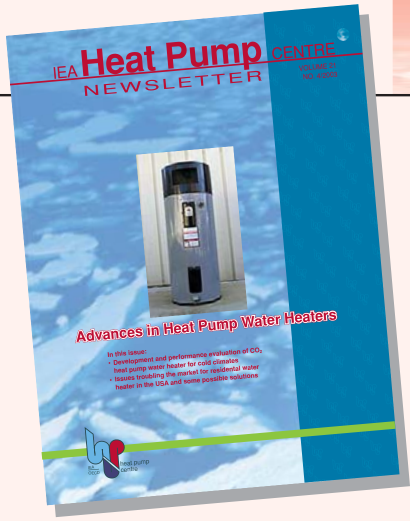
IEA Heat Pump CENTRE
NEWSLETTER

VOLUME 21
NO. 4/2003

Advances in Heat Pump Water Heaters

In this issue:
- **Development and performance evaluation of CO_2 heat pump water heater for cold climates**
- **Issues troubling the market for residental water heater in the USA and some possible solutions**

IEA
OECD
heat pump
centre



Front cover: Residential heat pump water heater

In this issue

Advances in heat pump water heaters

This newsletter focuses on heat pump water heaters. The heat pump water heater technology has encountered different kinds of problems. These problems have been solved and further research into this technology has resulted in the development of improved types of heat pump water heaters.

COLOPHON

Copyright:
Any part of this publication may be reproduced, with acknowledgement to the IEA Heat Pump Centre, Sittard, the Netherlands.

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 here in;
- 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 Dutch law.

Publisher:
IEA Heat Pump Centre
PO Box 17, 6130 AA Sittard
The Netherlands
Tel: +31-46-4202236, Fax: +31-46-4510389
E-mail: hpc@heatpumpcentre.org
Internet: http://www.heatpumpcentre.org

Editor in chief: Jos Bouma
Technical editing: Mohini Keunen - IEA Heat Pump Center, Eli Birnbaum, Jac. Janssen, Derix**Hamerslag*
Production: Patricia Bouts and de Vormgeverij, Meerssen

Frequency: quarterly

HEAT PUMP NEWS

FEATURES

TOPICAL ARTICLES

NON-TOPICAL ARTICLES

Fourteen years of progress

Contrary to what may be expected from the title, I am not a person who tends to look back at milestones and achievements. I prefer to look ahead and explore new ways and opportunities. Heat pumping technologies are no exception.

The theme of the final newsletter produced by Novem - Advances in Heat Pump Water Heaters - is indicative of where heat pump technology stands today. The majority of heat pump water heaters currently on the market are not good enough in terms of energy efficiency. The new generation water heaters ready for implementation uses carbon dioxide technology. Fascinating progress has been made by the heat pump industry in improving energy efficiency. Industry has demonstrated that it is able to develop advanced and safe products and equipment within a limited period of time. That gives confidence for badly needed additional heat pump technology improvements. Minimum energy efficiency regulations and market share are extremely important drivers for boosting the use of advanced technologies, but more should be done, notably by policy makers.

In "our" field there is still a tremendous potential left both market and technology-wise. Heat pump markets are developing positively, even in heating-mainly regions such as western, central and northern Europe. Heat pumps are gradually getting rid of their 'exotic' image. But a long way with plenty of impediments is still ahead of us.

Today's heating COPs of heat pumps range from 2.5 to 5.0 with a few installations reaching more than 6.0. But further improvements are envisaged, increasing the energy-related CO_2 emission reductions.

The future of heat pump technology in new buildings is in integrating active building components and heating/cooling/ventilating functions. Heat pump technology could and should not only be wider applied in buildings in an intelligent manner, but also in process industry. No longer should large amounts of waste heat from processes be rejected to the environment. Beginning at installation level, processes should be improved to produce less waste energy. Integrated heat pump technology could play an important role in process improvement. Sustainable industrial production is only at the beginning and the time is ripe for a renewed interest in industrial heat pumps.

There is one more challenge: to increase the level of sustainability of heat pumps by developing fully renewable solutions, both in driving energy and refrigerants applied. When this is achieved, heat pumps will be accepted and qualified as a true renewable energy technology and appear together with solar thermal and bioenergy in the agenda and minds of politicians.

On behalf of the entire staff of the HPC at Novem, I like to express our gratitude for having been part of an important process: the advancement of heat pump technology and international heat pump markets, but also the accelerated acceptance of heat pumps as an intelligent solution to energy and environmental challenges in buildings and industrial processes. We thank the contributors and readers of the Heat Pump Magazine for their confidence and wish the HPC staff at SP in Sweden inspiration, innovation and above all, perseverance.

Jos W.J. Bouma
Novem
Sittard, The Netherlands

Heat pump news

General

Clear Skies scheme grants offered

UK - The DTI (Department of Trade and Industry) funded and BRE (Building Research Establishment) managed "Clear Skies" renewable energy grant scheme, has offered over 1,287,742 Euro in grants to a range of not-for-profit community organizations during the second round of applications. In total nearly 2 million Euro has been awarded since July this year for community organizations, this is in addition to 578,803 Euro awarded to households.

Of the 40 grants offered, 6 include ground-source heat pumps. In addition, the grant scheme provides grants of 1,736 Euro to households for individual ground-source systems that meet the scheme's requirements. Over 30 such grants have been offered so far. Although a relatively small number, this is very significant relative to the existing size of the market.

More information: http://www.clear-skies.org

Anti-Global Warming Tax necessary in Japan

Japan - On 29 August, 2003, Japan's Ministry of the Environment released a detailed report that describes an environmental (anti-global warming) tax system. The report proposes to introduce the tax in fiscal year 2005, with a view to reducing greenhouse gas emissions.

The tax would be levied on all fossil fuels, including petroleum, coal and natural gas, and the tax rates would vary depending on the amount of carbon contained in each type of fuel. The report also says that raising the price of fossil fuels will help discourage their consumption and contribute to the development of alternative energy sources and new environment-related technologies. The Ministry estimates that this will cut greenhouse gases by two percent.

The Ministry of the Environment has invited public comment on the report.

The tax plan is expected to have a rough passage.

Source: http://www.japanfs.org/db/database.cgi?cmd=dp&num=451&UserNum=&Pas=&AdminPass=&dp=data_e.html

Europe Climate Change Programme

On June 12, 2003, the European Commission's Environment Directorate-General made proposals to phase-out stepwise HFC-134a in mobile air-conditioning through an annual transferable quota scheme until the final 2012 cut-off date (see http://europa.eu.int/comm/environment/climat/eccp_stakeholder_letter.pdf). According to the information provided in this report, the Commission is currently finalizing its legislative proposal, a Regulation on Fluorinated Gases and an explanatory memorandum with adoption by the Commission envisaged in the third quarter of 2003. The new regulation could enter into force in July 2004.

Consult a complete file on ECCP in the Regulations/Standardization section of the IIR website, http://www.iifiir.org/1enreglementation.asp.

Source: IIR, August 2003

Efficiency of ice thermal storage questioned

Washington – At the 21st IIR Congress the results of a theoretical analysis of the energy efficiency of a commercial combined heat pump ice thermal storage unitary air conditioner for an average office building in Tokyo were presented. The investigators from Japanese universities concluded that the cooling mode operation using nighttime ice thermal storage is not energy saving in comparison with the conventional, ie non-storage, cooling mode.

In addition they made measurements under even cooling loads at a Tokyo-based office building. The power consumption of an ice thermal storage unitary air conditioner and its non-storage equivalent were measured and it could be demonstrated that the storage system consumed 55% more energy than the non-storage type. The reason is the low COPs in the nighttime during ice-production. They concluded that the ice thermal storage system does not contribute to energy conservation and CO_2 emission reduction, but it does reduce peak electricity demand in summer.

Source: Toshihiko Fujita et al. Energy Consumption of Ice Thermal Storage Unitary Air Conditioner. Proceedings 21st IIR Congress, Washington.

Technology & Applications

Heat pumps for smoking and drying fish

Netherlands - For the drying and smoking of fish, fish food producer M. de Groot & Zoon BV in Volendam, the Netherlands, changed from applying traditional technology to heat pumps. Usually gas and electricity are used for processing. A new, subsidized concept for drying fish using heat pump technology was developed in collaboration with Dutch specialists in system technology and system control. Moist air in the drying chambers is used as the heat source. The recovered heat is used to preheat the drying air. Refrigerant evaporates at 5 ºC and condenses at 42 ºC. The advantages of using heat pumps are a nearly doubling of the production capacity, a substantially reduced drying time, energy saving and increased safety.

More information: J.G.B. Fransen,
TNO-MEP
Tel: + 31 055 549 3493

Source: http://www.senter.nl/asp/page.asp?id=i001341&alias=energiebesparing

Sewage water source heat pump in Tokyo

Japan - The Koraku Pumping Station, managed by Tokyo's Bureau of Sewage, is equipped with the nation's first community heating and cooling system utilising untreated wastewater at its environment-friendly wastewater treatment plant. The system serves an area of 21.6 hectares around the plant.

