REFRIGERATOR AND AIR-CONDITIONER TESTING IN THE REPUBLIC OF KOREA

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ENERGY LABELING PROGRAM

Korea has a limited natural resources, This, together with the aim of energy saving and reducing impact on environment, Korean government to enact a new policy for energy saving. Based on the Rational Energy Utilization Act, in 1992 the Korean Ministry of Commerce, Industry and Energy (MOCIE) mandated energy efficiency labeling for particular types of consumer products. The energy efficiency labeling program for particular appliances and lighting equipment has been enforced since 1992.

The Korea Institute of Energy Research (KIER) formulated the labeling rule for MOCIE, based on statistical and engineering analysis of efficiency data provided by manufacturers. In the beginning, refrigerators, room air-conditioners, incandescent lamps and, fluorescent lamps were included in this program. The following items have been added since :

- fluorescent lamps ballasts,
- Passenger cars.
- Electrical Washing Machine
- Household Gas furnaces (boilers)

The followings are being considered : *electric rice cookers(date not fixed), commercial compact gas furnace(2002), electric radiant heaters(2002), electric water heaters(date not fixed), dishwasher(2001), etc.*

The labeling program rates each particular model (or type of product) on a 5 levels scale of efficiency. Level 1 represents the most efficient in energy use and a Level 5 the least. Labels indicating the level of energy efficiency must be affixed on all products. The labels also provide information on energy consumption, determined in accordance with test standards. The program also requires that the information energy consumption be displayed on any technical material associated with the sale of the products. The labeling is now mandatory and helps consumers to make a purchase decision taking energy efficiency into consideration.

The energy consumption and efficiency must be measured by an authorized third party laboratory in accordance with the test procedures under proper standards. Energy efficiency labeling is now a key program for the Energy Ministry in Korea. As a whole, the labeling program is found to be operating successfully without major negative impacts. In general, it is seen that there will be significant reduction in energy consumption and in the greenhouse gas emissions associated with the use of the appliances.

REFRIGERATORS

1. SCOPE

The Korean Industrial Standard KS C 9305-1999 covers household electric refrigerator of storage volume 1000 L or less, and household vertical electric freezers of storage volume 400 L or less, with a compression type refrigerating machine and storage cabinet integrated in one body.

2. DEFINITIONS

2.1 Refrigerator

A refrigerator is defined as an appliance cooled by an electrically driven compression type refrigerating machine having one or more compartments intended for the preservation of foodstuffs, (except frozen foodstuffs) which is kept at the necessary storage temperature. This is called the fresh food compartment

2.2 Refrigerator-freezer

A refrigerator-freezer is defined as an appliance cooled by an electrically driven compression refrigerating machine having two or more compartments to preservation of foodstuff, at least one of which is a fresh food compartment and at least one of which can be maintained at a temperature necessary to store frozen food. This is called the freezer compartment. Freezer compartment comply with the freezing performance of Table 1. may be called fourstar compartments.

2.3 Electric refrigerator

A generic term for refrigerators and refrigerator-freezers.

2.4 Electric freezer

A Freezer is defined as an appliance cooled by an electrically driven compression refrigerating machine consisting of only a freezer compartments in which the mean freezer load temperature specified in Table 1 is –18 °C or lower (hereafter referred to as the "freezer").

2.5 One-star compartment

A freezer compartment in which the mean freezer load temperature is –6 °C or lower (see Table 1).

2.6 Two-star compartment

A freezer compartment in which the mean freezer load temperature is -12 °C or lower (see Table 1).
2.7 Three-star compartment

A freezer compartment in which the mean freezer load temperature is -18 °C or lower (see Table 1).
2.8 Four-star compartment

A freezer compartment which is able to freezer 4.5kg or more for each 100 L of storage volume over 24 hrs, and in which the mean freezer load temperature specifies is –18 °C or lower (see Table 1).

2.9 Storage volume

The net refrigerated volume contained within the interior walls of a storage cabinet with the door(s) closed.

3. ELECTRIC POWER CONSUMPTION TEST

3.1 Test Conditions

The test shall be carried out complying with the following item under the standard condition (30±1ºC) for power consumption of appliance.

