COLLOQUIUM ON TECHNICAL ISSUES OF MINIMUM ENERGY PERFORMANCE STANDARDS

RESPONSE TO DISCUSSION PAPER PREPARED BY Dr GEORGE WILKENFELD ON AIR CONDITIONERS

Response by:

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Background:

Email Ltd are the sole manufacturer of window/wall air conditioners in Australia and are also importers of split systems from Korea.

1. 'Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies'

1.1. Air Conditioners in each economy.

- **Australia**
  - The 'Overview of Framework' for Australia as detailed in the above review is satisfactory.
  - Energy labelling
    - The current Australian Energy Label requires the energy consumption to be scaled for 500 hours. This is not realistic, nor can an acceptable number of hours be determined that is fair and reasonable for Australia as a whole.
    - On the new Australian Energy Label proposed to be released in 2000, this requirement is changed to listing the Energy Consumption in kWh per hour. The individual consumer can then estimate their running costs knowing their own usage pattern.
  - Endorsement Labels
    - The major 'Endorsement Label' in Australia is the Galaxy Award label issued in Victoria for high efficiency models, is often incorrectly implied in advertising material to be applicable to the complete range of models produced by a manufacturer. This occurs in both national and international publications.
    - This is counter-productive to the intention of the award and so far this problem has not been successfully addressed.
- **Other Countries**
  - Noted with interest, but no comment.

1.2 Space Conditioning Equipment

- Terms used in definition of product types.
  - Rationalisation and clarification is required.
  - Recommend that these terms ultimately be defined in ISO 5151. Adoption of these definitions should be relatively easy in Australia.

1.3 Conversion Algorithms & Alignment

- Conversion algorithms are supported in principle to overcome the current differences in testing at fixed load.
- This would allow the original test data (to an accepted standard) to be 'converted' to align with test requirements in other countries, and allow time for member countries to consider harmonising of their test conditions and tolerances.
- Current test procedures using fixed conditions do not give 'real life' representative results and computer simulation methods should be investigated.
  - The option should be left open for manufactures to use the low cost option of computer simulation for 'off test condition' performance, or alternatively to do additional physical tests, at extra cost to them, if the computer simulation would disadvantage them.
- Recommend alignment with ISO 5151 T1 for cooling.

  - Note that ISO/CD 5151R modifies the test condition tolerances for T1 cooling capacity testing which should result in Australia accepting them unchanged.
- MEPS levels should be set on cooling EER with agreed conversion algorithms if necessary.
- MEPS on heating COP would be more difficult due to the greater design differences required to cover conditions from +7°C outdoor ambient (H1 in ISO/CD 5151R) to -7°C (H3 in ISO/CD 5151R).
- A conversion algorithm to convert test data at 21°C indoor dry bulb (old ISO R859) to 20°C (ISO 5151) may not need to be considered.
  - Typically the capacity and COP will improve slightly. Therefore manufacturers should either use the ISO R859 condition of 21°C and accept the slightly inferior performance, or re-test at 20°C. This would provide an incentive to preferably adopt ISO 5151.
- Harmonising of tolerances applied to the declared EER and cooling capacity need to be addressed.
  - ISO 5151 defines test conditions and methods. The tolerances on EER and cooling capacity come from the Energy Labelling regulations which are formulated in the individual countries.
  - MEPS levels should be set with a statement regarding the tolerance that can be applied to the supporting test data that is used to support a claimed EER value.
  - This is an issue of secondary importance after the alignment/conversion of the test conditions and tolerances to avoid the need to re-test.

1.4 Simulation Package & Variable Capacity Units.

- Recommend that the working group on the Simulation Package also includes development of a fair and equitable labelling system for variable speed air conditioners.
- This labelling could use a number of load points calculated by the package to reduce the amount of physical testing required.

2. Inconsistencies between Testing & MEPS in Australia

a) Government & Regulators

- I am not in a position to speak on their behalf, but I would see the following potential problems:
  - Confusion at time of registration of the Energy Label as to whether the product description and test method/conditions were valid in accordance with the Australian regulations.
  - Being in a position of having to request extra costs be incurred by a manufacturer/importer in order that the registration could be accepted.
  - Resolution of any Check Testing non-compliances when test methods and conditions are not exactly aligned.
  - Resolution of queries from other manufacturers/importers who might challenge the regulator’s interpretations.

b) Product Exporters

- Any cost in additional testing, or time delay in obtaining registration of labels in 'non-aligned' countries would be a problem.

c) Product Importers

- The inconsistencies add time and cost to the introduction of new models.
- This is often compounded by language differences between the manufacturing and the importing countries.

3. Increased Convergence.

- This would be a benefit due to the reduction of problems listed in item 2 above.

4. Energy Testing & MEPS in Australia for Air Conditioning

- Energy Labelling was first introduced into Australia in 1987, the label format has only been changed once in that time (in 1998) to incorporate the revised Australian Standard. Stability of the requirements has been a benefit.
- However, there is another change to take place in 2000 to cover revised algorithms for the star rating system. This will be two changes in two years, so it is important that this change lasts as long possible.
- The robustness of the previous Australian Standard (AS 1861.1) has helped to provide this stability which is very important to manufacturers, importers, regulators and customers alike.
- The recent move to an ISO 5151 based standard is to be commended.
- The recent incorporation of the Energy Labelling requirements into Part 2 of the Australian Standard, rather than in State based regulations, is an improvement in the ease of compliance.
- MEPS has not been previously been applied to air conditioning in Australia, so there is no prior history for this product.

5. Convergence Options

- Support for the options has been indicated in item 1.3 above.
- It is important that with either conversion algorithms, or computer simulation, that the manufacturer is given the option of using the algorithm/simulation or alternatively, doing extra tests if they prefer. i.e. physical test are to be allowed, and their results will take precedence over the calculated values if there is a variation.

6. Regulator Acceptance of Simulation Tests

- There is a positive indication that the Australian Regulators would accept conversion algorithms if they had international backing such as incorporated into an ISO standard.
- Their position on computer simulation to give a range of performance data is less clear. The only way that the Regulators would have to accept the simulation is if theses values were then used as part of the Energy Label calculation. This would complicate the label application compared to a single point test, and this may not be favourably accepted.

7. Realistic Convergence Timetable.

A possible timetable is listed below assuming that there is agreement to proceed with:

- Conversion Algorithms
- Aligned Product Descriptions
- MEPS for the APEC group based on minimum EER, but with individual national labels
- The use of a simulation package

Note: This timetable assumes multiple working groups with activities in parallel.

Action	Working Group	Time Period
Agreement on course of action	Colloquium	Oct. 99
Determine the required Conversion Algorithms	WG1	Nov 99 to May 00
Development & agreement on Conversion Algorithms	WG2	May 00 to May 01
Recommend product descriptions	WG3	Nov 99 to Nov 00
Agree on product descriptions (& include in ISO 5151?)	?	Dec 00 to Dec 01
Recommend the MEPS levels (after agreement on descriptions)	WG4	Jan 02 to Jan 03
Agree on MEPS levels	?	Feb 03 to Feb 04
Introduction into member economies	Various national groups	Mar 04 to Mar 06
Align national test standards with ISO 5151	Various national groups	Nov 99 to Mar 04
Propose a simulation package including variable speed units	WG5	Nov 99 to Nov 02
Agree on the simulation package	?	Dec 02 to Jun 05
Introduce MEPS on variable speed units as stage 2	?	Jul 05 to Jul 07

8. Other Suggestions.

None at this stage.

Energy Efficiency Standard for Fluorescent Lamp Ballasts in China

Zhao YueJin

China Standardization and Information-Classifying and-Coding Institute

1. Introduction

★ Two major components included in the Energy Efficiency Standards of ballasts as follows:

a. Limited values of energy efficiency • mandatory•

b. Evaluating values of energy conservation• voluntary•

The limited values of energy efficiency of ballasts for tubular fluorescent lamp is the minimum values of energy efficiency stipulated by the Law. Products with lower value shall be withdrawn according to the National Law. Evaluating values of energy conservation of ballasts for tubular fluorescent lamps is the threshold value for an enterprise to pass the energy conservation product certification, in other words, Energy Labeling is allowed to be used if the threshold is reached or exceeds.

2. The measure of ballast system efficacy and calculate BEF value

BEF=100×Ballast Factor/Input Power

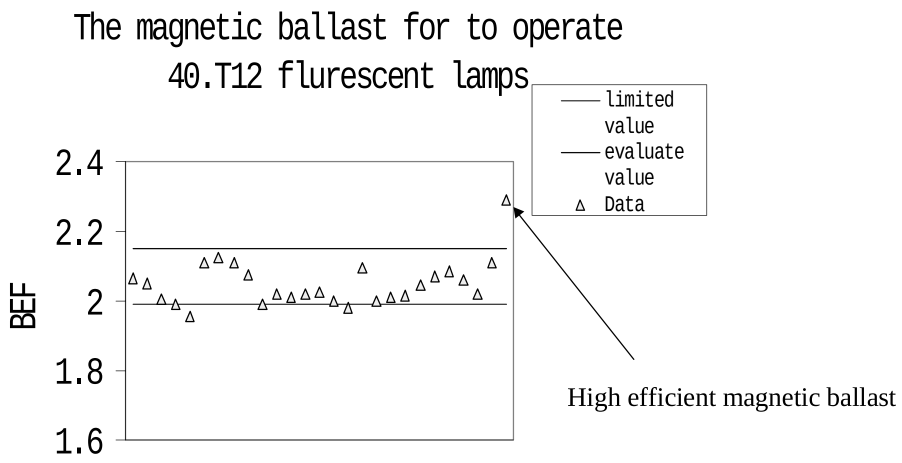
Notes:

