussions is the share of renewable energy and resources in the final consumption. As indicated above, Finland has a binding target of increasing this share by about 10 percentage points (from 28.5 % to 38 %). This corresponds to an increase of approximately 34 TWh per year. Today's over 250 000 heat pumps use a total of 2-3 TWh of renewable energy. We note in passing that these numbers will be strongly dependent on the exact SPF calculation method in the EU Renewable Energy Directive. However, subject to this reservation, the one million heat pumps that are forecast for 2020 could provide 10-30 % of the renewable energy goal for Finland.

Author contact information
Jussi Hirvonen
Finnish Heat Pump Association,
SULPU ry
Äyritie 8 E
FI-01510 Vantaa
Finland

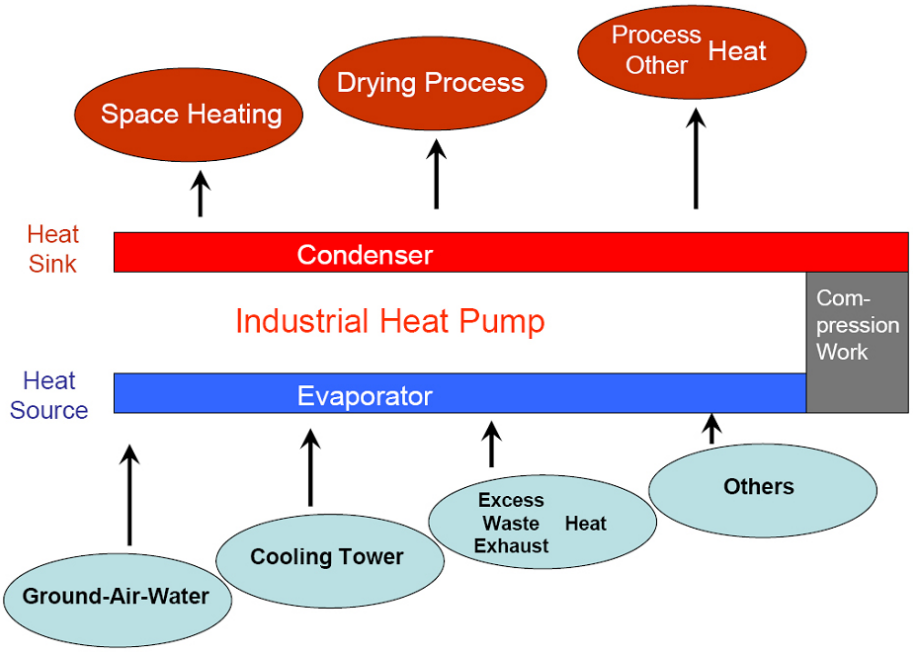
Annexes, ongoing

New IEA IETS Annex XIII / HPP Annex 35: Application of Industrial Heat Pumps

Heat pump markets are currently growing at a steady pace. Energy prices and environmental concerns focus on energy conservation and the use of renewable energy sources. In many countries, heat pump markets and policies have concentrated mainly on residential heat pumps for space heating and domestic hot water production. Heat pumps for high-temperature applications, industrial and commercial use, have often been neglected. Formerly, the share of energy costs has been low for companies. Increased energy costs, and awareness of the need to reduce CO_2 emissions, are drivers for large heat pumps.

While standardised products and installations may be suitable for the residential market, most industrial heat pump applications need to be matched to specific or unique conditions. In addition, a high level of expertise is crucial. In this context, industrial heat pumps are defined as heat pumps in the medium and high power ranges, which can be used for heat recovery and heat upgrading in industrial processes, as well as for heating, cooling and air-conditioning in industrial, commercial and multi-family residential buildings, and also for district heating. The main advantage of using heat pumps in industrial applications is to recover waste heat and to use free renewable energy sources.

The main market barriers are expected to be lack of experience, and thus lack of market acceptance by operators, industrial partners, manufacturers and their component suppliers, and consultants. Apart from the need for high-temperature refrigerants, there is a requirement to re-visit the technologies and potential applications. Recent studies show that, when using waste heat as a heat source, the higher the output temperatures that can be delivered, then the more important the potential processes of which the demands can be met.



Heat Source and Heat Sink in Industrial Heat Pumps

Under the IEA Implementing Agreement on Heat Pumping Technologies, two annexes have already dealt with industrial heat pumps:

HPP Annex 9: High-Temperature Industrial Heat Pumps (1990)
HPP Annex 21: Global Environmental Benefits of Industrial Heat Pumps (1992 -1994)

Since the final report of Annex 21, new possibilities, constraints and developments have occurred:

- Improved, further developed and simplified software
- Newly available compact components
- Gas regulations
- Higher energy costs, with expected further increases
- More stringent government legislation (reduction of carbon dioxide emissions)
- New refrigerant considerations

A new annex, "Application of Industrial Heat Pumps", has therefore started with participants from the IEA "Heat Pump Programme (HPP)" and the "Industrial Energy-Related Technologies and Systems (IETS)" Implementing Agreements. The annex is operated by the Information Centre on Heat Pumps and Refrigeration - IZW e.V., Germany (Informationszentrum Wärmepumpen und Kältetechnik - IZW e.V.), in collaboration with Laurent Levacher, EDF-R&D-ECLEER (European Centre & Laboratories of Energy Efficiency Research), France.

Contacts:
Hans-Jürgen Laue
E-mail: Laue.izw@t-online.de
Rainer Jakobs
E-mail: Jakobs@izw-online.de
Laurent Levacher
E-mail: laurent.levacher@edf.fr
Per-Åke Franck
E-mail: franck@cit.chalmers.se

Source: IZW eV. Hans-Jürgen Laue; Rainer Jakobs

Annexes, planned

New IEA HPP / SHC Annex: Solar and heat pump systems

The new combined "Solar and heat pump systems" SHC Task and HPP Annex has started, and will run from 2010 to 2013. It is a joint effort by the SHC and HPP bodies, and will be led by a single operating agent (JC Hadorn of Switzerland). For SHC, it is Task 44, while the annex number for HPP will be announced soon.

Over 50 experts from 14 countries, and from both technical backgrounds (solar heating and heat pumps), attended the first meeting in Bolzano, Italy (April 29-30, 2010) to start the new activity.

Subtask A (led by S. Herkel from ISE, Germany), dealing with real projects, has seen over 20 presentations of projects combining solar collectors and heat pumps, which will be evaluated during the Task.

Subtask B (led by I. Malenkovic from AIT, Austria) discussed a common seasonal performance factor definition, in addition to laboratory testing.

Subtask C (led by C. Bales from SERC, Sweden) reviewed existing solar collector models as collectors and heat pump evaporators, and started the review of transient heat pump models. A reference case was also discussed, which will be an extension of IEA SHC Task 32's well-documented case for TRNSYS simulations and comparisons.

Subtask D (led by W. Sparber from EURAC, Italy) discussed the final handbook, the future web site and the new logo (to be issued in July 2010).

New participants are welcome to join the work prior to the next meeting in Vienna (October 2010), in order to contribute to this cooperative work to optimise the possible combinations of solar collectors and heat pumps, mainly as intended for use with single-family houses.