Sewage water is stable in volume and its temperature is lower in summer and higher in winter than the air temperature. By applying a heat pump, the system can reduce energy demand by 40 percent, emissions of nitrogen oxide and carbon oxide by 52 percent, and sulphur oxide by 65 percent. The system also effectively conserves water because it does not use a cooling tower.

The Bureau of Sewage has been using untreated wastewater for heating and cooling purposes at its 12 waste water treatment facilities across Tokyo since a building-based air conditioning system using sewage was first introduced at the Ochiai Wastewater Treatment Plant in January, 1987.

Source: http://www.japanfs.org/db/database.cgi?cmd=dp&num=427&UserNum=&Pass=&AdminPass=&dp=data_e.html

Home Network Systems

Japan –Japanese building equipment manufacturers have announced and introduced their home appliances networking systems. Leading manufacturers of air conditioning appliances have introduced products capable of responding to the wireless network systems. This enables most building equipment to be operated from a remote place by use of a mobile phone, or exclusive terminals. Japanese home appliance manufacturers seem to have positioned the home network system as a strategic product for revamping their home appliance business.

Source: JARN Vol. 35. No. 9 (2003)

Combined Steam Injected Gas Turbine Heat Pump System

Netherlands - A system study has been conducted into the feasibility of a Steam Injected Gas Turbine (STIG) combined with a heat pump. The heat pump operates as a medium-size heat generating station. The thermal efficiency of the STIG improves if combined with an open type absorption heat pump. Because the heat distribution network is of small size, there will be an additional economic benefit.

More information: R.L. Cornelissen
Cornelissen Consulting Services
Tel: + 31 348 486 848
E-mail: info@ccs.nl

Source: Stromen, no 15 (Dutch)

Europe's biggest retrofit absorption chiller

Germany – Early 2004 a 5 MW two-stage water lithium-bromide absorption chiller will begin operation at the Ulm Technical University in Germany. The absorption chiller, which is manufactured in China, is driven by hot wastewater at 180 °C from a bio energy-fired co-generation plant. The absorption chiller replaces a 4 MW turbo chiller dating from 1978. The bio energy-based tri-generation installation is believed to be the largest in size in Europe, if not worldwide.

Source: CCI Print, 11/2003 (German)

Markets

Gas engine heat pump air conditioning

Japan – In the summer of 2003, air conditioning using a gas-engine heat pump (GHP) system with multiple air conditioners has seen growing attention in the Japanese market. Japanese and foreign manufacturers have announced GHP air conditioning that can reduce the economic burden on users, thus widening the application to large buildings including apartment buildings, hospitals and schools. As a result, GHP systems in the domestic air conditioning market are beginning to rival with electric heat pump systems.

Source: JARN, 2003, Vol. 35, no 8.

Norwegian heat pump sales boom

Norway - The yearly statistic from the Norwegian Heat Pump Association (NOVAP) show that sales increased more than 200 percent from 2001 to 2002 (**Figure 1**). Total sales where approximately 21,300 units, up from 6,300 in 2001. Outside air split units are over 90 percent of total sales.

A major reason for increased sales are higher electricity prices in the Nordic energy market. A substantial part of the production in this market is hydropower and periods with cold and dry weather are resulting in higher prices.

Including the heat pump sales in 2002 there are now approximately 58,300 heat pumps installed in Norway. The total heat production from installed heat pumps was 428 GWh in 2002 and the net gain compared to direct heating with electricity was 276 GWh.

With subsidies from the government and high energy prices NOVAP expect that the increase in sales will continue in 2003. With this booming market many new and less experienced players have entered the market. Also many new products have been introduced in the market during the last year. There is great uncertainty and concern how these new heat pumps will function in the severe Nordic climate.

Source: Norwegian Heat Pump Association(NOVAP)

http://www.novap.no

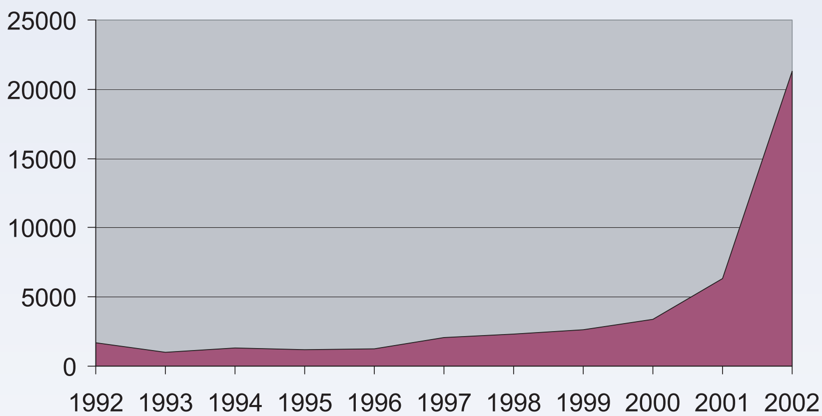


Figure 1: Heat pump sales in Norway 1992 - 2002.

Working fluids

NH_3/CO_2 cooling systems

Netherlands - The first industrial installation operating with CO_2 as refrigerant has been implemented last year in a NH_3/CO_2 cascade system. Fourteen additional installations are on the way to be implemented, or in use. Industrial end-users chose for CO_2 because of the safety and the environmental aspects. Safety is improved compared with ammonia.

More information: Refrigerant & Climate Control/Koude & Luchtbehandeling, June 2003 (Dutch)

http://www.robklimaat.nl

Black market CFCs

US - The black market for CFCs is huge. In spite of the prospect of up to 5 years in prison and fines of up to USD 250,000.- unscrupulous US operators of air conditioning equipment, particularly automobile air conditioning units, are buying CFCs from "frio banditos" based in Mexico, where CFCs will remain legal until 2010. Various organizations are reminding the unscrupulous of the penalties and potential damage to vehicles caused by poor-quality refrigerants. The Environmental Investigation Agency has highlighted the fact that new EU legislation curbs recycling of ozone depleting substances (ODS) for export but does not address the production of virgin ODS which, although theoretically manufactured for use in Article-5 countries, may in reality be hard to track.

More information:
http://www.airah.org.au/news_108.html
http://www.bbb.org/library/freon.asp
http://www.epa.gov/ozone/enforce/blackmkt.html
http://www.eiadb.org/campaigs

Source: IIR
http://www.iifiir.org

International Seminar on Natural Refrigerants

Japan – An international seminar on Natural Refrigerants will be held in Tokyo on February 5, 2004. The seminar is chaired by Prof. Eiji Hihara with English as the official language. This seminar focuses on the latest technology, international standards, market trends, and further prospects for natural refrigerants in the world. Four lectures Carbon Dioxide Technology in Europe, by Petter Nekså, SINTEF Energy Research A.S., Norway.

1) Research and Development of Carbon Dioxide Technology in Europe, by Petter Nekså, SINTEF Energy Research A.S., Norway.
2) The Use of Natural Fluids in Refrigeration and Heat Pump Systems in Europe, by Kim Christensen, Danish Technological Institute, Denmark.
3) Transcritical Carbon Dioxide Systems—Challenges and Recent Achievements, by Predrag Hrnjak, University of Illinois at Urbana-Champaign, USA.
4) Research and Development of Natural Refrigerant Technology in Japan, by Eiji Hihara, The University of Tokyo, Japan.

The seminar is organized and sponsored by the School of Frontier Sciences, The University of Tokyo (UT), and by the Heat Pump & Thermal Storage Technology Center of Japan (HPTCJ).

This seminar is planned as part of a two-day event. On February 6, the seminar will continue with lectures in Japanese. In addition, this seminar has been tied in with the HVAC&R JAPAN exhibition at Tokyo International Exhibition Center from February 3 to 6, 2004.
The venue of the seminar is Sanjio Conference Hall, The University of Tokyo at Hongo campus.

More information: Dr. Jianfeng Wang (jfwang@k.u-tokyo.ac.jp), or Dr. Xiaomei Li (Li@hptcj.or.jp).

Source: Japanese National Team (HPTCJ)

IEA Heat Pump Programme

Annex 29 approved

At the spring meeting in Borås, Sweden, the Executive Committee approved Annex 29, a project on advanced ground-source heat pumps. The overall objective of the Annex, with the title "Ground-Source Heat Pumps – Overcoming Market and Technical Barriers" is to investigate opportunities and identify solutions that could improve the performance and market attractiveness of ground-source heat pump systems, and to demonstrate their economic and environmental benefits. Work in the Annex will include analyzing options for performance improvement and cost reduction, identifying market barriers, improving acceptance by quality guarantee measures, heat supply contracting models etc. The Operating Agent will be either Austria or Sweden.

8th IEA Heat Pump Conference 2005

The dates for the next IEA Heat Pump Conference have been fixed at 30 May-2 June 2005. The venue will be the well-known Ceasars Palace hotel in Las Vegas, Nevada, USA.

The goal of the conference is to promote the worldwide implementation and improvement of heat pump technologies via exchange and discussion of technical, market, policy and standards information with respect to the environmental and energy-conserving benefits of these technologies. While the conference programme has not been set, session themes will be Technology, Systems, Applications, Policy/Standards/Market Strategies, Markets and International Activities.

In line with the tradition of the IEA Heat Pump Conference, speakers will be invited. However, there will also be a call for papers and additional speakers will be selected from these papers. A poster session will complete the papers programme.