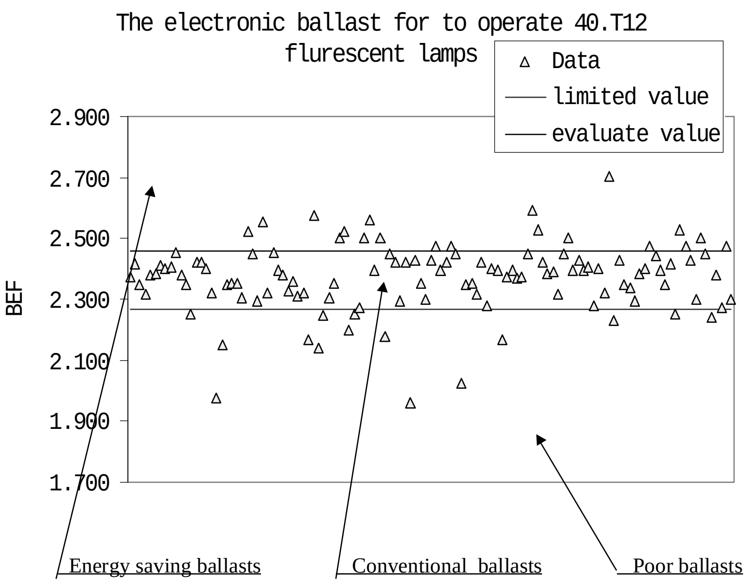
(1) “BEF” is defined as the ballast factor in percent divided by ballast input power in watts.

(2) “Input Power” is the total circuit power.

(3) “Ballast Factor” is the ballast factor(BF) for a specific ballast. It is the ratio of the light output of a lamp tested on the specific ballast divided by the light output of the same lamp tested on a reference ballast under identical environmental conditions.

(4) Input Voltage is 220V





★ Test Procedures

Test Procedures : GB/T 15144-1994
(GB/T15144 is equivalent to IEC 60929)

★ Limited values of energy efficiency of ballasts or MEPS

Table 1 Limited values of energy efficiency

Nominal Lamp watts (W)		18 (T8)	20 (T12)	22 (annular)	30 (T12)	32 (annular)	36 (T8)	40 (T12)
BEF	Magnetic ballast	3£ ®154	2£ ®952	2£ ®770	2£ ®232	2£ ®146	2£ ®030	1£ ®992
	Electronic ballast	4£ ®778	4£ ®370	3£ ®998	2£ ®870	2£ ®678	2£ ®402	2£ ®270

★ Evaluating values for certification of energy conservation product (or energy labelling technical requirements)

Table 2 Evaluating values for certification

Nominal Lamp watts (W)		18 (T8)	20 (T12)	22 (annular)	30 (T12)	32 (annular)	36 (T8)	40 (T12)
BEF	Magnetic ballast	3£ ®686	3£ ®458	3£ ®248	2£ ®583	2£ ®461	2£ ®271	2£ ®152
	Electronic ballast	5£ ®518	5£ ®049	4£ ®619	3£ ®281	3£ ®043	2£ ®681	2£ ®473

3. Import and Export

★ Main area(prefecture) of exported (1997)

- USA
- TAI WAN
- JAPAN
- HONG KONG
- PHILIPPING

★ Ballasts imported and exported

year	exported		imported	
	Mount (million)	US$ (million)	Mount (million)	US$ (million)
1996	49.845	141.74	39.614	12.567
1997	70.246	151.765	62.817	14.923

4. China’s energy efficiency standard of lighting products scheme (2000-2002)

★ products covered:

- Fluorescent lamp
- Compact fluorescent lamp
- Ballasts for high-voltage sodium lamp

STATUS of ENERGY SAVING PROGURAM

EFFICENCY TARGET,

PROCEDURE for EFFICENCY MEASUREMNT,

and REGULATION

In JAPAN

• • •

6, Oct,1999
TOSHIBA LIGHTING AND TECHONOLOGY CORPORATION
K.SUGIYAMA

Table 1.Revised Target Values for 2005 JPAN

Fixture Type	Lm/W
1. with straight 110w size rapid start FL	79.0
2. with straight 40w size Hf operation FL	86.5
3. with straight 40w size rapid start FL	71.0
4. with straight 40w size starter type FL	60.5
5. with straight 20w size starter start FL ,electronic ballast type	77.0
6. with straight 20w size starter start FL ,magnetic ballast type	49.0
7. with circular type FL(s) 72w < (total of lamp type wattage)	81.0
8. with circular type FL(s) 62w<(total of lamp type wattage)<=72w	82.0
9. with circular type FL(s) (total of lamp type wattage)<62w , electronic ballast type	75.5
10. with circular type FL(s) (total of lamp type wattage)<62w , magnetic ballast type	59.0
11. Table Light with compact FL	62.5
12. Table Light with straight FL	61.5

Example of “total of lamp type wattage”
FCL32/30 + FCL30/28 =62w

Definition of Efficacy of Lighting Fixture

Total Light Output

= Lamp luminous flux

× Ballast Factor

× Temperature Correction
Factor of a Lamp

Total Input Power

= Total Electric Power Consumption
of a Lighting Fixture

Efficacy

= Total Light Output

• •Total Input Power

Ballast Factor

Figure 1: Lamp Wattage (Test Ballast / Rfr Ballast)
For Starter Type Ballasts (JIS C 8108)

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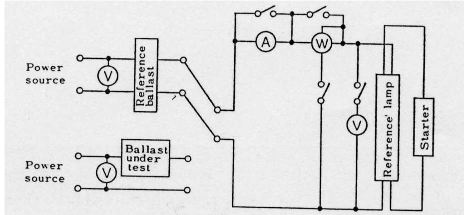

Figure 2: Light Output (Test Ballast / Rfr Ballast)
For Rapid-Start Type Ballasts (JIS C 8108)

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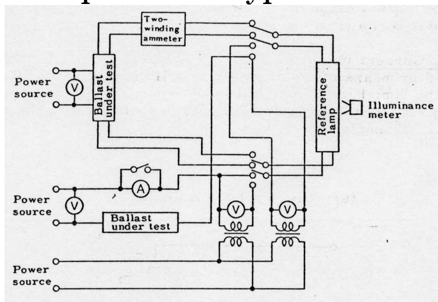

Figure 3: Light Output

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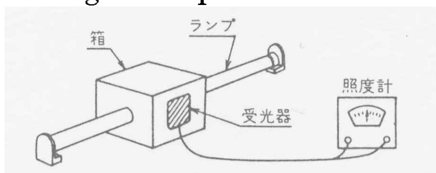

Temperature Correction
Factors for Typical Lamp Types

Table 2: Part of Temperature Correction Factor

Lamp Wall Temp . (•)	Temperature Correction Facto				
		HF circular FL		Compact FL	
	Others	Single Circle Type	Double Circle Type	Double Tube Type	Others
39	•	•	1.000	•	•
40	•	•	1.011	1.000	•
41	1.000	1.000	1.030	1.007	•
45	0.998	1.024	1.080	1.019	•
50	0.970	1.041	1.096	0.996	•
55	0.926	1.044	1.077	0.955	0.988
60	0.875	1.031	1.039	0.906	0.944
65	0.821	1.006	0.991	0.855	0.886
70	0.767	0.970	0.943	0.808	0.829
75	0.714	0.929	0.899	0.766	0.779

Part of the original table MITI announced ,which starts at 39•, ends at 90•, and divided by 1•.

Figure 4: Setup of measurement

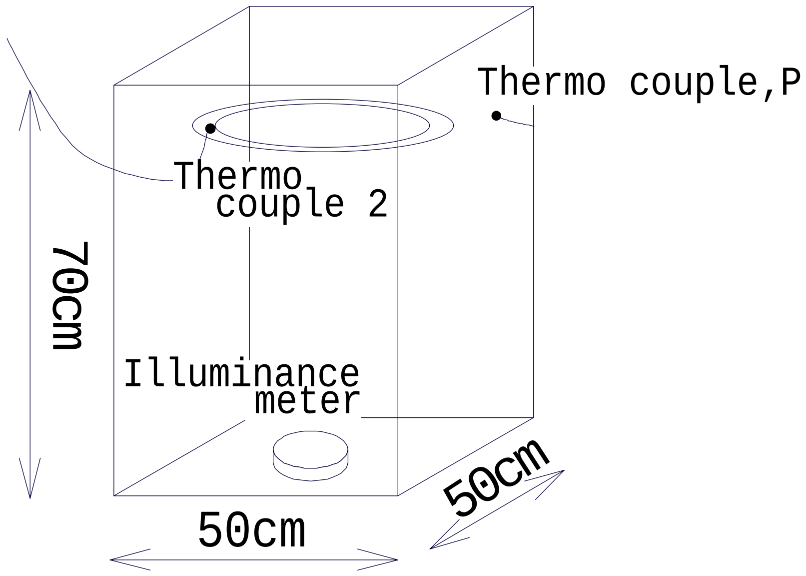

Table 3.•Estimated Ballast – Lamp system

Fixture Type	Ballast Lamp Color
1. with straight 110w size rapid start FL	EB W
2. with straight 40w size HF operation FL	EB EXN
3. with straight 40w size rapid start FL	EB W
4. with straight 40w size starter type FL	MB W
5. with straight 20w size starter start FL, EB	EB EXN
6. with straight 20w size starter start FL, MB	MB EXN
7. with circular type FL(s) •72W	EB EXN
8. with circular type FL(s) , 62w< W<=72w	EB EXN
9. with circular type FL(s) <62w, EB	EB EXN
10. with circular type FL(s) <62w, MB	MB EXN
11. Table Light with compact FL	EB EXN
12. Table Light with straight FL	MB EXN

- Ballast type: EB (Electronic Ballast) gives about 20% more Lm/w than MB (Magnetic Ballast).
- Lamp color

Phosphor Type	Relative lm
D 6500k Ca-halphosphate	100
N 5000k Ca-halphosphate	109.2
W 4200k Ca-halphosphate	114.9
EXD 6500k Tri-band phosphor	124.1
EXN 5000k Tri-band phosphor	132.2

40W Rapid-Start type Lamp, TOSHIBA catalogue

REGURATION

INDICATION OF EFFICACY
into catalogues
by Apr. 2000 .

