# Final Report by Air Conditioner Evaluation Standard Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy

Regarding air conditioners, the target fiscal year was set to 2004 freezing year for those of wall-hung and non-duct type (limited to the cooling capacity of which is 4.0kW or lower) among air conditioners used for cooling and heating. For this reason, the target standard values etc. for air conditioners for home use were reviewed and newly formulated in September 2006.

Meanwhile, the target fiscal year for air conditioners except those whose target year was in 2004 freezing year was set to 2007 freezing year. The new indicator for energy consumption efficiency was introduced when the new target standard values formulated in September 2006. As a result, now there are 2 types of evaluation indicators in the market. This means that simple comparison of the products cannot be performed.

To review on setting new target standard values for air conditioners other than those set in September 2006, Air Conditioner Evaluation Standards Subcommittee was established. It made deliberations on evaluation standards for the manufacturers and importers (hereinafter referred to as "manufacturers") about performance improvement of air conditioners, and the interim report was prepared as follows.

1. Scope added to the target (See Attachment 1)

Within the target scope of current energy conservation law, this review covers air conditioners other than those for home use for which new target standards with FY2010 target fiscal year were formulated in September, 2006 which are non-duct wall-hung type, for cooling and heating, and having the cooling capacity of 4.0kW or below.

About multi-type air conditioners (among separate type air conditioners, those which connect one outdoor unit with two or more indoor units and control the indoor units independently), in response to the recent status of shipment, models the cooling capacity of which is up to 50.4kW are included in the target scope.

However, the following air conditioners are excluded from the scope: i.e. those whose cooling capacity exceeds 28kW (50.4kW in the case of multi-type), those of window type/wall type only for cooling, those of water-cooling types, those using energy other than electricity as the thermal source for heating, those used for maintaining the performance of machineries or for sanitary management of food and/or drink, those exclusively sending cooled outdoor air to indoor, spot air conditioners, heat storage air conditioners, highly gas-tight/heat-insulating housing duct air conditioning systems, solar-power dedicated air conditioners, multi-functional heat pump air conditioners, and heat recovery multi air conditioners.

2. Items to be judgment standards for manufacturers

(1) Target fiscal year (See Attachment 2)

(i) Air conditioners for home use

1) Non-duct and wall-hung type: Fiscal year 2010

2) Others: Fiscal year 2012

(ii) Air conditioners for business use
Fiscal year 2015

(2) Target standard values (See Attachment 3 to 4)

For air conditioners that manufacturers ship for Japan in the target fiscal year, the weighted harmonic average of energy consumption efficiency (Annual Performance Factor (APF)) measured in (3), weighted by the volume of shipments for each manufacturer per category shown in the table below, shall not be below the target standard values.

(Air conditioners for home use)

| Category | Unit Form | Cooling Capacity | Target Standard Value (APF) |
|---|---|---|---|
| 1 | Wall-hung and non-duct type air conditioners (excluding, among multi-type models, those which control operation of indoor units separately) | Over 4.0kW 5.0kW or lower | 5.5 |
| 2 | | Over 5.0kW 6.3kW or lower | 5.0 |
| 3 | | Over 6.3kW 28.0kW or lower | 4.5 |
| 4 | Separate type air conditioners other than those of non-duct and wall-hung type (excluding, among multi-type models, those which control operation of indoor units separately) | 3.2kW or lower | 5.2 |
| 5 | | Over 3.2kW 4.0kW or lower | 4.8 |
| 6 | | Over 4.0kW 28.0kW or lower | 4.3 |
| 7 | Multi-type air conditioners that individually control operation of indoor units | 4.0kW or lower | 5.4 |
| 8 | | Over 4.0kW 7.1kW or lower | 5.4 |
| 9 | | Over 7.1kW 28.0kW or lower | 5.4 |

(Air conditioners for business use)

| Category | Form and function | Type of indoor unit | Cooling capacity | Target standard value and calculation formula |
|---|---|---|---|---|
| 1 | Separate type air conditioners of multi-combination as well as air conditioners which are not included in the following categories of forms and functions (so-called air conditioners for stores) | 4-direction cassette type | Lower than 3.6kW | E = 6.0 |
| 2 | | | 3.6kW or over<br>Lower than 10.0kW | E = 6.0 – 0.083 × (A–3.6) |
| 3 | | | 10.0kW or over<br>Lower than 20.0kW | E = 6.0 – 0.12 × (A–10) |
| 4 | | | 20.0kW or over<br>28.0kW or lower | E = 5.1 – 0.060 × (A–20) |
| 5 | | Other than 4 -direction cassette type | Lower than 3.6kW | E = 5.1 |
| 6 | | | 3.6kW or over<br>Lower than 10.0kW | E = 5.1 – 0.083 × (A–3.6) |
| 7 | | | 10.0kW or over<br>Lower than 20.0kW | E = 5.1 – 0.10 × (A–10) |
| 8 | | | 20.0kW or over<br>28.0kW or lower | E = 4.3 – 0.050 × (A–20) |
| 9 | Multi-type air conditioners that control operation of each indoor unit separately (so-called air conditioners for buildings) | — | Lower than 10.0kW | E = 5.7 |
| 10 | | | 10.0kW or over<br>Lower than 20.0kW | E = 5.7 – 0.11 × (A–10) |
| 11 | | | 20.0kW or over<br>Lower than 40.0kW | E = 5.7 – 0.065 × (A–20) |
| 12 | | | 40.0kW or over<br>50.4kW or lower | E = 4.8 – 0.040 × (A–40) |
| 13 | Air conditioners having on-the-floor type indoor units connected to ducts, and models like this (so-called air conditioners for facilities) | Non-duct type | Lower than 20.0kW | E = 4.9 |
| 14 | | | 20.0kW or over<br>28.0kW or lower | E = 4.9 |
| 15 | | Duct type | Lower than 20.0kW | E = 4.7 |
| 16 | | | 20.0kW or over<br>28.0kW or lower | E = 4.7 |

Note 1) E: Energy consumption efficiency throughout a year (APF: Annual Performance Factor). When calculating it with the target standard calculation formula, the obtained value shall be rounded down to the first decimal place, truncating at the second decimal place.

Note 2) A: Cooling capacity of the model (kW).

3) Energy consumption efficiency measurement method (See Attachment 5)

As an indicator of energy consumption efficiency of air conditioners, Annual Performance Factor (APF) shall be used. The measurement method shall be based on the calculation method specified in Japanese Industrial Standards C 9612: 2005 (Room Air Conditioner) and Japan Industrial Standards B 8616: 2006 (Package Air Conditioner).

(4) Display items and others

1) Display items shall be as follows.

a) Category
b) Cooling capacity
c) Cooling power consumption
d) Heating capacity
e) Heating power consumption
f) Annual Performance Factor
g) Name of manufacturer

Display items regarding air conditioners for home use is under the provision of the household product quality labeling law, and for the display of a) and f) above, revision of the Electric Machinery and Appliance Quality Labeling Regulations is required.

2) Compliance items

a) Cooling capacity shall be displayed in kilowatts measured by the method specified in the cooling capacity test in Japanese Industrial Standards B 8615-1 or B 8615-2 (the temperature condition shall be T1). In this case, the cooling capacity shall be the display value minus 5% or greater.
b) Heating capacity shall be displayed in kilowatts measured by the method specified in the heating capacity test in Japanese Industrial Standards B 8615-1 or B 8615-2 (the temperature condition shall be standard level). In this case, the heating capacity shall be the display value minus 5% or greater.
c) Cooling power consumption shall be in watts or kilowatts measured by the method specified in the cooling power consumption test in Japanese Industrial Standard B8615-1 or B8615-2. In this case, the cooling power consumption shall be the display value plus 10% or below.
d) Heating power consumption shall be in watts or kilowatts measured by the method specified in the heating power consumption test in Japanese Industrial Standard B 8615-1 or B 8615-2. In this case, the heating power consumption shall be the display value plus 10% or below.

e) Annual Performance Factor shall be obtained by dividing the sum of heat quantity to be removed from indoor air and that to be added to indoor air throughout cooling period and heating period by total energy consumption to be consumed during the same period. These heat quantities are obtained by the test and calculating method for seasonal energy efficiency specified in Japanese Industrial Standards C 9612: 2005 (room air conditioners) and Japanese Industrial Standards B 8616: 2006 (package air conditioners). The obtained APF shall be displayed up to one decimal place.

f) If any difference arise in measurements specified in a) to e) above due to different rated frequencies, the measured values shall be displayed for every rated frequency.

g) Display items listed in 1) above shall be clearly placed on prominent positions in catalogues and instruction manuals, etc. so that consumers can refer to them when selecting products.

## 4. Proposals for energy saving

### (1) Actions of users

1) Efforts shall be made to select air conditioners with excellent energy consumption efficiency through effective use of information such as "energy-saving labels" and "unified energy-saving labels", etc. At the same time, efforts shall also be made to reduce energy consumption of air conditioner by appropriate and effective utilization.
2) Efforts shall be made to select air conditioners, while considering the setting, size, etc. of the intended room in order to make full use of the capacity.
3) In some cases, air conditioners cannot fully realize their capacity due to inappropriate installation such as small installation space for outdoor units. Therefore, efforts shall be made to give due consideration to the installation place.

### (2) Actions of retailers

1) Efforts shall be made to sell air conditioners with excellent energy consumption efficiency as well as to provide appropriate information for users by utilizing "energy-saving labels" and "unified energy-saving labels", etc. to encourage them to select such air conditioners. When using the energy-saving labels, etc., as air conditioners vary in performance depending on areas where to be used, retailers shall carefully display labels in a manner that users can easily understand and get no false impression, for example, by means of showing conditions for calculating energy consumption efficiency.
2) In some cases, air conditioners cannot fully realize their capacity due to inappropriate installation such as small installation space for outdoor units. Therefore, efforts shall be made to give due consideration to the installation place.

(3) Actions of manufacturers

1) Efforts shall be made to promote technological development toward energy saving in air conditioners and to develop products with excellent energy consumption efficiency.
2) From viewpoint of aiming at the popularization of air conditioners with excellent energy consumption efficiency, efforts shall be made to provide appropriate information to encourage users to select such air conditioners, for example by displaying "energy-saving labels" in catalogues and so forth. When using the energy-saving labels, etc., as air conditioners vary in performance depending on areas where to be used, retailers shall carefully display labels in a manner that users can easily understand and get no false impression, for example, by means of showing conditions for calculating energy consumption efficiency.
3) To respond to improved energy-saving performances such as insulation performance of buildings, etc. in recent years, revision of a guideline for applicable room sizes corresponding to cooling capacity and heating capacity shall be considered.
4) Although cooling energy consumption efficiency and heating energy consumption efficiency were removed from the display items this time, efforts shall be made to provide such information as much as possible, because facility designers and others may utilize the information with respect to air conditioners for business use.
5) Taking into consideration that Annual Performance Factor (APF) adopted this time is based on numeric values computed under certain conditions, continued efforts shall be made to improve the measurement method so that evaluation can be carried out in a condition closer to actual use.

(4) Actions of Government

1) From viewpoint of aiming at the popularization of air conditioners with excellent energy consumption efficiency, efforts shall be made to take necessary measures such as the spread and enlightenment activities, in order to promote actions of users and manufacturers.
2) Implementation of the display items by manufacturers shall be checked periodically and continuously. Also, appropriate law management shall be made so that correct and easy-to-understand information regarding energy consumption efficiency will be provided for users.
3) Energy efficiency standards based on the Top Runner method is a very effective means to reduce energy consumption of products; therefore, efforts shall be made to disseminate it internationally by catching appropriate opportunities.

Attachment 1

# Target Scope of Air Conditioners

## 1. Basic idea

Within the target scope of current energy conservation law, this review covers air conditioners other than those for home use for which new target standards with FY2010 target fiscal year were formulated in September, 2006 which are non-duct wall-hung type, for cooling and heating, and having the cooling capacity of 4.0kW or below.

However, the target scope shall be extended or limited as follows depending on the change in the number shipped, the introduction of new products, etc.

## 2. Extension of target scope

About multi-type air conditioners (among separate type air conditioners, those which connect one outdoor unit with two or more indoor units and control the indoor units independently), those whose cooling capacity is up to 28kW are targeted under the current evaluation standard. Shipment volume of the multi-type air conditioners has been on the rise, and that of the products with cooling capacity of over 28kW is also increasing.

Although the scope of JIS B8616: 2006 is up to the cooling capacity of 28kW, giving a consideration to the circumstances mentioned above, multi-type air conditioners a single-unit cooling capacity of which is up to 50.4kW were included in the target scope. Basic items for evaluation method required this time were also determined.

With this expansion, 28 thousand units will be added to the target scope.

## 3. Limitation of target scope

In the Top Runner method, the following products are excluded from the target scope; 1) products used for special purpose, 2) products whose technical measurement method and evaluation method are not established and it is difficult to determine the target standars, and 3) products whose share in the market is extremely small.

### (1) Electrically driven unit-type air conditioners

1) Air conditioners the cooling capacity of which exceeds 28kW (50.4kW in the case of multi-type models)

As multi-type air conditioners the cooling capacity of which exceeds 50.4kW are few in quantity and it is difficult to secure facilities to test them, it is reasonable to exclude them from the scope.

Also, those other than multi-type, whose cooling capacity exceeds 28kW, are often special order products to be installed mainly in factories, with various specifications.

JIS standard does not stipulate the test method for these products, and evaluation methods for these products are not always well established.

* Estimation of the number shipped (FY2005): 19.8 thousand units.

2) Window type, wall type and cooling-only type air conditioners (additional exclusion)

As the shipment volume of those of window type and cooling-only type has been recently on the drastic decline, they are excluded from the target scope.

* Estimation of the number shipped (FY2005)
  - Window type, wall type: 48 thousand units (1997 freezing year: 152 thousand units)
  - Cooling-only type: 121 thousand units (1997 freezing year: 451 thousand units)

3) Water cooling type air conditioner

Water cooling air conditioners are used under special conditions in which cooling water system must exist; besides, they need different thermal source for heating. The shipment volume has been on the decline in the long term.

* Estimation of the number shipped (FY 2005): 12.4 thousand units (1997 freezing year: 21.0 thousand units)

4) Air conditioners that use any energy other than electricity as a heat source for heating

They are composite products that use electricity for cooling but combustion heat of gas, oil, etc, as a heat source for heating. They are used limitedly in cold region where heating by heat pumps cannot cover the heating load.

In addition,the measurement method is not established yet.

* Estimation of the number shipped (FY 2005): 4.4 thousand units (1997 freezing year: 47.0 thousand units)

5) Air conditioners used for maintaining the performance of machineries or for sanitary management of food and/or drink

They are special air conditioners used to maintain cleanness of air, temperature and humidity, not like ordinary air conditioners. They are known as package air conditioners for computer rooms, package air conditioners for clean rooms, package air conditioners for low temperature, etc. Most of them are special order products.

* Estimation of the number shipped (FY 2005): 6.8 thousand units (1997 freezing year: 8.0 thousand units)

6) Air conditioners which exclusively cool outdoor air and send it to indoors

They are called all-fresh type air conditioners and used for special application such as surgery rooms of hospitals, treatment of outdoor air at factories, explosion facilities, etc.

They are affected by restrictions on building constructions. The number of units is very few.

* Estimation of the number shipped (FY 2005): 1.6 thousand units (1997 freezing year: 0.6 thousand units)

7) Spot air conditioners

Special air conditioners used mainly in factories to send cool air to workers to improve working environment. The evaluation method has not been established yet.

* Estimation of the number shipped (FY 2005): 30.5 thousand units (1997 freezing year: 65.0 thousand units)

8) Heat storing storage air conditioners

Air conditioners which are equipped with a heat tank to store cold energy during the night and cool indoors during the daytime using the cold energy. They were developed to level the power demand and expected to spread more, but they are on the decrease now.

The evaluation method has not been established yet.

* Estimation of the number shipped (FY 2005): 6.8 thousand units (1997 freezing year: 2.5 thousand units)

9) Ducted air-conditioning systems for highly gas-tight/heat-insulating housing

Air conditioners specially developed for highly gas-tight/heat-insulating houses of recent years and are yet to spread. They have a heat exchange capability between exhaust air and intake air. No evaluation method has been established yet.

* Estimation of the number shipped (FY 2005): 3.5 thousand units (1997 freezing year: 5.0 thousand units)

10) Solar-power dedicated air conditioners

Solar-power dedicated air conditioners, including the power supply section, etc., are specially designed products. There are problems such as how to evaluate the consumption of power generated by the solar. Although they used to be shipped but not now, it is expected to spread hereafter.

* Estimation of the number shipped (FY 2005): 0 .0 thousand units (1997 freezing year: 0.04 thousand units)

11) Multi-functional heat pump system air conditioners

Air conditioners which are systems equipped with floor heating, hot water supply and/or other functions using heated water produced by heat pump systems. Although they are expected to spread hereafter, their shipment number is still small.

* Estimation of the number shipped (FY 2005): 2.0 thousand units (1997 freezing year: 2.0 thousand units)

12) Heat recovering multi air conditioners (additional exclusion)

Multi-type air conditioners using absorbed heat from cooling as the thermal source for heating other spaces, which are installed in buildings where partial cooling is required even in winter for computer rooms, etc. It is difficult to apply the same evaluation method as of ordinary air conditioners where the evaluations are made for cooling season and heating season separately. In addition, the number of units shipped is very few. Therefore, it is appropriate to exclude them from the scope.

* Estimation of the number shipped (FY 2005): 2.0 thousand units

(2) Air conditioners not electrically driven and those for transportation means

As for air conditioners without an electrical motor for compression or those designed for transportation means such as vehicles, their driving sources and structures are very unique. Moreover, there is no evaluation method established yet. From this reason, they are excluded from the scope.

1) Air conditioners having structure without electrical motor for compression

- Gas engine driven heat pump air conditioners
  * Estimation of the number shipped (FY 2005): 35.9 thousand units (1997 freezing year: 40.0 thousand units)

2) Designed for transportation means

- Air conditioners for automobiles
  * Estimation of the number shipped (FY 2005): 4,536 thousand units (1997 freezing year: 5,915 thousand units)
- Air conditioners for buses
  * Estimation of the number shipped (FY 2005): 13.2 thousand units (1997 freezing year: 15 thousand units)
- Air conditioners for railway cars
  * Estimation of the number shipped (FY 2005): Unknown (1997 freezing year: 4.3 thousand units)

Attachment 2

## Target Fiscal Year, etc. of Air Conditioners

1. Air conditioners for home use

(1) In general, a considerable improvement in energy consumption efficiency is made when a model change takes place, and a typical development period of these new products is approximately 2 to 3 years. For this reason, consideration should be given so that manufacturers can take 1 to 2 opportunities of bringing out new models before next target fiscal year.

Meanwhile, for the non-duct wall-hung type air conditioners the cooling capacity of which is 4.0kW or less as stipulated last time, the target year was set as 2010 fiscal year. Therefore, for the non-duct wall-hung type air conditioners reviewed this time, it is necessary to give considerations so that consumers will not misunderstand.

In the light of the above, the next target fiscal year for air conditioners under this review is made as follows.

1) Non-duct wall-hung type: As the target fiscal year for those whose cooling capacity of 4.0kW or less was set as 2010 fiscal year, it is appropriate to set it as the same.

2) Others: It is appropriate to set the target fiscal year as 2012 fiscal year, which is five years after establishment of the target standard values.

(2) In addition, it is expected that improvement rate of energy consumption efficiency in the target fiscal year will be approximately 15.6% (approximately 17.8% for non-duct wall-hung type, approximately 13.6% for others) based on an assumption that there will be no change in volume of shipment as well as model composition of each category from the current status (result of fiscal year 2006).

<Overview of Estimation>

○ Air conditioners for home use as a whole

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 4.5

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 5.2

(iii) Improvement rate of energy consumption efficiency

$$\frac{(5.2 - 4.5)}{4.5} \times 100 = \text{Approximately } 15.6\%$$

○ Non-duct, wall-hung type air conditioners

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 4.5

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 5.3

(iii) Improvement rate of energy consumption efficiency

$$\frac{(5.3 - 4.5)}{4.5} \times 100 = \text{Approximately } 17.8\%$$

○ Others

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 4.4

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 5.0

(iii) Improvement rate of energy consumption efficiency

$$\frac{(5.0 - 4.4)}{4.4} \times 100 = \text{Approximately } 13.6\%$$

2. Air conditioners for business use

(1) In general, a considerable improvement in energy consumption efficiency is made when a model change takes place. A new product development cycle of air conditioners for business use is approximately 3 to 4 years in the case of mainstream products such as 4 -direction cassette types. However, looking at air conditioners for business use as a whole, the model change cycle tends to become longer due to their wide varieties in spite of the small number of shipment.

Since consideration needs be given so that manufacturers can take 1 to 2 opportunities of bringing out new models before next target fiscal year, fiscal year 2015 is set as the target year.

(2) It is expected that improvement rate of energy consumption efficiency in the target fiscal year will be approximately 18.2% (approximately 18.2% for store-use air conditioners, approximately 19.2% for building-use multi-type air conditioners, approximately 29.7% for facilities-use air conditioners) based on an assumption that there will be no change in volume of shipment as well as model composition of each category from the current status (result of fiscal year 2006).