Tentative deadlines: 1 April 2004 for Abstracts (200-300 words) and 1 December 2004 for full Papers.

Abstracts should be submitted to the appropriate Regional Coordinator listed below:

- North and South America: Mr Gerald C. Groff (fax: +1 315 655 2748; e-mail: gcgroff@worldnet.att.net)
- Europe and Africa: Mr Jos W.J. Bouma (fax: +31 46 4510389; e-mail: j.bouma@novem.nl)
- Asia, Australia and Pacific Regions: Mr Takeshi Yoshii (fax: +81 3 5641 4501; e-mail: yoshii@host2.hptcj-unet.ocn.ne.jp)
- China: A National Coordinator for China will be appointed.

The conference will offer space for exhibitors. More information can be obtained from:
The Conference Secretariat
Oak Ridge National Laboratory (ORNL)
P.O.Box 2008, MS-6189
Oak Ridge, TN 37831
Tel: +1 865 576 8620
Fax: +1 865 574 9331
E-mail: lapsamv@ornl.gov
Conference Internet Site:
http://www.ornl.gov/hpconf (not active)

Annex 28 liaison with CEN

Standards Group CEN/TC 113 – Heat pumps and air conditioning units – has decided to initiate a formal liaison between the Heat Pump Programme/ Annex 28 and CEN/TC 113.

Annex 27 completed

Norway – SINTEF Energy Research, the Operating Agent for Annex 27 (Selected Issues on CO_2 as a Working Fluid in Compression Systems), announced completion of the project.

Liaison with IIR

Formal representatives of the IEA Heat Pump Programme to IIR Commissions B and E have been appointed. For Commission B1/B2: Mr Peter Rohlin of STEM, Sweden; for Commission E1: Prof. Hermann Halozan of Graz University, Austria; for Commission E2: Mr Rune Aarlien of SINTEF Energy Research, Norway (contact information can be found on the back cover).

From 1 January 2004, the HPC can be contacted at SP - Swedish National Testing and Research Institute
Industrigatan 4
Box 857,
SE-501 15 Borås,
Sweden
Tel: +46 3316 5000
(Monica Axell)
Fax: +46 3313 1979
http://www.sp.se

Ongoing Annexes

Red text indicates Operating Agent.

Annex 25 Year-round Residential Space Conditioning and Comfort Control Using Heat Pumps	25	FR, NL, UK SE, US
Annex 27 Selected Issues on CO_2 as a Working Fluid in Compression Systems	27	CH, JP, NO, SE, UK, US
Annex 28 Test Procedure and Seasonal Performance Calculation for Residential Heat Pumps with Combined Space Heating and Domestic Water Heating	28	AT, CA, CH, DE, FR, JP, NO SE, US, UK

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

Development and performance evaluation of CO_2 heat pump water heater for cold climates

Hiroshi Mukaiyama, Japan

The hot water supply system described here is based on an air-source heat pump utilizing CO_2 as refrigerant. The system is optimized for use in cold climates and can provide a heating capacity of 4.5 kW at ambient temperatures as low as -20°C. Technical data is presented for the CO_2 compressor and the heat pump system, and performance data are given based on field test.

Introduction

Sales of heat pump water heaters equipped with CO_2 compressors have steadily increased ever since their release on the Japanese market in 2001. As CO_2-based heat pump water heaters are still expensive (over USD 5,000), government subsidies were introduced to help promote sales. The demand for CO_2 heat pump water heaters then increased dramatically, with the entire budget for the subsidies being exhausted between June and August of 2003.

The CO_2 heat pump water heaters currently being marketed in Japan can be divided into 16 types based on function, heating capacity, tank capacity, and regional suitability. Products are available that are suitable for various uses. But until now, in cold climates where the daily peak ambient temperature stays below 0°C for days at a time, heat pumps have not found much use. This is because the efficiency and heating capacity of conventional air-source heat pumps drops considerably at such low temperatures. As a result, kerosene boiler heaters and electric heaters are still the dominant players in such regions.

In recent years, however, the development of low-cost and highly efficient air-source heat pumps has created new possibilities. Against this background, we developed a system for providing hot water in cold climates that makes use of an air-source heat pump and takes advantage of the excellent properties of CO_2 as a refrigerant. The system developed works well even at ambient temperatures as low as -20°C.

The CO_2-based heat pump systems for cold climates currently on the market can only be used for heating water and not for space heating. The technical information provided in this paper should make it clear that this technology can also be adapted for cold climates to provide space heating as well.

Development of CO_2 compressor for use in cold climates

We have been conducting field tests of CO_2 heat pump water heaters since 2001 in Sapporo and four other major cities in Japan's coldest region, Hokkaido. **Figure 1** shows ambient temperature data for Asahikawa city, which is representative of Japan's cold regions. During midwinter, temperatures often drop below -20°C and the daily maximum temperature often remains below 0°C.

The T-h diagram (**Figure 2**) presents data obtained for the water heater when operating at an ambient temperature of -21°C. As the evaporating temperature

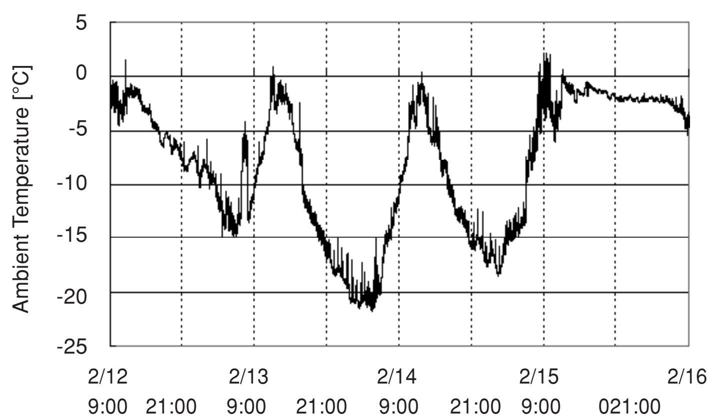


Figure 1: Ambient temperature data for Asahikawa city.

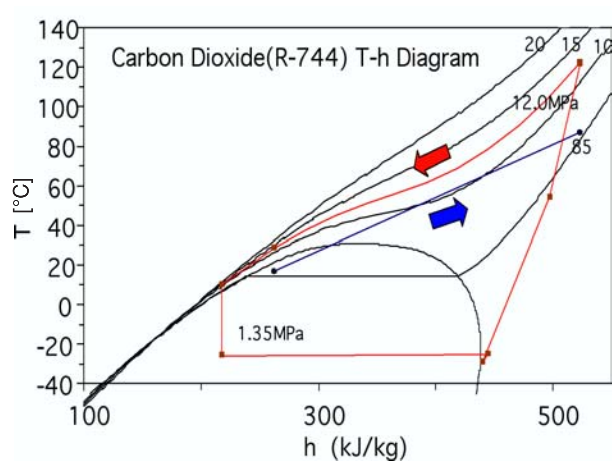


Figure 2: Example of data obtained when the hot water heater was operating in an ambient temperature of -21°C.

drops to -25°C, the compression ratio of the compressor increases approximately nine-fold while producing hot water of 85°C.

When operating the compressor at such a high compression ratio, the torque on the crankshaft fluctuates, and compression efficiency decreases due to the flow of refrigerant leaking from high to low pressure zones. The noise and vibration generated in the process is a prominent problem. To deal with this, the compressor for the two-stage compression system was designed so that the ratio in the pump of the first stage displacement to the second accommodates colder climate specifications (**Figure 4**).

Figure 3: Vessel design.

Table 1 compares the CO_2 compressor specifications for a CO_2 heat pump water heater sold in a temperate climate like Tokyo with that of the cold climate version. As can be seen, the first stage of the CO_2 compressor was designed a bit larger than its temperate climate counterpart.

Under operating conditions like those in **Figure 2**, the COP drops to 50% of the value at 15°C. To deal with this, a high-output motor is used to maintain the rated heating capacity of 4.5 kW during operation at -20°C. The motor is an intensive-winding DC brushless motor with the winding coils wrapped directly around the core. It is much more compact than the distributed winding DC brushless motor. Even though a high output motor is used, the dimensions of the compressor are identical with those of the temperate climate version, as seen in **Table 1**.

Table 1: Specifications of the CO_2 Compressor

Rated Power	900W	1100W
Compressor Model	C-CV93H	C-CV113H
Application	for temperate climate	for cold climate
Water Heating Capacity	4.5kW	4.5kW
Compressor Type	hermetic-type 2 rolling-piston & 2-stage compression	
Design Pressure	11 MPa	
Displacement ($1^{st}/2^{nd}$)	2.9/1.9	3.3/1.9
Motor Type	DC brushless motor (inverter driven)	
Revolution Range	30 - 120 s^{-1}	
Dimensions	diameter 118mm height 217mm	
Weight	9.3kg(with oil)	

CO_2 heat pump water heater for use in cold climates

Table 2 and **Figure 3** present the specifications and external appearance of the heat pump water heater with CO_2 compressor for cold climates. The system is divided into the outdoor unit and the indoor water tank unit, which are connected by refrigerant piping. The outdoor unit consists of the compressor and evaporator; the water tank unit consists of the water/refrigerant heat exchanger that produces the hot water and the tank that stores the hot water. In contrast, most models commercially available in Japan have the tank unit and the heat pump unit connected by hot water piping, and the water/refrigerant heat exchanger that produces the hot water is placed together with the outdoor (heat pump) unit. However, if such systems are installed for use in cold climates, measures to prevent freezing (such as the addition of an electric heater or circulating the hot water) become necessary. This uses up power, as well as introducing a risk that the connecting pipes will freeze or crack due to unforeseen events such as blackouts.

