

IEA Heat Pump Centre

NEWSLETTER

**Heat
Pump
Market
Forces**



IEA
OECD

heat pump
centre

Contents

News & Views

General	4
Technology & Applications	6
Working Fluids	7
Markets	8
IEA Heat Pump Programme	9

Features

Comment.....	3
Bibliography	37
Events	38
HPC Publications	39
National Team Contacts	40

Heat Pump Market Forces

Once persuaded of the benefits of heat pumps, policy makers must turn to the challenging business of choosing the best measures to support them. They will need a clear understanding of the heat pump market and the measures that can influence it. This issue looks at the market forces that have moulded the current pattern of heat pump sales, and highlights some key promotional initiatives.



Front Cover: In the US, utilities, government agencies, research institutions, and public interest groups are working together to stimulate the market for ground-source heat pump installations such as this one. Further details are given in the article on page 20.

Topical Articles

International Overview 11

Mike Steadman, IEA Heat Pump Centre
Heat pump market forces such as climate, economic, and technical factors, have led to wide differences between national markets. Governments and utilities can also influence the market through subsidies and other measures. Such support has varying degrees of success.

Developing the Market 20 for GSHPs

Marika Tatsutani, USA
While many utilities are keen to support ground-source heat pumps, their actions generally have only a limited market impact. The "Golden Carrot" initiative of the Consortium for Energy Efficiency holds up the hope of much bigger gains.

Market Forces in Japan 22

Toshihiko Tanaka, Japan
Widely recognized as a beneficial technology, heat pumps are strongly supported by both government and utilities. The latest initiative is a financial incentive scheme for ice thermal storage systems.

Heat Pump Promotion 25 in Switzerland

Franz Beyeler, Switzerland
Information, subsidies and a testing and training centre form the central planks of the Swiss Heat Pump Promotion Programme. While the targeted sales figures are still some way off, the results so far are impressive.

Non-Topical Articles

Software Tools for 29 Heat Pump Design

Thomas Afjei et al, Switzerland
Heating engineers are increasingly using software tools to reach an optimum design. Two programs from Switzerland look set to play an important role in heat pump installations.

Heat Recovery in a 34 Textile Plant

Frank Pucciano, USA
Responding to regulations on effluent temperature, the owners of a textile plant installed a heat recovery heat pump. Not only did they meet the regulations, they also gained many other benefits as well.

Editing:

Jos Bouma / Mike Steadman / Bert Stuij

Production:

Caroline Verschoor

Illustrations:

Offermans EPS, Maastricht, the Netherlands

Printer:

Leiter-Nypels, Maastricht, the Netherlands

ISSN 0724-7028

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

Market Forces and the Role of the HPC



Heat pumps have become so popular in Japan that they now account for 80% of all air conditioners sold. Such a situation would have been hard to imagine 35 years ago when electric utilities first started the positive promotion of the heat pump for its high efficiency in energy use.

One of the key market forces that have contributed to the strong penetration of heat pumps has been the development of high-performance units that meet the residential user's demands for easy operation and minimal maintenance. Like other new products that have succeeded in the residential market, such as computers, video recorders and facsimile machines, heat pumps

were initially only introduced into the business and commercial sectors, where equipment is properly operated and is well maintained. Gradually, as manufacturers gained experience in this sector, heat pumps became sufficiently sophisticated to make them suitable for widespread use in the residential sector.

An equally important market force has been the close collaboration among researchers, utilities and urban developers. The successful collaboration of these parties in Japan is largely due to the formation of the National Team of the IEA Heat Pump Centre.

I sincerely hope that the IEA Heat Pump Centre will continue to promote the rational use of energy through heat pumping technology by providing information on technology advancements and market developments, not only in its member countries but also in non-member countries.

I am firmly convinced that heat pumping technology is one of the decisive measures for mankind's sustainable existence, considering our limited resources and the restricted environmental capacity of the Earth. Support for this technology, in which the IEA Heat Pump Centre plays such a pivotal role, will contribute towards a better future for mankind.

Katsuhiko Narita
Director, The Tokyo Electric Power Company Inc.

News & Views

Competition winners set for success The Finnish-Scandinavian heat pump awards

Sweden - The winners of the Finnish-Scandinavian heat pump competition, for entrants from Denmark, Finland, Norway and Sweden, were announced in Stockholm on 11 May 1995. Heat pump manufacturers IVT Energy AB and Eufor AB, both of Sweden, picked up prizes for two separate categories for ground-coupled equipment for residential applications.

As competition winners, both companies are set to make a success of their advanced heat pumps. Sales of at least 2000 units are guaranteed through the availability of subsidies from the various companies and organizations that have supported the competition.

IVT Energy AB's Puls-Greenline heat pump unit was considered the best entrant for the category "heat pump unit". This unit is designed to extract heat from a brine/water heat source and supply hot water and space heating. The

design does not include the heat distribution system.

The 3.9 kW heating capacity unit features an advanced compressor and newly-developed heat exchangers. A special suction heat exchanger and a carefully selected expansion valve ensure 100% utilization of the evaporator.

Thanks to the condenser's large surface area, the compressor's working pressure is low – a key factor contributing to the unit's high efficiency and long life. A special filter, with a receiver, precisely controls the supply of refrigerant to the heat exchangers. This also reduces the required amount of refrigerant.

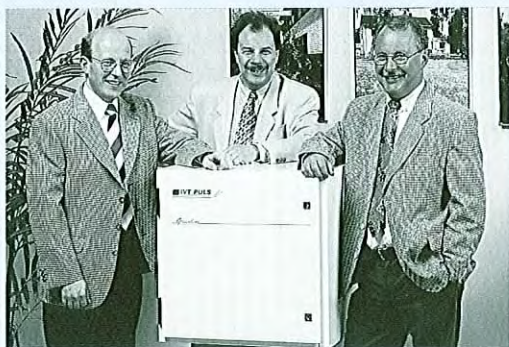
The chosen refrigerant is chlorine-free R-407C (a mixture of HFC-32/125/134a). Risk of refrigerant leakage has been minimized through the use of soldered joints.

The heat pump unit is intended for homes with oil or electric back-up heating. Its small, compact design ensures problem-free installation, and a display system allows easy operation.

The other winner of the competition, Eufor AB, developed a room unit for use in homes without a heat distribution system, such as those using baseboard resistance heating. This single-unit ductless system, which also uses R-407C, features two condensers for the provision of warm air and hot water. Suitable for wall mounting, the unit is designed for use with direct-evaporation ground coupling. The competition's judges were especially impressed by the unit's cost/performance characteristics.

The competition was organized by NUTEK (the Swedish National Board for Industrial and Technical Development) and attracted written designs from a large number of entrants last year. Ten companies were invited to submit prototypes which were rigorously examined by the Swedish National Testing and Research Institute (SP). In addition to ground-coupled systems, the judges also examined prototypes for outdoor-air/ventilation-air source residential heat pumps. However, none of the entries met the competition's stringent requirements.

(Source: Per Fahlén of the Swedish National Testing and Research Institute (SP). Tel.: +46-33-16-5520) and Håkan Persson of IVT. Tel: +46-140-17080)



IVT's Johnny Wärmelöv, Managing Director, Håkan Persson, Technical Manager, and Lars-Göran Appelberg, Marketing Manager, pose happily with their winning heat pump.

European R&D focuses on sorption technologies

Sweden - Under the European Union's (EU's) JOULE II Programme, a number of heat pump related research & development projects are ongoing including several on sorption technologies. The box on page 5 lists the projects that were highlighted at the sixth meeting of the EU's Concerted Action Group (CAG) held in Stockholm,

Sweden in October 1994. Under the JOULE II programme, research & development projects are carried out on a wide range of non-nuclear energy technologies.

Also at this meeting, the results were presented of the CAG's pan-European market study on heat pumps, which is to

be published this year. This highlights the stark variations between European countries, with many differences in the use and perception of heat pump technologies.

(Source: Ulf Rivenæs, Norwegian National Team)

Absorption heat pump users meet in Gothenburg

Sweden - GRAAB, a waste treatment company located in the City of Gothenburg, hosted the 1995 annual meeting of the Users Club of Absorption Systems on May 2. User representatives came from Sweden, Denmark and the Netherlands, and exchanged practical information about their installations.

This time, representatives of manufacturers (Sanyo Electric Co., Entropie S.A., Rinheat Oy) were invited to give their views on various aspects and

new developments. Issues discussed included inhibitor control, inspection methods, vacuum pump operation and maintenance aspects.

It was reported that what was once the world's largest absorption heat pump has been taken out of operation because the heat source (industrial cooling water) is no longer available. The steam driven heat pump, with a heating capacity of 7 MW, was installed in 1984 in Trolhättan, Sweden (see *IEA Heat Pump Centre*

Newsletter Vol.3, No.4). The chemical plant that delivered the cooling water has been closed down, so the heat pump, which has had ten years of trouble-free operation, is now for sale.

The good news is that a new absorption heat pump has recently been added to the existing four units that have been operating for some years at GRAAB's incineration plant in Gothenburg. The new heat pump has a heating capacity of 31.7 MW and produces 72°C water for the district heating system. The heat source is cooling water (42°C) from the wet scrubber in the plant's flue gas cleaning system. Lithium bromide/water is the working pair.

Box: Heat Pump R&D under the European Union's JOULE II Programme.

Plate-fin heat exchanger technology in absorption systems

This project aims to further improve the advanced GAX (generator-absorber heat exchanger) absorption heat pump developed by Colibri in the Netherlands, which is now operating with considerable success in a building in Maastricht, the Netherlands. (See *IEA Heat Pump Centre Newsletter* Vol.12, No.4 p.7). The project aims at improving the PER, reducing production costs and expanding its range of application. Work will focus on the improvement of the plate-fin heat exchangers as well as the development of a thermally driven pump and a heating tower (to use ambient air without the need for defrosting).

Advanced ammonia/water absorption heat pump

Italian contractor ENEA is developing an absorption heat pump for providing space heating and cooling and sanitary hot water for buildings in central and southern European countries.

Gas-solid sorption machines

Companies in Belgium, France (coordinator), Germany, Italy and Spain are cooperating on research into new high-performance solid-gas pairs, on new manufacturing techniques, on thermal-wave reactors and on the construction of high-performance chiller-heater reactors.

Residential absorption heat pump with water as refrigerant

German and Dutch companies are working at the construction of a double-effect absorption heat pump similar to the well-known lithium bromide/water systems but with a heating PER of at least 2.

Adsorption heat pump using metal-supported zeolites

This Dutch research project aims at integrating the water adsorption capacity of zeolites with the heat conductivity of porous metal substrates. Experimental results will be used to simulate a heating/cooling system.

Rotary vapour-recompression heat pump

Contractors in Finland, Portugal and the United Kingdom (coordinator) are developing a prototype system and modelling its thermal and economic performance in buildings.

Heat pump database

Germany, Italy and the Netherlands are cooperating on HPEC - a heat pump database for the European Community. This will contain a survey of European RD&D projects, information on heat pump incentive schemes and a list of companies concerned with the manufacture or installation of heat pumps.

The advanced design of the heat pump features vertical components that require relatively little space. Also for compactness, and to improve heat and mass transfer, the evaporator and absorber on the one side, and the generator and condenser on the other, have been integrated into two pressure vessels. Further details on this project will be given in a future issue of the *IEA Heat Pump Centre Newsletter*.

(Source: Jos Bouma, IEA Heat Pump Centre)

HPC Seminar

International Heat Pump Status and Policy Review

25 August 1995
The Hague, The Netherlands

(The seminar will be held as part of the 19th IIR Congress. Contact the HPC for further details)

Technology and Applications

And it even washes the dishes!

Belgium - A novel heat pump system in the St Norbertus hospital in Belgium, combines space cooling with hot water supply for a dishwasher. With around 630 meals served daily, the prospect of energy saving made a heat pump system an attractive option when the original electrically-heated dishwasher was replaced in October 1993.

In the new dishwasher, an integrated electric heat pump heats water using two heat sources (see Figure 1): Firstly, heat is extracted from ventilation air, and the cooled air provides space cooling for the kitchen. Secondly, the heat pump utilizes the 55°C air produced by the dishwasher during drying.

Water heating is done in several steps. Tap water is preheated by the heat pump's sub-cooler and fed to two storage tanks with a combined volume of 490 litres. The condenser maintains this water at 63°C, sufficient for some of the dishwasher's rinsing functions. For the washing process, water at 85°C is also produced, firstly by heating to 70°C in the heat pump's desuperheater and then finally by an 18 kW resistance heater.

The COP of the heat pump is reported to be 2.9. With the new dishwasher system, the electricity consumed to meet a daily

Multitalented: This heat pump helps wash the dishes and cools the kitchen at the same time.

heat demand of 187 kWh has been reduced from 323 kWh to 180 kWh.

The dishwasher cost around US\$ 80,000 (BEF 3 million), of which around US\$ 30,000 was for the heat pump. Financial support was given by the Flemish government. The simple payback period for the heat pump is five years based on an electricity price of US\$ 0.11/kWh (BEF 4.15/kWh).

A more detailed article has been published in *CADDET Energy Efficiency Newsletter* No. 1/1995.

(Source: Mr Johan Desmedt, VITO, Boeretang 200, 2400 Mol, Belgium. Tel: +32-14-335841; Fax: +32-14-321185.)

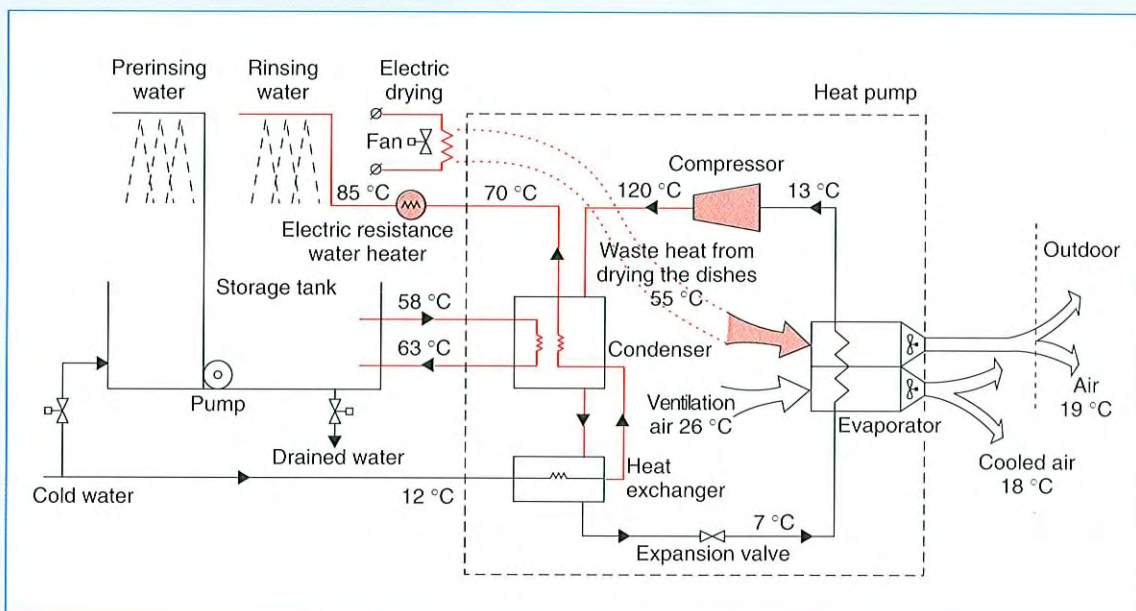


Figure 1:
Dishwasher
heat pump
system.

Domestic heat pumps use factory waste heat

Piping the heat source to each home yields SPF of 5.3

Germany - An award winning heating system in the city of Spenge heats 140 homes with decentralized electric heat pumps using cooling water from a nearby textiles factory as the heat source. The 25°C cooling water is piped to every home via a "cold water" district heating network. Each home has a low-temperature (35°C) heat distribution system, with underfloor heating or low-temperature radiators. Hot tapwater at 55°C is also provided by the heat pumps. The low-temperature lift results in an average SPF of 5.3 (with COPs ranging from 4.2 to 7.1). Because of the low temperature of the heat supply, the district heating network uses ordinary plastic pipe without insulation. The heat pumps reduce the water temperature to about 10°C and feed it back to the factory.

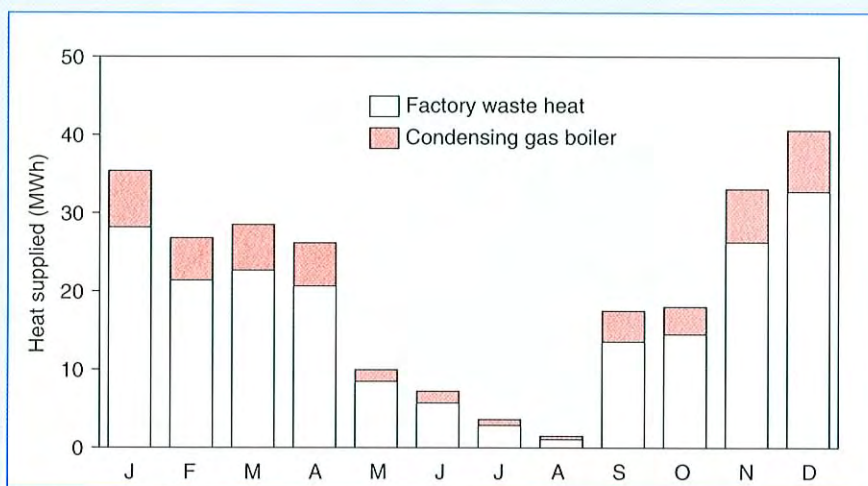


Figure 2: Heat supply pattern for the heat pump system at Spenge.

At weekends and holidays, when the factory is closed, a condensing gas boiler maintains the network at the required temperature. Figure 2 shows the extent of this back-up heating. Despite this drawback, the system makes primary energy savings of about 60%, and CO₂ emission reductions of nearly 50%

relative to the use of the best condensing gas boilers.