(1) The mean fresh food compartment temperature t_2 (exclusive of any special fresh food compartments) shall be set to 3±0.5ºC. When the control device is not adjustable, however, the temperature shall be below 3ºC .

The mean freezer compartment temperature of the refrigerator-freezer shall be set to the appropriate value in Table 1.

Table 1. Classification of Freezing compartment

Classification of Freezing compartment	One-star compartment	Two-star compartment	Three-star and Four Star compartments
Mean temperature of Freezing compartment	-6± 0.5ºC	-12± 0.5ºC	-18± 0.5ºC

Figure 1. Measurement point of Freezer and Fresh Food Compartment Temperature

As for an appliance in which the fresh food compartment temperature and the freezer compartment temperature are not independently adjustable, the temperature setting shall be made as follows. If the mean fresh food compartment temperature t_2 is 3ºC or below when the mean freezer compartment temperature is set to the appropriate value in Table 1, the temperature setting shall be left as it is. If the mean fresh food compartment temperature t_2 exceeds 3ºC, the control device shall be so reset that the mean fresh food compartment temperature falls to 3±0.5ºC, then the mean freezer compartment temperature and the reset temperature as prescribed above will be used.

(3) The mean freezer compartment temperature of the freezer, t_1 shall be set to -18±0.5 . If -18±0.5ºC is not available, the setting shall be selected to achieve a temperature as close as possible. When the control device is not adjustable, however, the temperature must be below the required temperature. If there are two or more independent freezer compartments or fresh food compartments with separate doors, and temperatures are not adjustable independently, then the specified conditions must be achieved in at least one freezer compartment temperature or the fresh food compartment.

(4) The ambient relative humidity of the electric refrigerator shall be 75 ± 5 per cent.

3.2 Test Method

The electric power consumption per 24 hr shall be measured after the steady state is obtained by operating the electric refrigerator under above test conditions, at ambient temperature 30±1ºC. The unit of electric power consumption shall be kWh.

(1) The measuring period is based on 24 h intervals. In cases where defrosting starts automatically(see below) and automatic at least two defrost cycles are completed within 24 hrs, the measuring period shall be 24h. If automatic defrosting isn't started within 24 h, the measuring period shall be 48 h, if it is started after 24 h, the test shall be terminated after 48 h, and if it isn't started within 48 h, the test shall be terminated after 72 h. The completion point of automatic defrosting is the moment when the freezer compartment temperature returns to the appropriate levels specified in Table 1.

(2) Defrosting shall be as follows.

a) Manually operated defrosting devices shall not be operated.
b) For others, defrosting shall be operated compulsorily at the start of the measuring period.
c) If compulsory defrosting is impossible, the start of automatic defrosting shall be regarded as the measuring start point.

(3) Features that have nothing to do with refrigeration such as defrost heaters and manually operated heating devices, shall be left in the ON state.

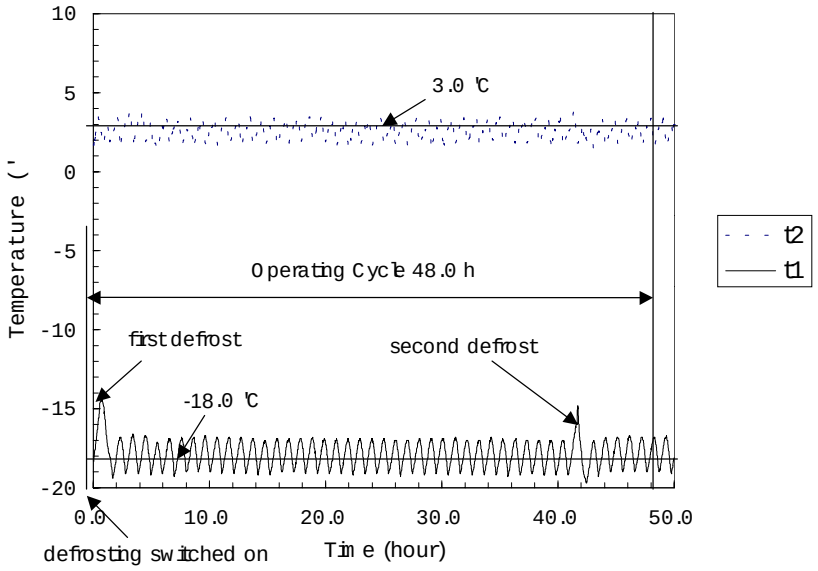

Figure 2. Example of an operating cycle of a frost-free refrigerator-freezer

3.3 Determination of Electric Power Consumption

The electric power consumption shall be determined as follows.