For further information on this work, please contact the Operating Agent, Jean-Christophe Hadorn, jchadorn@baseconsultants.com. Web site: www.ieashc.org/task44

Ongoing Annexes

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

Annex 29 Ground-Source Heat Pumps - Overcoming Market and Technical Barriers	29	**AT**, CA, JP, NO, SE, US
Annex 30 Retrofit heat pumps for buildings	30	**DE**, FR, NL
Annex 31 Advanced modelling and tools for analysis of energy use in supermarkets.	31	CA, DE, **SE,** UK**,** US
Annex 32 Economical heating and cooling systems for low-energy houses.	32	CA, **CH**, DE, NL, SE, US, JP, AT, NO
Annex 33 Compact Heat Exchangers In Heat Pumping Equipment	33	**UK**, SE, US, JP
Annex 34 Thermally Driven Heat Pumps for Heating and Cooling	34	AT, **DE**, NL, US
Annex 35 Application of Industrial Heat Pumps (together with Task XIII of "Industrial Energy-Related Technologies and Systems" (IEA IETS))	35	AT*, CA, DK*,**, FR, **DE**, JP, NL*, KR, SE*, CH*

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

IEA HPP Annex 30: Retrofit Heat Pumps for Buildings

H.-J. Laue and R. M. Jakobs, Germany

Energy utilisation in the built environment is one of the most important aspects that must be addressed if energy targets are to be met. In Europe, around 40 % of primary energy use is due to the building sector. Heat pumps are among the most environmentally friendly and efficient heating technologies available. Retrofitting is a means of rectifying poor existing building performance by improving the standards and thermal insulation of buildings and/or the replacement of old space conditioning systems by more efficient systems. The focus of HPP Annex 30 has been retrofitting in all kinds of domestic buildings. This article gives an overview of the work.

Introduction

Europe is facing unprecedented energy challenges resulting from increased dependence on imports, concerns over supplies of fossil fuels worldwide, and a clearly discernable climate change. In spite of this, Europe continues to waste at least 20 % of its energy due to inefficiency. Europe can and must lead the way in reducing energy inefficiency, using all available policy tools at all different levels of government and society. Technology is vital for reaching all the above mentioned objectives. The EU is therefore piecing together a far-reaching jigsaw of policies and measures: binding targets for 2020 to reduce greenhouse gas emissions by 20 %, ensuring 20 % of renewable energy sources in the EU energy mix and reducing EU global primary energy use by 20 % by 2020.

Energy utilisation in the built environment is one of the most important aspects that must be addressed in the near future if the 2020 targets are to be met. Around 40 % of primary energy use in Europe is related to the building sector. At present, it is demand for space heating and hot water production that accounts for almost 80 % of the energy demand in residential buildings and utility buildings, although the energy demand for cooling is growing year by year. There are more than 150 million dwellings in Europe. Around 30 % were built before 1940, around 45 % between 1950 and 1980, and only 25 % after 1980. The high ratio of heating energy demand of the buildings built before 1978 is demonstrated by the German situation in Fig. 1

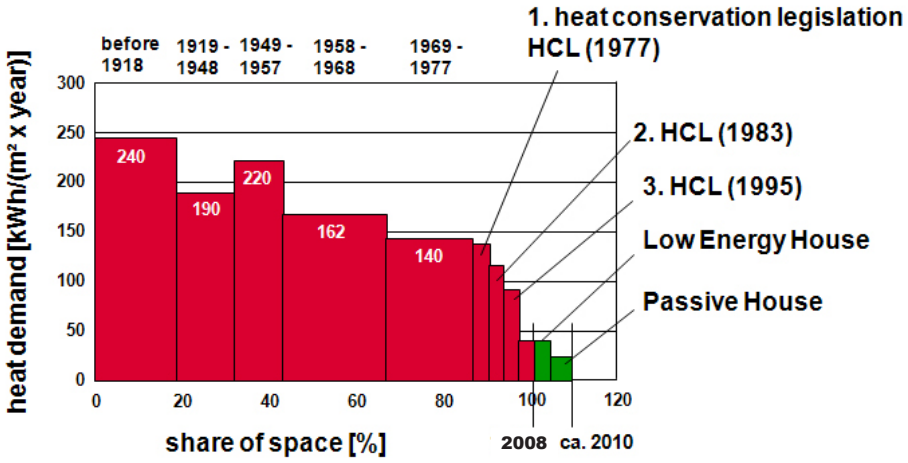


Fig. 1: Heat demand of the building stock in Germany

Retrofitting is a means of rectifying poor existing building performance by improving the standards and thermal insulation of buildings and / or the replacement of old space conditioning systems by energy–efficient and environmentally sound heating and cooling systems.

The use of renewable energy in the existing building stock must be considered if we are to meet the ambitious goals for reduction of fossil primary energy consumption and the related CO_2-emissions. This is possible and realistic with the existing basic technology and knowledge for new and renovated buildings.

Heat pumps are among the most environmentally friendly and efficient heating technologies available. The Energy Performance of Buildings Directive concentrates on new one- and two-family houses. There is, however, a much larger potential for replacement with heat pumps and other competing technologies in existing housing stock as well as in individual domestic dwellings. Whether this is feasible depends on the existing building and heating systems and the cost of necessary adaptations.

IEA Heat Pump Program Annex 30

From the beginning of the International Energy Agency's Heat Pump Program (HPP), the markets in the various IEA countries have been mainly concerned with the development and application of heat pumps for new buildings. Recognising the potential of the retrofit market, IEA-HPP initiated an international collaboration on "Retrofit Heat Pumps for Buildings".

The primary focus of this annex has been on domestic buildings, concentrated on:

- The application of available heat pumps in standard buildings that have been improved, resulting in reduced heat demand.
- The development and market introduction of new high-temperature heat pumps that use a compact source for application in existing buildings.
- The use of reversible (heating-cooling) heat pumps (air-to-air) in buildings without centralised heat distribution systems

The programme has been subdivided into four tasks:

Task 1: Overview Europe, State of the art – market analysis

The Annex started with collection and analysis of statistical and other information on the present status of existing residential buildings and the present heat pump market, and the potential technology economically applicable for retrofit of existing buildings in the different climatic regions in selected European countries.

The results have shown that the total market in Europe for space heating by heat pumps is growing.

For example, in Switzerland in 2006 75 % of all new one-family houses were equipped with heat pumps. This contrasts, as shown in Figure 2, with the retrofit market in residential buildings which, between 2002 and 2006, amounted to only around 25 % of the total. Figure 3 shows the sale of heat pumps in Switzerland in 2007, showing for the first time a lead over oil and gas boilers. In Switzerland, more than 125 000 heat pumps were running and more than 70 % of new residential houses are fitted with them.

Task 2: Matrix of Heat Pumps (Case studies, R&D projects)

Task 2 presented practical applications of heat pumps in existing buildings, analysing the present generation of heat pumps and possible improvement of components and systems for retrofit application, as well as research & de-

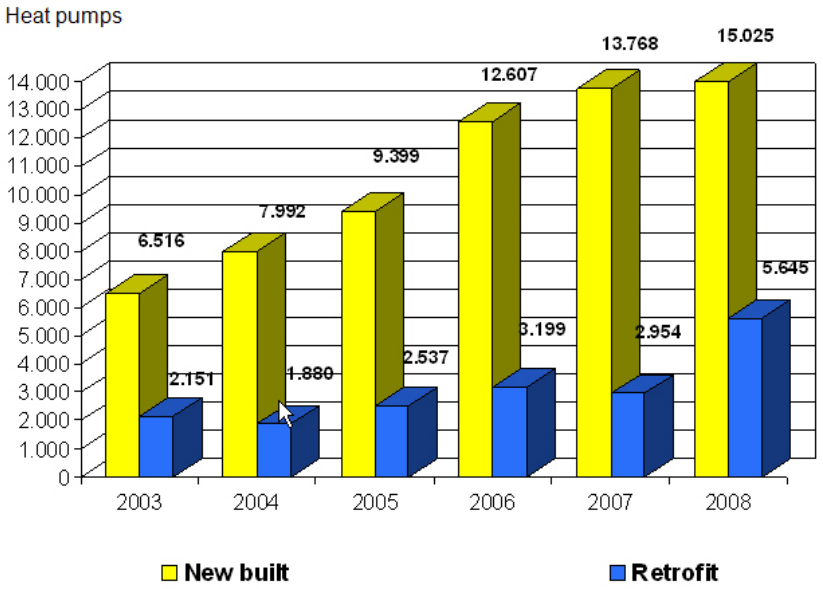


Fig. 2: Heat pump sales in Switzerland for new or retrofit buildings. (Source FWS).

