

IEA Heat Pump Centre

NEWSLETTER



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News & Views

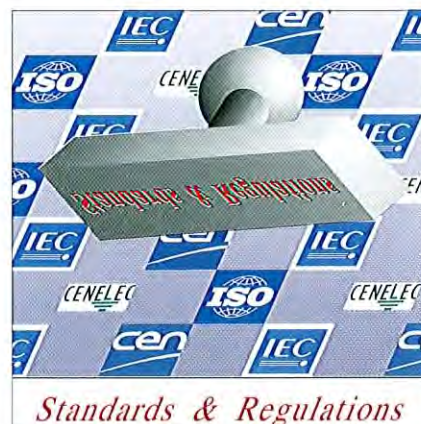
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Standards and Regulations

For heat pumps to play a bigger role in reducing energy demand, the market conditions must encourage trade in reliable, high-performance equipment. Standards and regulations have considerable impact on these conditions, sometimes supporting the heat pump market, and at other times acting as barriers. This issue provides views and information on this important topic.



Front cover: The international stamp of approval: The international and European standards authorities, ISO, IEC, CEN and CENELEC have made much progress in the harmonization of heat pump standards and regulations. Some ideas for future work are given in the article on page 13.

Topical Articles

International Overview 13

Mike Steadman, IEA Heat Pump Centre
Significant steps have been taken in the development of international standards for heat pump performance and safety. But, judging by the opinions of various members of IEA Heat Pump Centre National Teams, there is much more work still to do.

Standards and Regulations 20 in Japan

Yoshifumi Kumugi, Mitsuru Sawada and Takeshi Yoshii, Japan
Standards and regulations often pose severe difficulties. For example, Japanese safety laws restrict the use of HFC-134a even though it is needed to meet environmental regulations. This article gives a manufacturer's view.

Regulating 23 Heat Pump Efficiency

Arvo Lannus, USA
Energy efficiency regulations can have a profound and positive effect on the heat pump market. An ongoing analysis by the IEA Heat Pump Centre is closely examining the application of such regulations around the world. This article provides a preview.

Standards and Regulations 27 for GSHPs in Central Europe

Burkhard Samner, Germany
Despite the strong market for ground-source heat pumps (GSHPs) in Austria, Germany and Switzerland, currently available guidelines are by no means comprehensive. A new initiative in Germany looks set to fill this gap.

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Stirling Technology 31 for the Home

Jean-Pierre Budliger, Switzerland
Despite many advances, Stirling technology has yet to make an impact on the space conditioning industry. But a new development, involving the use of a ten meter tube, promises to bring the Stirling-Stirling heat pump into our homes.

1995 - A Year in Review 35

Jos Bouma, IEA Heat Pump Centre
With the introduction of lower-cost models in Europe, and new promotion initiatives in various countries, heat pumps are more ready than ever to become a mainstream technology. The IEA Heat Pump Centre's General Manager looks back on 1995.

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Removing the Hurdles



For equipment users and manufacturers alike, standards are needed to ensure a fair market. Within Technical Committee TC113 of the European Committee of Standardization (CEN), we are close to completing a new set of standards for air conditioners, liquid chillers and heat pumps, that will apply to our eighteen member countries.

The publication of standards EN 255 and EN 814 in 1996 will be the culmination of a process that dates back ten years to when TC113 was first formed. The time taken reflects all the different aspects that must be taken into account to reach agreements that not only satisfy the needs of both users and manufacturers, but also consider the varying interests of the member countries. At every step in the process, country representatives have had the opportunity to discuss and vote on the proposed standards. The result is a set of standards that has the consensus of all relevant parties.

An important criterium in developing standards is that they must help to eliminate the technical barriers that prevent the free circulation of equipment between countries. The new CEN/TC113 standards address important issues such as definitions, performance, test conditions and marking, and can be expected to have a significant impact on the heat pump market in Europe. The standards EN-255 that cover heat pumps will be the basic standards for EUROVENT certification as well as units certified according to CE mark and Construction Product Directive CPD89/106.

Standards EN-255 give reliable information on performance and coefficient of performance, so that those who buy heat pumps are better informed on the equipment on sale. The end users of heat pumps can compare different units and different heating systems, and can therefore choose or combine heating systems according to their needs, and depending on the winter conditions. And manufacturers will benefit also from the removal of many of the hurdles that have hampered trade across national boundaries.

TC113 is committed to the development of new standards such as on data presentation for compressors and on absorption chillers and multisplit condensing units. In short, to provide complete coverage of the equipment used for comfort applications.

A stylized, handwritten signature in black ink, appearing to read 'A. Alonso'.

Mr Agustín González Alonso
Chairman of CEN/TC113, Madrid, Spain

News & Views

50 years of ground-source heat pumping

USA - Ground-source heat pump (GSHP) technology has just reached 50 years of age. Those in the know, celebrated this anniversary on 1 October 1995, exactly 50 years after the first installation was switched on in the Indianapolis home of Robert C. Webber, an employee of the Indianapolis Power and Light Co.

The system featured a direct-expansion ground-coil buried in trenches, and supplied heat to a warm air heating system using a 2.2 kW compressor (see Figure 1). The plant was first described in a 1946 edition of the New York journal *Electrical World* (126/19, pp. 94-95) in an article by A.C. Crandall entitled "House Heating with Earth Heat Pump". The article states that monitoring of the plant began on 1 October 1945, a date that can be considered as the first day of GSHP operation documented in literature.

Crandall concludes his report with the words: "It is hoped, however, that this report of an actual

installation under average operating conditions will help give other utilities an idea of the practicability of electric power use in house heating with the earth heat pump."

In the following years, a variety of GSHP technology was tested to try and find the best way to exploit the earth as a heat source and heat sink for a heat pump. E.N. Kemler described many more GSHPs in his article "Methods of Earth Heat Recovery for the Heat Pump" published in September 1947 in *Heating and Ventilating* (New York). This described applications of virtually all methods in use until today, including groundwater wells, horizontal coils using direct expansion or brine circulation, and vertical borehole heat exchangers in coaxial, U-pipe and spiral form. Only the US "Slinky" coils, the Canadian SVEC spiral coils in trenches, and the German/Austrian trench collector are new variations.

In Philadelphia, two installations with horizontal pipes and brine

circulation were monitored in 1948-50. J.H. Harlow and G.E. Klapper reported on this work in 1952 (*AIIE Transactions* 71/II, pp. 366-375, New York) and stated that "the earth provided a reliable heat source and heat sink during the two years of heat pump operation, including the periods of highest heating and cooling requirements". In 1953, a study of GSHPs listed no less than 28 experimental installations in the US (*AEIC-EEI*, 1953).

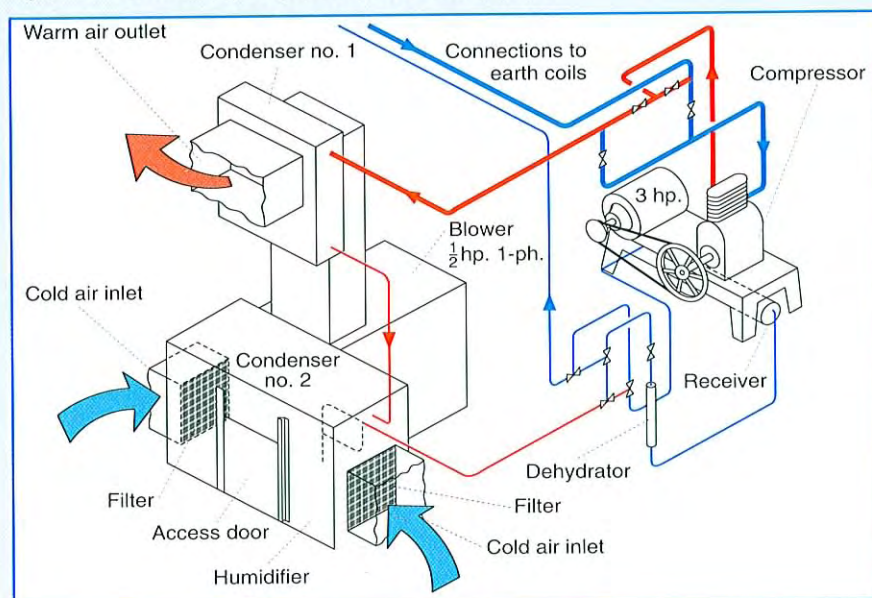
The first Canadian GSHP was installed in an experimental house of Toronto University and monitored since 25 October 1949. This is documented by F.C. Hooper in his article "An Experimental Residential Heat Pump" which was published in the *Canadian Journal of Technology* (1952, pp. 180-197, Ottawa).

Work on the theoretical background of ground heat use is linked to the name of L.R. Ingersoll from the University of Wisconsin in Madison. Ingersoll and his assistants applied mathematical methods to describe heat transport in the ground to the new GSHP technology and introduced ways for plant lay-out on a sound physical basis.

Today, 50 years after Robert Webber's first winter in a home heated by a GSHP, the technique is beginning to enter the market in a broad wave in North America (with the recently installed Geothermal Heat Pump Consortium in Washington as the focal point for R&D, infrastructure strengthening and market development), and, on a smaller scale and slower pace, in Europe.

(Source: Dr Burkhard Sanner, University of Giessen, Germany. Fax: +49-641-702-8244)

Figure 1: The world's first ground-source heat pump.



Cooperation through the "Alpine-Opec"

Germany - The "3rd International Meeting on Heat Pumping Systems", held on 21 to 22 June 1995 in the German city of Bayreuth, was the platform for further exchange of experiences and ideas between the heat pump promoting associations from Switzerland, Germany and Austria. Cooperation between these associations of Austria, Germany and Switzerland has now become so intense that one observer remarked that it represents the equivalent of OPEC (Organisation of the Petroleum Exporting Countries) for the heat pump market in the Alpine region.

The aim of this cooperation is to support the widespread, international use of heat pumping systems. Gabi Brugger, President of the Swiss Association for the

Promotion of Heat Pumps (FWS), presented a ground-source heat pump project from the Canton of Zurich as an example for others to follow. And she pointed out that designers of new projects will be able to take advantage of a recently completed drilling survey map for Zurich indicating where future earth probes can be installed. A similar map for the whole country is planned. With one in four new buildings heated by a heat pump, Switzerland is making a significant contribution towards the widespread use of geothermal heat in the Alpine region.

The meeting highlighted the need to produce objective measurement data. Many potential heat pump operators are still not convinced of the benefits of heat pumps and need

to receive far more detailed data on their performance than they would for conventional heating equipment. One role for heat pump promotion groups is to put forward evidence to show that heat pump systems are at least as safe and reliable as oil and gas-fired systems and that from an environmental aspect, they are in fact far superior.

The two-day meeting demonstrated the effectiveness and usefulness of activities on an international level. In future, even closer cooperation of the promoting associations is envisaged, perhaps within a kind of "Alpine Association for the Promotion of Heat Pumps".

(Source: Mr Thomas Afjei, Swiss National Team)

Government subsidizes heat pumps

Germany - Since 1 August 1995, the German Ministry of Economic Affairs (BMWi) has been offering a subsidy for heat pump applications as part of a general scheme to support the application of renewable energy technologies.

A subsidy of DM 300 (US\$ 220) per kW heating capacity, up to a maximum of DM 20,000 (US\$ 14,400) will be paid for the installation of space heating and hot

water heat pumps meeting strict criteria including minimum efficiency standards. Currently the minimum requirement for an electric heat pump is a seasonal performance factor (SPF) of 3.2. In 1998, this requirement will be raised to an SPF of 3.5.

The subsidy also applies to thermally-driven heat pumps such as absorption and gas-engine equipment. The minimum efficiency

requirement for such heat pumps is set at a primary energy ratio of 1.3.

Another criterion to be met is that the heat pump must use a chlorine-free refrigerant such as HFC-134a, R-407C or propane. The primary target of the scheme is the application of heat pumps in new buildings.

(Source: Wärmepumpe from IZW, September 1995)

UK makes its first heat pump awards

United Kingdom - On 27 September, the Heat Pump Association, which was formed in 1994, announced the winners of the first ever Heat Pump Awards for the United Kingdom. First prize was awarded for a system in the headquarters of the Royal Bank of

Scotland - a three year old, 4394 m² building in Jersey. The system uses 138 reversible room heat pumps, manufactured by Temperature Ltd., to transfer heat to or from rooms using an unlagged, two-pipe water loop. The same heat pumps were used in an office in Essex which

picked up the third prize. Second prize was awarded for a multizone system using Mitsubishi Electric heat pumps.

(Source: Mr Tony Bendall, Heat Pump Association. Fax: +44-1628-531186)

All change at the IIR

The Netherlands - At the 19th IIR Congress in The Hague, The Netherlands, held from 21 to 25 August 1995, the International Institute of Refrigeration (IIR) elected new chairmen, as well as presidents and vice presidents for its Commissions.

Prof. Fritz Steimle of Germany, a member of the IEA Heat Pump Programme Advisory Board, was appointed chairman of the General Conference. The Scientific Council will now be chaired by Prof. A. Cavallini of Italy and Prof. Eric Granryd of Sweden takes over the chairmanship of the Executive

Committee. The chairman of Section E (Air conditioning and energy recovery) will be Prof. V. Goldschmidt of the USA.

The IEA Heat Pump Centre's (HPC's) National Team Contact for Norway, Prof. Per-Erling Frivik will be the new president of Commission E2 (Heat pumps and heat recovery). Commission E1 (Air conditioning) will be presided over by Mr P. Novak of Slovenia.

Mr Jos Bouma, General Manager of the HPC, Mr Jerry Groff, Chairman of the IEA Heat Pump Programme Advisory Board, and Dr Hermann

Halozan, Austrian HPC National Team Contact and Executive Committee delegate, were appointed as vice presidents of Commission E2. The other three vice presidents are Prof. G. Carrington of New Zealand, Prof. B. Charters of Australia, and Prof. T. Saito of Japan.

The IIR also announced that the 20th IIR Congress will be jointly hosted by New Zealand and Australia and will take place in September 1999 in Sydney, Australia.

(Source: Mr Jos Bouma, IEA Heat Pump Centre)

Study shows benefits of exhaust-air HPWHs

Canada - In 1994, the US DOE (Department of Energy) published a proposed ruling that would make heat pump water heaters (HPWHs) the minimum standard for electric storage water heating (see *IEA Heat Pump Centre Newsletter*, June 1994 p.4). The proposed ruling has led to widespread opposition and is expected to be changed in the Final Rule.

In response to the issues raised, Caneta Research Inc. has undertaken a performance and economic analysis of the water heating options considered by the DOE under Canadian conditions. Using the simulation model WATSIM, the study examined the use of a range of water heating options in single-family homes with various combinations of central air conditioning, dehumidification and mechanical ventilation. The analysis was undertaken for the climate conditions of the Canadian cities of Vancouver, Winnipeg, Toronto and Montreal, and considered the effects of different draw schedules. The results were presented at the ASHRAE Annual Meeting held in June 1995 in San Diego, California, USA.

	Water heating energy (kWh)	Water heating impact on		Total Heating/ Cooling Energy (kWh)	Total cost (US\$)
		Space heating (kWh)	Space cooling (kWh)		
Electric resistance (baseboard) space heating - without mandatory ventilation					
Base case	5,398	488	-57	25,467	2,132
Ambient air HPWH	2,403	-1,657	142	24,417	2,043
Space heating heat pump - without mandatory ventilation					
Base case	5,398	252	-57	14,529	1,216
Ambient air HPWH	2,403	-902	142	12,489	1,045
Space heating heat pump - with mandatory ventilation					
Base case	5,398	252	-57	17,302	1,448
HR ventilator	5,398	206	-47	15,403	1,289
Exhaust-air HPWH	2,198	-570	86	13,904	1,164

Table 1: Comparison of water heating technologies in a Toronto home using different space heating systems.

From the results it is apparent that exhaust-air HPWHs are the most economically attractive option for a northern climate, offering higher avoided costs than the incremental installation costs in Vancouver and Montreal. They also confirmed that HPWHs result in the lowest emissions of all the water heating options, where fossil fuels are used for electricity generation. Furthermore, for homes with central air conditioning, the reduction in

instantaneous electricity demand is significant due to the "free" cooling supplied by the HPWH.

Some of the data presented at the ASHRAE Annual Meeting are shown in Table 1. The data show the impact of water heating equipment on space heating and cooling. By taking heat from the ambient air, HPWHs demand significant extra space heating in winter but assist the space cooling equipment in summer. With

an installation cost of US\$ 1,190, ambient air HPWHs have a simple payback period of 4.5 years for a Toronto home. With mandatory ventilation, exhaust-air HPWHs, which cost US\$1,390, have a simple payback period of just 2.4 years. A full report is available from NRC (Fax: +1-613-943-1590).