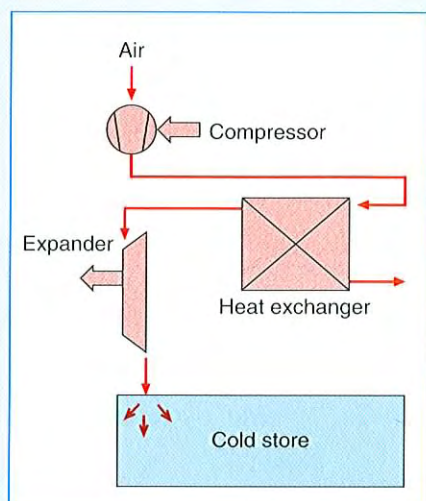
The system was realized by the local utility, Elektrizitätswerke Minden-Ravensberg GmbH, in cooperation with the local government of Spenge, and the textiles factory, Delius & Söhne. The project was supported by the state

government of Nordrhein-Westfalen, and received the "Environmental Award" of the German Industry Association (Bundesverband der Deutschen Industrie), beating 160 other applications.

(Source: *Wärmepumpe* from IZW, Germany, March 1995)

Working Fluids

Air-cycle plant goes into operation



The Netherlands - After less than one year of preparation, a pilot cooling system using air as refrigerant went into operation on 24 January 1995. The air-cycle equipment has been used to cool a 10 m³ cold store in a laboratory. After 100 hours of operation, the prototype system has proven the concept of the air cycle. Shown in Figure 3 is an open-cycle system whereby the refrigerant is expanded directly into the cooling space. The developers had to overcome problems of water condensation and ice forming in the heat exchanger, where refrigerant air gives off heat to the compressed ambient air.

The problem was solved by using a static regenerative heat exchanger. This uses a valve mechanism to reverse the flow of air over two identical packed-beds to provide a defrosting effect.

The project is being carried out by the Netherlands Organization for Applied Scientific Research - TNO, who are cooperating with contractors in Germany and the United Kingdom under the European Community's JOULE II programme. Work is continuing to further develop the technology in preparation for an eventual full-scale demonstration project.

(Source: *Food Management*, 24 March 1995)

Figure 3: Principle of the air cycle.

Markets

Air-source market exceeds one million

USA - In 1994, 1,008,072 unitary air-source heat pumps were shipped from US factories – exceeding the psychologically important 1 million level for the first time. With shipments up 14% on the previous year, 1994 was certainly a good year for the heat pump, though not as good as for cooling-only unitary air conditioners which registered a 22% rise in shipments.

The share of heat pumps among shipments of all types of unitary air conditioner thus fell slightly from 21.7% in 1993 to 20.6% in 1994. Figure 4 depicts the shipment of unitary heat pumps over the past ten years.

The reasons given for the buoyant air conditioner and heat pump shipment figures are the extremely low interest rates early in the year, the hot summer, and low levels of field inventory at the end of 1993. While some sources have predicted a slow down in the market (see the previous issue of the *IEA Heat Pump Centre Newsletter*), early 1995 figures suggest further growth. January

1995 heat pump shipments were up a massive 30% on the previous January.

(Source: *Air Conditioning and Refrigeration News*, April 10, 1995, and *Koldfax* from *ARI*, March 1995)

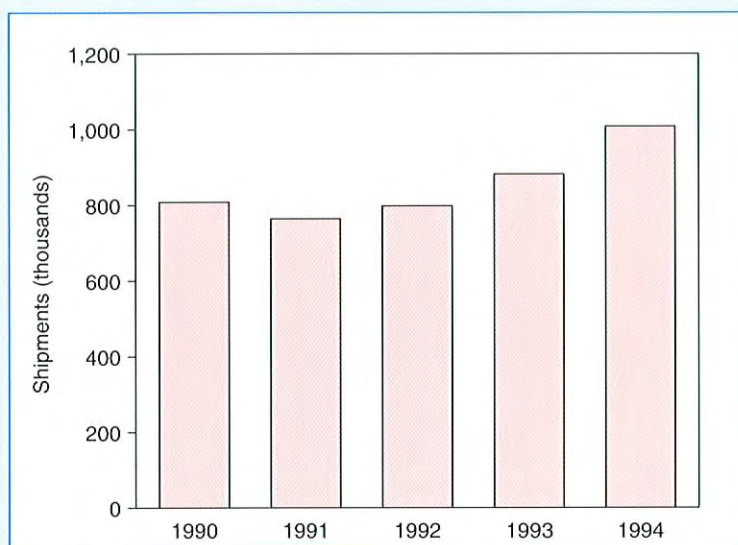


Figure 4: Shipments of unitary air-to-air heat pumps in the US.

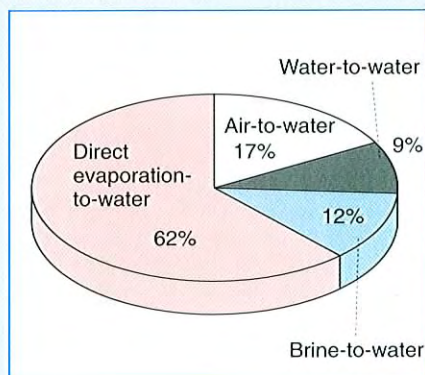
Market led by direct evaporators

Austria - An increase in the installation of monovalent ground-source systems, most of which are using direct-

evaporation ground coupling, has accounted for much of the recent rise in sales of space heating heat pumps here. In 1988, sales of space heating heat pumps were split almost equally between air-source, water-source and ground-source systems. Today, as depicted in Figure 5, the market is dominated by direct-evaporation systems.

The recent growth in space heating systems has, however, been offset by a fall in sales of heat pump water heaters (HPWHs). Table 1 shows the annual sales figures for space heating heat pumps and HPWHs over the past five years. By the end of 1994, accumulated sales of heat pumps had risen to 24,451 residential systems and 98,061 HPWHs.

Figure 5: Space heating heat pump sold in Austria in 1994.



Year	Space Heating	HPWHs	Total
1990	790	6420	7210
1991	1066	6940	8006
1992	920	6160	7080
1993	1125	4971	6096
1994	1350	4400	5750

Table 1: Austrian heat pump sales.

(Source: Hermann Halozan, Austrian National Team)

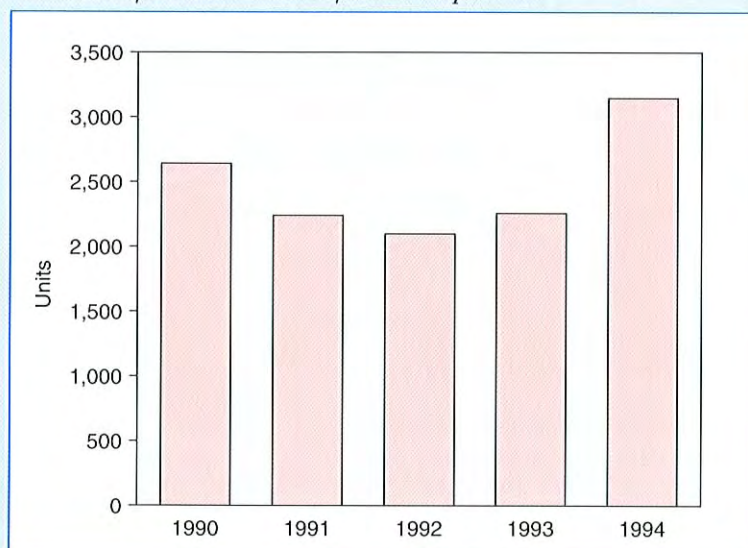
Subsidies stimulate record sales

Switzerland - The availability of a federal government grant for the replacement of existing heating systems with heat pumps helped to boost the heat pump market here in 1994. From March 1993 to the end of 1994, 840 heat pumps were installed under the scheme. This helped heat pump sales to grow to a record level of 3630 units in 1994. Federal subsidies ended in June 1995, although other financial incentives continue to be offered by some cantons and utilities. Figure 6 shows heat pump sales over the past five years.

The major trend in the type of equipment being sold was the increasing share of air-to-water heat pumps, which rose to 62.9%, while the share of ground-water source heat pumps fell to 6.5% from 11.4% in the previous year. The share of ground-source heat pumps remained at around 30% from 1993 to 1994.

(Source: Swiss Association for the Promotion of Heat Pumps (FWS))

Figure 6: Heat pump sales reported by member companies of the Swiss Association for the Promotion of Heat Pumps.



Sales figures break new records

Judging from the market figures from some of the world's key heat pump countries, 1994 was a very good year for the heat pump, with growth rates of between 11 and 40%. Record figures were recorded in Japan, Norway, Switzerland and the USA.

Norwegian heat pump sales registered the largest year-on-year growth rate, rising by 40% to 1400 units. Germany and Austria also registered a strong growth in sales of space conditioning heat pumps, with rises of 20% and 18% respectively.

(Source: IEA Heat Pump Centre)

Erratum

In IEA Heat Pump Centre Newsletter Vol.13, No.1, the member countries of Annex 22 were incorrectly listed in Table 3 on page 11. They should read Canada, Denmark, Japan, The Netherlands, Norway, Switzerland, United Kingdom and the United States.

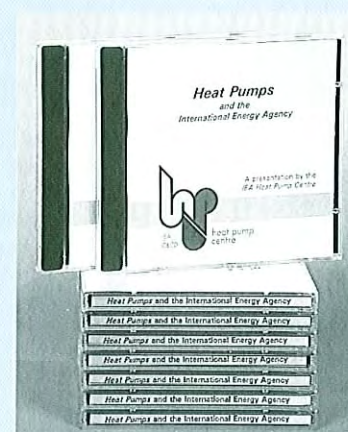
IEA Heat Pump Programme

Promoting the Programme

As part of its strategy to heighten awareness of the benefits of heat pumps and the activities of the IEA Heat Pump Programme, the IEA Heat Pump Centre has been stepping up its promotion activities in 1995. The "HPC Portfolio", which was distributed with the previous issue of the "Newsletter", is being sent to key personnel in utilities, universities and heat pump manufacturers around the world. In addition to the "Portfolio", two new promotional tools have been

developed. A computer diskette, shown in the photograph, entitled "Heat Pumps and the International Energy Agency", provides an on-screen presentation of the work of the Programme and the benefits of heat pumps. And a portable exhibition stand can be used to draw attention to the Programme at workshops, conferences and other events.

(Source: IEA Heat Pump Centre)



Executive Committee elects a new chairman

A report from the April '95 meeting in Madrid

Spain - The Spring Executive Committee Meeting of the IEA Heat Pump Programme saw the election of a new chairman to replace Mr Keith Snelson of the National Research Council, Canada, whose three-year tenure of the post has come to an end. The new chairman is Mr John Ryan from the US Department of Energy. Mr Hermann Halozan of the University of Graz, Austria was elected vice-chairman.

The meeting was held on April 27-28, 1995 at the Ministry of Energy and Industry in Madrid, Spain – a location which gave many opportunities to learn more about the Spanish heat pump situation. Four speakers from utilities and industry set the scene, with papers on electric and gas heat pumps in the buildings sector and industry. These presentations highlighted the growing interest in heat pumps in Spain and emphasized the opportunities for further international collaboration through the IEA Heat Pump Programme.

As usual, the meeting reviewed progress in the Programme's ongoing activities and discussed proposals for new Annexes.

Annex 18

This year has seen the publication of many valuable reports from the project "Thermophysical Properties of Environmentally Benign Refrigerants". Table 2 provides an overview.

Annex 21

This industrial heat pump project is approaching completion. The Final Report entitled, "Industrial Heat Pumps: Experiences, Potential and Global Environmental Benefits" is soon to be published and can be ordered from the IEA Heat Pump Centre (purchasing details are given on the back inside cover).

A brochure highlighting the results will be widely distributed, and workshops will be held later in the year in North America and Europe. Furthermore, a computer program for screening potential industrial heat pump applications is available to people in Annex 21 member countries.

Annex 22

Participants in Annex 22, "Compression Systems with Natural Working Fluids",

Publication date	Title of Publication
June '91	A Survey of Current Worldwide Research on the Thermophysical Properties of Alternative Refrigerants
January '95	Handbook for the Analysis and Identification of Alternative Refrigerants
March '95	Thermodynamic and Physical Properties of R123 and R134a
April '95	Extended Thermophysical Properties of R134a
April '95 *	An Assessment of the Current Status of the Thermophysical Properties of Ammonia
April '95 **	Comparison of Equations of State for HCFC-123
June '95 **	Comparisons of Equations of State with Experimental Data for R134a and R123
	published by the IEA Heat Pump Centre
	* first published in 1994
	** first published in 1993

Table 2: Annex 18 publications.

are currently preparing Country Reports in which information on applications, safety aspects and design rules, and research and development will be compiled. The findings of these reports will be presented at a workshop in Trondheim, Norway on 16-18 October 1995. This event is open to people in both participating and non-participating countries.

Single room systems

Many countries expressed their interest in the new Canadian Annex proposal, entitled, "Cold-Climate Heat Pump Systems for Single Room Applications". This would tackle many of the difficulties associated with the retrofit of heat pumps in buildings. The Annex will be of particular interest to electric utilities.

One element would be the collection of data on existing heating equipment and the documentation of ongoing research on the application of single-room heat pumps. A major aim of the project would be to share common experiences of electrical utilities in serving customers with single-room heating systems and to identify systems that retain the heat pump's benefits at cold temperatures, and avoid problems of peak loading.

A "kick-off" meeting was held for this Annex in February, 1995 in Chicago where the time schedule and work programme were discussed. A second "expert's" meeting is to be held soon.

Absorption equipment

Mr Bjorn Sellberg of Sweden announced that the "kick-off" meeting of the Annex proposal on "Absorption Heat Pumps" will take place on September 12, 1995 in Eksjö in Sweden. This Annex aims to find the reasons for the low use of absorption technology for heating and cooling.

Evaporators

Mr Sellberg also introduced another new Annex proposal from Sweden entitled "Performance of Environmentally Benign Working Fluids in Low-Charge Evaporators". This would build on the work of Annex 17, "Thermophysical Properties of the Environmentally Acceptable Refrigerants", to cover HFCs, hydrocarbons and mixtures of these refrigerants, as well as ammonia.

The next IEA Heat Pump Programme Executive Committee Meeting is to be held in Dresden, Germany on 15 and 16 November 1995.

(Source: IEA Heat Pump Centre/TSSU)

Heat Pump Market Forces

An International Overview

Mike Steadman, IEA Heat Pump Centre

The global heat pump market is characterized by large variations between different countries. Those who wish to build on these markets need to understand the market forces that have led to this situation. This article highlights the current market situation and the major influencing factors. It also discusses some of the measures that policy makers around the world have used to try and support the heat pump market. The market situation in a number of key countries is outlined in the blue boxes. For some countries, more detailed market data are given on pages 8 and 9 of this Newsletter.

* * *

There must be few products for which the international market exhibits such wide variation as it does for the heat pump. While heat pump sales are counted in their millions in the US and Japan, European countries are doing well when sales exceed a few thousand. Table 1 lists the latest sales data from various countries.

A more meaningful examination of heat pump markets must take account of the difference in the size of these countries. Figure 1 shows the 1992 heat pump stock in the building sectors as a function of

Austria	5750
Germany	1450
Japan*	6,217,819
Norway	1400
Switzerland	3309
USA	1,171,072

* year ending Oct. 1994

Table 1: 1994 sales or shipments figures for all types of heat pump.

population, using data from the HPC report AR3 "International Heat Pump Status and Policy Review".

Such data must be examined with caution since they do not allow for differences in heat pump size. Another way to compare the significance of heat pumps in different countries is to look at the percentage of heat demand they meet (see Figure 2 page 13). This reveals that large variations between the numerical significance of heat pumps do not necessarily equate to such a large gap in the heating significance.

In Sweden, heat pumps are significant both numerically and in terms of the heat demand they meet, especially when district heating systems are considered. Norway too meets a significant portion of its heat demand with heat pumps. In fact 5% of all

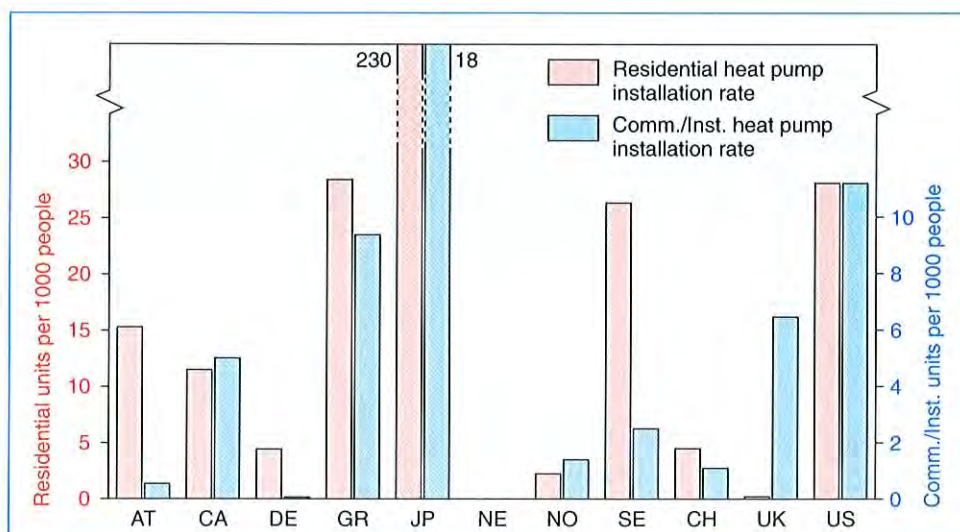
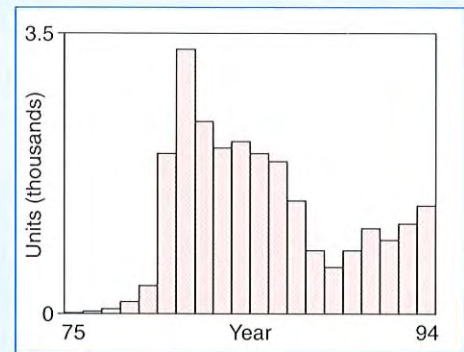


Figure 1: Heat pump significance in selected countries, relative to country population.

Austria

"Success on the market is not a phenomenon, it is the result of research, good products, the intention of planners and installers, the support of the utilities and the result of a political decision" (Leistungsgemeinschaft Wärmepumpe 1995).