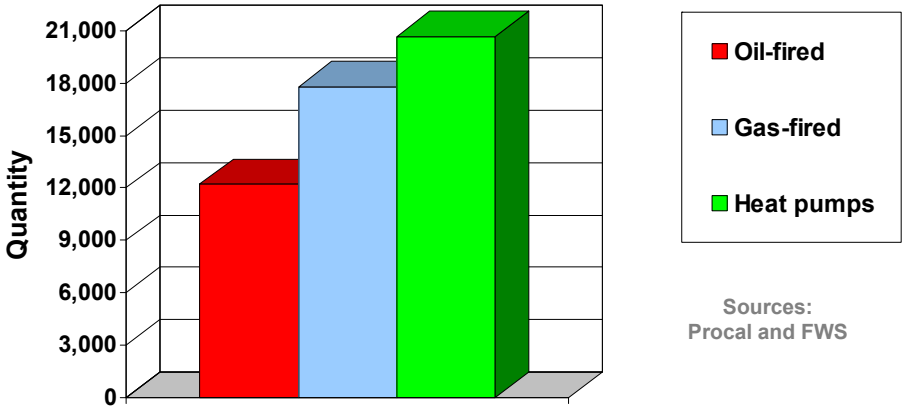


Fig. 3: Heating systems sold in Switzerland in 2008

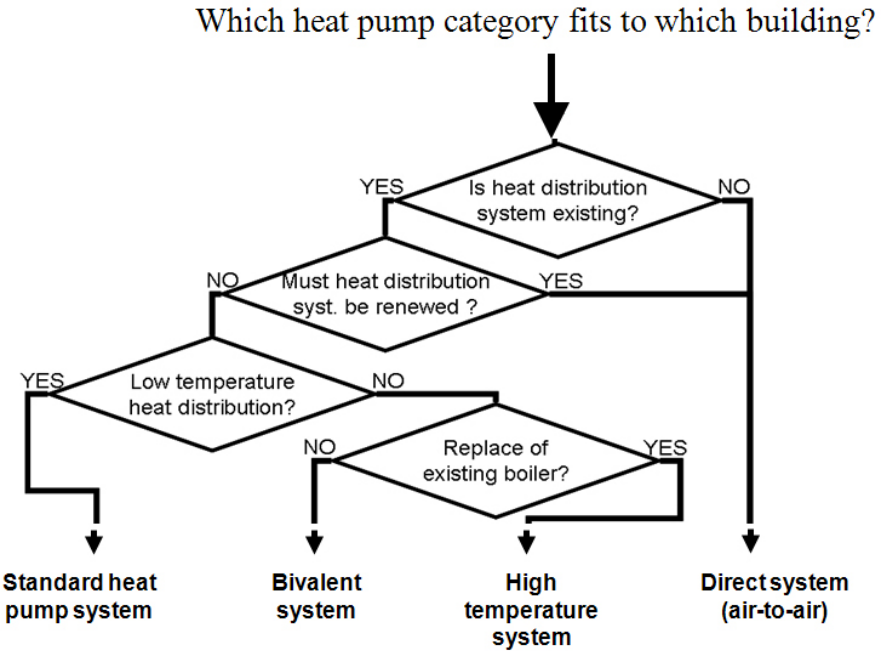


Fig. 4: Four categories of heat pumps for retrofitting purposes

velopment (R & D) projects directly related to the objectives of the annex.

Standard heat pump systems

Available standard heat pump systems will be economically sensible only in buildings with centralised heating systems, and which are well insulated, have double glazing or better, have an airtight building envelope and use a low-temperature heat distribution system.

Bivalent heat pump systems

Available standard heat pump systems can be used to upgrade an existing heating system by using an installed boiler to cover peak demand.

High-temperature heat pump systems

The replacement of conventional heating systems in existing residential buildings with centralised distribution temperatures up to 70 – 90 °C requires the development and market introduction of new high-temperature heat pumps. An additional ideal application for high-temperature heat pumps is that of domestic hot water production.

Direct heating heat pump systems (air-to-air)

Standard buildings without centralised heat distribution systems are best served by the general use of reversible (heating-cooling) modern standard heat pumps (air-to-air).

There is no general definition of an existing building that is the target group for retrofit with heat pumps. It could probably be agreed that dwellings which are over 20 years of age are the primary target.

Task 3: Overcoming economic, environmental and legal barriers

Task 3 compares the economy and ecology (energy - efficiency and greenhouse gas emissions) of retrofit heat pump systems with conventional heating and cooling systems, presents recommendations for governmental or utility promotion and support programmes as well as demonstration and awareness projects.

The main barrier for the use of heat pumps for retrofitting is the high distribution temperature of conventional heating systems in existing residential buildings with design temperatures up to 70 – 90 °C, which is too high for the present heat pump generation with its maximum, economically acceptable output temperature of around 55 °C. In addition to application of existing heat pumps in already improved standard buildings with reduced heat demand, the development and market introduction of new high-temperature heat pumps is a major task for the replacement of conventional heating systems by heat pumps in existing buildings. Particular emphasis should be given to higher heat distribution temperatures and environmental issues leading to lower greenhouse gas emissions, particularly through the use of low GWP working fluids.

08.07.05 – 07.07.06	(natural gas 2005-2006):	€ 3.637
20.07.06 – 19.07.07	(hp electricity, 2006-2007):	€ 1.569
08.07.07 – 07.07.08	(hp electricity, 2007-2008):	€ 2.030
08.07.08 – 07.07.09	(hp electricity, 2008-2009):	€ 2.254,60
Difference (average 2006 – 2009)		1.951,20 = - 46 %

In many cases, high investment costs are a barrier, in spite of the fact that the overall lifetime cost of a system is very satisfactory. Experience has shown that the highest cost element of a heat pump system for individual and semi-detached houses is that related to the ground source, and in particular to earth-probes.

The high investment costs are more than compensated for by the low operation costs, which would correspond with a payback period of around ten years, as shown by comparison of the operating costs of a water/water heat pump installed in an 80-year-old building below, comparing natural gas costs in 2005 to 2006 with the actual electricity costs in 2006 to 2009. Comparison with the actual natural gas costs for 2006 to 2009 would increase the difference to nearly 65 %:

Poor understanding or unrealistic expectations have occasionally had a detrimental effect on the retrofit heat pump market, which has tempted incompetent vendors and installers to enter. This has, in some instances and in combination with some brands not meeting a reasonable efficiency and quality standard, led to frustrated buyers and a setback in sales. This situation has arisen in several European countries, often in conjunction with energy-saving initiatives and programmes.
The limited awareness by decision makers, the public, authorities and politicians dealing with energy matters is due to a lack of professional information at all levels. It is worth mentioning that whereas such renewable energy sources as wind, solar, biomass and photovoltaic are well known alternatives, because of effective information campaigns and authority support, little emphasis has been placed on the energy saving and environmental potential of heat pump systems, and particularly for the retrofit market.

