In Japan subsidies are provided to the heat pump water heater Eco Cute. The budget of such subsidies is disbursed from the account involved in the development of power sources. The Japanese Ministry of Economy, Trade and Industry appropriated funds for "Leveling of Electric Power Demand" as one of the "Important Matters Related to Nuclear Energy." (This is because it is necessary to subsidize the practical application of high-efficiency water heaters (CO2 refrigerant heat pump water heaters) and promote the widespread use thereof, which have a large effect of leveling electric power demand day and night, rather than utilizing nighttime power with modest supply and demand, in order to promote efficient utilization of base power sources such as nuclear power generation as the load leveling of electric power demand is a big challenge.)

This load leveling effect is simply described as follows. As one unit of Eco Cute consumes 1 kW of electricity, if 20 million units thereof come into wide use, midnight loads increase by 20 GW and the availability factor (load factor) of electric power equipment as a whole increases.

The point that attention should be paid to here is that, in addition to mere improvement of availability factors of equipment at light load during nighttime, there is an effect of increasing the ratio of nuclear power and that of non-fossil fuels to generated energy, i.e., a large effect of improving the CO2 emission intensity of electric power, because if additional nuclear power plants equivalent to 20 GW are constructed, these plants can also be operated during daytime when Eco Cute is not operated. In other words, fossil fuels in energy utilization on the demand side are replaced (electrification and utilization of heat in the air by heat pumps), and the effects of replacing fossil fuels and reducing carbon in primary energy on the supply side are yielded at the same time.

Like this, heat pumps can yield the effects of drastically reducing the consumption of imported fossil fuels by "utilizing ambient heat" as a pure domestic resource, expanding the scope of development of nuclear power as a base load through load leveling of electric power, etc. The increased utilization of such heat pumps is expected to create a virtuous cycling of encouraging the demand side to casually use heat pumps just because "they are convenient" and "they are clean," and unwittingly reinforcing energy security of society at large. Moreover, heat pumps also contribute to effective utilization of renewable energy, too. It can be said that the combination of heat pumps, which do not cause the power generation side to produce CO2, provide high energy utilization rates on the user side and emit no CO2, is a very effective system as a measure against global warming, which produces no CO2. Though current situation related to heat pumps by using examples in Japan is outlined here, they can be applied not only to Japan but also to almost every country.
CO2 Reduction Potential of Japan

How much emissions of CO2 produced by energy consumption can be reduced by heat pumps as a whole? The estimation of potential CO2 emission reductions in Japan is introduced as follows.

Japan’s CO2 emissions now total about 1,300 million t-CO2. Of this total, the industrial sector accounts for nearly a half, and the commercial/business and residential sectors and transport sectors account for the remaining half. However, the comparison of growth rates of CO2 emissions by sector from fiscal 1990 through fiscal 2004 shows that CO2 emissions in the industrial sector decreased by 3.3% but CO2 emissions in the business sector increased by 38.4%, that in the residential sector by 32.3% and that in the transport sector by 20.7%. CO2 emissions in the commercial sector and transport sector have remarkably increased.

As for further details of composition of energy consumption in the commercial sector, heat demand such as heating and cooling and hot water supply accounts for about two-thirds in the residential sector. Similarly, heating and cooling and hot water supply account for more than 50% in the business sector, too.

This heat demand is mainly satisfied by heat energy, which is still generated by combustion of fossil fuels, representing a major cause of increase in CO2 emissions.

The potential CO2 emission reductions by meeting such heat demand with heat pumps instead of fossil fuel-combustion equipments in Japan as a whole amounts to about 100 million t-CO2 in the commercial sector and about 30 million t-CO2 in the industrial sector, for a total of about 130 million t-CO2, which accounts for about 10% of Japan’s total CO2 emissions of about 1.3 billion t-CO2. [see Figure 2.1 Table 2.1]

The details of the estimation for each sector showed the following results:

![Figure 2.1 Potential of Reducing CO2 Emissions by Heat Pumps](image-url)
① Residential Sector

(Heating)

As for the potential CO₂ emission reductions in houses, it is possible to reduce the present estimated CO₂ emissions from heating of 44 million t-CO₂ per year to 13.5 million t-CO₂ per year, representing a potential of reduction by 30.5 million t-CO₂ per year on the assumption that heating by conventional equipment in cold climate areas is replaced with heat pump heaters of COP = 3 and that in general areas with heat pump air-conditioners of COP = 6. [see. Figure 2.2]

(Hot water supply)

On the assumption that conventional water heaters are totally replaced with heat pump water heaters of COP = 4, the present estimated CO₂ emissions of 36 million t-CO₂ per year can be reduced to 12.3 million t-CO₂ per year, representing a potential of reduction by about 23.7 million t-CO₂ per year. [see. Figure 2.3]

