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Heat Pumps and the Environment - an International Overview

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Since the 1992 United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro, many countries are now committed to limiting the emissions of greenhouse gases. The HPC's analysis 'The Impact of Heat Pumps on the Greenhouse Effect' has suggested that heat pumps can make a major contribution towards meeting this commitment, especially with regard to the reduction of CO₂ emissions. This article summarizes the growing evidence on the emissions reduction potential of heat pumps, and highlights some of the measures now being taken to help realize this potential.

While the energy-saving benefits of heat pumps are clear, their environmental impact is complex to assess, as it depends on the technology, the drive energy and the working fluids. With the move away from CFCs,

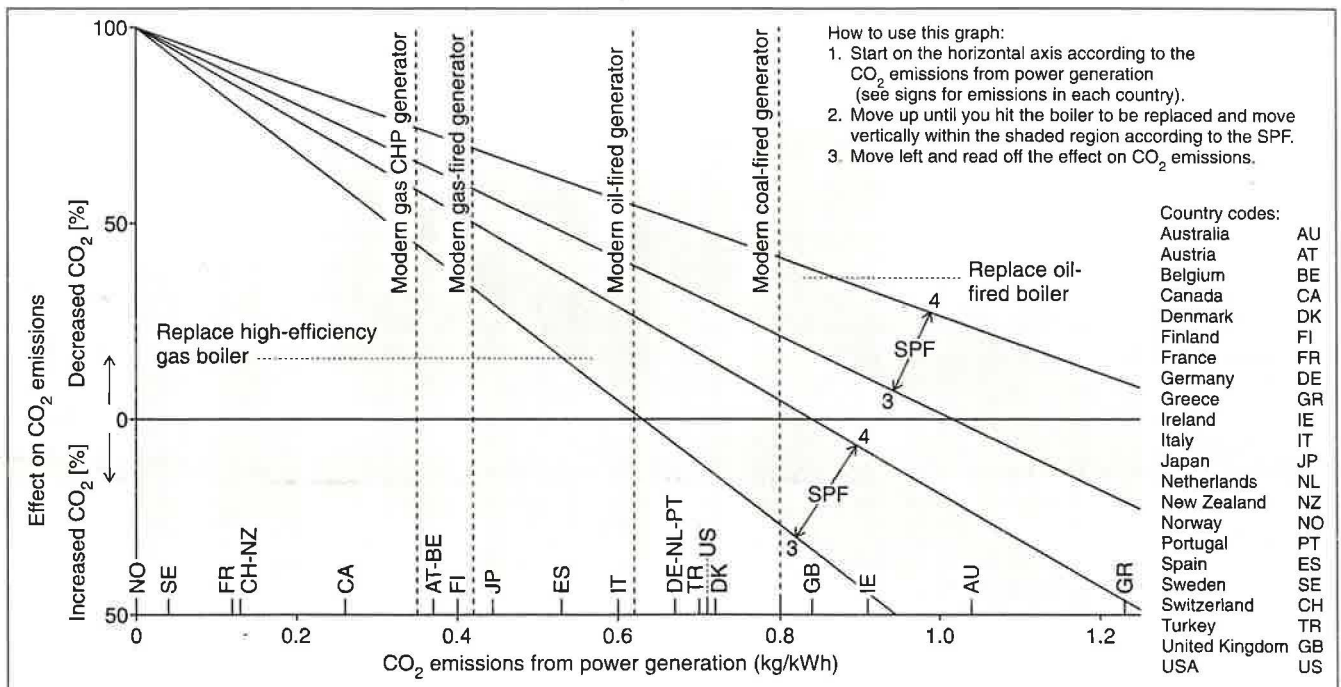
the environmental drawbacks from working fluids are rapidly diminishing. A closer look at progress in this field will be given in the March 1994 issue of this Newsletter.

The potential of electric heat pumps to reduce CO₂ emissions is to some extent open to interpretation - should the CO₂ emission rate from the total electricity network be considered, or just the marginal power used to drive newly installed heat pumps? And what type of conventional heating system should be used for comparison? This can depend on how the availability of gas is interpreted.