(Source: Mr Douglas Cane, Caneta Research Inc. Ontario, Canada. Fax: +1-905-542-3160)

Technology and Applications

LT system yields 400% efficiency

Germany - The benefits of combining a ground-coupled heat pump with a low-temperature (LT) heating system has been clearly demonstrated at a family home close to Munich. Using underfloor heating at a temperature of no more than 30°C, space heating for the '93/'94 winter was supplied with a seasonal performance factor (SPF) of four, or an efficiency of 400%.

The 159 m² house was built to high insulation standards in 1993, and has a heating² requirement of just 8.3 kW, or 52.2 W/m² according to German standard DIN 4701. This is met with a 10.2 kW (heating capacity) direct-expansion ground-coupled heat pump with HCFC-22 refrigerant.

The ground collector comprises 300 m of plastic-coated copper tubing, laid horizontally in four circles over an area of 190 m². The equipment used to excavate the garden is shown in Photo 1. ²

Underfloor heating is laid throughout the house at a spacing of 12 cm (6 cm in the bathroom). Hot water supply was met with an independent resistance heating



Photo 1: Digging for energy: installing the ground collector at a house in Puchheim, Munich, Germany.

system. The builder choose not to install an integrated hot water and space heating heat pump system for cost reasons.

Over the period August '93 to May '94, a demand of 15,556 kWh heating was met using just 3901 kWh electricity. Electricity costs equate to DM 0.043/kWh heating (US\$ 0.031/kWh heating) which is about 67% of the cost of supplying this heat with a gas heating system. The total installation costs, including those for the ground collector and underfloor heating system amounted to DM 27,500 (US\$

19,900) – comparable to the cost of an equivalent gas heating system if the costs of connecting to the gas supply and installing a chimney are included. According to the installer, future systems would cost DM 7000 (US\$ 5000) less due to savings in items such as the hiring of expert help.

(Source: Isar-Amperwerke AG, from an article in *Wärmepumpe* from IZW, September 1995)

Thermal energy transfer with ice crystals

Switzerland - A new medium for transferring and storing thermal energy promises to reduce the size and energy consumption of cooling equipment. Manufactured under the tradename "Flo-Ice", the new thermal transfer medium is a pumpable ice-slurry made up of a suspension of tiny ice crystals in water. Typically, the diameter of the crystals range from between 0.1 and 0.5 mm.

Up to an ice concentration of 20% by weight, "Flo Ice" has similar physical

properties to pure water, but its energetic density is some 450% higher over a temperature difference of 6°C.

This gives the pumpable ice slurry many remarkable advantages over the commonly-used brine systems. Pumps, heat exchangers, pipe diameters and thermal storage tanks can be considerably smaller. By storing the ice in a storage tank during periods of low cooling consumption, it is possible to reduce the size of installed chiller capacity.

Chillers with heat recovery are a good application for pumpable ice slurry. A cooling plant in Wettingen produces "Flo Ice" when heat is demanded, and stores it in a tank. When cooling is requested, the ice crystals are melted to supply cooling at the required temperature.

Further information is available from Unelco AG, Zurich.
Fax: +41-1-432-7733.

(Source: Mr Thomas Afjei, Swiss National Team)

Ice rink supplies heat for swimming pool

The Netherlands - The income of a swimming pool is dominated by two factors: the number of paying customers and energy costs. At a swimming complex in Etten-Leur, both these factors have been improved through the installation of an outdoor artificial ice-skating rink.

In winter, the skaters bring in extra income, when the outdoor swimming pools are out of use. But in addition, the ice rink is a source of solar energy for heating the

swimming pool. At the heart of the system is an electric heat pump.

During the winter season, the heat pump makes and maintains ice on the rink by supplying an ethylene-glycol loop. At the same time, heat pump condenser heat is recovered and used to supplement the swimming pool heating system.

Outside the skating season, a second circuit in the ice rink circulates water that can be used as the heat source

for the heat pump. During the height of the summer, heat from the skating rink is supplied directly to the swimming pool heating system.

With this system, it is estimated that primary energy consumption has been reduced by around 50%.

(Source: Mr. Mike Steadman, IEA Heat Pump Centre)

Demonstrating the potential of HPWHs

New Zealand - A home for the elderly is providing new evidence of the benefits of solar-assisted heat pump water heaters (HPWHs). The Woodlands Rest Home complex at Motueka, which was opened in 1993, is demonstrating the use of ten HPWHs to supply 4,500 litres of hot water per day to meet the needs of its 70 residents.

The HPWHs are air-source electric heat pumps and feature roof mounted collector/evaporators as shown in Photo 2. The refrigerant is HCFC-22.

Initial trials at the Woodlands Rest Home show that the seasonal

performance factor will be approximately 2.9. Energy consumption for hot water heating

would then be reduced by 65% compared to that from using conventional electric heaters. This

Photo 2: Hot water from thin air: rooftop collectors supply free heat to heat pump water heaters.



will save the operators NZ\$ 4,000 (US\$ 2,700) a year in operating costs. The ten HPWHs had a marginal cost over standard systems of approximately NZ\$ 15,000 (US\$ 10,000).

Tests have shown that the coefficient of performance (COP) of these HPWHs almost doubles when the sun is shining, reaching up to five on a hot sunny day (20°C). Operation at -20°C, with no sunshine, yields a COP of just 1.5.

The HPWHs are manufactured by Tasman Energy Quantum Ltd. of New Zealand under license to Australian company Quantum Link Energy Systems who first commercialized similar heat pumps ten years ago. The technology has been applied in both commercial and residential applications.

With 96% of New Zealand's hot water heaters using electric resistance heating, national power consumption for hot water heating is

some 6,000 GWh per annum. The potential for energy savings with hot water heat pumps is highlighted in a brochure published in September 1995 by the Energy Efficiency and Conservation Authority, an independent government agency.

(Source: Mr Dave Packer, Tasman Energy Quantum Ltd., Richmond, New Zealand. Fax: +64-3-544-6066)

Working Fluids

Experiments show hydrocarbons are better

United Kingdom - Scientists at the Institute for Cryogenics and Energy Research at the University of Southampton have demonstrated conclusively that hydrocarbons perform significantly better than CFCs. Using a fully instrumented experimental apparatus, the operation of domestic refrigeration equipment was monitored with CFC-12, propane and a range of propane/isobutane mixtures. Figure 2 shows the results of COP measurements which indicate that pure propane provides the best COP.

However, on comparing the saturation characteristics of the hydrocarbons with those of CFC-12, it becomes clear that neither propane, butane or any other hydrocarbons when used singly are suitable as a direct replacement for CFC-12, or indeed its HFC substitute HFC-134a.

The answer is to use a mixture of propane and isobutane. Then it is possible to produce a non-azeotropic mixture with saturation characteristics very close to those of CFC-12. The exact composition may be varied to give a precise match at any chosen temperature.

Whilst this work has been primarily

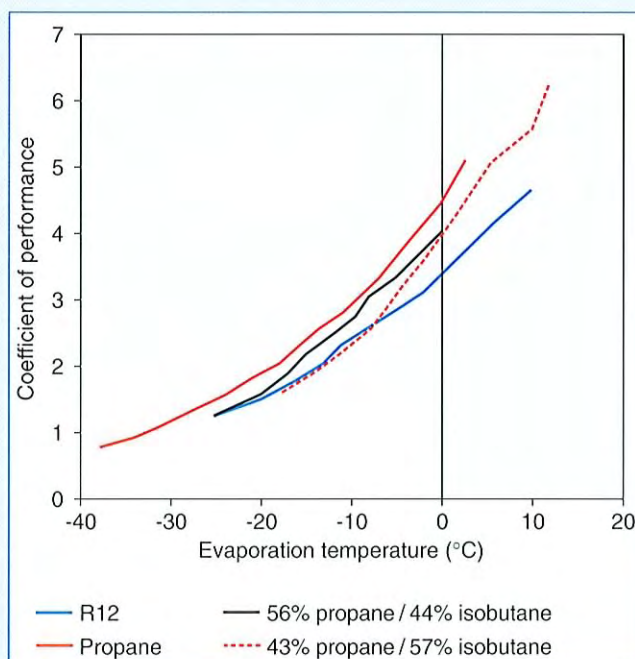


Figure 2: Coefficient of performance for refrigeration equipment using a range of refrigerants.

concerned with refrigeration systems, the results are, of course, equally applicable to heat pumps. Following advice from the Institute for Cryogenics and Energy Research, the London-based refrigeration company Morris & Young converted the reversible heat pump unit serving their offices to hydrocarbon operation and have reported excellent results.

The institute has also been involved in the development of the "Care" range of hydrocarbon refrigerants that are marketed by Calor gas.

(Source: Dr Neil Richardson, Institute for Cryogenics and Energy Research, Southampton, UK. Tel: +44-1703-592059)

Markets

Market survey on the Super Heat Pump

Japan - Completed in 1992, the R&D project "Super Heat Pump Energy Accumulation System" broke new ground in the development of heat pumps with very high COPs, including some for operation at high temperatures. The next step is to find out what the market is for these super heat pumps (SHPs).

The Heat Pump Technology Center of Japan, home of the IEA Heat Pump Centre National Team, undertook to survey the SHP market by distributing a questionnaire and undertaking a cost analysis.

Survey

The survey was conducted by sending a questionnaire, accompanied with an introductory brochure on SHPs, to potential installers of SHPs. SHPs for buildings and DHC systems were handled separately from the high-temperature SHPs for industrial applications. Of the 380 building constructors and 96 designers and suppliers of DHC systems who were contacted, some 300 replied – a good rate of response that suggests considerable interest in SHPs among the potential users. They were asked if they expected to be installing SHPs in the medium to long-term future. In response, 12.8% said they expected to do so by the year 2000 and 18% by 2010.

A much lower expectation was registered for the industrial SHPs. Of the 208 responses from factories, just 3.7% expected to be installing SHPs by the year 2000 rising to 12% by 2010.

This data was used to estimate the diffusion of SHPs as shown in Figure 3.

The survey also asked about the required payback period for an SHP. The responses indicated maximum payback periods of 5 years for large buildings, 7 years for DHC systems and 3.5 for industrial applications.

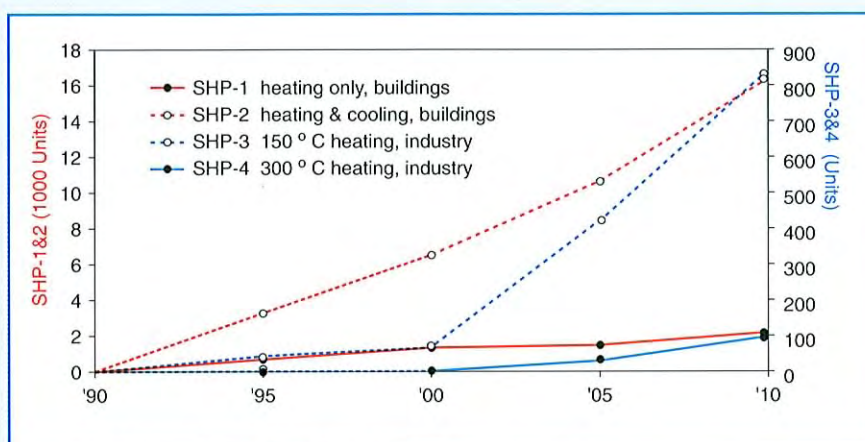


Figure 3: Predicted diffusion of super heat pumps.

Respondents also indicated the allowable installation space for an SHP relative to that required by conventional oil boilers, steam boilers, ordinary heat pumps, and furnaces. For large buildings this was registered as 1.7, for DHC systems 1.1 and for industrial applications 1.2.

Cost analysis

The cost analysis was made in consultation with the manufacturers involved in the SHP project. While it

is difficult to know the actual costs of SHPs as market products, the data shown in Table 2 provide a good indication. This indicates that SHPs are more likely to be economically attractive for use in buildings than for industrial applications. To achieve a wider diffusion of SHPs it will probably be necessary to lower the performance goal a little.

(Source: Mr Yoshio Igarashi of the Japanese National Team in an article published in JARN, August 1995)

Table 2: Cost survey of super heat pumps.

	Initial cost (US\$/kW)	Unit heat price (US\$/GJ)
SHP-1 (heating only for buildings)	436	20.6
Oil boiler	131	26.2
SHP-2 (heating and cooling for buildings)	855	39.7
Conventional heat pump	424	41.7
SHP-3 (150 °C heating for industry)	3772	40.3
Oil boiler	168	29.0
SHP-4 (300 °C heating for industry)	1903	26.8
Furnace	235	10.4

IEA Heat Pump Programme

HPC links up to the World Wide Web

The worldwide information services of the IEA Heat Pump Centre (HPC) now extend to anyone anywhere in the world with a personal computer and an Internet connection. Figure 4 shows the home page which can be reached using the following address:

<http://www.HeatPumpCentre.org>

We can also be found from the World Wide Web sites of other IEA information centres such as CADDET and GREENTIE.

By entering our World Wide Web site, people have access to a large amount of information presented in a clearly structured format. Newcomers to our activities can get information on all past and present Annexes of the IEA Heat Pump Programme and can learn about the activities, services and products of the HPC. And for those not familiar with heat pump technology, a tutorial is on hand to explain the principle of the heat pump and its ability to save energy.

New information continues to be added to the site. From the home

page, users will soon be able to enter the "IEA Heat Pump Programme Library" – a fully searchable database containing abstracts of all papers, articles and reports published under the IEA Heat Pump Programme since 1978. A total of around 1,000 records. This service will be on-line early in 1996.

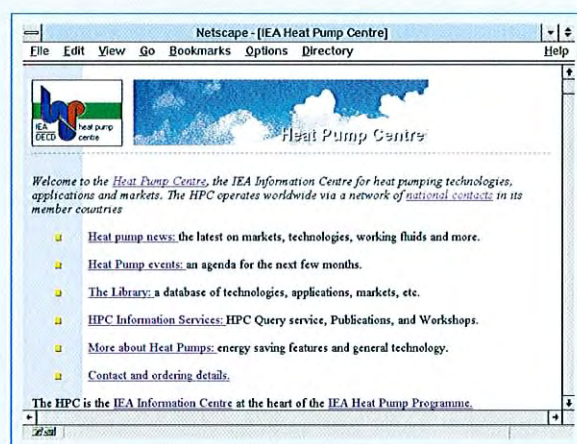
Other services are also in development, including a database of heat pump manufacturers, and

"bulletin boards" where users can exchange ideas and ask questions.

We hope you will find our site a useful source of information – one that complements the information services of this Newsletter. All those who access the site are encouraged to contact the HPC with their comments and suggestions.

(Source: Mr. Bert Stuij,
IEA Heat Pump Centre)

Figure 4:
The world's central
access point for
heat pump
information:
The HPC's Internet
Home Page.



Vital information for industry



a brochure,
free-of-charge



a report,
NLG 100

a program,
see below



Three products of IEA Heat Pump Programme Annex 21 that provide vital information for engineers and policy makers concerned with improving the operation of industrial plant and reducing energy consumption and associated emissions. The brochure and report are available worldwide.

For the program, people from Canada, France, Japan, the Netherlands, Norway, Sweden, the UK and the US can receive a free copy on ordering the report or can buy it separately for NLG 50. Those in other countries pay the same but cannot receive it until June 1996.

National Teams set HPC workplan

The Netherlands - The 1995 HPC National Teams Working Meeting was held on 9-10 October in Nuenen, just outside Eindhoven.

Together with the Advisory Board and HPC staff, the National Teams discussed the strategic objectives of the IEA Heat Pump Programme and

drew up a workplan for 1996. Table 3 lists the topics chosen for forthcoming Newsletters and shows the dates of the next workshop. In 1996 work will begin on the update of the analysis "International Heat Pump Status and Policy Review", and the completion and publication of the analysis "Building Equipment Energy Efficiency Regulations and Labelling Requirements". Furthermore, the HPC will begin a new activity known as monitoring, whereby information will be collected and disseminated using new media such as Internet. Initially monitoring will look at regulations on and applications of natural working fluids, complementing the work of Annex 22, that focusses on R&D.

HPC Newsletter Topics

March 1996	Systems and Applications
June 1996	Natural Working Fluids
September 1996	Heat Pumps in Commercial Buildings
December 1996	The 5th IEA Conference on Heat Pumping Technologies
March 1997	Thermally-Activated Heat Pump Systems

Workshop

7-8 May 1996 Tokyo, Japan	Heat Pump Systems and Controls for Energy Efficiency
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Table 3: 1996 HPC work programme.