<Overview of estimation>

○ Air conditioners for business use as a whole

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 4.4

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 5.2

(iii) Improvement rate of energy consumption efficiency

$$\frac{(5.2 - 4.4)}{4.4} \times 100 = \text{Approximately } 18.2\%$$

○ Air conditioners for stores

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 4.4

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 5.2

(iii) Improvement rate of energy consumption efficiency

$$\frac{(5.2 - 4.4)}{4.4} \times 100 = \text{Approximately } 18.2\%$$

○ Multi-type air conditioners for building,

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 4.2

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 5.0

(iii) Improvement rate of energy consumption efficiency

$$\frac{(5.0 - 4.2)}{4.2} \times 100 = \text{Approximately } 19.0\%$$

○ Air conditioners for facilities

(i) Energy consumption efficiency estimated from actual values of those shipped in fiscal year 2006: 3.7

(ii) Energy consumption efficiency estimated from the target standard values of those to be shipped in the target fiscal year: 4.8

(iii) Improvement rate of energy consumption efficiency

$$\frac{(4.8 - 3.7)}{3.7} \times 100 = \text{Approximately } 29.7\%$$

Attachment 3

Categories of Air Conditioners

1. Current categories of air conditioners

The following 3 factors affect the energy consumption efficiency (cooling and heating average COP) of air conditioners and the development of energy saving technologies. Thus, air conditioners are categorized according to these 3 factors, and a target standard value is set for each category.

1) Categorization by basic function
2) Categorization by unit form
3) Categorization by cooling capacity

Table 1. Current categories within the scope of this review

| Unit from | Cooling capacity | | | | |
|---|---|---|---|---|---|
| Non-duct and wall-hung type air conditioners (excluding among multi-type models, those which control operation of each indoor unit separately) | 3.2kW or lower | | Over 3.2kW 4.0kW or lower | Over 4.0kW 7.1kW or lower | Over 7.1kW 28.0kW or lower |
| Other non-duct type air conditioners (excluding among multi-type models, those which control operation of each indoor unit separately) | 2.5kW or lower | Over 2.5kW 3.2kW or lower | Over 3.2kW 4.0kW or lower | Over 4.0kW 7.1kW or lower | Over 7.1kW 28.0kW or lower |
| Duct connection type air conditioners (excluding among multi-type models, those which control operation of each indoor unit separately) | 4.0kW or lower | | | Over 4.0kW 7.1kW or lower | Over 7.1kW 28.0kW or lower |
| Multi-type air conditioners which control operation of each indoor unit separately | 4.0kW or lower | | | Over 4.0kW 7.1kW or lower | Over 7.1kW 28.0kW or lower |

* Those shaded, whose new standards have been set only for air conditioners for home use, are categorized according to the dimension type (defined or free) of indoor units.

2. New categorization method for air conditioners

(1) Basic idea

In the current categorization, categories are defined without separating air conditioners for home use and for business use. However, they are separately categorized in the development of target standard this time, because their loads in measurement method, design/specifications, development periods, etc. are different.

(2) Air conditioners for home use

(i) Categorization by unit form

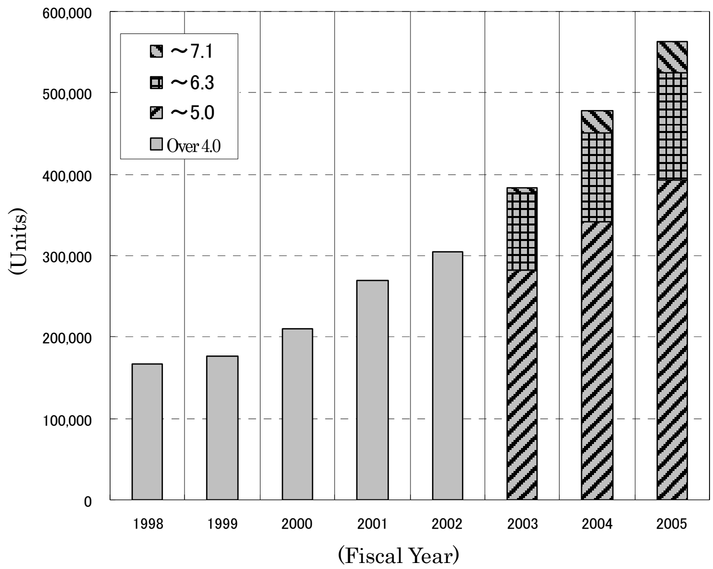
Among current categories, the category "duct connection type air conditioners (excluding among multi-type models, those which control operation of each indoor unit separately)" is combined with the category "other non-duct type air conditioners (excluding among multi-type models, those which control operation of each indoor unit separately)", because the former is not currently manufactured for home use. As a result, a new category, "separate type air conditioners other than those of non-duct wall-hung type (excluding among multi-type models, those which control operation of each indoor unit separately)", was developed (hereinafter called "separate type air conditioners other than those of non-duct wall-hung type).

(ii) Classification by cooling capacity

1) Non-duct wall-hung type air conditioners (excluding among multi-type models, those which control operation of each indoor unit separately) (hereinafter called "non-duct wall-hung type air conditioners").

For air conditioners the cooling capacity of which is 4.0kW or lower, the target standard values have already been developed with the target fiscal year set as fiscal year 2010. This time, target standard values are established for air conditioners the cooling capacity of which is over 4.0kW and up to 28.0kW.

As for air conditioners for home use, shipment volume of large-size models has been on the rise. With respect to those the cooling capacity of which is over 4.0kW, the shipment volume has increased about 3 times as large as that in fiscal year 1999 when the current target standard values were developed. (Figure 1)




(Source: The Japan Refrigeration and Air Conditioning Industry Association)

Figure 1. Changes in shipment volume of non-duct wall-hung type air conditioners with cooling capacity of over 4.0kW

Regarding air conditioners the cooling capacity of which is 4.0kW or lower, for which target standards were developed last time, the categories were developed according to the dimensional type (defined or free) of indoor units. As for air conditioners the cooling capacity of which is over 4.0kW, the similar categorization is not made this time, because most of their indoor units are free-dimension type.

Therefore, air conditioners the cooling capacity of which is over 4.0kW up to 28.0kW are classified according to the following cooling capacities.

i) Cooling capacity of over 4.0kW up to 5.0kW
ii) Cooling capacity of over 5.0kW up to 6.3kW
iii) Cooling capacity of over 6.3kW up to 7.1kW
iv) Cooling capacity of over 7.1kW up to 28.0kW

2) Separate type air conditioners other than those of non-duct wall-hung type

Basically, previous category setting shall be used as is.

The same as in the case of air conditioners with cooling capacity of 4.0kW or lower for which target standard values were developed last time, 2 categories are prepared, i.e. for the cooling capacity of 3.2 kW or lower and for the cooling capacity of over 3.2kW up to 4.0kW.

3) Multi-type air conditioners which control operation of each indoor unit separately (hereinafter called "multi-type air conditioners")

Current categories shall be used as is.

(iii) Basic category proposal

Based on the consideration above, the basic category proposal is established as follows.

| Unit form \ Cooling capacity | 3.2kW or lower | Over 3.2kW up to 4.0kW | Over 4.0kW up to 5.0kW | Over 5.0kW up to 6.3kW | Over 6.3kW up to 7.1kW | Over 7.1kW up to 28.0kW |
|---|---|---|---|---|---|---|
| Non-duct wall-hung type air conditioners | | | 415 | 125 | 41 | — |
| Separate type air conditioners other than those of non-duct wall-hung type | 42 | 48 | 24 | | | — |
| Multi-type air conditioners | 8 | | 48 | | | 8 |

Number of units shipped in FY2006 (Unit: 1,000)
(Source: The Japan Refrigeration and Air Conditioning Industry Association)

(3) Air conditioners for business use

(i) Categorization by form and function

Currently, air conditioners for business use are categorized roughly into 3 categories according to their major applications, i.e. “for store”, “for buildings” and “for facilities”, and catalogues are separately prepared for each. Load and other conditions to calculate APF stipulated by JIS B 8616: 2006 (package air conditioners) are different among these product categories.

Therefore, based on the form and function corresponding to these product categories, basic categories are set as follows.

1) Air conditioners for stores

- ○ Conditions for APF calculation: APF is calculated using stand-alone store as the building load.
- ○ Target scope: Among separate type air conditioners as defined by JIS B 8616, those of “multiple-combination type” for which multiple combinations of a single outdoor unit and connectable indoor units are available. In addition, among air conditioners with an outdoor unit which cannot make multiple combinations, the models which do not fall into either 2) or 3) below are included in this category, if it is appropriate for them to use stand-alone store as the building load in the calculation of APF. As for multi-type air conditioners, those which control each indoor unit separately are excluded from this category.

Therefore, the category of air conditioners for stores is defined as “separate type air conditioners with multiple combinations and those which are not included in either 2) or 3)”.

2) Multi air conditioners for buildings

- ○ Conditions for APF calculation: APF is calculated using office as the building load. Regarding a coefficient which expresses the performance change due to the change of outdoor temperature, the one stipulated for multi air conditioners, which is different from those for stores and facilities, shall be used.
- ○ Target scope: Among multi-type air conditioners as defined by JIS B 8616, those having 2 or more indoor units connected to one outdoor unit and controlling each indoor unit separately.

Therefore, the category of multi air conditioners for buildings is defined as “multi-type air conditioners which control each indoor unit separately”.

3) Air conditioners for facilities

- ○ Conditions for APF calculation: APF is calculated using office as the building load.
- ○ Target scope: Among air conditioners using office as the building load as stipulated by JIS B 8616 except for multi-type ones, those the indoor units of which are on-the-floor type and connected to ducts, and models like this. In addition, even if

the indoor units are not for being placed on floor and connected to ducts, such air conditioners are also included in this category as long as they use office as the building load (non-duct type), based on the assumption that air conditioners here are primarily used in factories .

Therefore, the category of air conditioners for facilities is defined as "air conditioners having on-the-floor type indoor units connected to ducts, and models like this".

(ii) Classification by cooling capacity

It is typical to make a series of models available for each category by form and function, which covers certain ranges of cooling capacity under outdoor units of the same enclosure.

Therefore, according to general cooling capacity ranges covered by a single enclosure, the following basic classification is made.

1) Cooling capacity of lower than 5kW
2) Cooling capacity of 5kW or over and lower than 10kW
3) Cooling capacity of 10kW or over and lower than 20kW
4) Cooling capacity of 20kW or over (and lower than 40kW)
5) (Cooling capacity of 40kW or over and up to 50.4kW)

* Figures in the brackets are applied only to multi air conditioners for buildings.

(iii) Basic category proposal

Based on the study above, the basic category proposal is established as follows.

| Cooling capacity / Form and function | Lower than 5kW | 5kW or over and lower than 10kW | 10kW or over and lower than 20kW | 20kW or over (and lower than 40kW | 40kW or over and up to 50.4kW | Total |
|---|---|---|---|---|---|---|
| Air conditioners for stores | 90.9<br>(13.3%) | 187.1<br>(27.4%) | 237.8<br>(34.9%) | 71.0<br>(10.4%) | | 586.8<br>(86.1%) |
| Multi air conditioners for buildings | 0.0<br>(0.0%) | 0.4<br>(0.1%) | 10.9<br>(1.6%) | 56.5<br>(8.3%) | 18.6<br>(2.7%) | 86.4<br>(12.7%) |
| Air conditioners for facilities | 0.0<br>(0.0%) | 0.0<br>(0.0%) | 1.1<br>(0.2%) | 7.6<br>(1.1%) | | 8.7<br>(1.3%) |
| Total | 90.9<br>(13.3%) | 187.5<br>(27.5%) | 249.8<br>(36.6%) | 135.1<br>(19.8%) | 18.6<br>(2.7%) | 681.9<br>(100.0%) |

(Upper figure: The number of units shipped in fiscal year 2006 (unit: thousand),
Lower figure: Percentage of total)

*Note that figures in the fields of air conditioners for stores and facilities whose cooling capacity of 20kW or over are the numbers of units whose cooling capacity of up to 28kW.

Attachment 4

# Target Standard Values of Air Conditioners

## 1. Idea on establishment of target standard values

Target standard values are set based on the idea of Top Runner method. The specific policies are as follows.

1) Target standard values shall be set for every category that has been defined appropriately.
2) As for categories where future technological advances are expected to improve efficiency, the target standard value shall allow for as much improvement as possible.
3) Target standard values shall not conflict among categories.

## 2. Target standard values for air conditioners for home use

(1) Room for improvement of energy consumption efficiency by future technology advances

Technology development of air conditioners has been undertaken primarily for establishment of a comfortable living environment. Although technology development related to improvement of energy-saving performance has been implemented to accomplish the current target standards, development of each elemental technology has almost reached its limit; thus, innovative technology development like those that has been achieved in the past cannot be expected.

[Examples of major technologies for efficiency improvement of air conditioners]

- Compressors: High-efficient compression technology, neodymium magnet, improvement of motor winding, low-iron-loss magnetic steel sheet, reduction of mechanical loss, reduction of pressure drop in suction/discharge, sine-wave drive control.
- Fan motor: Introduction of DC motor, introduction of multiple poles/slots, optimization of core shape, reduction of circuit loss, optimal energization.
- Electronically controlled valve
- Heat exchanger: Three-row arrangement of indoor units, multiple folding process, improvement of fin shape, improvement of pipe arrangement process.

Although these technologies have been introduced into the current Top Runner products, it can be said that there still remains room for efficiency improvement in individual technologies, considering the fact that these introduced technologies differ depending on manufacturers and that each manufacturer is taking its own approach for further improvement of efficiency.

Taking these circumstances comprehensively into account, effect of technological improvements is expected as follows.

1) Non-duct wall-hung type air conditioners:

Regarding air conditioners with cooling capacity of 4.0kW or lower, the target standards of which were established already, efficiency improvement by 3% to 4% was expected, taking technological improvement into consideration comprehensively. Some technological development already achieved is introduced to air conditioners the cooling capacity of which is 4.0kW or over, for which target standards are developed this time. Meanwhile, the target fiscal year of the product categories for which target standards were set last time is also applied to the product categories for which target standards are developed this time. It results in providing a relatively short period for them to achieve the target standards; accordingly, improvement by 2% from the Top Runner values is expected.

2) Separate type air conditioners other than those of non-duct wall-hung type:

Taking the technologies above comprehensively into account, improvement by 3% from the Top Runner values is expected.

3) Multi-type air conditioners

Currently the number of multi-type models shipped tends to decrease, and their model cycle is slow; therefore, the effect of technological improvement is basically not expected. When setting target standard values, as stated in 1.3), there should not be conflicts between categories.

(2) Specific target standard values (Figure 1 to Figure 3)

Target standard values of air conditioners shall be represented in real numbers.

The Top Runner values of this target scope are as follows.

| Unit form \ Cooling capacity | 3.2kW or lower | Over 3.2kW up to 4.0kW | Over 4.0kW up to 5.0kW | Over 5.0kW up to 6.3kW | Over 6.3kW up to 7.1kW | Over 7.1kW up to 28.0kW |
|---|---|---|---|---|---|---|
| Non-duct wall-hung type air conditioners | | | 5.4 | 4.9 | 4.4 | — |
| Separate type air conditioners other than those of non-duct wall-hung type | 5.0 | 4.7 | 4.2 | | | — |
| Multi type air conditioners | 5.1 | | 5.3 | | | 5.4 |

Table 1. Top Runner values of air conditioners

Target standard values are based on Top Runner values with consideration for the effect of technological improvement.

Regarding non-duct wall-hung type air conditioners and separate type air conditioners other than those of non-duct wall-hung type, although products the cooling capacity of which is over 7.1kW up to 28.0kW are currently not shipped, they may be supplied in the future. Therefore, they are combined with categories the cooling capacity of which is one level lower respectively, and a single target standard value is applied to each of the combined categories.

Regarding multi-type air conditioners, the Top Runner value in the class of cooling capacity over 7.1kW up to 28.0kW marks the highest efficiency, resulting in the inverse of values among the capacity classes. Therefore, the target standard value for the class of cooling capacity over 7.1kW up to 28.0kW is adopted as the target standard values for the classes of cooling capacity 4.0kW or lower and of cooling capacity over 4.0kW up to 7.1kW.

Based on these studies above, the target standard values are summarized as follows.

| Unit Form | Cooling Capacity | Top Runner value | Improvement rate (%) | Target Standard Value (APF) |
|---|---|---|---|---|
| Non-duct wall-hung type air conditioners (excluding, among multi-type models, those which control operation of each indoor unit separately) | Over 4.0kW up to 5.0kW | 5.4 | 2.0 | 5.5 |
| | Over 5.0kW up to 6.3kW | 4.9 | 2.0 | 5.0 |
| | Over 6.3kW up to 28.0kW | 4.4 | 2.0 | 4.5 |
| Separate type air conditioners other than those of non-duct and wall-hung type (excluding, among multi-type models, those which control operation of each indoor unit separately) | 3.2kW or lower | 5.0 | 3.0 | 5.2 |
| | Over 3.2kW up to 4.0kW | 4.7 | 3.0 | 4.8 |
| | Over 4.0kW up to 28.0kW | 4.2 | 3.0 | 4.3 |
| Multi-type air conditioners that control operation of each indoor unit separately | 4.0kW or lower | 5.1 | 5.0 | 5.4 |
| | Over 4.0kW up to 7.1kW | 5.3 | 2.0 | 5.4 |
| | Over 7.1kW up to 28.0kW | 5.4 | 0.0 | 5.4 |

Table 2. Target standard values of air conditioners

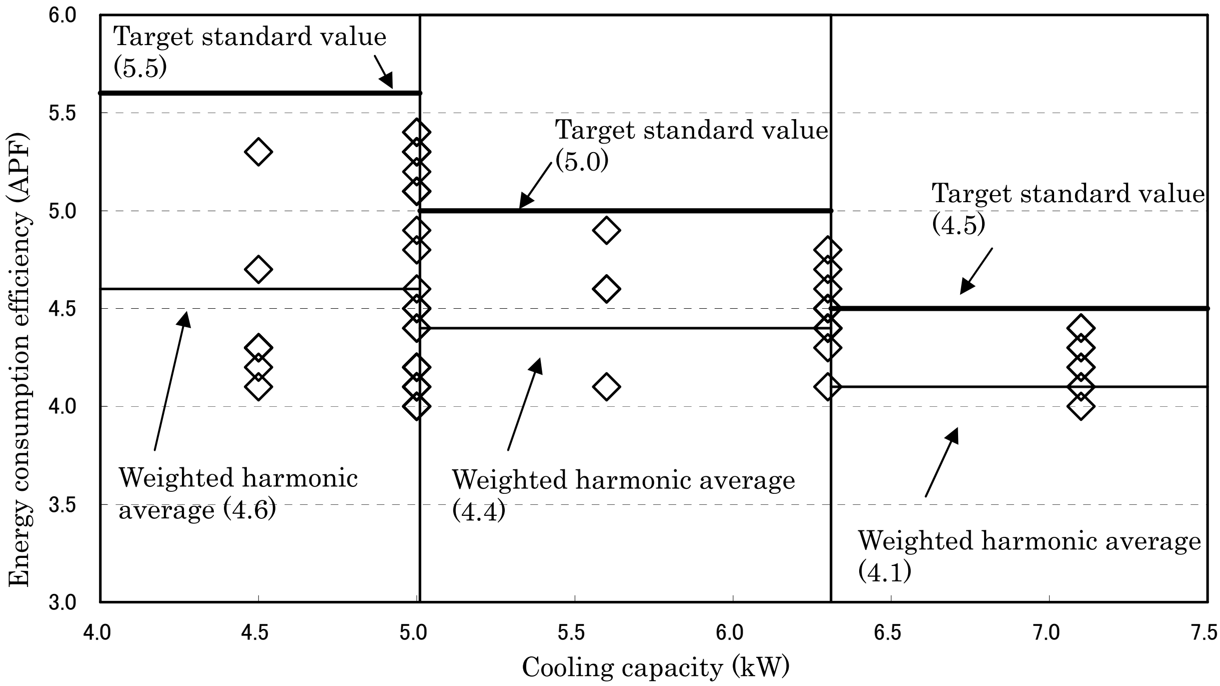



Figure 1. Top Runner values and target standard values of non-duct wall-hung type air conditioners

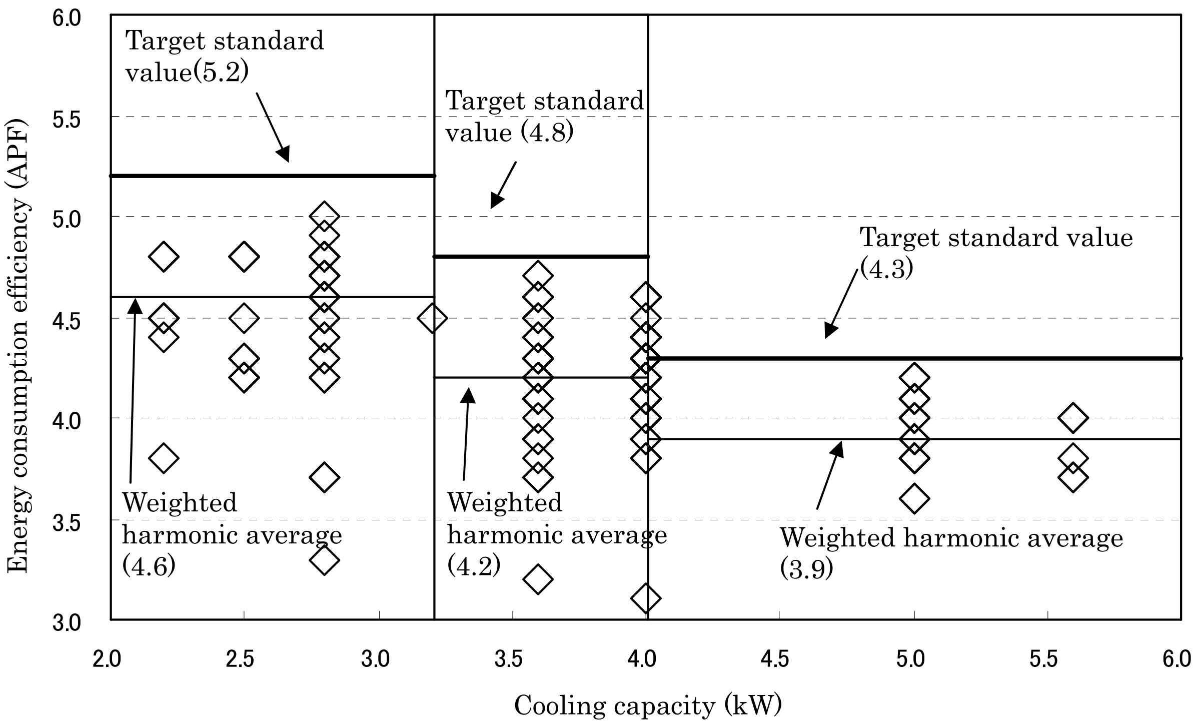



Figure 2. Top Runner values and target standard values of separate type air conditioners other than those of non-duct wall-hung type