Task 4: Successful factors for the marketing of retrofit heat pumps

Task 4 has analysed the market situation in the different European countries. There is no general trend for the energy demand and supply situation in general, or for the building sector in particular, e.g. types and standard of the building stock, heating only or heating and cooling. Nor are there any common features of energy policy in terms of the extent and type of heat pump promotion and support. In other words, each country has to develop its own marketing concept. The major market for heat pumps is single-family houses, for which most units range in output from 1 kW to 10 kW and no more than 25 kW.
In Europe, Sweden is the only country with long experience of retrofit heat pumps. Its heat pump market is the largest and arguably most dynamic. Strict building regulations and high levels of energy awareness mean that

new buildings constructed in Sweden require very high levels of insulation. The Swedish heating systems can be summarised as follows:

- 80 % of houses have hydronic heating systems,
- The rest have electric heating with electric radiators
- Old houses have water radiators, normal design temp 55-65 °C
- Oil boilers have been the dominant way of heating
- Gas is not available, except in southern Sweden
- New houses have mainly underfloor heating
- New houses normally have heat pumps or district heating

Sweden has 9 million inhabitants and 1,744 million private buildings, but heat pumps are well recognised by most one-family households today. As seen in Fig. 5, heat pumps dominate the heating market, with 550.000 to 600.000 Swedish dwellings currently heated by heat pumps. But over 85 % of all heat pumps are used in the building stock, as the retrofit market in Sweden is very open to heat pumps as the standard of building and insulation is basically better than in other parts of Europe.

The reasons for the Swedish success in retrofit heat pumps and the driving forces for the end users to install retrofit heat pumps can be summarised as follows:

- Suitable heating systems
- Temperature level below 65 °C
- Low electricity prices
- High oil prices
- Good geological conditions
- No focus on "super COP"
- High-temperature heat pumps simplified the retrofit installations
- Simple and reliable systems ("one-day installation")
- Network of drilling companies
- Reasonable investment, 10-12000 Euro, same prices as 1985
- Low running cost
- Annual saving on running cost is 1500 Euro in newly built houses, and 2500 Euro in an average old house
- Reasonable payback time, 5-8 years
- End users need to deal with only one contractor
- The 'neighbour' effect
- Use of renewable energy sources

Hitherto, Europe has been concentrating on heat-only heat pumps with water distribution systems and heat recovery systems, but sales of air-to-air dual-mode units for both heating and cooling are now growing, and not only in the southern part of Europe.

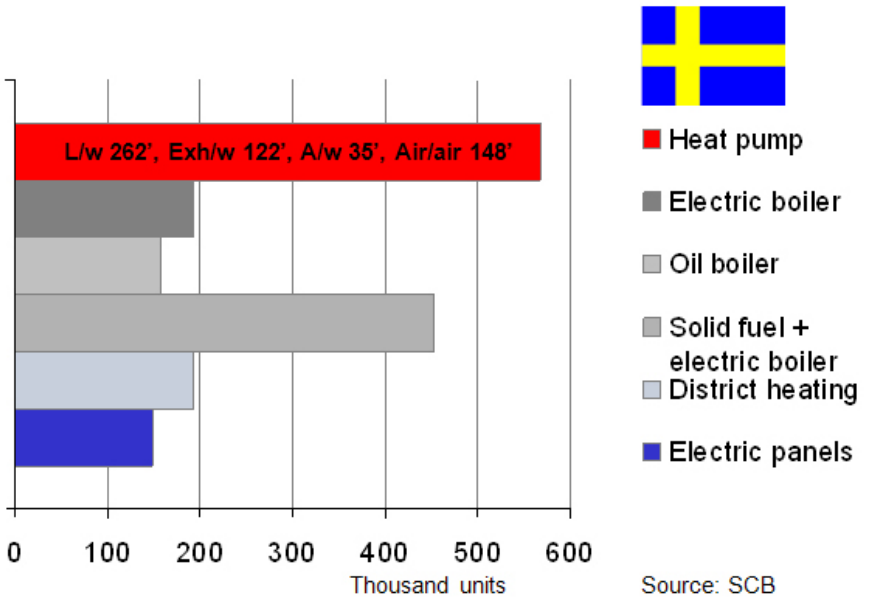


Fig. 5: Heating systems in Sweden 2007

Conclusion

In order to meet the ambitious targets for the reduction of fossil primary energy consumption and for the use of renewable energy, the existing building stock must be addressed today. This is possible and realistic with the existing basic technology and knowledge for renovating buildings.

The focus of IEA HPP Annex 30 has been on all kinds of domestic buildings. In order to reach the EU targets for such buildings it is recommended that the following solutions should be concentrated on:

- Application of available heat pumps in standard buildings that have been improved, resulting in a reduced heat demand.
- Existing and further development and market introduction of new high-temperature heat pumps (60-75 °C) for application in existing buildings.
- Use of reversible (heating-cooling) heat pumps (air-to-air) in buildings without centralised heat distribution systems, to achieve easy use of aerothermal energy sources
- Using 'bi-valent' (for this and other heat pump systems, see headings under Task 2, above) heat pump systems to upgrade existing heating systems by retaining existing boilers to cover peak demand
- A single radiator should not set the limit for the entire building. The combination of different heat pumps and heat exchangers in one house:
  1. Different heat pumps for individual temperature requirement: One 'standard' heat pump for space heating, and one for domestic hot water
  2. Eliminating bottlenecks: Additional 'direct' heat pump (air-to-air) for e.g. living areas
  3. Lower heat distribution temperatures: Combination of existing radiators and replacement by convectors with fans, by fan coils and, if possible, by floor heating in single rooms.

Last but not least, and no less important for the marketing of retrofit heat pumps, are the needs for highly experienced installers and drilling companies, quality assurance and the training of specialists. The heat pump manufacturers must, in cooperation with installers, provide a reliable and responsive customer service to maintain and repair heat pumps. This guarantees reliable and satisfactory heat pump operation. For more detailed information (Annex report), please contact the Heat Pump Centre

Author contact information
H.-J. Laue; R. M. Jakobs
Information Centre on Heat Pumps and Refrigeration – IZW e. V.
Kreuzfeldstr. 10a
D-64747 Breuberg
Germany

Retrofitting for Emissions Savings in North America: Residential Heating Options in the Canadian Provinces

Ted Kantrowitz and Denis Tanguay, Canada

The Canadian GeoExchange Coalition, Canada's heat pump industry association, deployed its national quality assurance program in 2005, and has been routinely collecting retrofit statistics as part of its System Certification since. Based on CGC's national database of over 11,400 residential GSHP systems, CGC analysis confirms that GSHP systems offer both an interesting GHG solution in most Canadian contexts and significant GHG reduction potential nationally. The study confirms recurring advantages in total greenhouse gas emission reductions generally when converting a conventional heating system to a GSHP system.

Context

At various times over the past few years the Canadian GeoExchange Coalition (CGC) has been asked to provide those in political and environmental circles with data and analysis to enable better positioning of GSHP technology in the ongoing climate change debates. Several studies on the subject have been published by various groups in recent years. However, these studies frequently lack clear research protocols or posit nebulous or unrealistic hypotheses based on limited data sources or even hearsay. The often fragmentary focus of these studies has created a great deal of confusion in North American policymaker circles, and has contributed little to advance the debate. The lack of coherence in the data published to date has been a solid argument for CGC to complete a more exhaustive study based on clear hypotheses and recognized environmental protocols.