(Source: Mr Mike Steadman, IEA Heat Pump Centre)

New Annex targets "ductless" home

France - At a meeting in Lyon, representatives from Canada, France, Spain, and Switzerland met to discuss how an Annex under the IEA Heat Pump Programme could help support the market for single-room heat pumps. Such equipment would target the difficult market for the retrofit of "ductless" homes with resistance (baseboard) or hydronic

heating systems. To be titled "Cold Climate Heat Pump Systems for Single-Room Applications", the proposed Annex would collect data on both conventional and heat pump equipment for single-room applications.

Particular emphasis would be placed on heat pumps that perform

efficiently in cold weather.

In addition to those represented at Lyon, several other countries have expressed an interest in this Annex, including the US where a similar meeting was held in August.

(Source: Ms Rebecca Jones, IEA Heat Pump Programme)

Experts discuss new Annex on sorption systems

Sweden - "Why do sorption heat pumping technologies fail to break into the market?" This was the main question discussed in preparation for a new Annex to be entitled "Application of Sorption Machines for Heating and Cooling in Future Energy Systems".

At the meeting, held in Eksjö, Sweden on 12 September 1995, experts from Italy, Japan, The Netherlands, Spain, Sweden and Switzerland described their country's interests and activities in

sorption systems and discussed the work of the proposed Annex.

Under the Annex, information on existing installations would be collected and an investigation would be carried out to assess the market impediments. Recommendations would then be made for R&D work to overcome these impediments. The work would be carried out by contractors in the participating countries on a task-shared basis. The programme would also include at least one workshop.

The meeting provided important input for the drafting of a complete Annex proposal which was to be presented at the autumn Executive Committee of the IEA Heat Pump Programme held in Dresden, Germany, in November 1995.

Participants of the meeting also visited an absorption heat pump at the Eksjö waste incineration plant.

(Source: Mr Jos Bouma, IEA Heat Pump Centre)

Standards and Regulations

An International Overview

Mike Steadman, IEA Heat Pump Centre

Standards and regulations play an important role in the development of heat pump markets. They can bring significant benefits by helping to raise the level of safety, performance and reliability. But they can also hamper market development by imposing undue costs and difficulties on the heat pump manufacturer.

A key factor is the introduction of international standards that alleviate some of the difficulties imposed by varying national standards. This article reports on the major international standards concerning heat pumps and discusses the type of developments in standards that the heat pump community would like to see. In the blue boxes, representatives of the member countries of the IEA Heat Pump Centre express their views on standards and regulations.

* * *

A non-regulated market would be an unhappy and dangerous place for the heat pump user. When purchasing equipment, there would be no reliable information on the size and efficiency of equipment. And once installed, the user may not only find that the equipment was of poor quality and unreliable, he or she and his property may also be exposed to hazards relating to electricity, rotating machinery and chemicals.

One might argue that market forces would help to alleviate these problems. Surely, consumer pressure would mean that only manufacturers of high-quality, efficient, reliable and safe equipment would succeed in the market place. However, experience tells us that the completely free market does not necessarily result in the best products. Nor does it create the best conditions in which businesses can flourish.

Control mechanisms are needed to influence the market so as to meet the specific requirements of the consumer and the wider needs of society as a whole.

An important mechanism is to produce standards. Standards specify minimum requirements for the manufacture and installation of equipment and can address a range of issues. For heat pumps, the main concerns are safety, performance, noise levels and

Published standards

ISO 5151	"Non-Ducted Air-Conditioners and Air-to Air Heat Pumps, Testing and Rating of Performance" (includes single split units but not multi-split units)
ISO 13253	"Ducted Air-Conditioners and Air-to Air Heat Pumps, Testing and Rating of Performance" (includes single split units but not multi-split units)
ISO 917	"Testing of Refrigerant Compressors"
ISO 9309	"Refrigerant Compressors - Presentation of Performance Data"

Working groups developing new ISO standards

ISO TC 86/SC 6/ WG2	"Equipment Sound Ratings"
ISO TC 86/SC 6/ WG3	"Water-to-Air and Brine-to-Air Heat Pumps -Testing and Rating for Performance" (standard on water-to-water and brine-to-water heat pumps also under consideration)
ISO TC 86/SC 6 WG4	"Air-Conditioning Condensing Units - Testing and Rating for Performance" air-cooled and water-cooled condenser units not covered by ISO 5151 or ISO 13253
ISO TC 86/SC 8/ WG3	"Fluorocarbon Refrigerant Specifications and Test Methods"

Table 1: ISO standards for the testing and rating of heat pump equipment.

environmental impact. Alongside standards, labelling requirements and advertising regulations also have an important role in creating desirable market conditions.

Standards may be implemented on a voluntary basis or enforced by regulations. Between these two extremes are measures that disadvantage those products that do not meet the standard. Such measures include:

Austria

Several standards and regulations in Austria address heat pump performance, installation and operation. Currently, many changes are being made as a result of Austria's entry into the European Union (EU).

The "Österreichisches Normungsinstitut" (ON) or "Austrian Standards Institute" is a private association legalized by the Austrian government to publish Austrian technical standards (ÖNormen). ÖNormen have the character of recommendations and have to be pre-arranged between partners. Only if an ÖNorm is explicitly specified in a law or a BGBl (Bundesgesetzblatt) regulation does an ÖNorm have the force of a law.

Most of the ÖNorm "M" heat pump standards will be replaced by the relevant CEN documents (standards) at the moment of their publication. For example, the ÖNorm M 7750 (Electrically driven heat pumps; terms and definitions) has already been replaced by ÖNorm EN 255 Part 1.

The standards ÖNorm M 7760, M 7761 and M 7762, as well as the proposed standard M 7763, are type testing standards which aim to show that the energy efficiency of a unit ("energiewirtschaftliche Zweckmäßigkeit") required by the regulations BGBl Nr. 135/1980 and BGBl Nr. 222/1982 can be met. In the case of a positive test result, the consumer who installs such an energy efficient unit can get a tax reduction. However, there is no prohibition to sell, import or install a heat pump, which does not meet the requirements of the above mentioned type testing standards.

Particular problems with standards and regulation have been experienced over the last years with regulations for the licensing of water extraction and/or heat extraction from the ground. Furthermore, existing regulations pose difficulties for the utilization of ammonia and especially of hydrocarbons as refrigerants.

(Source: Mr Hermann Halozan, Austrian National Team)

- informing the consumer of the products that meet a standard, such as by using a recognized label;
- excluding products that do not meet a standard from promotion schemes such as government or utility subsidies.

Traditionally, standards and regulations have been set up on a national basis. This inevitably means that the requirements for the equipment manufacturer can vary widely from country to country and presents many difficulties for international trade. In recent years, much progress has been made towards the development of international standards. Some of the major international standards that affect heat pumps are discussed below.

Making Heat Pumps Safe

The top priority for regulation is safety. For the safety of electric equipment, international standards are published by the International Electrotechnical Commission (IEC) to which around 50 countries belong. Modifications for the European Market are published by the European Committee for Electrotechnical Standardisation (CENELEC). Common standards and minimum safety requirements are set for household equipment under the standard "IEC 355-1 Safety of Household and Similar Electrical Appliances. Part 1 General Requirements". This international standard not only ensures safer and better products, it also simplifies trade between countries.

Heat pumps are given special attention in the standard "IEC 335-2-40 Particular Requirements for

Electrical Heat Pumps, Air Conditioners and Dehumidifiers". As with all standards, this one is updated on a regular basis to take account of changes, such as new technical developments in the current update procedure, consideration is being given to include equipment using flammable refrigerants.

Another IEC standard of relevance to heat pumps is IEC-335-2-34 which addresses the specific requirements of refrigerant compressors.

Mechanical and refrigerant safety aspects are dealt with by the International Organization for Standardization (ISO) in its publication "ISO 5149 Mechanical Refrigerating Systems used for Heating and Cooling - Safety Requirements".

In Europe, CEN (European Committee for Standardization) is developing standard EN 378 to define more detailed requirements on the design, construction, manufacture, installation, operation, maintenance and disposal of refrigerating systems and appliances. Entitled "Refrigerating Systems and Heat Pumps, Safety and Environmental Requirements", standard EN 378 is concerned with the hazards associated with the physical and chemical characteristics of refrigerants as well as the pressures and temperatures occurring in the refrigeration cycles. It deals not only with safety but also with the risks to the local and global environment. Standard EN 378 is expected to be ready for publication in 1996. Part 1 "Basic Requirements" was adopted in 1994.

Canada

Canada currently has in place energy standards for all heat pump equipment. These standards have been set through the consensus process at the Canadian Standards Authority (CSA) and regulated at both the Federal level (imports and products shipped between provinces) and by many provinces. Canada has been progressive in this area and has set energy standards for ground-source heat pumps and direct-expansion ground-source heat pumps, ahead of other countries.

Where there is no heat pump standard or regulation currently, introduction of the same has the following benefits:

- by eliminating the least efficient products from the market, all manufacturers can drop these product lines and concentrate on more efficient product and therefore lower prices for more efficient products by spreading costs over larger production runs;
- in market segments where the end user does not have a say in decision making for new equipment (e.g. new housing), minimum performance is ensured;
- it increases consumer and industry awareness and concern for energy efficiency. It finally becomes an issue in the market.

Some new developments and priorities for heat pump standards and regulations that Canada would like to see are:

- eliminate non-comparability of performance ratings for competing heat pump equipment for similar applications and develop a means for comparison of operating costs (e.g. ground-source and air-source heat pumps);
- quickly move to revise methods of test and ratings to encourage the use of energy-efficient multi-function equipment - e.g. ventilation heat recovery heat pumps, heat pump desuperheaters, conventional heat pump water heaters;
- the use of seasonal as opposed to steady-state ratings, otherwise it is impossible for consumers to compare product performance in a meaningful way and make rational purchasing decisions;
- countries without heat pump energy standards (e.g. most European countries) should adopt the same energy standards as Canada to eliminate low efficiency products from manufacturer product lines intended for export. This would further lower the cost of more efficient products in all home markets;
- calculation algorithms should be developed and certified to allow the use of existing steady-state performance ratings to calculate operation costs in different regions of the world. This would eliminate the need to undertake costly cyclic testing needed to characterize seasonal performance and operating costs of different heat pump types.

(Source: Mr Doug Cane, CANETA Research Inc., Canada. Tel: +1-905-542-2890; Fax: +1-905-542-3160)

Measuring Performance

More than for most other equipment types, the energy efficiency of a heat pump is a major factor affecting the customer's decision to buy. But providing a reliable guide to the energy efficiency of a heat pump is much more difficult than, say, for a gas boiler because of the strong influence of outside parameters such as source and supply temperatures. A number of standard methods for testing and rating heat pumps have been developed in recent years. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has taken a lead in this field as the first organization to publish standards for the method of testing and rating air conditioners and heat pumps. ASHRAE standards have been used to form the basis for other regional and

national standards. Table 1 (page 13) lists the standards published by the ISO and the ISO working groups that are developing new standards for other equipment types. In Europe, CEN will shortly be completing the following "Testing and Rating Standards":

CEN 255 "Air Conditioners, Liquid Chilling Packages and Heat Pumps with Electrically-Driven Compressors - Heating Mode;"

CEN 814 Testing and Rating Standard "Air Conditioners and Heat Pumps with Electrically-Driven Compressors - Cooling Mode."

Development of these standards began in 1985. Their

Japan

The heat pump market in Japan has experienced dramatic success during the last 15 years, specifically in the residential and commercial sectors. Of the various factors contributing to this market development, it is obvious that standards and regulations have played an important role along with technical developments in heat pumps.

Standards for testing and rating of heat pump performances, set up by government or industry associations, have so far been accepted and worked effectively for the sound development of the heat pump market in Japan.

The performance regulation entitled "Laws on the Rationalization of Energy Utilization" which was published in 1979, contributed to market development in the early 1980s. The decree covers minimum energy efficiency standards for space conditioning equipment (cooling cycle only), as well as the thermal efficiency of a building envelope. This motivated a significant increase in decentralized air-source heat pumps in the commercial building sector, which was repeated in the residential sector a few years later. A new, more stringent version of this law, to be introduced in October 1997, will include minimum efficiency standards for heat pumps in the heating mode.

As to the codes and regulations for safety in Japan, specifically those for pressure vessels and working fluids appear to act as barriers for the use of alternative or natural working fluids. Considering the recent technical development in the safe use of these working fluids, they are in need of revision. These codes and regulations are now being modified as part of the government's deregulation strategy. However, further difficulties for natural working fluids can be expected since the introduction of the product liability law on 1 July 1995 to protect consumers. This has made the issue of product safety more "legally" important.

Differences in national standards and regulations are the main obstacle for international trade. For the international market development, unification of heat pump standards and regulations are desirable and should be promoted.

(Source: Mr Yoshio Igarashi: Japanese National Team)

publication in 1996 will mark an important contribution towards the stimulation of heat pumps in Europe. All 18 member countries are obliged to adopt CEN 255 and 814 as national standards, thus easing the difficulties posed for heat pump manufacturers who wish to trade in various European countries.

Certifying Performance

Having established standards for the measurement of heat pump performance, a certification programme is needed to measure this performance and inform the customer. This is generally the task of national organizations.

In the international arena, a programme for the certification of heat pumps is carried out by EUROVENT – the European Committee of Air Handling and Air Conditioning Equipment. Its second "Directory of Certified Products" was published in 1995 and includes performance data on reversible air-source heat pumps for the European market.

Only those products that meet minimum performance standards are included in the directory and are allowed to display the Eurovent label (see Figure 1).

Regulating Performance

While certification programmes help to set minimum performance standards for heat pumps, they work on a purely voluntary basis and do not exclude "poorly" performing heat pumps from the market. In the US, Canada and Japan, however, mandatory minimum performance specifications have been set for air conditioners and reversible air-source heat pumps. Such regulations have clearly helped to raise performance levels in these countries, as illustrated in the article on page 23. However, there is a natural reluctance to set the requirements too high. In case they put up costs to the extent that heat pumps lose market share.



Figure 1:
The EUROVENT
label.

Netherlands The European standards EN 255 for testing, rating and marking, and EN 378 for safety and environmental aspects are relevant. However, at this moment, standards and regulations for HVAC systems design are more important for heat pump applications than the above mentioned standards focused on the heat pump itself.

Two Dutch standards NEN 2916 and NEN 5128 for the Determination of the Energy Performance of residential and non-residential buildings have been developed. These standards are very important for further reduction of the primary energy consumption of buildings and dwellings, and so for the application of sustainable techniques such as heat pumps, solar energy, geothermal and wind energy.

The standards assume a PER (Primary Energy Ratio) for heat pumps of one, without any differentiation to supply and source temperatures or to the heat pump type and design. They are therefore inadequate for heat pump evaluation and design.

Recently the ISSO (Building Research and Standardisation Organisation in The Netherlands) has published the "Handbook for Heat Pump Implementation in Buildings (ISSO 38)". Used in combination with other ISSO publications (particularly ISSO 213, 21, 8, 9 and 300) and the European standards for calculation of heat demand and cooling load in buildings (EN 5066 and 5067), this publication provides reasonably appropriate design guidelines for heat pump implementation in buildings in the Netherlands.

The Dutch experience with using the provisional CEN standard EN 255 and the very similar German standard DIN 8900 for the testing and rating of heat pumps has highlighted a number of problems, such as difficulties in fulfilling the prescribed measurement conditions. Furthermore, these standards are not appropriate to fix a seasonal performance of the heat pump in interaction with the building and the HVAC system. For this reason, the Dutch Organisation for Applied Scientific Research (TNO) has developed a dynamic test procedure and a dynamic test rig for heat pumps (See *IEA Heat Pump Centre Newsletter* Vol.13.No.3). This determines the HVAC system performance according to the heat pump performance, the occupants' behaviour, the building and the outdoor climate. There is a need to develop this test procedure into a formal guideline or standard.

For industrial heat pumps, the only relevant standards are those for components such as EN 1012-1 for compressors. EN 378 will be relevant for large industrial closed-cycle heat pumps which function mainly as a chiller.

CFC, HCFC and HFC refrigerants have been subject to very strict regulations since 1993. These specify leak-tight design, appropriate procedures for operation, servicing and maintenance, and the qualification of installers and personnel. For ammonia, comprehensive directives cover safety and environmental aspects.

(Source: Mr Jan de Wit, TNO Institute of Environmental and Energy Technology, The Netherlands. Tel: +31-55-5493-493; Fax: +31-55-5419-837)

Norway

Most Norwegian standards apply to a broad range of equipment and/or liquids and gases rather than specifically to heat pumping equipment. For example, the guidelines on the use of flammables are applicable for all kind of gases and liquids under pressure. And electrical standards deal with all applications of electrical equipment.