A Simple Comparison

Figure 1 provides a simple method for comparing the CO₂ emissions from space heating with an electric heat pump to those from a gas or oil-fired boiler. As shown, electric heat pumps driven by modern power generators, offer substantial CO₂ reductions over

Figure 1: Percentage reduction in CO₂ emissions when using an electric heat pump in place of a conventional boiler. CO₂ emissions from national power generation is calculated using IEA data on fuel supplied to power utilities, on electricity consumption, and on trade in electricity in 1990. Emissions: gas boiler 0.21 kg CO₂/kWh; oil boiler 0.34 kg CO₂/kWh. CHP: avoided CO₂ emissions allocated equally to heat and power.



Assessing the environmental impact

Austria

Heat pumps have been estimated as having the potential to reduce CO₂ emissions by 4% by meeting 15-20% of the heat demand. In 1992, 111,500 heat pumps were in use, avoiding an estimated 730,000 tonnes of CO₂ emissions. This is equivalent to about 1.3% of the total energy-related CO₂ emissions in 1990 in Austria estimated by the IEA.

Canada

Electric resistance heating is the principle heating method for about 30% of Canadian households and offers a large potential for reducing CO₂ emissions. Ontario Hydro have estimated that annual electricity demand could be reduced by 7.6 TWh in Ontario through the use of heat recovery heat pumps in single-family homes. Based on average emissions of 0.26 kg CO₂/kWh from total Canadian power generation, this equates to a saving of about 2 million tonnes of CO₂. In 1990, Canada's energy-related emissions totalled 435 million tonnes CO₂ according to IEA statistics.

Italy

Air-to-air electric heat pumps, with an average COP of 2.7, are now installed in about 1% of Italian homes, where it is estimated that they avoid around 15% of the CO₂ emitted from conventional heating systems. This amounts to a little less than 0.2% of the total CO₂ emissions resulting from the total demand for home heating. The potential of heat pumps to reduce CO₂ emissions is now recognized by the government which offers subsidies for heat pump systems.

Japan

The Japanese National Team estimates that heat pumps will save between 1 and 2% of the total energy supply in the year 2000. This will result in a 2 to 4% reduction in emissions of CO₂, SO_x and NO_x. However, they point out that the fact that most heat pumps are sold as air conditioners complicates matters. The widespread diffusion of air conditioners has significantly increased electricity consumption. In addition, the use of CFCs has also been an environmental drawback. The latter problem will be resolved when government measures to encourage recovery and recycling, currently under discussion, are realized.

Netherlands

In conjunction with their work for Annex 21 of the IEA Heat Pump Programme, Dutch research group TNO has estimated that industrial heat pumps could save an annual 12.7 TWh energy which would result in a CO₂ emissions reduction of 2.34 million tonnes CO₂ per year. Currently, less than 5% of this potential is realized today. In its newly initiated heat pump programme, the government has set a target of saving 10 PJ (2 TWh) in the year 2000 with heat pumps. IEA data on the Netherlands report energy-related emissions of 183 million tonnes CO₂ in 1990. Total primary energy supply was 896 TWh.

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conventional fossil-fuel heating systems, especially when SPFs (Seasonal Performance Factors) improve. A reduction in CO₂ emissions from power generation would also be beneficial, but IEA statistics suggest that the average CO₂ emissions from all OECD countries will remain at around 0.6 kg CO₂/kWh in the year 2000. Only Denmark, Greece, Ireland and the UK are predicting significant CO₂ reductions, while emissions from Belgium, Finland and New Zealand are increasing.

More studies are being made to assess the current and projected impact of heat pumps on the environment. Articles further in this issue of the Newsletter highlight the views of experts in Japan, Germany, the Netherlands, United Kingdom and the United States. Some environmental assessments from HPC member countries are highlighted in the blue sections of this article.

Commitment

Despite the growing evidence on the environmental benefits of heat pumps, only a few governments explicitly include heat pump technology as part of their energy policy.