FOLLOW UP

Manufactures should report
Efficacy of each product,
Shipping volume
to MITI

MITI will calculate
Efficacy of whole Japan
for each category

ACCOMPLISHUMENT OF TARGETS
•••••by Apr. 2005
Index : weighted average for each category

Energy Efficiency Standards and Labeling Program for Air-Conditioner in Korea

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For presentation at the Colloquium on Technical Issues of Minimum Energy Performance Standards Seoul, Korea, 6th To 8th October 1999

A Short History

Korea is one of country has a limited natural resources, as well as an energy saving and reduction was issued to protect the environment in World wide, which reached Korea government to act 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 the energy efficiency labeling for particular types of selected consumer products. Actually in Korea, the energy efficiency labeling program for particular appliances and lighting equipment has been enforced since 1992. Korea Institute of Energy Research (KIER) formulated the labeling rule for MOCIE, based on a statistical analysis and engineering analysis of efficiency data provided by manufacturers. In the beginning, 4 items, refrigerator (and refrigerator-freezers), room air-conditioner, Incandescent lamps, f1llorescent lamps were included for this program, and step by step more items were added to the program. At present, the products include as follows;

- Refrigerators and refrigerator-freezers,
- *Room air-conditioners*
- Incandescent lamps,
- T10 & T8 fluorescent lamps and associated ballasts,
- Compact fluorescent lamps, and Passenger cars.
- Electrical Washing Machine

The followings are considered to be added in the future ; microwave ovens, electric rice cookers, electric radiant heaters, electric water heaters, gas boilers, etc. The labeling program establishes an efficiency level table comprised of 5 levels of efficiency and a rating formula for each particular model (or type) of products. Labels are to be affixed on all products with an numerical designation which represents the level of energy efficiency. The labels also provide with an information on energy consumption. The efficiency is determined in accordance with test procedures under proper section of the Korean Industrial standard (KS). The program also requires that the information energy consumption be displayed on any technical material associated with the sale of the products. The energy labels being used in Korea rank appliances in five energy efficiency levels. The labeling is now mandatory and helps consumers to make a purchase decision taking energy efficiency into consideration. On the rating scale in the labeling, a Level 1 represents the most efficient in energy use and a Level 5 the least. The energy efficiency must be measured by an authorized third party laboratory in accordance with the test procedures under proper section of the Korea Industrial standards (usually ca1led KS). Anyway, the energy efficiency labeling is now a key program for 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 would be significant reduction of not only energy consumption but also greenhouse gas emissions associated with the use of the appliances.

Standards for Energy Efficiency Test of Air Conditioner

1.Scope

This Standard specifies room air conditioners of integral type (compressor refrigerating unit, fans, etc are accommodated in a cabinet) or separate type (compressor refrigerating unit, fans, etc are accommodated in two cabinet)with a rated power consumption for cooling not exceeding 7.5kW (hereinafter referred to as the air conditioner·)in the room air conditioners which carry out cooling(ones also carry out dehumidifying or heating are included) circulation of air and removal of dust for the purpose of comfortable air conditioning of rooms. And, it also specifies room air conditioner with cooling capacity 15,000 kcal/h or less.

Remark: The units and numerical values given in [ ] in this standard are in accordance with the International System of Units {SI}, and are appended for reference.

2.Definitions

For the purposes of this standard, the following principal definitions apply.

(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 kcal/h lW}.

(2) Power consumption for cooling

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

3. Classification

According to function, construction of unit, cooling system and rated cooling capacity, conditioners shall be classified as follows.

(1) Classification by Function

(a) Cooling, exclusive use.

(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 heater, combined use.

(f) Cooling, dehumidifying and heating by electric heater, combined use.

(2) Classification by construction of Unit

(a) Integrate type

(b) Separate type

(3) Classification by Cooling Method of Condenser

(a) Air-cooling type

(b) Water-cooling type

(4) Classification by Rated cooling capacity

3. Rated voltage and Rated Frequency

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

4.Tests

4.1 Test Conditions

Tests shall be conducted under the following requirements.

(1) The temperature and humidity condition shall be as given in Table 1.

(2) As 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.

4.2 Cooling capacity Test

After installation of the conditioner in the calorimeter, operation switches, exhausting and ventilating shutters, wind-diffusing grilles and others (Hereinafter referred to as “operation switches”)of the conditioner shall be set to attain the maximum cooling power, then putting the Table 1. at the rated voltage and rated frequency, cooling capacity shall be calculated with the measuring method.

4.3 Power Consumption Test for Cooling

When the measured value of cooling capacity becomes stable at cooling capacity test defined in above 4.2 electric power consumed by electric motors shall be measured. Operating power factor shall be computed after the measurement of operating current. However, in case of conditioner having two or more power supplies, there shall be measured for each power supply.

Table 1. 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	Dry Bulb °C	Wet Bulb °C
KS	**27 ± 1**	**19.5 ± 0.5**	**35± 1**	**24 ± 0.5**	**30 ± 0.5**	**35 ± 0.5**
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

4.3 Determination of Monthly Energy Consumption

The energy consumption shall be measured in 4.3 and determined as follows. The energy consumption shall be within 115% of the indicated value of electrical energy consumption.

(1) Electrical energy consumption shall be determined by rounding off the first place of decimal of the value in accordance with KS A 0021.
(2) Two samples shall be tested, and the larger shall be applied.
(3) 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)

4.4 Determination of Energy Efficiency Ratio

The energy efficiency ratio shall be determined from a cooling capacity measured in 4.2 and a electrical energy consumption measured in 4.3, and within ±10% 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 (kcal/Wh or W/W)

EER=C/H=(0.86C/H)

C : Cooling capacity (kcal/h or W)
H : Energy consumption (W)

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

TEPS, MEPS and Labeling

The TEPS (Target Energy Performance Standards) aims to reduce the current energy consumption by each covered product by 10~30 percent. Under the current "Regulation on Appliance Energy Efficiency Standards Setting and Rating Labeling" issued on March, 1999, the TEPS and MEPS for room air conditioners are set as seen in Table 2. and Table 3. MEPS (Minimum Energy Performance Standards) began to be applied from the 1st of January 1997, while the deadline for the TEPS requirement is the end of 1998. But, for the case that a cooling capacity is more than 9,000 kcal/h and less than 15,000 kcal/h, MEPS began to be applied from the 1st of September 1998, while the deadline for the TEPS requirement is the end of 1999.

Table 2. TEPS for constant speed

Classification		TEPS (kcal/hw, w/w)
Room type		2.500(2.900)
Split type	RCC < 3,550 kcal/h(4,110w)	2.700(3.132)
	3,550 kcal/h(4,110w) < RCC < 9,000 kcal/h(10,440w)	2.500(2.900)
	9,000kcal/h(10,440w) < RCC < 15,000 kcal/h(17,400w)	2.400(2.784)

Table 3. MEPS for constant speed

Classification		MEPS (kcal/hw, w/w)
Room type(Unitary)		2.200(2.552)
Split type	RCC < 3,550 kcal/h(4,110w)	2.500(2.900)
	3,550 kcal/h(4,110w) < RCC < 9,000 kcal/h(10,440w)	2.200(2.552)
	9,000 kcal/h(10,440w) < RCC < 15,000 kcal/h(17,400w)	2.000(2.320)

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

Table 4. TEPS for variable speed(SEER)

Classification		TEPS (kcal/hw, w/w)
Room type(Unitary)		2.630(3.051)
Split type	RCC < 3,550 kcal/h(4,110w)	2.840(3.294)
	3,550 kcal/h (4,110w)< RCC < 9,000 kcal/h(10,440w)	2.630(3.051)
	9,000 kcal/h (10,440w)< RCC < 15,000 kcal/h(17,400w)	2.520(2.923)

Table 5. MEPS

Classification		MEPS (kcal/hw, w/w)
Room type(Unitary)		2.310(2.680)
Split type	RCC < 3,550 kcal/h(4,110w)	2.630(3.051)
	3,550 kcal/h(4,110w) < RCC < 9,000 kcal/h(10,440w)	2.310(2.680)
	9,000 kcal/h(10,440w) < RCC < 15,000 kcal/h(17,400w)	2.100(2.436)

Note : Above are for variable-speed, two compressor type, or rotational frequency-control type.
RCC : Rated cooling capacity

The Efficiency Rating Criteria

Criteria for estimation of energy efficiency ratings are as follows under the last issued MOCIE Announcement No. 1999-24 “Regulation on Appliance Energy Efficiency Standards Setting and Rating Labeling”.