Norsk Kuldenorm, "Norwegian Code of Good Practice - Refrigeration", is an important document and tool for everyone concerned with design, construction, operation and maintenance of heat pump and refrigeration systems in Norway. This consultative document has been revised in 1995 in accordance with the new CEN-standard EN-378, and the new edition of "Regulations for Appliances and Plants for Chlorine, Sulphur Dioxide and Ammonia". The Norwegian Standard "NS 4622, Refrigerating Plants - Safety Requirements", which is based on ISO Recommendation R 1662-1971, is an integrated part of Norsk Kuldenorm.

For the development of future standards, the Norwegian National Team has made the following observations:

The implementation of international standards is needed to make trade in heat pumping equipment much easier. The new European CEN-standards are a good start and will eventually supersede corresponding Norwegian standards.

The number of standards applicable for heat pump installations is too high. For example, in addition to EN 255 and EN 378, four other CEN-standards are being developed that will apply to heat pump

Norway (continued)

and air-conditioning systems. These will cover:

- Thermal Performance of Buildings and Components (CEN/TC 113)
- Space Heating Appliances (CEN/TC 130)
- Ventilation for buildings (CEN/TC 156)
- Heating Systems in Buildings (CEN/TC 228).

In commercial and public buildings, standards are giving minimum requirements for ventilation air exchange. To decrease the use of energy, there should also be requirements on energy conservation and energy efficiency. As an example, hydronic systems should be required for heat distribution in commercial buildings, since hydronic systems are flexible regarding heat source and therefore also regarding energy efficiency.

Energy conservation in industry is also a great challenge, but there are many complex systems and it is therefore difficult to give general guidelines.

Standards are required that consider heat pump systems in connection with all the heating and cooling systems in the building. These include peak load systems, heating and cooling distribution systems, simultaneous heating and cooling systems, regulation strategy, and energy conservation. The guidelines should refer to both electrical, safety and equipment specific standards. Norsk Kuldenorm should be rewritten to be more applicable for heat pump and refrigeration systems and made into a legally binding document.

(Source: Ms Trude Tokle, SINTEF Refrigeration and Air Conditioning, and Norwegian National Team. Fax: +47-7359-3900; Tel +47-7359-3926. E-mail: tokle@kkt.sintef.no)

Labelling Performance

The regulation of standards should be supported by reliable and clear labelling standards. Figure 2 is an example of a label that is applied to air-source heat pumps in the United States. This informs the customer on the heating and cooling performance as measured under a government-approved standard. Labels for HVAC (heating, ventilation and air-conditioning) equipment have been applied in the US since 1980. Some also provide information on energy costs.

Towards Greater Harmonization

As expressed in many of the contributions to this article (see blue boxes), many people would like to see greater harmonization of heat pump standards and regulations. The ultimate goal would be an international system for measuring, certifying, regulating and labelling the performance of heat pumps and internationally agreed safety standards. Under such a regime, heat pump manufacturers would need only one line of products for similar applications in different countries. This in turn would result in considerable cost savings for the user. Many hurdles stand in the way of this dream situation. But recent developments to harmonize standards in Europe and North America are important steps in the right direction.

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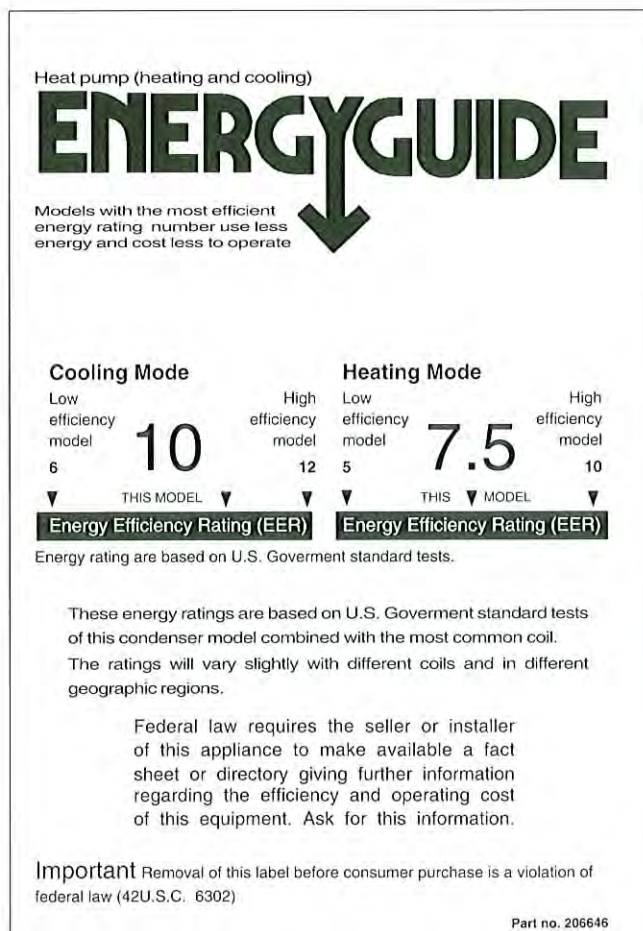


Figure 2: 'Energyguide' label for air-source heat pumps less than 65,000 Btu/h (19 kW) cooling capacity-USA.

Switzerland Standards and Regulations are a means to support users, manufacturers and governmental authorities in the dissemination and installation of heat pump systems. They are not intended to hamper heat pumps. The Swiss Association for the Promotion of Heat Pumps (FWS) deals with this topic in the department "Regulation/Assisting". Successful results are:

1. An atlas for earth-coupled and water-source heat pumps, showing the possible drilling locations.
2. The harmonization of the cantonal concession practice and solving of existing tariff problems.
3. An overview of available subsidy programmes and possibilities for tax deductions.

In addition the Swiss National Team seeks, in cooperation with heat pump and refrigeration equipment manufacturers, clear and detailed regulations for the use of flammable refrigerants in residential and commercial applications. These guidelines are necessary to support manufacturers, installers and users. Hydrocarbons offer highly efficient applications for heat pump water heaters and the retrofit of high-temperature heating systems. Certainly, the highest possible security standard has to be guaranteed with clear guidelines for the permitted refrigerant content and the installation procedure.

The new energy law of the canton Zurich requires that no more than 80% of the permitted energy demand for heating and tap water are covered by non-renewable energy sources. Although a specific piece of equipment, such as a heat pump, may not be prescribed by law in Switzerland, the new energy law provides very strong support for heat pumps. Further regulations in this direction are therefore highly desirable.

(Source: Mr Thomas Afjei, Swiss National Team)

USA

Appropriate efficiency regulations for heat pumps can be beneficial both to the environment and end users. Everyone agrees that energy efficiency is important, and the US advocates standards that yield affordable environmental benefits. US manufacturers are committed to lowering energy operating costs and helping the environment by providing energy efficient products. Equipment owners benefit from lower operating costs because efficient products consume less energy. Environmental benefits result from reduced emissions from fossil fuel power plants. The efficiency of heat pumps has increased dramatically over the last two decades, and reasonable federal efficiency standards are in place in the US and Canada. In the US, uniform federal standards are preferable to a patchwork of state standards. As these standards are reviewed for possible increases, it must be remembered that the practical limit of this technology is being approached. Any adjustments must be rational, so that the market retains elasticity and consumers have choice. The potential effects on product features and comfort must also be considered. Before establishing regulations, it is essential to determine if they are necessary, warranted, and cost effective.

The overriding issue is the need to change from HCFC-22 refrigerant. While the actual phase-out schedule for HCFCs allows many years of continued HCFC use, competitive pressures are expected to accelerate the use of alternatives. Chemical companies and heat pump manufacturers are now concentrating their efforts on future developments. The financial impact on companies to redesign and retool current product offerings to new technology equipment utilizing new refrigerant is enormous and does not allow for additional monies to be allocated for short-term changes in interim efficiency standards.

The bottom line is this: Efficiency standards for heat pumps should be maintained at their current levels until better information is available on the impact of alternative refrigerants. This information should be available in the near future. Temporarily holding the line on regulations is a rational approach in a very turbulent time in the industry. We should not attempt to establish new standards by assessing the products currently available in the marketplace which use HCFC-22, since the equipment that would be covered by new standards would utilize new refrigerants, with unknown impacts at this time.

In the meantime, the marketplace serves as an effective means of advancing energy efficiency. End users are the ultimate source of energy conservation decisions. They care about savings in their monthly utility bills, and are willing to purchase efficient products that have reasonable payback periods. Ultimately, any new regulations must be cost effective for both end users and manufacturers if society is to benefit.

(Source: Mr Larry Wethje, Director Public Policy, Air-Conditioning and Refrigeration Institute (ARI), USA. Tel: +1-703-524-8800; Fax: +1-703-524-3816)

Standards and Regulations in Japan

A Manufacturer's View

Yoshifumi Kunugi, Mitsuru Sawada and Takeshi Yoshii, Japan

In Japan, a variety of regulations and standards apply to the fields of refrigeration, air conditioning and heat pumps. Sometimes they work as positive market forces and at other times as restrictions for market development. In this article, the present situation is reviewed and the future prospects are surveyed through the eyes of the heat pump manufacturer.

* * *

In Table 1 the standards and regulations currently applicable to heat pumps in Japan are summarized by categories. As shown, they address energy, safety and environmental issues and include standards for testing and rating the performance of equipment.

Energy

A law to rationalize the use of energy was enacted in 1979. This so-called "Energy Saving Law" introduced target values for the energy efficiency (minimum energy efficiency) of air conditioners. In a subsequent revision of this law in 1993, the target values were set to a higher level and energy efficiency targets for heat pumps were set in addition to air conditioners. These new targets will come into effect in October 1997. The old and new energy efficiency standards are listed in Tables 2 and 3. Energy efficiency labelling regulations came into effect in 1994, more recently in combination with the "Household Goods Quality Labelling Law".

The enforcement of these laws has promoted the development and commercialization of energy

Table 1: Standards and regulations applied to heat pumps in Japan.

	Codes/Regulations/Standards	Content/Scope
Energy	Laws on the Rationalization of Energy Utilization	Set targets for the minimum energy efficiency of air conditioners and heat pumps with cooling capacity of less than 27 kW.
	Household Goods Quality Labelling Law	Energy efficiency labelling regulation (>3kW) Energy efficiency labelling regulation (<3kW)
Safety	High-pressure Gas Control Law	Regulates the production, sale, storage, transportation and other matters concerning the handling and consumption of high-pressure gas (liquefied gas not less than 0.2 MPa (2 bar), compressed gas not less than 1 MPa (10 bar). Includes a refrigeration safety regulation.
	Electrical Appliance and Material Control Law	Regulates the safety of all electrical appliances.
	Fire Service Law	Regulates the safe use of flammable hazardous materials.
Environment	Basic Law for Environmental Pollution Control	Pollution control of air, water and noise.
	Ozone Layer Protection Law	Regulates the production of ozone depleting substances.
Testing & Rating	National Standard (JIS)	Testing and rating procedures for room air conditioners, packaged air conditioners and water chillers.
	Association Standard (JRA)	Supplementing the national standards for testing and rating procedures for air conditioners and chillers.

Cooling Capacity	COP _c	COP _h	COP _{hc}
under 4.0 kW, single unit	2.19	2.38	2.33
under 4.0 kW, split unit	2.67	3.20	2.97
4.0 to 7.1 kW	2.34	2.56	2.50
more than 7.1 kW	2.45	2.62	2.59

Measured under JIS standard conditions. COP_c = cooling at 35°C outdoor temperature. COP_h = heating at 7°C outdoor temperature. COP_{hc} = arithmetic mean of cooling and heating mode COPs.

Table 2: Energy efficiency Standards for Heat Pumps (Effective from October 1997).

efficient air conditioners and heat pumps. They have also contributed to some extent to Japan's national energy savings and to strengthening the international competitiveness of products. Moreover, since the law has had the effect of reducing the emission of CO₂, it is probably inevitable that its conditions will become even more severe in the future.

Safety

Great emphasis is being placed on the safety of products in Japan. A typical example is the "High-Pressure Gas Control Law". The enforcement of such laws in the air conditioning and heat pump industry has had significant effects in achieving high reliability and safety of products.

At the same time, however, these safety regulations are felt to be slightly excessive in some respects and have resulted in many disadvantages when attempts are made to promote export and international business. And they also impose obstacles to the import of refrigerating machines and heat pumps.

For example, when the refrigerant in a centrifugal chiller or heat pump is changed from CFC-11 to HFC-134a, it then becomes subject to the application of the law that regulates the use of high-pressure gas. And this imposes various restrictions both in terms of usage as well as from the manufacturing aspect.

For this reason, the necessity to ease regulations in the laws in question has recently arisen and many studies are in progress. The spirit behind the relaxation of these laws is to amend regulations to conform to actual conditions and to simplify many of the procedures and formalities that are now in effect.

For the high-pressure gas regulation, items that require immediate attention are:

- a simplification of the requirement for qualified persons responsible for the operation of refrigerating machines and heat pumps;
- a simplification of the procedures for obtaining permission to produce and install refrigerating machines and heat pumps.

Cooling Capacity	COP _c	
	New	Current
under 4.0 kW, single unit	2.45	2.23
4.0 to 7.1 kW, single unit	2.20	2.04
under 4.0 kW, split unit	3.09	2.92
4.0 to 7.1 kW, split unit	2.42	2.19
more than 7.1 kW	2.42	2.22

Measured under JIS standard conditions at 35°C outdoor temperature. New standard will be effective from October 1997.

Table 3: Energy efficiency standards for air conditioners (cooling only).

Ammonia

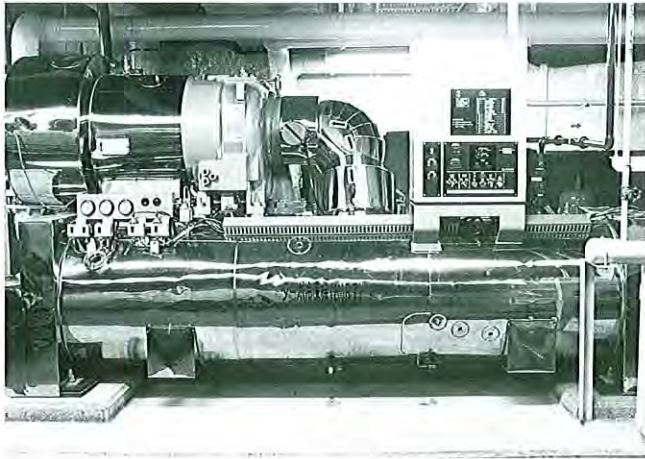
Another important safety issue is the use of ammonia. Although in the past ammonia was used extensively as a refrigerant in Japan, it has been subjected to restrictions for more than 20 years. The major reason for this is that, when the high-pressure gas regulation was re-examined in 1974, emphasis was placed on reducing the threat to the surroundings in the event of leakage or other accidents. Strong administrative guidance was therefore given to promote the use of fluorocarbons, and restraints were placed on the installation of facilities with ammonia.

A re-evaluation is now under way, however, because ammonia is now recognised as an environmentally benign substance which neither depletes the ozone layer, nor contributes to global warming, and is excellent in terms of thermodynamics and economy. Moreover, recent progress in the manufacturing and handling of ammonia is also being taken into consideration. A typical example of the move towards the use of ammonia is the availability of guidelines for the use of fully-automated unit type ammonia refrigerating facilities which were introduced for the Tokyo metropolis in May 1994. Another example is the relaxation by MITI (the Ministry of International Trade and Industry) in March 1994 of regulations for ammonia absorption chillers of less than 20 RT (70 kW cooling capacity).

An additional problem for ammonia is the lack of adequately trained technicians. Many of those who once handled ammonia have since left the profession without passing on their knowledge to their successors. In spite of this handicap, it is anticipated that ammonia will play an ever more important role in the air conditioning and heat pump industry in the near future.

Environment

Japanese environmental regulations relate to atmospheric pollution, quality of water, noise, vibration and waste. A recent addition is the "Ozone Layer Protection Law" which is expected to impose increasingly severe regulations.



Because it uses HFC-134a, this air-conditioning system must meet the requirements of the High-Pressure Gas Law.

With respect to the use of CFCs and HCFCs, agreements were reached at Montreal and Copenhagen to phase out the former by the end of 1995 and the latter by the end of 2020 (2030 for all applications). Ammonia, hydrocarbons and HFCs are all under consideration as possible long-term substitute refrigerants. Safety regulations on ammonia are discussed above. Hydrocarbons will also be subjected to strict restrictions because they are flammable substances. While HFC-134a is restricted by the "High-Pressure Gas Control Law" as explained earlier, it is used in a number of applications. The photograph above shows a 150 kW centrifugal refrigerating machine employing HFC-134a. This provides cooling air conditioning for a large building and can also operate in heat pump mode.