② Business Sector

(Air-conditioning)

As for the potential CO₂ emission reductions in buildings for business purposes such as office buildings, stores, etc., the present estimated CO₂ emissions from air-conditioning of 43 million t-CO₂ per year can be reduced to 14 million t-CO₂ per year, representing a potential of reduction by about 29 million t-CO₂ per year, on the assumption that air-conditioners of COP = 6 come into widespread use. [see. Figure 2.4]

(Hot water supply)

On the assumption that conventional water heaters are totally replaced with heat pump water heaters of COP = 4, the present estimated CO₂ emissions of 23 million t-CO₂ per year can be reduced to 7.7 million t-CO₂ per year, representing a potential of reduction by about 15.3 million t-CO₂ per year. [see. Figure 2.5]

Commercial Sector ( = ① + ②)

As mentioned above, the commercial sector alone has a potential of reduction by about 100 million t-CO₂ per year. This figure represents a potential that far exceeds the target to reduce CO₂ emissions of energy origin by about 60 million t-CO₂, which was assigned to the commercial sector under the Kyoto Protocol Target Achievement Plan (decided by the Cabinet of Japan in April 2005).

③ Industrial Sector

The CO₂ emissions in the industrial sector have remained almost unchanged since 1990, but this sector involves many heating fields where fossil fuels are directly burnt. As for the demand that can be met by heat pumps at present in such heating fields, plant air-conditioning, warming and drying at lower than 100°C by boilers are realistic.

As for plant air-conditioning, the present estimated CO₂ emissions of 17 million t-CO₂ per year can be reduced to 3.9 million t-CO₂ per year, presenting a potential of reduction by about 13.1 million t-CO₂ per year.

As for warming, the present estimated CO₂ emissions of 12 million t-CO₂ per year can be reduced to 2.9 million t-CO₂ per year, presenting a potential of reduction by about 9.1 million t-CO₂ per year.

As for drying at lower than 100°C, the present estimated CO₂ emissions of 14 million t-CO₂ per year can be reduced to 3.3 million t-CO₂ per year, representing a potential of about 10.7 million t-CO₂ per year.

All together, there is a potential of reduction by about 32.9 million t-CO₂ in the industrial sector. [see. Figure 2.6]
1. CO2 Reduction by Heat Pumps

Potential CO2 Emissions from Residential Heating in Japan

Energy Consumption by Residential Heating*1

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Mcal per Year</th>
<th>%</th>
<th>Mcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG*1</td>
<td>10,460</td>
<td>6.7%</td>
<td>716,760</td>
</tr>
<tr>
<td>Kerosene*1</td>
<td>100,690</td>
<td>64.8%</td>
<td>6,482,850</td>
</tr>
<tr>
<td>City gas*1</td>
<td>29,000</td>
<td>18.7%</td>
<td>540,000</td>
</tr>
<tr>
<td>Electric power*1</td>
<td>100,000</td>
<td>6.3%</td>
<td>6,300,000</td>
</tr>
<tr>
<td>Others*1</td>
<td>10,000</td>
<td>0.0%</td>
<td>100,000</td>
</tr>
</tbody>
</table>


In the case where combustion-based heaters (η = 0.75) are totally shifted to heat pump air-conditioners

- Amount of heating demand: 105,110 million Mcal
- LPG, kerosene and city gas consumption: 149,150 million Mcal
- Energy consumption: 7,550 million Mcal
- CO2 emissions: 9.6 million t-CO2 per year

Therefore, the present CO2 emissions amount to about 44 million t-CO2 per year (a) (excluding others)

*The efficiency of combustion type heaters is referred to the BL accreditation criteria. The CO2 emission intensity is based on the Enforcement Ordinance of the Law Concerning the Promotion of Measures to Cope with Global Warming (revised in December 2002).

In the case where electric heaters (η = 1.0) are totally shifted to heat pump air-conditioners

- Amount of heating demand: 105,110 million Mcal
- LPG, kerosene and city gas consumption: 21,890 million Mcal
- Energy consumption: 7,550 million Mcal
- CO2 emissions: 6.4 million t-CO2 per year

Therefore, the present CO2 emissions amount to about 36 million t-CO2 per year (b) (excluding others)

*The efficiency of combustion type heaters is referred to the BL accreditation criteria. The CO2 emission intensity is based on the Enforcement Ordinance of the Law Concerning the Promotion of Measures to Cope with Global Warming (revised in December 2002).

