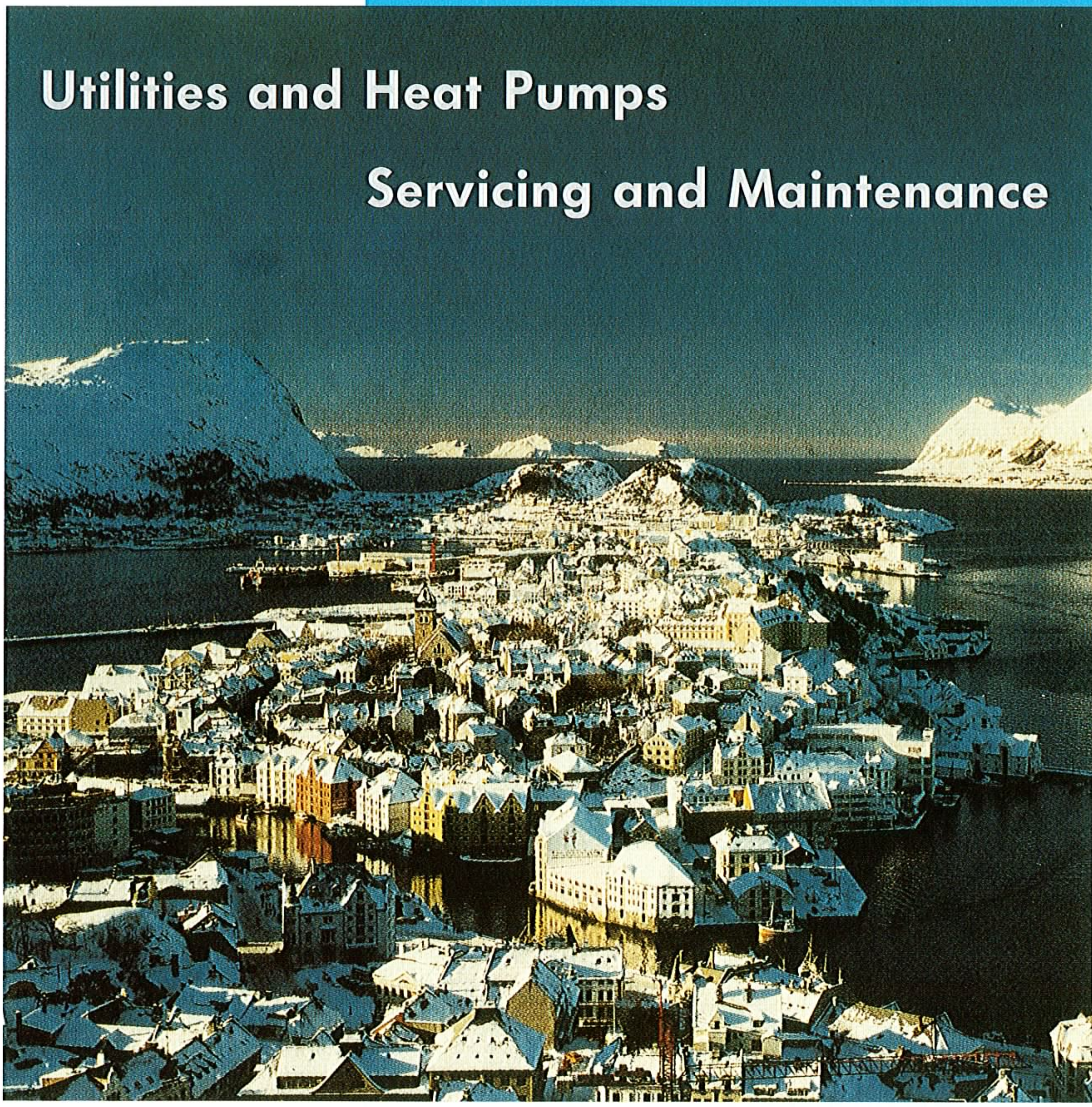
Vol. 10, No. 2, June 1992

IEA Heat Pump Centre

NEWSLETTER



IEA
OECD
heat pump
centre

Contents

Front Cover: The city of Ålesund, Norway, is served by a district heating system with a heat pump. More information is available in the article on page 18.

International Energy Agency
The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to implement an International Energy Programme.

A basic aim of the IEA is to foster cooperation among the 21 IEA participating countries to increase energy security through energy conservation, development of alternative energy sources and energy research, development, and demonstration (RD&D). This is achieved in part through a programme of collaborative RD&D consisting of 42 Implementing Agreements, containing a total of over 80 separate energy RD&D projects. This publication forms one element of this programme.

Editor: *Rosemarie Smith*
Production Team: *Lucinda Maclagan / Roswitha Muyres / Heleen Smeets.*
Technical Editing:
Jos Bouma / Mike Steadman.
Illustrations:
Offermans EPS, Maastricht.
Printers:
Huntjens Drukkerij, Stein.

ISSN 0724-7028

Editorial

The two topics dealt with in this Newsletter - *Utilities and Heat Pumps* and *Servicing and Maintenance* - are significant to the advancement of high-efficiency and reliable heat pump installations. Utilities are in an excellent position to act as an agent between manufacturer and end-user and they can provide information on heat pumps objectively, and influence manufacturers and installers, based on their experience with heat pumps. Utilities can also play an important role in initiating and supporting the development of national and regional standards and regulations, an area where much work is still needed.

In Canada, a survey by Ontario Hydro has demonstrated that heat recovery using heat pumps is an effective demand-side option with potential for displacing electrical energy in buildings, and providing savings in both electrical energy and demand.

In Japan, utilities actively cooperate in developing new equipment to reduce the aggravated electricity peak during summer cooling. Experience in the development of gas-fired heat pumps and thermal storage systems has shown how utilities can help to improve heat pump use.

In Norway, the environmental effects of energy consumption plays a significant role in energy policy. Although small in share, fossil fuel use there has been drastically reduced and the use of hydro-based electrical equipment such as heat pumps is stimulated through incentives. Interestingly some Norwegian utilities not so familiar with heat pumps are reluctant to promote them. The IEA network can help to reduce this resistance through information supply.

This issue also highlights two other major developments. Firstly, the participation of Switzerland in the IEA Heat Pump Centre and secondly, the 4th IEA Heat Pump Conference in 1993. This time the Netherlands, home of the Heat Pump Centre, will be the host country of this international event. We hope that many of our readers will participate and take the opportunity to experience a touch of the lowlands.

Jos W.J. Bouma
General Manager.

Electricity Savings through Heat Pump Heat Recovery in Buildings

*R.L.D. Cane, B. Clemes, D. Forgas

Introduction

Ontario Hydro expects that about 25% of its generating plants will have retired by the year 2014. Rather than simply building new generating plants Ontario Hydro wants to diversify its approach by reducing growth in demand as well as increasing supply. Heat recovery is one of several demand-side options with potential for displacing electrical energy in buildings.

Where space heating, cooling and service water heating in existing buildings is provided by electricity, savings both in electrical energy and demand are possible through heat pump heat recovery.

Heat Recovery in Ontario

A recent study [1] identified and described the most promising heat recovery applications, the status of the technology, and each application's maximum technical potential for electrical energy and demand savings in Ontario. The heat recovery technologies examined included desuperheater heat exchangers, heat pump water heaters, grey water heat recovery heat pumps, air-to-air heat exchangers, run-around heat exchangers, exhaust-air heat pumps, heat recovery chillers, dehumidification heat pumps and heat recovery ventilator heat pumps. The technical potential for electrical energy and demand savings of certain heat pump heat recovery technologies is the focus of this article.

Many of these heat recovery technologies have been applied, while others have not been developed commercially for largely economic reasons. While conventional end-user economics may be unattractive, from a utility demand-side management perspective, some heat pump heat recovery applications show sufficient promise to reduce electrical demand for space heating and service water heating to warrant incentives.

Heat Pump Heat Recovery Technologies

The three heat pump-based heat recovery technologies which showed the most promise are:

- the exhaust-air heat pump;
- the heat pump water heater (HPWH);
- the heat recovery ventilator heat pump.

Applications for these technologies in residential and commercial/institutional buildings were examined in detail.

Exhaust-air Heat Pumps

Exhaust-air heat pumps, (Figure 1), use warm ventilation exhaust air leaving the building as a heat source to pre-heat service water. They are well-suited to buildings with relatively constant occupancy, and high, continuous, domestic hot water loads such as high-rise residential buildings, hospitals and nursing homes.

Payback periods from 4 to 6 years and annual COPs between 3.5 and 5.0 have been reported.

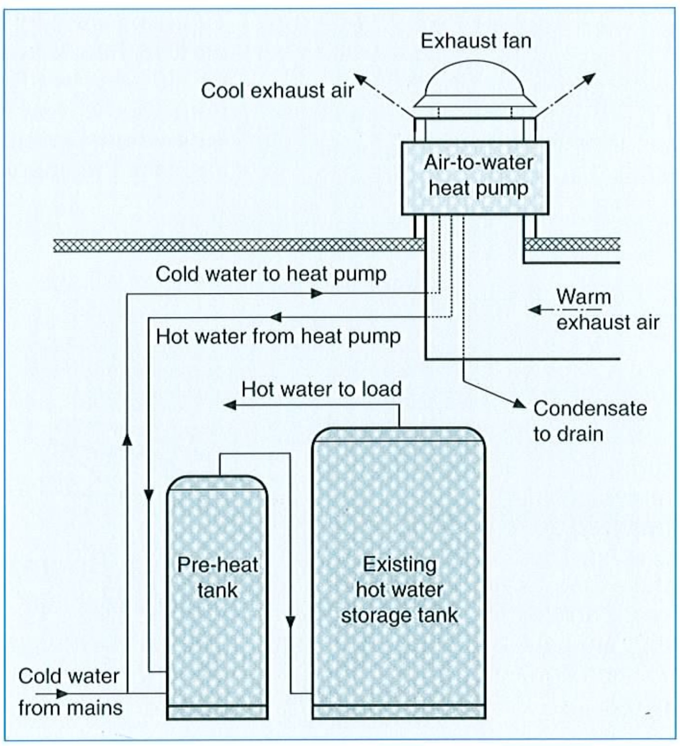


Figure 1: Exhaust-Air Heat Pump System.

Heat Pump Water Heaters

HPWHs recover heat from their ambient air surroundings to heat domestic water. The heat source generally varies between 7°C and 49°C. Two configurations are available in the North American market: an integral unit with a storage tank, and an add-on unit for retrofit applications to existing hot water tanks. In single-family applications, electrical energy savings of 1500 kWh per year compared with electrical resistance heaters with annual COPs up to 2.0, have been reported. Electrical demand can be reduced by anywhere from 1.5 kW to 3.0 kW. In summer, the same unit can cool and dehumidify the surroundings.

For commercial/institutional buildings, larger HPWHs can be applied in boiler or compressor rooms to recover heat from surroundings to pre-heat service water. COPs of 2.6 have been reported with 50 to 60% of the service hot water loads met by the heat pumps. Heat recovery from restaurant or cafeteria kitchen ambients has also been accomplished with HPWHs. In these applications, surroundings are often over 25°C and there are large requirements for hot water. A payback period of 3.5 years, energy savings of 40% and a demand reduction of 7.6 kW were reported in one study. More comfortable working conditions should also improve kitchen staff productivity.

Heat Recovery Ventilator Heat Pumps

These are used in single-family buildings where exhaust temperatures are between 20°C and 23°C, and ventilation air flow rates are between 50 and 100 litres per second. These units source from the exhaust stream to provide space and/or domestic water heating. Annual COPs between 1.5 and 2.0 and annual electricity savings between 1500 and 3000 kWh have been reported.

Technology	End-use	Building type	Estimated electricity reduction in end-use
Domestic HPWH	Water heating	Single-family	
Heat recovery ventilator heat pump	Space and water heating	Single-family	
Exhaust-air heat pump	Water heating	Comm./Instit.	
Kitchen HPWH	Water heating	Restaurants	
Boiler room HPWH	Water heating	Comm./Instit.	

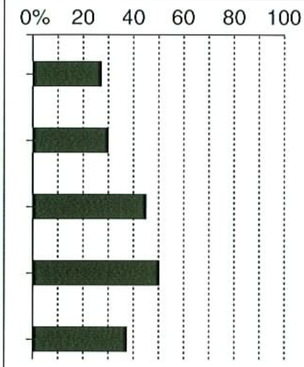


Table 1: Heat Pump Heat Recovery Applications.

Potential Electricity Savings

The primary objective of the study was to estimate the electrical load reduction potential through heat recovery. The information for this estimate was drawn largely from heat recovery technical literature and other published reports.

Estimating the electrical demand and energy saving potential for the identified applications involved a number of steps:

- the buildings to which the technologies were applicable were identified;
- the number of such buildings in Ontario were determined;
- potential end-uses for the recovered energy were identified;
- the amount of electricity associated with each end-use was established for each building type.

Consideration was also given to the type of distribution system, whether central or distributed, for both space and water heating systems. An estimate of the percentage or fraction of electrical energy saved with each heat recovery heat pump application was determined from published literature.

The total number of single-family dwellings in Ontario in 1988 was 2.6 million while the total floor area in commercial/institutional buildings was 165 million square metres. Each individual heat recovery technology was applicable to only a fraction of the total single-family or commercial/institutional building population.

Results

For each of the heat recovery technologies, the building types and potential end-uses are summarized in Table 1, together with an estimate of their percentage reduction in electrical end-use.

The electrical energy saved for each heat pump heat recovery technology covered in this article, depends on the number of buildings or households meeting the special requirements, and the amount of electricity currently used for the particular end-use. The estimated residential electrical energy savings through heat recovery for Ontario are shown in Figure 2 for single-family and commercial/institutional buildings.

Estimates of electricity demand reduction assume that the end-use hours of operation are unchanged after heat recovery implementation. By dividing the electrical energy savings by the end-use hours of operation, the average demand reduction can be determined. The results for Ontario for single-family and commercial/ institutional building heat pump heat recovery technologies covered in this article are summarized in Figure 3.