In addition to safety considerations, there is currently some discussion on the merits of considering global warming potential (GWP) when evaluating alternative refrigerants. However, none of the regulations that are currently in effect consider either the direct GWP effect of refrigerants or the indirect emission of CO₂.

For the replacement of CFC-11, new standards have been established for installing centrifugal refrigerating machines and heat pumps that employ HCFC-123, which is a low-pressure substitute refrigerant for CFC-11. Unlike equipment with HFC-134a, such equipment is exempt from the application of the "High-Pressure Gas Control Law".

Testing & Rating

Performance testing and rating standards have been prepared for heat pumps, air conditioners and chillers by the Japanese Standards Association (JSA) and published as the Japanese Industrial Standards (JIS) shown in Table 4. They are supplemented by Japan Refrigeration and Air Conditioning Industry Association Standards (JRA).

Progress has been made in the preparation of new test standards for multi-split heat pumps and air conditioners, and for a seasonal energy estimation procedure for inverter-driven heat pumps and air conditioners. These types of heat pumps have been developed as Japanese original technology and have recently become popular in the market.

Promoting Worldwide Trade

As outlined in this article, standards and regulations often pose restrictions to market growth. But the biggest problem, for manufacturers who wish to trade on the world market, are the variations from country to country. It is certainly desirable to establish common international standards and regulations in order to promote worldwide trade. However, there appear to be many difficulties to overcome before this goal will be reached.

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Table 4: Japanese testing and rating standards for heat pumps and air conditioners.

JIS B 8613-1994	water chilling units
JIS B 8616-1993	packaged air conditioners
JIS B 8622-1994	absorption refrigerating machines
JIS C 9612-1994	room air conditioners

Come to Japan !

For an HPC Workshop on:

*Heat Pump Systems & Controls
For Energy Efficiency*

7-8 May 1996, Tokyo

More details from the IEA Heat Pump Centre

Regulating Heat Pump Efficiency

Preview of an IEA Heat Pump Centre Analysis

Arvo Lannus, USA

A soon to be published IEA Heat Pump Centre Analysis Report will present and discuss the results of a survey of heat pump and air conditioner energy efficiency regulations, standards and labelling requirements. This article provides some first impressions of the initial survey.

Of the 37 countries included in the survey, only six reported regulations or standards governing the minimum energy efficiency of heat pumps and air conditioners. These include Japan and the United States – the two largest air-conditioning markets in the world – as well as Austria, Canada, France and Mexico. This article discusses the standards and regulations of these countries and assesses their effect on markets and technology.

* * *

Regulations and standards are the means by which a modern, industrial society protects its citizens and ensures an orderly marketplace. Laws and regulations governing buildings, and the manner of constructing the means of heating or cooling them, trace back at least to the city-building civilizations of the ancient Romans (and probably even before that to the Persians). The advent of mechanical refrigeration brought with it the need to consider the safety of operators and building occupants. In 1914, the American Society of Refrigerating Engineers (ASRE), a precursor society of the American Society of Heating, Air-conditioning and Refrigerating Engineers (ASHRAE), proposed safety regulations for refrigerating plants in cooperation with fire department officials in New York City, which were adopted as law in 1915. The first formal "Safety Code for Mechanical Refrigeration" was adopted by the society in 1922, to serve as a model for future legislation. Testing and rating standards were published by ASRE as early as 1942 and formalized as Standard 16-53 in 1953. The Air-conditioning and Refrigeration Institute's (ARI's) certification programme for unitary (i.e. self-contained) air conditioners started in 1958.

Efficiency

Energy efficiency regulations and standards are a more recent development. They represent a reaction to the oil supply disruptions and price run-ups of the 1970s, when many of the industrialized, oil-importing countries saw the heat pump as one means of solving

the problem of energy-supply vulnerability in the buildings and industrial sectors.

In 1975, the United States passed the National Energy Conservation Policy Act which established a programme for testing, rating, and energy-efficiency and cost labelling of a range of consumer appliances and equipment, including most residential-type air conditioners and heat pumps. However, the actual standards were not established until 1990, when they were introduced for room air conditioners. Packaged (unitary) air conditioner and heat pump standards first took effect in 1992. In Japan, the Law on Rational-

Table 1: Heat pump and air conditioner product classes covered by energy efficiency standards.

Country	Product Class	Mode
Austria	Air-water, surface water, groundwater and direct-expansion ground-source, heat pumps. Heat pump water heaters.	heating
Canada	Room, packaged and packaged-terminal air conditioners. Liquid chillers.	cooling
	Air-air, surface water, groundwater, ground-coupled, internal source, direct-expansion ground-source and packaged-terminal heat pumps.	cooling/ heating
France	Air-air, air-water, air-brine water-air, brine-air and water-water heat pumps.	heating
Israel	Room air conditioners (planned).	
Japan	Air conditioners, air-source heat pumps.	cooling/ heating
Mexico	Room air conditioners.	cooling
USA	Room, packaged and packaged-terminal air conditioners;	cooling
	Air-air, surface water, ground-coupled, internal-source, and packaged-terminal heat pumps.	cooling/ heating



Figure 1: Countries responding to the HPC survey on energy efficiency standards for heat pumps or air conditioners

lization of Energy Consumption established minimum efficiency standards for air conditioners in 1984, but this regulation covered only electric equipment for office buildings. Revised standards, which will cover heat pumps as well as air conditioners, will come into effect in late 1997. Thus it has taken nearly two decades after the first oil "shock" to establish minimum efficiency standards for the major energy-consuming equipment in buildings.

Survey

Figure 1 shows the countries responding to the HPC's initial survey and depicts the six countries which reported energy efficiency standards for one or more product classes. More details are given in the blue box on page 26.

Heat pump and air conditioner energy efficiency regulations are of the *performance* type (i.e. they establish a minimum required COP or related efficiency measure), rather than regulating equipment design or the manner of its application [1]. Not surprisingly, almost all of the regulations cover electric-driven vapour compression equipment, since electric equipment predominates the world's air-conditioning and heat pump markets. Only Canada has energy efficiency standards for indirect- and direct-fired absorption chillers, i.e. equipment that may be run on gas or fuel oil. As one would expect, there are specific capacity limits or ranges and other criteria for standards coverage. Most of them govern equipment with cooling capacity of 40 kW or below although some French standards go up as high as 150 kW in heating capacity. Table 1 summarizes the product classes covered by various energy efficiency standards.

Energy efficiency standards in Canada, Japan, Mexico and the United States were established by

government statute, or by regulations enacted to implement legislation. These laws and regulations make it illegal to manufacture, import or otherwise introduce in commerce, heat pump and air-conditioning equipment which has not been tested to meet the minimum efficiency levels specified by the standards. Not all of the standards are imposed by government regulation, however. Austrian and French minimum performance requirements are embedded in the heat pump equipment testing and rating standards issued by their respective national standards organizations (Oesterreichische Normungsinstitut and Association Francaise de Normalisation). Our respondents in those countries advised us that, technically, it would not be illegal to sell a heat pump that does not comply with the standards, but such equipment would be at a significant competitive disadvantage (e.g. ineligible for tax reduction and other incentives).

Effect

Energy efficiency regulations and standards are a mechanism for altering the economic choices that purchase decision makers would make otherwise. By removing certain products from the market, the average efficiency of the industry's product shipments is forced upward. If the standard is set high enough, manufacturers may be forced to redesign their product lines to meet it. In the more extreme case, market shares may shift in a market with competitive products using different technologies and different fuels.

Only in the United States have energy efficiency standards been in place long enough to hazard any conclusions regarding their effect on the market (and then just barely). Moreover, the effect of efficiency standards must be discerned from the confounding factors of long-established (and widespread) electric

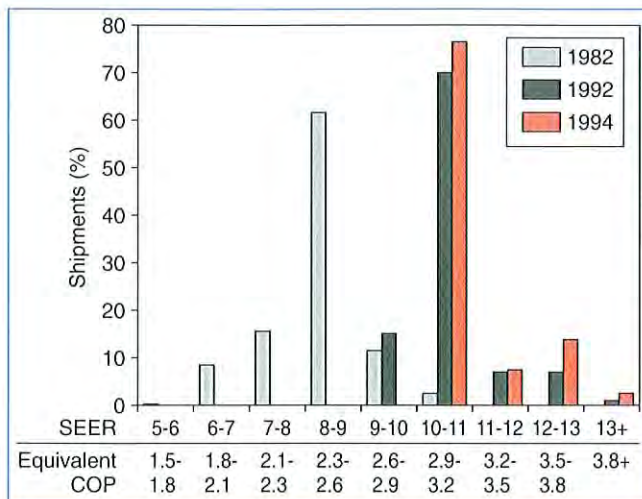


Figure 2: Shipment weighted cooling efficiencies for unitary heat pumps and air conditioners – USA.

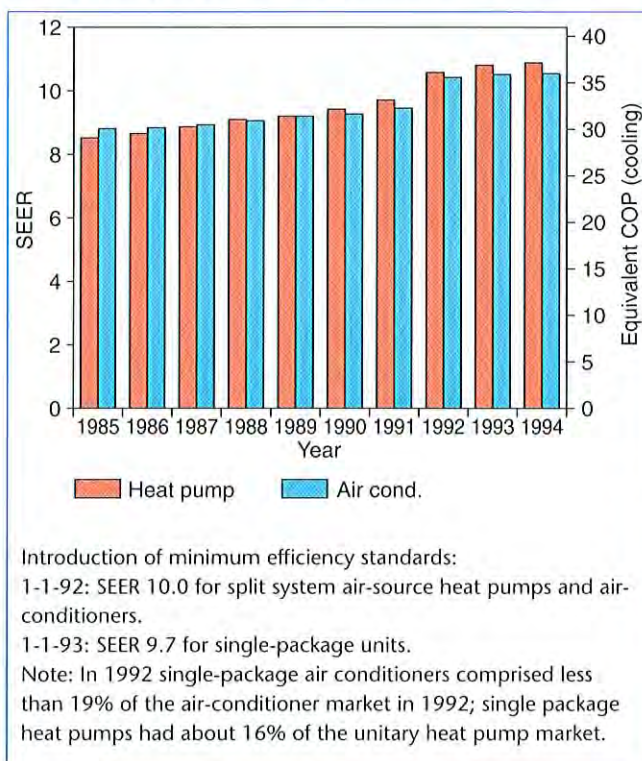


Figure 3: Distribution of unitary air conditioner and air-source heat pump cooling efficiencies before and after energy efficiency regulations – USA.

utility financial incentive programmes for energy-efficient equipment and increases in current (i.e. not inflation-adjusted) energy prices to residential and commercial consumers.

Figure 2 illustrates the last ten years' sales-weighted efficiency data, taken from ARI statistics [2], with the efficiency expressed in terms of the SEER (the Seasonal Energy Efficiency Ratio in Btu per watt-hour – the official cooling performance measure for products then covered by the regulations). Prior to the effective date of the standard for unitary equipment, shipment-

weighted average efficiency had been increasing at about 2.4% per year for heat pumps and 2% per year for air conditioners. The step-increase in efficiency from 1991 to 1992, when the standards for split systems first took effect, is evident. In the last three years, SEER increases have flattened and are now less than 2% for heat pumps and 1% for air conditioners.

The shift in product efficiency distribution is further illustrated in Figure 3, also based on ARI data. This shows the "normal" shape of the product efficiency distribution that persisted throughout the years leading up to the standard, presumably reflecting the economics of the marketplace. To meet the standard, most manufacturers had to go through a complete product line redesign for 1992, eliminating nearly 90% of the heat pump and air conditioner models made in earlier years. The mode (most probable value) of the product distribution has not changed, in the years since the standard, from the SEER 10-11 bracket (equivalent COP bracket of 2.9-3.2). In fact more than three quarters of heat pumps and air conditioners now have efficiencies in that range.

Harmonization

Except in North America, there has been little harmonization of energy efficiency regulations and standards – at least as seen from a world-wide perspective. This is to be expected. Energy efficiency regulations and standards are an instrument of government energy policy. They are dependent on the regulatory "culture" of that society, its conservation and environmental "politics", as well as its state of industrial development and the size of its air-conditioning market. Nevertheless, two factors tend to mitigate towards some uniformity in standards:

- a country planning new regulations tends to use another's existing regulations as a model;
- the growth of common or regional markets.

Similar drivers toward harmonization may be expected in Europe as are now operating in the North American market. As uniform European testing and rating standards, now under development by CEN committees, are issued, it is likely that national energy efficiency regulation will be supplanted by regulation at the regional level – at least among current EU and EFTA member countries. The European air-conditioning industry's recently introduced performance certification programme through EUROVENT is likely to speed this process along. But harmonization of energy efficiency standards in the other world markets is probably unlikely, given the large diversity of the societies and their widely differing developmental status.

Other Standards

The International Organization for Standardization (ISO) published testing and rating standards for

electric non-ducted heat pumps and air conditioners in 1995 and standards for ducted equipment have been approved and are awaiting publication. The ongoing effort by CEN (the European Organization for Standardization) to revise the current EN 255 series of standards and issue a new EN 814 series (the latter for equipment in the cooling mode) is making progress, and it is expected that those standards will be harmonized with the ISO standards. The basic ASHRAE standard test method for unitary equipment, Standard 37, is being revised and will be issued in metric (SI) form, harmonized with the ISO standards. Japan's newly revised testing and rating standards for room and packaged air conditioners and heat pumps are also virtually the same as the ISO's.

Electrical safety standards governing heat pump and air-conditioning equipment are also converging. Canadian and US standards for the electrical safety of heating and cooling equipment have been harmonized since 1990, and according to Underwriters Laboratories (the principal developer of electrical safety standards in the US), they plan to harmonize these standards in the next revision cycle with the International Electrotechnical Commission's standard 355-2-40 (the part relevant to air conditioners and heat pumps).

Covering Major Markets

Comprehensive energy efficiency regulation of heat pumps and air conditioners remains largely a US and Canadian undertaking. Only four other countries have them, while a few more are in the planning stages. Nevertheless, with Japan issuing new regulations that will cover heat pumps as well as air conditioners from October 1997, and with broad-ranging regulations already in effect in the US, the time is not far off when the majority of heat pump and air-conditioning products sold in the world's largest air-conditioning markets will be covered by energy efficiency standards.

Literature and Notes:

1. Several countries have applications guidelines which may be viewed as de facto energy efficiency standards. For example, The Netherlands provides a government subsidy to heat pump installations provided the primary energy ratio is at least 1.2. The Swiss Association of Engineers and Architects has guidelines for electric systems which require that electric heat pump installations achieve a monthly performance factor in excess of two in the months of December through February; otherwise a bivalent system must be installed.
2. "Statistical Profile of the Air-Conditioning, Refrigeration, and Heating Industry", Arlington, VA, USA: Air-Conditioning & Refrigeration Institute (1993), p. 25.

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Austria	Besides standards for more "typical" air-to-water, surface-water-source and ground-source systems, Austria has standards governing heat pumps for domestic and service water heating and has proposed a standard for direct-expansion ground-coupled heat pumps – both a reflection of the market importance of these types of products. Standards apply to heat pump heating mode operation only.
Canada	Efficiency regulation was initiated by Ontario and several other provinces, with the federal government following suit. Efficiency regulations are uniform in all provinces that have them, but effective dates and products covered may differ. Canada has probably the most comprehensive set of efficiency standards for heat pump and air-conditioning equipment. The standard levels and categories of products covered are essentially identical to those in the US, although Canada's standards cover some products not covered by US regulations. Efficiency labelling requirements cover room air conditioners only.
France	A comprehensive set of heat pump standards establish minimum COPs for heating mode operation only. French standards differentiate among outdoor air and exhaust air as heat sources and fresh air and recycled air as heat sinks.
Japan	Current efficiency standards govern air conditioners only. Revised standards will take effect on October 1, 1997. Although Japan has probably the largest market for gas-fired heat pumps, those products are not regulated by the efficiency standards.
Mexico	At the time of writing, efficiency regulations apply to room air conditioners only. However, Mexico has planned to extend regulation to central air-conditioning equipment in 1995. Standards are identical to those in the US. Efficiency and cost labelling requirements cover room air conditioners only.
United States	As a result of the latest energy policy law, efficiency standards now cover most commercial as well as residential electric heat pump and air conditioner product classes. Unlike Canada, however, groundwater-source heat pumps, direct-expansion ground-coupled heat pumps and liquid chillers are not regulated. Efficiency and cost labelling requirements cover residential-type products and are being extended to the others.