In the case where electric heaters (η = 0.9) are totally shifted to heat pump water heaters (COP4.0)

- Amount of heating demand: 7,340 million Mcal
- LPG, kerosene and city gas consumption: 13,340 million Mcal
- Energy consumption: 8,160 million Mcal
- CO2 emissions: 3.3 million t-CO2 per year

Potential CO2 emission reductions by introduction of heat pump air-conditioners

a - (b+c) = about 30.5 million t-CO2 per year

Potential CO2 emission reductions by introduction of heat pump water heaters

a - (b+c) = 23.7 million t-CO2 per year
Heat Pumps

2. CO2 Reduction by Heat Pumps

Energy Consumption by Air-Conditioners for Business Use*1

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy Consumption (Mcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil*1</td>
<td>85,670 million Mcal</td>
</tr>
<tr>
<td>Gas*1</td>
<td>22,260 million Mcal</td>
</tr>
<tr>
<td>Electric power*1</td>
<td>31,960 million Mcal</td>
</tr>
</tbody>
</table>

Others*1 1.2% 1,910 million Mcal


As for electric air-conditioners, the efficiency of conventional heat pump type is assumed at COP3.

\[
\text{CO2 emissions} = \frac{31,960 \text{ (Mcal)}}{860 \text{ (kcal/MWh)}} \times 1,000 \times 0.378 \text{ (t-CO2/MWh)} = 14.05 \text{ million t-CO2 per year}
\]

Therefore, the present CO2 emissions amount to about 43 million t-CO2 per year (excluding others)

In the case where combustion-based air-conditioners (COP3) are shifted to high-efficiency heat pump air-conditioners (COP6)

<table>
<thead>
<tr>
<th>Combustion-based air-conditioners</th>
<th>Conventional heat pump air-conditioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of air-conditioning demand 97,140 million Mcal</td>
<td>Amount of air-conditioning demand 95,880 million Mcal</td>
</tr>
<tr>
<td>Oil and gas consumption: 107,930 million Mcal</td>
<td>Electricity consumption 31,960 million Mcal</td>
</tr>
<tr>
<td>COP = 3.0</td>
<td>COP = 6.0</td>
</tr>
</tbody>
</table>

Therefore, the CO2 emissions in the case of total shift to COP6 air-conditioners 16,190 million Mcal / 860 (kcal/MWh) x 1,000 x 0.378 (t-CO2/MWh) = 7.12 million t-CO2 per year

In the case where conventional heat pump air-conditioners (COP3) are shifted to high-efficiency heat pump air-conditioners (COP6)

<table>
<thead>
<tr>
<th>High-efficiency heat pump air-conditioner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of air-conditioning demand 95,880 million Mcal</td>
</tr>
<tr>
<td>COP = 6.0</td>
</tr>
</tbody>
</table>

Therefore, the CO2 emissions in the case of total shift to COP6 air-conditioners 16,190 million Mcal / 860 (kcal/MWh) x 1,000 x 0.378 (t-CO2/MWh) = 7.12 million t-CO2 per year

Potential amount of reduction in CO2 emissions by introduction of high-efficiency heat pump air-conditioners \( a - (b+c) \) = about 29 million t-CO2 per year

Heat Pumps

Energy Consumption by Hot Water Supply for Business Use*1

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy Consumption (Mcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas*1</td>
<td>34,790 million Mcal</td>
</tr>
<tr>
<td>Oil*1</td>
<td>54,690 million Mcal</td>
</tr>
</tbody>
</table>

Others*1 12.6% 12,880 million Mcal


As for gas-based water heaters, the efficiency of city gas combustion type is assumed at n0.78.

\[
\text{CO2 emissions} = \frac{34,790 \text{ (Mcal)}}{860 \text{ (kcal/MWh)}} \times 1,000 \times 0.378 \text{ (t-CO2/MWh)} = 15.85 \text{ million t-CO2 per year}
\]

Therefore, the present CO2 emissions amount to about 23 million t-CO2 per year (excluding others)

In the case where combustion-based water heaters (n0.78) are totally shifted to heat pump water heaters (COP4.0)

<table>
<thead>
<tr>
<th>Combustion-based water heaters</th>
<th>Heat pump water heaters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of water heating demand 69,790 million Mcal</td>
<td>Amount of water heating demand 69,790 million Mcal</td>
</tr>
<tr>
<td>Electricity consumption 17,450 million Mcal</td>
<td>COP = 4.0</td>
</tr>
</tbody>
</table>

CO2 emissions in the case of total shift to COP4.0 water heaters 17,450 million Mcal / 860 (kcal/MWh) x 1,000 x 0.378 (t-CO2/MWh) = 7.67 million t-CO2 per year

Potential amount of reduction in CO2 emissions by introduction of heat pump water heaters \( a - b \) = about 15.30 million t-CO2 per year