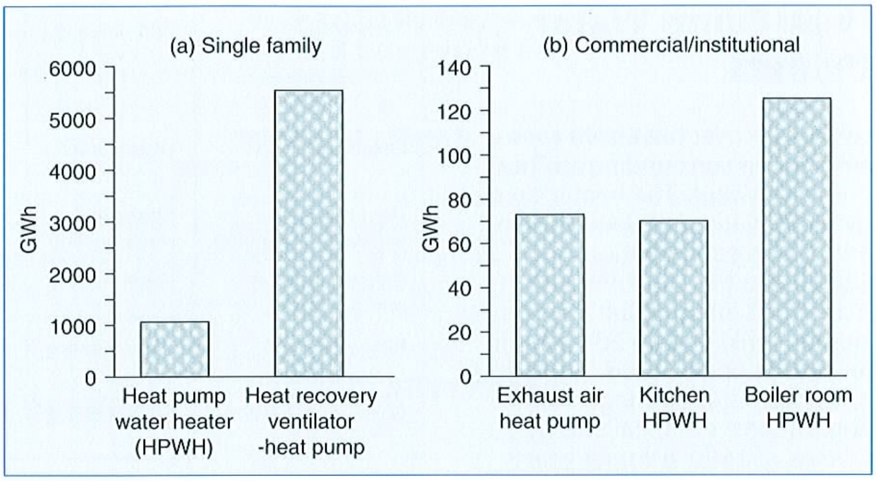


Figure 2: Electrical Energy Savings.

Conclusions

Looking at all single-family heat recovery applications examined, the total potential for annual electrical energy savings is estimated to be 7600 GWh. The potential winter electrical demand reduction is over 900 MW, while in summer the peak demand reduction is estimated to be about 700 MW.

In the commercial/institutional building sector in Ontario, where electricity use for all end-uses of interest (space and service water heating) is significantly less than in the residential sector, the total potential for annual electrical energy savings, through all heat recovery applications examined, is estimated to be about 440 GWh. The potential winter electrical demand reduction is estimated to be 110 MW. The potential impact on summer demand is an estimated reduction of 85 MW.

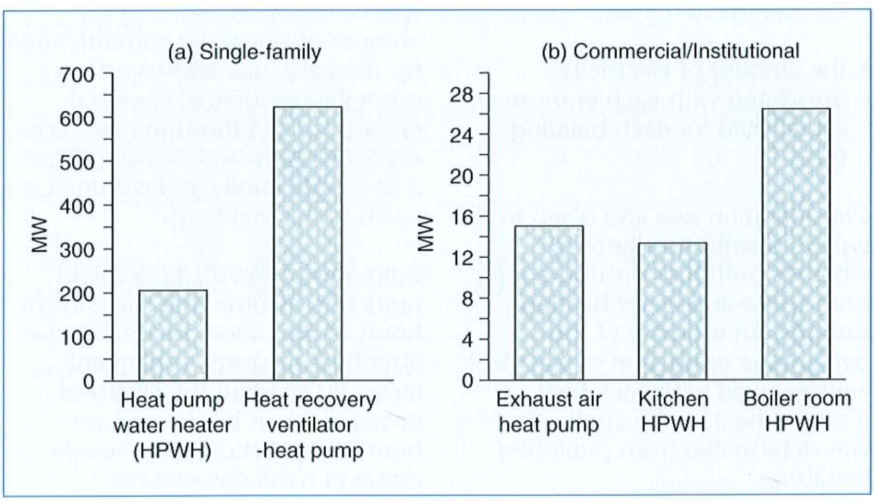
While the potential impact of all heat pump and non-heat pump-based heat recovery technologies examined in the study are included in the total potential energy and demand savings reported above, the heat pump heat recovery technologies described in this article offer significant potential for electricity savings by themselves, as shown in Figures 2 and 3.

The most promising residential heat pump heat recovery application is the replacement of electric water heaters by HPWHs, in all homes using gas or oil for space heating (estimated to be 680,000 homes in Ontario). This could achieve an electrical demand reduction of 200 MW.

In the commercial/institutional building sector in Ontario, while the total heat recovery potential is less, the applications are larger and concentrated on fewer sites, therefore they are easier to target with demand-side management programmes. Heat pump heat recovery from boiler or compressor room ambient air using HPWHs has an estimated total potential demand reduction of 27 MW. Exhaust-air heat pumps could reduce electrical demand for water heating in Ontario's commercial/ institutional buildings by about 15 MW. HPWHs applied to restaurant kitchens have a technical potential to reduce electrical demand by another 14 MW.

One can therefore conclude that exhaust-air heat pumps and HPWHs are capable of achieving significant demand reductions, in both single-family and commercial/ institutional buildings. In some applications, exhaust air heat pumps or HPWHs can contribute useful space cooling and improved working conditions as an additional benefit.

Figure 3: Electrical Demand Reduction.



1) Caneta Research Inc., "Opportunities for Electricity Savings Through Heat Recovery in Residential and Commercial Buildings", prepared for Ontario Hydro Research Division, November, 1991.

*Authors:
D. Cane, B. Clemes, D. Forgas, Caneta Research Inc., Mississauga, Ontario, Canada.*

Utilities and Heat Pumps - an Austrian View

*W.A. Ritter

Introduction

About 140 years ago Peter Ritter von Rittinger designed and constructed - based on the theoretical investigations of S. Carnot - the first hydro power driven MVR (mechanical vapour recompression) heat pump system, which was utilized for salt production in Ebensee, Oberösterreich. Since that time, many other heat pump applications have been implemented in the industrial and residential/ commercial sectors. And components and heat pump units have been improved to increase energy efficiency, a process which is still going on.

At present, the main application of heat pumps is space conditioning and hot water production. However, the acceptance of heat pumps in this market segment strongly depends on the support of electric utilities.

The Role of Utilities

Barriers for heat pump installations are investment costs, operating costs and the knowledge of consumers of the reliability and efficiency of heat pumps. Utilities can influence all these items and thereby support the market introduction of heat pump systems.

Utilities are suppliers of the drive energy for heat pumps, in most cases electricity. This offers the possibility of supporting heat pumps with special tariffs to demonstrate the importance of such heating systems, which are in strong competition with fossil-fuel fired boilers (in Austria, oil-fired boilers are the most common). Utilities can reduce both the demand charge and the operating costs by special tariffs for heat pump operation. However, it is not the task of utilities to react immediately to fluctuations of the oil price: Stable electricity prices are in the interest of the consumer who has taken his decision to utilize electricity, trusting in long-term calculations of electricity prices.

The role of utilities - only supplying the energy for driving heat pumps - gives them a neutral position with respect to heat pump manufacturers, distributors and installers; furthermore, this position is generally accepted by the consumer.

National Activities of Utilities

The neutrality of utilities allows them to become active in improving systems. They can carry out measurement and analysis programmes, and use the results for discussions with heat pump manufacturers and distributors to improve their systems. Analysis results can also be used to demonstrate to installers how to design more efficient systems.

In this way, the utility gains an expertise in heat pumps which it can use to support consumers against manufacturers and installers when systems fail to work in a satisfactory manner. By improving efficiency and reliability of heat pump systems, the reputation of such heating systems will be increased significantly and the market penetration of heat pumps will be accelerated.

A further task of utilities is to influence the setting up of national standards and regulations concerning heat pumps and heat pump systems. Their expertise can be helpful to establish standards which avoid heat pumps with poor efficiency and which give guidelines for installing heat pump systems for optimum reliability and efficiency.

Presently one of the major problems of heat pump utilization is the discussion on refrigerants. The fully halogenated chloro-fluoro-carbons (CFCs) are already prohibited, the main refrigerant used in residential heat pumps, HCFC-22, is also facing a ban. Utilities should support R&D in finding alternative working fluids - not so much in basic research but mainly in novel application techniques, and in their environmental impact. Utilities should help manufacturers and distributors to investigate possible alternatives, and to test alternative refrigerants in demonstration plants to ensure efficient and reliable operation of future systems. Large utilities can use their own laboratories to carry out such investigations. Others should cooperate in and jointly finance R&D. Results should be freely available to all interested parties and should be published.

International Exchange of Know-How

Beside these national activities it is necessary to cooperate with other utilities with the same or similar problems in establishing or supporting their heat pump market. One of the international platforms for this information exchange is the International Power Utility Heat Pump Committee (IPUHPC) which meets annually.

Figure 1: Newly Constructed Elementary School in Windischgarsten with Heat Pump and Electric Resistance Heater.

This Committee acts as a forum of know-how exchange for heat pump related problems concerning systems as well as effects of heat pumps on the supply grid. Ontario Hydro (Canada), for example, varies subsidies for heat pump installations according to the heat source and the operating mode, respectively. Systems with low peak demand - for example ground-source heat pumps - are preferred to outside-air heat pumps with direct electric heaters for peak load operation. In this way, power distribution on the grid can be more balanced. Other countries support retrofitting of electric resistance heating systems with heat pump systems. And each country can use experiences made by other members depending on their generation mix and their load characteristics.

Support of Heat Pump Installations

Based on national and international knowledge of heat pumps and heat pump systems, utilities can influence decisions on heating systems for commercial and residential buildings. Besides economy, the environmental issue has become more and more important - properly designed and sized heat pump systems offer the opportunity to avoid local emissions, and are a tool for limiting the greenhouse effect by reducing the use of fossil fuels.

The selection of heat pump heating systems often depends on providing reliable information for the consumer - utilities can influence this.

An example of a successful installation of a heat pump is the elementary school in Windischgarsten, Oberösterreich

Figure 2: Heat pump (HP) and Electric Resistance Heater (R) Operation for School Heating.

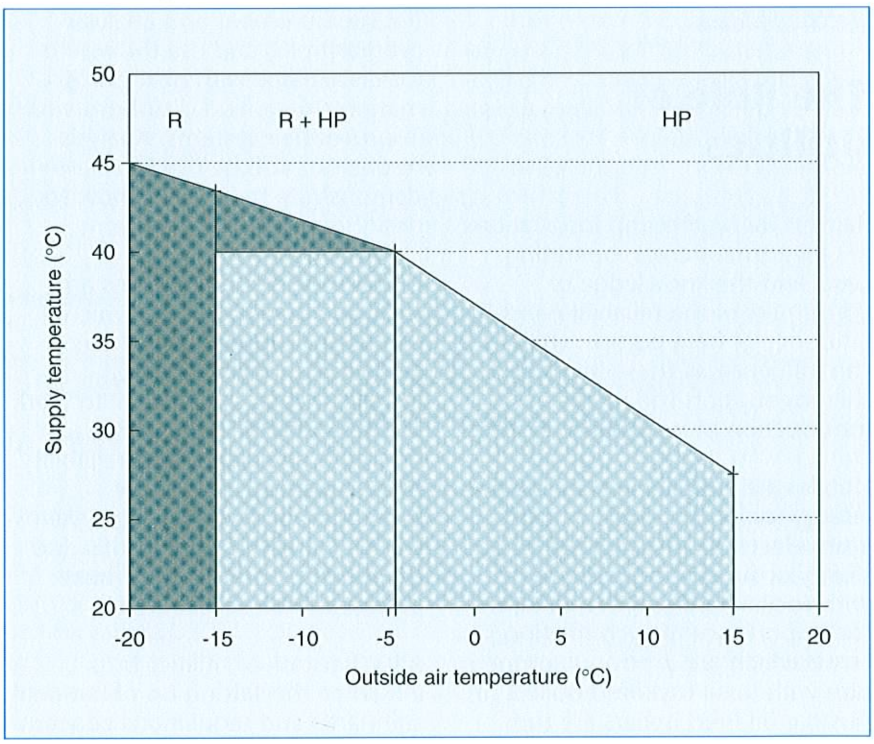


Figure 3: 27 Single-Family Houses in Vöcklamarkt, Oberösterreich, with Ground-Source Heat Pumps.

(see Figure 1). On the basis of a project carried out in the eighties, i.e. "Thermal end Energetic Improvement of School Building No. 1", it was easy to convince the local government to install an air-to-water heat pump system in the extension building. In combination with a computerized energy management system it was possible to reduce the annual energy demand of the school building to 21 kWh/m^2; conventionally heated school buildings require more than 50 kWh/m^2 per annum. Figure 2 shows the different operation modes of the heat pump and the direct resistance heater which is required for peak load operation.

Another example is a housing estate consisting of 27 single-family houses (Figure 3): After discussing a central oil-fired system and individual ground-source heat pumps, the decision was taken to install the heat pumps. The reason for choosing heat pumps was influenced by environmental consideration as well as by stable energy costs. Two types of heat pumps were used, brine/water heat pumps with a 120 m vertical probe, and direct-evaporation heat pumps with 180 m^2 horizontally installed collectors. The seasonal performance factor (SPF) of the brine system is above 3.3, the SPF of the direct-evaporation system is about 3.6.

Such reliable working systems are helpful to increase the reputation of heat pump systems. But such systems are also an important tool to improve the reputation of utilities which support the efficient utilization of electricity.

Conclusion

The role of utilities in promoting heat pumps is important for the development of a stable heat pump market. On the other hand the heat pump is an important tool for utilities to demonstrate the possibilities of efficient electricity utilization and to contribute to the improvement of the environmental situation by reducing the use of fossil fuels.

References

Schneeberger, M.F. (1985), Heat Pump Activities of an Austrian Electric Utility Company. HPC Newsletter, Vol. 3, No. 3, October 1985, 2-6.

Gilli, P.V. (1991), Heat Pumps and the Environment, Proceedings of the Workshop on Industrial Heat Pumps, Budapest, Hungary, October 1991. HPC-WR9. IEA HPC.

Zegers, Ir. P. (1991), Heat Pumps - an Option for an Energy Efficient and Clean Society. Commission of the European Communities, September 1991.

**Author:
W. A. Ritter, Head of Energy Conservation Department, Oberösterreichische Kraftwerke AG, Linz, Austria.*

Current Development and Market Penetration of Gas Heat Pumps in Japan

*M. Ogura

Introduction

One consequence of Japan's rapid economic growth has been a steep rise in energy demand, driven largely by domestic consumers. An increase in comfort demand and affluence, as well as the dilution of energy-saving consciousness means that consumption is expected to expand further in the public sector. The effective utilization of energy resources is thus urgently needed to combat energy supply and environmental issues. In Japan, Tokyo Gas and the other major city gas suppliers have exerted strenuous efforts for the improvement of efficiency in gas production, distribution, and of gas-consuming equipment and appliances. To this end, Tokyo Gas has been engaged in the development and dissemination of systems that reduce primary energy resource consumption and minimize losses by using unused energy.

This article describes the current status of development and penetration of gas heat pump systems (GHPs) in Japan, with special reference to small-size engine driven GHPs and to GHPs using unused energy sources.