Standards and Regulations for GSHPs in Central Europe

Burkhard Sanner, Germany

The increasing market penetration of ground-source heat pumps (GSHPs) in Austria, Germany and Switzerland has made it necessary to establish standards and technical guidelines for their design and installation. Such regulations are especially crucial for vertical borehole heat exchangers (BHEs) for which no widespread knowledge exists with engineers and contractors. This article provides an overview of existing standards and regulations on GSHPs in central Europe including a new initiative in Germany to develop technical guidelines.

* * *

While the current number of GSHPs in Germany is relatively low, new market conditions should bring about a steady growth. New incentive schemes have been introduced by the Federal Ministry of Economics (BMWi) to support the market introduction of renewable energy technologies such as GSHPs. Also, there is a trend towards the use of GSHPs for both heating and cooling (including cold storage), which makes them more economically favourable than with heating-only applications.

However, while some regulations on the use of the ground have been issued by water and mining authorities, no standards exist for the installation of plants for the thermal use of the ground. In a growing market, it can be expected that some contractors will be tempted to make intolerable simplifications and under-dimensioning in order to save first costs. This makes a set of technical guidelines an indispensable tool to ensure good installation practice.

New Guidelines in Development

Following a suggestion of the Geothermal Association (Geothermische Vereinigung e.V.), the German Association of Engineers (VDI) – the largest technical association in Europe – has established a committee to develop such technical guidelines for the thermal use of the ground, down to a depth of around 400 m. In this zone, above the zone of classical geothermal applications, a number of technologies for heat and cold supply have been established in recent decades, including GSHPs. The first meeting of the committee, which is located at VDI's Society for Energy Technology (VDI-GET), took place in July 1995.

The "Guidelines for the Thermal Use of the Ground" (VDI-Richtlinie 4640) aim to ensure that plants for thermal use of the ground are correctly sized, use adequate materials, are properly drilled, and installed to a high standard with due regard for their integration with other systems. They will be based on current state-of-the-art technology. By guaranteeing technically and economically satisfying plants, the guidelines will help to save primary energy and to reduce emissions. Such plants must be designed for long-term operation without major problems and without noxious impact to the environment. It is also hoped that the guidelines will become a tool which authorities can use to control the application of technologies for thermal use of the ground in an environmentally sound way.

Members of the committee are from water and mining authorities, drilling contractors, installers, heat pump manufacturers, utilities and research institutions. Its chairman is Prof. Erich Hahne from the University of Stuttgart, the author of this article being his deputy.

VDI-4640 shall consist of six main chapters:

- definitions, fundamentals, material parameters;
- site investigation, layout;
- drilling, installation, system integration;
- quality;
- environment, licensing;
- heat carrier fluids, working media.

It is hoped that a draft version of these guidelines will be ready for presentation in 1996.

Existing Regulations

Table 1 lists current European standards and regulations concerning GSHPs. Probably the most concise paper is the one produced by the Swiss manufacturers' association, AWP, entitled memo AWP T1. It focuses on vertical borehole heat exchangers (BHEs) for residential houses, and thus is confined to heating-only plants with no more than 2000 hours of operation per year. For correct sizing of the BHE under these conditions, the specific heat transfer performance in W/m is used, with values of up to 30 W/m for dry soil, 50-55 W/m for moist soil and rock, and 80 W/m for groundwater-bearing layers. For longer operation, recharging of the ground in summer, such as by solar heat, is suggested as a solution. Concise recommendations are given for the

Country	Organization* (Number)	Title	Year
Austria	ÖWAV (Arbeitsbehelf Nr. 3)	Wasserwirtschaftliche Gesichtspunkte für die Projektierung von Grundwasser-wärmepumpenanlagen (<i>Water household aspects for design of groundwater heat pumps</i>)	1986
	ÖWAV (Regelbl. 207)	Anlagen zur Gewinnung von Erdwärme (AGE) (<i>Equipment for Extraction of Earth Heat</i>)	1993
Germany	DIN (DIN 8901)	Wärmepumpen mit halogenierten Kohlenwasserstoffen; Schutz von Erdreich, Grund- und Oberflächenwasser (<i>Heat Pumps with Halocarbons; Protection of Soil, Ground- and Surface-Water</i>)	1994
	LAWA	Grundlagen zur Beurteilung des Einsatzes von Wärmepumpen aus wasserwirtschaftlicher Sicht (<i>Fundamentals for Evaluating the Use of Heat Pumps by Water Authorities</i>)	1980
	VDI (VDI-4640)	Thermische Nutzung des Untergrundes (<i>Guidelines for the Thermal Use of the Ground</i>)	in prep.
Switzerland	AWP (Merkblatt T1)	Wärmepumpenheizungsanlagen mit Erdwärmesonden (<i>Heat Pump Applications with Vertical Earth Heat Exchangers</i>)	1992
	BUWAL	Wassergefährdende Flüssigkeiten: Wegleitung für die Wärmenutzung mit geschlossenen Erdwärmesonden (<i>Fluids Hazardous for Water: Guidelines for Heat Extraction with Closed Vertical Earth Heat Exchangers</i>)	1994

* See Table 2 for full name.

Table 1: Standards and regulations concerning GSHPs in central Europe.

drilling and installation procedures, including how to grout the hole from bottom to top with pumpable grout. Advice is given on the type and concentration of antifreeze, the sizing of the heat pump and brine circulation pump, and on the system operation. An example calculation for a 13.6 kW (3.9 ton) heat pump helps understanding of the sizing procedure. Although AWP T1 is only binding for member companies of AWP, it nevertheless gives a minimum quality requirement for the Swiss market.

Also in Switzerland, the BUWAL guidelines cover the environmental impact of BHEs and must be observed by everybody who plans to install and operate a BHE. In a short introduction these guidelines provide a description of a BHE and discuss the related law and energetic aspects of using them. The environmental impact of BHEs is considered, mainly with respect to their impact on groundwater. Licensing for GSHPs in Switzerland is not made at the federal level, but by the Cantons. Hence these guidelines, which have to be interpreted by the cantonal authorities, include a suggestion on how a licensing procedure could be set up. The guidelines discuss system start-up, regular checking procedures and regulations for abandoning a BHE. It is important to note that direct-expansion technology is strictly banned for use in BHEs in

Switzerland. The BUWAL guidelines also provide a useful list of recommended antifreeze agents.

A similar approach is taken in Austria for ÖWAV 207. This regulation considers both BHEs and horizontal ground coils. The use of groundwater wells as heat source is dealt with in a separate paper, ÖWAV Arbeitsbehelf Nr.3 from 1986, which is not intended as a standard, but gives necessary information for the licensing process.

ÖWAV 207 begins with some fundamentals regarding water law and licensing. Since 1990 all new plants with ground-coupling must be licensed according to paragraph 31c of the water law ("Wasserrechtsgesetz", WRG). For horizontal coils, or the so-called trench collector, a simplified procedure is required. The regulation mainly describes drilling, installation and antifreeze. Unlike in Switzerland, direct-expansion plants are covered by the regulations. Guidelines for system layout, design and operation do not exist in Austria. Thus the environmental aspects are regulated, but the requirements of consumers for guarantees of comfort and reliability, are not covered by standards at present.

In 1980, a paper published by LAWA, in Germany, attempted to advise on the licensing of GSHPs. LAWA

is an association of the water authorities of the German states. Similar to the situation in Switzerland, the Federal Water Household Law ("Wasserhaushaltsgesetz", WHG) gives only a framework for the water laws of the individual states. Water authorities, and thus the licensing offices, are at the state level. The requirements for a license for all ground-coupled plants, including those not using groundwater directly, are a consequence of paragraph 3 (2) of WHG. LAWA's paper, "Fundamentals for Evaluation of the Use of Heat Pumps" attempts to give a common recommendation for all states. Published back in 1980, the paper reflects the application trends of that time and makes groundwater and horizontal coils the main topic, with BHEs only mentioned marginally. Furthermore, much of the information included in the paper has become obsolete or must be changed to take account of new research results. A new issue of the LAWA paper seems to be very desirable. Hopefully, the new publication VDI 4640 will give an initiative to either update the LAWA paper or to substitute it with modern regulations within its own guidelines.

The German DIN-standard 8901 focuses on the heat pump rather than the heat source, and gives design requirements and test procedures to avoid leakage of

working media (CFC and HCFC in particular) to groundwater and the ground.

Organizations

In Europe, no specific organization for GSHPs exists. The market is too small to justify organizations such as the Canadian Earth Energy Association (CEECA), the International Ground Source Heat Pump Association (IGSHPA) in Oklahoma or the Geothermal Heat Pump Consortium in Washington DC. Hence GSHPs are covered either by heat pump manufacturers associations or by scientific societies on the geothermal and engineering side. Table 2 gives an overview of the related groups in central Europe. International cooperation takes place between the three heat pump groups as well as between GtV and SVG. However, contact between heat pump and geothermal people needs to be improved.

Manuals

To date, no "official" manuals for GSHP design and installation, such as those published in the USA by ASHRAE, have been issued in central Europe. While some studies and reports do provide a lot of relevant

Table 2: Organizations concerned with heat pump standards and regulations.

Austria			
LWP	Leistungsgemeinschaft Wärmepumpe, Wiedner Hauptstr. 63, A-1045 Vienna (Performance Association Heat Pumps, Austria)	IZW	Informationszentrum Wärmepumpen und Kältetechnik, Postfach 2465, D-76012 Karlsruhe (Information Centre for Heat Pumps and Refrigeration Technology)
ÖWAV	Österreichischer Wasser- und Abfallwirtschaftsverband, Vienna (Austrian Authority for Water and Waste)	Switzerland	
Germany		AWP	Arbeitsgemeinschaft Wärmepumpen, Postfach 7190, CH-8023 Zurich (Working Group Heat Pumps, Switzerland)
IWP	Initiativkreis WärmePumpe, Elisabethstr. 34, D-80796 Munich (Initiative Group Heat Pumps, Germany)	SVG	Schweizerischer Vereinigung für Geothermie, c/o Büro Inter-Prax, Dufourstr. 87, CH-2502 Biel (Swiss Association of Geothermics, Switzerland)
GtV	Geothermische Vereinigung, Gartenstr. 53, D-49744 Geeste (Geothermal Association, Germany/Austria)	SIA	Schweizerischer Ingenieur- und Architektenverein, Postfach, CH-8039 Zurich (Swiss Association of Engineers and Architects, Switzerland)
VDI-GET	Verein Deutscher Ingenieure, Postfach 101139, D-40002 Düsseldorf (Association of German Engineers, Germany)	BEW	Bundesamt für Energiewirtschaft, Bern (Federal Office of Energy)
LAWA	Länderarbeitsgemeinschaft Wasser (National Association of Water Authorities)	BUWAL	Bundesamt für Umwelt, Wald und Landschaft, Bern (Federal Office of Environment, Forestry and Countryside)
DIN	Deutsches Institut für Normung e.V., Berlin (German Institute for Standardization)		
colour code:			
	heat pump groups initiated by utilities and manufacturers		standards authorities
	technical/scientific associations for using geothermal energy		government departments
	national associations for engineers		information centres
	water authorities		

Organization* (Report No.)	Title	Year
Germany		
IZW (Ber. 2/92)	Erdgekoppelte Wärmepumpen (Ground-Source Heat Pumps)	1992
IZW (Ber. 3/91 & 1/94)	1./2. Symposia Erdgekoppelte Wärmepumpen (1st & 2nd Symposia on Ground-Coupled Heat Pumps)	1991/1994
IZW	Wärmepumpen - Beispiele ausgeführter Anlagen (Heat Pumps - Examples of Realized Plants)	1992/1994
IWP	Arbeitsordner Wärmepumpe (Design Manual for Heat Pumps)	1994
Switzerland		
SIA (D 025)	Base de dimensionnement des systèmes exploitant la chaleur du sol à basse température (Fundamentals for the Dimensioning of Systems that Extract Earth Heat at Low Temperatures)	1988
SIA (D 028)	Guide du stockage saisonnier de chaleur Wegleitung zur saisonalen Wärmespeicherung (Guidelines for Seasonal Heat Storage)	1989
BEW (Studie 46)	Erdwärmesonden: Durch Messungen und Berechnungen bestimmte Auslegungs- und Betriebsgrößen (Vertical Borehole Heat Exchangers: Design and Operation Parameters as Determined by Measurements and Calculation)	1989

* See Table 2 for full name.

Table 3: Manuals and documentation.

information, the designer has to use his own initiative to apply it to a particular case. Table 3 lists some recent publications from Germany and Switzerland.

In Germany, the Information Centre for Heat Pumps, IZW, has published a detailed report on GSHPs plus the proceedings of two symposia on GSHPs. In addition, its publication on realized heat pump plants describes many applications using various heat sources. IWP's manual covers all heat pump types, including GSHPs, with information based upon the experience of the member manufacturers. In Switzerland, studies published by SIA and the Federal Office of Energy (BEW) compile information on GSHPs. BEW Studie 46, in particular, is a very comprehensive paper giving the results of numerous computer simulations validated by field experiments. A manual on BHEs is now under development.

Software

Simple design software for BHEs has been developed through the cooperation of Lund Institute of Technology, Sweden and Giessen University, Germany and is currently in a test phase. Titled "Earth Energy Designer" (EED), the code is based on the well-known Lund PC programs for borehole heat exchangers. The user is guided to establish a model of his plant with ground properties, BHE-design, heat carrier fluid, and heating and cooling load. The load profile can be given in different ways. Databases on ground properties, pipe material and antifreeze fluids can be called up to provide reliable data. It is hoped that EED

will open the way for a routine design procedure that is much better than the rules of thumb usually applied for small plants (such as prescribed in AWP T1), but avoids the time-consuming use of numerical simulation models requiring skilled programmers.

Towards Further Market Growth

After a boom in the years around 1980, and after a dramatic recession in the mid 1980s, heat pumps are once again penetrating the market at a low, but sound level. And GSHPs now have a higher share of this market. Standards and regulations can help to bring about further market growth. Minimum quality requirements are indispensable to assure satisfied customers. And with so much environmental awareness in central Europe, regulations are essential to ensure that GSHPs have only a positive impact on the environment. The decision of VDI to develop guidelines for the thermal use of the ground (VDI-4640) is a big step in the right direction.

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Stirling Technology for the Home

A Practical Stirling-Stirling Heat Pump with a Resonance Tube

Jean-Pierre Budliger, Switzerland

In Switzerland, a Stirling-Stirling heat pump system has been developed whose characteristics suitably fit the many requirements imposed on small domestic heating units. Many of the difficulties associated with more conventional Stirling technology have been overcome by using a resonating gas column to transfer mechanical energy. This article compares the proposed concept with some alternative concepts and describes the progress made so far in the development and demonstration of this technology.

A large majority of our homes are heated by means of oil or gas. When burning these fossil fuels, heat is released in the flame at temperatures well beyond 1000°C, which is then used for heating radiators up to merely 50°C, or for preparing warm water at some 60°C. Despite the fact that more than 90% of the energy released can be made available for heating (only the chimney losses may be considered as a waste stream from the house) one should not overlook the fact that this process involves an important degradation in the quality of the heat, during which an important exergy loss occurs.

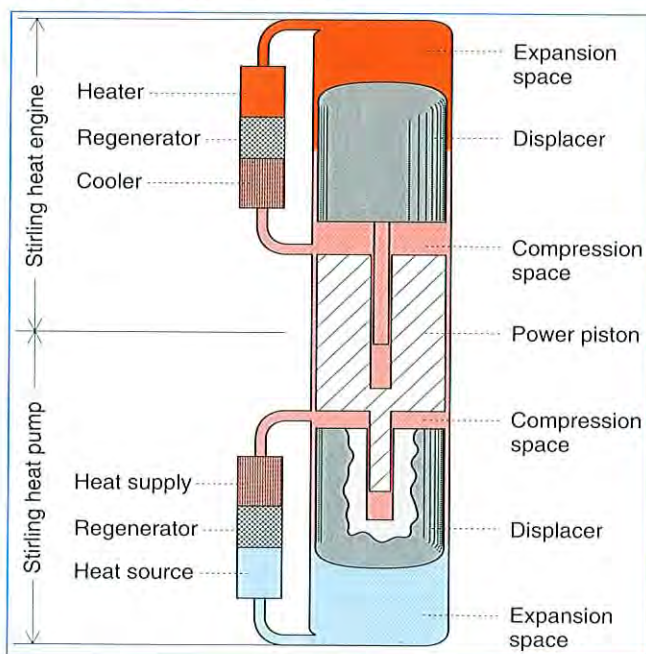
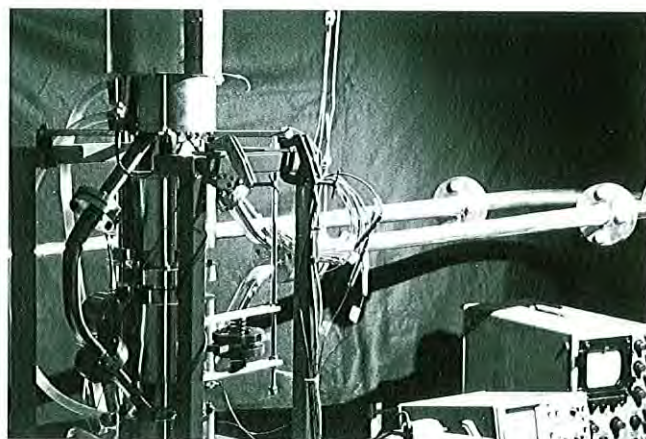


Figure 1: Duplex Stirling heat pump of Prof. W. Beale.