If all these preconditions for a market fit together, a growing market can be established. Experience in Austria shows that if only one of these preconditions is missing, market development is handicapped. The figure shows sales of space heating heat pumps in Austria.



The rapid growth at the beginning of the eighties was the result of strong support by the government and the impact of the second oil price shock. However, other market conditions were less favourable. The support of the utilities was mixed, with many of them incorrectly considering the heat pump to be a competitor to direct electric heating. Furthermore, there were few skilled installers (the majority did not know what a heat pump was) and few good products. Consequently, after peaking in '81, the market broke down and many tiny manufacturers disappeared. Those remaining produced better products and those installers still interested in heat pumps began to specialize in the field. The continued support of the government allowed the market to stabilize.

In 1986 two things happened: The oil price dropped (the 'third oil price shock') and the support of the government was essentially withdrawn. This resulted in a second breakdown of the market.

Since 1990 things have changed again: The market has switched from retrofitting existing buildings with bivalent systems to providing new buildings with monovalent systems. The ground has become the dominating heat source, mainly through the use of direct-evaporating systems. Much R&D work has been carried out, and more utilities are supporting heat pumps. The result is a slightly growing market: The barrier to a stronger increase in heat pump installations is now the inactivity of the government.

(Source: Hermann Halozan, Austrian National Team)

Canada

The driving forces behind the Canadian heat pump market are the environmental and financial benefits. The present low-cost of heating residential homes with conventional natural gas systems makes most heat pump systems difficult to justify. However, in most commercial buildings and non-gas heated residential areas, heat pumps are economical if properly designed and installed. The space cooling benefit is often used to justify the first cost of a reversible heat pump. The need for mechanical ventilation in new buildings could create a market for exhaust-air (heating-only) heat pumps as it has in Sweden.

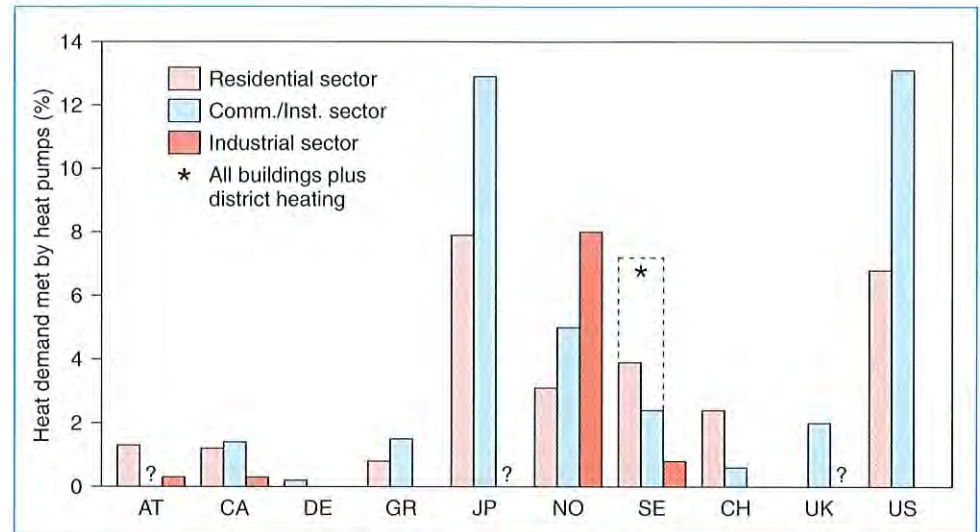
When government and utility information and incentive programmes are promoting heat pumps, sales increase. However, few Canadian utilities presently promote heat pumps. Many utilities have the perception that heat pumps are not reliable in the cold Canadian climate, are expensive to operate, and difficult to install. Furthermore, Canadian utilities are undergoing dramatic structural change, with deregulation, privatization and increasing price competition.

Without utility support, potential heat pump customers faced with a heating/cooling decision must rely on the installing contractor for information on the benefits of heat pumps. Many contractors are not familiar with heat pumps and are uncomfortable in recommending them over more conventional systems. A growing number of consumers have an awareness of environmental issues and are keen to listen to those offering superior environmental choices such as heat pumps. For the heat pump market to expand in Canada, the dissemination of reliable third party information is key.

The Canadian National Team, which is also undergoing restructuring, has forged a strategy to deliver accurate, independent and objective information and advice on heat pump technologies. The plan calls for developing closer ties with trade associations, governments, utilities, manufacturers and consumer groups. The National Team has a mission statement to promote the benefits of heat pumps, clear up misunderstandings, and help overcome drawbacks often related to inexperience in installation and design.

(Source: Canadian National Team)

Figure 2:
Heat demand met by heat
pumps in selected countries.



heat demand from buildings and industry is reported to be met by heat pumps, the highest portion of any country.

There are marked variations between other European countries. For example, Switzerland has a large and growing market for residential heat pumps, while penetration in the commercial sector is modest. In contrast, the United Kingdom reports the third largest penetration of heat pumps in the commercial sector, while residential heat pump sales are limited to modest sales of swimming pool heat recovery heaters.

In Greece, heat pumps are sold in relatively high numbers in both the residential and commercial sectors, but their contribution to heat demand is modest. Austria has a particularly large market for heat pump water heaters.

Many factors account for this peculiar market situation. Both the buildings and industrial markets are strongly influenced by the presence or absence of a cooling demand, and by cost factors. For building applications, local variations in the design of buildings and of building services equipment are also key market forces. For industrial heat pumps many technical factors associated with different types of industry have a strong bearing on the market. The paragraphs below look at these forces in more detail.

Impact of Cooling Demand

The main driving force for the voluminous markets of the US and Japan is cooling demand. Most heat pumps sold are reversible systems for use in regions with both a cooling and a heating demand.

Countries with similar climate conditions in some areas, such as Australia, China, Greece, Italy and Spain, seem to have the potential to mimic the situation in the US and Japan. The sizeable market for heat pumps in large buildings in the United Kingdom

is also driven by cooling demand. As in many other countries, the increasing use of office equipment is increasing the demand for space cooling in offices. However, pressure is growing to severely curtail the use of "active" cooling systems, as is already the case in parts of Switzerland, and this may restrict the commercial/institutional market for heat pumps.

Cooling demand is also a strong influencing force on the industrial heat pump market, for instance where environmental regulations require industries to reduce effluent temperatures and the use of ground-water for cooling.

Impact of Heating Demand

The large heat pump market in Sweden shows that heat pump markets can also thrive where there is no cooling demand. Here, the relatively cold climate has stimulated heat pump sales in that the high heat demand has created a culture whereby measures to reduce heating costs are given a high priority. Consequently, Swedish homes are well-insulated and people are prepared to pay extra for an efficient heating system. Regulations to enforce heat recovery have also helped the heat pump market.

Heat pumps have not fared so well in other "heating mainly" markets. It is interesting to note that the countries with the greatest interest in heat pumps, such as Austria, Norway and Switzerland, are those where hydropower is a dominant source of electricity.

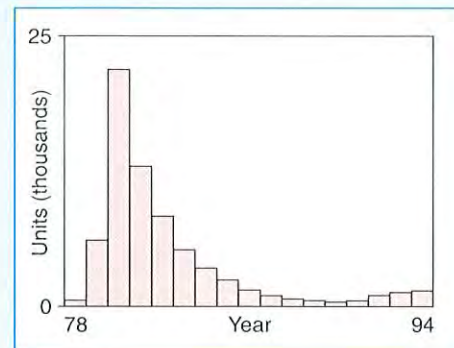
Cost Factors

Undoubtedly the main barrier to selling a heat pump for heating-only purposes is the additional cost of the equipment. A heat pump can cost 1.5 to 5 times as much as a gas or oil-fired heater of the same capacity. And the price differential for electric resistance heating is even greater.

Germany

Since 1993, heat pumps have been supported by the Munich based *Initiativkreis WärmePumpe (IWP) e.V.* (Heat Pump Promotion Group). The promotion group's goal is to promote the spread and acceptance of heat pump technology through activities to increase the significance of heat pump technology on the market.

Manufacturer-neutral information material has been published and seminars, training schemes and congresses have been organized for planners and members of the specialist trade. The recently held European congress, *SOLARTEC '95*, was attended by 460 people and attracted considerable media coverage, including television.



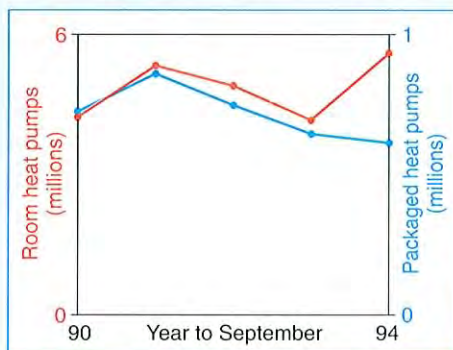
The electric utility *RWE Energie* offers a number of incentives for monovalent and bivalent heat pumps for homes, including a 25% discount on the electricity rate, a two year guarantee on components of the cooling circuit and a four year financing loan to cover 15% of the installation costs at just 3% interest. The installers, manufacturers and equipment must meet various criteria, otherwise the only incentive is a 15% discount on the electricity rate.

(Sources: *Johannes Zaugg of heat pump manufacturer KKW GmbH. Fax: +49-9221-709. Peter Göricke of RWE Energie. Fax: +49-201-185-4543*)

Japan

Annual heat pump sales now exceed six million units, with 5.6 million room heat pumps and over 600,000 packaged heat pumps shipped for sale in the year to October '94. Furthermore, 4,300 gas-fired heating/cooling units were installed in the year to April 1994.

Clearly, there is little need to stimulate the heat pump market here. Nonetheless, the support of heat pump technology is given a high priority in Japanese energy policy.



The advancement of heat pumping technology and the dissemination of results are considered to be the most significant measures to force the heat pump market. Much effort has focused on large national projects. Current programmes such as the "Unused Energy Utilization Project" and the "Broad Area Energy Utilization Network System Project (Eco-Energy City Project)" aim to construct energy networks, where for instance industrial waste heat is upgraded via heat pumps, and then made available to the residential/commercial consumers.

(Source: *Yoshio Igarashi, Japanese National Team*)

In new buildings, the effect of such price differentials is less significant as the cost of a complete space conditioning and water heating system, including heat distribution equipment, is the most relevant statistic. The cost of connecting a building to the gas network can also work in the heat pump's favour. For existing buildings, heat pumps must generally be installed as bivalent systems and thus present an additional investment which the customer will hope to recoup from savings in energy costs.

Unfortunately, despite the heat pump's high efficiency, the reduction in energy costs can be moderate. In terms of energy value, the electricity

consumed by a heat pump is typically about one quarter of the energy consumption of fossil-fuel equipment. The price ratio of electricity to fuel must therefore be less than four for financial savings to be made. At today's low oil and gas prices, daytime electricity/fuel price ratios are over 3.5 in many countries. Unless special tariffs are available, heat pumps must be designed to use off-peak electricity if they are to offer energy cost savings.

Higher prices for fossil fuels would help the heat pump market since they reduce the electricity/fuel price ratio even when fossil fuels are used for power generation. On the other hand, very low electricity prices make

resistance heating more attractive. The trend towards the deregulation of electricity markets may reduce the electricity/fuel price ratio as competition acts as an incentive to bring down the fixed costs of power supply.

For industrial heat pumps, cost factors play a more complex role. Often the best way to use an industrial heat pump is to install it as part of an overall programme to optimize an industrial process. In choosing a system with a heat pump or a cheaper alternative such as one using heat exchangers, the cost of the heat pump is just one variable among many other factors such as the cost of additional equipment, throughput time, maintenance requirements and the quality of the product. In many cases, savings in energy costs are not the main incentive for installing an industrial heat pump.

Building Factors

Building practice is moving towards ever higher standards of insulation. This has both pluses and minuses for the heat pump market. On the one hand, for some climates, a high level of insulation can reduce the heat demand to such a small level that the energy saved with a heat pump has little value to the consumer. On the other hand, a sealed building requires forced ventilation, for which a ventilation-air heat-recovery heat pump provides a cost-effective system for further reducing heat loss. In some countries, building regulations are driving the market for this type of heat recovery.

Heat distribution systems are another influencing factor on heat pump markets. The traditional high-temperature hydronic (wet) heating systems, such as are prevalent in central and northern Europe, are not well-suited for heat pumps. Even in new buildings, traditions die hard and considerable effort is needed to encourage building designers to install the low temperature systems favoured by heat pumps such as underfloor or forced-air heating systems. For existing buildings, the best chance of expanding the heat pump market is with systems that require a minimum of installation work. This factor has led to increased interest in the development of single room heat pumps – a proposal to conduct a project on single room heat pumps under the IEA Heat Pump Programme is now being discussed.

Industry Factors

The main market forces affecting the use of industrial heat pumps are technical factors such as temperature levels. The traditional markets are in evaporation, drying and distillation processes, where the temperature lift is often very low. Industrial heat pumps are also used in large numbers to provide heating services to buildings. The proximity of buildings is a major market force for these applications.

Supporting the Market

The discussion so far has examined the basic factors that affect the heat pump market. Manufacturers of heat pumps must try to develop products and market strategies to make the most of the existing market opportunities.

However, interest in the sale of heat pumps is not confined to the manufacturers. For society as a whole, heat pumps are increasingly recognized as a key technology for energy conservation and environmental protection. For utilities, heat pumps can play a role in meeting many strategic goals, including both economic and environmental aims.

Both for society, as represented by government bodies or other organizations, and for utilities, a number of measures can be used to stimulate the market for heat pumps in buildings and industry.

Developing the Technology

In many countries, heat pumps are supported by providing funds for projects that work towards the advancement of heat pump technology. Sources of funds may be the government, utilities, or consortiums of manufacturers. Such support is often, but not always, restricted to areas of so-called pre-competitive research. Recently, the focus of attention has been on the replacement of refrigerants, most notably the Alternative Refrigerants Evaluation Programme (AREP) under which manufacturers from many countries have collaborated. Other programmes are aimed at further increasing the effectiveness of heat pump technology. In Japan, for example the government is supporting a number of projects, including one to developing heat pumping systems that can allow the effective use of industrial and urban waste heat for the heating and cooling needs of buildings.

Another way to encourage the development of heat pump technology is to hold design competitions. Both Switzerland and the Scandinavian countries have recently held competitions for residential heat pump designs. The winners will receive substantial subsidies to help sales of their new equipment. In Japan, an annual award scheme honours manufacturers and installers of well-designed heat pump systems.

Demonstrating the Technology

New technologies must go through many stages of evolution before they are ready for commercialization. Once a mature product is ready, the market must be made aware of its existence and needs to be convinced that it really works. Demonstration projects can play a vital role in this. In the US, for example, a partnership has been formed between the government, gas utilities and manufacturers, plus three national organizations, to demonstrate new natural gas heat pumping technologies. And the Swiss

Netherlands

Despite the availability of a 25% subsidy for energy-saving technologies such as heat pumps, readily available low-cost gas makes a gas boiler the preferred heat source for almost all buildings and industrial applications. Heat pump installations in buildings are restricted to a few notable demonstration projects. A stronger market exists for industrial heat pumps, especially for agricultural applications.

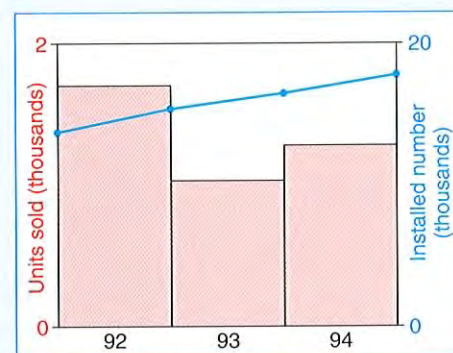
Structural support for the heat pump market dates back to the period 1980-1990 when the national gas utility and the government supported a programme to demonstrate the use of gas engine heat pumps in the buildings sector. More recently, a government-backed heat pump programme has been working on improving the boundary conditions for the heat pump market through information activities such as the provision of manuals and education material. Recently, a much more ambitious programme has commenced to stimulate heat pump use in buildings and industry through a range of measures. This government-backed programme is being executed by the Netherlands Agency for Energy and Environment (Novem) in close collaboration with utilities. The overall aim is for heat pumps to achieve energy savings of 5 PJ per annum by the year 2000.

(Source: Dutch National Team)

Norway

Support for heat pumps by the Norwegian government has been in decline in recent years. The subsidy of 40%, which was first made available in 1991, was reduced to 20% in 1992 and removed in 1993. The Norwegian National Heat Pump Programme (1989-1996) was essentially stopped in 1993 due to a lack of government funds, although support for IEA and EU activities, plus some very limited national activity is continuing this year.

Despite the withdrawal of subsidies, preliminary data show an increase in heat pump sales in 1994 compared to 1993. One reason is probably the fall in interest rates from 15% to 7% from '92 to '94. But it also suggests that the intensive National Heat Pump Programme has had a lasting effect.



One feature of the market is the increasing popularity of ground-source heat pumps. Further growth in the market for heat pumps for single-family homes is expected to result from the Scandinavian Heat Pump competition. The result was announced at the International Heat Pump Conference in Oslo on May 11, 1995.

The government continues to support the spread of knowledge on heat pumps, although no longer as a separate programme. About US\$ 10 million will be spent in 1995 on education, information and campaigns on energy efficiency, including the use of heat pumps.

Electric utilities, deregulated since 1991, continue to undergo change. The government is at the moment supporting the establishment of 10-20 Regional Energy Efficiency Offices (REEOs) which will be responsible for all kinds of energy efficiency work done in their region. Owned by the utilities, the REEOs are financed by an extra tax on the electricity distribution (not the production) tariffs of 0.2 øre/kWh (0.032 US\$/kWh). It will take another 1-2 years before all the REEOs are established. Their attitudes towards heat pumps, which will be very important in the years to come, is positive at this early stage. Currently, the attitude of utility managers, who are at best quite indifferent to heat pumps, is hampering the market.