CGC began deployment of its national quality assurance program in 2005, and has been routinely collecting statistics as part of its System Certification routine, in cooperation with national and provincial incentive programs for approximately four years. Based on CGC's constantly growing national system certification database of over 11,000 residential GSHP systems (comprising 40 data fields or about 440,000 data points, almost all for retrofit systems) CGC staff felt prepared to execute a more rigorous analysis and add value to the conversation.

To illustrate the importance of GSHP systems in the process of GHG reduction, CGC staff first conducted a theoretical analysis that relies on a number of scenarios to demonstrate the recurring advantages of GSHP systems.

In reviewing the report's context, readers should note a generalised and comprehensive lack of rigorous or reported data for either North or South American markets. This historical fact has systematically crippled industry's ability to represent or even describe itself to partners or governments, and development of information in this sphere is a sign of the developing professionalisation currently in Canada. Starting in 2007 Canadian GeoExchange Coalition has deployed about 35 metering kits to residential installations across Canada that are presently collecting data. Once two calendar years have been completed CGC intends to analyse those performance results in greater detail, resources permitting, and publish further analyses.

In 2003-2006, CGC, a provincial utility and Government of Canada jointly funded a similar study of ten residential homes in the centre of the country. The study showed a performing seasonal heating COP of 2.8 (ranging from 1.9 to 3.5) vs an average manufacturer equipment rating of 3.6. We assume that this installed field performance is above average as installers have their utility observing installation, but again, based on a sample of ten systems, and one type of residential system in one region of the country, CGC staff is not comfortable drawing any conclusions about ratings and installed or average Canadian or US performance.

Finally, CGC conducted an industry consultation in June 2009 and asked some 125 stakeholders in about seven cities their opinions on metrics issues, in particular about transitioning to Seasonal Performance Factor or other measure from simple COP. Each session responded with a clear preference for COP. While some of this response is due to field technician inertia, most agreed that the added complexity would complicate field work for a refinement more meaningful to theoreticians than industry. The discussion summary appears in CGC's full report.

Table 1
GHG savings potential in Canada compared with different Geoexchange market penetration scenarios, considering replacement of actual heating systems

Market penetration*	2%	4%	8%	16%
Electric baseboard				
GHG savings (tons CO_2 eq.)	115 350	230 701	461 402	922 804
Natural gas				
GHG savings (tons CO_2 eq.)	201 589	403 178	806 356	1 612 713
Oil				
GHG savings (tons CO_2 eq.)	59 315	118 630	237 261	474 521
Total				
GHG savings (tons CO_2 eq.)	376 255	752 510	1 505 019	3 010 038
Equivalent number of cars	111 981	223 961	447 922	895 845

*There are 7 181 000 single detached houses in Canada (OEE 2006b)

Table 1 summarizes the Canadian potential for GHG reduction for various GSHP system penetration rates. The data show the potential for GHG reduction for all single-family homes of 185 m^2 (2,000 ft^2) in Canada using various forms of heating, compared to a GSHP system with a COP of 2.8.

Methodology

The efficiency of GSHP systems must be worked out carefully. Although it is not uncommon that GSHP systems present coefficients of performance (COPs) of 4 or higher, it is wiser, in our opinion, to posit the hypothesis that a lower COP is much more realistic when you consider seasonal factors as well as real heat losses.

This hypothesis relies on the important distinction to be made between the theoretical COP of the heat pump, which reflects laboratory tests under predetermined conditions, and the system COP, which reflects the real functional conditions of the entire system (i.e. ground loop, appliance, and distribution in the home), and not just that of the heat pump. For purposes of this analysis, when the COP is mentioned, we understand it to mean the system COP, since it reflects the real and annual performance of the entire system – rather than the exclusive theoretical performance of the heat pump.

For purposes of comparison with other types of heating systems, three coefficients of performance have been used: 2.8, 3.2 and 3.6. For the detailed analysis by province, the comparison is based on a heat pump system COP of 2.8; this is our minimum comparative threshold. Any performance of GSHP systems above 2.8 would therefore improve the GHG performances for GSHP which we are presenting here.

This study used data that are both precise and specific to each of the capitals of the Canadian provinces in order to compare the GHG emissions of various heating systems. The study limits itself exclusively to heating analysis because heating represents almost 60% of total energy consumption in single-family homes (OEE 2006b). Although water heating is usually in second place with regard to residential energy consumption, we chose not to take it into account for purposes of this study. The use of desuperheaters is not generalized in geoexchange systems and thus would tend, in a comparative analysis, to give a favourable bias to geoexchange systems.

Furthermore, as the use of air conditioning is variable and disparate in most regions of the country, we also chose to exclude this component from the analysis in order to make interprovincial comparisons more uniform and consistent, even though air conditioning using geoexchange systems represents a significant source of energy savings compared to conventional systems, and therefore a potential source of GHG reductions or increases.

The proportion of single-family homes using the various types of heating systems has been used in order to make this analysis realistic. The calculations of market penetration and their associated reductions are based on the number of homes having a specific system, and not on the total number of single-family homes in each province.

Furthermore, with the goal of increasing the precision of this analysis, and to better consider the energy performance of buildings, three different building sizes were used. This was done to more effectively represent a wide proportion of the Canadian residential sector. The average size of single-family residences in Canada is 135 m^2 (1,475 ft^2), but we have noted a constant increase in the size of new residences (NRCan 2006a). Based on this fact, GHG emissions were calculated for homes of 140 m^2 (1,500 ft^2), 185 m^2 (2,000 ft^2), and 230 m^2 (2,500 ft^2) in order to better reflect the characteristics of the future building stock rather than the existing stock. The analysis presented in the full report concerns a

reference building of 185 m² (2,000 ft²) with average insulation.

Out of concern for a fair comparison with electricity, indirect emissions related to natural gas distribution have been included in our calculations. These fugitive emissions, mainly composed of methane (CH_4), have a coefficient of emission allocated per kilometer of natural gas distribution network. As defined by Environment Canada (2009a), this leakage rate is evaluated at 0.0007 kt of CH_4/km. By adding this correction factor, we limit the scope of the natural gas efficiency coefficients which are determined on a theoretical basis and do not necessarily reflect their true operational efficiency, contrary to those used for geoexchange systems. Line losses for electricity are reflected in electricity efficiency factor of 95 % retained in the study.

For certain provinces, the difference between the GHG emissions from electricity produced in the province and the GHG emissions from imported electricity is considerable and sufficient to make any comparison between the various forms of energy pointless. Interprovincial – and international – trade in electricity cannot be ignored, and we have taken this into account in our study. For example, Prince Edward Island, which imports almost 95% of its electricity from New Brunswick, sees its GHG emission intensity vary significantly by including interprovincial electricity transfers. This is also the case for other provinces.

In a thesis submitted at the University of British Columbia, Jana Hanova (2007) suggested including the electricity imports of each province in order to more precisely reflect the sources of production of the electricity consumed. Our study retains this idea, but adds further depth to the concept by integrating interprovincial transfers and international trade, and by establishing an average over 5 years. This average enables us to avoid, at least partly, having the analysis biased by exceptional annual statistical data – the electricity imports and exports of a province may vary considerably from year to year. Since 2008 data are not yet available in Canada nor in the United States, we have used the average for the period between 2003 and 2007.