Switzerland's Energy 2000 programme includes a commitment to increase the contribution of renewable energy to 3% of total heat production, or 3000 GWh. Heat pumps are expected to contribute roughly 40% towards the attainment of this target by the replacement of fossil fuel boilers by electric heat pumps. The policy considers the environmental effect of the increased electricity capacity this demands: It stipulates that the electricity used to drive newly installed heat pumps must come firstly from the replacement of existing electrical heating systems, or secondly from cogeneration plants running on a portion of the fuel saved by replacing oil or gas-fired heating systems.

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Norway

Estimates by Energidata A/S show that the technical potential of heat pumps is an avoidance of 3.27 million tonnes CO₂. More realistically, an avoidance of 2.43 million tonnes CO₂ is considered to be economically viable for the country as a whole although this would be reduced to between 0.96 and 2.28 million tonnes (depending on interest rates) when left to private investments. For comparison, the IEA estimate of the total energy-related CO₂ emissions in Norway in 1990 was 31.9 million tonnes.

Sweden

Chalmers Industrieteknik has studied the options available for reducing the CO₂ emissions currently emitted from its many oil-fired district heating systems. Electrically driven heat pumps were shown to be a more cost-effective option than cogeneration plants using natural gas or biomass fuel, or than solar plants. This result is not very sensitive to electricity prices - the main limiting factor is the availability of suitable fuel sources. Of course, Sweden's electricity mix (mainly nuclear and hydro) favours the electric heat pump. However, this study went on to show that heat pumps in combination with cogeneration based on biomass fuel is also a cost-effective option for CO₂ emissions reduction.

Switzerland

Heat pumps currently in operation here reduce CO₂ emissions by 410,000 tonnes through the replacement of fossil-fuel fired boilers. This is equivalent to about 0.9% of the total energy-related CO₂ emissions from Switzerland in 1990 estimated by the IEA. Every year, additional heat pump installations reduce the annual emissions by a further 42,000 tonnes. Under the Energy 2000 programme, heat production from electric heat pumps is planned to rise to 2.25 TWh/year leading to an avoidance of 800,000 tonnes of CO₂ emissions every year. This will be realized through the installation of some 100,000 25 kW_{heat} electric heat pumps (or the equivalent number for the same heat production) between 1990 and 2000.

USA

The Environmental Protection Agency (EPA) has recently released a report titled "Space Conditioning: The Next Frontier." In it, EPA clearly states its view that heat pumps have a strong potential to reduce pollutant emissions. It finds that ground-source heat pumps have the lowest CO₂ emissions of all the technologies available, emitting 23 - 44% less than air-source heat pumps and 63 - 73% less than air conditioners with electric resistance heating. Energy Research Group Inc. has estimated the potential CO₂ savings from using heat pumps in the commercial sector. In the year 2000, ground-source heat pumps could avoid 43.5 million tonnes CO₂, and heat pump water heaters 49.6 million tonnes CO₂. The total energy-related CO₂ emissions in the USA was estimated by the IEA to be 5,020 million tonnes in 1990.

In the Netherlands, the government is moving towards a commitment to the promotion of heat pump technology, although details of this policy are still being formulated.

In Japan, the government is supporting many important R&D programmes which focus on heat pumps for large district heating and cooling systems. These heat pumps will use unused energy sources such as renewable energy in nature and waste heat energy from industry, and will be combined with thermal storage systems.

In Norway, a three-year heat pump programme focusing on knowledge transfer and education was completed last year, and helped to increase sales of heat pumps there. A new four-year programme puts renewed emphasis on research, especially on the use of natural refrigerants, and aims to stimulate manufacturing.

Gaining Experience

As more and more experience is gained, the potential of heat pumps to help meet environmental aims will become clearer. Policy makers should be made aware of the progress being made by heat pump programmes currently underway in some countries. Only when heat pump programmes can be shown to be cost-effective in comparison to other CO₂ emissions reduction measures, will there be more widespread support for this technology.

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