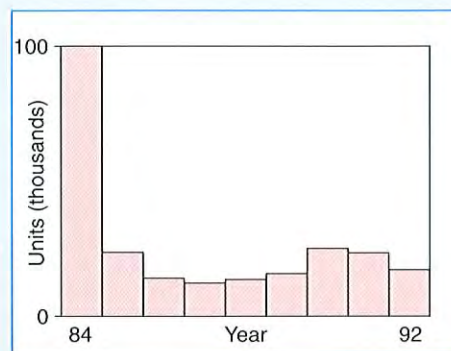
(Source: Ulf Rivenæs, Norwegian National Team)

Heat Pump Programme has generated significant interest in heat pumps amongst the general public by holding "open days". At these events, the public is invited to view a heat pump system in somebody's home and to put their questions to relevant people such as the installers, the local utility and the heat pump users themselves.

The quality of demonstration projects is vitally important. Well publicized projects that end up as failures can severely dent confidence in the market.

Sweden

Approximately 220,000 heat pumps are installed at present. Of these, around 200,000 are small units with a capacity of less than 10 kW. Between 10 and 12% of Sweden's 1.9 million homes use a heat pump, most of them extracting heat from outside air. In addition, much larger heat pumps are used in district heating and industrial applications, and also for heating blocks of flats and large municipal buildings. Today, heat pumps consume between 3% and 4% of Swedish electricity and produce approximately 10% of the heat in district heating plants and 10-15% of the heat in single-family houses.



A government subsidy of 25% was available up until 1985. The removal of the subsidy, coupled with a decrease in the oil price, had a dramatic effect with sales dropping from just over 100,000 in 1984 to 22,000 in 1985. Over the past ten years, annual sales have ranged from 12,000 to 24,000 units, the best year being 1990. Government building regulations on ventilation and heat recovery, together with increasing electricity prices, are expected to help the heat pump market.

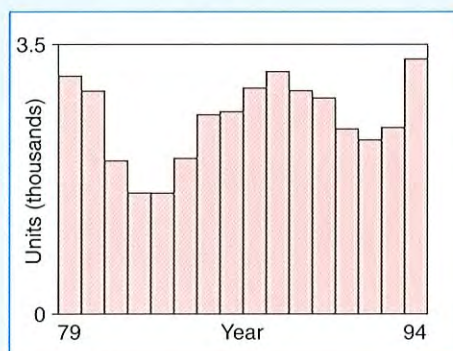
(Source: HPC Workshop Proceedings HPC-WR-14 "Utility Perspectives on Heat Pumps for Retrofit and New Applications in Buildings", Paper by Gunnar Bröms, Vattenfall Utveckling AB)

Switzerland

With 1994 heat pump sales 28% higher than in 1993, the activities of the Swiss Association for the Promotion of Heat Pumps, described in the article on page 25 appear to have been successful. Nearly all sales are in the residential sector, and are dominated by air-to-water type systems. The federal government subsidy scheme, which began in March 1993, ended in June 1995. However, several cantons are continuing to offer subsidies. For example, Solothurn offers SFR 2,500 (US\$ 2,200) per installation plus SFR 0.15 (US\$ 0.13) per kWh of energy saved in the first year of operation. The table below shows the criteria for qualifying heat pumps.

Utilities too are helping to stimulate heat pumps by offering advice and special tariffs. The power utility of the canton of Bern, BKW, offers heat pump users an interruptible supply at a rate of about 25% lower than usual. Under this scheme power may be switched off for a maximum of two 2-hour periods per day after a two hour warning is given.

(Source: Thomas Afjei of the Swiss National Team)



Heat pump type	Minimum SPF		Annual operation (hrs)
	new building	re-novation	
air/water	3.0	2.9	1400
air/air	3.0	2.9	1400
water/water	3.3	3.2	1550
ground/water	3.3	3.2	1550

Setting Equipment Standards

Equipment standards can have a positive impact on the heat pump market. Minimum efficiency standards in the US have led to an average COP improvement of 2.5% per year over the past 20 years in unitary air conditioners and heat pumps. In Switzerland, a heat

pump testing centre forms a key element of the Swiss promotion strategy by ensuring that heat pumps installed in Switzerland meet minimum standards for efficiency plus other criteria such as noise level and safety. In many cases, financial incentive schemes are only provided when stringent quality and performance requirements are met.

United Kingdom

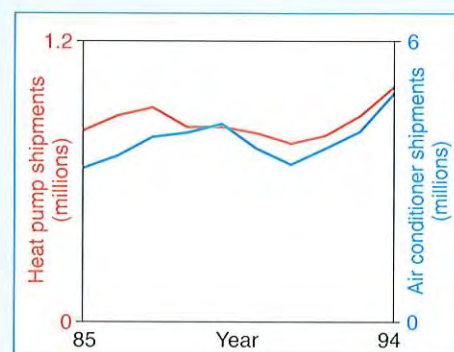
The UK heat pump market is characterized by a mature market in the commercial/institutional buildings sector and almost no market in the residential sector. Heat pumps share around 50% of the packaged air-conditioning market and are installed in approximately 2% of commercial/institutional buildings. The residential market is confined to sales of swimming pool heaters, of which 300 are reported to have been sold in 1992.

In 1994, the first formal organization was formed to promote the benefits and proper use of heat pump technology. The "Heat Pump Association" is supported by various UK based heat pump manufacturers and distributors, together with the Electricity Association (which represents all electric utilities) and a number of Regional Electricity Companies. Its first task has been the organization of an award scheme for designers of heat pump installations. The winning entries, to be announced on 27 September 1995, will be used to provide publicity material which will highlight the energy efficiency, versatility and other benefits of heat pump systems.

(Source: HPC report AR3 "International Heat Pump Status and Policy Review" and Vic Brown of the Heat Pump Association (HPA). The HPA can be contacted at: Fax: +44-1628-810423)

United States

Following the general trend in HVAC equipment sales, shipments of heat pumps are growing strongly (see Figure), reaching an annual figure of more than 1 million units in 1994 – an all-time high. The efficiency of unitary heat pumps and air-conditioners has improved an average of 2.5% per year over the past 20 years and this trend continues. However, the current debate on the deregulation of utilities is expected to lead to a reduction in spending on DSM programmes in the near future.



Out of the more than 2,700 (mostly investor-owned) electric utility companies in the US, at least 100 offer rebate programmes to promote the use of heat pumps. The rebates are usually directly associated with the rated SEER (Seasonal Energy Efficiency Ratio) level, sometimes combined with the HSPF (Heating Seasonal Performance Factor). The rebate programmes are part of utilities' demand-side management (DSM) programmes. The Consortium for Energy Efficiency (CEE) has also established initiatives aimed at stimulating sales of energy-efficient appliances in the residential and commercial markets through utility DSM programmes (more details are given in the article on page 20). However, spending on DSM programmes is likely to be reduced in future as a consequence of the current debate over deregulation.

The US Department of Energy (DOE), the American Gas Cooling Center, the Gas Research Institute, Oak Ridge National Laboratory, along with several major US manufacturers and gas utilities have formed a partnership to facilitate commercialization of energy-efficient and environmentally-safe, natural gas heat pumping technologies. Carrier, Trane, and York International participate in the partnership which is focused on four technologies.

- the residential Generator-Absorber Heat Exchange (GAX) heat pump;
- the "Triple-Effect" absorption chiller;
- the engine-driven "Triathlon" residential heat pump;
- desiccants materials to improve indoor air quality.

Efforts will initially focus on technology demonstrations and education.

It is significant to note that there is increasing awareness of the advantage of water-source and ground-coupled ("geothermal") heat pump technology, and rebates are being offered by electric utilities. Under the DOE's National Earth Comfort Program, there are also plans underway to actively promote the use of geothermal heat pumps through a new DOE-Industry-Utility consortium being led by the Edison Electric Institute and the National Rural Electric Cooperative Association. The Geothermal Heat Pump Consortium, Inc. has been formed specifically to implement the National Earth Comfort Program. The programme's goal is to increase the annual sales of geothermal heat pump units from the present day level of 40,000 to 400,000 by the year 2000, by creating a sustainable market independent of utility-provided rebates or government incentives. Cumulative energy savings of more than 98 PJ would result from the increased sales.

(Source: Melissa Voss and Phil Fairchild of the US National Team)

Education and Training

A key hurdle in developing a heat pump market is to ensure that the personnel who are to install and maintain heat pumps are adequately trained. A lack of such people will mean that many heat pump users will have bad experiences. Once this becomes well known, the market can collapse.

Norway set a good example of how to improve education and training on heat pumps with a teaching programme conducted within its "Heat Pump Implementing Programme" of 1989 to 1992. Courses were run for consultants, energy advisors and installers, ranging from a basic introduction to heat pumps to detailed training on installation and fault finding. Such measures are now included in the currently active Swiss Heat Pump Promotion Programme which informs potential heat pump users of those installers with the relevant training.

Financial Incentives

As outlined earlier, cost factors present the biggest barrier to heat pump sales. In recent years, a host of financial incentive schemes have been introduced by governments and utilities. Such schemes generally only run for one or two years after which they are withdrawn, either as part of a planned programme or for political or economic expediency. However, when the right incentive level is set, even short-lived schemes can have a positive effect of on the heat pump market. Incentives give manufactures, installers and maintenance companies the confidence to enter the heat pump market. After the incentive is removed, these companies will tend to stay in what has become a mature market, with more consumers familiar with the product. Norway's experience supports this view, where despite the withdrawal of a 20% government subsidy in 1993, sales in 1994 went up by 40%.

Financial incentive schemes work best when they are coupled to stringent quality and performance requirements. The German electric utility RWE provides a good example. It offers a special tariff, a guarantee, a low interest loan and assists the customer in arranging for the installation. But this support is only given for heat pumps meeting minimal standards for seasonal performance factor (SPF) and safety, and when the equipment installers and manufacturers conform to a set of guidelines.

Gas utilities are also supporting heat pumps. In Italy, Italgas has provided incentives for gas heat pumps since 1992. Customers are offered either a contribution to the installation costs, or a 30% reduction in the gas tariff. In 1992 and 1993, around 550 units were installed under these schemes.

A Role for the HPC

Clearly, as an international centre for the dissemination of information on heat pumps, the IEA Heat Pump

Centre has a role to play in the promotion of heat pumps. Traditionally, the main focus has been on exchanging the sort of information that can support the development of better heat pumps. Recently, the HPC's role has been extended to allow greater attention to be paid to information transfer to people outside the heat pump community.

In its new promotion strategy, the HPC is targeting those people in governments and utilities who can have an impact on the heat pump market. The strategy is to inform such people on the benefits of heat pumps and to make them aware of the work of the IEA Heat Pump Programme. The result should be that heat pumps are given greater consideration when governments and utilities make decisions on energy policy. This in turn should lead to the further implementation of the measures to support heat pump technology outlined in this article.

Such a result is a long-term goal, but one that is achievable through the combined efforts of the IEA Heat Pump Centre and its National Teams. A variety of tools will be used, including publications, personal contacts and a mechanism for exchanging experiences on heat pump promotion. Initial efforts are focused on raising the profile of the HPC and on widening support for our activities amongst IEA member countries and beyond.

Building on Experience

If heat pumps are to be chosen as a key technology for tomorrow's energy policies, policy makers must look closely at the market forces that can bring about their widespread use. As highlighted in this article, the heat pump market is influenced by many factors, and a range of measures can be taken to try and support the market. Around the world, much experience, both positive and negative, has been gained in programmes to stimulate the heat pump market. Through international cooperation, programmes to support heat pumps can build on these experiences, so that market forces can effectively be used to realize the benefits of heat pump technology.

Author:
Mike Steadman
IEA Heat Pump Centre



Annex 21 Report Industrial Heat Pumps

Experiences, Potential and
Global Environmental Benefits

Order your copy with the form on the back inside cover.

Developing the Market for GSHPs

US Consortium Launches "Golden Carrot" Initiative

Marika Tatsutani, USA

Ground-source heat pumps (also known as geothermal heat pumps in the US) are among the most cost-effective and energy-efficient heating and cooling systems available today. However, this technology has yet to achieve widespread application in the US market due to high first cost and, for some areas, a shortage of available equipment and qualified installation contractors. A new initiative by the Consortium for Energy Efficiency aims to promote continued improvement in the efficiency of ground-source heat pumps and an increased market penetration. This article gives an overview of this so-called "Golden Carrot" initiative.

* * *

Though commercially available, ground-source heat pump (GSHP) technology is still considered "emerging" in the US, with annual sales at about 40,000 units and installed units totalling only 150,000. Because of the significant energy savings and environmental benefits associated with the expanded application of GSHPs, the US government, numerous utilities, and other organizations are actively seeking to promote this technology.

More Golden Carrot Initiatives

Alongside the GSHP support described in this article, the Consortium of Energy Efficiency (CEE) is running two other "Golden Carrot" initiatives in the field of heat pumps. High efficiency air conditioners and heat pumps are being promoted through separate initiatives for the residential and commercial buildings sectors.

Utilities throughout the US and Canada, have been invited to participate. By March 1995, 18 utilities had announced their intention to participate in one or both of these initiatives. As with the GSHP initiative, utilities agree to use a common set of efficiency specifications in their promotion programmes. This gives equipment manufacturers clear energy performance targets – and the potential of large markets – to plan for.

Installation of a GSHP in a US home.



Golden Carrot

One of these efforts is being led by the Consortium for Energy Efficiency (CEE), a non-profit organization whose membership includes utilities, government agencies, research institutions, and public interest groups. CEE seeks to promote the development and commercialization of energy-efficient technologies through market-pull strategies, known as "Golden Carrot" initiatives (Golden Carrot is a registered trade name). Through these initiatives, CEE encourages manufacturers to manufacture and market energy-efficient technologies by helping to create large markets.

An initial example of the "Golden Carrot" approach was the Super Efficient Refrigerator Program in which 24 utilities nationwide pooled US\$ 30 million to fund a successful contest to bring to market a new, highly efficient refrigerator. CEE was subsequently created to develop market pull strategies for other technologies. CEE is based in Boston, Massachusetts. Its membership includes utilities serving over 25 million households. This article describes CEE's initiative for GSHPs. Two other initiatives to promote high efficiency air conditioners and heat pumps are described in the blue box.

Recently CEE launched the High Efficiency Residential Geothermal Heat Pump Initiative to encourage the development of self-sustaining, competitive markets for efficient GSHP systems. In addition to advancing the goals of continued efficiency improvement and increased market penetration, this "Golden Carrot" initiative includes design and installation components to help ensure that customers realize the operating cost savings and comfort they expect from GSHP systems.

Specifications

One of the central components of the GSHP initiative is a set of efficiency specifications that utilities can voluntarily adopt in their programmes to promote GSHPs for residential and – where appropriate – commercial applications. Numerous utilities around the US are interested in running programmes to promote increased application of GSHP technology in their service territories. By using a common set of efficiency specifications in these programmes, utilities can provide a clear target for manufacturers and demonstrate that there are large potential markets for efficient GSHP systems nationwide. The CEE initiative is intended to address certain limitations of past utility programmes in other technology areas. These often resulted in a proliferation of different efficiency specifications in utility programmes around the country. Consequently, manufacturers found it difficult to respond to these programmes when no single utility's service territory represents a significant share of the national market.

As shown in Table 1, the CEE specifications are divided into three tiers, and address both heating and cooling performance. They are based on the available data for the cooling and heating COPs at standard conditions with a closed-loop configuration. In the US, these data are termed the Energy Efficiency Ratio (EER) and the Coefficient of Performance respectively. Credit is given for water heating and for variable speed operation.

Data for heating and cooling seasonal performance (the Seasonal Energy Efficiency Ratio (SEER) and the Heating Season Performance Factor (HSPF)) are not used as they are less widely available. CEE and many utilities are interested in seasonal performance and encourage manufacturers and the Air Conditioning & Refrigeration Institute (ARI) to certify and publish this data.

Table 1: Required efficiencies (at standard rating conditions) for GSHPs installed under the CEE initiative.

Tier	Cooling COP (EER)	Heating COP
G1	3.8 to 4.7 (13.0 to 15.9)	2.80 - 3.39
G1 (beginning 1/1/97)	4.1 to 4.7 (14.0 - 15.9)	3.00 - 3.39
G2	4.7 to 5.5 (16.0 - 18.9)	3.40 - 3.99
Advanced	>5.5 (>19.0)	4.00 & above

Premiums over standard rated efficiencies:
Water Heating (Desuperheater/triple function)
Variable or Multi-Speed Blowers or Compressors

To be considered for participation in the CEE initiative, utilities must offer their support for GSHP systems that meet the Tier G1 specifications, and must offer financial incentives for Tier G2 systems. Such incentives may include loans, leasing, and site-based tariffs or rates as well as consumer rebates. Use of CEE specifications is entirely voluntary and non-exclusive. Utilities can also offer incentives at additional efficiency levels below or above these specifications.

In addition to using these specifications, utilities participating in the CEE initiative must incorporate a few basic system design guidelines in their programmes. These guidelines must address such issues as proper system sizing and improvements in the building envelope that can reduce heating and cooling loads. Additional guidelines contained in the initiative address inside and outside equipment installation and contractor certification. The installation guidelines are optional in terms of formal participation in the CEE programme.

The Bigger Picture

The CEE initiative provides a simple, no-cost opportunity for utilities to enhance the impact of their individual programmes by taking part in a national initiative to promote efficient GSHP systems. It is intended to complement other efforts currently underway in the US to increase the market penetration of this technology. One such effort is the Geothermal Heat Pump Consortium, Inc. in which a large number of US utilities are taking part. This consortium proposes to expand the production and installation of GSHPs to 400,000 units per year by the year 2000. CEE serves as a liaison to this effort.

In addition, the Northeastern Utilities Group for Geothermal Energy Technology (NUGGET), a group of 15 utilities, plans to use the CEE initiative as a template for future national GSHP marketing demonstrations.

Growing Support

These activities are taking place against a backdrop of growing support for GSHPs. The US government has a strong interest in the successful commercialization of GSHPs in the context of achieving the goals of the National Climate Action Plan (see *IEA Heat Pump Centre Newsletter* Vol.12 No.4 p.4). It is estimated, for instance, that 1.5 million GSHPs can avoid about one million tonnes of greenhouse gas emissions per year. The CEE High Efficiency Residential Geothermal Heat Pump Initiative is an example of the type of partnership between diverse organizations that can help ensure that the environmental and energy saving benefits of this exciting new technology are realized.