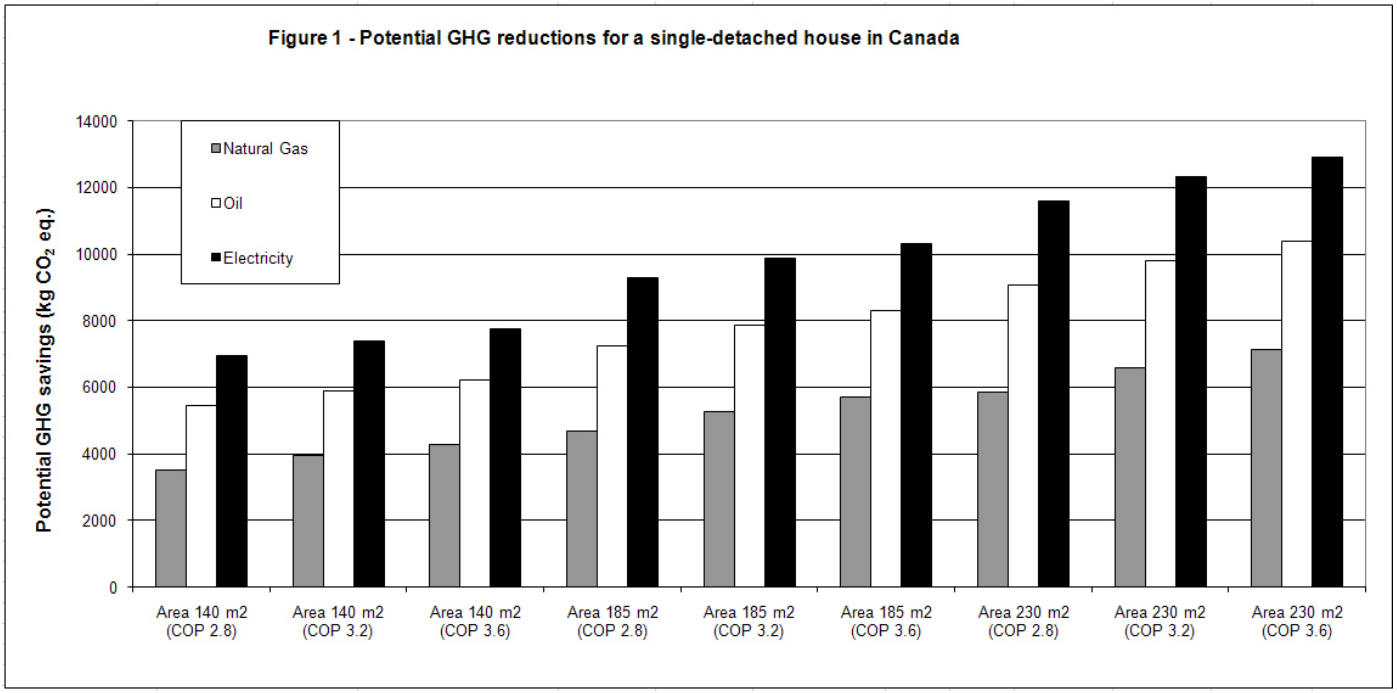
Results

It is useful, and important, to note here that replacement of oil heating systems represents the greatest potential for GHG reduction at the level of a single-family home. On the other hand, Canada-wide, the replacement of natural gas heating systems with GSHP systems represents the greatest global potential, since natural gas is used for space heating in almost half the single-family homes in the country (OEE 2006a).
Note also that the data presented in Table 1 reflect only the potential reductions in GHGs from single-family homes in Canada, and do not take the commercial, institutional and industrial sectors into account at all. So it is clear that GSHP systems possess a potential for GHG emission reductions that is much higher than the partial potential shown here.

Furthermore, Figure 1 below illustrates the progression of GHG reductions enabled by an increase in performance (COP) of GSHP systems. The figure also clearly gives evidence of the direct relationship between increasing the building area and the total volume of GHGs avoided. With regard to system performance, three theoretical COPs were used for purposes of this study: 2.8, 3.2 and 3.6.

It is clear that the progression of the COP from 2.8 to 3.2 and from 3.2 to 3.6 enables additional reductions in

Figure 1 - Potential GHG reductions for a single-detached house in Canada



GHGs of 6.4% and 4.7% in the case of electric systems substitutions. In addition, it should be noted that these reductions are cumulative. Stated differently, an increase in the COP from 2.8 to 3.6 represents a reduction of 11.1%. In the case of replacing natural gas and heating oil, we obtain supplementary reductions on the order of 12,5% and 8,6% for natural gas and 8,2% and 5,9% for heating oil.

If we look at the potential for GHG reductions from the point of view of building size, the results are consistent with the logic: higher gross energy consumption in large buildings will result in a higher potential GHG reduction if GSHP systems are adopted. The results demonstrate that, all other things being equal, buildings of 185 m^2 have a reduction potential that is 33% higher than that of buildings with an area of 140 m^2. For a building of 230 m^2, this increase in potential is 67% compared to the potential of buildings of 140 m^2.

CGC's selected approach, which represents a deeply pessimistic scenario, nevertheless produces results favourable to GSHP systems for the entire Canadian territory. Any installed system performance above this coefficient leads to a greater reduction in energy consumption, further reduces GHG emissions and improves the comparative advantages of GSHP systems vis à vis other residential heating systems.

Therefore this report demonstrates that GSHP systems do offer both an interesting GHG solution in most Canadian contexts and significant potential for reducing greenhouse gas emissions nationally. The results of the study confirm the recurring advantages in total greenhouse gas emission reductions generally when converting a conventional heating system to a GSHP system.

The study establishes that potential reductions vary from province to province because the climatic factors and the sources of energy used for heating, and for electricity production, differ from region to region. However, the results of the study demonstrate that GSHP systems in the residential sector are advantageous in every province, especially when they replace electric baseboards or oil furnaces.

The full report and appendices are available directly on the web at www.geoexchange.ca; the principal author of the report, David Paré, may be contacted via david.pare@geoexchange.ca or at +1 514 807 7559 ext 29.

Selected References

Andrushuk, Rob and Phil Merkel "Performance of Ground Source Heat Pumps in Manitoba." GeoConneXion Magazine, . pp. 17-18, Vol 3. No 2, Spring Summer 2009. Canadian GeoExchange Coalition, pub. Montréal, Canada.

Canadian GeoExchange Coalition, 2010. Comparative Analysis of Greenhouse Gas Emissions of Various Residential Heating Systems in the Canadian Provinces. Montréal, Canada.

Environment Canada. 2008, Canada's Greenhouse Gas Emissions: Understanding the Trends, 1990-2006 http://www.ec.gc.ca/pdb/ghg/inventory_report/2008_trends/trends_eng.cfm (Consulted May 2009)

Environment Canada. 2009a, National Inventory Report 1990-2007: Greenhouse Gas Sources and Sinks in Canada. Annex 13: Emissions Factors, Environment Canada's Greenhouse Gas Division, consulted before release by Library and Archives Canada, 713 p.

Environment Canada. 2009b, Canada's Offset System for Greenhouse Gases - Overview, 32 p. http://ec.gc.ca/creditscompensatoires-offsets/92CA76F4-7A25-42F4-A1E0-E8361655A09D/Offsets_Overview_June_11_final_e.pdf (Consulted June 2009)

Hanova, Jana. 2007, Environmental and techno-economic analysis of ground-source heat systems, The University of British Columbia, 78 p.

Intergovernmental Panel on Climate Change (IPCC). 2007, Working Group III Report - Mitigation of Climate Change.