For constant speed

Table 6. The efficiency rating criteria (R) for Room type air conditioner

EER(kcal/hw, w/w)	Level(or Grade)
2.500(2.900) < EER	1
2.300(2.668) < EER • 2.500(2.900)	2
2.100(2.436) < EER • 2.300(2.668)	3
2.000(2.320) < EER • 2.100(2.436)	4
EER • 2.000(2.320)	5

Table 7. The efficiency rating criteria (R) for Split type air conditioner, Rated cooling capacity < 3,550 kcal/h(4,110w)

EER(kcal/hw, w/w)	Level(or Grade)
2.900(3.364) < EER	1
2.700 (3.132)< EER • 2.900(3.364)	2
2.500 (2.900)< EER • 2.700(3.132)	3
2.300(2.668) < EER • 2.500(2.900)	4
EER • 2.300(2.668)	5

Table 8. The efficiency rating criteria (R) for Split type air conditioner, 3,550 kcal/h(4,110w) < Rated cooling capacity < 9,000 kcal/h(10,440w)

EER(kcal/hw, w/w)	Level(or Grade)
2.600 (3.016)< EER	1
2.400(2.784) < EER • 2.600(3.016)	2
2.200 (2.552)< EER • 2.400(2.784)	3
2.000(2.320) < EER • 2.200(2.552)	4
EER • 2.000(2.320)	5

Table 9. The efficiency rating criteria (R) for Split type air conditioner,
9,000 kcal/h(10,440w) < Rated cooling capacity < 15,000 kcal/h(17,400w)

EER(kcal/hw, w/w)	Level(or Grade)
2.400(2.784) < EER	1
2.200(2.552) < EER • 2.400(2.784)	2
2.000(2.320) < EER • 2.200(2.552)	3
1.800(2.088) < EER • 2.000(2.320)	4
EER • 1.800(2.080)	5

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

For variable-speed, two compressor type, or rotational frequency-control type

Table 10. The efficiency rating criteria (R) for Room type air conditioner

EER(kcal/hw, w/w)	Level(or Grade)
2.630(3.050) < EER	1
2.420(2.807) < EER • 2.630(3.050)	2
2.210(2.564) < EER • 2.420(2.807)	3
2.100(2.436) < EER • 2.210(2.564)	4
EER • 2.100(2.436)	5

Table 11. The efficiency rating criteria (R) for Split type air conditioner,
Rated cooling capacity < 3,550 kcal/h(4,110w)

EER(kcal/hw, w/w)	Level(or Grade)
3.000(3.480) < EER	1
2.840(3.294) < EER • 3.000(3.480)	2
2.630(3.051) < EER • 2.840(3.294)	3
2.420(2.807) < EER • 2.630(3.051)	4
EER • 2.420(2.807)	5

Table 12. The efficiency rating criteria (R) for Split type air conditioner,
3,550 kcal/h(4,110w) < Rated cooling capacity < 9,000 kcal/h(10,440w)

EER(kcal/hw, w/w)	Level(or Grade)
2.730(3.167) < EER	1
2.520(2.923) < EER • 2.730(3.167)	2
2.310(2.680) < EER • 2.520(2.923)	3
2.100(2.436) < EER • 2.310(2.680)	4
EER • 2.100(2.436)	5

Table 13. The efficiency rating criteria (R) for Split type air conditioner,
9,000 kcal/h(10,440w) < Rated cooling capacity < 15,000 kcal/h(17,400w)

EER(kcal/hw, w/w)	Level(or Grade)
2.520(2.923) < EER	1
2.310(2.680) < EER • 2.520(2.923)	2
2.100(2.436) < EER • 2.310(2.680)	3
1.890(2.192) < EER • 2.100(2.436)	4
EER • 1.890(2.192)	5

Note : Above are for variable-speed, two compressor type, or rotational frequency-control type.

Table 14. Energy Efficiency management System in Practice in APEC Member Economies

APEC Member Economy	Refrigerators, Refrigerator-Freezer	***Air-conditioner***
Australia	MEPS, L(Oct 1999)	***L(NGRS)***
Brunei Darussalam	-	-
Canada	MEPS, R, L	***MEPS, R, L***
Chile	-	-
China	MEPS, L?	***MEPS, L?***
Hong Kong	MEPS, L(V)	***MEPS, L(V)***
Indonesia	L(V-'97/'98)	***L(V-'97/'98)***
Japan	MEPS,L	***TEPS***
Korea	MEPS, R, L	***MEPS, R, L***
Malaysia	-	-
Meico	MEPS,L	***MEPS,L***
New Zealand	MEPS,R , L	***L(V)***
Papua New Guinea	-	-
Philippines	MEPS	***MEPS, R, L***
Singapore	-	***MEPS, R***
Chinese Taipei	MEPS	***MEPS***
Thailand	MEPS, R, L(V)	***MEPS, R, L(V)***
USA	MEPS, R, L	***MEPS, R, L***

Note: MEPS = Minimum Energy Performance Standards, TEPS = Target Energy Performance Standards
R = Energy efficiency rating, L = Labeling Requirements, V = Voluntary program

Future Works

Since the "Equipment & Appliance Energy Efficiency Management System" was introduced in 1992, It has been observed that the market share of higher efficiency appliance, refrigerator, and air-conditioner has increased significantly. As shown in Table 8, the ratio of the high efficient models, air-conditioner, equivalent to grade 1 or 2, has steadily increased from 92.4% in the end of 1993 to 96.8% in the end of 1998, in spite of the reinforced and stricter standards and rating criteria.

Table 15. Ratio of high energy-efficient Products

	Refrigerators (%)	***Air-conditioners (%)***
1992	50.9	-
1993	60.5	***92.4***
1994	68.2	***98.5***
1995	82.2	***97.0***
1996	60.9	***95.6***
1997	83.1	***96.0***
1998	91.5	***96.8***

*Note: the decrease of high-efficient models in refrigerators between 1995and 1996 is mainly due to the reinforced standards and rating criteria as well as the increased use of large models.

As of the 1st of January 1997, out of total 1,066 target appliance models (all appliances) manufactured or imported by 150 manufacturers and importers, 187 models by 75 companies fail to meet the MEPS, making the average compliance ratio 82% which is relatively high (but in terms of the number of manufacturing or importing companies it is 50%). But the overall TEPS attainment ratio is relatively row marking 28% with the exception of the high ratio of 77% in air-conditioners, Table 9 shows the compliance with the TEPS and MEPS of target appliance models.

Table 16. TEPS & MEPS compliance of Target Appliances(as of Jan. 1,'97)

Appliances	Total No. of Models	TEPS		MEPS	
		No. of Attainment	Ratio	No. of attainment	Ratio
Electric refrigerators	164	66	40	120	73
Air-conditioners	***247***	***190***	***77***	***238***	***96***
Incandescent	96	1	1	72	79
Fluorescent lamps	165	39	24	163	99
Ballasts	394	1	0.3	285	72
Total / average	1,066	297	28	878	82

It is estimated that saving effect of the energy efficiency standards and Labeling programs in the area of the target appliances amount to approximately 10~13 per cent between 1992 and 1996. Encouraged by this energy saving effects through the rapid spread of the high efficient models, the Korean government considers extending the target products to include other appliances such as TV, vending machine, dish washer 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.

Table 17. Number of Grade for Air-Conditioner (as of Sep. 17,'99)

Grade	The Number	Percent(%)
1	537	74.4
2	163	22.5
3	22	3.0
4	1	0.1
5	0	0
Total	723	100

Energy Efficiency Standards and Labeling Program for Air-Conditioner in Korea

Choi, Jun Y.
KTL

A Short History

- "Regulations on Appliance Energy Efficiency Standar ds Setting and Rating Labeling" issued on August 199 2
- Revised five times on 1993, 1994, 1995, 1996 ,1999
- 7 items
  - Electric Refrigerator, ***Electric Air-Conditioner***, ballast, Electric Washing Machine, incandescence lamp, fluores cent lamp, ballast lamp

Standards
Scope

- Room air conditioners of integral type (compressor ref rigerating unit, fans, etc are accommodated in a cabine t) or separate type (compressor refrigerating unit, fans, etc are accommodated in two cabinet)with a rated pow er consumption for cooling not exceeding 7.5kW and with cooling capacity 15,000 kcal/h or less.

Definition

- Cooling Capacity
  - The heat quantity which can be removed from the room per unit time when an air conditioner is operated for cooling. It s hall be expressed in kcal/h [W].
- Power Consumption
  - The total sum of electric powers consumed by an electric mo tor when the air conditioner is operated for cooling

Classification

- Classification by Function
  - Cooling, exclusive use.
  - Cooling and dehumidity control, combined use.
  - Cooling, heating by heat pump, combined use.
  - Cooling, dehumidifying and heating by heat pump, combine d use.
  - Cooling, heating by electric heater, combined use.
  - Cooling, dehumidifying and heating by electric heater, comb ined use.
- Classification by construction of Unit
  - Integrate type
  - Separate type
- Classification by Cooling Method of Condense
  - Air-cooling type
  - Water-cooling type
- Classification by Rated cooling capacity

Test

- Test Condition

Table 1. 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	Dry Bulb °C	Wet Bulb °C
KS	27 ± 1	19.5 ± 0.5	35± 1	24 ± 0.5	30 ± 0.5	35 ± 0.5

  - For Cooling Capacity

- Determination of Monthly Energy Consumption
  - Electrical energy consumption shall be determined by round ing off the first place of decimal of the value in accordance with KS A 0021
  - Two samples shall be tested, and the larger shall be applied.
  - 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)

- Determination of Energy Efficiency Ratio
  - Energy efficiency ratio shall be determined by rounding off t he third place of decimal of the value in accordance with KS A 0021.
  - Energy efficiency Ratio (kcal/Wh or W/W)
    - EER=C/H=(0.86C/H)
    - C : Cooling capacity (kcal/h or W)
    - H : Energy consumption (W)

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

TEPS, MEPS and Labeling

- TEPS (Target Energy Performance Standards)
  - reduce the current energy consumption by each covered product by 10~30 percent
  - the deadline for the TEPS requirement is the end of 1998.
- MEPS (Minimum Energy Performance Standards)
  - from the 1st of January 1997
  - the case that a cooling capacity is more than 9,000 kcal/h and less than 15,000 kcal/h, MEPS began to be applied from the 1st of September 1998
  - while the deadline for the TEPS requirement is the end of 1999.