Figure 4: CO_2 heat pump water heater.

The refrigerant pipe connection system presented in this paper is economical because it does not need power for defrosting, and it is reliable because there is no danger of the pipe cracking due to freezing.

Table 2: Specifications of the CO_2 Heat Pump Water Heater

System	rated voltage	single phase, AC200V
	maximum current	17.5A
	frequency	50/60Hz
Storage tank unit	tank capacity	370 liter
	maximum working pressure	170kPa
	dimensions	height 2055—width 610 diameter 750mm
	weight	102kg
	power consumption	78/86W
	hot water temperature	max. 90°C
Heat pump unit	dimensions	H620—W930—D29 0mm
	weight	52kg
	refrigerant	carbon dioxide
	(rated heating capacity)/ (input electric power)1	4.5kW/1.24kW
	(rated heating capacity)/ (input electric power)2	4.5kW/1.14kW
	(rated heating capacity)/ (input electric power)3	4.5kW/1.34kW
	(rated heating capacity)/ (input electric power)4	4.5kW/1.78kW
	(rated heating capacity)/ (input electric power)5	4.5kW/2.51kW
	operating noise	45dB 40dB at midnight

JRA reference operating conditions :
1 Outdoor temperature (DB/WB) 16/12°C, Water temperature 17°C, Hot water temperature 65°C
2 Outdoor temperature (DB/WB) 25/21°C, Water temperature 24°C, Hot water temperature 65°C
3 Outdoor temperature (DB/WB) 7/4°C, Water temperature 9°C, Hot water temperature 65°C
4 Outdoor temperature (DB/WB) 7/6°C, Water temperature 9°C, Hot water temperature 85°C
5 Outdoor temperature(DB) -20°C, Water temperature 5°C, Hot water temperature 85°C. Only this operating condition is not JRA reference operating condition
DB: dry bulb; WB: wet bulb

Performance of CO_2 heat pump

Figure 5 shows the heating capacity of the CO_2 heat pump water heater and the results of COP measurement. The heating capacity of 4.5 kW can be maintained by controlling the revolutions of the compressor with the inverter, even when the ambient temperature decreases. Moreover, a COP of approximately 1.7 was obtained even at an ambient temperature of -20°C.

The average annual COP is expected to be over 3.0 in Tokyo, where the average annual ambient temperature is 16°C, and approximately 2.5 in Sapporo, where the average annual ambient temperature is 8°C. When compared to electric heater type water heaters, the system described here can reduce running costs by 60% even when installed in cold climates.

In Japan, late night power rates are set to approximately one third of daytime rates in order to level out power consumption. By using inexpensive power late at night, it is possible to run the system described here economically even when compared to fuel-based water heaters that use the cheapest per-calorie fuel available: kerosene. Based on Japanese kerosene prices and late night power rates, the minimum average annual COP value of the heat pump water heater that provides the greatest benefit in terms of running costs is 1.8.

Figure 6 shows the results obtained from monitoring the amount of heat used (mainly kitchen and bathroom) by a household (two adults, two children) using a heat pump water heater. The amount needed was found to be 10-15 kWh/day when calculated over a period spanning winter to summer. With a capacity of 370 liters, the storage unit stores hot water at over 75°C, and therefore can cover one day's hot water supply by operating once late at night. But the amount of hot water remaining in the tank is continually monitored and the heat pump is also designed to operate at daytime rates as well, to prevent the hot water supply from running out in the event that an excessive amount is used.

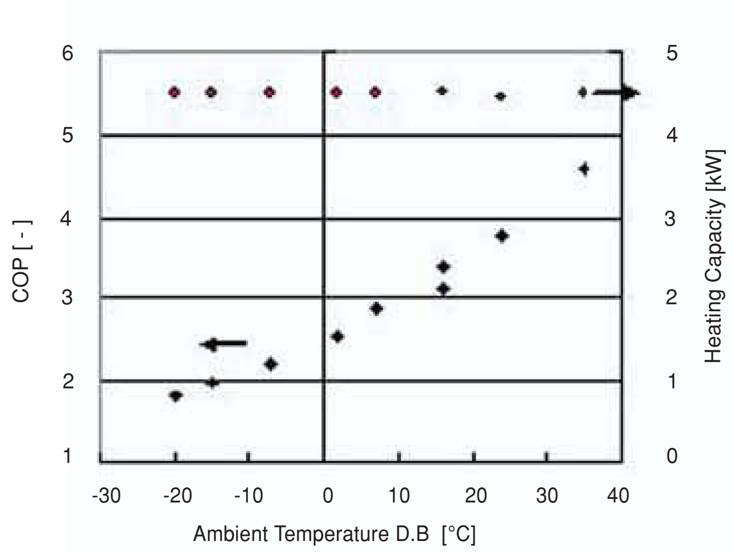


Figure 5: The performance of CO$_2$ heat pump water heater.

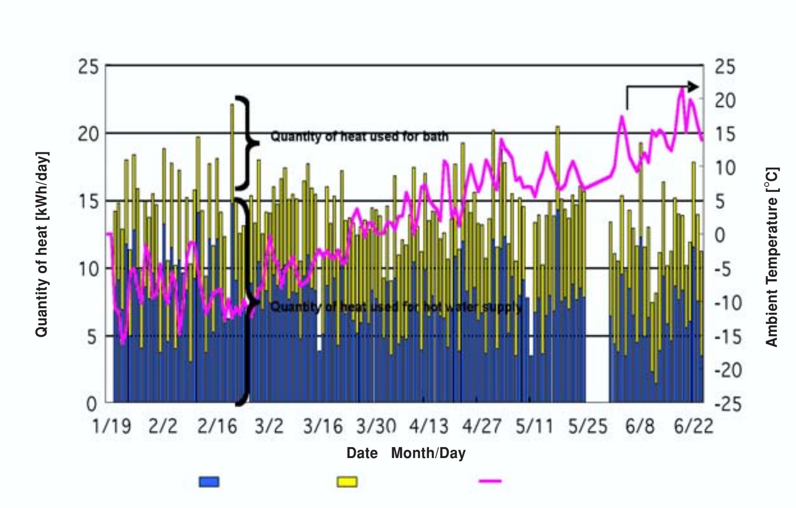


Figure 6: Example of the results obtained from monitoring the amount of heat used by household (two adults, two childeren) using a heat pump water heater.

Basic functions of the CO$_2$ heat pump water heater

CO$_2$ heat pump water heaters sold in Japan are of the storage type that store the hot water produced with cheap late night power in a tank. The temperature of the water stored in the tank is 85°C during winter when the temperature of unheated tap water is low (5-9 ºC), 65°C during summer when it is relatively high (17-24 ºC), and 75°C for the period in between. The quantity of heat necessary to heat water is regulated according to the temperature of the tap water.

The temperature of the hot water supply to the bathtub can be set by remote control to anywhere between 36°C and 48°C, or even 60°C by combining it with cold water at the mixing valve. 'Full Auto' types can be operated by a remote control to fill the bathtub with hot water, and stop at the preset water level. They automatically raise the temperature when the water cools, and add water when the water level drops. The remote control is set in the kitchen and bathroom, and displays information such as the tank level, tank temperature, water temperature, and bath temperature. It also displays water temperature settings, bath temperature settings, and automatic bath functions

Summary

Recent technological developments in CO$_2$ heat pump water heaters allow them to reliably provide adequate heat in cold climates with ambient temperatures as low as -20°C. It is now possible for air-source heat pumps to be used in frigid climates that were previously unsuitable for the use of conventional heat pumps. We believe that water heaters of the type described here will become more widely used because the running costs are competitive - even in cold climates - when compared with kerosene-powered water heaters that run on cheap fuel.

Mukaiyama Hiroshi
Ecology and Energy Systems Development Center
Technology R&D Headquarters
SANYO Electric Co., Ltd.
1-1-1, Sakata, Oizumi-Machi,Ora-Gun,
Gunma 370-0596, Japan
E-mail: h-mukaiyama@rd.sanyo.co.jp

Issues troubling the market for residential heat pump water heaters in the USA and some possible solutions

Titu R. Doctor, Russell K. Johnson and Robert Stone, USA

This article is based on two previous papers - the first presented by Titu R. Doctor ('New concepts in residential HPWH technology') at the Residential heat pump water heater technology and markets meeting in Portland, Oregon, USA, on December 4, 2002, and the second by Russell K. Johnson and Robert Stone ('The ideal HPWH – a wish-list') at the June 2002 ASHRAE meeting. It addresses the historical lack of success enjoyed by heat pump water heaters (HPWHs) in the USA market, explains some of the major issues involved, and presents some possible solutions **(Figure 1).**

The USA market

In the 1980s, about 20,000 HPWHs were sold in the US every year. Over the last three years, sales have averaged only 2,000 to 4,000 units per year, and most of these recent sales were to a single electric utility customer. What happened?