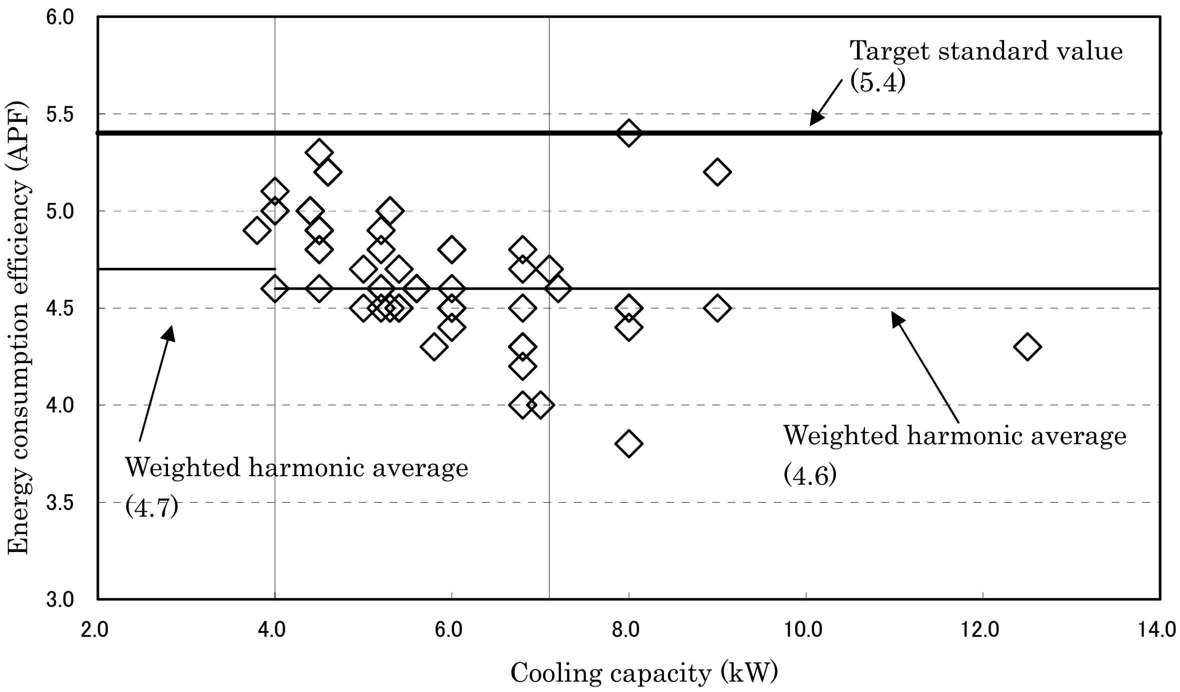



Figure 3. Top Runner values and target standard values of multi-type air conditioners

3. Target standard values of air conditioners for business use

(1) Idea on establishment of target standard values

In buildings where air conditioners for business use are installed, the area and shape of rooms that require cooling and heating vary; thus, products matching such variety must be prepared. For this reason, while ensuring the variety in forms of indoor units, 4 to 5 types of enclosures, from large to small, covering a certain rage of cooling capacity are prepared for an outdoor unit, allowing to cope with the demand for the wide range of cooling capacity. With respect to outdoor units, while they need to secure a certain range of cooling capacity with one enclosure, the space for heat exchanger is required to be almost unified due to the dimensional restriction of enclosures. Therefore, given the enclosure is the same, the energy consumption efficiency of units with larger cooling capacity tends to become less efficient than units with smaller cooling capacity.

In the light of the above, outdoor units sharing the same enclosure and multiple indoor units to be combined with are handled as one model group, and the target values are set by relational formulas using the cooling capacity of each class.

(i) Idea on air conditioners for stores

In the case of air conditioners for stores, while there are many types of indoor units to be combined with outdoor units, the majority of the combinations selected are the 4-direction cassette type, and the share is more than half of the total (Table 3). The energy consumption efficiency of the combination of 4-direction cassette type has become considerably higher than those of other combinations due to the introduction of current target standard (Figure 4). Thus, from the perspective of target setting based on Top Runner method, it is necessary to establish target standards for the combination of 4-direction cassette type.

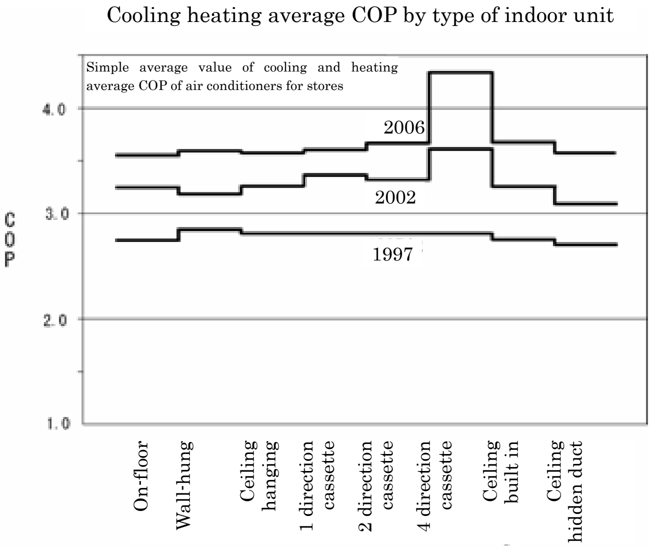



Figure 4. Cooling heating average COP of air conditioners for stores

| | Lowe than 5kW | 5kW or over and lower than 10kW | 10kW or over and lower than 20kW | 20kW or over (28kW or lower) | Total |
|---|---|---|---|---|---|
| 4-direction cassette | 40.4 | 53.2 | 60.6 | 51.4 | 54.0 |
| Others | 59.6 | 46.8 | 39.4 | 48.6 | 46.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Other status | | | | | |
| 2 direction | 18.3 | 13.5 | 8.7 | 5.0 | 11.7 |
| 1 direction | 12.1 | 7.5 | 1.3 | 1.3 | 5.5 |
| Ceiling hanging | 16.4 | 31.5 | 50.2 | 45.8 | 36.6 |
| Wall-hung | 43.9 | 33.3 | 11.4 | 7.0 | 24.7 |
| Ceiling built-in | 5.2 | 5.8 | 10.0 | 6.7 | 7.2 |
| Ceiling embedded | 1.5 | 2.2 | 4.8 | 9.5 | 3.8 |
| On-the-floor | 2.6 | 6.3 | 13.8 | 24.7 | 10.4 |
| Sub total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Table 3. Composition ratio (%) of air conditioner combinations for store by indoor units in fiscal year 2006

With respect to the target standard values for the combinations of indoor units other than 4-direction cassette, it becomes difficult for them to achieve the targets, if the same value is adopted as it for the 4-direction cassette types whose share almost reaches the half of the total air conditioners for stores. To the contrary, if the target value is to be set for combinations of each indoor unit, the categorization becomes too meticulous; therefore, substantial energy saving may not be realized. Meanwhile, if they are to be excluded from the target scope, no target value will be made; as a result, substantial energy saving may not be achieved either.

Therefore, for air conditioners for stores, 2 standards are made, i.e. the standard for 4-direction cassette type as a typical combination and the one for combinations with other type of indoor units.

As for cooling capacity for which basic classes are set as shown in Attachment 3, considering the current status that units the cooling capacity of which is lower than 3.6kW are not being shipped, it is reasonable to change the threshold of the cooling capacity from 5kW to 3.6kW.

Based on the above, 2 standards are established for air conditioners for stores as follows.

1) Regarding the standard for a combination of 4-direction cassette type indoor unit, it is reasonable to set the value with a relational formula using cooling capacity of each class, based on the Top Runner value of the model group made by a combination of one outdoor unit with one 4-direction cassette type indoor unit (in the case of class the cooling capacity of which is 20kW or over, a combination of one outdoor unit and two 4-direction cassette type indoor units shall be used, because the combination of one 4-direction cassette is rarely shipped for this class).
2) Regarding the standard for a combination with indoor units other than 4-direction cassette, it is reasonable to set it at the lowered level obtained by multiplying the standard 1) above by a certain ratio.

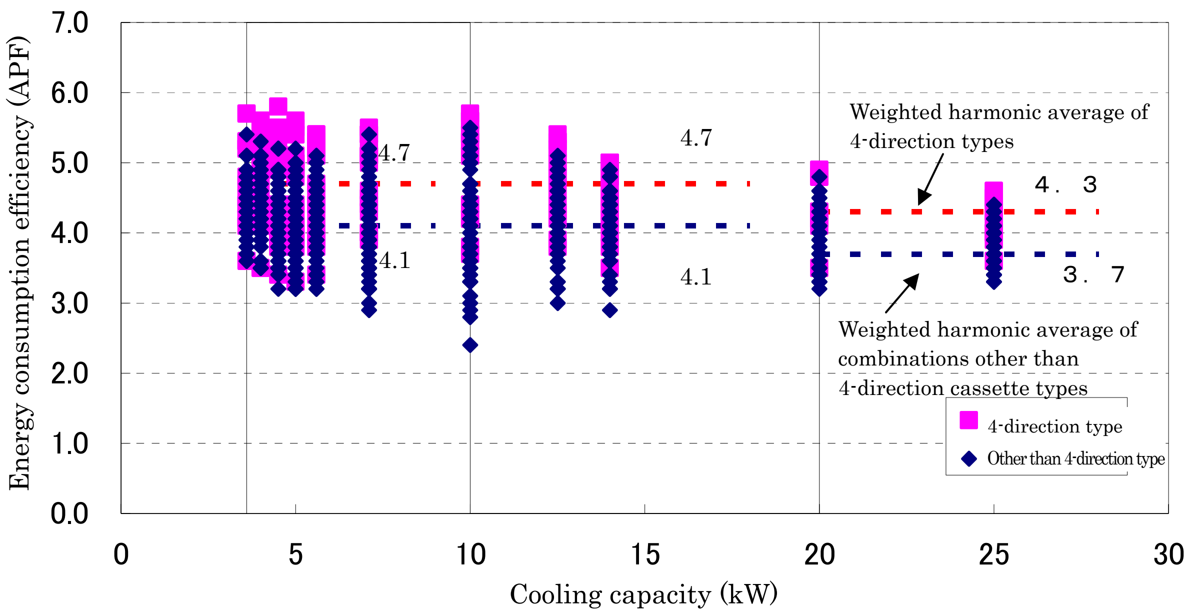



Figure 5. Current status of air conditioners for stores

(ii) Idea on multi air conditioners for buildings

Regarding multi air conditioners for buildings, as the models the cooling capacity of which is lower than 8kW are not available in the market, it is reasonable to integrate the class for cooling capacity of lower than 5kW into the class for cooling capacity of 5kW or over and lower than 10kW, making a class for cooling capacity of lower than 10kW.

Regarding the establishment of standard value, considering current APF status, it is appropriate to set it with a relational formula using cooling capacity for each class.

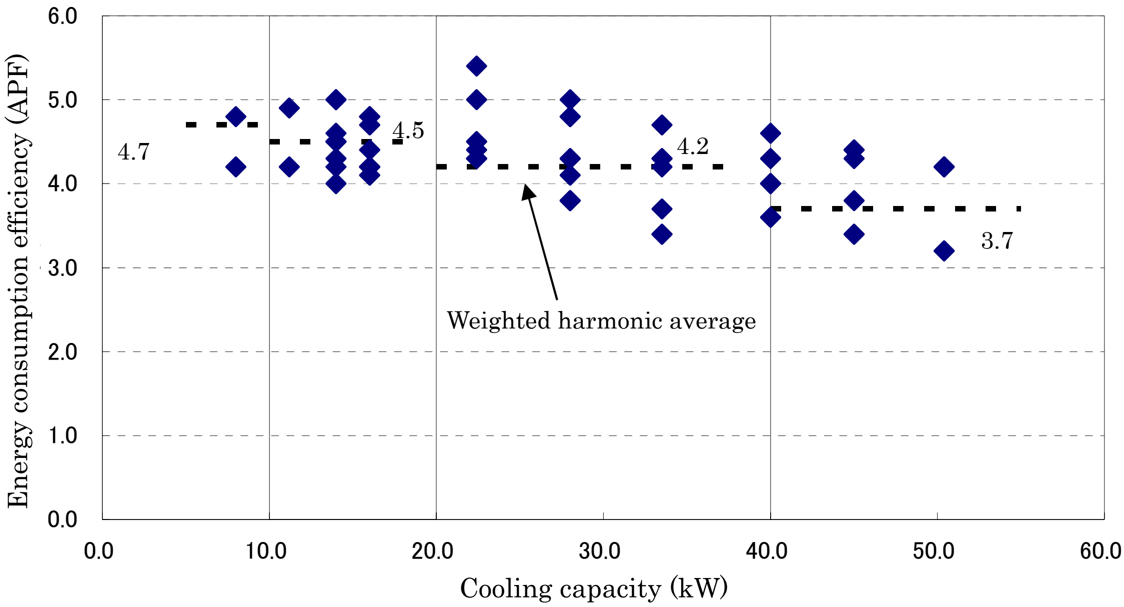



Figure 6. Current status of multi air conditioners for buildings

(iii) Air conditioners for facilities

Regarding air conditioners for facilities, there are duct-connected type and non-duct type in the market. Since preconditions for measurement are different from each other, it is appropriate to categorize them separately.

Regarding cooling capacity, since models with cooling capacity of lower than 14kW are currently not available in the market, all classes for cooling capacity of lower than 20kW are integrated. As a result, there will be two classes prepared for air conditioners for facilities, i.e. the class for cooling capacity of lower than 20kW and the class for cooling capacity of 20kW or over.

Meanwhile, as shown in Figure 7, the top values of air conditioners for facilities are not affected much by the difference in cooling capacity. It is appropriate to set the target standard with a constant value instead of a relational formula.

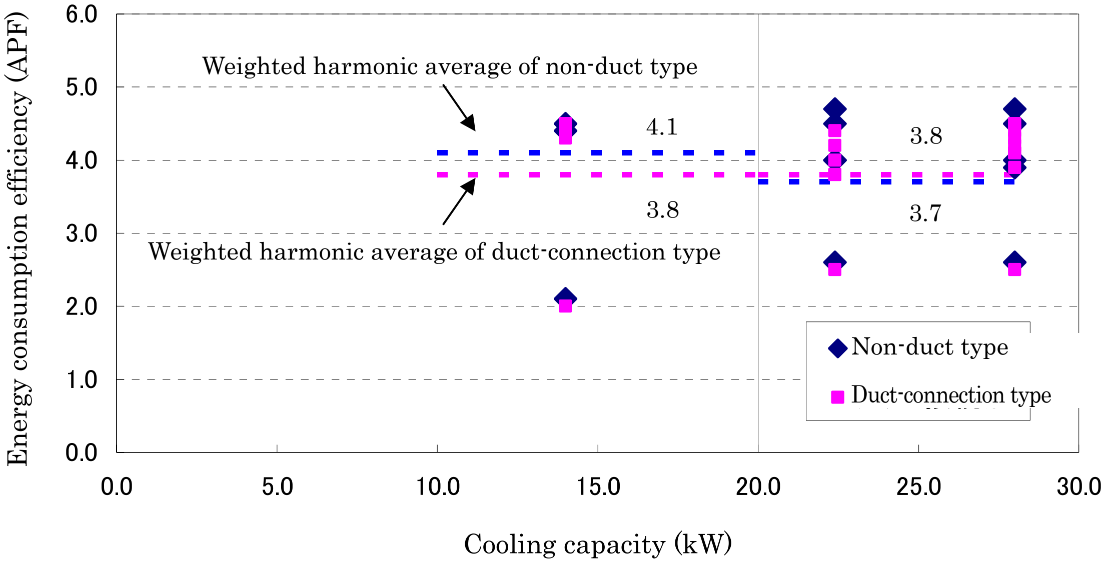



Figure 7. Current status of air conditioners for facilities

(4) Room for improvement of energy consumption efficiency by future technology advances

Technology development of air conditioners has been undertaken primarily for establishment of a comfortable living environment. Although technology development related to improvement of energy-saving performance has been implemented to accomplish the current target standards, development of each elemental technology has almost reached its limit; thus, innovative technology development like those that has been achieved in the past cannot be expected.

[Examples of major technologies for efficiency improvement of air conditioners]

- Compressors: High-efficient compression technology, neodymium magnet, improvement of motor winding, low-iron-loss magnetic steel sheet, reduction of mechanical loss, reduction of pressure drop in suction/discharge, sine-wave drive control.
- Fan motor: Introduction of DC motor, introduction of multiple poles/slots, optimization of core shape, reduction of circuit loss, optimal energization.
- Electronically controlled valve
- Heat exchanger: Three-row arrangement of indoor units, multiple folding process, improvement of fin shape, improvement of pipe arrangement process.

Although these technologies have been introduced into the current Top Runner products, it can be said that there still remains room for efficiency improvement in individual technologies, considering the fact that these introduced technologies differ depending on manufacturers and that each manufacturer is taking its own approach for further improvement of efficiency.

Taking these circumstances comprehensively into account, effect of technological improvements is expected as follows.

1) Air conditioners for stores:

Taking comprehensively into consideration the above technologies, improvement by approximately 3% from the Top Runner value is expected. Regarding products in the class for cooling capacity of 10kW or over, since the area of heat exchanger in an outdoor unit enlarges, improvement by approximately 4% is expected.

2) Multi air conditioners for buildings:

Taking comprehensively into consideration the above technologies, improvement by approximately 3% from the Top Runner value is expected. The Top Runner values of larger air conditioners such as those for stores are relatively higher than those of smaller air conditioners; therefore, approximately 3% improvement is expected in like wise for categories of smaller air conditioners.

3) Air conditioners for facilities:

Taking comprehensively into consideration the above technologies, improvement by approximately 3% from the Top Runner value is expected.

(2) Specific target standard values (See Figure 8 to Figure 11)

Based on the idea on target standard values stated in paragraph 1 (3), the target standard values shall be established through determination of Top Runner values and development of relational formulas, while considering the effects from technological improvement and consistency among categories.

(i) Idea on relational formulas

Idea on a relational formula to calculate target standard values for each category is as shown below.

$E = Et - C \times (A - B)/B$

Where, E, Et, A, B and C are defined as follows.

E: Target standard value for the target model

Et: Top Runner standard value for the relevant category

A: Cooling capacity of the target model

B: Lower cooling capacity bound of the relevant category

C: Decrease coefficient based on cooling capacity increase within a single category

The inclination of the relational formula is calculated from the inclination with which the target standard value calculated by the relational formula becomes most severe, in relation to the Top Runner value in each category and the Top Runner value of each cooling capacity available in the market.

(ii) Top Runner values and theirs relational formulas

The Top Runner values and their relational formulas in this target scope are as follows.

<< Air conditioners for stores (4-direction cassette type only) >>

| Cooling capacity | Top Runner value and its relational formula |
|---|---|
| Lower than 3.6kW | — |

| | |
|---|---|
| 3.6kW or over and lower than 10kW | E = 5.9 – 0.4 × (A–3.6)/3.6 |
| 10kW or over and lower than 20kW | E = 5.7 – 1.2 × (A–10)/10 |
| 20kW or over (to 28kW) | E = 4.9 – 1.2 × (A–20)/20 |

<< Multi air conditioners for buildings >>

| Cooling capacity | Top Runner value and its relational formula |
|---|---|
| Lower than 10kW | 4.8 |
| 10kW or over and lower than 20kW | E = 5.4 – 1.1 × (A–10)/10 |
| 20kW or over and lower than 40kW | E = 5.6 – 1.3 × (A–20)/20 |
| 40kW or over (to 50.4kW) | E = 4.6 – 1.6 × (A–40)/40 |

<< Air conditioners for facilities >>

| Cooling capacity | Top Runner value | |
|---|---|---|
| | Non-duct type | Duct type |
| Lower than 20kW | 4.5 | 4.5 |
| 20kW or over (to 28kW) | 4.7 | 4.5 |

(iii) Target standard values

Considering technological improvement expected in each category and consistency among categories, the target standard values shall be established as follows.