Cascade Energy Utilization

Cascade thermal utilization systems such as cogeneration and gas heat pumps (GHPs) reduce primary energy consumption and waste heat losses by converting the high temperature energy of city gas with high efficiency, and utilizing the spent heat of engines and gas turbines for heating and hot water supply. Tokyo Gas is engaged in an extensive programme to develop and install high-efficiency GHPs. Furthermore, Tokyo Gas is

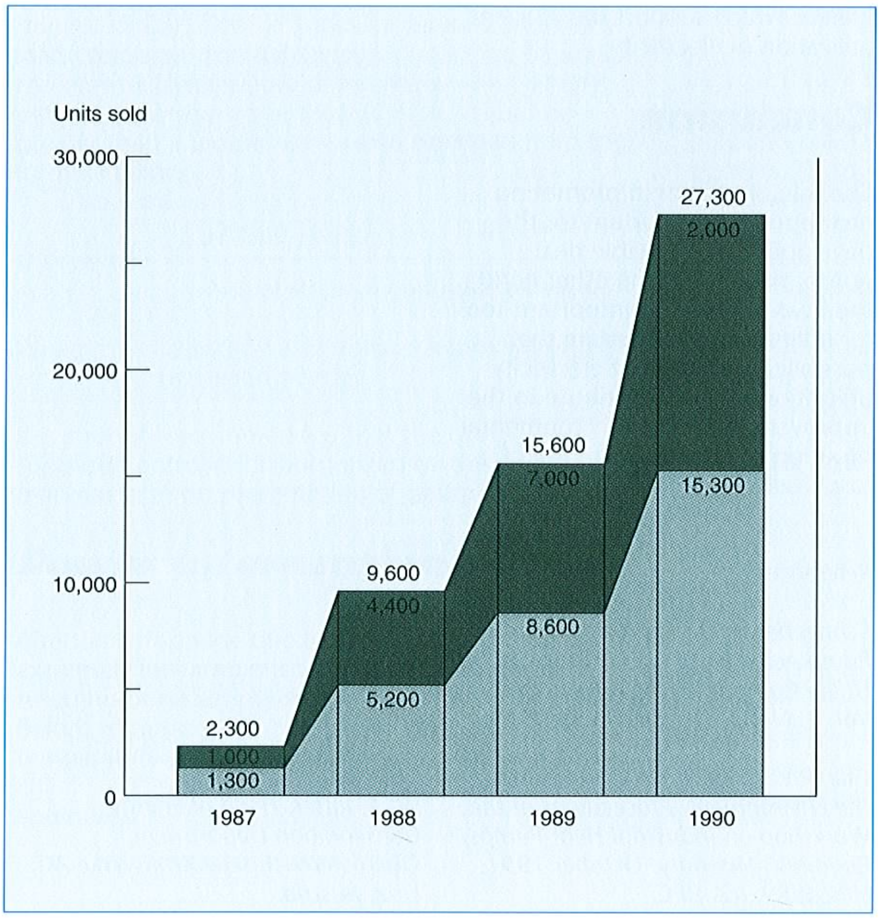


Figure 1: Sales Growth of GHPs Using City Gas (Upper Part) and LPG (Lower Part).

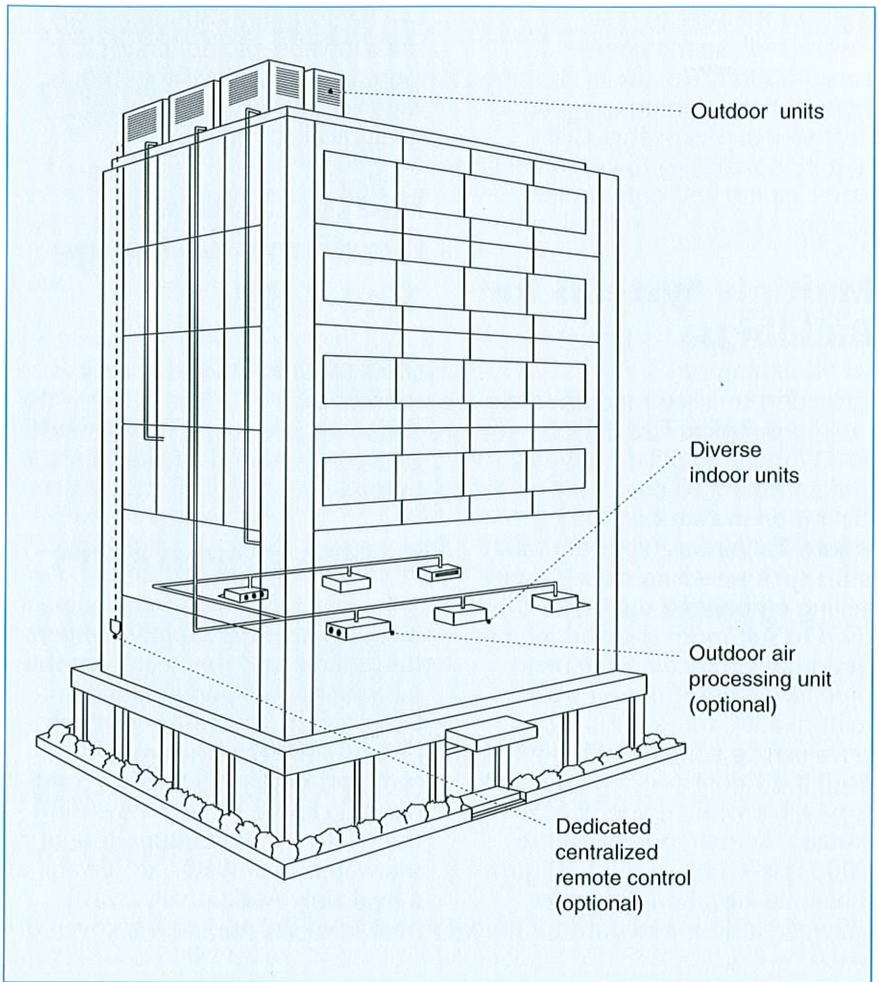


Figure 2: Building Multiple Unit Type GHP.

interested in utilizing the unused energy abundantly available from river water and sewage effluent.

Small-Size Gas Engine Heat Pumps

Background to GHP Introduction

In Japan, the market for small-size air conditioners has been on the increase in recent years. The output of packaged air conditioners in refrigeration year (RY) 1989 (Oct. 1989 - Sept. 1990) was approximately 786,000 units, of which heat pumps accounted for 75%, thus occupying an ever-increasing share in the space-heating market. Packaged air conditioners are expected to show market growth in terms of the number of units because of the constantly intensifying trend towards computerized office facilities and the increasing number of tall buildings in large cities. Since almost all the present packaged air conditioners are driven by electricity, their penetration aggravates the peak power consumption in summer, which is now a critical issue in Tokyo. In contrast, the city's gas supply needs are significantly lower in summer than in winter. Cultivating the use of gas for cooling is obviously the most effective way to mitigate this seasonal demand discrepancy. Tokyo Gas has therefore enthusiastically promoted the development of gas/driven refrigeration and air conditioning equipment. As a result, the development of large-size absorption refrigerators has advanced, and consequently large refrigeration demand has been acquired. As of the end of March 1989, demand was 1.4 million RT (refrigerant tons), marking a growth rate of 10% over the preceding year.

However, suitable equipment had to be developed to compete in the major market sector of small-to-medium-size air conditioning. Thus Tokyo Gas began substantial development work in GHPs in 1981, and introduced commercial products in 1987.

Commercial Product Development

As part of Japan's national energy policy the "Small-Size Gas Air Conditioning Technology Research Consortium" was established, in which a total of fifteen corporations including three major gas supply companies and twelve engine heat pump manufacturers participated. From 1981 to 1983, the Consortium was engaged in a development programme for air-source heat pumps with emphasis on gas engines and compressors. Following the development of prototypes, a commercialization project was started with the following objectives:

- reducing initial cost;
- decreasing operation noise and vibration;
- improving durability;
- reducing size and weight;
- enhancing maintainability.

As a result, an air-source engine heat pump with high thermal efficiency was developed of which the installation area was comparable with electrical heat pumps. Since 1987, nine models of small-size GHPs ranging from 1.5 to 15 kW, have been commercialized.

Market Status of GHPs

GHPs were first marketed in 1987, and sales have increased as shown in Figure 1 with a range of applications including offices, factories, stores, schools, hospitals, hotels, temples and sports facilities. Although the capacity range is still much less than with electrical heat pumps, GHPs have penetrated the market by offering several important advantages.

By effectively utilizing the waste heat from gas engines, GHPs exhibit higher energy efficiency. They are largely unaffected by outdoor air temperatures in winter and provide quick and vigorous space heating. Moreover, some models require no defrosting operation. Easy control of gas engine rpm leads to high partial-load efficiency thus ensuring highly efficient operation throughout the year.

Since a GHP requires no electric power except for its auxiliary units, it allows the user to save contracted electric power consumption. The use of dilatation type air conditioning using an air heat source means that GHPs require no cooling tower or cooling water piping and only coolant piping.

Multiple Systems for Buildings

Targeting small-to-medium-scale buildings, Tokyo Gas developed a 15 kW multiple building type GHP and commenced commercialization in October 1991 (see Figure 2). Various types of indoor units such as ceiling cassette and ceiling embedded duct type can be used to suit room size and interior design. By branching the main pipe for an outdoor unit with a joint header, three to six indoor units can be connected together. Both individual and central control is possible with engine speeds variable in the range of 700 to 2000 rpm with a step of 50 rpm. Since the elevation difference between indoor and outdoor units can be as high as 30 meters, and the allowable piping length is as long as 85 meters, the system is suited to a wide variety of geological conditions.

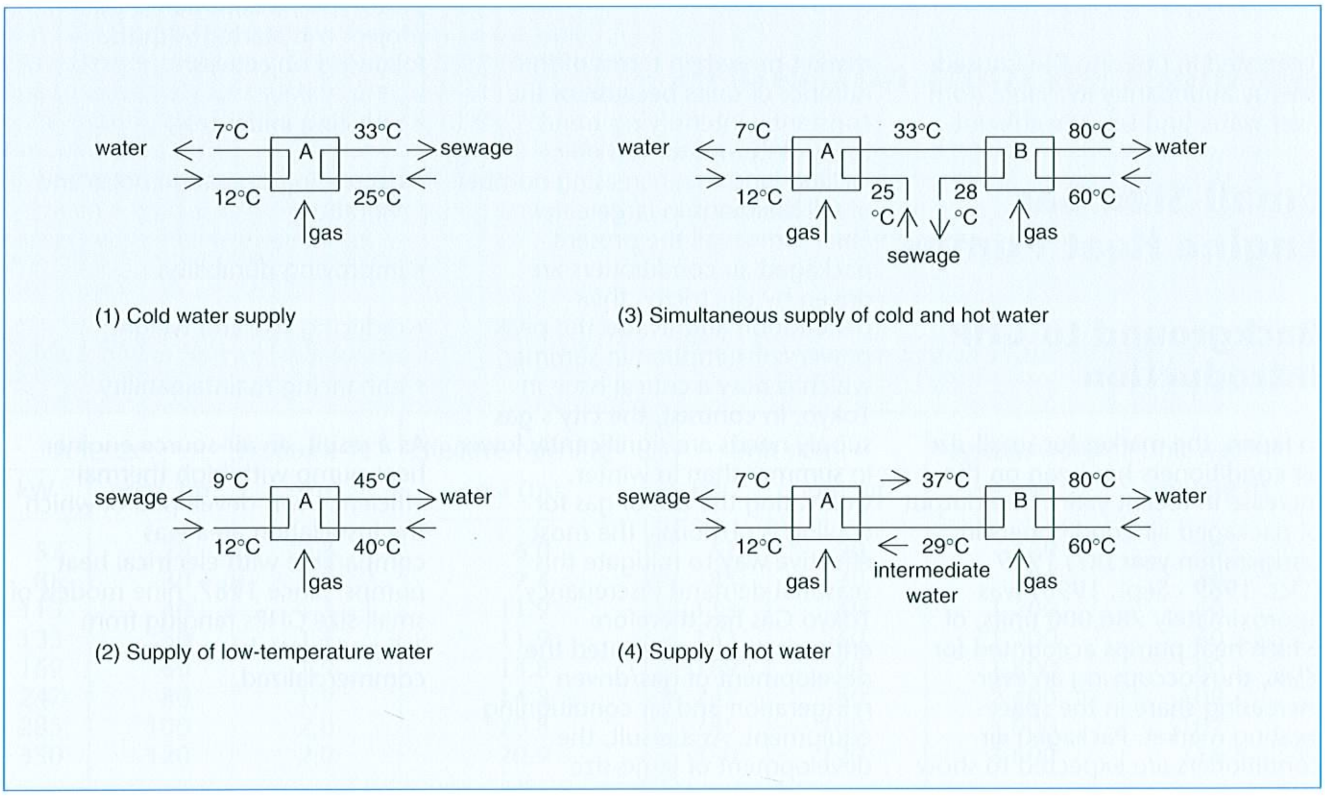
Water-Source Medium-to-Large Size GHPs

GHPs utilizing unused energy sources such as sea and river water and sewage effluent include both engine driven and absorption heat pumps.

Engine Driven GHPs

By using heat from a low temperature source and the heat from the gas engine itself, engine driven GHPs achieve an extremely high performance factor in winter. In summer, highly efficient air conditioning can be achieved by using the relatively low temperature of sea water, river water, or sewage as a heat sink. Additionally, waste heat from the engine is recovered

Figure 3: Functions of the New, Heat-up Type Absorption Heat Pump.