In our opinion, the HPHW technology offered did not adequately take into account market demands and consumer preferences in the US, as explained below.

Problems and possible solutions

Problem: In the early years of development and sales, residential HPWHs were sized so that they would provide water heating for the home at the same rate as the customer's electric water heating elements – about 4,500 W (i.e. 15,000 Btu/h). It was assumed that the HPWH had to be equal in heating capacity to the (typically) 4,500 W elements in the electric water heater, to match its recovery rate and to avoid increasing the possibility of hot water runouts (i.e. periods when the hot water was not hot enough).

Solution: By lowering the heating capacity of the HPWH (e.g. to 4,000 to 8,000 Btu/h, equivalent to an electric element of 1.1-2.3 kW), it can become smaller and less expensive. Modern controls can integrate the tank's electric heating elements into its operation, while ensuring that these elements are used only sporadically for peak-use backup. The tank's storage volume is more important than the heating rate in preventing hot water runouts.

Problem: Designers tended to focus on higher efficiency rather than cost and reliability.

Figure 1: Residential heat pump water heater.

Solution: A savings of 50% ('half') on the customer's annual cost of water heating is a reasonable goal and easy to advertise. Savings claims of 52% or 57% are fairly meaningless distinctions to the typical customer. Besides, such small differences do not represent any significant additional dollars per year of savings. An increase in efficiency from 2.0 to 2.5 might represent only USD 40 per year additional savings at a typical US electricity price of USD 0.10/kWh. Manufacturers have found that it is better to focus design efforts on other factors, such as reliability and serviceability.

Problem: HPWHs occasionally failed prematurely.

Solution: HPWHs must be manufactured with the quality and lifetime expected of the typical room air conditioner, which means quality must be further improved. Field service must be easily obtainable. Field service is generally best provided by specialists, rather than installation plumbers. A lengthy warranty will be necessary to give potential customers adequate assurance when investing in this unknown technology. Sales in the US have not yet reached the level of volume at which more rigorous quality control can be implemented without raising retail prices.

Problem: Manufacturing cost alone is still typically greater than USD 500 for add-on HPWH units (i.e., HPWHs that attach to an existing electric storage water heater), and a bit more than that for drop-in units (HPWHs with tank included). Studies have shown that it is difficult to market HPWHs in the US at retail prices above USD 500 (and definitely very difficult in the USD 900 to USD 1,000 range).

Solution: Economies of scale are needed. Customers do not understand why the retail price for a HPWH (less installation) should be over USD 150 more than that of a window air conditioner or a dehumidifier. As a matter of fact, most of these air conditioners and dehumidifiers are now imported from countries with very low labour costs.

Problem: HPWHs have been marketed and sold strictly on the basis of their water-heating savings.

Solution: We should recognize and quantify the value of the dehumidification that the

HPWH provides. Many customers value this dehumidification as greatly as they do the hot water savings. In a mature market, HPWHs could be optimized for high- or low-dehumidification applications.

Problem: Installation labour for add-on HPWHs is a significant part of the customer's total cost. Without training, a plumber and his helper might need a half-day to a whole day to install the typical add-on unit.

Solution: Utility training programs have shown that with training and tight quality control, an add-on HPWH can be installed in less than 2 hours by one person.

Additional installation efficiency can be achieved by simplifying and pre-assembling the add-on's 'balance of system' plumbing components. One storage water heater manufacturer, in fact, can supply high-quality 'HPWH-ready' tanks.

Integral (drop-in) HPWHs also solve this problem, though their use is generally limited to sites needing new or replacement water heaters.

Problem: Codes and inspectors. Some jurisdictions require two trades to share the work – a plumber and an electrician, each with proper local licenses.

Solution: Further modularization of installation parts will help. For example, the electrical connection to the existing tank could be converted to a plug-and-socket arrangement. This would require pre-wired tanks – which one manufacturer has already offered to build – and would simplify replacements.

Manufacturers and large-scale installers will need to work with state code offices to establish special rules that would apply. Some states, for example, established special licenses in the 1970s for installers of solar water heaters.

Problem: Existing add-on HPWHs look like rough sheet metal boxes, i.e. like prototype products rather than finished appliances.

Solution: With sufficient production volume, manufacturers will be able to build HPWH 'shells' that rival those of modern dehumidifiers, with smooth lines and rounded corners.

Final note

We hope this article will provoke some discussion, and we welcome reader comments, observations, and suggestions. Write us at johnson.research@att.net.

Titu R. Doctor
CENC Inc.
3832 Fox Hills Dr.
Marietta, GA 30067
Tel: +1 770 951 8032
Fax: +1 770 951 5474
E-mail: titu_doctor@hotmail.com
Or cenc@aaahawk.com

Russell K. Johnson
Johnson Research, LLC
170 Timrod Trail
Glastonbury, CT 06033
Tel: +1 860 633 9020
E-mail: johnson.research@att.net

Robert Stone
Tel: +1 860 7632741
E-mail: stonerg1@hotmail.com
Or bobstone4@netzero.com
(retired)

The Dutch heat pump quality mark foundation gains acceptance and prepares for future challenges

Paul Vermeulen, The Netherlands

The benefits provided by heat pump systems include a high comfort level and reduced energy costs. Lower energy consumption also translates into lower CO_2 emissions and less damage to the global environment. The Dutch Heat Pump Quality Mark Foundation plays an important role in encouraging the use of heat pumps

Dutch heat pump quality mark

The Dutch Heat Pump Quality Mark Foundation ('Stichting Kwaliteitskeur Wamtepompen') was set up to ensure the quality of the heat pump systems offered on the market. The Foundation is independent and aims to implement a quality mark programme for heat pumps used in the residential, utility and - if possible - agrarian sector. This quality mark aims to give users more certainty and clarity about the performance and reliability of both the product and its suppliers, and by doing so, to encourage the use of heat pumps. To that end, the Foundation has incorporated a number of quality requirements into the test procedures, which are carried out by independent test institutes.

In the past year, nearly 50% of the major suppliers on the Dutch market have tested their heat pumps according to the guidelines set down by the Foundation. In an early batch of tests, four suppliers were the first to receive a quality mark during the 'BouwRAI' (Building Trade Fair). These suppliers included several European companies offering a wide range of heat pumps.

Future challenges

Heat pump suppliers, project owners, building companies and users all provide advice to the Dutch foundation on how to meet future challenges. The Foundation plans to broaden its goals for the years to come. A heat pump as such is only a single part of an entire climate comfort system in a building. A single residential user is not capable of overseeing the entire system but is definitely affected by it. That is why a quality mark for an entire heat pump system is presently in preparation. The challenges facing the Foundation in this regard include the complex nature of the environments and technologies concerned, the large variety of players involved and rules and regulations that have not been harmonized.

European collaboration

The Dutch as well as international heat pump markets are quite dynamic, and it is important to take international conditions into account. Collaboration with other players within Europe is therefore essential. Manufacturers and suppliers are often more internationally focused and can therefore play a key role in the acceptance of recognized European quality mark organizations. Companies that do not participate risk being left behind. The existence of healthy local organizations, such as the Dutch Heat Pump Quality Mark Foundation, will contribute to the establishment of broader international organizations. The Dutch organization is well aware of this and will continue to look for ways to work together with other European organizations involved in the market, as well as continuing its efforts to further strengthen the strong position of the heat pump quality mark in the Dutch market.

Paul Vermeulen
The Dutch Heat Pump Quality Mark Foundation
Stichting Kwaliteitskeur Warmtepompen
http://www.kwaliteitskeurwarmtepompen.nl

The greenhouse of the future: an enormous solar collector

René Didde, The Netherlands

By using greenhouses to collect surplus solar energy in the summer, combined with underground energy storage and heat pump technology, it should be possible to realize large savings in fossil fuel consumption and corresponding reductions in CO_2 emissions.

The greenhouse as an energy source

The greenhouse of the future will produce not only vegetables and flowers but energy as well. Studies conducted by the KEMA (Dutch Institute affiliated with utilities) and others have shown that by 2008 greenhouses will be able to produce horticultural products without consuming fossil energy. In less than 20 years, the Dutch greenhouse horticultural sector will even be able to supply net energy, i.e. the equivalent of ten cubic metres of natural gas per square metre of glass. The research for this concept, referred to as 'The greenhouse as an energy source', has been done by the 'InnovatieNetwerk Groene Ruimte en Agrocluster' (Innovation Network Green Space and Agro-group) and the 'Stichting Innovatie Glastuinbouw' or SIGN (Foundation for Innovation in Greenhouse Horticulture). The studies were recently presented to the Dutch Minister of Agriculture, Mr Veerman, and to representatives of trade and industry.