(1) The electric power consumption per 24 h measured by the method of 3.2., shall be rounded off to two decimals places. (This value is termed W_d)

(2) The annual electric power consumption and the annual average electric power consumption per month shall be calculated from the formula given below.

$$W_y = W_d \times 365$$
$$W_{my} = W_y \div 12$$

Where, W_d : Daily electric power consumption (kWh/day)
W_y : Yearly electric power consumption (kWh/year)
W_{my} : Monthly average electric power consumption for a year (kWh/month)

4. MEPS, TEPS AND LEVEL

The "Regulation on Appliance Energy Efficiency Standards Setting and Rating Labeling" issued on September, 2000 set the TEPS and MEPS levels in Table 2. The Target Energy Performance Standard (TEPS) is a reference value for expressing the energy efficiency of the product for labeling purposes. For example, a unit with energy consumption equal to or less than the TEPS value will have a label rating of 1 (see Table 3). The TEPS and MEPS values announced in the regulation are about 20~30 per cent lower than the previous values.

Table 2. Operations Guideline on Labeling System for Energy Consumption and Efficiency of Refrigerator & freezer

Name of Item	Target Energy Performance Standards (TEPS)	Minimum Energy Performance Standards (MEPS)	Remarks
• Refrigerator only •Refrigerator-freezer whose compensated cubic volume is less than 500 liter •Refrigerator-freezer whose compensated cubic volume is no less than 500 liter	$P^1 \leq$ 0.037AV+16.75 $P^1 \leq$ 0.025AV+29.45 $P^1 \leq$ 0.043AV+16.19	$P^2 \leq$ 0.067AV+30.15 $P^2 \leq$ 0.045AV+53.01 $P^2 \leq$ 0.099AV+37.24 (from 1st Jan. 2001) $P^2 \leq$ 0.078AV+29.14 (from 1st Apr.2002)	P^1=Target power consumption P^2=Maximum power consumption (kWh/month) AV = compensated cubic volume =cubic volume of the freezing compartment×K+cubic volume of the fresh compartment *K value in the refrigerator is 0 while that of the refrigerator-freezer is 1.78(in case the average indoor temperature of the freezing compartment is -18ºC) K(compensation coefficient) = (T1-T3)/(T1-T2) T1=ambient temperature in testing(30ºC) T2=averaging indoor temperature of the fresh compartment(3ºC) T3=averaging indoor temperature of the freezing compartment(-18ºC)

(a) P^1 (Target power consumption, kWh/month) to be achieved by 31st Dec. 2002
(b) P^2 (Maximum power consumption, kWh/month) to apply from 1st Jan. 2001

Table 3. The relationship of energy efficiency levels to TEPS levels

Efficiency rating criteria (R)	Efficiency Level(or Grade) For labeling purposes
R 1.00	1
1.00 < R 1.20	2
1.20 < R 1.40	3
1.40 < R 1.60	4
1.60 < R 2.30 (from 1st Jan.2001)	
1.60 < R 1.80 (from 1st Apr.2002)	5

R = Measuring Power Consumption (kWh/month) / TEPS (kWh/month)
= W_{my} / TEPS

Since the program was introduced in 1992, it has been observed that the market share of higher efficiency refrigerators (equivalent to grade 1 or 2) has increased significantly from 60.5 per cent in the end of 1993 to 90.8 per cent in the end of 2000 (see Table 4). This has occurred in spite of the stricter standards and rating criteria. It is estimated that the energy efficiency standards and labeling programs have reduced the energy consumption of the target appliances by approximately 10~15 per cent percent a year between 1992 and 1995. And, even after the standard was raised in 1996, high efficiency products have continued to come on the market. Encouraged by this the Korean government is considering extending the program to cover other appliances such as vending machine, dish washers and the like in a near future. More efforts will be made to promote research on appliance energy efficiency and to build up their facilities, test methods, and the like. In addition we are very considering to change the program for the refrigerators and air conditioners. From 2004 the refrigerator and the air conditioner does not need to represent the level if meet the stricter MEPS.