Author:

*Ms Marika Tatsutani, Consortium for Energy Efficiency
Boston, USA*

Tel: +1-617-330-9755; Fax: +1-617-330-1136

E-mail: dsmcee@igc.apc.org



Market Forces in Japan

Promotion Activities Focus on Load Levelling and Emissions Reduction

Toshihiko Tanaka, Japan

Both from the viewpoint of climate change prevention, and to increase the energy utilization efficiency, it is widely recognized in Japan that the diffusion of heat pump systems should be encouraged. Many projects are being carried out to promote and develop certain types of heat pump. Special attention is given to systems for load levelling the electricity demand. Incentives for ice thermal storage air-conditioning systems have been launched recently by the Japanese government and electric power companies. This article gives a brief review of heat pump promotion activities in Japan.

* * *

The Environmental Agency has primary responsibility for climate change policy in Japan. In 1990, the Japanese government issued a Global Warming Action Plan. The plan had two major targets: stabilization of per capita emissions at 1990 levels by the year 2000, and stabilization of total emissions as soon as possible. It has been reported that Japan can meet the per capita stabilization goal, but the nation will exceed the total emissions target by about 3%.

Emissions

Heat pump systems are recognized as key technologies for reducing CO₂ emissions and many projects are being carried out.

Multi-functional heat pump chiller systems for residential use are being actively promoted. These systems can utilize not only thermal energy in air-conditioning, but also waste heat from the condenser to provide hot water. Thus, this type of heat pump system contributes to the saving of energy in residential applications.

Projects are also being carried out to develop heat pump systems for facilitating energy recycling in commercial and industrial fields. Such heat pumps will recover waste heat from refuse incinerators, underground cables, and other resources. In Tokyo, where many business functions are concentrated,

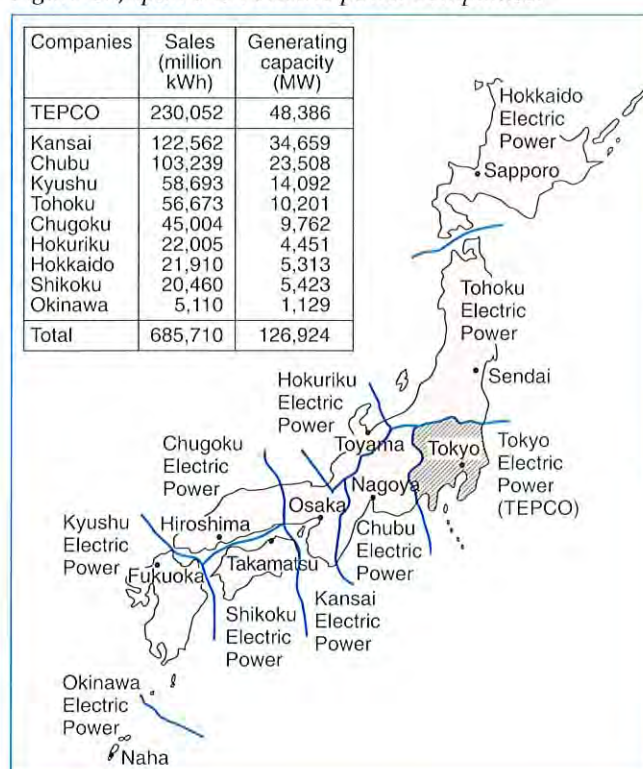
large-scale development projects are ongoing in the central and bay areas of Tokyo, and also in the surrounding regions.

More in general, projects are being implemented to improve heat pump COPs.

Load Levelling

Japanese electric power companies (see Figure 1) must not only deal with the problem of rapidly increasing total electric power consumption, which may cause climate change, but must also face the important issue of load levelling. The rapid increase in demand for air-conditioning from residential and commercial sectors, has widened the demand gap between day and night. This is especially pronounced in summer when the daily maximum demand is twice as much as the minimum demand (see Figures 2 and 3).

Figure 1: Japan's ten electric power companies.



The increase in air-conditioning load is mainly caused by the widespread use of office automation machines such as personal computers and facsimile machines, and the installation of high-grade insulation and air-tight window frames. It is considered that this increase will continue at least for several years. Figure 4 plots the trend, from the viewpoint of capacity, in the installation of various types of heat pump and chiller equipment in Japan, indicating the significance of package type air-conditioning units.

Thus it has become necessary to achieve load levelling by shifting the air-conditioning power peak through the utilization of night-time electric power.

Strategies to achieve this are being considered by organizations such as the Ministry of International Trade and Industry (MITI) and utility companies. One of the most effective measures is to promote the installation of thermal storage in air-conditioning systems for commercial and industrial buildings.

Responding to Market Forces

Small buildings of up to 3,000 m², which usually use package type air-conditioning systems, are often structured in such a way that it may be difficult to install a thermal storage water tank. For such buildings, ice thermal storage with a smaller tank is an attractive option. In response to these market forces, an ice thermal storage multiple heat pump system has been developed for small buildings, that meets the

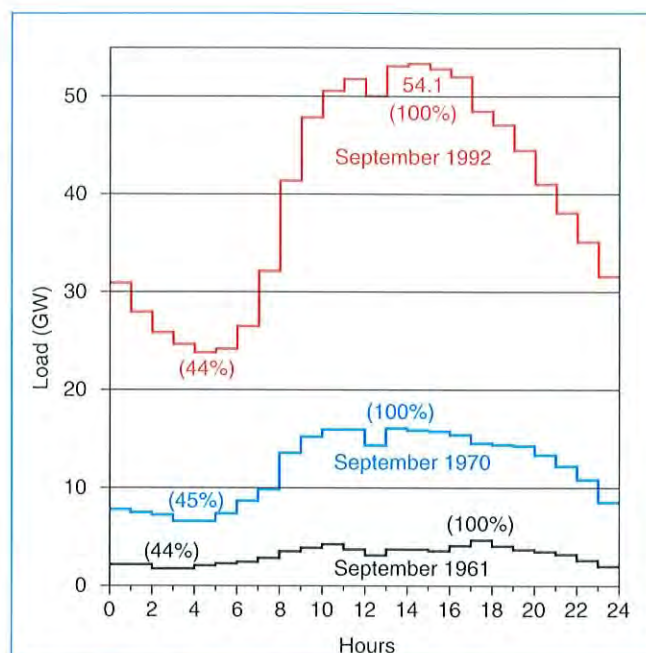


Figure 2: Daily Electric Load Curves (TEPCO region).

decentralized requirements for air-conditioning and provides load levelling.

In TEPCO's area, if all package type air-conditioning systems for small buildings were fitted with ice thermal

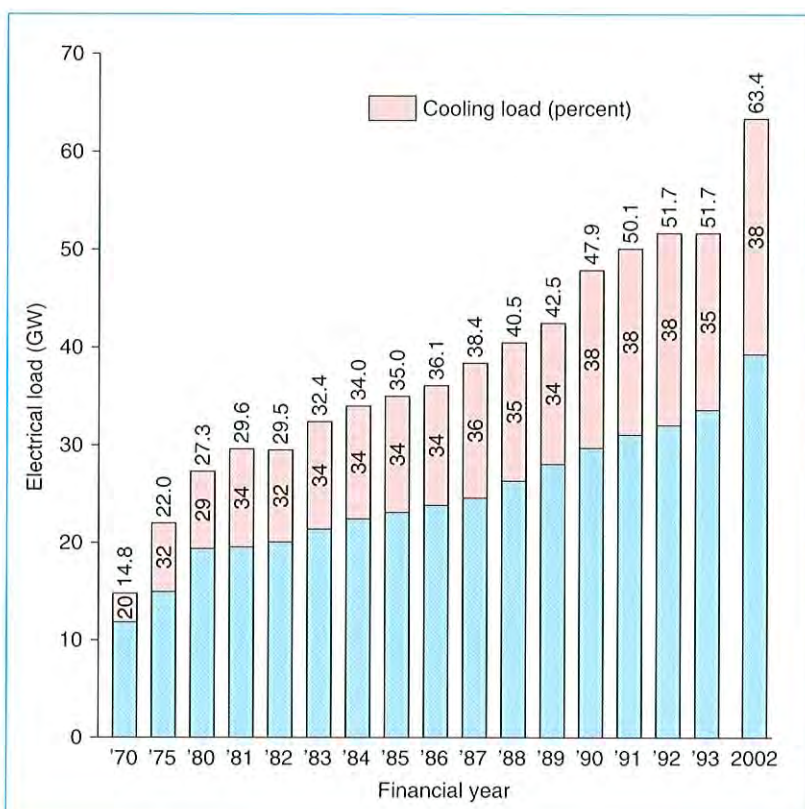


Figure 3: Peak electrical load in the TEPCO region, showing contribution of cooling equipment.

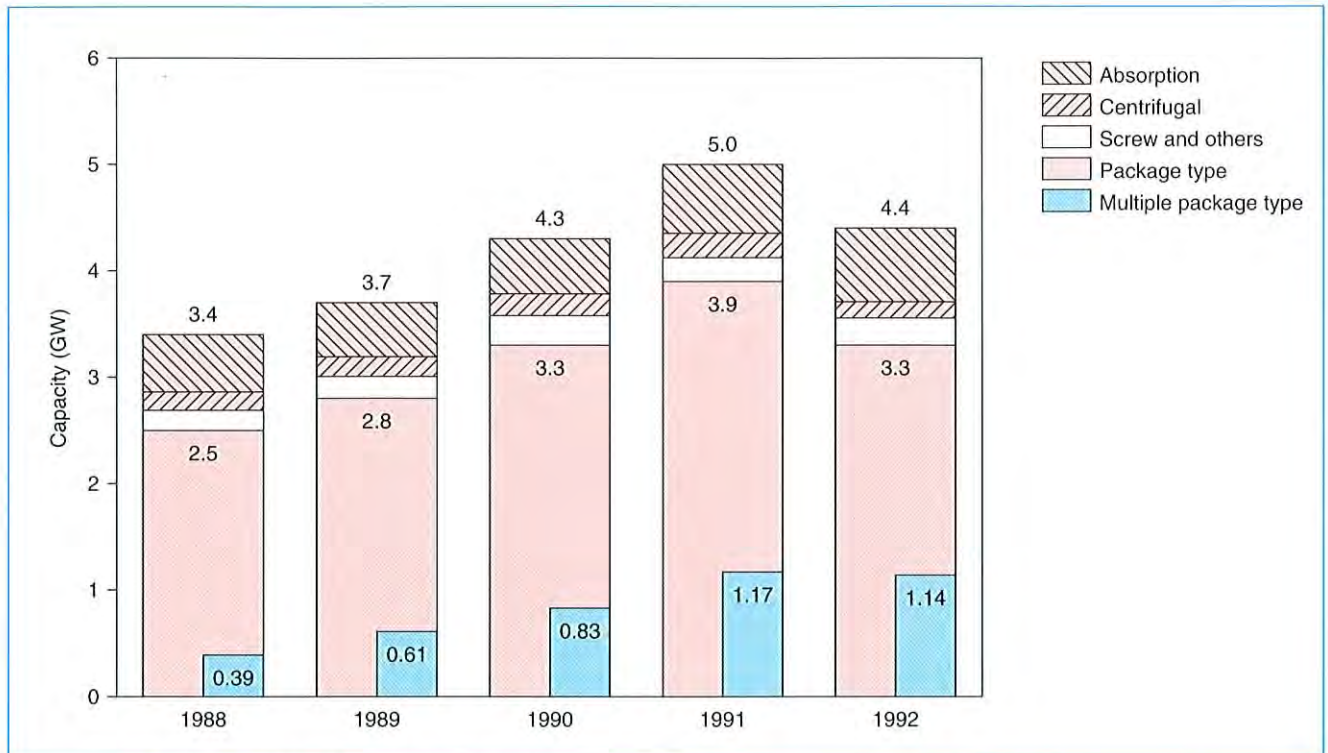


Figure 4: Installation of heat pumps and chillers.

storage tanks, 120 GW electricity would shift from daily peak hours to off-peak hours at night. This shifted electricity demand is equivalent to the electricity generated from a unit of a large atomic or thermal power plant.

Ice thermal storage package heat pump systems for department stores, supermarkets, factories and so on are the subject of joint research and development projects involving several electric power utilities and manufacturers. A few types of ice thermal storage package type air-conditioning systems will be made available in 1995.

Incentives

However, there are disadvantages to ice thermal storage systems, such as the system's initial cost, which is 20% higher than that of conventional air-conditioning systems. Since environmental issues such as climate change and acid rain are involved, the Japanese government and electric power companies are providing financial incentives in order to encourage the diffusion of ice thermal storage air-conditioning systems.

Firstly, the Japanese government provides a subsidy for owners which covers the interest at the rate of 3% on a loan for ice storage air-conditioning systems. This subsidy is equivalent to 10% of the total amount of the loan.

Secondly, electric power utilities pay financial incentives to manufacturers at the rate of 30,000 to 50,000 Yen (US\$ 300 to US\$ 500) per kW of shifted daily electricity demand at peak hours. This incentive was introduced in April 1995 and will be provided for the next five years to increase the competitiveness of ice thermal storage air-conditioning systems, especially package type systems.

Such financial incentives, together with cheaper electricity costs at night, enable owners of ice thermal storage air-conditioning systems to recover the extra investment in an ice storage tank within a few years.

Author:

Dr Eng. Toshihiko Tanaka,
 Manager of the Buildings Systems Engineering
 Project Team
 Market Development Department
 Tokyo Electric Power Company
 1-1-3, Uchisaiwaicho, Chiyoda-ku, Tokyo, Japan
 Fax: +81-3-3596-8521



Heat Pump Promotion in Switzerland

Coordinated Activities are Yielding Good Results

Franz Beyeler, Switzerland

Switzerland provides a prime example of how coordinated national activities can have a significant impact on the heat pump market. Since 1993, the Swiss Heat Pump Programme has been stimulating the market by offering subsidies and through a host of other promotion activities.

As highlighted in this article, a key role is played by the Swiss Association for the Promotion of Heat Pumps which is conducting a targeted promotion campaign. Equally important has been the work of the Heat Pump Test and Training Centre. Recent sales figures suggest that the programme has had considerable success so far.

* * *

Through its Energy 2000 Action Programme, the Swiss federal government hopes to achieve a new, sensible and environmentally acceptable standard of energy use. The contribution of heat pumps to this aim is being implemented under the Swiss Heat Pump Promotion Programme. This programme has taken on the specific aim of reaching an annual saving of 250 million litres of heating-oil by the year 2000. This will necessitate specific promotion of a number of heating options:

- installing bivalent heat pump systems where oil heating systems are used;
- installing monovalent, ground or water-source heat pump systems in new or renovated buildings;
- installing bivalent heat pump systems with air as the heat source and, for example, a modern wood-burning stove for extra heating in private houses;
- replacing electric heating systems and electric boilers with heat pumps;
- using heat from purified water in sewage treatment plants.

Today, a total of 43,000 heat pumps are in use in Switzerland. By the year 2000, targeted promotion should raise this figure to 100,000, resulting in a significant supply of heat from heat pumps. Were this amount of energy to be produced from heating-oil instead of heat pumps, around 250 million litres of heating-oil would be consumed each year. This would

release 657,000 tonnes of CO₂ into the air, and 540 tonnes of nitric oxide – one of the factors causing smog in summer.

The Swiss Heat Pump Promotion Programme hopes to reach the above targets through the combined effects of a promotion association, a testing and training centre and subsidies from the federal government.

Promotion Association

Founded in the autumn of 1993, the Swiss Association for the Promotion of Heat Pumps, or FWS (Fördergemeinschaft Wärmepumpen Schweiz), operates under the motto "Achieving Our Aim Through Concentrated Energy". The aim of the FWS is to promote the use of heat pumps in Switzerland while ensuring a high quality in the systems and products used. The FWS's tasks include collaborating with the Federal Office of Energy as well as implementing and coordinating activities financed, in part, by the Energy 2000 Action Programme.

Another important activity of the FWS is to provide information for the general public and the media, as well as for property-owners, engineers, architects, planners and energy consultants. The FWS also works towards improving the way heat pumps are installed, and promotes research and development in this field. In addition, the FWS works together with the Heat Pump Test and Training Centre near Winterthur and coordinates training for specialists.

Members of the FWS, who fund its operation, include several federal and cantonal offices, professional associations of heating engineers and planners, heat-pump manufacturers and a number of electricity companies. International cooperation is ensured through the National Team of the IEA Heat Pump Centre.

Testing and Training

The Heat Pump Test and Training Centre, near Winterthur, has been type-testing heat pumps since the middle of 1993. Heat pumps of any type are subjected to detailed technical tests in order to ensure high quality and improve efficiency and attractiveness. Over 40 different heat pumps have been examined so far, and the results of these tests are regularly published in the Test Centre's newsletter. The heat pumps are tested according to the latest European

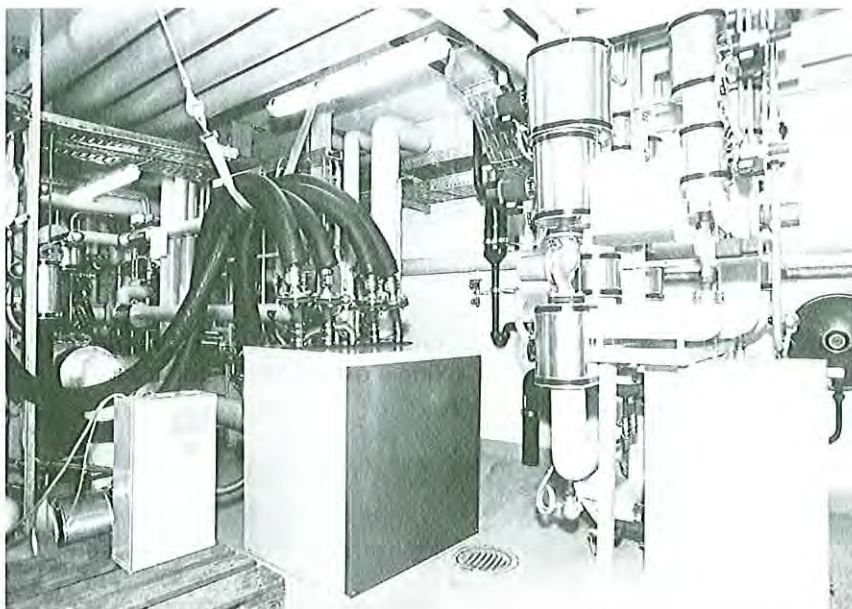


Photo 1: Test equipment for brine-source heat pumps at the Heat Pump Test and Training Centre.

standards by a team of technical experts. The stringent testing levels are an important tool with regard to the quality assurance which the FWS demands. A further task of the Heat Pump Test and Training Centre is to provide detailed information and training courses for planners and engineers.