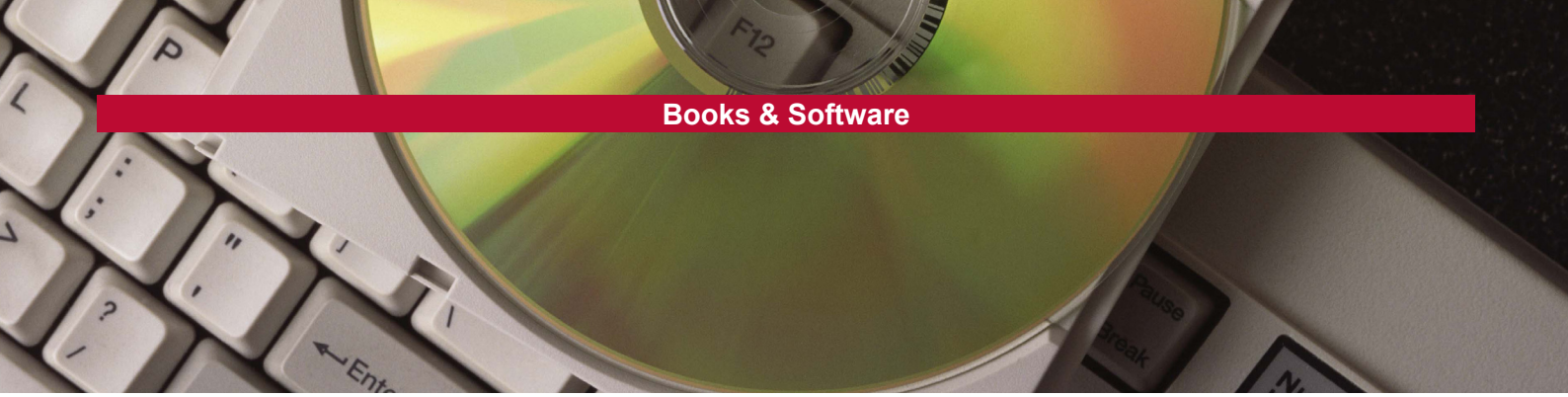
Office of Energy Efficiency. 2006a, Energy Use Data Handbook Tables (Canada). http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0 (Consulted May 2009)

Office of Energy Efficiency. 2006b, Comprehensive Energy Use Database Tables. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_ca.cfm?attr=0 (Consulted May 2009)

Natural Resources Canada. 2010, Oil-fired Forced-air Heating Systems. http://oee.nrcan.gc.ca/residential/personal/oil-forced-air-heating-systems.cfm?attr=4 (Consulted March 2010)

Statistics Canada. 2001, Natural Gas Transportation and Distribution, Catalogue No 57-205-XIB, 38 p. http://www.statcan.gc.ca/pub/57-205-x/57-205-x2001000-fra.pdf. (Consulted March 2010)

Author contact information
Canadian GeoExchange Coalition
1030, rue Cherrier, Bureau 405
Montreal, (Québec) H2L 1H9
Canada



Energy Technology Perspectives 2010 - to be released in July
The 2010 edition of the publication highlighting the most significant recent achievements of the IEA Implementing Agreements is now available in print.
Source: http://www.heatpumpcentre.org/en/aboutHPP/news/Sidor/ETI2010.aspx

Mechanical cooling guide
A mechanical cooling guide, describing the main refrigeration systems and the ways renewable forms of cooling energy can be used, has been published by BSRIA. The guide provides commissioning and maintenance guidance and design checks for each technology described.
Source: http://www.acr-news.com/news/news.asp?id=2103

Ground-source Heat Pump Systems for Heating, Cooling and Hot Water booklet
An introduction to ground-source heat pump systems, this booklet explains the basics about the different systems and how they work to save money and energy.
Source: http://www.igshpa.okstate.edu/publication/brochures_booklets.htm

Codes, standards and regulations in the Canadian geothermal heat pump industry.
The Canadian GeoExchange Coalition (CGC) is pleased to announce the publication of a summary report of a national consultation conducted last year to assess the effectiveness of codes, standards and regulations in the Canadian geothermal heat pump industry.

At the beginning of 2009, and after having analysed more than 4500 requests for certification of geothermal systems as part of the CGC's Global Quality GeoExchange Program, CGC personnel and accredited professionals identified several anomalies and weaknesses in the codes, standards and regulations affecting the geothermal industry in Canada. In the months following the implementation of its quality program, the CGC collected - and continues to identify - several contradictions in the current standards. There are also important omissions that slow, and sometimes wholly block, the introduction of new technologies in the market place. At the same time, officials from regulatory organisations and other public-sector parties, notably municipalities, are concerned about following the existing codes, standards and regulations.

In this context, and as part of its market transformation initiative and its efforts to consolidate the industry, the CGC organised a national consultation in June 2009, dealing with the regulatory issues affecting the geothermal industry in Canada. A total of seven intensive workshops was offered.
This report presents a summary of the seven workshops organized across Canada.
Source: http://www.geoexchange.ca/en/codes_standards_and_regulations_in_the_canadian_g_nw182.php

CGC releases comprehensive report on GHG emission reductions
The Canadian GeoExchange Coalition (CGC), Canada's national industry association for ground source heat pump technology, announces the release of a research report entitled "Comparative analysis of greenhouse gas emissions of various residential heating systems in the Canadian provinces".

The research document, the first of its kind, presents a comprehensive analysis of the specific and strategic role of geoexchange technology (ground source heat pumps) for the reduction of GHG emissions. The study's results demonstrate that geoexchange system installations are advantageous in every province, especially when they replace electric baseboard heaters or oil furnaces.
Source: http://www.geo-exchange.ca/en/gcg_releases_comprehensive_report_on_ghg_emission_nw178.php

ZeroCarbonBritain 2030:
A new Energy Strategy.
This report, by the UK's Centre for Alternative Technology, offers a road map for addressing carbon emissions in the UK. It argues that not only does the UK have a responsibility to take leadership in the international process of decarbonisation, but that it is possible to go beyond the national commitment to cut emissions by 80 % by 2050 compared to 1990. It proposes a 90 % reduction by 2030, which could be possible by applying heat pumps on a large scale and reducing F-gas emissions, among other measures.
http://www.hydrocarbons21.com/papers.view.php?Id=86

Online data of energy consumption for heat pump users - A German pilot project
A pilot project between electricity supplier "Yello Strom" and heat pump producer "Stiebel Eltron" has recently been set up in Germany in order to deliver a maximum of transparency for clients. Special software provides consumption data from a smart electricity meter (provided by Yello Strom) available to the user. It will show heat pump owners the concrete amount of energy consumed by their system, and also calculate running costs.
http://www.ehpa.org/news/article/online-data-of-energy-consumption-for-heat-pump-users-a-pilot-project-in-germany

2010

8-9 July
DENEX
Trade Fair and Conference for Decentralized Energy Systems and Energy Efficient Building and Renovation
Wiesbaden, Germany
http://www.denex.info/messe.html?&L=1

10-15 July
Purdue Compressor Engineering and Refrigeration and Air Conditioning Conferences and Short Courses
West Lafayette, USA
https://engineering.purdue.edu/Herrick/Events

12-15 July
20th International Compressor Engineering Conference at Purdue
IIR-co-sponsored, Commissions B1, B2, E1
West Lafayette, USA
E-mail: herlconf@ecn.purdue.edu
https://engineering.purdue.edu/Herrick/Events

14-16 July 2010
Energy Storage – Matching the supply and demand in future
ECES Workshop
Bad Tölz, Germany
http://www.energy-storage.org/energy-storage/news/workshop-2010.html

19-21 July
7th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2010)
Antalya, Turkey
http://www.hefat.net

8-11 August
2010 ICARHMA Annual Meeting
Portland, Oregon, USA
http://www.ahrinet.org/Pages/ShowMeMore.aspx?src=single&lpk=1315