Table 4. Market share of “high efficiency” Refrigerator-freezers

Year	High Efficient Refrigerators
1992	50.9
1993	60.5
1994	68.2
1995	82.2
1996	60.9
1997	83.1
1998	91.5
1999	92.0
2000	90.8

*Note: the decrease in the market share of high-efficiency models between 1995and 1996 is mainly due to stricter MEPS and TEPS levels and to the increased sales of large models.

5. MARKET

The domestic market (include imports) in 1999 was 1.53 million units, 5 per cent more than in 1998. Following the economic crisis in 1997, there was a reduction in domestic demand, and manufactures tried to develop oversea markets. As a result of it, exports were 3.3 million units in 1999 (26 per cent higher than in 1998), while domestic sales were 1.5 million units (13 per cent higher than in 1998 – see Figure 3). Total domestic production was 4.7 million units in 1999.

As Figure 3. shows, the total domestic market was fairly constant between 1995 and 1997, at about 1.8 million including the imported products. Due to the economic it decreased to 1.36 million units. Even though the total market has been depressed, the larger capacity refrigerators have been popular. Three big manufactures have made an endeavor to develop the larger refrigerator market. In 1997 over 75 per cent of the refrigerator-freezer market had compensated volume is of 400 liters or more. In 1998, units larger than 500 liter were the main models in the domestic market. Since LG Electronic introduced a side-by-side model whose volume is no less than 620 liter, the larger capacity refrigerator market has been more competitive. Until 1997 most side-by-side refrigerator were imported, but domestic models now have over 70% of this market. In 1999 0.14 million side-by-side units were sold. This was only 9per cent of the total market, but almost 20 per cent of the total market value because of the high unit cost.

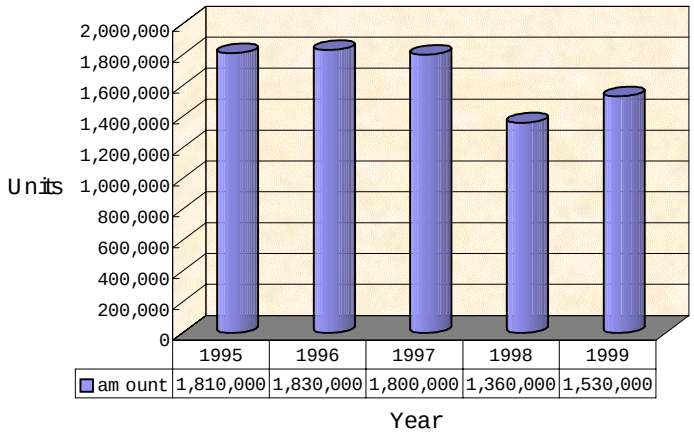

Figure 3. Domestic Market

In 1996 a new type of refrigerator came in the market. It is designed especially for the storage of Kimchi, the general term given to a group of fermented vegetable foods in Korea. (Kimchi has been traditionally served as a "must" at almost every meal along with cooked rice and other dishes. It is an excellent way to preserve vegetables like Chinese cabbages and radishes for a long time, especially during the winter season when fresh vegetables are scarce.) As shown in Figure 4 it is smaller than the typical refrigerator.

In 1999 this market was over 0.7 million units, almost a half of the total refrigerator market, and it is estimated that over 1.0 million units were sold in 2000 even though the official record is not published yet. Now 15 manufactures including three big companies produce this refrigerator, and this market has become more competitive than the market for conventional refrigerators. The dramatic growth of this refrigerator has led to a new Korea Standard, KS C 9321, “Electrical storage box for Kimchi”. This may be revised because there are still many areas to clarify, e. g. scope, definition, power consumption test etc. The market for this special refrigerator is certain to keep growing for a while.