Regarding air conditioners for stores, as stated in (1) describing the idea on the establishment of target standard values, the target standard values are set for the category in which outdoor units are combined with 4-direction cassette type indoor units and for the category in which outdoor units are combined with indoor units other than 4-direction cassette type. When developing the standard values for the combination of indoor unit other than 4-direction cassette type, if they are set based on the Top Runner values in this category, it may disturb the diversity of indoor units. To prevent this, they are set based on the target standard values for the combinations of 4-dimention cassette type indoor units.

Thus, the target standard values for the combination of indoor units other than 4-direction cassette type are set at approximately 85% of the target standard values for the combination of 4-direction cassette type indoor units. In this standard setting, consideration shall be given to the values of the combinations of indoor units other than 4-direction cassette types obtained from Top Runner models of the combination of 4-direction cassette types for each cooling capacity class, and the difference between the weighted harmonic averages of the combinations of 4-direction cassette type and of the combinations of the others, and other factors.

When calculating the APF, the value shall be rounded down to the first decimal place, truncating at the second decimal place. Therefore, the same applies to the calculation using the target standard formulas.

<< Air conditioners for stores >>

| Type of indoor unit | Cooling capacity | Target standard value and target standard value calculation formula |
|---|---|---|
| 4-direction cassette type | Lower than 3.6kW | $E = 6.0$ |
| | 3.6kW or over and lower than 10kW | $E = 6.0 - 0.3 \times (A-3.6)/3.6$<br>$= 6.0 - 0.083 \times (A-3.6)$ |
| | 10kW or over and lower than 20kW | $E = 6.0 - 1.2 \times (A-10)/10$<br>$= 6.0 - 0.12 \times (A-10)$ |
| | 20kW or over (to 28kW) | $E = 5.1 - 1.2 \times (A-20)/20$<br>$= 5.1 - 0.060 (A-20)$ |
| Other than 4-direction cassette type | Lower than 3.6kW | $E = 5.1$ |
| | 3.6kW or over and lower than 10kW | $E = 5.1 - 0.3 \times (A-3.6)/3.6$<br>$= 5.1 - 0.083 \times (A-3.6)$ |
| | 10kW or over and lower than 20kW | $E = 5.1 - 1.0 \times (A-10)/10$<br>$= 5.1 - 0.10 \times (A-10)$ |
| | 20kW or over (to 28kW) | $E = 4.3 - 1.0 \times (A-20)/20$<br>$= 4.3 - 0.050 \times (A-20)$ |

<< Multi air conditioners for buildings >>

| Cooling capacity | Target standard value and target standard value calculation formula |
|---|---|
| Lower than 10kW | $E = 5.7$ |
| 10kW or over and lower than 20kW | $E = 5.7 - 1.1 \times (A-10)/10$<br>$=5.7 - 0.11 \times (A-10)$ |
| 20kW or over and lower than 40kW | $E = 5.7 - 1.3 \times (A-20)/20$<br>$= 5.7 - 0.065 \times (A-20)$ |
| 40kW or over (to 50.4kW) | $E = 4.8 - 1.6 \times (A-40)/40$<br>$= 4.8 - 0.040 \times (A-40)$ |

<< Air conditioners for facilities >>

| Cooling capacity | Target standard values | |
|---|---|---|
| | Non-duct type | Duct type |
| Lower than 20kW | 4.9 | 4.7 |
| 20kW or over (to 28kW) | 4.9 | 4.7 |

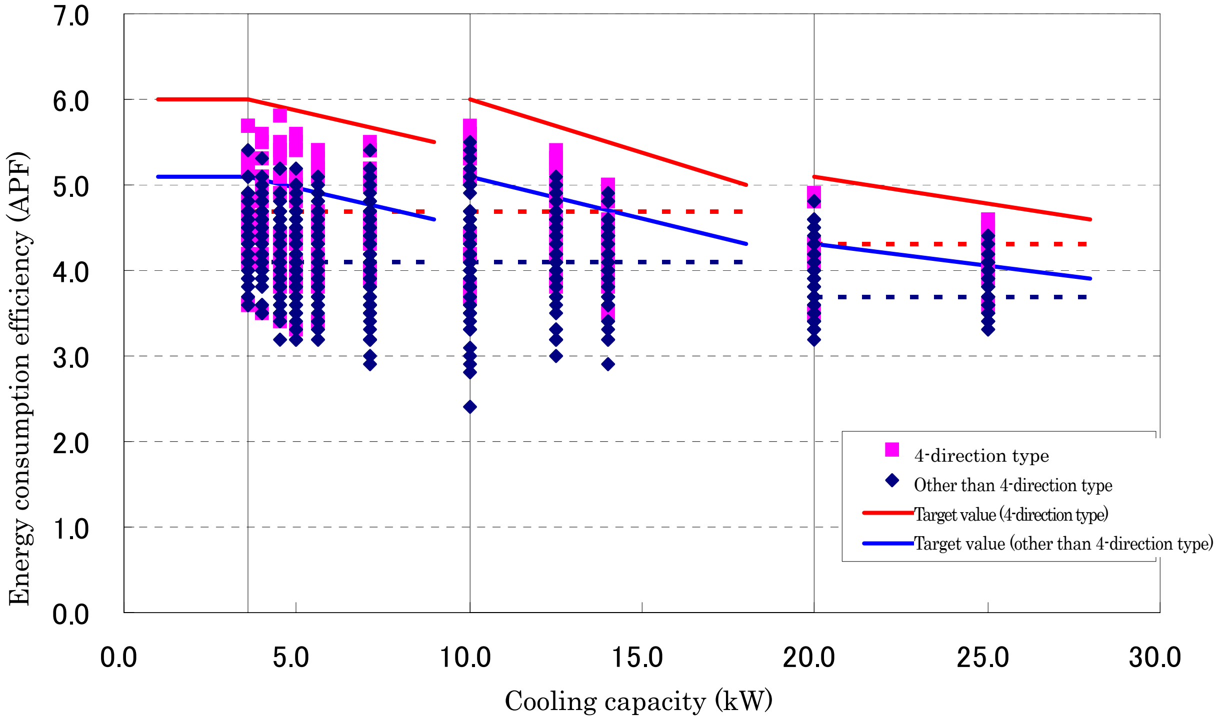



Figure 8.　Target standard values for air conditioners for stores

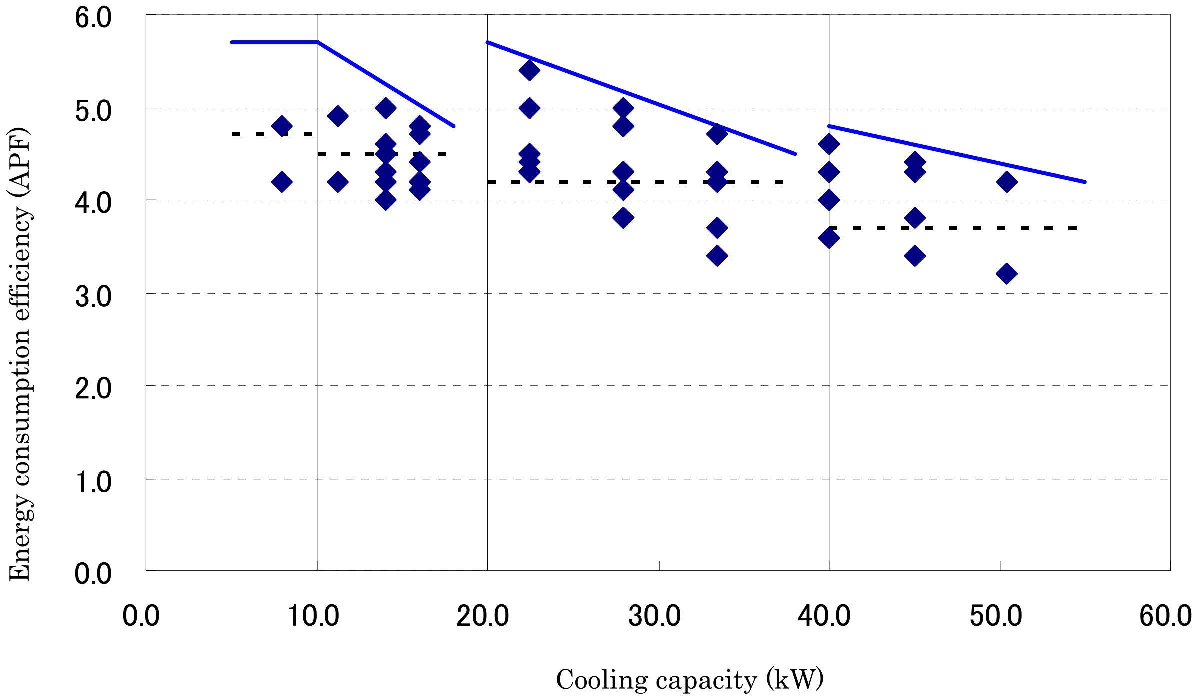



Figure 9.　Target standard values for multi air conditioners for buildings

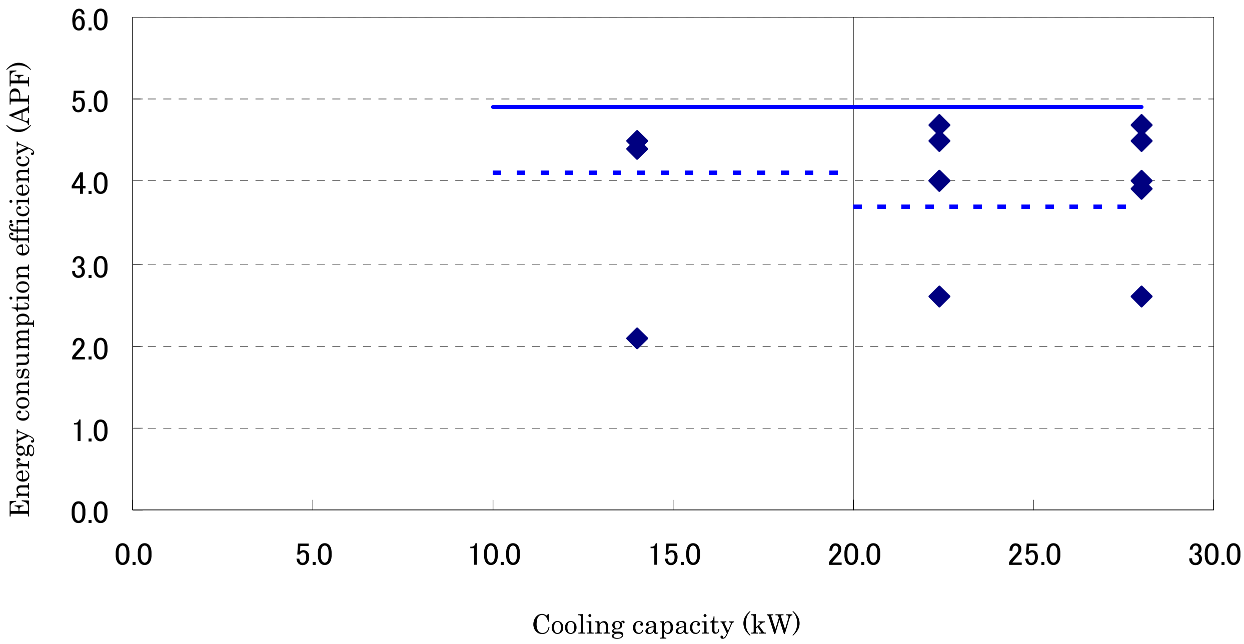



Figure 10. Target standard values for air conditioners for facilities (non-duct type)

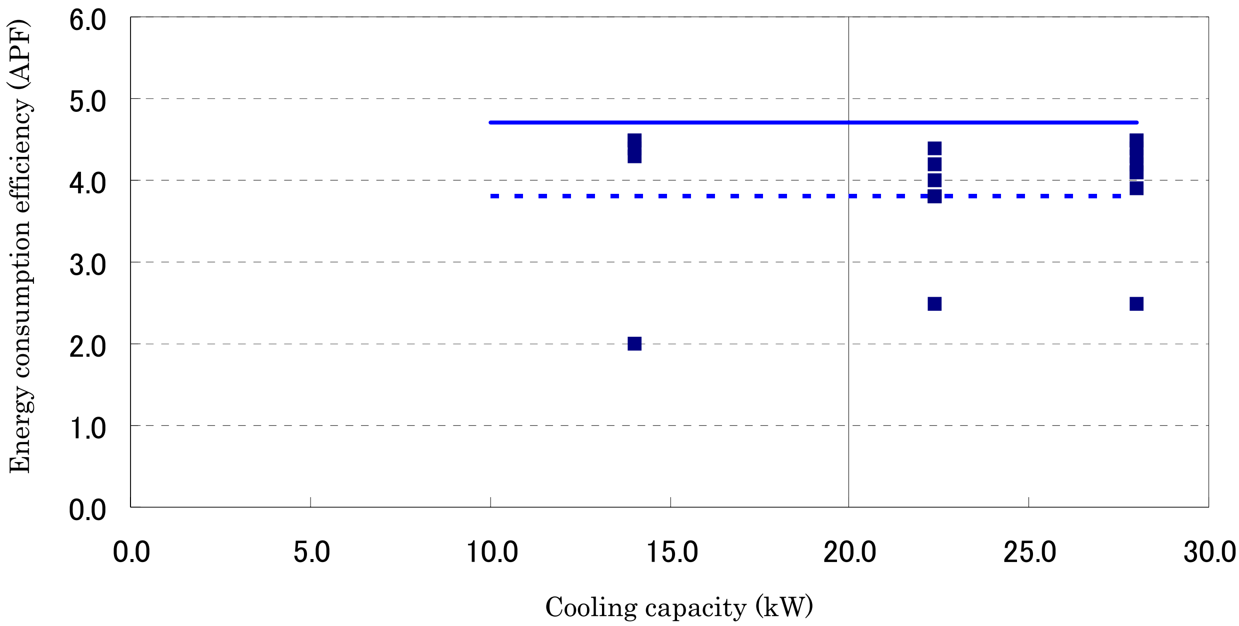



Figure 11. Target standard values for air conditioners for facilities (duct type)

Attachment 5

## Energy Consumption Efficiency of Air Conditioner and the Measurement Method

### 1. Basic Idea

When air conditioners were designated as specific equipment under the Top Runner Standard in 1998, "COP (Coefficient of Performance)" was adopted as the indicator to express the energy consumption efficiency. It was expressed by the figure dividing the cooling capacity (kW) by power consumption for cooling (kW) (hereinafter called "cooling COP") and the figure dividing the heating capacity (kW) by power consumption for heating (kW) (hereinafter called "heating COP"). Air conditioners used for both cooling and heating took the average of cooling COP and heating COP as the coefficient.

However, the evaluation using this indicator focuses on constant speed models, and it is said to be not always the best evaluation method these days when inverter models make up the majority of the market. Therefore, it is deemed reasonable to adopt the energy consumption efficiency throughout a year (APF: Annual Performance Factor) anew as the energy efficiency performance evaluation indicator which is more suitable to represent the actual status.

As regards air conditioners for home use the cooling capacity of which is 4kW or lower (air conditioners used for both cooling and heating and limited to non-duct, wall-hung type), which were studied by the last Air Conditioner Evaluation Standard Subcommittee and whose standards were stipulated in September 2006, the annual performance factor (APF) was adopted as the indicator expressing the energy consumption efficiency, and the target standard values were set using this indicator.

### 2. Specific Energy Consumption Efficiency and Measurement Method

"Annual performance factor (APF)" is used as the indicator expressing energy consumption efficiency of air conditioners. As for the method to measure energy consumption efficiency, the calculation method stipulated by Japanese Industrial Standards (JIS) C9612: 2005 (room air conditioners) is used for those for home use, and the calculation method stipulated by JIS B8616: 2006 (package air conditioners) is used for those for business use.

### 3. Annual Performance Factor (APF)

Performance indicator under the current energy conservation law is COP in rated conditions for cooling and heating.

However, aiming at evaluations representing the actual usage, there is a problem in performing them under rated conditions only, because the efficiency of air conditioners changes depending on load and outside temperature. Furthermore, in the case of inverter models which are dominant now, the performance depends on the number of revolution of compressor (performance-variable type room air conditioners).

In the light of the above, the annual performance factor (APF) was stipulated. As a result, the evaluation of energy consumption efficiency which matches the actual usage becomes possible, while considering various factors: buildings in which air conditioners are used, load conditions such as applications, outside temperature occurrence hours during cooling/heating period, and efficiency of air conditioners along with performance change which is a characteristic of inverter models.

The following table shows the comparison of COP and APF.

Table 1. Comparison of COP and APF

| | Cooling heating average COP | Annual Performance Factor (APF) |
|---|---|---|
| Calculation method | Cooling heating average COP = (Cooling rated COP + Heating rated COP) / 2<br>Where, rated COP is a value dividing performance (W) at a rated point by power consumption (W) at that time.<br>(Evaluation shall be made under both cooling and heating conditions) | Ratio of the sum of heat amount (Wh) removed from and added to the indoor air throughout cooling and heating periods to the sum of energy (Wh) consumed during the same periods. |
| Measurement points | 2 points cooling rated<br>heating rated | 5 points cooling rated, cooling intermediate,<br>heating rated, heating intermediate,<br>heating low temperature |
| Features | - Measurement points are as few as 2 points, making the measurement easier.<br>- Measured values represent efficiency at the rated points, and not the actual usage. | - Measurement points are as many as 5 points, making the measurement time longer.<br>- Efficiency closely representing the actual usage can be obtained due to the calculation taking into consideration the intermediate performances which frequently occurs in actual usage. |

(1) Conditions for calculating the annual performance factor (APF)

Basic factors of building load used as the conditions for calculating the annual performance factor (APF) are provided in Table 2 below. As the assumed building for calculating APF, JIS C9612: 2005 adopts "stand alone wooden house", and JIS B8616:2006 adopts "stand-alone store" and "office" in buildings.

Cooling load and heating load are set in consideration of heat transmission load, sun light load, ventilation, internal heat generation, etc. which are appropriate for each house/building.

Table 2. Basic factors of assumed building load

| | House | Store | Office |
|---|---|---|---|
| Outline of building | Stand-alone wooden house, first floor, facing south | Stand-alone store, first floor, facing east | Middle floor of multiple story building, facing east |
| Cooling and heating load ratio | 1.25×0.82 | 1.11 | 0.55 |
| Outside temperature when cooling load becomes 0. | 23°C | 21°C | 17°C |
| Outside temperature when heating load becomes 0. | 17°C | 15°C | 11°C |

As regards the hours when cooling or heating load occurs, taking Tokyo as a model, occurrence hours of every outside temperature are recorded under the conditions listed in Table 3.

Table 3. Cooling and heating operating days and hours (Tokyo)

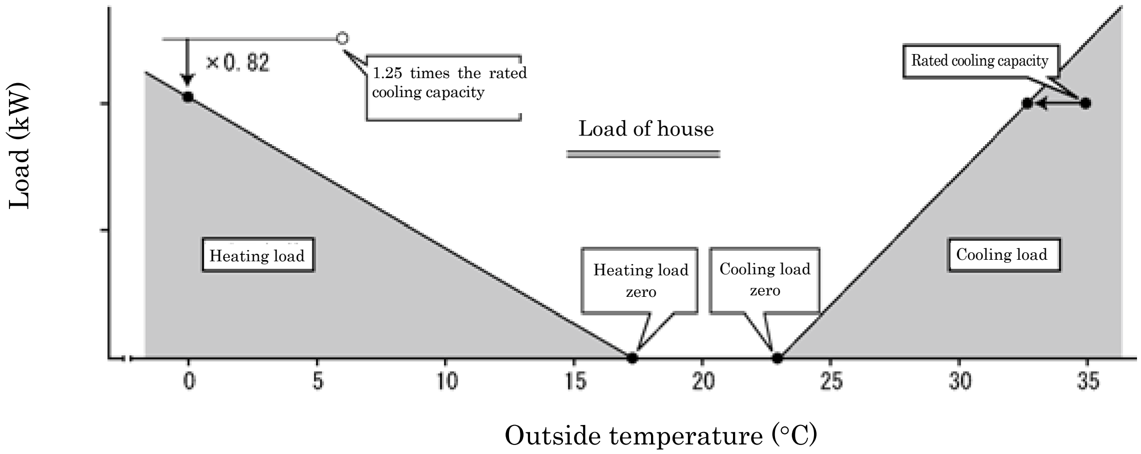
| | House | Stand-alone store | Office |
|---|---|---|---|
| Cooling period | 6/2 – 9/21 | 5/23 – 10/10 | 4/16 – 11/8 |
| Heating period | 10/28 – 4/14 | 11/21 – 4/11 | 12/14 – 3/23 |
| Operating days a week | 7 days | 7 days | 6 days |
| Operating hours a day | 6:00 to 24:00 | 8:00 to 21:00 | 8:00 to 20:00 |

(2) Calculation of total load in a period

The annual performance factor (APF) can be obtained by dividing the total load in a period by the energy consumption in the same period. In the calculation of total load in a period for air conditioners, load and occurrence hours according to outside temperature are different for house, stand-alone store and office. The following figures illustrate the method for calculating the total loads of cooling and heating periods.