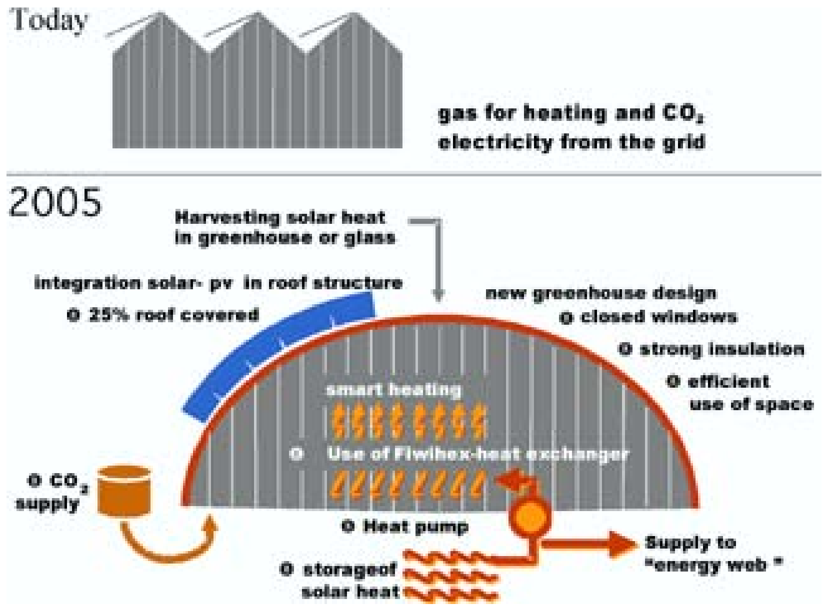


Figure 1: Greenhouse today and in the future

Pilot project

By 2005, a pilot project with 4,000 m^2 of glass (costing USD 3.2 million) should provide proof of principle that it is possible to realize a greenhouse that does not use any net energy. In particular, heat-intensive crops, such as tomatoes and sweet peppers, will benefit from this development. This 'zero energy' greenhouse will make use of the surplus of summer energy by storing it in underground water reservoirs (aquifers). In wintertime, the stored summer heat is made available using heat pump technology. In a similar fashion, the surplus winter cold can be stored and used in summertime for cooling and dehumidifying purposes, again with the aid of heat pump technology **(Figure 1)**.

Energy efficient windows/ screens

The energy-efficient greenhouse is equipped with extra insulating polycarbonate, hollow plated windows (Lexan). Due to a zigzag configuration, these windows both insulate and, at the same time, allow extra light to pass through. Once PV foils become commercially available, they will also be integrated into the energy screens. Such screens are already being used today to protect horticultural products from the blazing sun in summertime and to provide heat insulation in wintertime. Shell and Akzo are presently carrying out research into such thin PV foils.

Large energy savings possible

The energetic basis of the pilot greenhouse is the considerable surplus of solar energy in the Netherlands available in the summer months. In summer, a greenhouse receives a maximum of 7 MW of thermal energy per hectare, while in winter a maximum of 2 MW is needed. A Dutch greenhouse for growing tomatoes now requires 45-50 m^3 of natural gas plus 1200 kW of electricity per square metre of glass per year, which works out to a total primary energy consumption of 1600 MJ/m^2 of glass. In the Netherlands, the sun provides an average of 3800 MJ/m^2 as thermal energy.

"The future greenhouse is, in fact, an enormous solar collector," says Krijn Braber [MSc], a KEMA research scientist. "We are just not making an optimal use of this fact. Air heating and cooling/dehumidifying are the basic mechanisms of the low-energy greenhouse. By capturing the energy from the hot and humid air with the aid of very efficient heat exchangers and ventilators and by storing it, considerable energy savings are within reach. The principle has, in fact, already been applied for a decade in commercial and industrial buildings. The fact that nowadays greenhouses are often heated while their windows are open just goes to show how wasteful we are of energy and CO_2. Innovative energy-efficient in greenhouses may very well become Dutch export commodities in future.” Another idea proposed by the KEMA is the collective processing of waste biomass from the horticultural sector, for purposes of energy recovery, in central biomass plants. Fermentation technology could play a role in this regard.

According to the initiator of the 'zero-energy greenhouse' concept, Henk van Oosten [Ph.D., MSc] of InnovationNetwork and SIGN Greenhouse Farming in The Hague, this is quite an opportunity. “At present, greenhouses account for 10% of Dutch natural gas consumption, or 5% of overall Dutch energy consumption. In the process, they emit vast amounts of greenhouse gases. From a long-term perspective, the key technology is the use of PV cells. In the short term, the 'zero-energy greenhouse' is already within reach if existing technologies using heat pumps and aquifers are intelligently combined with less energy intensive farming concepts."

Contact: Krijn Braber
KEMA Nederland B.V.
PB 9035
6800 ET Arnhem
The Netherlands
Telephone: +31 26 356 6047
Telefax : +31 26 445 8279
E-mail: krijn.braber@kema.com
http://www.kema-kps.nl

2 MegaWatt project

The most energy efficient heating system in a retrofit housing project

Hans Buitenhuis, The Netherlands

In March 2003 a unique energy system was set into operation. Nine blocks with 382 apartments are to be heated with solar energy. Seasonal aquifer storage and heat pumps are applied for optimal utilization of the solar energy. The apartments are going to save 70% energy compared to the original situation. Initiators of the project were three housing corporations and a utility company. This project is expected to be the first in a series of similar projects in existing housing districts.

Large-scale retrofit

The 40-year-old apartments have been upgraded by an extensive retrofit. New toilets, bathrooms and kitchens were installed. The thermal quality of the envelope has been improved by additional insulation of the walls and floors and new windows with low-emissive glazing. As a result the existing radiator heating system is oversized and can operate at lower temperatures. This makes them more suitable for sustainable 'lower-grade' energy sources. In each dwelling a mechanical ventilation set was installed. With this package the apartments are expected to last for at least 15 more years.

Heating system

Originally tap water heating was done by individual gas fired heaters without a flue gas outlet. These heaters had to be replaced by another more convenient solution allowing a somewhat larger warm tap water flow. Space heating was provided per block by centrally placed boilers with a heat distribution network. The boilers had also to be replaced.

The housing corporations had originally planned to install individual gas-fired boilers per apartment for both space heating and hot tap water. However, such a solution would take up scarce living space, making it less attractive for the residents.
A centralized heating system based on sustainable energy therefore appeared to be a good alternative. Both the housing corporations and the local government strongly supported this solution and initiated a cooperative venture with a utility company. **Table 1** shows the timeline for the project

Figure 1: Solar collector modules.

Table 1: Project timeline

	1998	1999	2000	2001	2002	2003
Initiative	■	■				
Energy study, system concept			■			
Preliminary and final design, tendering				■		
Start realisation					■	
Delivery						X

Overall system concept

The system **(Figure 2)** consists of solar collectors **(Figure 1)**, short-term storage, seasonal storage, heat pumps and peak demand boilers.
In summer the energy for domestic hot water is supplied by solar collectors. A total of 2,850 m^2 glass covered solar collectors have been installed on the roofs of the nine housing blocks (7,6 m^2 per apartment). Each block of houses has its own technical service space with a storage tank, heat pumps and boilers. The surplus heat in summer is stored in a central aquifer storage at a temperature of 45 °C. In winter, the heat is extracted and used mainly for pre-heating and additionally as a heat source for the heat pumps.

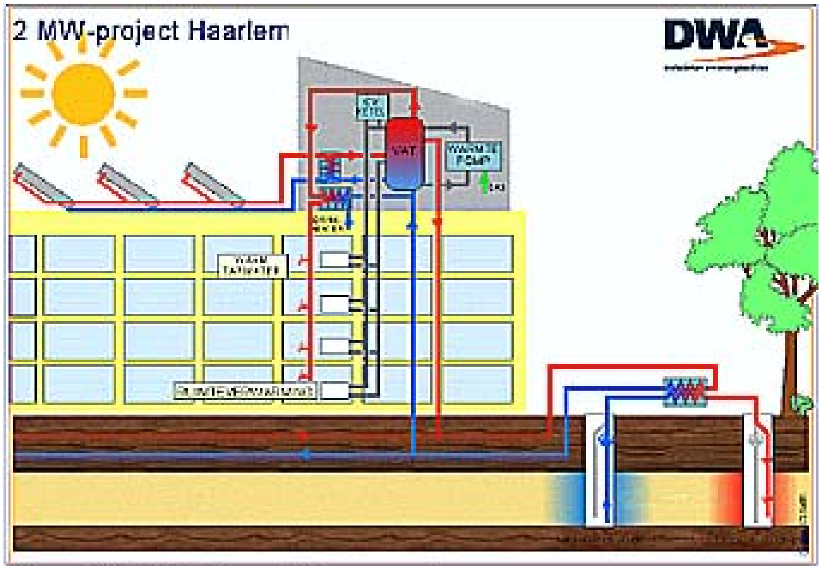


Figure 2: Simplified scheme of the energy system.

Figure 3: Absorption heat pump units.

Heat pumps

In this particular project, it made sense to use gas-fired heat pumps, as the natural gas infrastructure was already installed. The existing electricity network might have been insufficient for the installation of electrical heat pumps.