Figure 4. Refrigerator for Kimchi
Features : 91 liter, 20 kWh/m, Energy Efficiency Grade : 1st

AIR-CONDITIONER

1. SCOPE

The Korean Industrial Standard KS C 9306-1999 covers air conditioners of rated cooling power consumption of not more than 13,000 W and rated cooling capacity of not more than 35,000 W (30,100 Kcal/h). It covers air conditioners that carry out cooling, dehumidifying, heating, air circulating, and air purifying. The energy labeling program covers air conditioners with cooling capacity 17.4 kW or less. However, the ducted type and multi-split type are not included in the energy labeling program.

2. DEFINITIONS

2.1 Cooling capacity

The heat quantity which can be removed from the room per unit time when an air conditioner is operated for cooling. It is expressed in W or kW.

a) rated cooling capacity
The cooling capacity marked on the product.
b) normal cooling capacity
The cooling capacity measured in the test of Table 5.

2.2 Cooling power consumption

The total electrical powers consumed by the electric motor when the air conditioner is operated for cooling.

a) rated cooling power consumption
The cooling power consumption expressed to mark on the product
b) normal cooling power consumption
The cooling power consumption measured in the test of Table 5.

2.3 Cooling energy efficiency ratio

The value obtained from the normal cooling capacity divided by the normal cooling power consumption.

$$EER = \frac{Q_c}{P_c}\left\{\frac{0.86Q_c}{P_c}\right\}$$

where, EER : Cooling energy efficiency ratio W/W {kcal/Wh}
Q_c : Normal cooling capacity W {kcal/h}
P_c : Normal cooling power consumption W

2.4 Cooling seasonal performance factor

The value obtained from the calculating SEER method.

$$CSPF = \frac{\sum Q_c}{\sum P_c}\left\{\frac{0.86\sum Q_c}{\sum P_c}\right\}$$

where, CSPF : Cooling seasonal performance factor W/W {kcal/Wh}
Q_c: Sum of the total cooling capacity during cooling season W {kcal/h}
P_c : Sum of the total power consumption during cooling season W

2.5 Power quantity consumption per month during cooling season

The value obtained in accordance with the calculating method specified in the Annex 4, KS C 9306-1999, wherein the total energy used during the cooling season is divided per month. The unit is kWh/month.

a) rated unitary compressor type air conditioner
Cooling power consumption × 12 hours × 0.6 × 30 days = kWh/month
(Operating time per day : 12hours, Operating ratio per day: 0.6)

b) performance variable and binary compressor, and rotation control type air conditioners
Sum of the total power quantity during cooling season ÷ 2 = kWh/month
(P_c÷2 months)

3. CLASSIFICATION

Units are classified according to function, construction of unit, cooling system and rated cooling capacity as follows.

(1) Classification by Function
a) Cooling only.
b) Cooling and dehumidity control, combined use.
c) Cooling, heating by heat pump, combined use.
d) Cooling, dehumidifying and heating by heat pump, combined use.
e) Cooling, heating by electric resistance heater, combined use.
f) Cooling, dehumidifying and heating by electric resistance heater, combined use.

(2) Classification by construction of Unit
a) Integrated type
b) Separate type

(3) Classification by Cooling Method of Condenser
a) Air-cooled type
b) Water-cooled type

(4) Classification by Rated cooling capacity

4. RATED VOLTAGE AND RATED FREQUENCY

The Rated voltage of conditioner shall be single phase AC 220V or 110V or three phase AC 220V/380 common use and the rated frequency shall be 60Hz.

5. ENERGY EFFICIENCY TEST

5.1 Test Conditions

Tests shall be conducted under the following requirements.

(1) The temperature and humidity condition shall be as given in Table 5.
(2) For separate type appliance the length of pipe for connection between indoor unit and outdoor unit shall be 4 to 6m when it is a free choice, and the fitting of indoor unit, outdoor unit and piping shall be so installed that the capacity becomes the maximum.