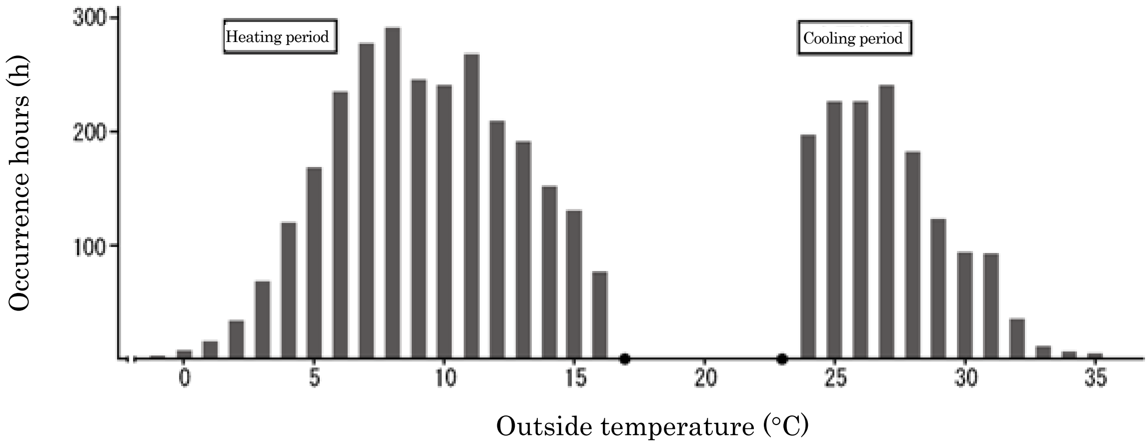
(A) House

1) Outside temperature and building load

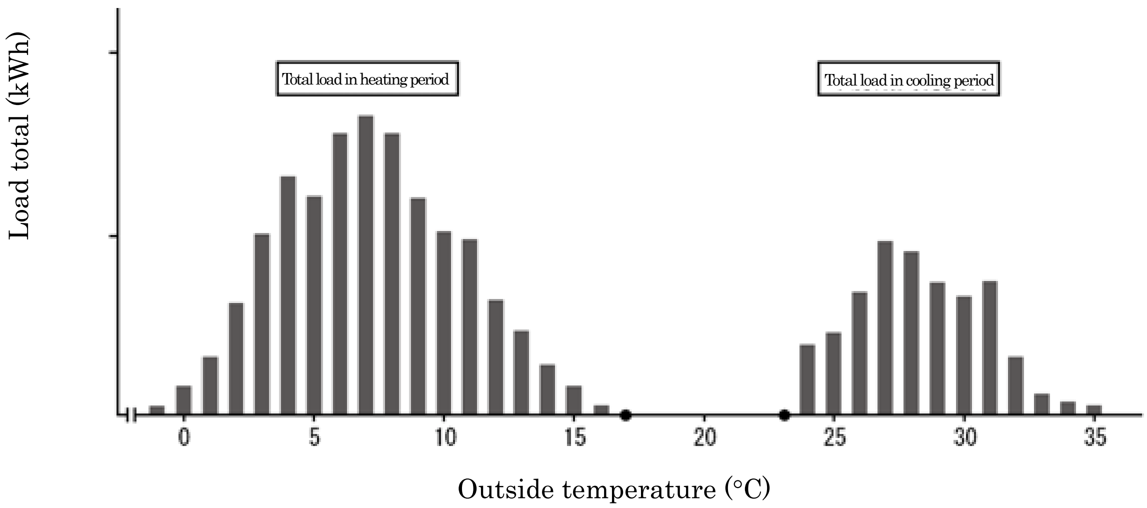



2)

2) Occurrence hours of each outside temperature

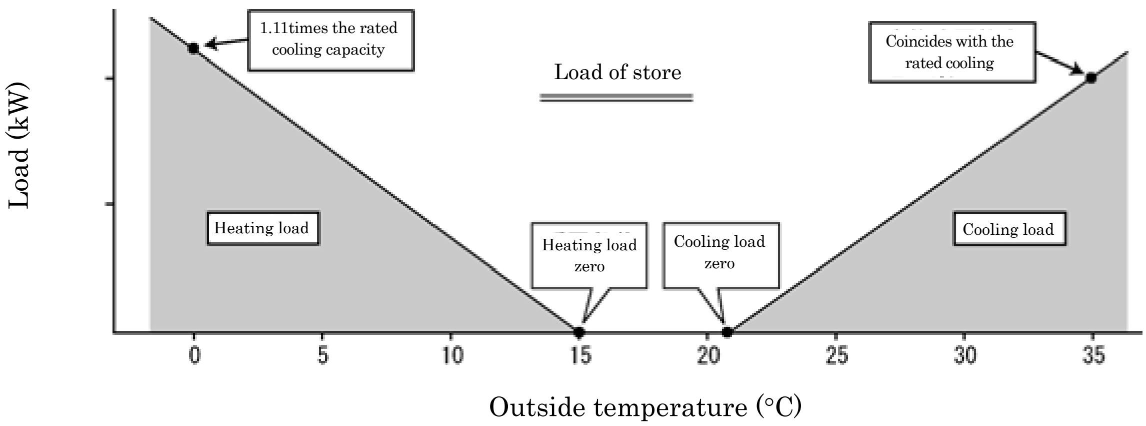



3) Annual load at each outside temperature

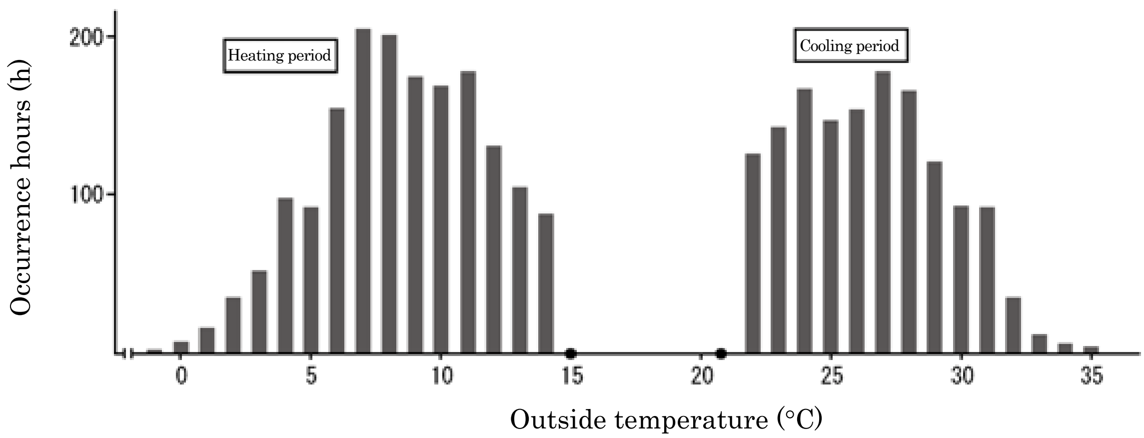


(B) Stand-alone store

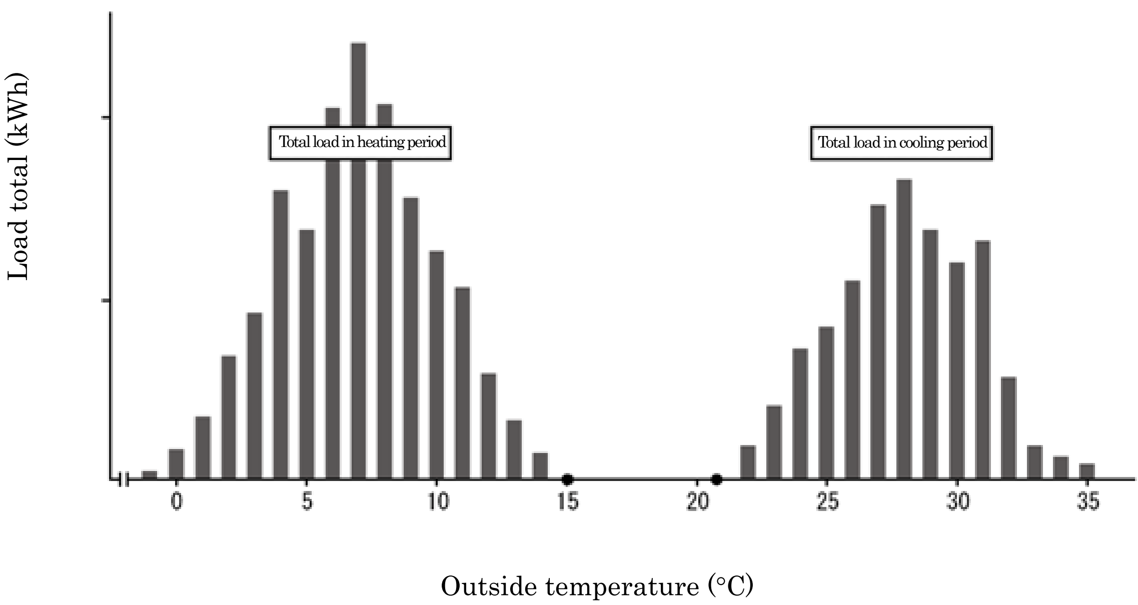
1) Outside temperature and building load




2) Occurrence hours of each outside temperature

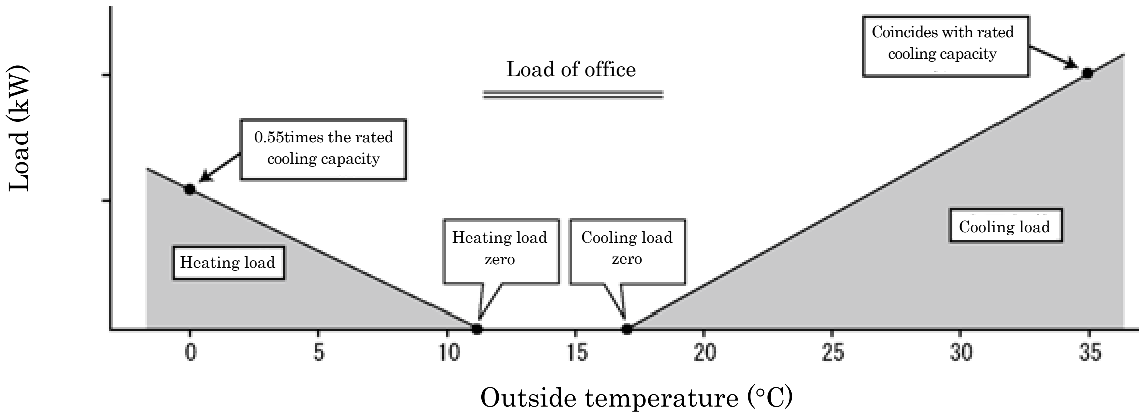



3) Annual load at each outside temperature

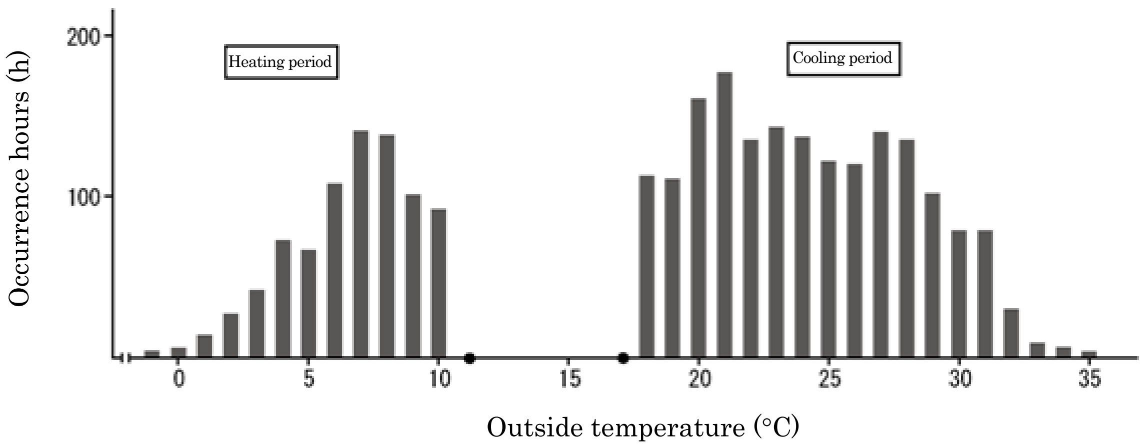


(C) Office

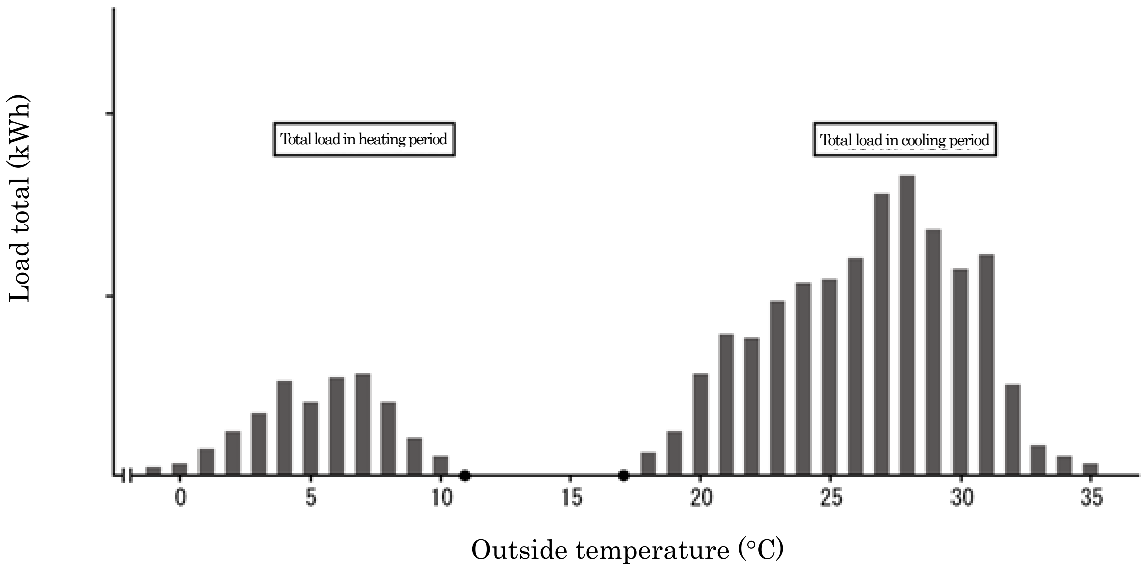
1) Outside temperature and building load




2) Occurrence hours of each outside temperature




3) Annual load at each outside temperature

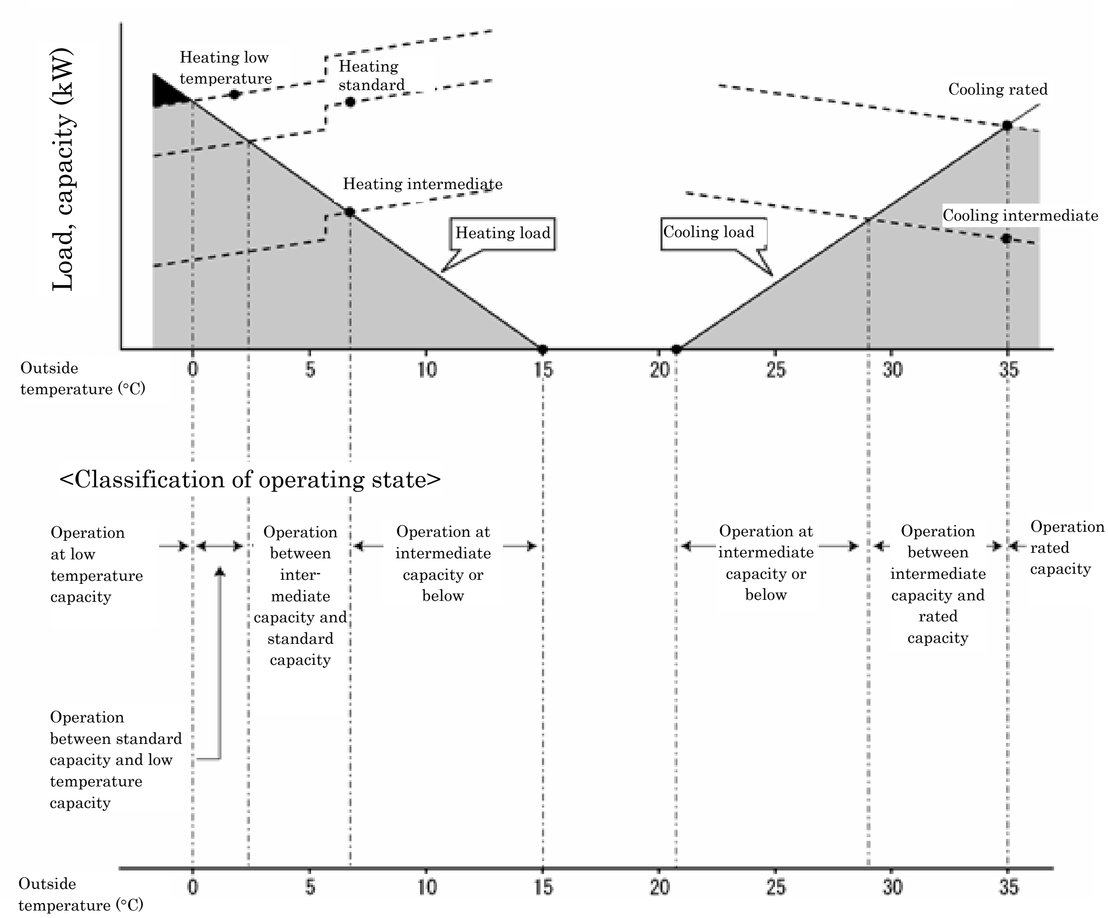


(3) Calculation of total energy consumption in a period

(i) Measurement point

Performance values used in the conventional cooling and heating average COP represent 2 performance points under the rated condition, i.e. a cooling condition with outside temperature at 35°C and a standard heating condition with outside temperature at 7°C. In the concept of APF, 2 more performance points are added, which are under an intermediate cooling condition and an intermediate heating condition where the performance is adjusted to one-half level, using the same outside temperature condition as above. Further, the performance value at the rated heating low temperature capacity with outside temperature at 2°C is also added. Consequently, APF uses 5 points in total.

<< Change of capacity according to measurement points and outside temperature >>




(ii) Classification of operating state

1) In cooling, taking into account the change of capacity due to outside temperature calculated from the evaluation points at rated cooling capacity and intermediate cooling capacity, following scopes are made for the building loads: the scope of outside temperature in which the load is handled by operation at intermediate or lower cooling capacity, the scope of outside temperature in which the load is handled by operation between intermediate cooling capacity and rated cooling capacity, and the scope of outside temperature in which the load is handled by cooling rated operation.

2) Meanwhile, calculating the change of capacity due to outside temperature using the evaluation points at rated heating standard capacity, intermediate heating capacity and heating low temperature capacity, following scopes are made: the scope of outside temperature in which the load is handled by the operation at intermediate or lower heating capacity, the scope of outside temperature in which the load is handled by operation between intermediate heating capacity and heating standard capacity, and the scope of outside temperature in which the load is handled by operation at heating standard capacity and hating low temperature capacity, and the scope of temperature in which the load is handled by operation at heating low temperature capacity. (For the scope in which the load cannot be covered by operation at heating low temperature capacity, assuming that this shortage of capacity is covered by operation of another electric heater, power consumption of which shall be included in the total power consumption).

(iii) COP corresponding to outside temperature

1) COP of air conditioners is calculated at each outside temperature under each operating state corresponding to the building load, in consideration of the relation between the change of capacity based on outside temperature and the change of power consumption.
2) For heating, the change of COP caused by the change of outside temperature is similarly calculated for each class of operating state.

(iv) Calculation of energy consumption

1) From the load based on temperature and COP at each outside temperature, power consumption at an outside temperature is calculated. From power consumption and occurrence hours, energy consumption (kWh) for cooling building is calculated for each outside temperature. By totaling energy consumed for cooling operation at each outside temperature, energy consumption (kWh) in cooling period is obtained.
2) Similarly, for heating, from the load based on temperature and COP at each outside temperature, power consumption at an outside temperature is calculated. From power consumption and occurrence hours, energy consumption (kWh) for heating building is calculated for each outside temperature. By totaling energy consumed for heating operation at each outside temperature, energy consumption (kWh) in heating period is obtained.

(4) Annual Performance Factor (APF)

The annual performance factor is calculated from the total load at cooling and heating operations and the energy consumption during these periods.

APF=

$$\frac{\text{Total load during cooling period + Total load during heating period}}{\text{Energy consumption during cooling period + Energy consumption during heating period}}$$

(5) APF of multi air conditioners for home use

The APF of multi air conditioners for home use shall be calculated according to the method stipulated by Japanese Industrial Standards (JIS) C9612: 2005 (room air conditioners). In doing this, the connection between an outdoor unit and indoor units must be the one that makes the ratio of the indoor unit's total nominal capacity to the outdoor unit's nominal capacity to be 1 or closer to 1, while connecting indoor units which allow for 100% of outdoor unit’s nominal capacity.

(6) APF of air conditioners for business use the rated cooling capacity of which is over 28kW

The APF of air conditioners for business use the rated cooling capacity of which is over 28kW shall be calculated according to the calculation method stipulated by JIS B8616: 2006 (package air conditioners). In doing this, the number of indoor units connected must be appropriate for the capacity of outdoor unit.

Attachment 6

Air Conditioner Evaluation Standard Subcommittee
Energy Efficiency Standard Subcommittee of the Advisory Committee for Natural Resources and Energy
Background of Holding

First Subcommittee Meeting (June 13, 2007)

- Disclosure of the Air Conditioner Evaluation Standard Subcommittee
- Current status of air conditioners
- Scope of air conditioners to be covered
- Energy consumption efficiency of air conditioners and the measurement method

Second Subcommittee Meeting (September 21, 2007)

- Categories for target setting for air conditioners (for home use)
- Target standard values and target fiscal year for air conditioners (for home use).