- For constant speed.

Table 2. TEPS for constant speed

Classification		TEPS (kcal/hw, w/w)
Room type		2.500(2.900)
Split type	RCC < 3,550 kcal/h(4,110w)	2.700(3.132)
	3,550 kcal/h(4,110w) < RCC < 9,000 kcal/h(10,440w)	2.500(2.900)
	9,000kcal/h(10,440w) < RCC < 15,000 kcal/h(17,400w)	2.400(2.784)

Table 3. MEPS for constant speed

Classification		MEPS (kcal/hw, w/w)
Room type		2.200(2.552)
Split type	RCC < 3,550 kcal/h(4,110w)	2.500(2.900)
	3,550 kcal/h(4,110w) < RCC < 9,000 kcal/h(10,440w)	2.200(2.552)
	9,000 kcal/h(10,440w) < RCC < 15,000 kcal/h(17,400w)	2.000(2.320)

- For variable-speed, two compressor type, or rotational freq uency-control type

Table 4. TEPS for variable speed(SEER)

Classification		TEPS (kcal/hw, w/w)
Room type		2.630(3.051)
Split type	RCC < 3,550 kcal/h(4,110w)	2.840(3.294)
	3,550 kcal/h (4,110w)< RCC < 9,000 kcal/h(10,440w)	2.630(3.051)
	9,000 kcal/h (10,440w)< RCC < 15,000 kcal/h(17,400w)	2.520(2.923)

Table 5. MEPS

Classification		MEPS (kcal/hw, w/w)
Room type		2.310(2.680)
Split type	RCC < 3,550 kcal/h(4,110w)	2.630(3.051)
	3,550 kcal/h(4,110w) < RCC < 9,000 kcal/h(10,440w)	2.310(2.680)
	9,000 kcal/h(10,440w) < RCC < 15,000 kcal/h(17,400w)	2.100(2.436)

The Efficiency Rating Criteria

- For constant speed.

Table 6. The efficiency rating criteria (R) for Room type air conditioner

EER(kcal/hw, w/w)	Level(or Grade)
2.500(2.900) < EER	1
2.300(2.668) < EER ¡ Â2.500(2.900)	2
2.100(2.436) < EER ¡ Â2.300(2.668)	3
2.000(2.320) < EER ¡ Â2.100(2.436)	4
EER ¡ Â2.000(2.320)	5

Table 7. The efficiency rating criteria (R) for Split type air conditioner, Rated cooling capacity < 3,550 kcal/h(4,110w)

EER(kcal/hw, w/w)	Level(or Grade)
2.900(3.364) < EER	1
2.700 (3.132)< EER ¡ Â2.900(3.364)	2
2.500 (2.900)< EER ¡ Â2.700(3.132)	3
2.300(2.668) < EER ¡ Â2.500(2.900)	4
EER ¡ Â2.300(2.668)	5

Table 8. The efficiency rating criteria (R) for Split type air conditioner, 3,550 kcal/h(4,110w) < Rated cooling capacity < 9,000 kcal/h(10,440w)

EER(kcal/hw, w/w)	Level(or Grade)
2.600 (3.016)< EER	1
2.400(2.784) < EER ¡ Â2.600(3.016)	2
2.200 (2.552)< EER ¡ Â2.400(2.784)	3
2.000(2.320) < EER ¡ Â2.200(2.552)	4
EER ¡ Â2.000(2.320)	5

Table 9. The efficiency rating criteria (R) for Split type air conditioner, 9,000 kcal/h(10,440w) < Rated cooling capacity < 15,000 kcal/h(17,400w)

EER(kcal/hw, w/w)	Level(or Grade)
2.400(2.784) < EER	1
2.200(2.552) < EER ¡ Â2.400(2.784)	2
2.000(2.320) < EER ¡ Â2.200(2.552)	3
1.800(2.088) < EER ¡ Â2.000(2.320)	4
EER ¡ Â1.800(2.080)	5

- For variable-speed, two compressor type, or rotational freq uency-control type.

Table 10. The efficiency rating criteria (R) for Room type air conditioner

EER(kcal/hw, w/w)	Level(or Grade)
2.630(3.050) < EER	1
2.420(2.807) < EER ¡ Â2.630(3.050)	2
2.210(2.564) < EER ¡ Â2.420(2.807)	3
2.100(2.436) < EER ¡ Â2.210(2.564)	4
EER ¡ Â2.100(2.436)	5

Table 11. The efficiency rating criteria (R) for Split type air conditioner, Rated cooling capacity < 3,550 kcal/h(4,110w)

EER(kcal/hw, w/w)	Level(or Grade)
3.000(3.480) < EER	1
2.840(3.294) < EER ¡ Â3.000(3.480)	2
2.630(3.051) < EER ¡ Â2.840(3.294)	3
2.420(2.807) < EER ¡ Â2.630(3.051)	4
EER ¡ Â2.420(2.807)	5

Table 12. The efficiency rating criteria (R) for Split type air conditioner, 3,550 kcal/h(4,110w) < Rated cooling capacity < 9,000 kcal/h(10,440w)

EER(kcal/hw, w/w)	Level(or Grade)
2.730(3.167) < EER	1
2.520(2.923) < EER ¡ Â2.730(3.167)	2
2.310(2.680) < EER ¡ Â2.520(2.923)	3
2.100(2.436) < EER ¡ Â2.310(2.680)	4
EER ¡ Â2.100(2.436)	5

Table 13. The efficiency rating criteria (R) for Split type air conditioner, 9,000 kcal/h(10,440w) < Rated cooling capacity < 15,000 kcal/h(17,400w)

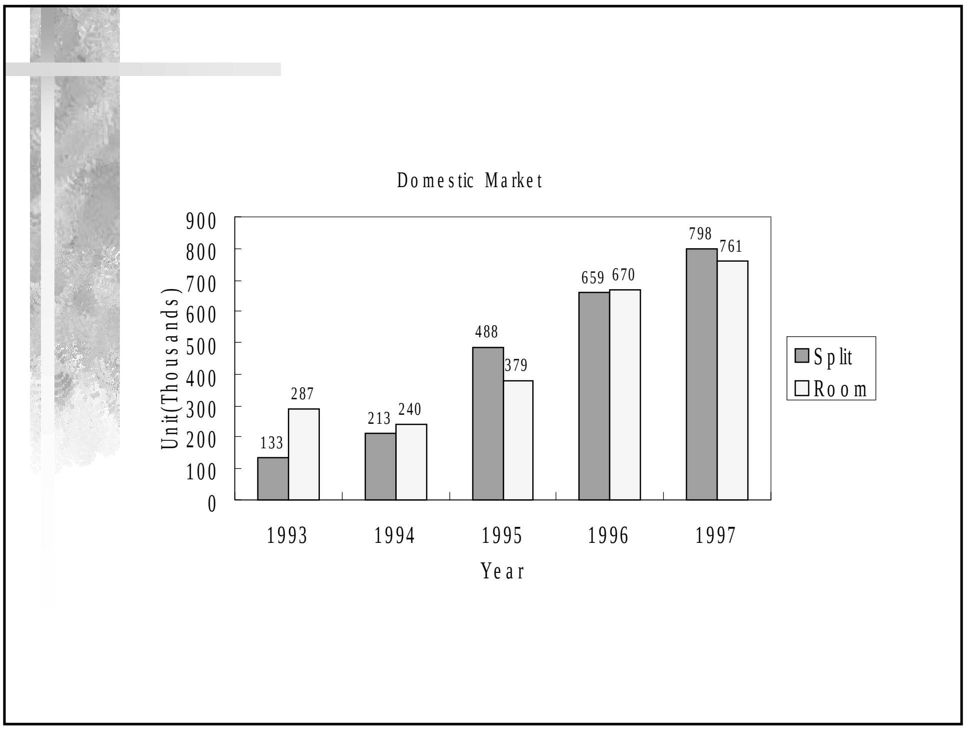
EER(kcal/hw, w/w)	Level(or Grade)
2.520(2.923) < EER	1
2.310(2.680) < EER ¡ Â2.520(2.923)	2
2.100(2.436) < EER ¡ Â2.310(2.680)	3
1.890(2.192) < EER ¡ Â2.100(2.436)	4
EER ¡ Â1.890(2.192)	5

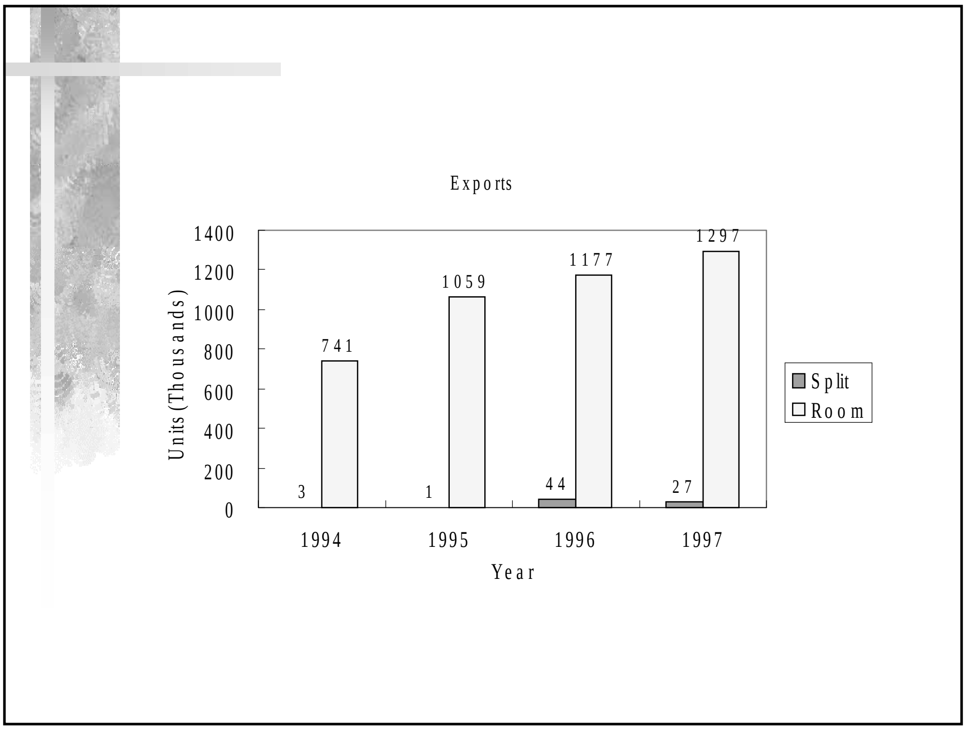
Table 14. TEPS & MEPS compliance of Target Appliances(as of Jan. 1,'97)