5.2 Cooling capacity Test

After installation of the air conditioner in the calorimeter room, operation switches, exhausting and ventilating shutters, wind-diffusing grilles and others (Hereinafter referred to as “operation switches”)of the conditioner shall be operated at the rated voltage and rated frequency and set to attain the maximum cooling power under the indoor and outdoor conditions specified in Table 5. Cooling capacity is then calculated using the specified method.

5.3 Power Consumption Test for Cooling

When the measured value of cooling capacity the electric power consumed by electric motors is measured. Operating power factor is computed after the measurement of operating current. However, in case of air conditioners having two or more power supplies, there are measured for each power supply.

Table 5. Test Conditions

Conditions for Cooling Capacity	Indoor		Outdoor			
			Air cooling type		Water cooling type	
	Dry Bulb °C	Wet Bulb °C	Dry Bulb °C	Wet Bulb °C	Inlet °C	Outlet °C
KS	27 ± 0.3	19.5 ± 0.2	35± 0.3	24 ± 0.2	30 ± 0.3	35 ± 0.3
CNC	27 ± 1	19.5 ± 0.5	35± 1	24 ± 0.5	30 ± 0.2	35 ± 0.2
JIS	27 ± 1	19.0 ± 0.5	35± 1	24 ± 0.5	30 ± 0.3	35 ± 0.3
ISO(T-1)	27 ± 1	19.0 ± 0.5	35± 1	24 ± 0.5	30 ± 0.2	35 ± 0.2
SAA	27 ± 1	19.0 ± 0.5	35± 1	24 ± 0.5	30 ± 0.2	35 ± 0.2

5.4 Determination of Monthly Energy Consumption

The energy consumption shall be measured in 5.3 and determined as follows. The energy consumption shall be within 115 per cent of the indicated value of electrical energy consumption.

a) Electrical energy consumption shall be determined by rounding off the first place of decimal of the value in accordance with KS A 0021.
b) Two samples shall be tested, and the larger shall be applied.
c) Monthly electrical energy consumption (kWh/month)

W_{mv}=W x 12(hr) x 0.6(operation rate) x 30(days)

W : electrical energy consumption (W)
W_{my}: monthly electrical energy consumption (kWh/month)

5.5 Determination of Energy Efficiency Ratio

The energy efficiency ratio shall be determined from a cooling capacity measured in 5.2 and a electrical energy consumption measured in 5.3, and within ±10 per cent of the indicated value of electrical energy consumption.

(1) Energy efficiency ratio shall be determined by rounding off the third place of decimal of the value in accordance with KS A 0021.
(2) Energy efficiency Ratio (W/W)

EER=C/H
C : Cooling capacity (W)
H : Energy consumption (W)

Note : Above standards are only available to room air-conditioner with a constant speed compressor.

Figure 5. Testing in calorimeter room

6. MEPS, TEPS AND LEVEL

A new guideline issued on September, 2000, set the TEPS and MEPS levels in Table 6 and Table 7, and the criteria for estimation of energy efficiency ratings in Table 8, Table 9, Table 10, Table 11. It is approximately stricter than before about 5~7 per cent, and. energy efficiency should be indicated as COP (W/W) or CEER(Cooling EER) instead of EER according to ISO standards. This new level is available to both of room air-conditioner with a constant speed compressor and variable-speed.

Table 6. The TEPS for Air-conditioners

	Type	TEPS (kW/kW)
Split type	Wall mounted type(Unitary)	3.05
	RCC < 4.0 kW	3.54
	4.0 kW ≤ RCC < 10.0 kW	3.14
	10.0 kW ≤ RCC < 17.5 kW	2.93

P^1 (Target power consumption) should be accomplished to 31st Dec. 2002
RCC : Rated cooling capacity

Table 7. The MEPS for Air-conditioners

	Type	MEPS (kw/kw)
Split type	Wall mounted type (Unitary)	2.37
	RCC < 4.0 kW	2.86
	4.0 kW ≤ RCC < 10.0 kW	2.46
	10.0 kW ≤ RCC < 17.5 kW	2.25

Table 8. The efficiency rating criteria (R) for Wall mounted type air conditioner