Third Subcommittee Meeting (February 12, 2008)

- Categories for target setting for air conditioners (for business use)
- Target standard values and target fiscal year for air conditioners (for business use)

Fourth Subcommittee Meeting (February 22, 2008)

- Interim summary report

Interim report was open for public comments during the period from March 1, 2008 through March 30, 2008; and no comment was received. As a result, the interim report was adopted as the final report.

Attachment 7

Air Conditioner Evaluation Standard Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee on Natural Resources and Energy
List of Members

| | | |
|---|---|---|
| Chairman: | TAKAMOTO SAITO | Professor Emeritus, University of Tokyo |
| Members: | SATORU AKAMA | Assistant Chairman, Business Air Conditioner Committee, Japan Refrigeration and Air Conditioning Industry Association |
| | HIROSHI ASANO | Professor in Department of Mechanical Engineering, Graduate School of Engineering, University of Tokyo |
| | KAZUO UENO | Deputy Director, Energy Technology Research Institute, National Institute of Advanced Industrial Science and Technology |
| | AKIRA OKAGAKI | Executive Officer and Principal Consultant, NIKKEN SEKKEI Research Institute |
| | HIROYUKI KUDO | General Manager, Technology Dept., Energy Conservation Center, Japan |
| | HARUKI SATO | Professor, Department of System Design Engineering, Faculty of Science and Technology, Keio University |
| | KIKUKO TATSUMI | Managing Director & Chairperson of Environment Committee, Nippon Association of Consumer Specialists |
| | KIYOSHI NAGASAWA | Chairman of Home Air Conditioner Committee, Japan Refrigeration and Air Conditioning Industry Association |
| | EIJI HIHARA | Professor Specialized in Environmental Studies, Graduate School of Frontier Science, University of Tokyo |
| | CHIHARU MURAKOSHI | Director and Vice President, Jyukankyo Research Institute Inc. |

Reference 1

# Current Status of Air Conditioners

## I. Air conditioners for home use and business use

Air conditioners used in houses and buildings are electrically driven and directly cool or heat indoor spaces. They are roughly classified into for home use and for business use.

The number of air conditioners for business use shipped in a year is approximately 1/10 of those for home use. But the capacity of an air conditioner for business use is approximately 6 times the capacity of an air conditioner for home use.

Market size of air conditioners for home use and for business use

Air conditioners for home use
Number of units shipped in a year: 7,573,000
Average cooling capacity: Approx. 2.5kW

Air conditioners for business use
Number of unit shipped in a year: 808,000
Average cooling capacity: Approx. 15kW

Source: Japan Refrigeration and Air Conditioning Industry, FY2005 Survey

With respect to air conditioners for business use, there are some models which are driven by gas engine instead of electricity. In the case of those for large buildings, central air conditioning systems which cool or heat indoor spaces by circulating cold water cooled with thermal source units are normally installed, instead of air conditioners which cool and/or heat indoor spaces directly.

## II. Current status of air conditioners for business use

### II.1 Market trend

#### II.1.1 Air conditioners for business use

Air conditioners for business use are designed and manufactured to be primarily used at offices, stores and others in industrial/commercial buildings. They are also called "package air conditioners".

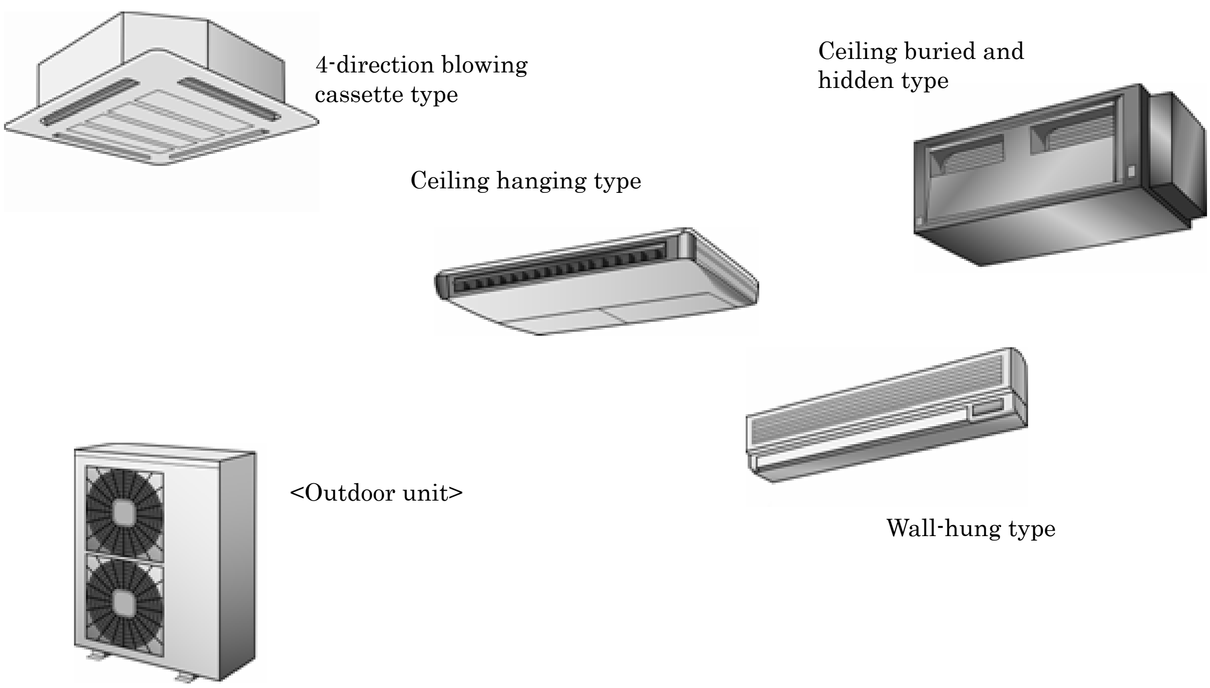
Having the same basis as air conditioners for home use, they electrically drive the freezing cycle and directly cool and heat rooms. There are many types based on unit structure, form of indoor units, etc. to support various building structure and applications.

They are currently classified into "air conditioners for stores", "multi air conditioners for buildings" and "air conditioners for facilities" according to the main building applications, and catalogues are prepared separately for each type.

(1) Air conditioners for stores

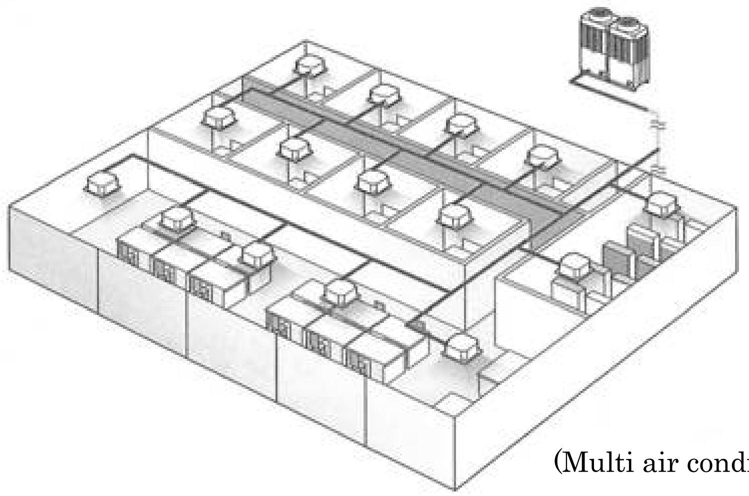
Those are mainly for small-scale stores and offices. The representative ones are those having 4-direction air outlet on the ceiling, which are often seen inside stores. There are so many other types of indoor units such as ceiling hanging type, ceiling hidden type, on-the-floor type, etc. The range of their cooling capacity is as wide as from around 3kW to 30kW. It is typical to combine one outdoor unit and one indoor unit with an air thermal source and a separate type system; however, there are also types consisting of two or three indoor units (in this case, they are not individually controlled because they are operated in the same room).

<Various indoor units>



(2) Multi air conditioners for buildings

Those are air conditioners systemized mainly for small to medium scale buildings, combining modularized outdoor units to which many indoor units are connected, resulting in having a capability to control each indoor unit separately. Most common system is air thermal source, separate type, but there is also water thermal source type.



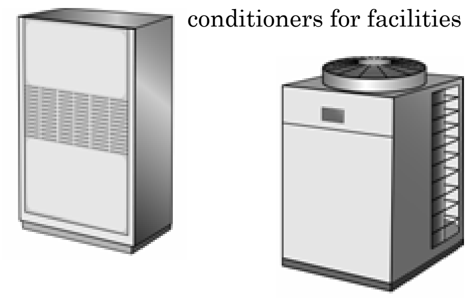
(Multi air conditioners for building)

(3) Air conditioners for facilities

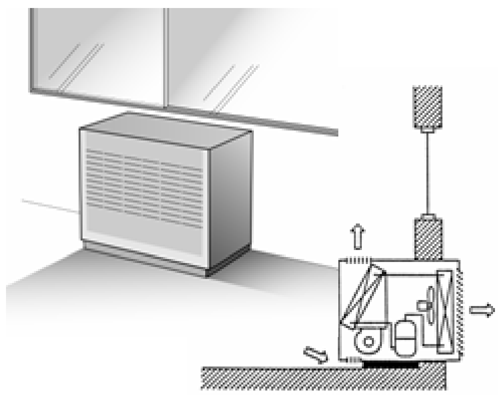
Those are frequently used in large space such as in factories, specifically box-shaped air conditioners put on the floor. They are the original form of air conditioners for business use. Water cooling integrated type and air cooling remote condenser type are used to be common before, but separate type air conditioners are recently increasing.

There are also "wall-through type" air conditioners, at the installation site of which the wall of perimeter (window-side) of medium size buildings is penetrated.

Air cooling, standard on-the-floor type air conditioners for facilities



Wall-through type



Number of air conditioners for business use and total cooling capacity

Electric air conditioners for business use
808 thousand units
Approximately 12.2 million kW

| [For stores] | [Multi type for buildings] | [For facilities] |
|---|---|---|
| 653 thousand | 97 thousand | 58 thousand |
| Approx. 7.5 million kW | Approx. 3 million kW | Approx. 1.7 million kW |

(Reference)
Equipment other than electric air conditioners for business use

| Gas engine heat pump air conditioners | Chilling unit | Absorption freezer | Turbo freezer |
|---|---|---|---|
| 35.9 thousand | 9.9 thousand | 2.4 thousand | 0.5 thousand |
| Approx. 1.6 million kW | Approx. 800 thousand kW | Approx 1.6 million kW | Approx 1 million kW |

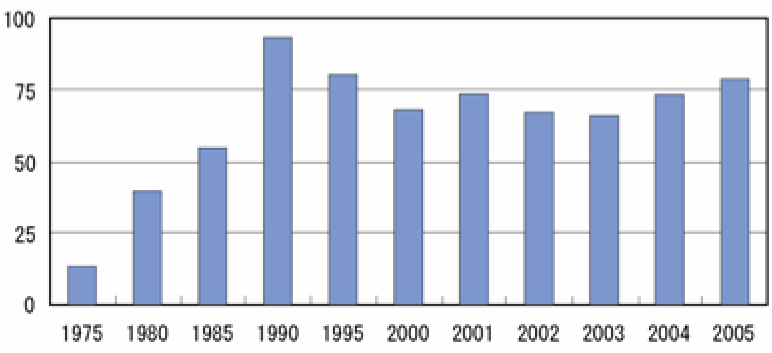
Note 1) Source: Japan Refrigeration and Air conditioning Industry Association, FY 2005 Survey
2) kW above is the unit of cooling capacity or chilling capacity (not the unit of power consumption).

### II.1.2 Status of domestic shipment

The shipment of air conditioners for business use was rapidly increasing until 1990, reaching 1.08 million units in 1991. It decreased after that, but is still keeping 750 thousand a year level in recent years.

Transition of shipment of air conditioners for business use

Unit: Ten thousand




Fiscal Year

The shipment of air conditioners for business use as a whole has been recovering in recent years as the recovery of trend of economy such as capital investment. Especially, growth of multi air conditioners for buildings is notable.

Recent trend of product type

(Unit: thousand)

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Total number of air conditioner for business use | 708.3 | 725.3 | 648.2 | 684.9 | 758.6 | 808.0 |
| Air conditioners for stores | 590.8 | 603.6 | 528.3 | 554.5 | 617.6 | 652.8 |
| Multi air conditioners for buildings | 67.5 | 68.2 | 75.0 | 80.5 | 87.2 | 97.3 |
| Air conditioners for facilities | 50.5 | 53.6 | 44.9 | 49.8 | 53.8 | 57.8 |

Source: Japan Refrigeration and Air Conditioning Industry Association

### II.1.3 Transition of the number of units imported

The import of air conditioners for business use was almost none before, but it has been slightly increasing in recent years.

(Unit: thousand)

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Quantity imported | — | — | — | 16.9 | 21.4 | 31.8 |
| Ratio to domestic shipment (%) | — | — | — | 2.5% | 2.9% | 3.9% |

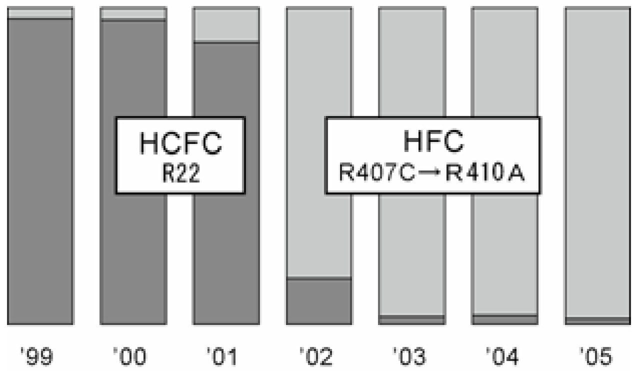
Source: Japan Refrigeration and Air Conditioning Industry Association

### II.1.4 Change from HCFC refrigerant

To protect the ozone layer, following the total abolishment of CFC in 1995, HCFC also became a subject of restriction, which is basically to be completely abolished by 2020 under international agreement.

HCFC had been used for air conditioners for business use. However, the voluntary program was drawn up to switch the refrigerant to HFC by January, 2004 when the restriction on HCFC started, and the change to HFC whose ozone layer destruction coefficient is 0 had been promoted since then. This refrigerant change was almost completed at the time of 2002 among air conditioners for stores and for buildings, followed by the completion of the change among air conditioners for facilities and special units.

Change to HFC refrigerant among air conditioners for business use



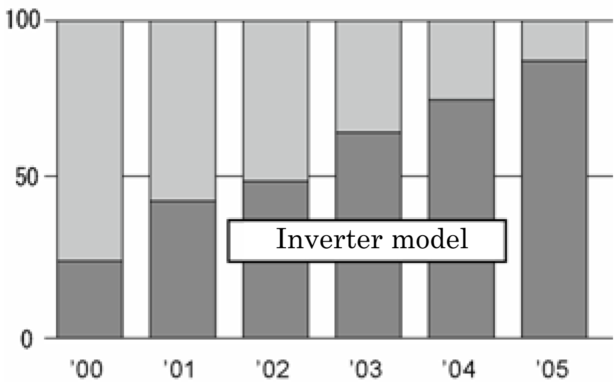

There are some types in HFC refrigerant, and air conditioners for business use would frequently use R407C the characteristics of which were close to these of HCFC (R22). However, following a review of basic structure of air conditioners in response to the situation so compelling to require further energy saving, transition to R410A was hammered out again and has been going under way fast.

II.1.5 Changes of energy consumption efficiency

Due to the two oil crises in the 1970s, necessity of energy saving in equipment was recognized, and the energy consumption efficiency of air conditioners for business use was steadily improved. Since Kyoto conference on the prevention of global warming in 1997 (COP3), interests in energy saving in equipment has been on the rise again. The industry of air conditioners for business use took up the matter as the most important issue along with the change from HCFC.

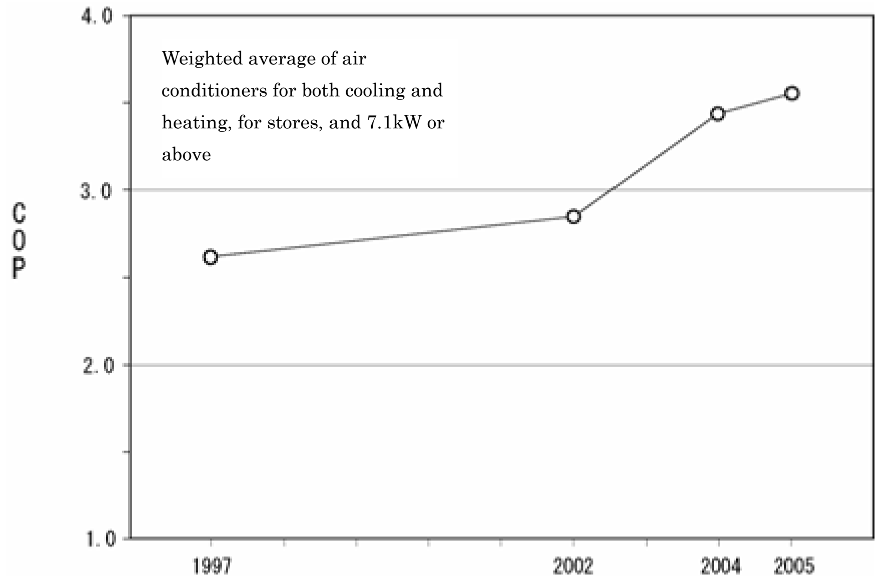
To promote energy saving, inverter control was introduced and it is now spreading rapidly.

Introduction of inverter control to air conditioners for stores




As a result of these efforts, cooling and heating average COP of air conditioners for business use in a typical range was raised from 2.7 in 1997 to 3.5 or above in 2005.

Transition of cooling and heating average COP of recent air conditioners for business use

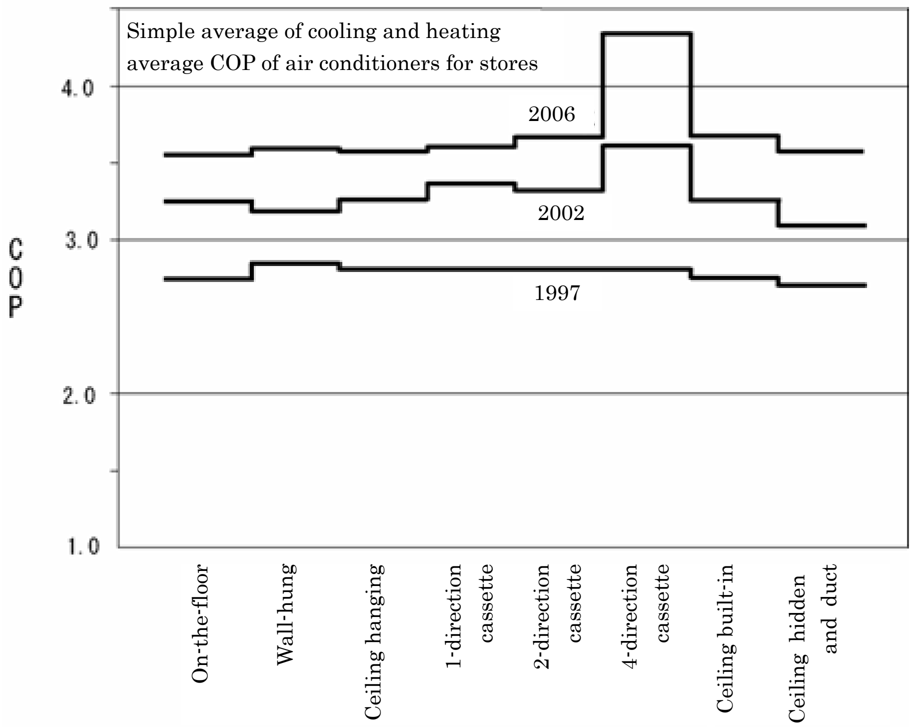



| | 1997 | 2002 | 2004 | 2005 |
|---|---|---|---|---|
| Class of air conditioners for stores | 2.7 | 2.8 | 3.4 | 3.5 |

Source: Japan Refrigeration and Air Conditioning Industry Association

Cooling and heating average COP by the type of indoor unit was raised as a whole by the introduction of energy saving technologies to outdoor unit, while it was mostly achieved by air conditioners with 4-direction cassette type indoor units which account for nearly half of the total.

Transition of cooling and heating average COP by type of indoor unit



II.1.6 Penetration rate and number of units installed per site

There are no relevant data available for air conditioners for business use.