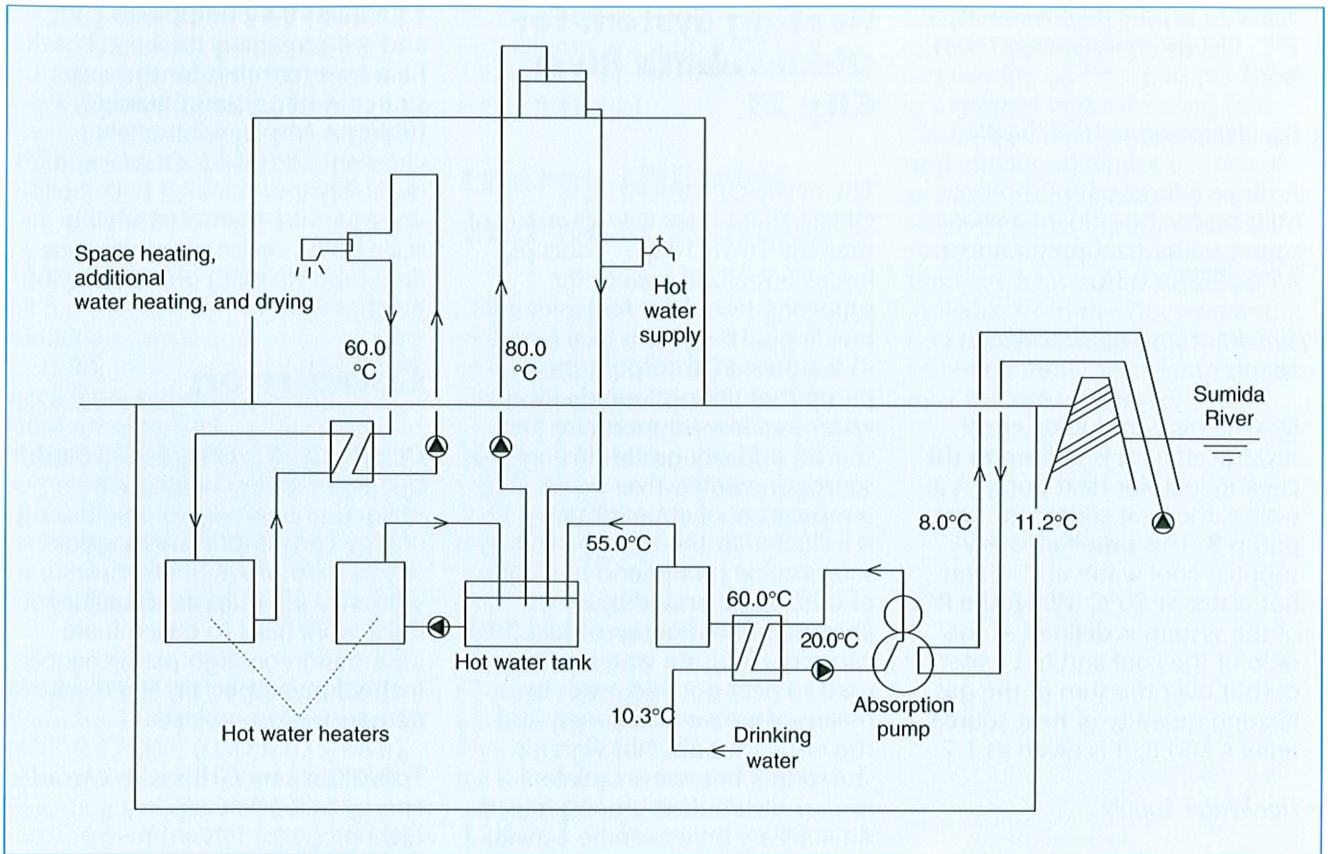


Figure 4: Configuration of Heat Source Units for a River Water Utilization System (Ohkawabata River City).

to generate hot water or steam or to drive absorption chillers with a very high performance factor.

Since hot water at a temperature of 85°C or higher can be obtained from the jacket of a gas engine and steam from waste gas, the system can meet a wide variety of heat demand. Efficiency can be further improved by controlling engine rpm.

With gas engines, high efficiency is maintained even when the rpm drops. Moreover, compressor, condenser and evaporator efficiency generally increase with a decrease of rpm and coolant circulation rate, so that the overall efficiency of the system is enhanced under partial loading.

High Temperature Engine Driven GHP

Recovering heat from hot water at a temperature of 80°C or higher using conventional compression type heat pumps requires the use of restricted refrigerants such as CFC-12 and CFC-114. The new heat-up type GHP currently under joint development by Maekawa Manufacturing and Tokyo Gas uses a mixture of non-restricted refrigerants (HCFC-22, HCFC-142b and some others) in order to recover hot water at 80°C with high efficiency. Moreover, this advanced heat pump provides cooling using the heat from the heat pump compressor and gas engine waste heat, to drive a newly developed absorption type refrigerator. Also, it features simultaneous supply of cold and hot water (Compound type heat pump).

Absorption GHPs

The "Class 1" absorption type heat pump consists of an evaporator, absorber, condenser, regenerator and a heat exchanger. It incorporates water as refrigerant and lithium bromide as absorbing agent, and operates at subatmospheric pressure. Six companies now supply absorption heat pumps in different capacities ranging from 0.35 to 9.3 MW. So far more than 100 units have been installed.

Sewage Water System

A new heat-up type absorption heat pump jointly developed by Tokyo Gas and Sanyo Electric is a system that can provide both space heating and air conditioning as well as hot water supply using sewage water as heat source/sink. The system can be switched between single and duplex effect operation to provide four operating modes (see Figure 3):

- *Cooling Water Supply*

  A single effect refrigeration cycle utilizes sewage effluent as cooling water to supply cool water at 7°C. PER (primary energy ratio) is 1.1.

- *Low-temperature Heat Supply*

  A single effect heat pump cycle utilizes sewage effluent as heat source water to supply water at 45°C. PER is 1.35.

- *Simultaneous Cool/Hot Water Supply*

  By switching to duplex effect, sewage effluent is utilized as the cooling load for heat pump A as well as the heat source for heat pump B. This simultaneously supplies cool water at 7°C and hot water at 80°C. When the PER of the system is defined as the ratio of the cool and hot water output over the sum of the gas heating quantity of heat source units A and B, it is given as 1.2.

- *Hot Water Supply*

  Sewage effluent is utilized as the heat source for heat pump A. In order to first generate intermediate lukewarm water at 37°C and then to produce hot water at 80°C using heat pump B. The PER of this "two-stage heat-up type cycle system" is 1.05.

Demonstration Test

To conduct a demonstration test of this system, test equipment was installed at the premises of Tokyo Gas and various data were obtained for each mode. In the demonstration test, the items requiring special attention were the operation limit and the PER value. With aqueous lithium bromide solution employed as the operating medium, the heating temperature was set to a maximum of 160°C and the maximum concentration was set to 65%. The maximum pressure was set to match atmospheric pressure.

Heating System for Ohkawabata River City 21

The newly constructed Ohkawabata River City 21, (part of the "My Town Tokyo" concept) has a centralized system for supplying hot water for residential buildings. The system (see Figure 4) features an absorption heat pump that utilizes Sumida River water as a low-temperature heat source, and city gas as driving heat source. In winter, river water at a temperature of approximately 11°C is inducted to the energy plant by a submersible pump, and hot water of 60°C is generated by an absorption heat pump of 580 MW capacity. That hot water is then used to heat potable water by means of a heat exchanger, and the resultant 55°C hot water is stored in a hot water tank for further distribution among houses. An auxiliary boiler can be activated to supply hot water at 80°C to meet extra demands of space heating and additional bath heating as well as for bathroom drying. The test results prior to the delivery of the system indicate that the PER value with the predicted minimum water temperature of 8°C is l.3, and is l.7 with the maximum water temperature of 29°C. With these test results, the annual PER value of the absorption heat pump is calculated to be 1.4, which suggests that the new system saves primary energy by approximately 40% as compared with conventional gas boiler systems.

The Sumida River water near Ohkawabata River City can be termed as dilute sea water by the results of water quality analysis. Further, a survey of temperature fluctuation throughout the year revealed that the fluctuation is within the range between 8°C and 29°C. The river water quantity requirement is 700 m^3/day or 60 m^3/h. The water intake is provided by a pressurized pumping system with submersible pumps. Foreign matter is removed by bar screens at each pump pit, and by equipping the pumps with cutters and self-screening strainers. For the heat transfer tubes for the heat source water system, titanium tubing is employed. It offers excellent corrosion resistance, high durability and minimal scale build-up. As a measure for removing scale in the evaporator, a reverse-flow tube cleaning unit with nylon brushes is used.

Conclusion

Despite the current trend towards better amenities, utilities are obliged to find ways of minimizing energy consumption. Alongside efforts to improve the technical efficiency of equipment, utilities must work hard to disseminate information on high performance technology, especially the results of demonstration projects.

Tokyo Gas sees GHPs with cascade energy utilization as a key technology for future energy-saving systems. Japan now has a diverse assortment of both absorption and gas-engine GHPs available, all using city gas as fuel, and exhibiting good applicability as well as excellent efficiency. Promotion of both the development and deployment of this technology is now a main priority for Tokyo Gas.

**Author:*
M. Ogura, Tokyo Gas Co., Ltd., Tokyo, Japan.

Heat Pumps Aimed at Load Levelling

*K. Kishida

Introduction

In recent years, in order to secure a stable supply of electric power and satisfy increasingly diversifying customer needs, it has become necessary to decrease the cost of supply. To attain it, it is necessary to hold down the ever-rising summer peak or daytime peak load and shift it. Therefore, Kansai Electric Power Co., Inc. is recommending customers to adopt heat storage type heat pump systems which can contribute to load levelling. This article describes the circumstances which led to Kansai Electric's load levelling activities and its approach to load levelling.

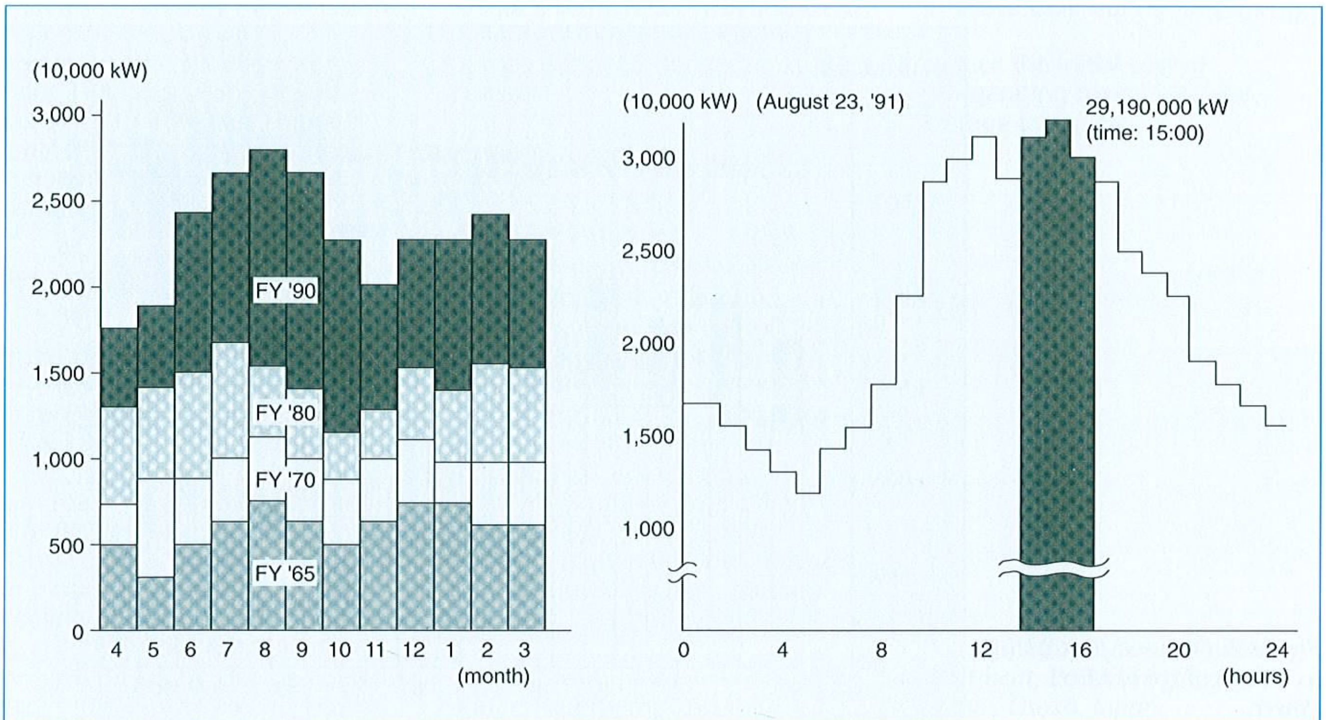
Transition of Demand for Electric Power

The recent expansion of Japan's economy, led by favourable domestic demand has resulted in an increase in private energy consuming equipment and a sharp rise in electric power demand. Electric power sold by Kansai Electric Power (see Figure 1) totalled 112 TWh in fiscal 1989 and 120 TWh in fiscal 1990, up about 4% and 7%, respectively, over the preceding years. Peak power amounted to 22.47 GW in fiscal 1989, 27.88 GW in 1990, and 29.19 GW in 1991, up about 2%, 13% and 5%, respectively, over the preceding year. The growth rate in fiscal 1990 was particularly significant, representing a 3.11 GW increase on 1989.

Load Levelling

The expanding peak power, due mainly to daytime cooling demand, lowers the rate of operation of electric power facilities, and causes electric tariffs to increase. With atomic power stations, which require a high rate of equipment operation, satisfying an increasing share of power demand, it is most important to take steps, such as shifting consumption to night-time and tapping potential night-time demand, to level the power consumption curve over a 24 hour period. Measures for improving the load factor (to increase the rate of operation) are extremely important to electric power services, and Kansai Electric Power is endeavouring to improve the load factor by the following means:

Figure 1: Electric Power Demand Trends: (left) Max. Monthly Demand; (right) Power Demand on the Day when Max. Power Occurred.



- An electric tariff system to shift demand to night-time by, for instance, providing customers with significant discount on night-time rates;
- Promoting increased employment of heat storage heat pump systems through advice and consultation;
- Involvement in district heating/cooling (DHC) systems.

Electric tariff agreements include:

- commercial heat storage adjustment;
- regular time adjustment;
- industrial heat storage adjustment.

These adjustments are suited to systems that store electric power at night in the form of thermal energy, and discharge it in the daytime to satisfy cooling demand. The system is widely applicable and is most effective when combined with highly energy-efficient heat pump systems.

Heat Storage Heat Pump (HSHP)

The features of a "heat storage heat pump" may be enumerated as follows:

1. Reduced construction cost: equipment costs are lower due to reduced capacity of the heat source unit and power receiving /transforming equipment. In addition, machine room space is reduced.
2. By utilizing cheap night-time power, customers benefit from reduced electricity bills.
3. By operating a heat source unit under a high load, efficiency can be improved.
4. Easy to perform partial load operation.
5. Quick response to load increases.
6. Easy to take countersteps against heat source problems.
7. Water in the heat storage tank can be used for fire fighting.

Expanding the Diffusion of HSHPs

Since the share of cooling demand as a percentage of peak electric power reaches some 40% (see Figure 2), expanded diffusion of heat storage heat pump systems using water or ice for heat storage - used mainly as building air conditioning systems - is the most effective measure for load levelling. It is also advantageous in that customers can utilize clean, cheap and stable electric power.