COP(CEER)	Level(or Grade)
3.05 < COP	1
2.88 < COP 3.05	2
2.71 < COP 2.88	3
2.54 < COP 2.71	4
2.37 < COP 2.54	5

Table 9. The efficiency rating criteria (R) for Split type air conditioner, Rated cooling capacity < 4.0 kW

COP(CEER)	Level(or Grade)
3.54 < COP	1
3.37 < COP 3.54	2
3.20 < COP 3.37	3
3.03 < COP 3.20	4
2.86 < COP 3.03	5

Table 10. The efficiency rating criteria (R) for Split type air conditioner, 4.0 kW Rated cooling capacity < 10.0 kW

COP(CEER)	Level(or Grade)
3.14 < COP	1
2.97 < COP 3.14	2
2.80 < COP 2.97	3
2.63 < COP 2.80	4
2.46 < COP 2.63	5

Table 11. The efficiency rating criteria (R) for Split type air conditioner, 10.0 kW Rated cooling capacity < 17.5 kW

COP(CEER)	Level(or Grade)
2.93 < COP	1
2.76 < COP 2.93	2
2.59 < COP 2.76	3
2.42 < COP 2.59	4
2.25 < COP 2.42	5

7. MARKET

The domestic total market (exclude car air conditioner) was 0.7 million units in 1999, it decreased slightly by 1998, because summer in 1999 was not hotter than before. As Figure 6 shows, the total domestic market increased dramatically between 1995 and 1997, but the economic crisis made it drop down in 1998. The domestic demand still has a big potential, because the statistic says the potential customers who don't have air conditioner in his house or office are over 70 per cent of all houses. We expect the market will get back a steady condition, and increase highly as the economic recovery. As a reduction in domestic demand, the manufactures tried to develop the oversea market. Successfully exports in 2000 will be expected over 6.5 million even the official record has been not published yet.

In Korea there are two big manufactures, LG and SAMSUNG, which occupy over 70 per cent of the domestic market, and others(DAEWOO, Carrier, Mando, Century and imported) occupy the rest. It is very interesting thing that the imported products have very weak competition in Korean market, even Japanese big manufactures. In 1999 market we can find the one interesting which the small capacity models, less than 4.0 kW as shown in Figure 7 occupied over 45 per cent in room air conditioners market, but the very favorite models, 6.0~7.5kW as shown in Figure 8 lost the market share 10 per cent.

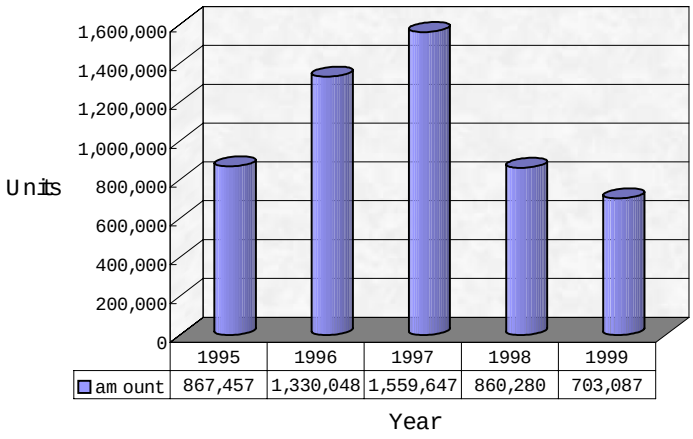

Figure 6. Domestic Market

As similar to refrigerators since the energy efficiency standards and labeling program was introduced in 1992, it has been observed that the higher efficiency air conditioners have continued to come on the market significantly. As shown in Table 12, the high efficiency models, equivalent to grade 1 or 2, have increased from 92.3 per cent in the end of 1993 to 97.1 per cent in the end of 2000, in spite of the stricter standards and rating criteria

Table 12. The ratio relate to the models on the market of "High Efficiency" Air-Conditioners

Year	The ratio relate to the models on the market of "High Efficiency" air-
1992	-
1993	92.3
1994	98.5
1995	97.0
1996	95.6
1997	93.1
1998	91.5
1999	92.0
2000	97.1

Figure 7. Split air conditioner

Figure 8. Package air conditioner

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