The prototype Stirling-Stirling heat pump with resonance tube.

Combined heat and power (or cogeneration) plants readily demonstrate how to make better use of the energy potential contained in the fuel. However, up to the present time, such systems have been built almost exclusively as rather large units. Another efficient way to use fuel energy is with the Stirling cycle – a concept that is well suited to small-scale applications. The blue box, on page 33, provides a basic introduction to this concept. In Switzerland, a new Stirling concept has been developed with the eventual aim of producing an economic heating system for the home.

The Concept

The new concept has been derived from the well-known "duplex Stirling heat pump system" of Professor W. Beale, in which a free-piston Stirling engine drives a Stirling heat pump (see Figure 1). In the new Stirling-Stirling concept, the heavy engine, or power piston, which transfers mechanical energy from the engine to the heat pump, is replaced by a resonating gas column (see Figure 2). The problematic engine piston seal, which is exposed to high, periodically varying pressure differences, can thus be avoided. In addition, the assembly is simplified as the two displacer pistons can be suspended directly against the outer cylinder. The system oscillates in a perfectly stable mode and promises operation for extended periods with a minimum demand for maintenance.

Figure 3 shows a more practical version where the engine and heat pump components are arranged at the same end of the resonance tube. This concept can

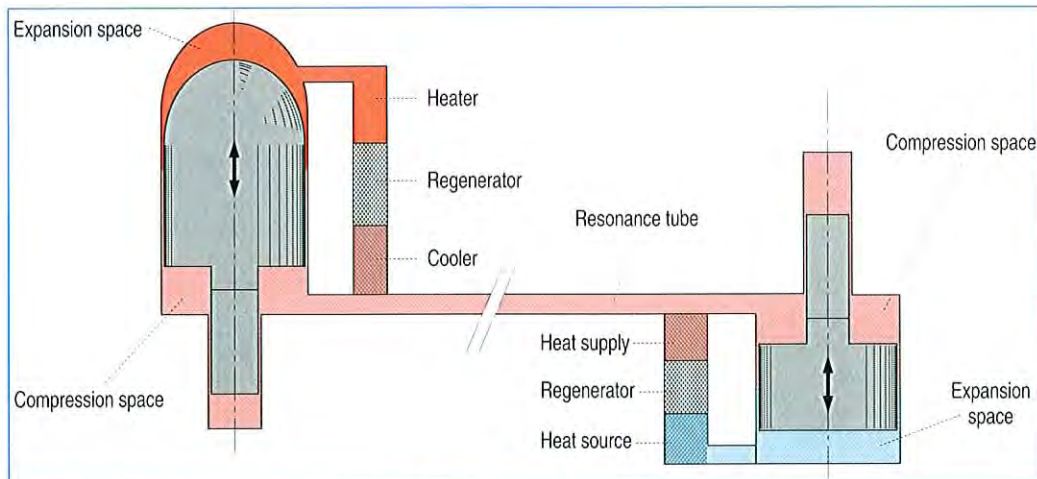


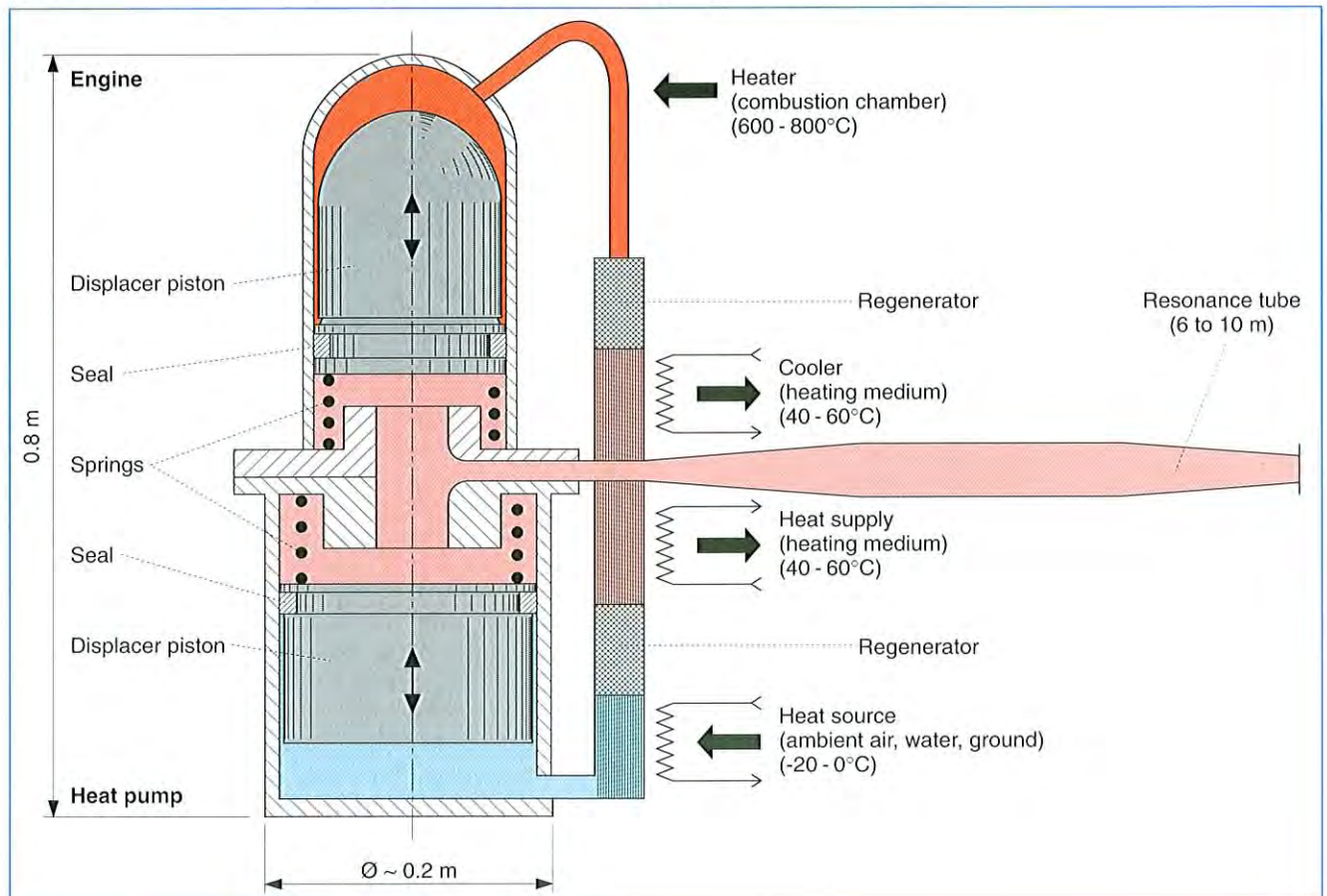
Figure 2: Basic concept of a Stirling-Stirling heat pump with resonance tube.

be considered as a "Vuilleumier" unit with an attached resonance tube. Here the resonance tube serves to enhance the periodic pressure variation taking place in the Vuilleumier volumes, and thus acts as a super-charging device for the entire unit. This supercharging considerably boosts the power density of the unit and increases the coefficient of performance (COP) of the heat pump and the overall energy efficiency.

The Resonance Tube

Quite obviously, a large number of conditions need to be met in order to make such a system operable. To avoid excessively long resonance tubes, the system should operate at fairly high frequencies (e.g. 50 Hz) and use a working gas with a relatively low speed of sound. Preference will therefore be given to a gas of sufficiently high molecular mass (e.g. higher than 12). The tube, which may be bent or spirally wound, will then be in the order of 4 to 6 m long.

Figure 3: Practical arrangement of a Stirling-Stirling heat pump with resonance tube.



Extensive studies have been carried out to ascertain the best shape for the tube. In particular, the tube should have conically shaped (or tapered) end sections to avoid shock waves. Correctly shaped tubes show nearly perfect sinusoidal pressure waves with almost negligible friction pressure drop or energy losses.

The Heat Pump

The heat pump part of such a Stirling-Stirling system considerably differs from the most commonly-used electrically driven heat pumps. Firstly, a mixture of helium and carbon dioxide is used as working gas so there are no concerns about ozone depletion or the greenhouse effect.

Secondly, like other thermally driven heat pumps, the heat source provides only about $\frac{1}{3}$ of the useful heat (as compared to $\frac{2}{3}$ in conventional electric heat pumps). Consequently, the required heat transfer surface is reduced, which saves costs, and the environmental heat is more readily available. Furthermore, the performance of such heat-driven heat pumps is less dependant on the ambient temperature. High seasonal performance figures and correspondingly high energy

gains may therefore be achieved. And for air-source heat pumps, less energy is required for periodic de-icing.

The Benefits

Extensive studies show that the addition of a resonance tube improves the Vuilleumier process in many important ways.

The resonance tube approximately doubles the pressure amplitudes as compared to those obtained in conventional Vuilleumier concepts. The power density of these units is then increased correspondingly.

The compact design reduces heat conduction losses through the hot regenerator. This greatly contributes to achieving better performance figures with supercharged units.

The resonance tube acts as a feedback coupling between the engine and heat pump parts of the system. This results in a highly stable oscillation mode for a large range of operating conditions.

The system can be operated within a large range of power ratings, which can be adjusted to demand by a

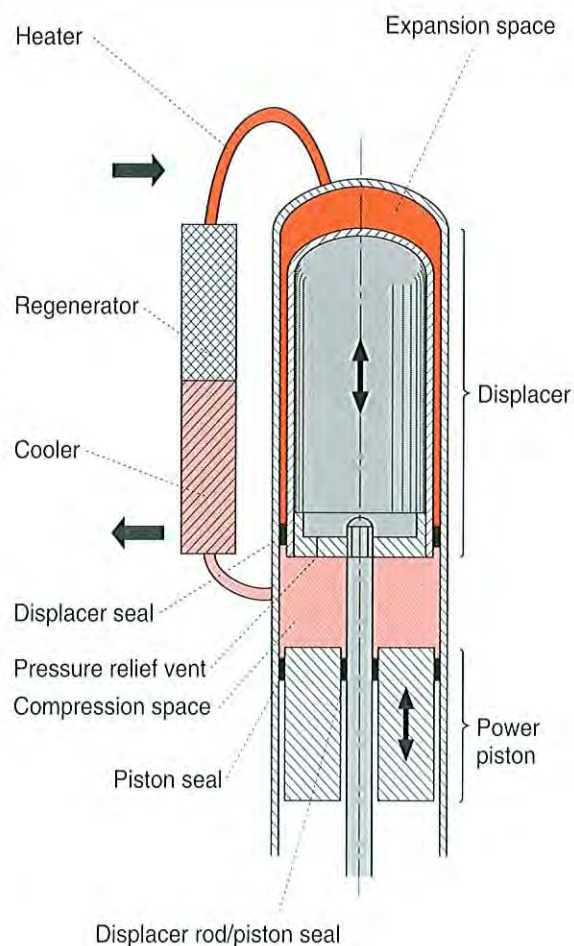
OPERATING PRINCIPLE OF A STIRLING ENGINE

The basic Stirling engine comprises a cylinder in which a volume of gas is contained by a movable piston. In the first phase of operation, the cylinder is heated at the outside so that the gas expands and pushes the piston outwards. In a second phase, the cylinder is cooled at its outside, so that the gas retracts and pulls the piston back into its original position. By repeating this process, mechanical energy can be produced, although at very low frequency and efficiency.

The same process can be performed far more efficiently when one part of the cylinder is heated and another part is cooled. The working gas must then be transferred periodically between these two parts. The figure shows the displacer piston which is used to perform this internal gas transfer. Using the heater and cooler, either hot gas is supplied to the expansion space or cool gas to the compression space. The expansion and compression of the gas causes the displacer piston and power piston to oscillate. Mechanical coupling ensures that the displacer piston oscillates at a given phase relationship with regard to the power piston (preferentially with some 90° advance).

In order to avoid significant heat loss when the hot gas is displaced towards the cold compartment, it is pushed through a regenerator. This has a stack of fine wire mesh which picks up and stores the heat from the hot gas and then releases it to the returning flow of cold gas.

Engines of high efficiency and significant power densities can be conceived, particularly when they are contained in hermetically sealed units under high pressure. A Stirling heat pump works the same way as the engine, except that the heat is supplied (at the cooler) and that the power piston must be driven.



Basic Stirling engine arrangement.

simple modulation of the burner heat input. This favourable part-load behaviour offers the prospect of operating such units in a continuous mode at the required heat demand. The temperature differences at all heat exchange surfaces are thus minimized.

Studying the Theory

The above presented concepts have been analyzed in detail by means of specifically developed computer codes. Studies have shown that for optimized layouts of domestic heating systems, seasonal performance factors of between 1.6 to 1.7 can be achieved. This corresponds to energy savings of between 35 and 40% as compared to existing, modern domestic home heating systems. The studies clearly show the key role played by the resonance tube in the improvement of Vuilleumier heat pump systems. A substantial energy saving potential thus exists, especially considering that domestic heating represents between 25 and 30% of Switzerland's total national energy consumption.

Demonstrating the Concept

The feasibility of the proposed concept has been demonstrated by means of a pilot installation. The photograph above shows the components used to make the Stirling engine. The heat pump part comprises similar components. The prototype system is about 1 m high. A commercial installation would be equipped with a vertical tube and arranged within a volume of 0.4 x 0.6 x 1.8 m, excluding the heat source connection.

The objective of the experimental studies was to confirm the various mechanisms involved, particularly the detailed understanding of the complex interactions between flow, heat transfer and mechanical oscillations taking place in such a resonating system. Until now, no particular effort has been taken to reach high performance figures.

The prototype shown is equipped with an electrically powered radiative furnace of 1 kW power input. Once the system is started, this sole heat supply maintains the prototype in a fully autonomous oscillation mode, without requiring any feedback mechanism for stabilizing its operation. The cold source of the heat pump cools down to temperatures of approximately -5°C, whereby air humidity is condensed at its outer surface and an ice layer is formed.

Later, the prototype will be equipped with a gas heating system, for operation with a heat input rate of 2 to 3 kW. It is expected that under full design power, a significant amount of heat will be extracted from the low-temperature heat source.

Preparing for Market Introduction

As a next step, a second prototype will be developed with the aim of maximizing the performance figures.



Ready to assemble: the Stirling engine is made from these simple components.

The energy saving potential and the manufacturing cost of such units may then be assessed, yielding a sound basis for evaluating the market potential for such systems.

It is expected that this applied research stage may be carried out jointly with one or several industrial partners, such as manufacturers of boilers, burners, heat pumps or engines, possibly in the framework of a European research programme. On completion of the applied research, all patents and relevant know-how would be made available to the industrial partners. Such partners would then have the opportunity to undertake the mass production and marketing of the eventual product.

Acknowledgement

The author gratefully acknowledges the support of the Swiss Energy Research Foundation, NEFF, and the Federal Department of Energy, BEW.

References

- [1] Weber, R., 1994. "Eine Stirling-Wärmepumpe mit Resonanzrohr - Besser und sparsamer heizen". Olynthus-Verlagsanstalt, Vaduz, Liechtenstein.
- [2] Budliger, J.P., 1987. "New Concept for a Stirling-Stirling Heat Pump System". ASME-Paper 87-WA/AES-5, USA.
- [3] Budliger, J.P., "Stirling Heat Pump System with Resonance Tube" from proceedings of the 5th International Stirling Engine Conference (ISEC) - Dubrovnik, 1991; and the 6th International Stirling Engine Conference (ISEC) - Eindhoven, 1993.

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1995 - A Year in Review

Jos Bouma, IEA Heat Pump Centre

1995 was the year when national heat pump promotion programmes began in Germany, Italy, the Netherlands and the USA, and when a big step forward was made in the development of low-cost equipment for the European market. For the IEA Heat Pump Programme, it also saw the beginning of a new initiative on natural working fluids and the completion of a study on industrial heat pumps. This article looks back on the major developments in 1995.

The box on page 36 lists the articles that appeared in the IEA Heat Pump Centre Newsletter in 1995. As usual, these articles addressed the issues that most concerned the National Teams of the IEA Heat Pump Centre member countries.