II.1.7 Main domestic manufacturers

| | | |
|---|---|---|
| Sanyo Electric Co., Ltd. | DAIKIN INDUSTRIES, Ltd. | DENSO ACE |
| Toshiba Carrier Corporation | NIPPON PMAC CO., LTD | Hitachi Appliance, Inc. |
| Matsushita Electric Industrial Co., Ltd. | MITSUBISHI HEAVY INDUSTRIES,LTD . | Mitsubishi Electric Corporation |

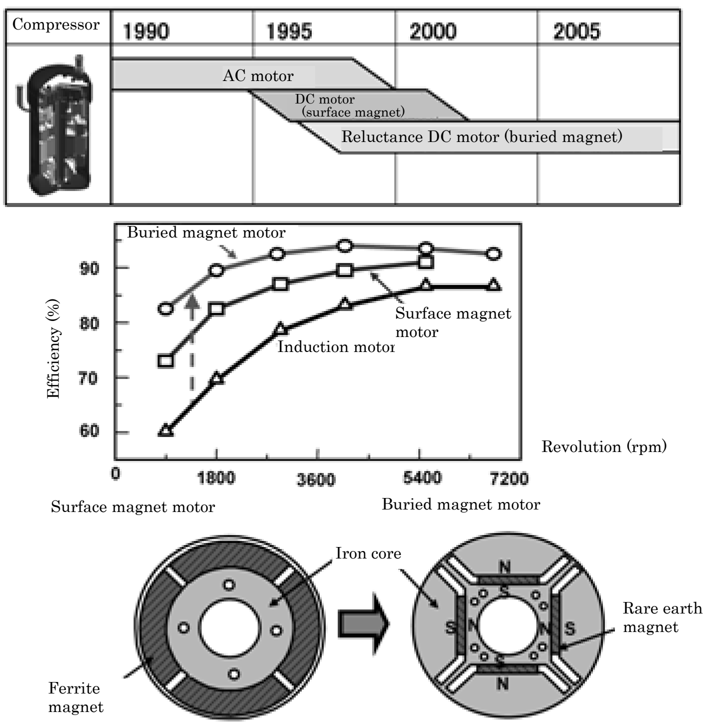
(In the order of Japanese syllabary)

II.2 Energy saving efforts in air conditioners for business use

(1) Compressor performance improvement technology

- Highly efficient compressor motor

“Compressor motor efficiency” has been raised to approximately 95% by changing AC motor (inductor) to highly efficient DC motor and by improving the magnet.




- Improvement of compressor efficiency

In addition to the efficiency improvement of compressor motor as mentioned above, further energy saving was achieved by reducing mechanical loss by enhancing as high as possible the preciseness of machine processing for the sliding parts and by reducing the pressure loss of refrigerant passage.

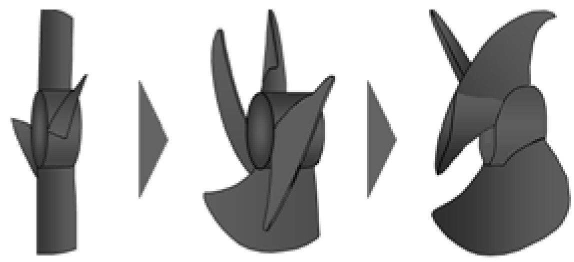
(2) Fan performance improvement technology

- Highly efficient fan motor

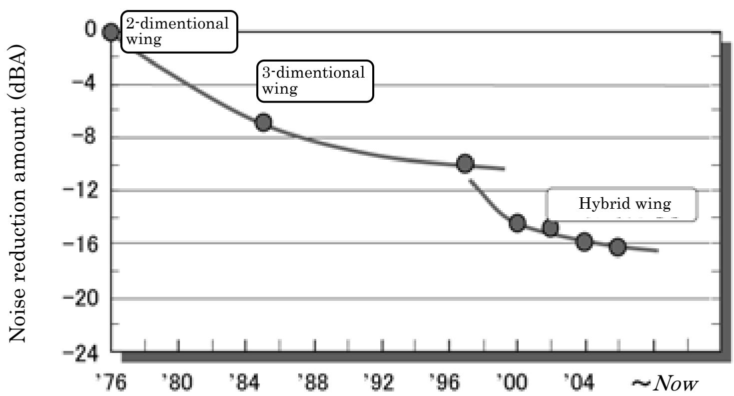
Fan motors of both indoor units and outdoor units have been changed from conventional AC motors to efficient DC brushless motors. Besides, the technology developed for compressor motors which consume large amount of power was introduced to improve the efficiency.

- Efficiency improvement of fan

Generally, propeller fans are used for outdoor units of air conditioners. By improving and reforming the wing shape, while reducing the noise, it became possible to send a great deal of air, thus, achieving high efficiency.



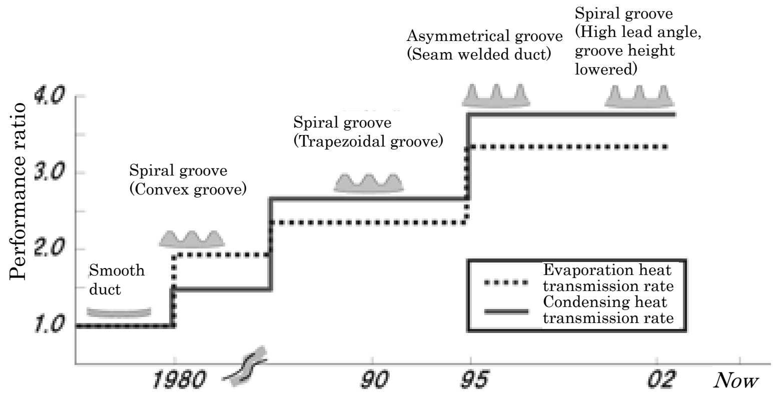
2-dimentional wing 3-dimentional wing Hybrid wing

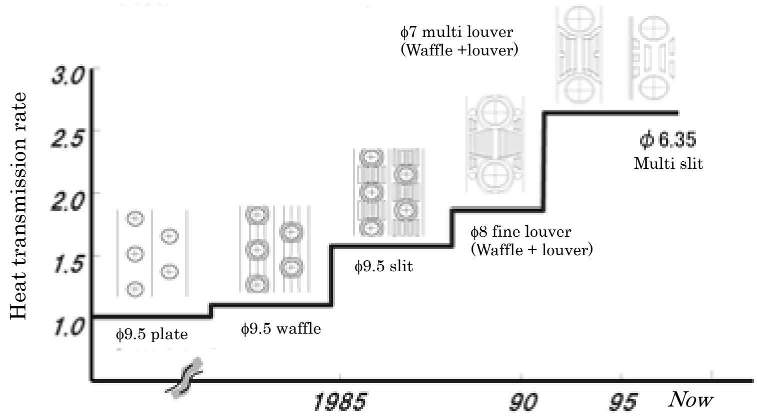



(3) Heat exchanger performance improvement technology

- Highly efficient heat transfer ducts for heat exchangers

Smooth ducts without having inner surface machine processed, which is similar to copper ducts, were originally used for heat exchangers; however, to promote energy saving, ducts with inner groove were developed. Besides, the groove shape was optimized to enlarge heat transmission area and enhance the turbulent flow effect.




- Highly efficient heat exchanger fins

Originally, flat aluminum plates were used for heat exchangers. To improve energy efficiency, the heat transmission area was enlarged (waffle fins), the development of the temperature boundary layer on the fin surface was contained (louver fins), and the airflow resistance was reduced to increase blowing air (smaller diameter of heat transmission duct).

## II.3 Future approach to energy saving and challenges

As it now stands, increasing size of a heat exchanger is a key factor for energy efficiency improvement.

### II.3.1 Various problems accompanying growing size of air conditioners

(1) Installability

In Japan, the pitch of ceiling aggregate to which ceiling materials are fixed is in standard 910mm. The width of aggregate is 50mm and the space between aggregates is 860mm. The size of ceiling buried cassette type air conditioners, which account for almost the half of air conditioners for business use, is fixed to approximately 840mm x 840mm that is a size to fit the space between aggregates.

If the size of air conditioners becomes larger than this, they may no longer be suitable for stores or buildings.

When replacing multiple outdoor units installed in a limited space such as the rooftop of buildings, if the size of a unit becomes larger, it is concerned that the same number of outdoor units cannot be installed, making the replacement impossible.

(2) Comfort

It is concerned that the further growth in size of a heat exchanger and a fan might damage the basic comfort. That is to say, "evaporation temperature rises and thus humidity in a room is difficult to be cleared" in the case of cooling operation; and "condensation temperature is dropped so that it doesn't feel warm because the temperature of air sent out is lower than human body temperature" in the case of heating operation.

(3) Resource saving

Increased size of equipment might also increase the amount of material used, such as copper and aluminum for heat exchangers, and steel sheets and resin for cabinets. Also, the refrigerant used will increase. Thus, problems will remain in view of resource saving.

As regards the rare earth elements used for the high function magnet, it is important to secure stable supply of such materials. If failed in doing so, it may retard the spread of high performance equipment.

### II.3.2 Relationship between difference in running cost and sales price

In order to achieve the next efficiency level of future energy efficient models, it is essential to increase size of a heat exchanger, which leads to cost increase for material input. Therefore, it is necessary to advance product development, while consideration must be given to whether an increase in initial cost due to introduction of an energy-efficient model can be compensated for by the decreased running cost within a product life. It is also important to promote the development of energy-efficient models in a way prevents the total cost increase for a manufacture. In the future, the discussion on how energy saving should be compatible with economic rationality, including the relationship between a manufacture etc and a user, will be required.

## III. Current status of air conditioners for home use

### III.1 Market trend

### III.1.1 Air conditioners for home use

Air conditioners for home use, also called "room air conditioners", are designed and manufactured for the use for rooms in regular houses. Having the same basis as air conditioners for business use, they electrically drive the freezing cycle and directly cool and/or heat rooms. 1-to-1 separate type, wall-hung type air conditioners for both cooling and heating, the cooling capacity of which is 4kW or lower was studied last time; and they account for 90% (6,827,000 units) of total products. Models other than the above are reviewed this time.

Air conditioners for home use, the number of units shipped

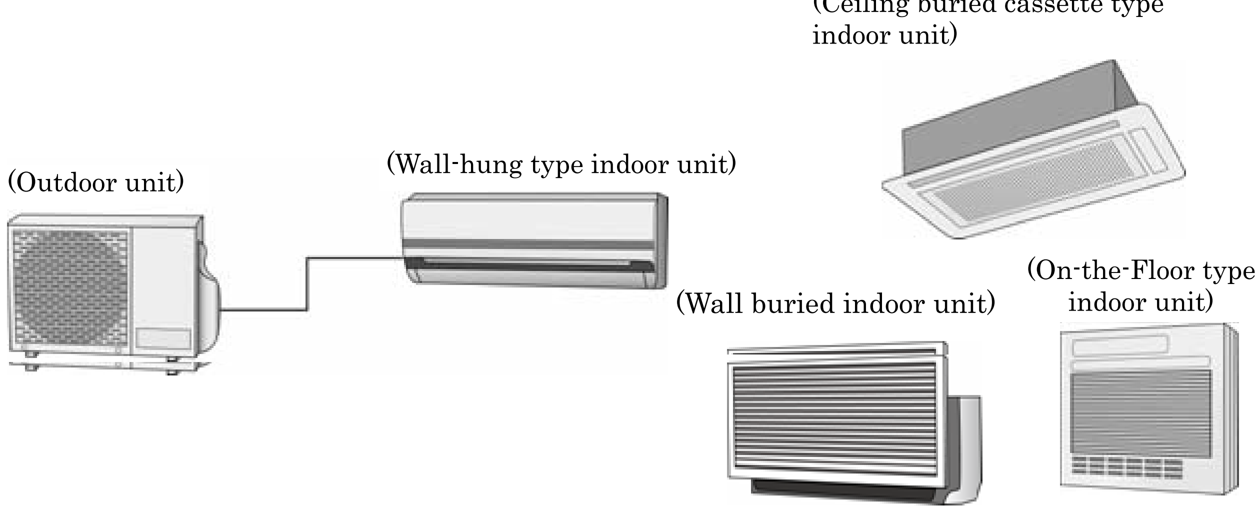
| | | Separate type | | | | | |
|---|---|---|---|---|---|---|---|
| | | Single (1 to 1) | | | | | |
| | | Wall-hung type | | | | | |
| | Window type | Cooling capacity 4kW or lower | Cooling capacity over 4kW | Other than wall-hung type | Multi | Sub total | Total |
| Both cooling and heating | 4 | 6,827 | 476 | 110 | 68 | 7,485 | 7,573 |
| Cooling Only | | | | | | 88 | |

(Unit: thousand, fiscal year 2005)

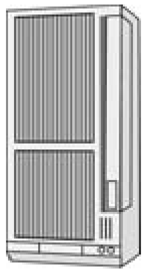
Source: Japan Refrigeration and Air Conditioning Industry Association

Window type is an integrated style of product installed into the window. Other than wall-hung type, forms of indoor units include ceiling cassette type, wall buried type, and on-the-floor type. Multi type, which is a kind of separate type, is referred to those capable of having 2 or more indoor units connected to one outdoor unit.

(1 to 1 air conditioners)

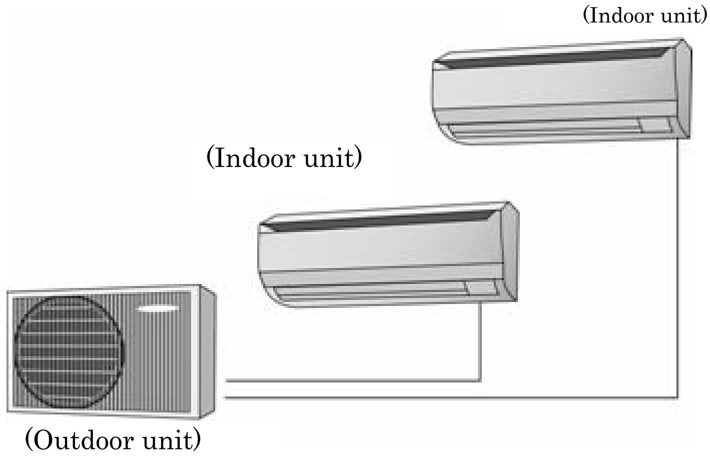


(Window type)



(Multi type)

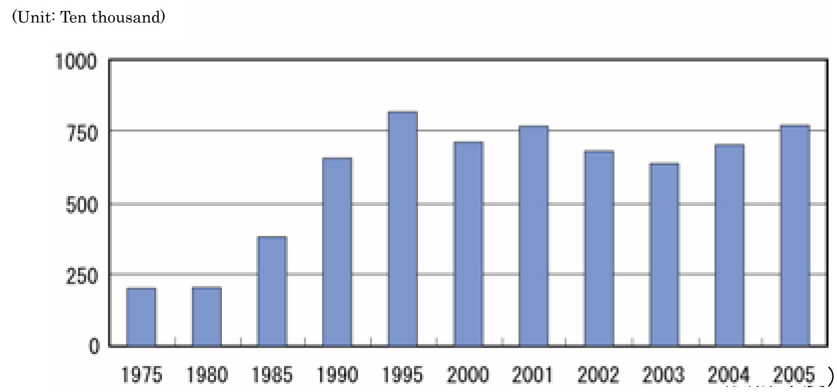
(Indoor unit)




III.1.2 Status of domestic shipment

Although shipments of air conditions for home use tend to be greatly affected by climate factors, they have been stabilized around 7.0 million units for past ten years.

Transition of shipment of air conditioners for home use




Source: Japan Refrigeration and Air Conditioning Industry Association

III.1.3 Transition of the number of units imported

The majority of imported air conditioners for home use are from overseas production bases of Japanese manufacturers. The percentage of air conditioners for home use that are manufactured overseas and sold in Japan is estimated to be approximately 50%.

(Unit: thousand)

| Fiscal year | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Import | World Total | 1,304 | 2,071 | 2,119 | 3,052 | 3,732 |
| | China | 752 | 1,625 | 1,743 | 2,611 | 2,854 |
| | Thailand | 252 | 160 | 157 | 324 | 692 |
| | Malaysia | 215 | 152 | 79 | 34 | 118 |

Source: Ministry of Finance, Customs Statistics

(Reference) (Unit: thousand)

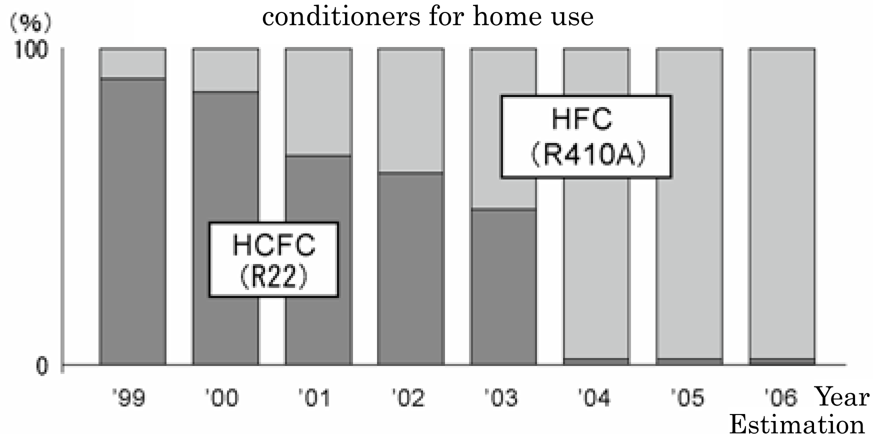
| Fiscal year | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Domestic shipment | 7,521 | 6,866 | 6,466 | 7,037 | 7,573 |

Source: Japan Refrigeration and Air Conditioning Industry Association

III.1.4 Change from HCFC (restricted substance) refrigerant

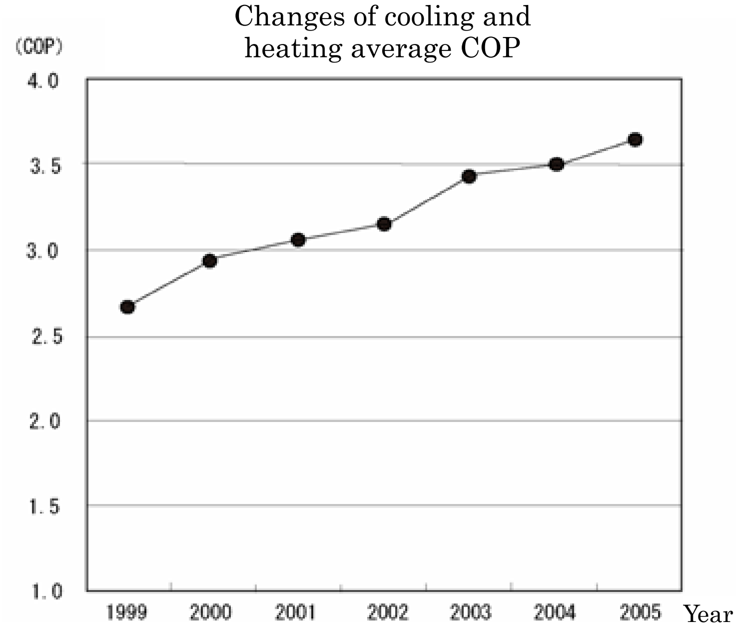
With respect to air conditioner for home use, most of the models have already changed to HFC (substitute substance) refrigerant which does not destroy the ozone layer in time for the first target fiscal year for major models in 2004 under Energy Conservation Law.

Change to HFC refrigerant for air conditioners for home use




III.1.5 Changes of energy consumption efficiency

Average COP (Coefficient of Performance: energy consumption efficiency) of weighted harmonic average of wall-hung type air conditioners for home use the cooling capacity of which is over 4.0kW up to 7.1kW or lower has changed as follows.




| Category | | Industry weighted harmonic average cooling and heating average COP achievement | | | | | | | Target value |
|---|---|---|---|---|---|---|---|---|---|
| Unit form | Cooling capacity | FY1999 | FY2000 | FY2001 | FY2002 | FY2003 | FY2004 | FY2005 | |
| Wall-hung type | Over 4.0kW up to 7.1kW | 2.69 | 2.90 | 3.15 | 3.31 | 3.44 | 3.50 | 3.53 | 3.17 |
| Category | | Achievement rate (%) | | | | | | | |
| Unit form | Cooling capacity | FY1999 | FY2000 | FY2001 | FY2002 | FY2003 | FY2004 | FY2005 | |
| Wall-hung type | Over 4.0kW up to 7.1kW | 85 | 91 | 99 | 104 | 109 | 110 | 111 | |

### III.1. 6 Penetration rate and number of units owned per household

Penetration of air conditioners for home use is near the saturation point. However, according to the statistic survey of housing/lands by the Ministry of Internal Affairs and Communications, the number of rooms per house is 4.77 rooms, so the number of air conditioners owned by a household will possibly increase. In FY2006, the number of air conditioners owned per household has reached 2.9 units.

| Year/Month | Penetration rate (%) | Number of owned air conditioners | Number of owned air conditioners per household |
|---|---|---|---|
| March, 1986 | 54.6 | 88.0 | 1.6 |
| March, 1991 | 68.1 | 126.5 | 1.9 |
| March, 1996 | 77.2 | 166.1 | 2.2 |
| March, 2001 | 86.2 | 217.4 | 2.5 |
| March, 2006 | 88.2 | 255.3 | 2.9 |

Number of owned air conditioners: per 100 households

Source: Cabinet Office, Survey of consumer behavior

### III.1.7 Main domestic manufacturers

CORONA CORPORATION SANYO Electric Co.,Ltd. SHARP CORPORATION
DAIKIN INDUSTRIES, Ltd. CHOFU SEISAKUSYO,Ltd. Toshiba Carrier Corporation

| | | |
|---|---|---|
| Hitachi Appliance, Inc. | FUJITSU GENERAL LIMITED | Matsushita Electric Industrial Co., Ltd. |
| MITSUBISHI HEAVY INDUSTRIES,LTD | Mitsubishi Electric Corporation | |

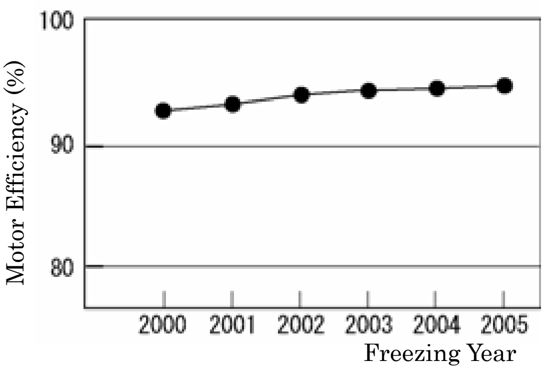
(In the order of Japanese Syllabary)

III.2 Technological approach to energy saving in air conditioners for home use

(1) Compressor performance improvement technology

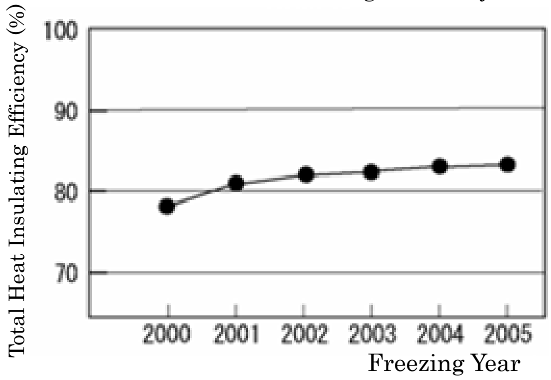
Efficiency of a compressor is represented by "motor efficiency" in a power output section and by "total heat-insulating efficiency" which indicates how much compression actually takes place using the obtained motive energy without loss. Currently, the "compressor motor efficiency" is approximately 95%, and "total heat-insulating efficiency" is over 80%.