Appliances	Total No. of Models	TEPS		MEPS	
		No. of attainment	Ratio	No. of attainment	Ratio
Electric refrigerators	164	66	40	120	73
Air-conditioners	***247***	***190***	***77***	***238***	***96***
Incandescent	96	1	1	72	79
Fluorescent lamps	165	39	24	163	99
Ballasts	394	1	0.3	285	72
Total / average	1,066	297	28	878	82

Table 15. Number of Grade for Air-Conditioner (as of Sep. 17,'99)

Grade	The Number	Percent(%)
1	537	74.4
2	163	22.5
3	22	3.0
4	1	0.1
5	0	0
Total	723	100


Domestic Market
Unit(Thousands)
900
800
700
600
500
400
300
200
100
0
133
287
213
240
488
379
659
670
798
761
1993
1994
1995
1996
1997
Year
Split
Room


Exports
Units (Thousands)
1400
1200
1000
800
600
400
200
0
3
741
1
1059
44
1177
27
1297
1994
1995
1996
1997
Year
Split
Room

Related Standards

- KS C 9306, Room Air-Conditioners
- KS A 0006, Standards Atmospheric Conditions for Te sting
- KS A 0021, Rules for Rounding of Numerical Values

Energy Performance Standards and Regulations of The Fluorescent Lamp Ballast in Korea

October 6-8, 1999

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Overview of Regulation on Ballast

- Regulations on Labeling and MEPS were initially announced in 1992

- Revised five times in 1993, 1994, 1995, 1996 and 1999

- Items are extended to five in 1999

  - Ballast for tubular lamps (T10/20W, T10/40W and *T8 32W*)

  - Ballast for 32W and *40W* circular lamps

Efficiency Rating Criteria

- EER Index R for labeling and MEPS

$$R = \frac{\text{Lumen/Watt of tested ballast with reference lamp}}{\text{Lumen/Watt of reference ballast with reference lamp}}$$

- Each Item has target R,
  and mandatory MEPS is also applied.

- Labeling is graded into five levels.

MEPS and Target Efficiency

Ballast Type (All 220V Input)	R for Target Efficiency (Until May 30, 2002)	R for Minimum Energy Performance Standards	
		Until Dec. 31, 1999	From Jan. 1, 2000
For Tubular 20W (T10)	1.15	0.83	0.83
For Tubular 40W (T10)	1.20	0.97	0.97
For Tubular 32W (T8)	1.18	-	0.97
For Circular 32W	1.18	0.97	0.97
Fore Circular 40W	1.18	-	0.97

Labeling formulae

Ballast Type (All 220V Input)	R Values for Labeling Grade				
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
For Tubular 20W (T10)	≥ 1.15	1.06-1.15	0.97-1.06	0.92-0.97	0.83-0.92
For Tubular 40W (T10)	≥ 1.2	1.18-1.2	1.10-1.18	1.01-1.10	0.97-1.01
The Others (Tubular 32W (T8), Circular 32W & 40W)	≥ 1.18	1.09-1.18	1.05-1.09	1.01-1.05	0.97-1.01

Related Standards

- KS C 8102-1999(in press)
  Magnetic Ballasts for Fluorescent Lamps

- KS C 8100-1999(in press) AC Supplied
  Electronic Ballasts for Fluorescent Lamps

- KS C 7601-1995 Fluorescent Lamps for General
  lighting Services

- IEC 929 A.C. Supplied Electronic Ballasts
  for Tubular
  Fluorescent Lamp-Performance Requirements

Condition for Common Test Procedure

- Comparable test equipment in performance should be used.
  - Power analyzer, Standard power source, and Photometer

- Common standard ballast/lamp should be used.
  - FLR 32W, FL 40W, FLR 40W, FCL 32W and FCL 40W lamp/ballast in Korea

- Common Standard in measurement should be used.

Measuring Methodology of Ballast Efficiency

- Approach based on lumen/W (ballast+lamp) rather than W (ballast only)
  - Ballast is an auxiliary device to help the lamp operation.
  - Lamp output can be different with same loss ballast.
    - ∵ Ballasts on market have different circuit topologies
      ➔ Different characteristics in impedance matching and conversion efficiency

- Practically, measuring the ballast loss is not simple
  - Many ballast types exist.
  - Need power meter with high accuracy and fast sampling for magnetic ballast as well as electronics ballast.

Efficacy Index: Core for Harmonized Standard

- Two way for defining ballast efficiency

  - Absolute Watt: Consider only ballast loss
  - Normalized value: Consider system

- System approach uses the followings

  - BF(Ballast Factor) or BLF(Ballast Lumen Factor)

$$= \frac{\text{light output(Lumen) of tested ballast with reference lamp}}{\text{Light output(Lumen) of reference ballast with reference lamp}}$$

Efficacy Index: Core for Harmonized Standard

- BEF(Ballast Efficacy Factor)

$$= \frac{BF * 100}{\text{System Input Watt}}$$

- LPW(Lumen per Watt)

$$= \frac{\text{Light Output Lumen}}{\text{System Input Watt}}$$

❑ New index such as R

Barrier of Harmonization and comment

- Each country has different items/levels in MEPS & Labeling
- Each country has different in main market products and main policy.

  For example, Korea Government heavily guides that T10 lamp system can be displaced by T8 lamp system.

- It is prefer to begin the most common and important items.

Future of Policy in Korea

- Revision on regulations will be considered every 3 years.

- Government hopes to substitute T10 lamp/ballast by T8 lamp/ballast in Korea market until next revision.

- Government will include T5 lamp/ballast in next revised regulation under the consideration of market.

- Government will actively cooperate with APEC, and hopes to do an important role for harmonization.

APEC Project No. : EWG 03/99
"Colloquium for Minimum Energy Performance Standards"

Room Air-Conditioners

National Commission for Energy Conservation
Jose Pedro Guzman Valenciano, Mechanic-Electric Engineer
Certification Sub-Director

Mexican Experience: ***NOM-021-ENER-1999 Energy efficiency for room air-conditioners. Limits, test method and labeling.***

The normalization of energy efficiency in Mexico respect to room air conditioners begins in 1994, with the publication of the NOM-073-SCFI-1994 Energy efficiency of room air conditioners. Limits and test method.

The normalization has progressed enough, due to the constant search in the harmonization of test methods of the standards of United States and Canada.

This standard was based on the ANSI/ASHRAE 16-1998 Standard "*Method of testing for rating room air conditioners and packed terminal air conditioners*, and with the values of efficiency proposed by the Department of Energy (DOE) of the United States. In the year of 1997 begins the revision of this standard, incorporating the Packed terminal air conditioners and taking the values of efficiency of DOE for the year 2000, originating the NOM-021-ENER-1999.

NOM-021-ENER-1999

Objective

The present Mexican Official Standard establishes the specifications and the test method to determine the Energy Efficiency Ratio (EER). Also, the label's information (value of the saving for the consumer).

Application

This standard applies to the new rooms air-conditioners, with or with out heating, with condenser cooled by air and with cooling capacities until of 10 600 watts (36 000 BTU/h) national and imported. It doesn't apply for mini-split

The next year, we wait begin the work in official standard for de mini-split air conditioners, probably in February.

Classification

The room-air conditioner for its cooling capacity, cycle and louvered sides, the following classification:

Type	Class	Cooling Capacity (W)
Without reverse cycle and with louvered sides	1 2 3 4 5	Less than 1 759 And 1 760 to 2 343 And 2 344 to 4 101 And 4 102 to 5 859 And 5 860 to 10 584
Without reverse cycle and without louvered sides	6 7 8 9 10	Less than 1 759 And 1 760 to 2 343 And 2 344 to 4 101 And 4 102 to 5 859 And 5 860 to 10 584
With reverse cycle and with louvered sides	11 13	Less than 5 859 And 5 860 to 10 584
With reverse cycle and without louvered sides	12 14	Less than 4 101 And 4 102 to 10 584

The Department of Energy (DOE) has adopted new product classes in addition the twelve product classes specified by National Appliance Energy Conservation Act (NAECA). The twelve product classes specified by NAECA apply to units that are designed to be installed in single -or double - hung windows and are defined according to the following criteria: capacity, whether the outside portion of the cabinet has louvered sides, and whether a reversing valve is present.

