

Small Heat Pump Air Conditioners

- The Environmental Impact of their Rapid Growth

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In view of the rapid expansion of the heat pump market in Japan, a rough calculation has been made to determine the expected impact of the increased use of heat pump air conditioners on the environment. It was found that, through the use of heat pumps, the emission rate of substances into the environment can be reduced in comparison to the use of fuel oil. To make efficient use of this characteristic, measures to prevent the release of refrigerant from heat pumps are required.

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The share of different types of air conditioning equipment has changed drastically in recent years. The primary factor behind these changes has been the expansion of the small heat pump air conditioner market. In home and office building air conditioning, small heat pump air conditioners are replacing the conventional kerosene stove and boiler. This drastic increase in small heat pump air conditioners brings with it a large impact on the environment.

The majority of heat pump air conditioners in Japan are small models with a power consumption in the range of 1 to 10 kW. The refrigerant used is HCFC-22, and the compressors are driven by electric motors.

Rapid Growth

In recent years, annual domestic deliveries of heat pump air conditioners for home use have been in the order of 5 million units, and the number of units installed over the last ten years total roughly 30 million. Considering, however, that there are about 200 million residential rooms in Japan and that normally one heat pump is installed in each room, the diffusion rate of heat pumps for home use is only

about 15% (30 M/200 M), which certainly leaves much room for expansion.

Deliveries of small heat pump air conditioners for use in office buildings add up to 1 million units per year. The total number of heat pump type package air conditioners for business use delivered over the past 10 years is roughly 5.5 million units. In fact, the share of heat pump types in the office building air conditioning market, estimated on the basis of heat generating capacity, is thought to have reached about 40%.

In view of these circumstances, a rough calculation was made based on the assumptions given in Table 1, in order to project the impact of a continued increase in the number of heat pump air conditioners between now and the year 2000.

Environmental Impact

The use of heat pumps is certain to result in environmental improvement and conservation of energy. Assuming the power generating efficiency at 35%, the boiler heat efficiency at 90%, and the average COP of a heat pump at 3.5, a heat pump requires only 74% of the primary energy needed to produce the same thermal capacity as an oil-fired boiler in homes and office buildings. This means that the use of heat pumps for heating could result in energy conservation of 26% when replacing oil-fired boilers. The amount of energy conserved was then calculated for each application area and for all of Japan. The result showed that, in the year 2000, energy equivalent to roughly 1.4 million m³ of crude oil could be conserved annually by replacing oil-fired boilers and kerosene stoves with heat pump air conditioners. This amount corresponds to 0.3% of Japan's primary energy supply.

Application	Millions of units delivered			Share of total heat demand	
	Annual	Total by the year 2000	Net increase after deduction of scrapped units	1993	2000
Home use	5	35	20	15%	25%
Business use	1	7	4	40%	70%

Table 1: The heat pump market in Japan.

Ozone depletion impact

- Annual delivery volume of CFCs in Japan : 95,000 tonnes (1991)
- Annual delivery volume of HCFC-22 in Japan : 37,000 tonnes (1991)

The impact of HCFC-22, in terms of COP, is approx. 2.1% that of CFCs.

Global warming impact

- Annual CO₂ emission rate in Japan : 1,170,000 tonnes
- Annual delivery volume of HCFC-22 in Japan : 37,000 tonnes

The impact of HCFC-22, in terms of GWP, is approx. 2.2% that of CO₂ emissions.

- Reduction of CO₂ emissions by the year 2000 due to an increase of heat pumps
1170 x 0.6% = 7 million tonnes/year
- Progressive global warming effect of HCFC-22 (converted to CO₂) if not recovered (released into the atmosphere)
7- 20 millions tonnes/year

There is a strong possibility that the progressive effect on global warming resulting from release of the refrigerant (HCFC-22) of heat pumps will be considerably greater than the effect of suppressing global warming expected from a reduction of CO₂ emissions through the use of heat pumps.

The environmental impact of heat pump refrigerant (HCFC-22).

One of the effects on the environment that the expansion of the heat pump market is expected to have is improvement through energy conservation. In terms of CO₂ emission, a reduction of approximately 0.3% of the total CO₂ from combustion of fossil fuels in all of Japan could be achieved. Virtually the same effect can be expected with regard to SO_x and NO_x.

Another main factor resulting in improvement of the environment is the shift from oil to electric energy. Currently, non-fossil fuels (nuclear and hydroelectric power) account for roughly 40% of power generation in Japan. The emissions corresponding to electricity supply for heat pumps equates to an overall reduction of 0.3% in comparison to the use of fuel oil. In this way, the spread of heat pumps over a period of 7 years would result in an across-the-board reduction of all emitted substances of 0.6%. In terms of emissions from the private sector (households, businesses) alone, the reduction will add up to 3-4% over the same 7-year period.

Refrigerant Release

One point that has to be kept in mind when relating the heat pump to the environment is that the release of refrigerant is an environmental problem of global scale. The refrigerant normally used in small heat pumps is HCFC-22. In 1991, approximately 37,000 tonnes of HCFC-22 were used as refrigerant. The impact of this refrigerant on the environment, assuming that the use of HCFC-22 continues at the same rate up to the year 2000, was roughly calculated as shown in the blue box.

Concerning the impact on the ozone layer, greater importance will have to be attached to HCFC-22 in this regard in view of the sudden moves to reduce the use of CFCs. Regarding the influence on global warming, measures must be adopted to prevent the release of refrigerant from scrapped small heat pump air conditioners. Otherwise, the effect of suppressing global warming by reducing CO₂ emissions will be more than offset by the progressive effect of the diffusion of refrigerants.

Positive and Negative Impact

Compared with oil-burning equipment, the use of small heat pump air conditioners in Japanese homes and office buildings can reduce SO_x, NO_x and CO₂ emissions by roughly 0.6% over a 7-year period. On the other hand, the release into the atmosphere of HCFC-22, has the striking negative potential of contributing to the progress of global warming. This shows that the environmental impact of the increasing use of heat pumps will only be beneficial when measures are taken to prevent the release of refrigerant.

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