In each block of about 40 houses two absorption heat pump **(Figure 3)** units were installed with 38 kW condensor capacity each. Gas-fired heat pumps in this power range are readily available. The heat pumps used were manufactured by Robur in Italy. They were originally designed for cooling and had air-cooled condensers, but were redesigned to serve as water/water heat pumps. According to the manufacturer, the COP will be in the range of 1.4 to 1.6. This is comparable to the COP of an electrical heat pump (at an average efficiency of electricity production in the Netherlands of 39%).

The water inlet temperature of the evaporator may increase until 30 °C, and the heat pump can easily provide 60 °C water. These parameters make the unit very suitable for retrofit housing projects. Another plus is the relatively small evaporator capacity of the absorption type heat pump, which is about half the capacity of an electrical type. The sizing of the groundwater circuit for the aquifer storage (wells, piping, and pumps) is based on the required evaporator power for all the heat pumps together. A smaller evaporator capacity is therefore favorable from the viewpoint of storage investment costs.

Heat storage

Seasonal heat storage

The aquifer-based (underground sandy layers containing water) storage solution chosen is quite common in the Netherlands. About 200 such projects have already been realized, mainly for cooling purposes in office buildings, or a combination of cooling and heating.

The seasonal storage for the 2 MW-project described here comprises 2 wells with a depth of 115 meter and a maximum capacity of 50 m^2 groundwater per hour. The storage temperature in the warm well is 45 °C. This temperature is the result of an optimization process involving the following parameters: storage efficiency, material selection, heat yield of the collectors and direct heating capacity of the storage.

Short term storage
Steel tanks with a volume of 9.5 m^3 are used for short term heat storage. The thermal stratification in the storage tank is an important factor influencing proper operation. This stratification is shown in **Figure 4**. During sunny winter days, solar heat can be stored at a rather high temperature, which makes the heat usable for space heating and pre-heating of domestic hot water.

Savings/ costs

Before the retrofit, annual gas consumption was 1,915 m^3 per apartment. This figure is expected to drop to 565 m^3 gas per year, a decrease of 70%! The investment costs for the energy system amount to 5.3 million euro. The actual investment is lower due to subsidies. For the residents, the total heating bill will decrease somewhat.

Hans Buitenhuis MSc
DWA consultancy & engineering
E-mail: buitenhuis@dwa.nl

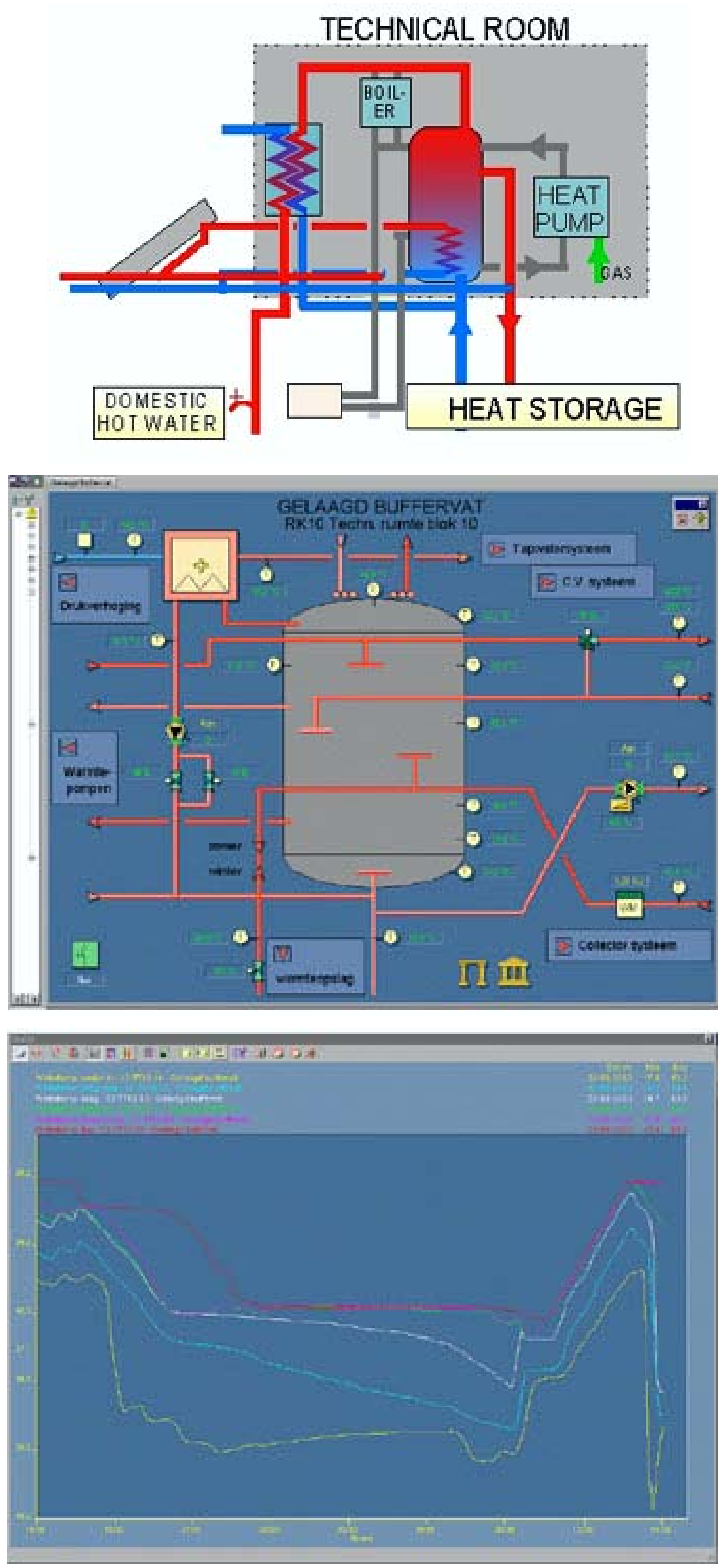


Figure 4: The thermally stratified buffer is the connection between heat suppliers and heat consumers. The temperature curves show the stratification from bottom to top of the buffer.

Building double ECO with heat pumps

Daaf de Kok, The Netherlands

A new building project in the Netherlands uses heat pump technology to provide optimum climate control for both working and living areas in a manner that is both ECOnomically and ECOlogically beneficial and sustainable.

The building project

On the outskirts of Kaatsheuvel, a Dutch village near De Efteling (one of Europe's most popular amusement parks), a commercial/ residential building structure with 1200 m^2 of office space topped off by 12 apartments is erected. It is a very modern structure with a rigid design, in which office space and residential space are each optimized for their separate functions. The building is expected to be completed in the third quarter of 2003.

Sustainability

A multidisciplinary project team was formed, including external parties, in order to optimize the building from the viewpoint of durability and sustainability. As the development process was already well underway when the team was formed, the team could not modify the choice of location or basic building design. Rather they were asked to make sure that, within the given design framework, optimum use was made of existing technologies to promote sustainability and conserve energy.

System design

A major concern was the difference in energy requirements between the office space and the apartments. Due to the different daily working and living schedules, the offices needed more cooling capacity whereas the apartments needed more heating capacity. Various options were evaluated using heat pumps, which fell into two categories: heat pumps for individual spaces or collective heat pumps. The concept finally chosen combines the following elements:

- a collective heat pump installation for the office space and individual heat pumps for the apartments;
- low-temperature heat distribution via floors and walls;
- seasonal storage of surplus energy via underground thermal storage system.

The energy storage system makes it possible to utilize surplus waste heat from the office space to heat the apartments. An evaluation of the possible use of solar panels showed that this was not an economically viable option due to the long time it would take to recover the investment costs.

Heating/cooling/ventilation

The use of a floor-based energy delivery system combined with heat pumps makes it possible to heat the areas in winter and cool them in summer. Surplus energy (either heat or cold) can be stored in the seasonal energy storage system until needed.

In order to minimize the energy needed to heat up cold air during cold periods, much attention was paid to optimizing the ventilation multiple, i.e. the rate at which the total volume of air in a room is refreshed. To conserve energy, heat is recovered from the air leaving the room and used to warm up the cold air entering the room.

The low-temperature floor-based heating system, in combination with options for additional air-based heating and air-based cooling, ensure that the people working in the building as well as those living there can enjoy a very comfortable working/living climate. Some additional advantages are:

- very little draft and very stable temperature;
- floor-based heating feels very comfortable;
- radiators or central heating pipes not needed - freeing up more living space;
- less dust which is positive for asthma patients.

Savings

Compared to more conventional systems, the climate control system is expected to reduce energy costs by nearly 30%. In addition, the installation of a 'building management system' should make it possible to reduce energy consumption even further.

Conclusion

The use of heat pump technology, seasonal underground storage, and floor-based delivery systems makes it possible to optimize climate control functions for office space as well as residential space in the same building envelope. The end result is a very comfortable environment for all the building's users, a significant reduction in energy consumption, and an ECOnomically as well as ECOlogically sustainable building environment.

Drs. Daaf de Kok
De Kok & Partners bv, Management Consultants
De Wetstraat 4
Postbus 896
6800 AW Arnhem
Tel: +31 026 352 3311
Fax: +31 026 352 3310
E-mail: daaf@dekok-partners.nl
http://www.dekok-partners.nl

Books & Software

Geo Heat Pumps – Leading Energy Utility Marketing

The book explains why geothermal heat pump technology is of interest to electric utilities and their customers and what is required to sustain a national market. Niche marketing successes and struggles are introduced together with strategies to develop sustainable programmes.