15-18 August
IAQVEC 2010
Syracuse, New York, USA
http://www.iaqvec2010.org/

29 August - 2 September
13th Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction
Prague, Czech Republic
http://www.conferencepres.com

1-3 September
HVAC ASIA
Singapore, Singapore
http://hvacrseries.com/asia/2010/

14-18 September
JSRAE Annual Conference
Kanazawa University, Ishikawa, Japan
http://www.jsrae.or.jp/nenjitaikai/E/index.html

20-21 September
ICBP 2010 - International Conference on Building Performance
Berlin, Germany
http://www.eb-ing.com/icbp/index.asp?lang=1&divmain=

27-28 September
ATMOsphere 2010 - How to bring CO2 technology faster to market
Brussels, Belgium
http://www.atmosphere2010.com/

29 September-1 October
9th IIR Conference on Phase-Change Materials and Slurries for Refrigeration and Air Conditioning
Sofia, Bulgaria
http://www.iceslurry.org

30 September - 1 October
Road to Climate Friendly Chillers: Moving Beyond CFCs and HCFCs
ASHRAE UNEP Chiller Conference
Cairo, Egypt
http://www.ashrae.org/events/page/2614

13-15 October
Chillventa 2010
Nuremberg, Germany
www.chillventa.de

26-28 October
ICEBO 2010 - 10th International Conference for Enhanced Building Operations
Kuwait
www.icebo2010.org

26-28 October
AHR EXPO - Mexico
Mexico City, Mexico
http://www.ahrexpomexico.com/eng/

27-29 October
GREENEXPO - Alternative Energy 2010
Kyiv, Ukraine
http://www.greenexpo.kiev.ua/en/?pid=0

In the next Issue

ETP 2010
(Energy Technology Perspectives 2010)

Volume 28 - No. 3/2010

International Energy Agency

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

IEA Heat Pump Programme

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

Vision

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

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

Mission

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

IEA Heat Pump Centre

A central role within the programme is played by the IEA Heat Pump Centre (HPC). The HPC contributes to the general aim of the IEA Heat Pump Programme, through information exchange and promotion. In the member countries (see right), activities are coordinated by National Teams. For further information on HPC products and activities, or for general enquiries on heat pumps and the IEA Heat Pump Programme, contact your National Team or the address below.

The IEA Heat Pump Centre is operated by

SP Technical Research Institute of Sweden

IEA Heat Pump Centre
SP Technical Research
Institute of Sweden
P.O. Box 857
SE-501 15 Borås
Sweden
Tel: +46 10 516 50 00
Fax: +46 33 13 19 79
E-mail: hpc@heatpumpcentre.org
Internet: http://www.heatpumpcentre.org

heat pump centre

National team contacts

AUSTRIA
Prof. Hermann Halozan
Technical University of Graz
Innfeldgasse 25
A-8010 Graz
Tel.: +43-316-8737303
Fax: +43-316-8737305
Email: halozan@tugraz.at

CANADA
Dr Sophie Hosatte
Natural Resources Canada
CETC – Varennes
1615 Bd Lionel Boulet
P.O. Box 4800
Varennes
J3X 1S6 Québec
Tel.: +1 450 652 5331
E-mail: sophie.hosatte@nrcan.gc.ca

FINLAND
Mr Jussi Hirvonen
Chair of the Board
Finnish Heat Pump Association SULPU ry,
Tel: +358 50 500 2751
Email: jussi.hirvonen @ ivt.fi
Internet: www.sulpu.fi

Dr Arto Kotipelto - Alternate
Senior Technology Advisor
TEKES (Finnish Funding Agency for Technology and Innovation)
PO Box 266
Yrjönkatu 20
FI-28101 Pori, Finland
Tel: +358 44 712 4138
E-mail: arto.kotipelto@tekes.fi

FRANCE
Jean-Michel Parrouffe
ADEME
Service des Réseaux et des Energies Renouvelables
500 route des Lucioles
FR-06560 Sophia Antipolis

GERMANY
Prof. Dr.-Ing. Dr. h.c. Horst Kruse
Informationszentrum Wärmepumpen und Kältetechnik - IZW e.V
c/o FKW GmbH
D-30167 Hannover
Tel. +49-(0)511-16 74 75-0
Fax +49-(0)511-16 74 75-25
E-mail: email@izw-online.de

Prof. Dr.-Ing. H.J. Laue - Alternate
Informationszentrum Wärmepumpen und Kältetechnik - IZW e.V.
Unterreut 6
D-76 135 Karlsruhe
Tel.: +49 721 9862 856
Fax: +49 721 9862 857
E-mail: laue.izw@t-online.de

ITALY
Dr Giovanni Restuccia
Italian National Research Council
Institute for Advanced Energy Technologies (CNR – ITAE)
Via Salita S. Lucia sopra Contesse
5 - 98126 Messina
Tel.: +39 (0)90 624 229
Fax: +39 (0)90 624 247
E-mail: giovanni.restuccia@itae.cnr.it

Dr Angelo Freni - Alternate
Italian National Research Council
Institute for Advanced Energy Technologies (CNR – ITAE)
Via Salita S. Lucia sopra Contesse
5 - 98126 Messina
Tel.: +39 (0)90 624 229
Fax: +39 (0)90 624 247
E-mail: angelo.freni @ itae.cnr.it

JAPAN
Mr Makoto Tono
Heat Pump & Thermal Storage Technology Center of Japan
1-28-5 Nihonbashi Kakigara-Cho Chuo-Ku,
TOKYO 103-0014
Tel: +81-3-5643-2404
Fax: +81-3-5641-4501
E-mail: tono.makoto@hptcj.or.jp

NETHERLANDS
Onno Kleefkens
Agentschap NL
Divisie NL Energie en Klimaat
P.O. Box 8242
Croeselaan 15
3521 BJ Utrecht
Tel: +31 30 2393 449
Fax: +31 30 2316 491
E-mail: onno.kleefkens@agentschapnl.nl

NORWAY
Mr Bård Baardsen
NOVAP
P.O. Box 6734, Rodeløkka
N-0503 Oslo
Tel. +47 22 80 5006
Fax: +47 22 80 5050
E-mail: baard.baardsen@rembra.no

SOUTH KOREA
Mr Seong-Ryong Park
Korea Institute of Energy Research
Department of Renewable Energy
71-2, Jang-dong, Yuseong-gu, Daejeon
Republic of Korea 305-343
Tel.: +82 42 860 3224
Fax: +82 42 860 3133
E-mail: srpark@kier.re.kr
http://www.kier.re.kr/eng/index.jsp

SWEDEN
Ms Emina Pasic (Team leader)
Swedish Energy Agency
Energy Technology Department
Bioenergy and Energy Efficiency Unit
Kungsgatan 43
PO Box 310
SE-631 04 Eskilstuna
Tel.: +46 16 544 2189
emina.pasic@energimyndigheten.se

SWITZERLAND
Dr Thomas Kopp
Hochschule Rapperswil
On behalf of the
Swiss Federal Office of Energy
Energy Renewable Division
Oberseestrasse 10
8640 Rapperswil
Tel.: +41 55 222 4923
E-mail: tkopp@hsr.ch

USA
Ms Melissa Voss Lapsa
Oak Ridge National Laboratory
Engineering Science and Technology Division
Bethel Valley Road
PO Box 2008
Oak Ridge, TN 37831-6054
Tel.: +1-865-576-8620
Fax: +1-865-576-0279
E-mail: lapsamv@ornl.gov