Energy Efficiency Ratio (REE)

Class	Stage I (W/W)	Stage II (W/W)
1	2,34	2,84
2	2,49	2,84
3	2,64	2,87
4	2,58	2,84
5	2,40	2,49
6	2,34	2,64
7	2,49	2,64
8	2,49	2,49
9	2,49	2,49
10	2,40	2,49
11	2,49	2,64
12	2,34	2,49
13	2,49	2,49
14	2,34	2,34

Calorimeters:

This standard to consider two calorimeters types:

a) Calibrated room type calorimeter

b) Balanced ambient room type calorimeter

Calculating EER:

$$EER = \left[\frac{\phi}{P}\right]$$

Φ_{ti}= its the net total effect of cooling in the indoor

P= its the average from the seven measures of electric power entrance to the room air-conditioner

So the test is accepted:

$$\left[\frac{\phi_{ti-}\phi_{te}}{\phi_{ti}}\right]\times 100 \leq 4\%$$

Φ_{te}= net total effect of cooling capacity in the outdoor

The net total effect of cooling in the indoor is calculated:

$$\Phi_{ti} = \left[\sum P_i + qm_i\left(h_{qm1} - h_{qm2}\right) + \Phi_{1p} + \Phi_{1r}\right] \times \left[1 + \frac{0{,}0024\left(101325 - p_{bl}\right)}{1000}\right]$$

ΣP_i= sum of all power input to indoor compartment (W)

qm_i= water vapor condensed by air conditioner (kg/s)

h_{qm1}= enthalpy of water or steam supplied to maintain humidity (kJ/kg)

h_{qm2}= enthalpy of condensed moisture leaving the indoor compartment

Φ_{1p}= heat leakage into indoor compartment, through separating partition between rooms, as determined from calibrating test (W)

Φ_{1r}= heat leakage into indoor compartment through walls, floor and ceiling, as determined for calibrating test. (W)

factor to correct the variations from the standard barometric pressure.

and the net total effect of cooling in the outdoor:

$$\Phi_{te} = \left[\Phi_c - \Sigma P_e - P + qm_i\left(h_{qm3} - h_{qm2}\right) + \Phi_{1p} + \Phi_{1o}\right] \times \left[1 + \frac{0{,}0024\left(101325 - p_{bl}\right)}{1000}\right]$$

Φ_c= heat removed by cooling coil in outdoor (W)

ΣP_e= sum all power input to any equipment in outdoor (W)

P= total power input to air conditioner (W)

h_{qm3}= enthalpy of condensed moisture leaving the indoor (kJ/kg)

h_{qm2}= enthalpy of condensed removed by air-treating coil in outdoor reconditioning equipment, taken at the temperature at which the condensed leaves the compartment (kJ/kg)

Φ_{1p}= heat leakage out of the outdoor through separating partition between indoor and outdoor, as determined from calibrating test (W)

Φ_{1o}= heat leakage out of outdoor side (but no including the separating partition), as determined from calibrating test (W)

This standard establish one label with information of the saving value for the consumers:

EFICIENCIA ENERGETICA

Relación de Eficiencia Energética (REE)

Acondicionador de aire tipo cuarto (enfriamiento solamente)
Capacidad: 3,516 W

Marca reg. Superiris
Modelo 123

REE mínima para esta capacidad: 2.49 W/W

A
B
C
D
E

B

REE de este modelo
(Capacidad de enfriamiento en Watts entre la potencia eléctrica en Watts)
Determinado como se establece en la NOM-073-SCFI-1994

2.64

Ejemplo del costo anual de operación (N $)
En función del tiempo de uso y la tarifa correspondiente

Costo del kWh según tarifa (N$)	Horas de uso anual				
	250	750	1000	2000	2800
0.14	46.6	139.8	186.5	372.9	522.1
0.17	56.6	169.8	226.4	452.8	633.9
0.32	106.5	319.6	426.2	852.4	1193.3
0.47	156.5	469.5	625.9	1251.9	1752.7
0.50	166.5	499.4	665.9	1331.8	1864.5

NOTA: Precios de tarifas eléctricas en base al consumo mensual, vigentes a septiembre de 1994.

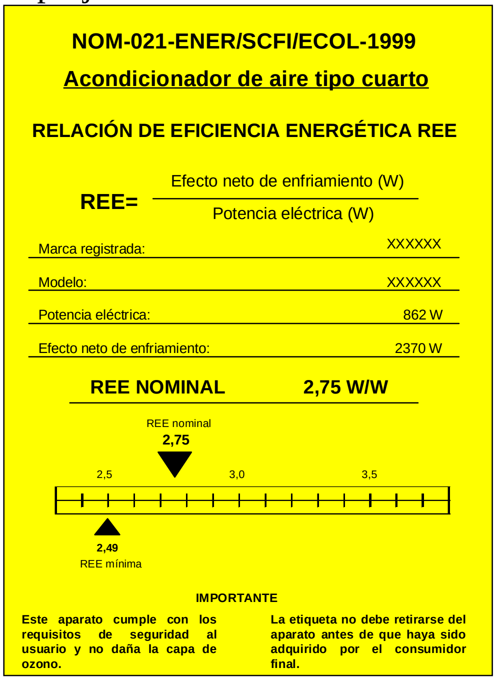
El costo anual de operación se obtiene multiplicando la capacidad del acondicionador por las horas de uso anual y por el costo estimado del kWh, todo lo anterior dividido entre la REE de la etiqueta y 1,000:

$$\frac{3{,}516 \text{ W} \times 750 \text{ hrs.} \times \text{N\$ } 0.32}{2.64 \text{ W/W} \times 1{,}000} = 319.6 \text{ N\$/año}$$

IMPORTANTE

La etiqueta no debe retirarse del producto
hasta que haya sido adquirido por el consumidor final

Proposal for the standard project NOM-021-ENER-1999



Bibliography

- ANSI-ASHRAE 16 Method of testing for room air conditioners and packaged terminal air conditioners (PTAC).
- ISO R859 Testing an rating room air conditioners.
- ISO 5151 Non ducted air conditioners and heat pumps. Testing and rating for performance.

National producers:
Carrier, York, Kelvinator, Polaris, Mirage.

Principal importers:
Samsung, LG electronics, Fedders, Whirlpool, Westinghouse, Rheem, Ideal Standard, McQuay, Panasonic, Daewoo.

Now a day, Mexico has two capable laboratories for room air-conditioners (with balanced ambient room type calorimeter):

- **Carrier Mexico**, in Monterrey, Nuevo Leon
- **Instrumentos Electrónicos**, in Nogales, Sonora

http://www.conae.gob.mx
no@energia.gob.mx
nor@energia.gob.mx

National Commission for Energy Conservation

COMISION NACIONAL PARA EL AHORRO DE ENERGIA

http://www.conae.gob.mx

National Commission for Energy Conservation

NOM-021-ENER-1999

Energy efficiency for Room air conditioner

National Commission for Energy Conservation

Introduction:

The normalization of energy efficiency in Mexico respect to room air conditioners begins in 1994, with the publication of the NOM-073-SCFI-1994 Energy efficiency of room air conditioners.

The normalization has progressed enough, due to the constant search in the harmonization of test methods of the standards of United States and Canada.

National Commission for Energy Conservation

This standard was based on the ANSI/ASHRAE 16-1998 Standard "*Method of testing for rating room air conditioners and packed terminal air conditioners*", and with the values proposed by the Department of Energy of the United. In the year of 1997 begins the revision of this standard, incorporating the Packed terminal air conditioners and taking the values of efficiency of DOE for the year 2000, originating the NOM-021-ENER-1999.

National Commission for Energy Conservation

Objective:

The present Mexican Official Standard establishes the specifications and the methods of test to determine the Energy Efficiency Ratio (EER). Also, the label's information (Value of the Saving for the consumer).

National Commission for Energy Conservation

Application:

This standard applies to the new room air conditioners, with or without heating, with condenser cooled by air and with cooling capacities until of 10 600 watts (36 000 BTU/h), national and foreigners. It doesn't apply for mini-split.

The Department of Energy (DOE) has adopted new product classes in addition the twelve product classes specified by National Appliance Energy Conservation Act (NAECA). The twelve product classes specified by NAECA apply to units that are designed to be installed in single -or double-hung windows and are defined according to the following criteria: capacity, whether the outside portion of the cabinet has louvered sides, and whether a reversing valve is present.

National Commission for Energy Conservation

Classification:

Type	Class	Cooling Capacity [Watts]
Without reverse cycle and with louvered sides	1	less than 1 759
	2	and 1 760 to 2 343
	3	and 2 344 to 4 101
	4	and 4 102 to 5 859
	5	and 5 860 to 10 584
Without reverse cycle and without louvered sides	6	less than 1 759
	7	and 1 760 to 2 343
	8	and 2 344 to 4 101
	9	and 4 102 to 5 859
	10	and 5 860 to 10 584
With reverse cycle and with louvered sides	11	less than 5 859
	13	and 5 860 to 10 548
With reverse cycle and without louvered sides	12	less than 4 101
	14	and 4 102 to 10 548

National Commission for Energy Conservation

Efficiency Energy Ratio (EER):

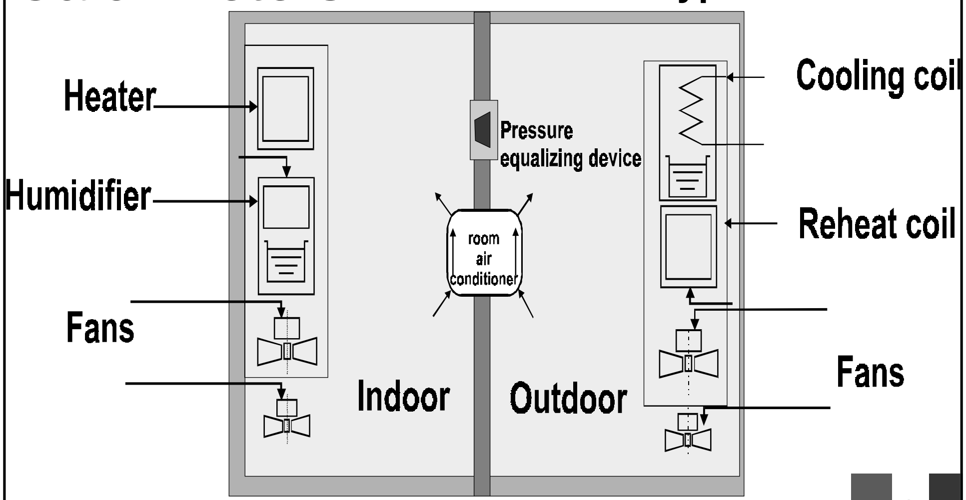
Class	Stage I	Stage II
1	2,34	2,84
2	2,49	2,84
3	2,64	2,87
4	2,58	2,84
5	2,40	2,49
6	2,34	2,64
7	2,49	2,64