CFC and HCFC Replacement

The international community's desire to rid the world of chlorine containing working fluids leads to difficult choices. Designers of tomorrow's heat pumps must choose between using new families of synthetic fluorocarbons or to go for the "so-called" natural refrigerants. Annex 22 of the IEA Heat Pump Programme, which was launched in 1995, is helping to support those who make the second choice. This project aims to further develop the technology and expand the knowledge on using ammonia, hydrocarbons, water, air and CO₂ in compression heat pumping systems. The participation of European, Japanese and North American representatives highlights the worldwide interest in this topic.

Manufacturers in Japan and the USA are working on the adaption of technology for HFC blends. The signs are that optimized compressors, heat exchangers and controls will result in performances with HFC blends that are competitive with those of existing heat pumps. The challenge now is to achieve cost reductions, and to demonstrate reliability and safety. (H)CFC replacement is also an issue for existing heat pump systems. That satisfactory solutions can be found has been most clearly demonstrated in the world's largest heat pumps in Gothenburg, Sweden which have been converted from CFC-12 to HFC-134a.

Heat Pump Market Forces

Generally the most effective heat pump promotion programmes are those where all relevant market players work together to achieve an effective policy. A good example is the "Golden Carrot" initiative by the Consortium for Energy Efficiency in the US which began in 1995. Under this scheme, government authorities, utilities and industry combine efforts with the aim of accelerating annual sales of "geothermal" heat pumps from 10,000 residential units today, up to 100,000 in the year 2000.

In 1995, further government support was demonstrated in Germany, where a subsidy scheme for space heating heat pumps has begun, and in the Netherlands where an ambitious programme to support the implementation of all types of heat pump has been initiated. In Italy, the national electricity agency began a promotion campaign for reversible heat pumps.

The Swiss promotion programme continues to provide a good example for others to follow, although the government subsidy for heat pumps was removed in 1995. Norwegian experience suggests, however, that such a development need not have a negative impact. Despite the removal of subsidies there in 1993, heat pump sales went up the following year. In Japan, the government continues to support the development of highly advanced, large-scale heat pump technology. And it has introduced a tax relief scheme to support ice thermal storage technology. But stimulation of the heat pump market is mainly the business of the equipment manufacturers, along with the coordinated efforts of utilities and urban developers.

Residential Heat Pumps

The challenge for industry is to develop and market heat pumps that have low equipment and operational costs, while meeting the customer's expectations for comfort and reliability. The Finnish-Scandinavian heat pump competition, which was completed in 1995, has encouraged the development of such heat pumps for the European market. The two winners, one a complete factory-made system, and the other a universal heat pump unit, look set to have a significant impact on the European heat pump market by offering efficient and reliable operation at remarkably low installation costs.

In the 5.6 million units a year Japanese market, large-scale manufacture keeps down the costs of room heat pumps. But alongside low-cost units, manufacturers are also marketing high-performance units, with

sophisticated comfort control and very high COP.

Standards and Regulations

A key strategy for the IEA Heat Pump Programme is to facilitate the development of international standards for quality and safety, and uniformity in performance and rating methods. Regulating efficiency is a very effective measure that can force industry to develop qualitatively adequate heat pumps. This has been demonstrated clearly in the US and Japan.

In the ongoing preparation of our analysis on energy efficiency regulations and standards, the IEA Heat Pump Centre has found only six countries where regulations or standards govern the minimum efficiency of heat pumps and air conditioners. With the growing interest in heat pumping technologies and increasing sales of equipment, it is desirable and timely for other countries with a growing market to consider implementing similar measures now. Only then is it likely that proper equipment is installed by qualified contractors and a maximum energy impact achieved.

Industrial Applications

In 1995 the IEA Heat Pump Programme completed Annex 21 "Global Environmental Benefits of Industrial Heat Pumps". The final report presents persuasive evidence of the benefits of industrial heat pumps

(IHPs). And the IHP screening program provides a useful tool to help realize these benefits. It is to be hoped that the widespread dissemination of this information will stimulate IHP use.

New opportunities continue to be found for IHPs. In particular, they are used increasingly to help meet environmental regulations on using groundwater for cooling, and in the drying of sludge and manure. 1995 also saw the installation of a very large IHP in the Netherlands. Used in propene production, this 6.2 MW (electric) MVR (mechanical vapour recompression) heat pump is among the largest IHPs ever built.

Getting the Message Across

A highlight of the HPC's 1995 agenda was the completion of the final part of our analysis "International Heat Pump Status and Policy Review" and the follow-up seminar which was held in August. The message of the seminar was clear: heat pumps are an important technology for tackling global environmental issues, and there are many policy options which governments and utilities can and should consider to encourage their widespread use. The experience of 1995 is that, in more and more countries, this message is getting across.

Author:

Mr Jos Bouma, IEA Heat Pump Centre

Articles Published in IEA Heat Pump Centre Newsletter Volume 13 / 1995

CFC and HCFC Replacement

Safety Aspects of Natural Working Fluids *van Gerwen, The Netherlands*

New Refrigerants for Japan's Heat Pump and Refrigeration Markets *Sakamoto, Japan*

Water-Source Heat Pump Performance with HFC Refrigerants *Glamm, USA*

HCFC-22 Phase Out in North America - Impact on Future Equipment Production *Godwin et al, USA*

Replacing CFC-12 in the World's Largest Heat Pumps *Berglöf et al, Sweden*

* International Heat Pump Status and Policy Review - HPC Completes Comprehensive Study *Stuij, HPC*

Heat Pump Market Forces

Developing the Market for GSHPs - US Consortium Launches "Golden Carrot" Initiative *Tatsutani, USA*

Market Forces in Japan - Promotion Activities Focus on Load Levelling and Emissions Reduction *Tanaka, Japan*

Heat Pump Promotion in Switzerland - Coordinated Efforts are Yielding Good Results *Beyeler, Switzerland*

* Software Tools for Heat Pump Design - Improving the Quality of Building Heating Systems *Afjei et al, Switzerland*

* Heat Recovery in a Textile Plant - Heat Pump Brings Down Effluent Temperature *Pucciano, USA*

Residential Heat Pumps

Vertical Borehole Heat Exchangers - Bringing Heat From the Ground into the Home *Hopkirk et al, Switzerland*

Earth Energy Heat Pumps for Canadian Homes *McNeil, Canada*

The Nordic Heat Pump Competition - Winners set New Standards in Performance and Price *Fahlén, Sweden*

The World's Best Selling Heat Pump - What Makes the Japanese Room Heat Pump so Successful? *Itoh, Japan*

Getting the Best out of Residential Heat Pumps *Halozan, Austria*

* Heat Pump Development Trends in Japan *Bouma, HPC*

Standards and Regulations

Standards and Regulations in Japan - A Manufacturer's View *Kunugi et al, Japan*

Regulating Heat Pump Efficiency - Preview of an IEA Heat Pump Centre Analysis *Lannus, USA*

Standards and Regulations for GSHPs in Central Europe *Sanner, Germany*

* Stirling Technology for the Home *Budliger, Switzerland*

Note: in addition to the articles listed, each issue includes an extended international overview article on the topic. * denotes non-topical article.

Books & Software

Market Survey on Heat Pumps in Europe

Final Report of a European Union Study financed under the JOULE 2 R&D Programme. More information is available from the IEA Heat Pump Centre (HPC).

Application of R290 (Propane) in Refrigeration Equipment

"Anwendung von R290 (Propan) in Kälteanlagen."
Published in German by FKW / IKET, Germany. More information is available from the HPC.

The products below are available from the HPC. See page 39 for ordering details.

Seminar Proceedings: International Heat Pump Status and Policy Review

Held within the 19th International Institute of Refrigeration (IIR) Congress, this HPC seminar built on the findings of the HPC analysis of the same name. Much new information was presented on market trends, and on the activities of utilities and governments.

Annex 22 Workshop Proceedings: Compression Systems with Natural Working Fluids - Applications, Experience and Developments

This workshop provided a valuable review of worldwide knowledge on natural refrigerants, including the results of Annex 22 country reports. The proceedings will be published early in 1996.

Industrial Heat Pump Screening Program

Using pinch technology theory, this software package lets engineers screen their industrial processes for the technical and economic suitability of an industrial heat pump (IHP). The program was developed under IEA Heat Pump Programme Annex 21 and contains data on more than 100 processes, and over 50 types of IHP equipment.

Industrial Heat Pumps - A Means to Mitigate Global Industrial Emissions

This 12-page, full-colour brochure highlights the results of Annex 21. Aimed at both engineers and policy makers, it outlines the multiple benefits of IHPs to industries, and the national and global impact of IHPs on energy consumption and the environment.

HPSEL - an Expert System for Selecting Heat Pumps

Produced by EA Technology with the support of the Heat Pump Concerted Action Group of the European Union. For more information contact Dr Mark Bertinat, EA Technology, United Kingdom. Fax: +44-151-357-1581.

By following menu options, users of this PC program can select a residential heat pump according to the climate, building features and the availability of heat sources. After indicating the most suitable heat pump type, the program simulates the energy consumption and environmental and economic performance of a commercially available product. First additions will be available early in 1996.

*The following heat pump simulation programs are available from Mr Even Thorbergsen, SINTEF Refrigeration and Air Conditioning, Norway.
Fax: +47-7459-3926;
E-mail: Even.Thorbergsen@kkt.sintef.no*

PRODIM - Design of Main Components in Heat Pumps

Price: NOK 7,000 (US\$ 1,095). NOK 700 for universities etc. Demo version for free.

This PC program helps in the design of compressor, motor, evaporator, condenser, suction gas heat exchanger, intermediate pressure vessel and tubing in a heat pump. With working fluid selected from a library of 26 different fluids, the program simulates either one-stage or two-stage heat pump operation, and can provide detailed component data and log-p-h diagrams.

PROSIM - Simulation of Heat Pump Systems

Price: NOK 12,000 (US\$ 1,875). NOK 1,200 for universities etc. Demo version for free.

With 62 different component models, and incorporating the PRODIM software (see above), this Windows-based program performs a detailed simulation of simple as well as complex heat pump systems. Components can be connected in any possible configuration and nine different control strategies can be simulated.



Events

* Call for papers

Refrigeration, Climate Control and Energy Conservation
11-14 February 1996 / Melbourne, Australia. IIR Meeting of Commissions E2/E1 and B1/B2. Contact: Mrs Siew-Ling Teh, AIRAH, Australia. Fax: +61-3-328-4116

Absorption/Sorption Heat pumps and Refrigeration Systems
14 February 1996 / Atlanta, USA.
Contact: Srinivas Garimella, Western Michigan University, USA.
Fax: +1-616-387-3358. E-Mail: srinivas.garimella@wmich.edu

1996 ASHRAE Winter Meeting
17-21 February 1996 / Atlanta, USA.
Contact: ASHRAE Meetings Department, USA. Fax: +1 404-321-5478

Frigair '96
6-8 March 1996 / Johannesburg, South Africa.
Contact: Melanie Campbell, FRIGAIR '96, South Africa.
Fax: +27-11-442-5927

RECLIEN '96 - 4th International Congress on Refrigeration, Air Conditioning and Non-Conventional Energy
18-22 March 1996 / Havana, Cuba.
Contact: H. Remedios Carbalajes, RECLIEN '96, Cuba.
Fax: +53-537-33-8501

Air-Conditioning, Heating, Refrigeration - Innovation and Trends
29-30 March 1996 / Milan, Italy.
AICARR International Congress. Contact: Secretary General, AICARR, Italy. Fax: +39-2-2900-0004

1st UAE Conference on Air Conditioning in the Gulf
14-18 April 1996 / Al Ain City, United Arab Emirates.
Contact: ACG96 Organizing Committee Chairman, UAE University, UAE. Fax: +971-33521

AIRAH 1996 International Conference and Exhibition
17-19 April 1996 / Adelaide, Australia.
Organized by the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH). Contact: James Harrison, AIRAH, Australia. Fax: +613-328-4116

2nd European Thermal Sciences Conference
29-31 May 1996 / Rome, Italy.
Contact: Mr G.P. Celata, ENEA Casaccia, Energy Department, Via Anguillarese, 301-1-10060 Rome, Italy.

1996 ASHRAE Annual Meeting
June 22-25 1996 / San Antonio, Texas, USA.
Contact: ASHRAE Meetings Department, USA. Fax: +1-404-321-5478

ROOMVENT '96 - the 5th International Conference on Air Distribution in Rooms
17-19 July 1996 / Yokohama, Japan.
Contact: Prof. S. Murakami, University of Tokyo, Japan.
Fax: +81-33746-1449

Indoor Air '96
21-26 July 1996 / Nagoya, Japan.
The 7th International Conference on Indoor Air Quality and

Climate. Co-sponsored by ASHRAE.
Contact: Dr Koichi Ikeda, Secretary, The Institute of Public Health, Japan. Fax: +81-3-3446-4723

Purdue International Compressor Engineering Conference
21-26 July 1996 / West Lafayette, IN, USA.
Contact: Prof. R. Cohen, Purdue University, Ray W. Herrick Laboratories, West Lafayette, IN 47907, USA.

TIEES-96 First Trabzon International Energy and Environment Symposium
29-31 July 1996 / Trabzon, Turkey.
Contact: Prof. Teoman Ayhan, Karadeniz Technical University, Turkey. Fax: +90-462- 325-7405; E-Mail: energy96@risc01.bim.ktu.edu.tr

Sustainable Thermal Energy Storage Conference
7-9 August 1996 / Chicago, USA.
Contact: Beverly Speer, Thermal Storage Applications Research Center, University of Wisconsin. Tel: +1-608-262-8220

Applications for Natural Working Fluids
3-6 September 1996 / Aarhus, Denmark.
Contact: Mr Frank Elefsen or Mr Michael Kauffeld - Danish Technological Institute. Fax +45-8943-8543

Research, Design and Construction in Refrigeration and Air Conditioning in Eastern Countries
10-14 September 1996 / Bucharest, Romania.
Contact: Prof. F. Chiriac, Asotatia generala a frigotehnistor din Romania, Bucharest, Romania. Fax: +40-312-6880

International Absorption Heat Pump Conference
17-20 September 1996 / Montreal, Canada.
Contact: Darius Nikanpour, EDRL, Fax: 1-514-652-5177.
E-Mail: Darius.Nikampour@cc2smtp.emr.ca

***Geothermie - Energie der Zukunft**
(Geothermal Heat - Energy of the Future)
18-20 September 1996 / Konstanz, Germany.
Deadline for abstracts: 31 March 1996. Contact: 4. Geothermische Fachtagung, c/o Stadtwerke Bad Urach, Fax: +41-7125-156133

***Analysis and Applications of Heat Pump and Refrigeration Systems**
(Symposium within ASME International Congress
17-22 November 1996 / Atlanta, Georgia, USA. Deadline for Abstracts: 12 February 1996. Contact: Dennis L.O'Neal, Texas A&M University, USA. Fax: +1-409-862-2762. E-Mail: dennis@loanstar.tamu.edu

IEA Heat Pump Programme

Heat Pump Systems and Controls for Energy Efficiency
7-8 May 1996 / Tokyo, Japan

5th IEA Conference on Heat Pumping Technologies
22-26 September 1996 / Toronto, Canada
(co-sponsored by HR and ASHRAE)

Contact the HPC for registration information

Available from the HPC

<i>Title</i>	<i>Publication type</i>	<i>Order No.</i>	<i>Price (NLG)*</i>
International Heat Pump Status & Policy Review	Analysis Report (Vol. 1, 2A & 2B)	HPC-AR3	250
	National Position Papers	HPC-NPP**	40
Working Fluid Safety	Annex 20 Report	HPP-AN20-1	100
Industrial Heat Pumps: Experiences, Potential and Global Environmental Benefits	Annex 21 Report	HPP-AN21-1	100
International Heat Pump Status & Policy Review	Seminar Proceedings	HPC-WR-15	60
A Means to Mitigate Global Industrial Emissions Contact the HPC for ordering details	Annex 21 Brochure	HPP-AN21-2	free
Industrial Heat Pump Screening Program	Annex 21 Software	HPP-AN21-3	***
Compression Systems with Natural Working Fluids -Applications, Experience and Developments	Annex 22 Proceedings	HPP-AN22-1	60

New publications

Next Issue of the Newsletter

Systems and Applications - March 1996



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National Team Contacts

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 24 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

Set up by the IEA in 1978, the IEA Heat Pump Programme carries out a strategy to accelerate the development and use of heat pumps, in all applications where they can reduce energy consumption for the benefit of the environment. Within the framework of the programme, participants from different countries collaborate in specific heat pump projects known as Annexes.

IEA Heat Pump Centre

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

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