To increase the benefits to suppliers and customers, Kansai Electric Power has made an all-out effort for achieving more load levelling mainly by developing the following activities:

- PR and consulting activities conducted by visiting building owners, general contractors, design offices, etc. and recommending them to adopt heat storage systems.
- Comparing the economic merits of various heat sources for air conditioning according to installation location - offices, department stores, hospitals,

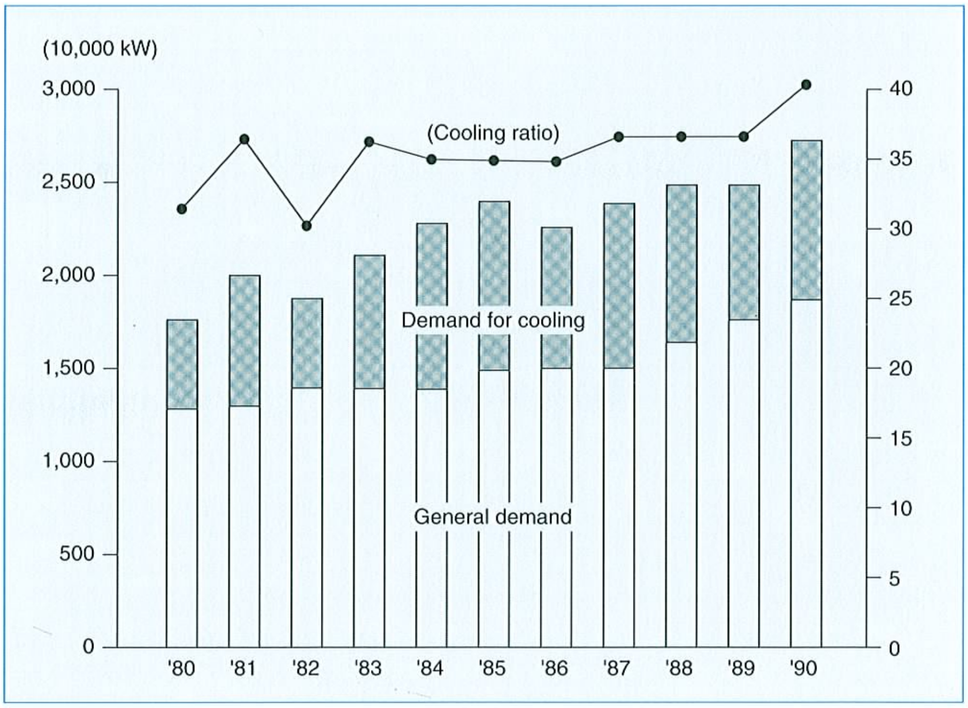


Figure 2: Demand for Cooling as a Percentage of Max. Power.

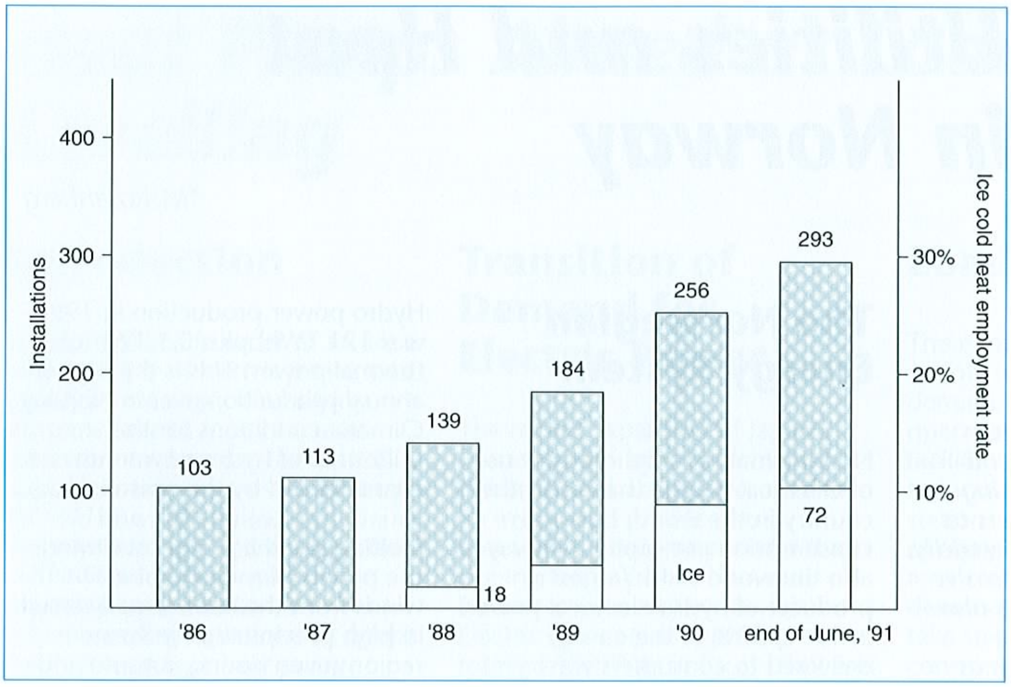


Figure 3: Entries in the Heat Storage Adjustment Agreement.

halls, etc. - and proposing the most economic system.

- General consultation on electric power supply matters.

Thanks to these efforts, coupled with technological development and improvement of heat storage systems by machinery manufacturers, general contractors, etc., the number of heat storage systems covered by Kansai Electric's heat storage adjustment agreement has steadily increased since 1988 at a yearly growth of about 20 to 30% (see Figure 3). In June 1991, the figure reached 293, including both industrial and commercial sectors.

Installations

Installations of ice heat storage systems have increased remarkably in recent years, jumping from 18 in fiscal 1988 to 72 as of the end of 1991. Furthermore, in order to contribute to improvements in regional infrastructures in general, Kansai Electric is also endeavouring to participate in district heating/ cooling (DHC) systems through heat supply. Participation in DHC systems driven by electric power is very significant to electric power suppliers, since it contributes a great deal to load levelling. Since DHC systems can utilize unused energies - e.g. energy derived from sea water, river water and sewage (which are cooler than air in summer and warmer than air in winter), and from waste heat from garbage incinerating plants, subway stations, etc. - they can contribute to improved efficiency of energy utilization. At present, Kansai Electric is constructing DHC systems with heat storage heat pumps using ice storage tanks in Osaka.

Future Prospects

Although installations of heat storage systems have increased steadily, for further diffusion, it is necessary to develop the existing heat storage adjustment system into a more customer-oriented system. Furthermore, consulting activities must be improved. Although ice storage systems require less running costs than conventional systems, their relatively high initial cost, means their diffusion has been partially impeded.

The following measures need to be undertaken to improve this:

- establish technologies for low-temperature air blowing, and water feeding, etc. to effectively utilize the low temperature energy of ice heat storage systems;
- develop optimum control technologies such as load prediction for ice heat storage systems;
- improve COP during ice making;
- reduce the initial cost of refrigerating machines, heat storage tanks, etc.

**Author:*
K. Kishida, Market Development Department, Kansai Electric Power Co., Inc., Osaka, Japan.

Energy Utilities and Heat Pumps in Norway

*M. Rosenberg

Introduction

With electricity in Norway generated almost entirely from hydro power, government and utilities in Norway are working hard to encourage consumers to switch from fossil fuels to electricity. But, as the world's most intensive user of electricity, Norway is also taking measures to promote efficient energy systems such as district heating and cooling using heat pumps.

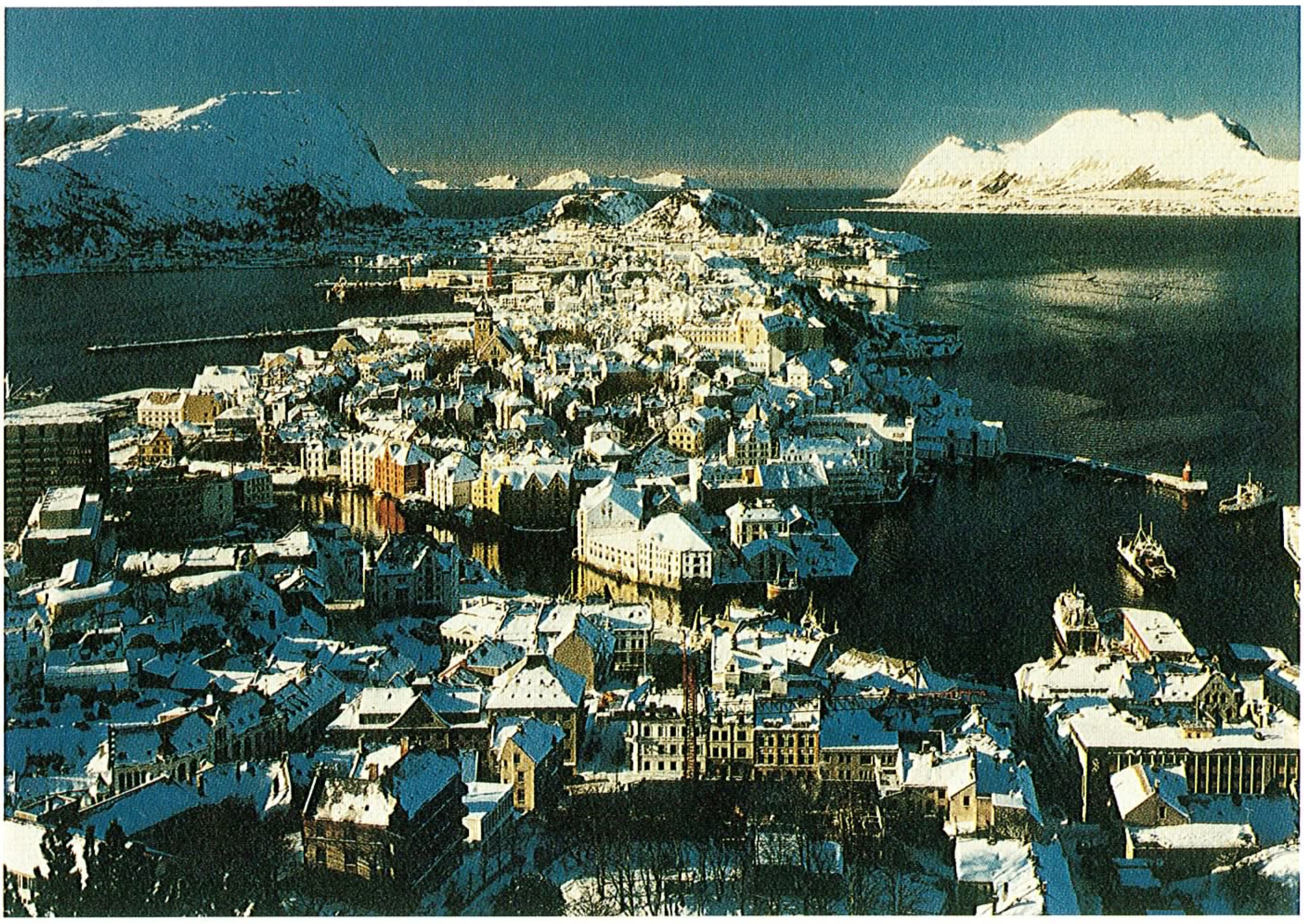
The Norwegian Energy System

Norway makes more intensive use of electrical energy than any other country in the world, based on consumption per capita. Norway is also the world's fifth largest producer of hydro electrical power. In 1990, 50% of the energy delivered to consumers was electricity. Petroleum products covered 38% and solid fuels 12%. District heating represents approximately 0.5%.

Hydro power production in 1990 was 121 TWh, plus 0,5 TWh of thermal power. This is the highest annual production ever in Norway. Climatic conditions for the utilization of hydro power are characterized by the seasonal variations. Precipitation and melting snow are highest during the period May to October. Mild winds from the sea normally result in high precipitation in western regions even during autumn and early winter.

The gross firm power consumption (consumption of standard hydro-

The City of Ålesund, Norway, is Served by a District Heating System with a Heat Pump.



electric power) was 99,3 TWh in 1990. The total consumption of occasional power (surplus hydro-electric power resulting from favourable conditions and sold tax-free) for electric boilers has been estimated at 6,1 TWh in 1990. The sale of light fuels has been reduced by more than 40% from 1980 to 1990, while the sale of heavy fuel oil has reduced by over 70%. These reductions are due to a mild winter in 1990, increased consumption of occasional power and a substitution of fuel oils by firm hydro-electric power. Throughout the summer it was necessary to let considerable quantities of water by-pass operational machines, resulting in a production loss of more than 6 TWh.

The average price for electric power (01.01.91) delivered to households and agriculture was NOK 0.47 kWh (USD 0.075/kWh), all taxes included. Several utilities have begun experiments with rebates to domestic customers with a relatively high electricity consumption level. This must be viewed against the background of a favourable power balance and a desire to substitute oil by electricity.

The Government and Heat Pumps

The environmental effects of energy consumption have been at the centre of discussions concerning energy policy during recent years. In Norway, this increased environmental concern has lead to an energy policy to reduce the use of fossils fuels. Greater weight is given to the development of renewable and environmentally sound sources of energy. The Government now promotes the use of heat pumps and the development of CFC alternatives. The Government has proposed an arrangement with subsidies for energy-saving measures in commercial and industrial premises and a preliminary loans arrangement for energy-saving in the private housing sector. Heat pump installations are supported with subsidies of up to 40% of the investment cost.

Energy Utilities and Heat Pumps

There are about 215 energy utilities in Norway. The seven largest utilities supply about 31% of the subscribers. The 51 utilities with 10,000 or more subscribers, supply about 72% of the subscribers. During the past five years, many electrical utilities have changed name to become energy companies. These companies are now responsible for energy production and distribution in general, not only electricity. All energy systems are considered for each new area of development. The system which offers the lowest overall cost (and consumer price) will be selected, unless environmental or other aspects are of greater importance.

Today, many district heating and cooling projects based on heat pumps have a lower cost compared to new hydro power with electric heating and individually driven air conditioners. However, energy utilities are reluctant to invest in this technology. The main reasons are:

- For energy utilities, heat pumps and district heating/cooling systems are new technologies which they are not used to. It is much easier for the utilities to work with direct electrical heating than heat pumps;
- In Norway today, there is a surplus of electricity from hydro power and the price level for electricity is relatively low. This makes it difficult for energy utilities to make an investment that may not give a payback for the next 10-15 years.
- The low oil price means that heat pumps are only financially beneficial in industries with a long utilization period.

Despite these drawbacks, energy utilities are building up their knowledge on heat pumps. There is a general understanding that centralized heat pumps for heating and cooling minimize the use of primary energy resources. And, the environmental aspects of these systems cannot be underestimated. With the heat pump subsidies available from the Government, it is expected that utilities in Norway will build more heat pump systems over the next few years.

*Author:
M. Rosenberg, The Federation of Norwegian Energy Utilities, Oslo, Norway.*

Licensing Requirements for Installation, Servicing, and Maintenance Personnel

*R.Aarlien

Introduction

The Norwegian heat pump and refrigeration industry strongly advocates the introduction of licensing requirements for personnel performing servicing, maintenance and installation of heating and cooling units containing CFCs and other ozone destructive refrigerants. This should be done by Government-imposed regulations, they say, and claim that without such regulations, the goals of CFC emission reductions, according to the Montreal Protocol and the Norwegian Government, will not be achieved. So far the Government has not acted, preferring that the various CFC consuming industries deal with this problem themselves - on a voluntary basis. It is expected, however, that licensing will be introduced, but it is still unclear which body will organize and enforce it. Once introduced, such a programme would aim at both lowering refrigerant releases and at increasing product quality.