Federal Subsidies

The numerous advantages of heat pumps persuaded the federal government to help launch and promote this type of heating by offering subsidies. Federal subsidies of up to CHF 6,750 (US\$ 5,800) have been made available until the end of June 1995, for heat pumps meeting certain criteria.

The availability of these subsidies for replacing old heating systems with heat pumps is aimed at encouraging property-owners to install heat pumps despite the fact that they are more expensive than traditional heating systems. Between March 1993, when federal subsidies were first made available, and the end of 1994, over 1,200 applications have been submitted, and 840 heat pumps installed. Figure 1 shows the type of heat pumps installed with the help of federal subsidies.

A survey involving the owners of these heat pumps showed that it was not primarily the financial factor which had persuaded them to install a heat pump system. In fact the subsidy had been an important or major factor for only four out of ten heat pump buyers. Almost three-quarters of the people included in the survey said that environmental protection was a major reason for choosing a heat pump.

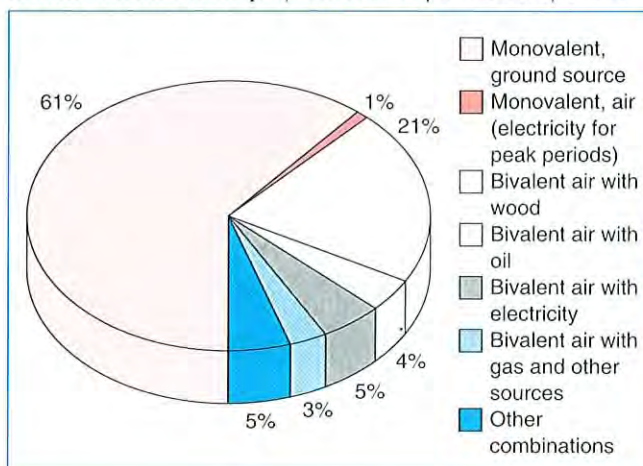
A Targeted Campaign

Since 1993, the FWS has been conducting a targeted promotion programme. The programme focuses on small systems (less than 25 kW heating output) and aims mainly at property owners, heating engineers and planners, while also addressing the general public.

The programme informs people on heat pumps using a range of publicity tools including the distribution of publications, through specific media campaigns and by organizing "open days". In addition, the programme ensures that all heat pump installation work is carefully checked by the FWS and, in part, by the federal authorities.

In view of the fact that different languages are spoken in different parts of Switzerland, three Information Centres were set up right from the start — in Bern,

Figure 1: Type breakdown of the 840 heat pumps installed with the help of subsidies by the end of 1994.



Neuchâtel and Lugano. Every day, these Information Centres deal with enquiries from property owners, heating engineers, planners and journalists. In 1994, the Bern centre alone answered about 3,000 telephone calls and 1,700 enquiries by letter and fax. While many people ask for documentation on heat pumps, increasingly, people are making more specialist enquiries. The Bern Information Centre has a list of over 5,000 names of people interested in heat pumps.

Persuasive Information

Information on heat pumps is conveyed through the FWS's 16-page informative brochure, which is available in three languages under the title "Heat with a Heat Pump – Using Renewable Energy Sources – Safe, Clean and Efficient". Within 15 months, about 80,000 of these brochures were sent out free-of-charge. The aim of this publication is to increase public awareness of heat pumps and to inform property owners, architects, planners and heating engineers of the advantages and main features of heat pump systems. An accompanying information sheet gives information on federal subsidies and a list of important addresses. This is designed to help those interested find suitable and competent people right from the start for planning, designing and installing a heat pump system.

There is also an information video to go with the brochure and which can be borrowed. The Bern Information Centre lent out approximately 450 of these videos in 1994. The latest publication, titled "The Swiss Market Guide for Heat Pumps", is now available for CHF 9 (US\$ 8). With a summary of the most important advantages of heat pumps, this 100-page brochure includes the first full list of companies involved in the field of heat pumps (manufacturers,

importers, drilling companies) with details of what they offer. A service section provides an overview of the various sources of heat and makes it possible for a non-specialist to calculate the cost of installing a heat pump using the examples provided.

Alongside these publications, the Information Centres also offer the *IEA Heat Pump Centre Newsletter* (free-of-charge) and a booklet about the FWS.

National Media

In 1993, the first advertising campaign was launched with 91 advertisements in Swiss daily papers and trade journals. A list of 3,875 addresses of people interested was compiled from the returned reply coupons. The success of the advertising campaign was estimated through a telephone survey of 100 property owners and 100 other people with influence in this field. Out of the people included in the survey, 22% had noticed and read the advertisement, 50% of whom could remember details of the advertisement.

A new six-week advertising campaign was launched in February this year, to inform property owners and other interested parties about heat pumps through advertisements in the press. The publicity campaign also included regular public relations bulletins about subsidies, the Test and Training Centre, and test results.

Open Days

There are no better advocates of heat pumps than satisfied owners who are keen to tell others about their positive experiences. During the winter of 1993/1994, the first seven open days were held in collaboration with heat pump manufacturers, electricity companies and heating engineers under the motto "Pass on your

Photo 2: These six homes in Worblaufen opened their doors for the first heat pump open day. As shown by the white lines, three different heat source systems were being demonstrated.



satisfaction". These open days were organized all over the country and were advertised locally through the following channels:

- advertisements in the regional press;
- personal invitations;
- articles in the local press;
- interviews on local radio stations.

550 people visited the first open day in Worblaufen – a number which far exceeded expectations. The visitors were shown installations in six houses, where heat pump technology has been in use for ten years (see Photo 2). At this site are three heat pumps using horizontal ground collectors, two with vertical probes and one air-source system. Visitors were able to discuss the heat pump systems with the house-owners and with experienced heat pump consultants, heating engineers and representatives of electricity companies and the FWS.

Most of those involved were astonished by the technical and detailed questions from the public concerning the use, purchase and running of heat pump systems. Many visitors brought along their architect, planner or heating engineer, and often their building plans too.

Each visitor who gave their name at an open day was later contacted by a specialist to deal with their questions. According to information provided by heat pump manufacturers, heating engineers and electricity companies, several heat pump systems were sold either at the open day or very shortly afterwards. The open days also resulted in a noticeable increase in enquiries received by manufacturers and heating engineers. Over 6000 visitors attended the first eleven open-days. The next series of open days is planned for autumn 1995.

Photo 3: Open days are generally so popular that nearby rooms must be hired to cope with all the people.



Direct Mail

Through direct mail, 12,350 heating engineers, planners, architects, energy consultants, heat pump manufacturers and electricity companies have been given detailed information about the FWS's promotion programme. A reply coupon was included for ordering further documentation, and to ask specific questions. Such mail campaigns with questionnaires are carried out regularly in order to obtain new contacts.

Courses

Heat pump courses are planned for heating engineers and planners. These courses will cover such topics as heat pump marketing and customer advisory services. A programme is being drawn up for promoting heat pumps at trade fairs and home-design exhibitions. Suitable material is now available.

Looking Forward with Confidence

The sales figures for 1994 provide an insight into the impact of the Swiss Heat Pump Promotion Programme so far. Heat pump sales for 1994 are estimated at 3,630 — up around 30% on the previous year, and a record for Switzerland, surpassing the previous sales figures of 1979. Furthermore, one-in-four newly-built private houses are heated with a heat pump system.

These figures show that despite the drop in the price of heating-oil, heat pumps are rapidly gaining popularity in Switzerland. While federal subsidies played a role in some installations in 1994, there can be little doubt that the activities of the FWS have provided a significant boost to heat pump sales. And despite the withdrawal of federal subsidies in June 1995, the heat pump industry can look forward to the future with confidence. Continued growth in sales and an increasing share of the heating market are expected.

Author:

Mr Franz Beyeler

Head of the Bern Information Centre

Swiss Association for the Promotion of Heat Pumps (FWS)

Steinerstrasse 37/P.O.Box 298

3000 Bern 16

Switzerland

Tel.: +41-31-352-4113

Fax: +41-31-352-4206

Software Tools for Heat Pump Design

Improving the Quality of Building Heating Systems

Thomas Afjei, Thomas Baumgartner, Hanspeter Eicher,
Martin Stalder and Dieter Wittwer, Switzerland

If the recent growth in heat pump sales in Switzerland is to be built on, it must be accompanied by continued progress towards improving the performance of the installed systems. The two software design tools described in this article should make an important contribution to this process.

The W-CALC program is an easy-to-use tool to enable design engineers to simulate both the technical and economic performance of various types of heat pump system. The YUM WP/Holz program provides detailed information on the performance of a heat pump in combination with a wood-fired boiler. Both programs will help to further improve the quality of heat pump systems installed in buildings.

* * *

In recent years, a number of computer programs for the design and optimization of energy systems have been developed under contract to the Swiss Federal Office of Energy. Two of these programs, which concern heat pump systems for building applications, have now been completed. They are directed mainly toward design engineers and energy consultants.

The W-CALC program (Program for the Dimensioning of Heat Production Systems) employs the method of characteristic daily profiles to specify dynamic heat demand. The performance of heat pump, CHP or other heat supply systems can be calculated under various meteorological conditions at hourly time steps. The program is suitable for air-to-water, water-to-water or ground-coupled type heat pumps. Payback times may be calculated using a separate economics module.

The YUM WP/Holz program (Yearly Utilization Model - Heat Pump / Wood) simulates the operating characteristics of stand-alone heat pumps and heat pumps combined with wood-fired boilers to cover peak-load demand. Energy balances and typical characteristic values such as yearly average COP, overall system utilization factor, etc., may be

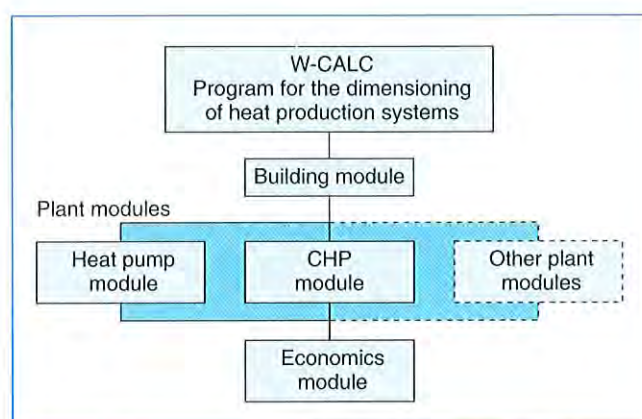


Figure 1: Structure of the W-CALC program family.

calculated using the various standard system configurations provided.

The W-CALC Program

The PC program W-CALC was developed with the objective of providing the design engineer with a professional and easy-to-use tool with which to design and optimize heating systems. The program is intended for preliminary design, system definition and dimensioning, during the engineering design procedure.

The user interface is based on MS EXCEL under MS Windows. Particular attention was paid to clear comprehensibility and easy-to-use instructions.

For W-CALC, a 386 PC, or higher, with co-processor, 8 MB RAM, about 5 MB free hard disk space, DOS 3.1, MS Windows 3.1 and MS EXCEL 4.0 or 5.0 are required. Instructions in German or French can be chosen.

Structure

The W-CALC family consists of separate modules, each of which represents a particular function, such as the heat production of the system. Thus the program may be adapted to the calculation of widely varying system configurations.

As shown in Figure 1, the program consists of three main parts:

- The **building module** generates the daily load demand profile from building data;
- The **plant module** calculates the operating data according to the load profile and system data;
- The **economics module** calculates the economic data based on the operating data.

The modular structure of the program results in a family of design programs which allow diverse system configurations to be dimensioned and compared with one-another on a unified basis. To date, the following types of heat production systems may be calculated:

- Heat pumps with WP-CALC;
- CHP systems with WKK-CALC;
- Wood-fired systems (program available at the end of 1995).

Procedure

The characteristic daily profile method was chosen as a straightforward procedure for generating realistic time variations of the heat demand. This method is based on the assumption that for a particular average ambient temperature and building type, the same basic daily heat demand profile results.

In applying the characteristic profile method, the following procedure is adopted (see Figure 2):

Figure 2: Generation of typical daily heat demand profiles by linear interpolation between the base-load profile and the load profile at design ambient temperature.

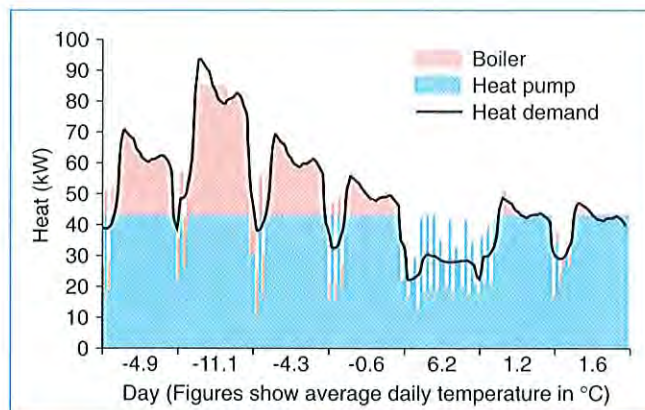
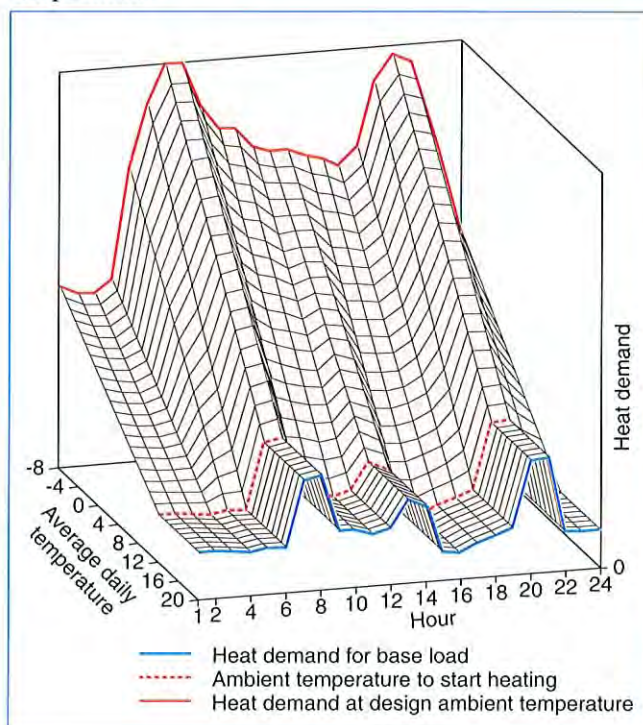


Figure 3: Output example showing weekly energy balance.

1. Demand Profile

The user inputs two daily heat demand profiles, one of which represents the heat demand at design ambient temperature, and the other for base load, i.e. domestic hot water and process heat. Default values for these profiles are available from the program library for single and multi-family dwellings and schools.

The program requires a weather data file in the form of average daily ambient temperatures for the design reference year. Weather data for 16 Swiss weather stations are currently available.

Finally, on the basis of the average daily ambient temperatures, the daily heat demand profiles are generated, and from these the yearly demand profile is obtained.

2. Operating Data

The plant module requires input of heat pump data such as the heat source (air, water or geothermal well), the heat pump operating mode (stand-alone, combined parallel, combined alternative) and the storage loading method (plug flow in multiple or single step).

On the basis of the system data supplied and the yearly heat demand profile, the program determines the yearly characteristic values using a simple simulation algorithm with a time step of one hour. The monthly variations of data such as COP, duration of operation, energy input and energy supplied, are displayed. As a final check, the heat balance for any given week, based on a time step of one hour, may be displayed. An example is shown in Figure 3.

3. Economics Data

The operating parameters calculated above are employed in the economics module for the determination of system profitability. As a basis for the profitability calculation, values for energy charges,

inflation rate, amortization time, investment costs, etc. are required. On the basis of this information, the program displays the operating costs of a heat pump system in comparison to a conventional heat production unit.

The YUM WP/Holz Program

The main objective of the PC program YUM WP/Holz is to optimize the engineering design and dimensioning of a heating system comprising a combined air-to-water heat pump and a wood-fired boiler. On the basis of the parameters obtained, the program enables the dynamic yearly operating characteristics to be simulated and optimized. The user can call hourly weather data for eight typical Swiss weather regions.

The program is based on the Yearly Utilization Model (YUM), a simulation model for a stand-alone heat pump system developed under Annexes 10 and 12 of the IEA Heat Pump Programme. YUM WP/Holz has been derived by adding simulation models for a two-stage wood-fired boiler and a central heating boiler to the original YUM program. The program was validated on the basis of test results.

Heat Pumps and Wood Burners

Combining wood-fired heating systems with electric heat pumps will contribute to a reduction of anthropogenic CO₂ emission. This is particularly true for Switzerland, where very little CO₂ is emitted per kWh electricity. Also, the emission of CO₂ from burning wood can be considered to be neutral – CO₂ emissions are the same whether wood is burnt or is allowed to decompose naturally.

A combination of a heat pump and wood-fired boiler offers several advantages over separate systems. For example:

- Easy operation;
- Bivalent operation yields high heat pump seasonal performance factor (SPF);
- Heat pumps allow greater flexibility in filling the wood-fired boiler;
- Freeze-proof in winter;
- Efficiently combines space heating and domestic hot water supply.

Using YUM WP/Holz

The program YUM WP/Holz is directed primarily at engineering designers and energy consultants. It requires a PC with at least 512 kB working memory and approximately 3 MB of free hard disk space. It requires MS DOS version 3.1 or higher and runs under DOS or MS Windows. The program operates in English or German. The documentation is partly in English and partly in German.