Motor Efficiency




Source: Japan Refrigeration and Air Conditioning Industry Association

Total Heat Insulating Efficiency

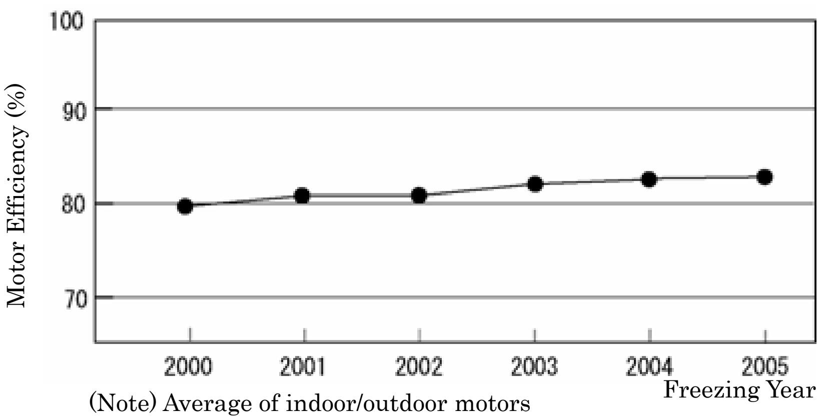



Source: Japan Refrigeration and Air Conditioning Industry Association

(2) Fan motor performance improvement technology

Currently, "fan motor efficiency" is greater than 80%.

Fan Motor Efficiency




(Note) Average of indoor/outdoor motors

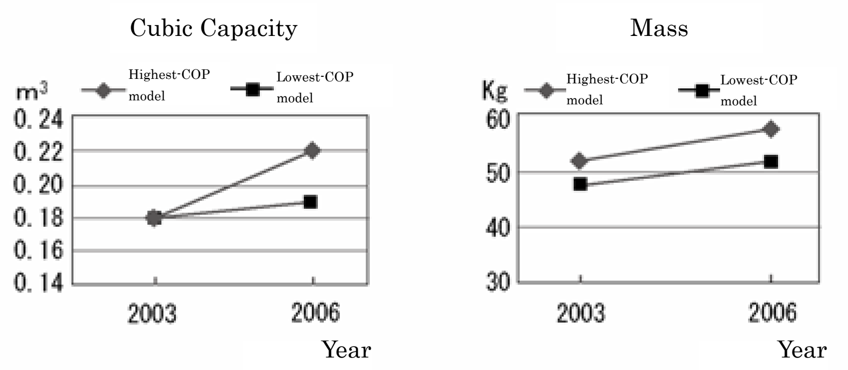
Source: Japan Refrigeration and Air Conditioning Industry Association

(3) Growing size of heat exchangers

An attempt has been made to save energy through reduction of the compression ratio by increasing size of a heat exchanger.

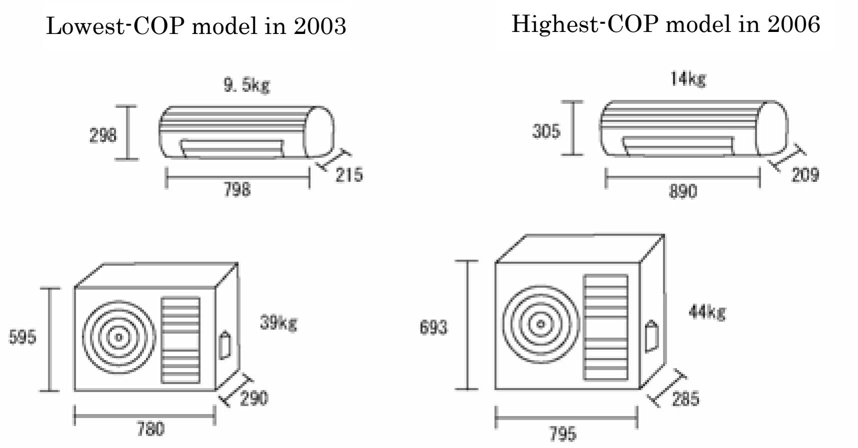
(Reference)

Cooling capacity 5.0kW (total values of indoor and outdoor units)




Source: Japan Refrigeration and Air Conditioning Industry Association

Dimensions and mass of highest-COP and lowest-COP air conditioners




Unit of Dimensions: mm

Source: Japan Refrigeration and Air Conditioning Industry Association

III.3 Future approach to energy saving and challenges

The development of elemental technologies such as compressors and fan motors has already advanced considerably so far; thus, further drastic improvement is not expected at present. As it now stands, increasing size of a heat exchanger is a key factor for energy efficiency improvement. Various problems accompanying growing size of air conditioners are as follows.

(1) Installability

There is a restriction by dimensional standards of houses. If indoor units become larger, it is concerned that they may no longer suitable as household equipment.

(2) Comfort

It is concerned that the further growth in size of a "heat exchanger/fan" might damage the basic comfort. That is to say, "evaporation temperature rises and thus humidity in a room is difficult to be cleared" in the case of cooling operation.

(3) Resource saving

Increased size of products might also increase the amount of copper and aluminum used, in particular, which are materials for a heat exchanger. Thus, from the standpoint of resource saving, the problem still remains.

Reference 2

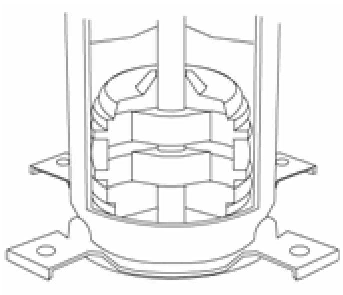
Examples of Main Technologies for Improving Efficiency of Air Conditioners

(1) Compressor

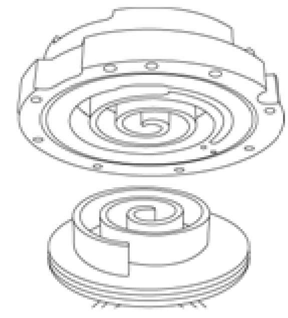
1) High-efficient compression technology

Compressor is the heart of an air conditioner and requires high-precision processing technology.

Although a rotary compressor with rotary method was widely adopted before, a twin rotary method or scroll method with better compression efficiency has now been developed and adopted.



Twin Rotary Compressor



Scroll Compressor

[Reduction of mechanical loss]

Sliding loss is reduced by improving precision in process of a sliding unit. In a scroll compressor, swirling scroll and fixed scroll are made to stick together, thereby reducing leak. When the sticking force is strong, sliding loss between these scrolls increases. On the other hand, when the sticking force is weak, a gap appears and causes leak. Thus, in order to maintain the minimum sticking force to reduce sliding loss, a control valve is provided which controls back pressure of the swirling scroll so that the back pressure can be adjusted based on operating state.

[Reduction of pressure loss in suction/discharge]

An attempt to reduce a pressure loss is being made by improving a shape of passage. For instance, a suction passage is made to be tapered for a suction opening, and a discharge opening is stepped to be expanded.

2) Compressor motor

[Neodymium magnet]

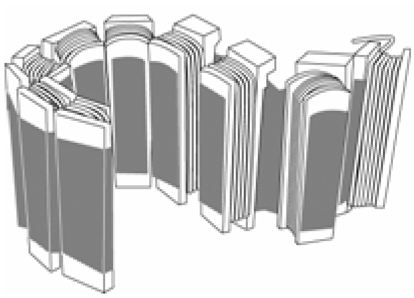
An attempt to improve motor efficiency is made by changing ferrite that has been conventionally used in a rotor to neodymium that has high magnetic flux density.

[Improvement of line area ratio of winding]

A proportion of total coil sectional area within a stator to a stator slot area is referred to a line-area ratio. If the line-area ratio could be increased, the coil sectional area could be expanded, thereby reducing copper loss.

In the past, as coil was threaded through a narrow space within a closed stator and winded, there remained a large dead space in the stator slot. However, development of a new manufacturing method allows for the high line-area ratio by winding the coil to the stator divided and spread out.

In addition, coil covering an end face of a stator core can be reduced by directly coiling the stator (intensive winding), thus also reducing copper loss.



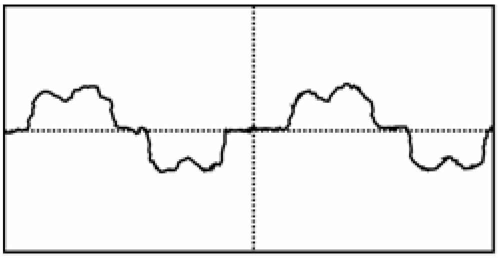
[Low-iron-loss magnetic steel sheet]

One of the factors for iron loss is eddy-current loss caused by eddy current generated in an iron core. Attempts have been made to prevent this current from flowing easily by means of, for example, adoption of silicon steel plates and/or thin laminated steel sheets.

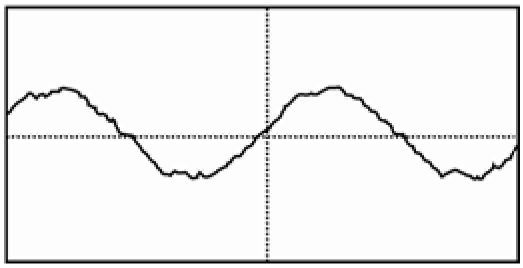
3) Sine-wave drive control of compressor motor

In the past, a square wave drive system, which switches current-conducting phases at every 60 degrees, was adopted as an operating method of a compressor for an inverter air conditioner. With this system, a position of a rotor could be sensed from induced voltage of the motor while motor current was not conducting, and thus the motor speed could be changed easily.

However, this method causes the lowered motor efficiency due to the square wave motor current. To respond to this, the sine wave driving of motor current was made possible recently through development of the control technology to estimate a rotor position from motor current as well as the improved arithmetic performance of microcomputers, thereby improving motor efficiency.



Waveform of Motor Current of
Square-Wave Driving System



Waveform of Motor Current of
Sine-Wave Driving System

(2) Fan

1) Indoor fan

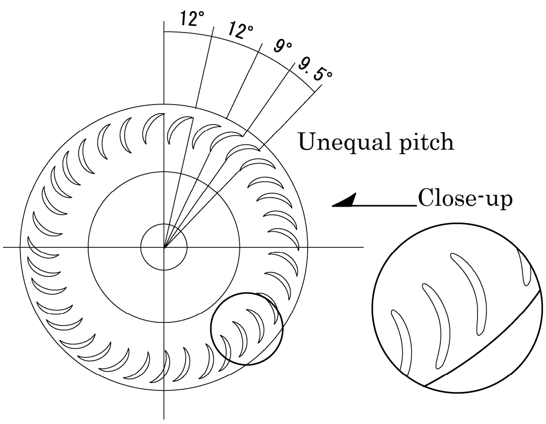
Various types of fans are used for indoor units depending on unit form. A "cross flow fan" is used for most of the wall-hung type air conditioners.

[Cross Flow Fan]

Although a cross flow fan was composed of blades that were processed metal sheets in the past, an attempt to increase air volume has been made through introduction of plastic blades having a wing-shaped section and growing size of fan diameter, while controlling noise.

The layout and molding of a fan and blades have also been improved, by having random spacing between blades, angling a fan shaft, etc.

<Random Pitch>




[Turbo Fan]

As for turbo fans which are often used in 4-direction cassette type indoor units, improvement efforts, such as three-dimensional process of blades, have been adopted.

2) Outdoor fan

In general, a propeller fan is used for an outdoor unit of an air conditioner. Although it was made of processed metal sheets in the past, it is now made of plastics. An attempt to increase air volume has been made by improving a blade shape, while reducing noise.

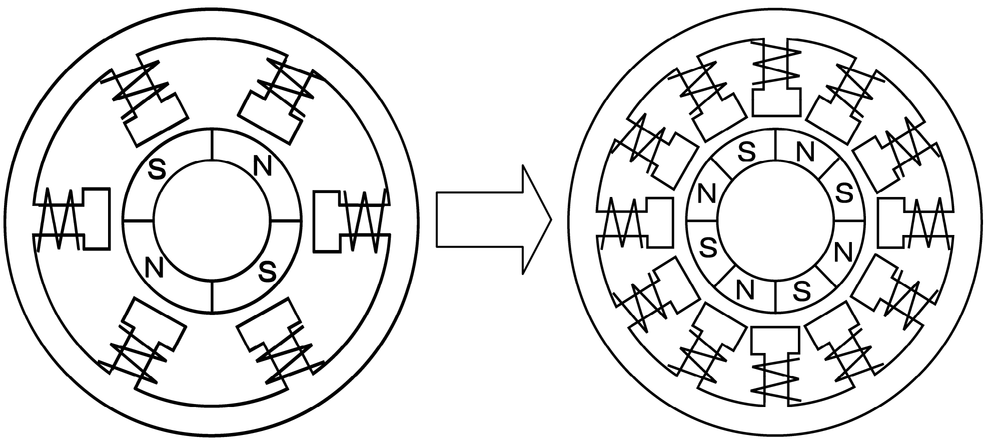
3) Fan motor

For fan motors for both indoor and outdoor units, an efficient DC brushless motor has replaced a conventional AC motor. In addition, to improve efficiency of a DC brushless motor, techniques that were developed for a compressor motor having high power consumption are incorporated, and optimization efforts have been made to achieve the most efficient combination of technologies, such as increased number of poles/slots, a devised core shape, reduction of circuit loss, optimal energization, etc.

Example of Increased Number of Poles/Slots

4-pole 6-Slot

8-pole 12-Slot



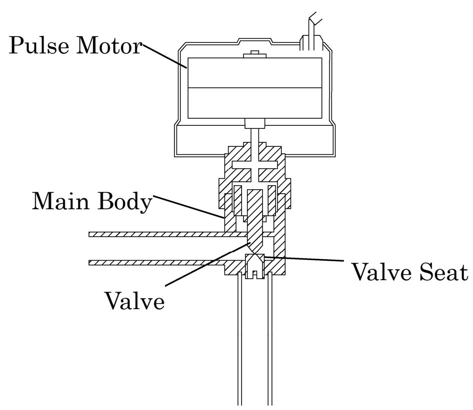

(3) Electronically controlled expansion valve

A decompressor is a component to create high-pressure and low-pressure states in a refrigerant circuit. Until now a capillary tube has been used primarily. A capillary tube refers to a thin and long copper pipe being about 0.2 to 2 m long and having an inside diameter of 1 mm to 2mm. This pipe generates pipe resistance and achieves throttling action (decompression).

A capillary tube has been widely used for a room-air conditioner as it can be implemented with a simple structure. However, adjustment of appropriate degree of throttling according to number of revolutions is not possible because the degree of throttling is constant even when the number of revolutions of a compressor varies.

Thus, an electronically controlled expansion valve has become used, which enables appropriate degree of throttling based on an electronic signal from a microcomputer determining the operating state of an air conditioner. The valve is structured so that a pulse motor rotates based on an electronic signal, and a gap between the valve and the valve seat is adjusted by converting the rotation into up-and-down motion, thereby controlling the degree of throttling.

This could achieve efficient control of refrigerant flow, depending on the operating state, such as changes in number of revolutions of a compressor used in an inverter air conditioner. Thus, the electronically controlled expansion valve has become mainly used.




(4) Heat exchanger

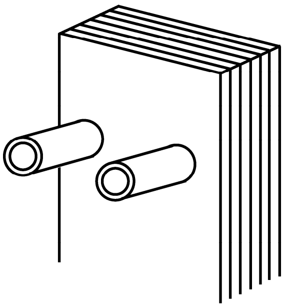
A heat exchanger is one of the important components of an air conditioner. It exchanges heat between indoor air and refrigerant in an indoor unit, and between outdoor air and a refrigerant in an outdoor unit.

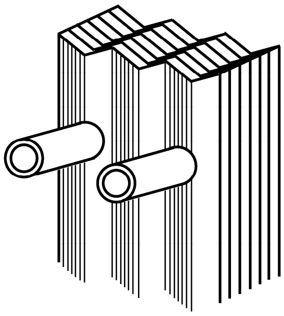
A fin-tube-type heat exchanger, in which a copper tube for refrigerant penetrates a plate-form aluminum fin for air, is used for this heat exchange.

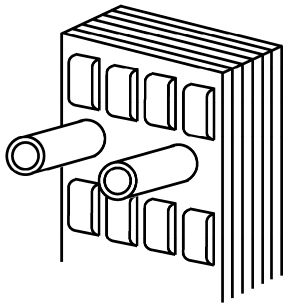
1) Fin for heat exchange

Initially, a flat aluminum plate (plate fin) was used as a fin of heat exchangers. Then, a corrugated fin and a slit fin with cutouts were adopted, and improvement of the slit shape has been made. In addition, to cope with a case that wind speed of air passing through a heat exchanger is nonuniformly distributed, improvement has been carried out to increase the overall heat exchange capacity by equalization of the wind speed distribution, such as increasing the height of a fin facing faster wind and lowering the height of a fin facing slower wind.

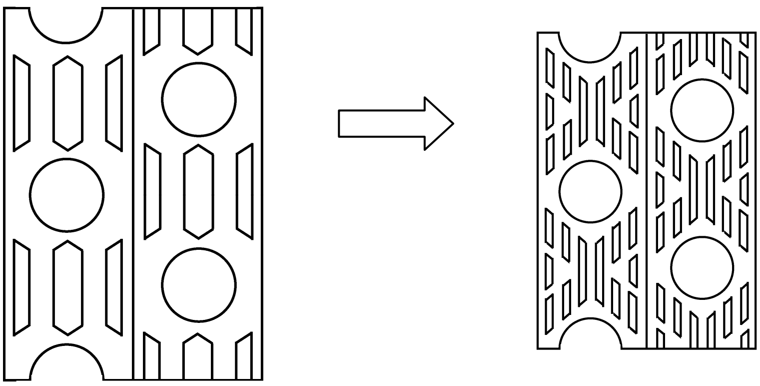
<Plate Fin> <Corrugated Fin> <Slit Fin>







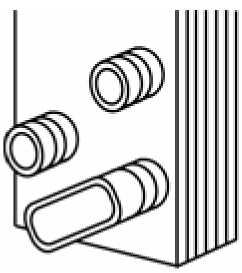
<Improvement of Slit Shape>

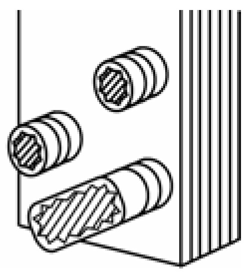


2) Copper tube for heat exchange

Initially, a smooth tube, like a copper tube in general, inner surface of which was not processed, was used for a heat exchanger. For energy saving, a tube with internal groove was developed, and optimization of a groove shape has been pushed forward.

<Smooth Tube> <Tube with Internal Groove>





<Optimization of Groove Shape>

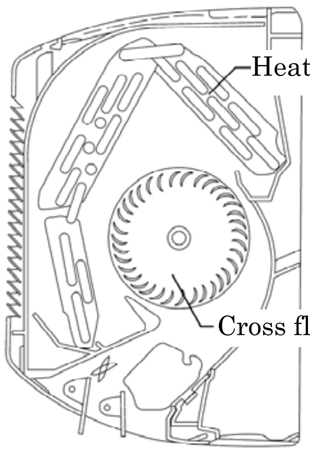
In addition, in order to improve heat conduction between refrigerant and copper pipes, reduction of pipe diameter has been implemented.

[Example]　Pipe Diameter　9.5mm　→　7.0mm　→　6.3mm

Improvement has also been made to reduce pressure loss and thereby increase the total heat exchange capacity, by means of changing pipe diameter depending on the state of refrigerant flowing through piping, i.e. decreasing pipe diameter for a part of liquid state and increasing it for a part of gas state.

3) Form of heat exchanger

In separate wall-hung type indoor units that account for most of the room-air conditioners, a cross section of the conventional heat exchanger was molded like a plate. However, in order to expand heat exchange area in a limited space, those of bent type and those molded in a curved surface have been developed.




In addition, heat exchangers in an initial indoor unit were arranged in two columns. However, improvement has been on the way to increase the heat transmission area and to augment the heat exchange capacity by means of partially arranging them in three columns, as long as an indoor unit structure can afford enough space for it.

As for 4-direction cassette type indoor units which are used in the most of air conditioners for business use, the change of unit shape, such as from usual square-shape to pentagon-shape, has been attempted, in order to enlarge the heat exchange area without interrupting internal electrical components.