Background

From January, 1992, buyers of heat pumps in Norway may be granted a 40% investment subsidy. This is a direct result of both the Government's willingness to support the introduction of energy efficient technologies and its desire to reduce CO_2 emissions. No doubt, this will spur heat pump sales. However, sceptics believe it will be extremely difficult for Norway to achieve its objective of reducing CFC- and HCFC consumption, according to self-imposed goals, at a pace that is faster than that set out in the Montreal Protocol.

In 1986, the base year for CFC reduction, the refrigeration and heat pump industry was responsible for 19.8% (or 298 tonnes) of total Norwegian CFC consumption (which was 1,508 tonnes). Since these goals were established, Norway has successfully reduced total consumption by 71.5% and is, consequently well ahead of even the more stringent reduction demands imposed by the London Agreement of June 1990 (see Figure). However, the refrigeration and heat pump industry's share of total consumption has grown to roughly 55%, although some reduction measures have been successfully implemented. In 1991, absolute consumption within heat pumping technologies was down 64 tonnes compared to 1986. It is believed that approximately 10% of the refrigerant volume still escapes through leakages and by accidents every year, and this has heated the discussion on introducing licensing requirements for installation, servicing, and maintenance personnel.

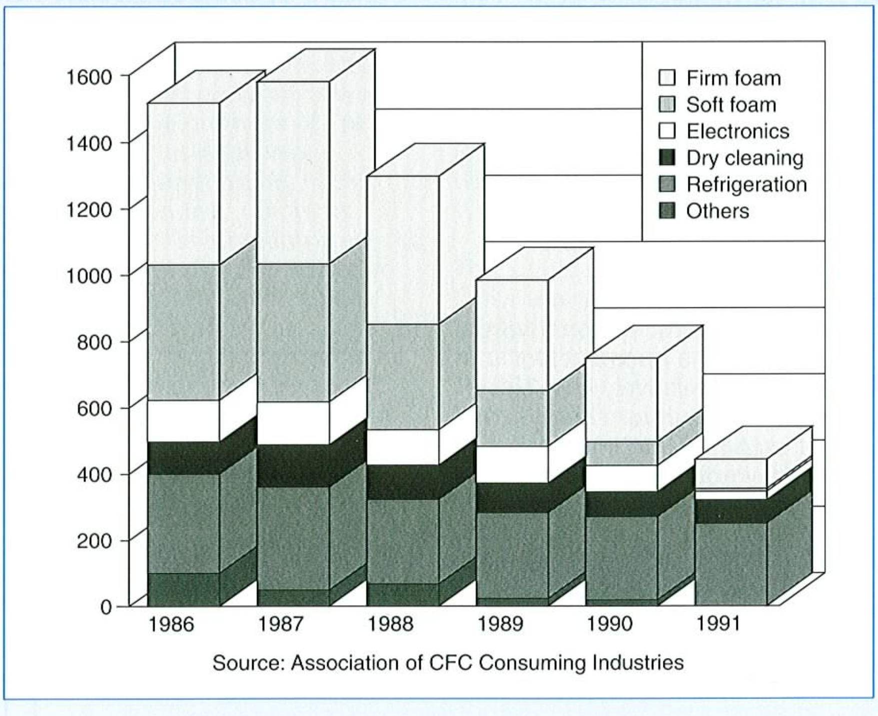


Figure 1: Norwegian CFC Consumption (ODP tonnes/yr)

Norwegian Refrigeration Code of Good Practice

One impediment for increasing heat pump sales in Norway has probably been the occasionally mediocre quality of installation and servicing. This is the result of strong price competition and, to some degree, sloppy work.

The Norwegian Heat Pump Association (NOVAP) and the Norwegian Association of Refrigeration Contractors (KELF), among others, have acknowledged this problem. Both associations, with the aid of the Norwegian Refrigeration Code of Good Practice, have initiated projects to improve installation and maintenance routines. The Code states that owners of heat pumps and refrigeration units must hire licensed, qualified personnel for all servicing, including charging and discharging of refrigerants. A problem, however, is the absence of rules and regulations concerning licensing. There are no exact definition of the words "qualified" and "licensed", and consequently, the Code is not enforced.

Why Licensing of Servicing Personnel?

There are several reasons for promoting the introduction of licensing requirements:

CFC Emission Reduction

Even though a 71% cut in consumption has been realized since 1986 on a voluntary basis, proponents believe it will be virtually impossible for the heat pump and refrigeration industry to achieve the goals without imposing requirements for servicing personnel.

Product Quality

The introduction of licensing will increase customer satisfaction, due to better product quality, and this will in turn stimulate the demand for heat pumps. A general fear at the moment is that the investment subsidy programme will encourage companies with limited or no knowledge about heat pumps to start selling equipment with little concern about product quality and customer satisfaction.

Quality Recognition

Third, licensing would also be recognized as a "stamp of quality" for companies in the business, and this would be an invaluable asset in conducting business both inside and outside the Norwegian heat pump market. This has been one of the major driving forces within the industry for promoting licensing. On the international front, a standard set by CEN (European Committee for Standardization) will soon be issued. While the final version is not yet introduced, the draft Standard sets specific requirements to both companies and personnel working on machinery containing CFCs. With such a standard in effect, it is important for Norway to either comply with the international standards or to establish its own.

Split Opinions

Companies do disagree about licensing as a requirement. At the moment there are roughly 200 companies of different sizes in the Norwegian heat pump and refrigeration industry. In general, the larger companies support such a programme and see great potential for improvements, benefits, and increased market share. However, the smaller the company, the greater is the resistance, due to fear of an increased work load, more expensive operations, and lost competition. Still, the general attitude is relatively positive.

A Question for Parliament

The question of whether the Government should impose licensing requirements has also been raised in the Norwegian Parliament. The Minister of Environmental Affairs stated that he would prefer self-imposed regulations within each industry instead of regulations coming from the Government. The Ministry is of the opinion that the responsibility to comply with the goals set by the Government rests with industry, with each sector deciding its own course of action. More directly, the Minister said that he expects the question of licensing to be given high priority.

This article is based on:

1) *KFK-brukernes fellesutvalg: KFK-statistikk*

2) *Kuldeautorisasjon opp i Stortinget, KULDE nr. 6/91*

3) *KFK-forskriftene krever autorisasjon og sertifisering, KULDE nr. 6/91*

**Author:*
R. Aarlien, SINTEF Refrigeration Engineering, Norwegian National Team.

Tips for Installation of Air-to-Water Heat Pumps

*K. Sato

Introduction

Field experiences show that air-to-water heat pumps require special attention to the entire system when installed in cold climates. Generally, equipment manufacturers provide installation and start-up instruction manuals on their factory-assembled heat pumps. Most manuals describe installation methods, precautions and warnings as to unit handling for example, but they normally cover only limited information about special applications of the units.

Neglect of manufacturer's instructions will often lead to such serious troubles as repeated compressor failures and insufficient heating. This article discusses a few examples of important design considerations and recommendations gained by Toyo Carrier's field experience, which would be of practical use in designing a trouble-free system with air-to-water heat pumps.

Sound Barrier Installation

Many situations require sound barriers around an outdoor heat pump unit to prevent noise problems. When erecting sound barriers, consideration must be given to providing sufficient air flow space around the unit (see Figure 1). Insufficient air flow to the unit causes major problems. Compressor failures can occur due to extremely low suction pressures in the heating cycle causing excessive superheating of the refrigerant vapour and reducing the motor cooling effect. Table 1 gives the minimum recommended distance (L) between a typical air-to-water heat pump and sound barriers with effective openings.

The maximum height of the barrier or fence is shown in Figure 1. If distance "L" is not available between the unit and the barrier, the shortage (α) should be compensated by providing an opening on the lower part of the fence (see Figure 1).

The height of the barrier should not exceed 0.5 m above the unit top. If the barrier or fence exceeds this limit, a discharge air duct should be installed at least 0.5 m higher than the top of the fence.

Discharge Air Duct

The discharge air duct should be designed so that the maximum static pressure loss is kept within the available static pressures of the unit fans. The air duct needs a partition for each fan or each group of fans per circuit (Figure 2) to prevent operating fan(s) from interfering with inoperative fan(s).

Enclosed Unit

When enclosing the unit with sound barriers and overhead roofs, an adequate area of opening must be provided on the lower part of the barrier. The effective area of opening should be equal to or greater than the value shown in Table 1. As mentioned above, the discharge air duct should be partitioned for each fan or each circuit to prevent interference among fans.

Protection from Ice Build Up

When determining the height of the unit base, the potential depth of snowfall in the location must be considered. Concrete base and curbs should be used to raise the unit above the ground.

Table 1: Sound Barrier Dimensions.

Unit size		Distance "L"	Effective opening
kW	nom. hp	(m)	area (m)
57	20	0.8	6.0
85	30	1.0	7.4
113	40	1.5	11.9
133	50	1.5	11.9
169	60	1.9	14.8
247	80	1.9	14.8
285	100	2.0	20.8
350	120	2.0	20.9

Table 2: Minimum System Water Volume.

Unit size		System water	Unit water
kW	nom. hp	volume (l)	volume (l)
57	20	600	30
85	30	900	40
113	40	1,200	60
133	50	1,200	60
169	60	1,800	80
247	80	2,400	109
285	100	3,000	107
350	120	3,600	116

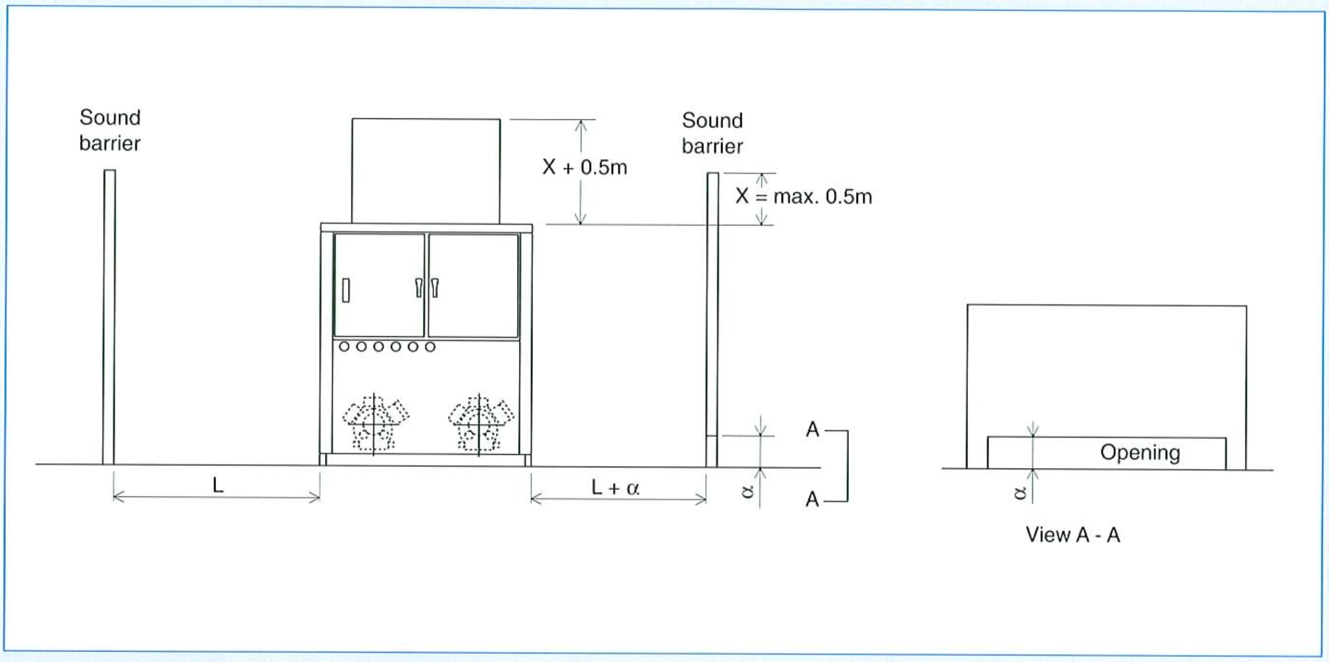


Figure 1: Air Flow Space.

System Water Volume

Figure 3 shows a typical air-to-water heat pump system. The entire system must maintain sufficient water volume to prevent a rapid cycling of the compressor and provide enough energy to defrost the coils. Table 2 shows the minimum water volume to be held in the system according to unit size.

The system water volume is the minimum amount of water needed to maintain proper operation of the heat pump circuit (above the broken line in Figure 3).

Even when the 3-way valve completely closes, the heat pump circuit must hold enough water volume to allow the unit to run for 5 minutes without load.

When the heat pump is inoperative, e.g. due to too low an ambient temperature, the hot water from the boiler must not be allowed into the heat pump unit. Standard air-to-water heat pumps are normally designed to be used for constant water flow with an allowance of ± 10% and therefore, should never be used for variable water flow.

Water Temperature Control

On general principles, the factory-installed temperature controller should always be used. The controller is normally factory-set to control the temperature of return water to the unit. The field-supplied controllers should sense the return water and the thermostat differential must be set so that one

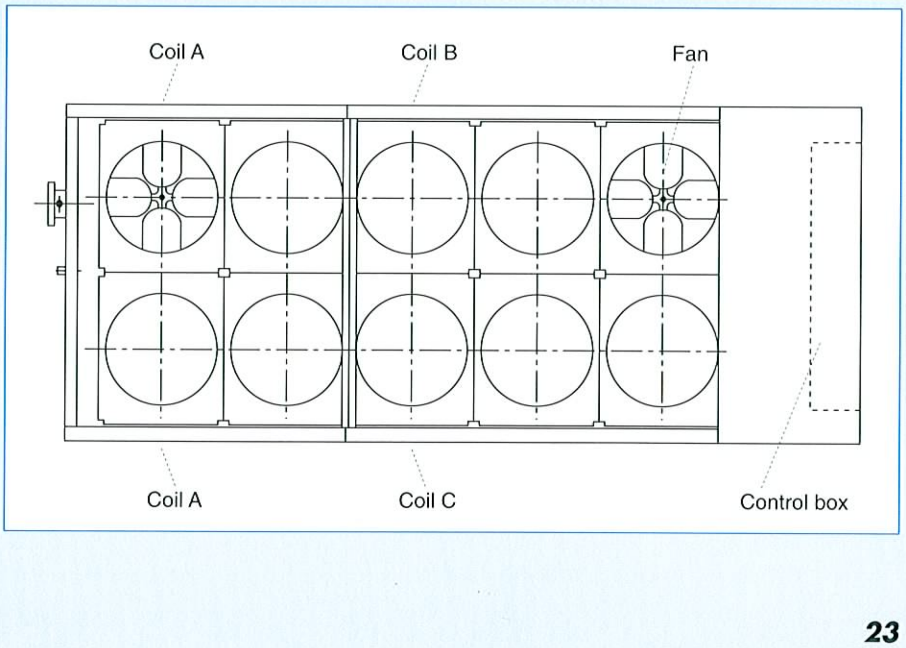


Figure 2: Multiple-Fan Unit.