The simulation results provide information on:

- The maximum demand coverage by the heat pump;
- The yearly wood consumption and costs;
- The electricity consumption at standard and peak rates and the costs;
- The influence of power-off times on the load characteristic;
- The SPF of the heat pump;
- The yearly energy efficiency of the heat pump and wood burner.

The program enables critical periods of operation, e.g. during transition from separate to combined operation

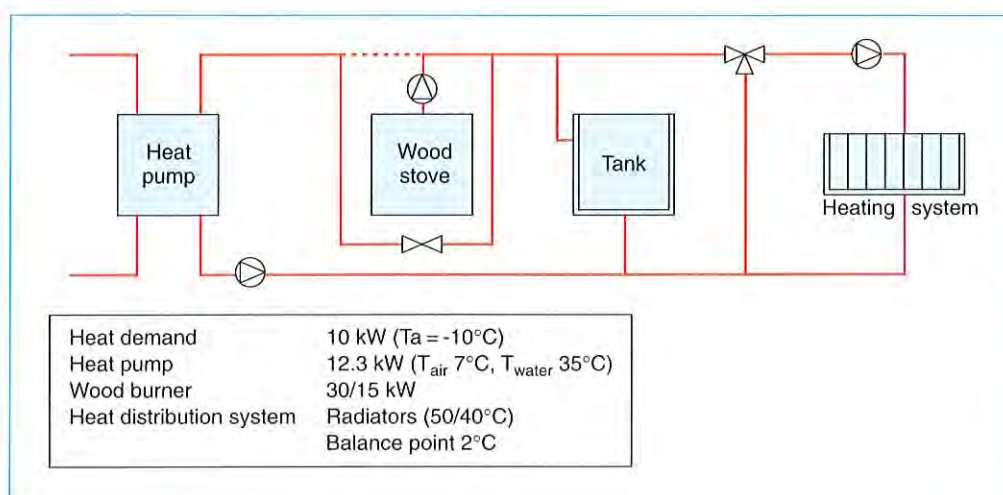


Figure 4:
Typical heat pump/wood-fired boiler space heating system.

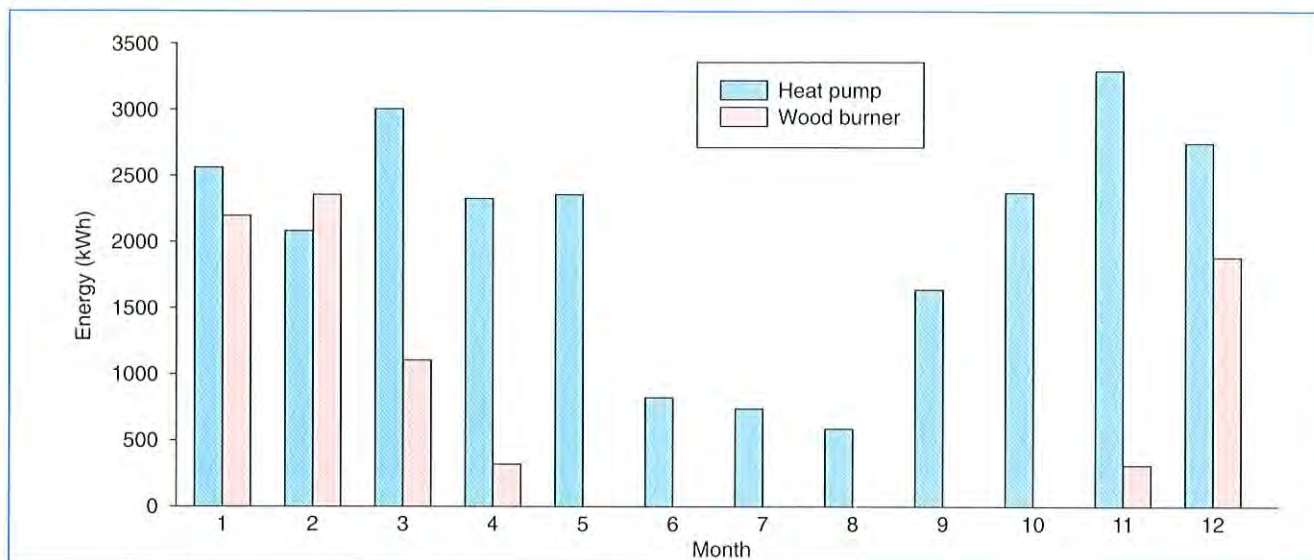


Figure 5: Monthly heat supply from heat pump and wood-fired boiler.

or on very cold days, to be simulated in more detail using a very short time step. By this means, information on the dynamic behaviour of the system at critical points may be studied, and the set points for the heating controller determined.

For Example...

Figure 4 is a flow diagram of a typical heat pump/wood-fired boiler for space heating and domestic hot water supply. The design values shown are specified in the input file of YUM WP/Holz. A range of standard system configurations can be specified. Data on the heat demand must then be provided either by using the program's simplified single-zone building model, or by manually inputting the hourly values. The building model incorporates passive solar and internal gains.

The program simulates the dynamic behaviour of the system by computing quasi steady-state conditions of all system components at discrete time intervals. Under normal conditions, the simulation employs a time step of between 0.2 and 0.5 hours. Critical periods of operation can be simulated in more detail using a shorter time step down to a minimum of three minutes. The simulation time using a 486 PC is only a few minutes for a complete year's operation.

Results

As shown in Figure 5, the wood burner supplies approximately half the heat demand during the colder months, while the heat pump covers most of the demand in the spring and autumn. The heat pump SPF is calculated as 2.41, while the wood burner operates at a seasonal energy efficiency of 70%. Seasonal energy efficiency for the system works out at 121%.

For domestic tap water, it is necessary to ensure that on very cold days, the temperature of the heating system reaches the desired set point. To determine this, a detailed simulation must be performed for those days on which the yearly results indicate the greatest energy deficit. An example of heat pump operation over four cold days is shown in Figure 6, where for two days the set point was not reached. On each of these days, the temperature in the hot water tank is below 45°C for a duration of about 4 hours. This drop can be tolerated, since it only occurs during a short period during the heating season.

Validation and accuracy

Simulation results were compared to laboratory tests carried out at the Swiss Federal Institute of Technology in Lausanne, Switzerland. Measurements were made on three typical days with average ambient temperatures of 12°C, 2°C and -10°C.

The results showed that the principal operation phases of the wood burner (start-up, full-load, part-load and burn-out) are, qualitatively speaking, correctly simulated. For each firing, the simulated energy production is about 5% higher than measured. The simulated heating rates and temperature levels are in good agreement with measurement. The divergence between simulation and measurement is of the order of 10% with separate operation of the heat pump, and up to 20% during wood-fired operation. Tests currently in progress on two pilot systems show that the mode of operation and the characteristic values of the system can be strongly influenced by the user who may, for example, use more wood than necessary.

Towards Better Quality Control

PC design tools of the type described in this article permit simple comparison of different system configurations. Further work is planned to integrate the two programs within a unified framework running under MS Windows.

The use of these tools will lead to better quality control of tomorrow's heat pump systems. This is especially important with the recent rise of heat pump sales in Switzerland. Encouraging developments on the sales side must necessarily be accompanied by quality control measures to ensure reliability in operation. Only in this way can user satisfaction be guaranteed and the mistakes of previous years avoided.

Acknowledgements

The W-CALC programs have been developed by Mr. A. Schweizer and Mr. M. Nani. The modelling and implementation of the wood furnace module in YUM WP/Holz was carried out by Dr. J. Good. Their work is gratefully appreciated.

Literature

Afjei, T. "YUM: A Yearly Utilization Model for Calculating the Seasonal Performance Factor of Electric Driven Heat Pump Heating Systems", ENET, Switzerland, Report ENET-Nr. 9003003-2, December 1991.

Afjei, T. "Simulation von Wärmepumpenheizanlagen mit Holzkessel, Validierung YUM: System mit Luft-Wasser-Wärmepumpe und Elektrischer Zusatzheizung", ENET, Switzerland, Report ENET-Nr. 9201141-4, July 1994.

Afjei, T., Wittwer, D., Good, J. "Simulation von Wärmepumpenheizanlagen mit Holzkessel, YUM/Holz : Erweiterung auf Bivalente Heizsysteme mit Wärmepumpe und Holzkessel", ENET, Switzerland, Report ENET-Nr. 9201141-5, October 1994.

Stalder, M., Schweizer, A. "Rechenhilfe WKK-CALC für die Dimensionierung von Wärmekraftkopplungsanlagen", ENET, Switzerland, Report ENET-Nr. 9201101, December 1993.

Nani, M. "Softwareentwicklung WP-CALC", ENET, Switzerland, Report ENET-Nr. 9106480, October 1994.

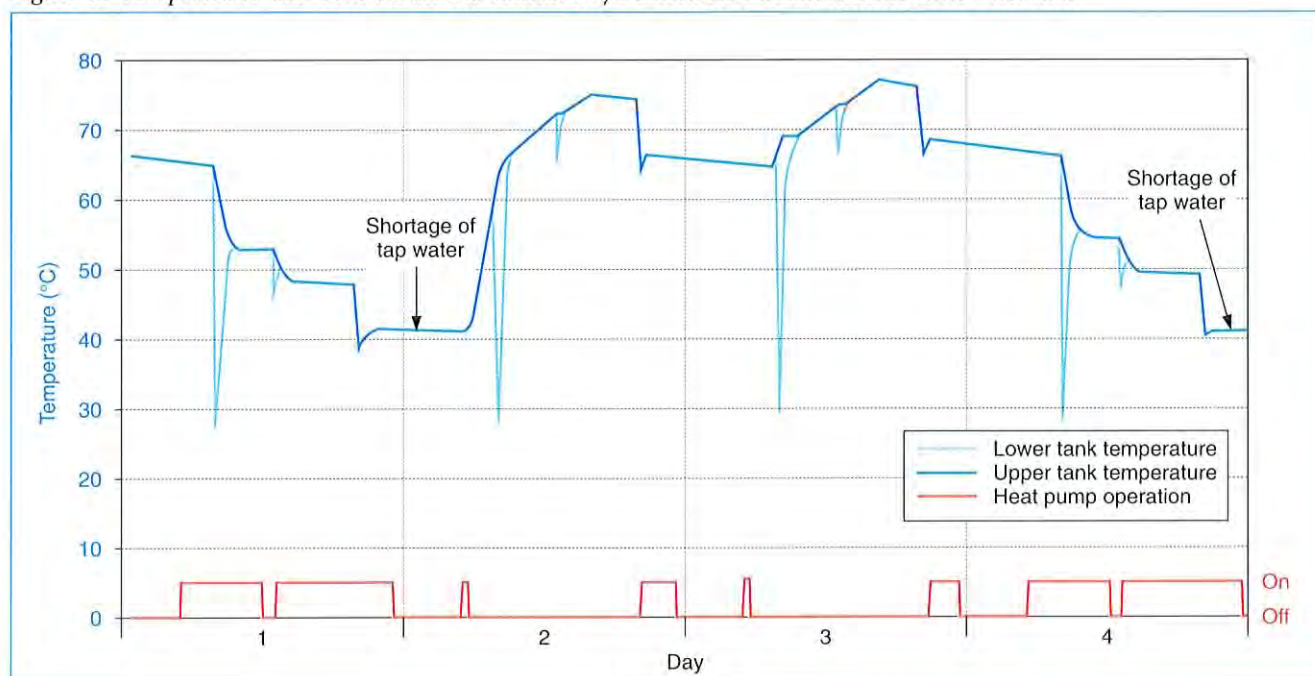
Authors:

Mr Thomas Afjei and Mr Dieter Wittwer
INFEL, Lagerstrasse 1, Postfach, CH-8021 Zurich,
Switzerland
Tel: +41-1-291-0102; Fax: +41-1-291-0903

Dr Hanspeter Eicher and Mr Martin Stalder
Dr. Eicher+Pauli Ltd., Orisalstrasse 85, CH-4410, Liestal,
Switzerland
Fax: +41-61-923-0025

Mr Thomas Baumgartner,
Consultant Engineer, Switzerland
Fax: +41-1-820-2822

Figure 6: Temperature distribution on the coldest days calculated at six minute time intervals.



Heat Recovery in a Textile Plant

Heat Pump Brings Down Effluent Temperature

Frank Pucciano, USA

At American & Efird's (A&E's) thread plant in Mount Holly, North Carolina, as in many textile plants with dyeing and finishing operations in the southeastern United States, environmental regulations required that measures be taken to reduce the temperature of the factory's effluent. At the same time, the owners also sought to reduce energy costs, improve yarn quality and increase production. A heat recovery heat pump (HRHP) helped them with all four objectives and brought about several other environmental benefits as well.

* * *

At the outset of the project, Herschel Ellis, A&E's Corporate Engineer, first called on the local utility, Duke Power Company, to hear their ideas on ways to reduce the effluent temperature and decrease the operating cost. Bill Mann, Duke's area marketing engineer, and Steve Smith, their corporate staff engineer, suggested that a HRHP might be the answer, and offered to obtain the services of EnvironTherm Technologies, Inc. to perform a feasibility study.

The feasibility study determined that an HRHP could bring down the effluent temperature to the 40°C level requested by the environmental code of the city authority, or even lower. Furthermore, it would improve process water temperature control and would reduce loading on the plant's natural gas-fired boilers. With grants from Duke Power Company and the North Carolina Alternative Energy Corporation, the simple payback time on energy savings alone was less than three years. In addition, a lease could be arranged to finance the project.

Partial Recovery

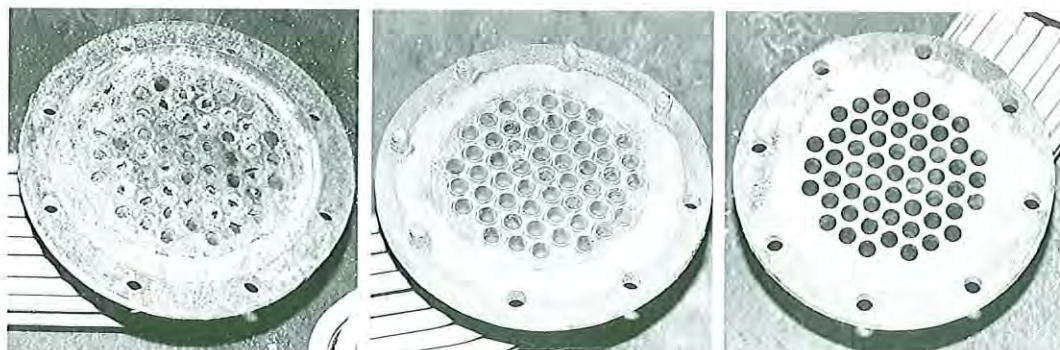
Many textile plants recover as much thermal energy as they can to reduce operating cost. At A&E's thread plant, the hot water generated by an Avesta dryer condenser coil is utilized and heat from the effluent has been recovered in the past, using a four-pass, stainless steel, heat exchanger from Ludell Manufacturing. However, the combination of hot, cold and tempered flows in the effluent prevented the plant from utilizing all of the available waste heat, and meant that the 40°C temperature restriction imposed by the city authority was exceeded.

Getting a Face Lift

The Ludell heat exchanger had been used in the plant since 1969 and had not been fully serviced for nearly 17 years. Close inspection revealed that it was high time for a face lift. Photo 1, left, shows the state of one of the cross-over headers as it was first removed during renovation. Cleaning this plate (centre picture) revealed that about one quarter of the plate had corroded to expose the tube ends. The missing material was filled with steel epoxy putty and sanded smooth as shown in Photo 1, right.

The heat exchanger was also split into two two-pass heat exchangers to accommodate the HRHP, and a new centrifugal waste-water pump (trash pump), reversing valve (RV) and flow control valve (FCV), were fitted. Some of this equipment is shown in Photo 2. The renovated exchanger was reassembled using full-face gaskets, a new horizontal cross-over header and two fresh water supply/return circuits. The renovated heat exchanger system now comprises four 7.3 m shell-and-tube heat exchangers, and three continuous-tube cross-over headers – two vertical and one horizontal.

Photo 1: Twenty-year old heat-exchanger gets a face lift. Left: after removal. Centre: after cleaning. Right: after filling.



HRHP Operation

Figure 1 shows a diagram of the HRHP system as it was installed. The temperature of effluent from the plant's processes can range from about 27°C to 80°C with the blended average being about 51°C. The effluent is collected in a concrete pit under the HRHP room and the waste-water pump delivers it to the inlet of the tube side of the Ludell heat exchanger. Once the effluent enters a tube, it remains in the same tube through both sections (all four shells) of the heat exchanger. When cooled, the effluent is piped to the plant's water treatment facilities.

As shown in Figure 1, the plant effluent first enters the preheat section of the heat exchanger where heat is transferred to the process make-up water – the HRHP's heat sink. The cleaning and renovation of the existing heat exchanger has allowed the two shells in this section to do what all four did before the project: preheat water to about 45°C and cool effluent to 41°C. The cooled effluent then enters the heat pump heat source section of the heat exchanger where additional heat is transferred from the effluent to the recovery loop of the HRHP – this is the HRHP's heat source. The HRHP condenser adds between 11°C and 17°C to the process water and reduces the effluent temperature to approximately 30°C. Key data on the installation are listed in Table 1.

No Alternative

Two alternative designs that are frequently considered for the Ludell heat exchanger configuration were rejected for this project. One alternative is to use the first two shells for the heat pump heat source, and the last two for the preheat. While this increases the heat pump system COP, this option is usually not advisable as the total amount of "free heat" recovered in the preheat is reduced.

The second option is to split the effluent into two flows – one for the heat pump heat source and one for the preheat. This requires two waste-water pumps, two reversing valves and two flow control valves, which usually drives the first cost above that needed for an acceptable payback time.

Off the Shelf

The HRHP system installed at A&E comprises standard "off-the-shelf" equipment. The HRHP is a York Centrifugal Code Pak with CFC-113 refrigerant – a standard water chiller with very similar maintenance requirements to conventional chillers. All interconnecting piping is schedule-10 stainless steel with welded connections. Controls are simple and maintenance requirements are low. The heat exchanger system has been in operation for 25 years, with only two overhauls, of which one was just for cleaning. The entire project has a footprint of approximately 9-7 m.