Energy Central Research Report Watch
E-mail: service@energycentral.com.
Price: USD 595.00
To order call tel: +1 800 459 2233

Refrigerated Transport – Progress Achieved and Challenges to Be Met

The16th IIR Informatory Note on refrigerating technologies presents progress achieved and challenges facing the refrigerated transport sector. Reducing energy consumption without compromising temperature, safety and hygiene requirements governing perishable food-stuffs transported is of major concern.

The Informatory Note will be useful reading for governments, agencies researchers, manufacturers haulage contractors and trade organisations.

Available from the IIR at:
http://www.IIFIIR.org

Events

2004

3rd International Symposium on Heat Transfer Enhancement and Energy Conservation (ISHTEEC 2003)
12-15 January 2004 / Guangzhou, China
Contact: Prof. Dongsheng ZHU, ISHTEEC'03 Secretary General
Chemical Engineering Research Institute
South China University of Technology
Guangzhou, 510640, P.R. China
Tel: +86 20 8711 4568
Fax: +86 20 8711 4140
E-mail: ishtee@scut.edu.cn
http://www.ishtee.gd.edu.cn

ASHRAE Winter Meeting and AHR Expo
24 - 28 January 2004 / Anaheim, California, USA
Contact: ASHRAE meetings section
Tel: +1 404 636 8400
E-mail: jyoung@ashrae.org
http://www.ashrae.org

Interclima, HVAR International Exhibition
3-6 February 2004 / Paris, France
Contact: Philippe Brocart
Tel: +33 1 4756 5088
E-mail: philippe_brocart@reedexpo.fr
http://www.interclima.com

Exhibition of HVAC&R Japan
3 – 6 February 2004 / Tokyo, Japan
Tokyo International Exhibition Centre
Contact: Dr. Jianfeng Wang, jfwang@k.u-tokyo.ac.jp,
or Dr. Xiaomei Li, Li@hptcj.or.jp.
http://www.ashrae.org

International Seminar on Natural Refrigerants
5 February 2004 / Tokyo, Japan
Sanjio Conference Hall
University of Tokyo
Hongo Campus
Contact: Dr. Jianfeng Wang, jfwang@k.u-tokyo.ac.jp
or Dr. Xiaomei Li, Li@hptcj.or.jp

Mostra Convegno Expocomfort
2 - 6 March 2004 / Milan, Italy
Tel: +39 02 48555 01
Fax: +39 02 4800 5450
E-mail: mce@planet.it

Improving Energy Efficiency in Commercial Buildings IEECB'04
19-20 April 2004/Frankfurt. Germany
Tel: +39 0332 78 9299
Fax: +39 0332 78 9992
E-mail: JRC-IEECB04@cec.eu.int
http://energyefficiency.jrc.cec.eu.int/events.htm

International Sanitary and HVAC Exhibition
6 – 9 May 2004 / Istanbul, Turkey
Tel: +90 212 216 08 90
Fax: +90 212 212 06 93
E-mail: info@hmsf.com
http://www.hmsf.com

ASHRAE Annual Meeting
26 - 30 June 2004 / Nashville TN, USA
Tel: +1 404 636 8400
E-mail: jyoung@ashrae.org
http://www.ashrae.org

World Renewable Energy Congress VIII
28 August - 3 September 2004 / Denver, Colorado, USA
http://www.nrel.gov/wrec

Natural Working Fluids - 6th IIR Gustav Lorentzen Conference
29 August-1 September 2004 / Glasgow, UK
Contact: Miriam Rodway, secretary
Institute of Refrigeration
Kelvin House, 76 Mill Lane
Carshalton, Surrey SM5 2JR
Tel: +44 (0)20 8647 7033
Fax: +44 (0)20 8773 0165
E-mail: oir@ior.org.uk
http://www.ior.org.uk/gl2004

5th International Conference on Compressors and Coolants – Compressors 2004
29 September-1 October 2004 / Nitra, Slovak Republic
Contact: Peter Tomlein
SZ CHKT, Hlavnà 325
900 41 Rovinka, Slovak Republic
Tel: +421 2 4564 6971
Fax: +421 2 4564 6971
E-mail: zvazchkt@isternet.sk
http://www.isternet.sk/szchkt

2005

8th IEA Heat Pump Conference 2005
30 May – 2 June 2005 / Las Vegas, Nevada, USA
Contact: The Conference Secretariat
Oak Ridge National Laboratory (ORNL)
P.O.Box 2008, MS-6189
Oak Ridge, TN 37831
Tel: +1 865 576 8620
Fax: +1 865 574 9331
E-mail: lapsamv@ornl.gov

2007

22nd IIR International Congress of Refrigeration
21 – 26 August 2007 / Beijing, China
http://www.iifiir.org

For further publications and events, visit the HPC internet site at http://www.heatpumpcentre.org.

Next Issue

Natural Working Fluids

Volume 22 - No. 1/2004

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 world-wide source of independent information & expertise on heat pump, refrigeration and air–conditioning systems for buildings, commerce and industry. Its international collaborative activities to improve energy efficiency and minimise adverse environmental impact are highly valued by stakeholders.

Mission

The Programme serves the needs of policy makers, national and international energy & environmental agencies, utilities, manufacturers, designers & researchers. It also works through national agencies to influence installers and end-users.

The Programme develops and disseminates factual, balanced information to achieve environmental and energy efficiency benefit through deployment of appropriate high quality heat pump, refrigeration & air-conditioning technologies.

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

Novem

Netherlands agency for energy and the environment

IEA Heat Pump Centre
Novem, P.O. Box 17
6130 AA Sittard,The Netherlands
Tel: +31-46-4202236
Fax: +31-46-4510389
E-mail: hpc@heatpumpcentre.org
Internet: http://www.heatpumpcentre.org

National Team Contacts

AUSTRIA
Dr Hermann Halozan
Technical University of Graz
Institute of Thermal Engineering
Inffeldgasse 25,
A-8010 Graz
Tel.: +43-316-8737303
E-mail: Halozan@iwt.tu-graz.ac.at

CANADA
Mrs Sophie Hosatte
1615 Lionel-Boulet Blvd
Varennes (Quebec)
Canada J3X 1S6
Tel.: +1 450 652 5331
E-mail: sophie.hosatte@nrcan.gc.ca

FRANCE
Mr Etienne Merlin
ADEME/DIAE
27 rue Louis Vicat
F-75737 PARIS Cedex 15
Tel.: +33-1-47-65-21-01
E-mail: Etienne.Merlin@ademe.fr

GERMANY
Dr Claus Börner
Forschungszentrum Jülich GmbH
PO Box 1913,
D-52425 Jülich
Tel.: +49-2461-613816
E-mail: c.boerner@fz-juelich.de

ITALY
Mr Marco Brocco
ENEA
C.R.E. Casaccia
Via Anguillarese 301
I-00100 Rome
Tel.: +39-06-3048 4948
E-mail: brocco@casaccia.enea.it

JAPAN
Mr Takeshi Yoshii
HPTCJ
Kakigara-cho, F Building (6F)
1-28-5 Nihonbashi, Kakigara-cho
Chuo-ku, Tokyo 103-0014
Japan
Tel:+81-3-5643 2404
E-mail: yoshii@hptcj.or.jp

MEXICO
Dr Roberto Best
Departamento de Sistemas Energéticos
Centro de Investigación en Energia de la UNAM
Apartado Postal 34,
62580 Temixco, Morelos
Tel.: +52-5-622 9736
E-mail: rbb@mazatl.cie.unam.mx

THE NETHERLANDS
Mr Onno Kleefkens
Novem
P.O. Box 8242
NL-3503 RE Utrecht
Tel.: +31 30 2393 449
E-mail: o.kleefkens@novem.nl

NORWAY
Mrs Trude Tokle
Enova SF
Abelsgatan 5
N-7030 Trondheim
Tel.: +47 73 19 04 54
Fax: +47 73 19 04 31
E-mail: trude.tokle@enova.no

SPAIN
Ms Marta Garcia
ENEBC
Po General Martinez Campos, 11 1o
28010 - Madrid
Tel.: +34 914445904
E-mail: enebc@enebc.org

SWEDEN
Dr Björn Sellberg
FORMAS
PO Box 1206
S-11182 Stockholm
Tel.: +46-8-775 4028
E-mail: Bjorn.Sellberg@formas.se
Peter Rohlin
STEM
Buildings & Community Systems
PO Box 310
S-63104 Eskilstuna
Tel.: +46 16 544 2112
E-mail: Peter.rohlin@stem.se

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

UK
Mr Roger Hitchin
BRECSU, BRE
Energy Efficiency
Garston, Watford, WD25 9XX
Tel.: +44 1 923 664773
E-mail: HitchinR@bre.co.uk

USA
Mrs Melissa V. Lapsa
Oak Ridge National Laboratory
Building 4500 N, P.O. Box 2008
Oak Ridge, TN 37831-6183
USA
Tel.: 1 865 576 8620
E-mail: lapsamv@ornl.gov