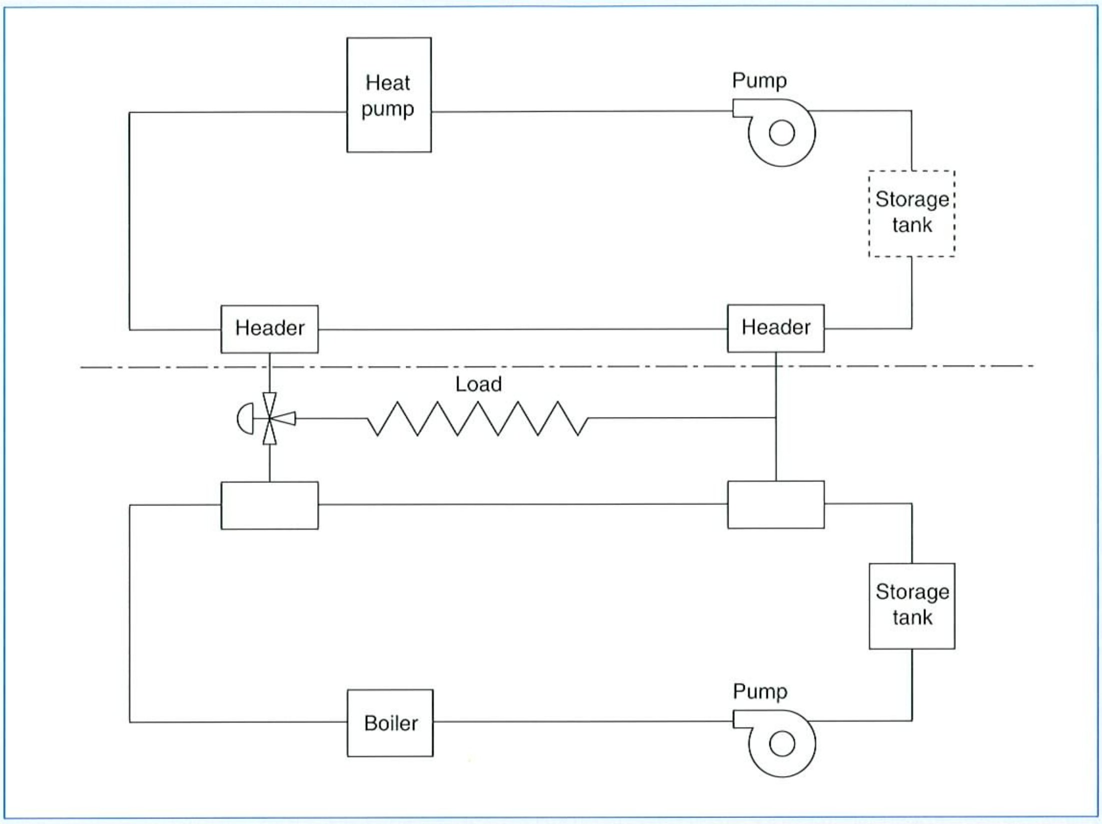


Figure 3: Air-to-Water Heat Pump System.

cycle (ON-OFF-ON) will be over 15 min. (OFF for 3 min. or longer, ON for 5 min. or longer) under any load condition. The thermostat should not be set for too narrow temperature differentials. The ON-OFF differential within a thermostat stage should be greater than a temperature value obtained from the formula below:

$$\text{Differential} \geq \frac{\text{Design Temperature Difference } (\Delta t)}{\text{No. of steps of controller (Max. 4)}}$$

Where Δt = Leaving water temp. − return water temp. (in heating cycle)

It is strongly recommended that the use of a field-supplied controller be authorized by the unit manufacturer on presentation of design documents.

Power Interruption

After unit stoppage due to power interruption or extremely low ambient temperature, automatic resetting or restarting of the unit is not recommended. Before restarting the unit, the oil level and temperature in the compressor crankcase must be checked. This should be done by a qualified service engineer.

Conclusion

Any air-source heat pump should be able to operate under severe winter conditions such as experienced in hilly and coastal areas of northern Japan. In such districts, air-to-water heat pumps should be installed with the greatest possible care to prevent unit failure or unsatisfactory operation of the unit. Field experiences of Toyo Carrier show that sufficient air flow is one of the most important factors for a satisfactory operation of air-to-water heat pumps. Also, maintenance of the water volume in the entire system is essential, and is often neglected or belittled. Control system maintenance is no less vital for thermal storage operation with a heat pump, especially when the water system is in common with a supplementary boiler.

**Author:*
K. Sato, Toyo Carrier Eng. Co., Ltd., Tokyo, Japan.

News and Views

An Opportunity

The IEA Heat Pump Centre, operated by NOVEM, The Netherlands Agency for Energy and the Environment, has a position available for a

Technologist

Responsibilities include:

- Contributing to the production of publications
- Organizing workshops
- Coordinating projects
- Contributing to planning
- Handling inquiries
- Promotion

The position is based in Sittard, The Netherlands.

For more information contact:
IEA Heat Pump Centre
Mr. J. Bouma
Tel.: +31-46-595236
Fax: +31-46-510389.

IEA and Member Countries

Norwegian Energy Students Visit HPTCJ

In April, about twenty students studying master degree courses at Norway's University of Trondheim, met with representatives of member companies of the Heat Pump Technology Center of Japan. The opportunity was used to exchange ideas and the students were shown some important Japanese heat pump systems.

(Source: Japanese National Team.)

Norway Offers 40% Investment Subsidy

Although heat pump sales in Norway have recently increased, growth continues to be slow. The total number installed is approximately 12,000 units, including everything from small residential, to large district heating system applications. The total energy demand covered by heat pumps is between 1.5 and 2.0 TWh.

From this year, the Ministry of Oil and Energy has introduced a 40% investment subsidy programme for heat pump purchases. By paying up to 40% of the initial cost, the Government hopes to spur heat pump sales considerably to reduce CO_2 emissions from oil burning.

One consequence of this scheme may be the introduction of licensing to ensure that those involved in selling and maintenance are sufficiently qualified.

(Source: Norwegian National Team.)

Norwegian University Celebrates 40 years of Refrigeration Engineering

Forty years have past since the inception of the Division of Refrigeration Engineering at NTH (the Norwegian Institute of Technology) in Trondheim, Norway. This summer, June 22-24, a symposium titled "Refrigeration, Energy and Environment" will be arranged in Trondheim.
Invited speakers will present state-of-the-art information on the latest developments, trends and possibilities related to energy and environmental issues in the field of refrigeration technologies. The symposium is organized by NTH-SINTEF Refrigeration Engineering, and is sponsored by the International Institute of Refrigeration (IIR).

(Source: Norwegian National Team.)

Switzerland Joins HPC

The number of countries participating in the IEA Heat Pump Centre (HPC) has risen to nine, now that Switzerland has formally joined. The formation of a National Team is still in an early stage of development, under the management of Mrs. Luisa Prista of Info Energia (see back cover for contact details). More details on the Swiss National Team will be given in the next issue of the "Newsletter".

(Source: Swiss National Team.)

Systems/Installations

Japan's Superior Heat Pump Systems

The Heat Pump Technology Center of Japan (HPTCJ) has awarded "superior status" to the following heat pump systems:

- Sewage Heat Utilization System for Air Conditioning (A/C) - Features an automatic washing system
- Bathroom Waste Heat Recovery System for Water Heating - Features an automatic brushing system
- Clathrate Storage Heat Pump System for Office A/C - Stores heat or cold at night
- Air/Water Source Storage Heat Pump for Office A/C - Features automatic mode selection
- Air-cooled Twin Turbo Heat Pump System for District

Heating/Cooling - Uses three water storage tanks
- Ice Storage Heat Pump for Office A/C - Provides simultaneous heating and cooling
- River Water Source Heat Pump for District Heating and Cooling - Accommodates tidal flow
- Hot Water Supply Heat Pump - Uses waste water at 10-30°C
- Road Heating System Utilizing Subway Heat - Produces 25°C water + antifreeze from 5-10°C ventilated air
- Universal "Through The Wall" Heat Pump for Office A/C - Comprises three units
- Air Source Heat Pump - Combines swimming pool heating, hot water heating and room A/C

Contact the HPTCJ or the HPC for more information.

(Source: Japanese National Team.)

Rotterdam District Heating System Supplies Energy for Cooling

In summer, waste heat from Rotterdam's District Heating System is used to drive a novel cooling system featuring an absorption heat pump. Despite using relatively low temperature heat (only 90°C) to fire the absorption heat pump, a temperature drop of 20°C has been achieved. The system supplies cool water for air conditioning of offices and computer rooms and saves an estimated 120,000 m^3 of natural gas equivalent per year.

(Source: Koude Magazine, December 1991)

Compact Loop Design Reduces GSHP Installation Cost

In the U.S., research funded by EPRI (Electric Power Research Institute) has resulted in a new ground-loop design that promises to lower the installed cost of GSHPs (ground-source heat pumps) by 30 to 50%. Named SLINKY™, the new design is a polyethylene tube, coiled and stretched to form a long series of overlapping loops. This arrangement requires a much shorter trench than standard designs and doesn't demand special materials or digging equipment.

(Source: EPRI Heat Pump News Exchange, Spring 1992.)

Market Trends

US Heat Pump Shipments Fall in 1991

Figures (Source 1) released by ARI (the Air-Conditioning and Refrigeration Institute) for US factory shipments for 1991 show how the US recession has hit heat pump sales (see Table 1). The fall in sales is attributed to a sharp decline in new housing, particularly in the south, where heat pumps are favoured (43.2% penetration rate among single-family homes). Latest figures, (Source 2) however, indicate a change in fortune for heat pump sales, with February figures for unitary air-to-air heat pump sales rising by 15% on the previous year to 123,534.

Table 1: US Domestic Shipments in 1991.

	No. Units	% Change
Unitary A/C		
Cooling only	3,006,296	+3
Air-to-air heat pumps	764,067	-5.5
Water source heat pumps	94,300	-20
Packaged terminal heat pumps	80,160	-21

(Source 1: Air Conditioning, Heating and Refrigeration News, March 30, 1992; Source 2: Koldfax from the Air-Conditioning and Refrigeration Institute, April 1992.)

Gas engine heat pumps top 80,000 in Japan

With a rise of 20% in shipments of gas engine heat pumps in ref. year '91 (Oct '90 - Sept. 91) the number of gas engine driven heat pumps (GHPs) installed in Japan is in excess of 80,000 units. In ref. year '91, sales were split 55:45 between LPG and city gas type GHPs with an average power of 5.5 kW and 4 kW respectively.

(Source: JARN, January, 1992.)

Refrigerants/CFCs

Research Points to HFC-32/134a Mix

A research project in the U.S. suggests that ground-source heat pumps using an HFC-32/HFC-134a mixture could achieve greater efficiency than with HCFC-22 if equipment modifications were made. The modifications include using counterflow heat exchangers and adding a liquid suction-line heat exchanger between evaporator and compressor. Using these measures, the zero ODP (Ozone Depletion Potential) mixture offers the closest match to HCFC-22 and has acceptable flammability. The research was carried out by the National Institute of Standards and Technology (NIST) with the support of EPRI.

(Source: EPRI Heat Pump News Exchange, Winter 1992.)

ICI and Teijin Join up to Build CFC Replacement Plant in Japan

A joint venture with Japanese agrochemical firm Teijin Ltd. will allow ICI Americas Inc. to supply its zero ODP refrigerant KLEA 134a (HFC-134a) to the Asia Pacific markets. Under the partnership a 4.5 million kg capacity factory at Mihara, near Hiroshima, Japan will come on-line in 1993.

(Source: Air Conditioning, Heating and Refrigeration News, April 13, 1992.)

Early Phase-Out of CFCs and HCFCs

With latest studies giving a worsening picture of ozone depletion, policy makers around the world are recommending earlier dates for phasing out both CFC and HCFC refrigerants. For CFCs, a consensus is forming for a total termination of CFC production by the end of 1995, with the U.S., U.K. and Germany (among others) supporting this view. Meanwhile Germany is pledged to ban CFC production in 1993 and Austria has already outlawed CFCs in large air conditioners and refrigeration equipment.

On the less harmful HCFCs, opinion is more widespread. Perhaps the most radical move has been Switzerland's ban on all equipment with HCFC-22, HCFC-142b and HCFC-123 from 1st January 1994. In the U.S., ARI (the Air-conditioning and Refrigeration Institute) is opposed to the Bush Administration's proposal to phase out HCFCs in new equipment by 2005. ARI's view is that such an early date could have a negative effect on the ozone layer by discouraging users from switching to HCFC equipment.

International group ICARMA (International Council of Air-conditioning and Refrigeration Manufacturers' Association) has recommended banning new equipment with HCFC-22, HCFC-141b and HCFC-142b in 2010, and HCFC-123 in 2020. They would like a further 10 years to be allowed for the use of these refrigerants in existing equipment.

In July, a meeting sponsored by the United Nations Environment Programme will establish recommendations for ammendments to the Montreal Protocol which will be approved in Copenhagen in November.

(Compiled from: Clima Commerce International (German Edition), April 1992; and Koldfax from the Air-Conditioning and Refrigeration Institute.)

Codes and Guidelines

U.S./Canadian Standards Agreement

The United States Air-Conditioning and Refrigeration Institute (ARI) and the Canadian Standards Association (CSA) have entered into an agreement for reciprocal performance testing of air conditioners and heat pumps. The agreement means that CSA will recognize and accept ARI certification test results for the following products: split-system unitary air conditioners and air-source heat pumps, ground-source closed-loop heat pumps, ground water-source heat pumps, and water-source heat pumps.

(Source: Koldfax from the Air-Conditioning and Refrigeration Institute, March 1992.)

The 4th IEA Heat Pump Conference

To be held in Maastricht, the Netherlands, on April 26-29, 1993

An international exchange of information with the aim of promoting heat pump technology for optimizing the use of energy resources for the benefit of the environment.