Photo 2: New equipment at the A&E's thread plant including a trash pump (right) and a reversing valve (centre).

One System, Many Benefits

Like many applied technologies, HRHP systems must be evaluated individually. However, the A&E project highlights many potential benefits for a wide range of textile plants.

A major benefit is that the system is able to control effluent temperature down to acceptable levels which are not reachable with heat exchange alone. Furthermore, the hot water supplied by the HRHP leads to other environmental benefits by reducing loading on the plant boilers. SO_x, NO_x and CO₂ emissions from the boiler stack are reduced along with boiler chemical requirements.

The hot water generated by the HRHP can also serve special purposes in textile plants. When it is used at the start-up of a dye cycle it will reduce dye time and increase the production rate. Other applications are as rinse water – improving the quality of rinsing, or for cleaning purposes – for shorter clean-up times and reduced water consumption.

The use of an effluent storage pit adds further benefits. It allows better control of the solid concentration and chemical pH of the effluent. And when high and low pH flows mix together in the pit, the need for chemical neutralizers is reduced.

Incorporated in the HRHP system are hot water storage tanks (not shown in Figure 1). These give some additional benefits by improving the reliability and availability of hot process water. Furthermore, since the process water supply temperature will be constant, dyeing, finishing and clean-up are likely to be more consistent.

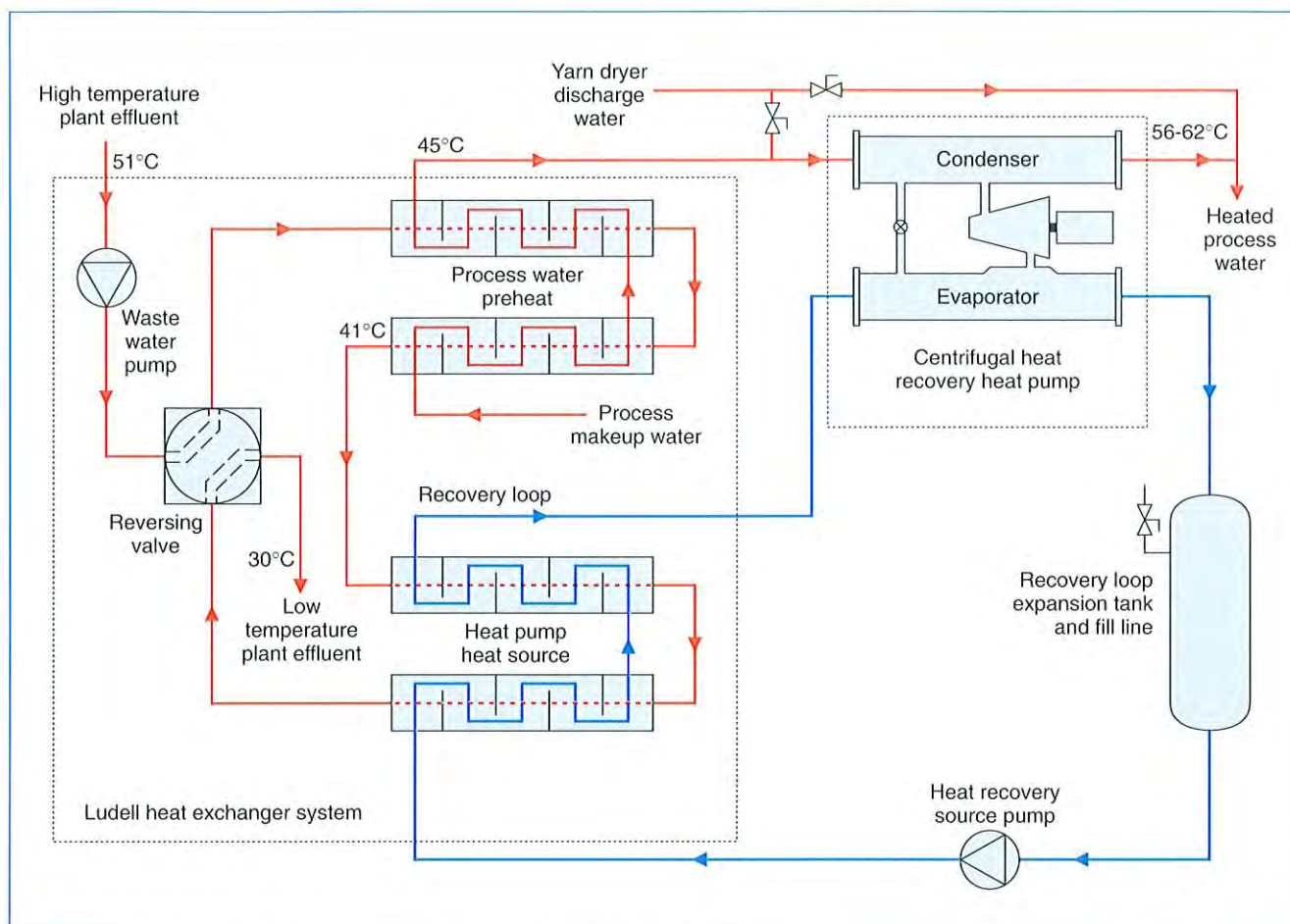


Figure 1: Heat recovery heat pump system for a textile plant.

The economic benefits of HRHP projects are improving, despite the need to design with alternative refrigerants such as HCFC-22. With plants operating longer hours, and with natural gas prices rising slightly against steady electric rates, payback times are shortening. When the offset of environmental code compliance cost is taken into consideration, typical payback times can be as low as 1.5 to 2.5 years.

Compelling Results

Clearly, HRHP systems are not the only means of controlling effluent temperature to improve dyeing and finishing. However, an HRHP system can be designed to suit a specific application. And the results in terms of product quality improvement, energy savings, environmental code compliance and lessened environmental impact can be compelling.

Table 1: A summary of the heat pump system at A&E.

System energy performance in one year

Heat recovery	20.526 PJ (5.70 TWh)
System power consumption	1.47 TJ (0.407 TWh)
Net energy savings	19.1 PJ (5.29 TWh)
Plant hot water requirements	428 l/min
System COP	14

System economics

Customer investment (less grants)	US\$ 60,000
Avoided natural gas cost	US\$ 39,273
System electric cost	US\$ 17,512
Annual savings	US\$ 21,761
Simple Payback	2.76 years

Author:

Mr Frank J. Pucciano
Senior Power Engineer
Georgia Power Company, USA
Fax: +1-404-621-2457

Bibliography

2nd Symposium on Ground-Coupled Heat Pumps "2. Symposium Erdgekoppelte Wärmepumpen" Proceedings of the Symposium held in Schloss Rauschholzhausen on 17-19 October 1994.

Published by IZW, Germany; Fax: +49-7247-808-135.
376 pages (German; English Summary)

Thirty three papers on topics such as experiences, heat exchangers, direct evaporation, thermal energy storage in the ground, and modelling.

Heat Pumps in Japan (Third Edition)

Published by the Heat Pump Technology Center of Japan;
Fax: +81—3-3507-0076. (A limited number of copies is
available from the IEA Heat Pump Centre) March 1995;
333 pages (English).

An in depth review of the Japanese heat pump situation, covering trends in equipment and systems, utilization, R&D, policy support and the energy situation.

Heat Pump Water Heaters - A Technology Assessment and Market Survey

Published by E-Source Inc., Colorado, USA. Fax: +1-303-
440-8502. Order No. TU-94-9, Price US\$ 50

Montreal Protocol on Substances that Deplete the Ozone Layer. 1994 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee. 1995 Assessment

Kuipers L.. Published by UNEP, Ozone Secretariat, United
Nations Headquarters, PO Box 30552, Nairobi, Kenya.
November 1994. 301 pages.

High-Performance Adsorption Module for a Zeolite-Water Adsorption Heat Pump "Leistungsfähige Adsorptionsmodule für eine Zeolith-Wasser-Adsorptionswärmepumpe"

Rainer Lang; ISBN 3-86111-902-1, 69 pages, DM 89,
(German)

Software

YUM/WP/Holz: A PC Program for the Design and Optimization of Monoenergetic and Bivalent Heat Pump Systems with Wood-Fired Boiler

Available from INFOENERGIE, Fax: +41-56-412-015.
Program in English and German. Manual mostly in
German. Price CHF 573/350.

The simulation programme for DOS or MS-Windows is directed primarily at engineering designers and energy consultants. The results provide information about heat coverage by the heat pump, wood and electricity consumption, efficiency, solar gains, and costs.

IEA Heat Pump Programme

Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps

Annex 14 Report from 1991. Two Volumes. Republished
by the IEA Heat Pump Centre in May 1995; Order No.
HPP-AN14-1; 600 pages; Price NLG 100.

Volume 1 contains the results of surveys on thermo-physical properties, advanced absorption cycles and transport phenomena. Volume 2 is a reference document on the state-of-the-art for advanced absorption equipment, based on country presentations by the participants in Annex 14.

An Assessment of the Current Status of the Thermophysical Properties of Ammonia

Annex 18 Report from 1994. Republished by the IEA Heat
Pump Centre in April 1995; Order No. HPP-AN18-1; 62
pages; Price NLG 40.

Comparison of Equations of State for HCFC-123

Annex 18 Report from 1993. Republished by the IEA
Heat Pump Centre in April 1995; Order No. HPP-AN18-
2; 45 pages; Price NLG 40.

Comparisons of Equations of State with Experimental Data for R134a and R123

Annex 18 Report from 1993. Republished by the IEA Heat
Pump Centre in April 1995; Order No. HPP-AN18-3; 45
pages; Price NLG 40.

Industrial Heat Pumps: Experiences, Potential and Global Environmental Benefits

Annex 21 Report published by the IEA Heat Pump Centre
in June 1995; Order No. HPP-AN21-1; 45 pages; Price
NLG 100.

The comprehensive final report of Annex 21 gives industrial companies and process engineers information that will highlight the opportunities for using industrial heat pumps (IHPs) in their industries. It reviews the worldwide experience with IHPs, summarizes the applied technologies, and gives guidelines for the economic integration of IHPs in a range of industries and processes. Of particular interest for policy makers and energy programme managers, in both governments and utilities, are the estimates of the potential energy-related and environmental benefits from using IHPs.

Events

* Call for papers

24th National Heat Transfer Conference

5-9 August 1995 / Portland, Oregon, USA.

Sponsored by ASME. Contact: Prof. James R. Welty
Oregon State University, Corvallis, Oregon, USA.

19th International Congress of Refrigeration - For a Better Quality of Life (IIR Congress)

20-25 August 1995 / The Hague, The Netherlands.

Contact: Van Namen & Westerlaken Congress Organisation
Services. Fax: +31-80-601159

Tsinghua - HVAC '95- 2nd International Symposium on Heating Ventilation and Air Conditioning

22-25 September 1995 / Beijing, China.

Contact: Prof. Yi Jiang, Secretariat of the Symposium.
Fax: +86-1-254-5093

Heat Transfer in Condensation - 47th Eurotherm Seminar

4-5 October 1995 / Paris, France.

Contact Mrs M.J. Basset, CRETH-CENG, Fax: +33-7688-5161

Solar Assisted Cooling with Sorption Systems

17-18 October 1995/Munich, Germany.

Contact: Dr Peter Lamp, ZAE Bayern eV.

Fax: +49-89-3294-4212

*1995 International Gas Research Conference

6-9 November 1995 / Cannes, France.

Deadline for abstracts: 31 July 1995. Contact: Gas Research
Institute. Fax: +1-312-399-8170

Symposium on Heat Pump and Refrigeration Systems Design, Analysis and Applications

12-17 November 1995 / San Francisco, California, USA.

Organized within the 1995 ASME International Congress.

Contact: Dennis L. O'Neal, Texas A&M University.

Fax: +1-409-862-2762

Electric Heat Pumps: Meeting Customer and Utility Needs

6-8 December 1995 / St Louis, Missouri, USA.

Contact: Linda Nelson, Conference Coordinator, Electric
Power Research Institute. Fax: +1-415-855-2041

*Refrigeration, Climate Control and Energy Conservation

11-14 February 1996 / Melbourne, Australia.

IIR Meeting of Commissions E2/E1 and B1/B2. Deadline for

abstracts: 14 July 1995. Contact: Mrs Siew-Ling Teh, AIRAH.
Fax: +61-3-328-4116

Absorption/Sorption Heat pumps and Refrigeration Systems

14 February 1996, Atlanta, USA.

Contact Srinivas Garimella, Western Michigan University.

Fax: +1-616-387-3358.

E-Mail: srinivas.garimella@wmich.edu

1996 ASHRAE Winter Meeting

17-21 February 1996, Atlanta, USA.

Contact: ASHRAE. Fax: +1 404-321-5478

Frigair '96

6-8 March 1996 / Johannesburg, South Africa.

Contact: FRIGAIR '96, Melanie Campbell.

Fax: +27-11-442-5927

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. Fax: +971-33521

2nd European Thermal Sciences Conference

29-31 May 1996 / Rome, Italy.

Contact: Mr G.P. Celata, ENEA Casaccia, Energy
Department, Via Anguillarese, 301-I-10060 Rome, Italy.

Energy and Environment Towards the Year 2000

6-8 June 1996 / Capri, Italy.

Contact: EURO MEETING IN. Fax: +39-81-7141414

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.

Natural Working Fluids in Refrigeration and Air Conditioning

2-8 September 1996 / Aarhus, Denmark.

Contact: Mr M. Arnvig, Danish Refrigeration Association.

Tel: +45-42-88-4622

Research, Design and Construction in Refrigeration and Air Conditioning in Eastern Countries

10-14 September 1996 / Bucharest, Romania.

Contact: Prof. F. Chiriac, Asociatia generala a frigotehnistilor
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

IEA Heat Pump Programme

International Heat Pump Status and Policy Review

25 August 1995 / The Hague, The Netherlands

One-day HPC Seminar within the

19th International Congress of Refrigeration

Annex 22 Workshop on Natural Refrigerants

16-18 October / Trondheim, Norway

5th IEA Conference on Heat Pumping Technologies

22-26 September 1996 / Toronto, Canada

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) National Position Papers	HPC-AR3 HPC-NPP**	250 40
Consequences of (H)CFC Replacement in HVAC Applications	Workshop Proceedings	HPC-WR-13	60
Utility Perspectives on Heat Pumps for Retrofit and New Applications in Buildings	Workshop Proceedings	HPC-WR-14	80
Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps	Annex 14 Report	HPP-AN14-1	100
An Assessment of the Current Status of the Thermophysical Properties of Ammonia	Annex 18 Report	HPP-AN18-1	40
Comparison of Equations of State for HCFC -123	Annex 18 Report	HPP-AN18-2	40
Comparisons of Equations of State with Experimental Data for R134a and R123	Annex 18 Report	HPP-AN18-3	40
Industrial Heat Pumps: Experiences, Potential and Global Environmental Benefits	Annex 21 Report	HPP-AN21-1	100

New publications

Next Issue of the Newsletter

Residential Heat Pumps - September 1995



- ☐ Please send me the IEA Heat Pump Centre Newsletter***
- ☐ I live in a HPC member country and am therefore entitled to a free subscription.
- ☐ I do not live in a member country and will pay the annual subscription of 110 Dutch Guilders*
- ☐ Please cancel my subscription to the Newsletter
- ☐ I would like to order the following HPC publications (Order No.):

Please charge me: NLG VAT No. (For EU countries only)

Payment via : ☐ bank transfer (you will be billed) ☐ Eurocard ☐ Mastercard ☐ VISA

Card No.: Expiry Date:

Card Holder:

Name: Company:

Address: City/Town:

Post/ZIP Code: Country:

Signature: Date:

*1 Dutch Guilder (NLG) is worth about 0.6 US Dollars.

**Add name of country.

***Your subscription will be automatically renewed unless written cancellation is received by 1 October.

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.

IEA Heat Pump Centre
P.O. Box 17, 6130 AA Sittard
The Netherlands
Tel: +31-46-595-236
Fax: +31-46-510-389
E-Mail: NLNOVHPC@IBMMAIL.COM



Austria
Mr Hermann Halozan, TU Graz
Inffeldgasse 25
A-8010 Graz, Austria
Tel: +43-316-873-7303
Fax: +43-316-873-7305
E-mail: HALOZAN@IWT.TU-GRAZ.AC.AT
NATIONAL RESEARCH COUNCIL



Canada
Mr W. Keith Snelson
Heat Transfer and Thermodynamics
Institute for Engineering, Building M-17
Ottawa, Ontario K1A 0R6, Canada
Tel: +1-613-993-4892
Fax: +1-613-954-1235
E-mail: Keith.Snelson@NRC.CA



Japan
Mr Yoshio Igarashi,
Heat Pump Technology Center of Japan
Galant Toranomon Bldg. (3F), 2-7-3,
Toranomon, Minato-ku, Tokyo, Japan
Tel: +81-3-3507-0071
Fax: +81-3-3507-0076
E-mail: LDK00100@NIFTYSERVE.ORG



The Netherlands
Mr Onno Kleefkens
Novem, P.O. Box 8242
3503 RE Utrecht, The Netherlands
Tel: +31-30-363-449
Fax: +31-30-316-491
E-mail: NLNOVOKL@IBMMAIL.COM



Norway
Mr Ulf Rivenæs
NVE's National Heat Pump Programme
P.O. Box 131, Vinderen,
N-0319 Oslo, Norway
Tel: +47-22-492-600
Fax: +47-22-492-600



Switzerland
Mr Thomas Afjei
c/o INFEL, Informationsstelle
für Elektrizitätsanwendung
Lagerstrasse 1, Postfach,
CH-8021 Zurich, Switzerland
Tel: +41-1-291-0102
Fax: +41-1-291-0903



USA
Ms Melissa Voss,
Oak Ridge National Laboratory
Building 3147, P.O. Box 2008
Oak Ridge, TN 37831-6070, USA
Tel: +1-615-576-1013
Fax: +1-615-574-9338
E-mail: VOSSMK@EDERR1.ED.ORN.L.GOV

STAMP

IEA Heat Pump Centre
P.O. Box 17
6130 AA Sittard
The Netherlands

To subscribe to the IEA Heat Pump Centre Newsletter please use this card.