Invited speakers from North America, Europe, Asia-Oceania will present papers in the following sessions:

- environmental overview
- new refrigerant technology status
- technology advances
- market aspects
- market influences

Other Events:

- Plenary Session
- Poster Session
- Organized site visits

Regional coordinators:

North America:
Mr G. Groff
Marquard Switches

Asia/Oceania:
Mr Y. Igarashi
Heat Pump Technology Center of Japan

Europe:
Mr J. Bouma
IEA Heat Pump Centre

Sponsored by the International Institute of Refrigeration (IIR)

Conference Secretariat: Van Namen & Westerlaken Congress Organization Services
Tel.: +31-80-234471; Fax : +31-80-601159

IEA Heat Pump Programme

Annex Update

Since its inception in 1978, the IEA Heat Pump Programme has completed thirteen Annexes (tasks in which member countries cooperate). The table below shows the current on-going Annexes. This year a new Strategy Plan will be set out for the IEA Heat Pump Programme, outlining new goals and action plans.

Annex XVII - Experimental Plants are Up and Running

The participants have now identified how each country can contribute to this Annex and several experimental plants are up and running. As the Operating Agent, Chalmers University of Technology will evaluate results and compare different models.

Annex XVIII - First Report Now Available

The first task of this Annex - a survey of current worldwide research on the thermophysical properties of alternative refrigerants - is now complete and the report is available. The report covers a wide range of fluids (including mixtures) and examines properties such as thermodynamic, transport and phase equilibria.

The Report (in English) is available from NIST (National Institute of Standards and Technology) U.S. Department of Commerce.

Annex XXI - Market Survey Planned

As soon as the participating countries have been finalized, work will begin on the first task - a survey to project the industrial heat pump market potential in participating countries. An Information Sheet about this Annex is available from the Heat Pump Centre.

Associate Membership

The International Energy Agency (IEA) has recently introduced a new mechanism enabling wider participation in its programmes. Organizations located in countries not affiliated with the IEA may now participate in the activities of IEA programmes (Implementing Agreements) such as the Heat Pump Programme, by becoming Associate Members. For more information, contact the Heat Pump Centre.

Summary of Annexes per April 1992.

Annex	XII	XIII	XV	XVI	XVII	XVIII	XX	XXI
Austria	+		+	+		+		
Belgium	+*						OA	
Canada		+	OA	+	+	+		+
Denmark								
Germany	+	+				+		(+)
Finland								
Italy	OA			+			+	
Japan	+*	+	+	+		+	+	+
Netherlands				OA	+		+	+
Norway		+		+	+			(+)
Sweden		OA		+	OA	+		(+)
Switzerland	+			+	+		+	
UK						+		+
USA	+	+	+	+		OA		OA
Status	cr	cr	cr	cr	cr	cr	cr	p
Start	'86	'87	'89	'90	'91	'90	'91	'92
Completion	'88	'89	'90		'92	'92	'92	'94
Extended until	'92	'91	'91		'92			

* country is not involved in extension
(+) = participation not yet confirmed
cr = current
p = proposed
OA = Operating Agent

Explanation of Annexes:

- XII Modelling techniques for simulation and design of compression heat pumps.
- XIII State and transport properties of high temperature working fluids and non-azeotropic mixtures.
- XV Heat pump systems with direct expansion ground coils.
- XVI IEA Heat Pump Centre
- XVII Experiences with new refrigerants in evaporators.
- XVIII Thermophysical properties of the environmentally acceptable refrigerants.
- XX Working fluid safety.
- XXI Global environmental benefits of industrial heat pumps.

Bibliography

HPC and Member Countries

The Impact of Heat Pumps on the Greenhouse Effect

This is the title of a Heat Pump Centre Analysis Report (English) to be published this summer. This report presents and analyzes the results of 45 in-depth studies giving a comprehensive overview available on this subject. The effect of heat pumps on greenhouse gas emissions is quantified, taking into account the local conditions of many countries. Alongside this report, two other documents will be published: A Summary Report providing an overview of the analysis findings, and a brochure which aims at bringing this important topic to the attention of decision makers.

Systems/Installations

Brayton-Cycle Heat Pump Recovers Solvents

Leaflet, (English) produced for the U.S. Department of Energy (DOE) through its Office of Industrial Technologies.

This leaflet explains how a Brayton-Cycle Heat Pump (BCHP) can recover solvents and outlines practical experience in the U.S. of both on-site and mobile BCHP solvent recovery systems. Copies are available at the HPC.

Markets

European Building Services Study on Air Conditioning

BSRIA (The Building Services Research and Information Association), 12-volume set (English).

BSRIA has now completed its series of country reports on the air conditioning markets in the EC (European Community). Each report gives market details on air conditioning equipment and components, including heat pumps. The 12 volume set costs GBP 2,500, or GBP 750 per country. Copies can be ordered in the UK from BSRIA. Tel.: +44-344-426511; fax: +44-344-487575.

Proceedings

IEA Heat Pump Centre Workshop on Industrial Heat Pumps

Held in October 1991 in Budapest, Hungary, 361 pages (English).

Sited at the heart of the newly democratized Eastern European countries, this workshop was an excellent opportunity for the "established" energy world to exchange ideas with experts who, until recently, have had to work, more or less, in isolation. The proceedings include papers on various programmes on industrial heat pump technology including Japan's Super Heat Pump Programme. Topics covered include process integration, high temperature performance, thermal storage and hybrid heat pumps. The proceedings are available from the IEA HPC, Report No. HPC-WR-9. Price: NLG 60.00.

The XVIIIth International Congress of Refrigeration

Held in August 1991 in Montreal Canada.
IIR, 2083 pages in 4 volumes (English/French).

Under the theme "New Challenges in Refrigeration", 408 scientific papers were presented at this congress, covering the wide interests of the IIR. The four volume set includes valuable information on new research work on working fluids and heat pump systems, including modelling techniques. The proceedings are available from IIR, 177 Boulevard Malesherbes, F-15017, Paris , France; Tel.: +33-1-4277-3235; Fax: +33-1-4763-1798.

Refrigerants/CFCs

UNEP report on refrigeration, air conditioning and heat pumps

United Nations Environment Programme (UNEP) Report No. RWR-570-LK-91423-al - 294 pages (English).

This report was prepared by UNEP according to the requirements of the Montreal Protocol. It serves as base material for the "4th meeting of the Parties" at Copenhagen, Denmark in November 1992, when a second revision of the Montreal Protocol will be agreed. The report presents options for eliminating CFC refrigerants and investigates the viability of HCFC and HFC replacement refrigerants.

Conferences

*Call for Papers

ASHRAE Annual Meeting
June 27 - July 1, 1992 / Baltimore, Maryland (USA)
Contact: Meetings Co-ordinator ASHRAE,
1791 Tullie Circle, NE, Atlanta, GA 30329, USA
Tel.: +1-404-636-8400; Fax: +1-404-321-5478.

Symposium Ground-Source Heating & Cooling Systems
June 27 - July 1, 1992 / Baltimore, Maryland (USA)
To be held at the same time as the 1992 ASHRAE Annual Meeting, TC 6.8 (Geothermal Energy Utilization) and TC 9.4 (Applied Heat Pump, Heat Recovery Systems) intend to organize the above-mentioned symposium
Contact: Steve Kavanaugh, University of Alabama,
P.O. Box 870276, Tuscaloosa, AL 35487-0276, USA.

1992 International Refrigeration Conference - Energy Efficiency and New Refrigerants
1992 International Compressor Engineering Conference
July 14-17, 1992 / Purdue University, West Lafayette (USA)
Short courses on above subjects are held July 12-14, 1992
Contact: Phyllis Hurst, Conference Secretary,
Purdue University, 1077 Ray W. Herrick Laboratories,
West Lafayette, IN 47907-1077, USA
Tel.: +1-317-494-0117; Fax: +1-317-494-0787.

6th Conference on Refrigeration and Air Conditioning
August 24-29, 1992 / Bucharest (Romania)
Contact: Prof. Florea Chiriac, Civil Engineering Institute,
176, Carol I, Bul., 73232 Bucharest, Romania
Fax: +40-00400-12-77-80.

International Congress COLD '92
September 7-9, 1992 / Buenos Aires (Argentina)
Organized by Commissions B2, C2 and E2 of the IIR.
Contact: International Congress COLD '92, CC5109,
Correo Central, 1000 Buenos Aires, Argentina
Telex: 22421 INARG AR; Fax: +54-1-111984.

13th AIVC Conference: Ventilation for Energy Efficiency and Optimum Indoor Air Quality
September 14-18, 1992 / Nice (France)
Contact: IEA Air Infiltration and Ventilation Centre, University of Warwick Science Park, Barclays Venture Centre,
Sir William Lyons Road, Coventry CV4 7EZ, Great Britain
Tel.: +44-203-692-050; Fax: +44-203-416-306.

Energy Economy 1992
September 15-17, 1992 / Maastricht (Netherlands)
Conference and trade fair on energy and environment
Contact: Vereniging Krachtwerktuigen
Tel.: +31-33-602-506; Fax: +31-33-602-505

Energy efficiency in Process Technology
October 19-22, 1992 / Vouliagmeni-Athens (Greece)
Organized by the Commission of the European Communities
Contact: Dr. P.A. Pilavachi, Commission of the European Communities, DG XII - SDME 3/34,
Rue de la Loi 200, B-1049 Brussels
Tel.: +32-2-235-3667; Fax: +32-2-236-3024.

Symposium on Heat Pump Design, Analysis and Application
(1992 ASME Winter Annual Meeting)
November 8-13, 1992 / Anaheim, California (USA)
Contact: Keith E. Herold
Tel.: +1-301-405-5268; Fax: +1-301-314-9477.

Pragotherm '92 - International Exhibition of Heating and Air-conditioning
November 10-15, 1992 / Prague (Czechoslovakia)
Contact: INCHEBA Company Limited,
Viedenská cesta 5, 852 51 Bratislava, Czechoslovakia
Tel.: +42-801111; Fax: +42-847-982.

Solid Sorption Refrigeration
November 18-20, 1992 / Paris (France)
Symposium organized by Commision B1 of the IIR
Contact: Mr. Francis Meunier, LIMSI-CNRS,
P.O. Box 123, F-91403 Orsay Cedex, France
Tel.: +33-1-69-85-80-56; Fax: +33-1-69-85-80-88.

Building Design, Technology & Occupant Well Being in Cold and Temperate Climates
February 17-19, 1993 / Brussels (Belgium)
Sponsors: ATIC (Association Royale Belge Technique de l'Industrie du Chauffage, de la Ventilation et des Branches Connexes) and ASHRAE.
Contact: ATIC-CDH
Tel.: +32-2-348-0550; Fax: +32-2-343-9842.

The 4th IEA Heat Pump Conference
April 26-29, 1993 / Maastricht (Netherlands)
Sponsor: International Institute of Refrigeration
More details on page 27
Conference Secretariat: Van Namen & Westerlaken Congress Organization Services
Tel.: +31-80-234-471; Fax: +31-80-601-159.

***Indoor Air '93 - International Conference on Indoor Air Quality and Climate**
July 4-8, 1993 / Helsinki (Finland)
Sponsors include: the IEA, ASHRAE and the World Health Organisation.
Contact: Prof. Olli Seppänen, Helsinki University of Technology, SF-02150 Espoo, Finland
Tel.: +358-0-451-3600; Fax: +358-0-451-3611.

Future Issues

Vol./No.	*Topic*	*Deadlines*
10/3	Space conditioning heat pump equipment and applications, including novel applications	**1 July 1992**
10/4	Unitary gas heat pumps	**1 September 1992**
11/1	Industrial heat pumps	**20 December 1992**

New HPC Products

HPC-WR9 HPC Workshop Proceedings on Industrial Heat Pumps (available to member countries for NLG 60.)

Name

Company

Address

City / Postal Code

Country

☐ My country participates with the IEA Heat Pump Centre. Please send me my free copy of the HPC Newsletter each quarter.

☐ My country does not participate with the IEA Heat Pump Centre, but I would like to subscribe to the HPC Newsletter. (Annual subscription charge NLG. 90, including postage).

☐ Please cancel my subscription to the HPC Newsletter as of the next issue.

Date

Signature

Austria
Mr. H. Halozan, TU Graz
Infeldgasse 25
A-8010 Graz, Austria
Tel.: +43-316-873-7303
Fax: +43-316-873-7305

Canada
Mr. D. Cane, CANETA Research Inc.
6981 Millcreek Dr., Unit 28
Mississauga, Ontario, Canada L5N 6B8
Tel.: +1-416-542-2890
Fax: +1-416-542-3160

Italy
Mrs. L. Manduzio, ENEA - C.R.E. Casaccia
Via Anguillarese, 301
00060 S. Maria di Galeria, Rome, Italy
Tel.: +39-6-3048-6445
Fax: +39-6-3048-6306

Japan
Mr. Y. Igarashi, Heat Pump Technology Center Japan
Azuma Shurui Bldg. 9-11 Kanda Awaji-cho 2-chome,
Chiyoda-ku, Tokyo 101, Japan
Tel.: +81-33-258-1035
Fax: +81-33-258-1037

The Netherlands
Mr. P. Oostendorp, TNO
Department of Heat and Refrigeration Technology
P.O. Box 342, 7300 AH Apeldoorn , The Netherlands
Tel.: +31-55-493-493
Fax: +31-55-419-837

Norway
Mr. R. Aarlien, SINTEF
Norwegian Institute of Technology
Division of Refrigeration Engineering, N-7034 Trondheim, Norway
Tel.: +47-7-593-929
Fax: +47-7-593-926

Sweden
Mr. B. Bäckström
Chalmers Teknikpark
S-41288 Göteborg, Sweden
Tel.: +46-31-7724-226
Fax: +46-31-418-056

Switzerland
Mrs. L. Prista
c/o Dipartimento dell'Ambiente
CH-6500 Bellinzona, Switzerland
Tel.: +41-92-243-755
Fax: +41-92-244-429

USA
Mr. M.A. Broders, Oak Ridge National Laboratory
Building 3147, P.O. Box 2008
Oak Ridge, TN 37831-6070, USA
Tel.: +1-615-576-2731
Fax: +1-615-574-9338

IEA Heat Pump Centre
Swentiboldstraat 21, 6137 AE Sittard
P.O. Box 17, 6130 AA Sittard, The Netherlands
Tel.: +31-46-595-236
Fax: +31-46-510-389

STAMP

IEA Heat Pump Centre
P.O. Box 17
6130 AA SITTARD
THE NETHERLANDS

For your subscription please use the attached card.

The IEA Heat Pump Centre Newsletter will be published quarterly.

Subscribers from countries participating with the IEA Heat Pump Centre (see list above) will receive the newsletter free of charge.

Subscribers from other countries will be charged NLG. 90, a year, which includes postage.

Cancellation of the subscription must be made at least one month before the end of the subscription year.