Class	Stage I	Stage II
8	2,49	2,49
9	2,49	2,49
10	2,40	2,49
11	2,49	2,64
12	2,34	2,49
13	2,49	2,49
14	2,34	2,34

EER [W / W]

National Commission for Energy Conservation

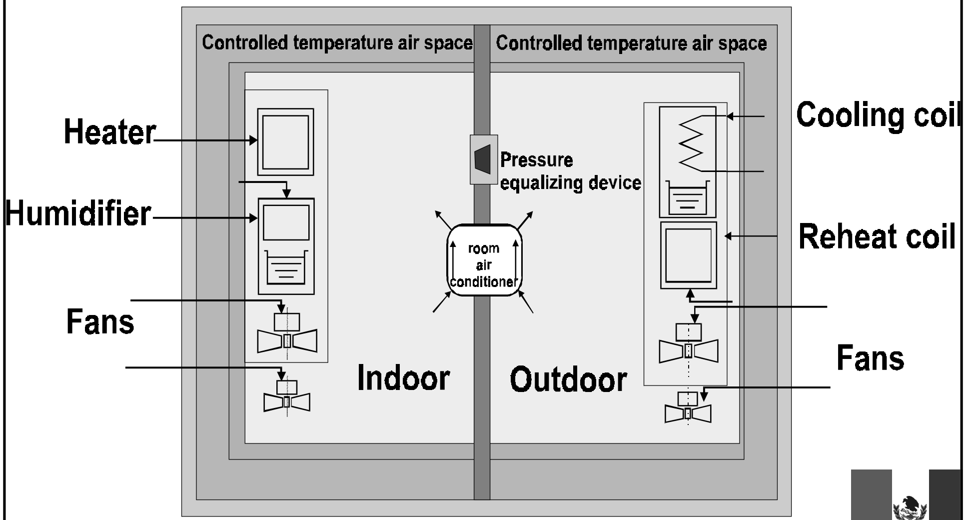
Calorimeters: **Calibrated room type calorimeter**



National Commission for Energy Conservation

CONAE

Calorimeters: Balanced ambient room type calorimeter



National Commission for Energy Conservation

CONAE

Calculating EER:

$$EER = \left[\frac{\Phi}{P} \right]$$

Φ_{ti} = its the net total effect of cooling in the indoor

P = its the average from the seven mensurations of electric power electric entrance to the room air conditioner

So the test is accepted:

$$\left(\frac{\Phi_{ti}-\Phi_{te}}{\Phi_{ti}}\right)\times 100 \leq 4\%$$

National Commission for Energy Conservation

The net total effect of cooling in the indoor

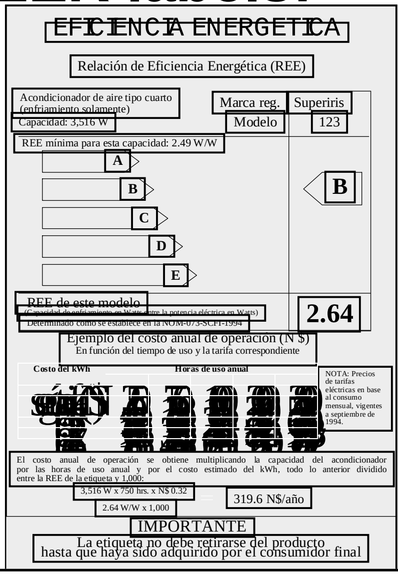
$$\Phi_{ti}=\left[\sum P_i + qm_i\left(h_{qm1}-h_{qm2}\right)+\Phi_{1p}+\Phi_{1r}\right]\times\left[1+\frac{0{,}0024\left(101325-p_{bl}\right)}{1000}\right]$$

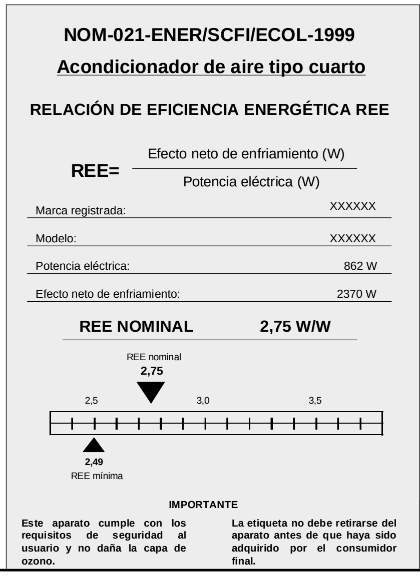
The net total effect of cooling in the outdoor

$$\Phi_{te}=\left[\Phi_c-\sum P_e - P + qm_i\left(h_{qm3}-h_{qm2}\right)+\Phi_{1p}+\Phi_{1o}\right]\times\left[1+\frac{0{,}0024\left(101325-p_{bl}\right)}{1000}\right]$$

National Commission for Energy Conservation

EER labels:





National Commission for Energy Conservation

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- ASHRAE-16-1988 Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners. December 1988

Bibliography:

- AS 1861.1-1988 Air Conditioning Units- Methods of Assessing and Rating Performance. Part 1: Refrigerated Room Air Conditioners. January 1988
- AHAM-RAC-1-1989 Room Air Conditioners. March 1989
- FINAL RULE Energy Conservation Program for Consumer Products; Conservation Standards for Room Air Conditioners. Document published for Office of Codes and Standards- Office of Energy Efficiency and Renewable Energy, U.S. DEPARTMENT OF ENERGY. September 1997

National producers:

CARRIER
YORK
KELVINATOR
POLARIS
MIRAGE

National Commission for Energy Conservation

Principal importers:

SAMSUNG
LG ELECTRONICS
FEDDERS
WHIRLPOOL
WESTINGHOUSE
RHEEM
IDEAL STANDARD
McQUAY
PANASONIC
DAEWOO

National Commission for Energy Conservation

Capable laboratories for room air-conditioners in Mexico:

2 laboratories

- Monterrey, Nuevo Leon
- Nogales, Sonora

National Commission for Energy Conservation

Thanks

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Republic of the Philippines
DEPARTMENT OF ENERGY
FUELS AND APPLIANCE
TESTING LABORATORY

Philippines MEPS and Labeling for Room Air Conditioners

Isagani C. Soriano
Fuels and Appliance Testing Laboratory
Department of Energy, Philippines

Colloquium on Technical Issues
of Minimum Energy Performance Standards

Tower Hotel Seoul, Korea
6-8 October 1999

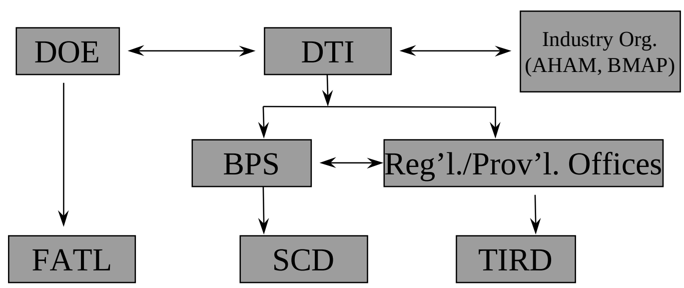
History of RAC Labeling Program

- 1980 - Passed Energy Conservation Law
- 1984-1985 - Testing of room air-conditioners
- 1987 - Consultative meeting with Stakeholders. Start development and formulation of PNS 240 (based on ISO R859)
- 1989 - Finalized the RAC Labeling Implementing Guidelines
- July 1992 - Signing of MOA with AHAM and BPS - voluntary labeling.
- October 1993 - Mandatory Labeling
- June 1994 - Full implementation for all sizes of window type RAC
- 1994 to present - Nationwide information campaign and market monitoring
- 1995 - Increased Minimum Level of EER
- 1999 - inclusion of mini-split type RAC.

Product Labeling Scheme

- Administered by DOE, BPS and AHAM
- Intended to provide consumer with information to compare energy efficiency of competing products.
- Encourage local manufacturers to produce more energy efficient products.
- Energy performance ratings are based on standard test procedure.
- Provides a uniform disclosure scheme
  - RAC: energy consumption,cooling capacity, and EER.
  - Refrigerators: storage volume/temperature, energy consumption, and EEF.
  - Fluorescent Lamp Ballast: ballast loss (watt).

BPS / FATL / Industry Organization Role on EER Labeling of RAC



- Validation of energy labels
- Efficiency Testing

- Product Sampling
- Product Certification
- Enforce the implementation of the standard

- Market Monitoring
- Penalize non-complying retailers/dealers, mftrs. & assemblers

Background: Development of Standards

- 1983 - Start of development, adopted ISO R 859
- 1987 - Consultative meeting with Stakeholders. BPS/TC-30 reviewed the standard.
- 1989 - Finalized the PNS 240 based on ISO R 859, used ISO/DIS 5151 as working draft. RAC Labeling Implementing Guidelines
- 1991 - Finalized PNS 396 - Part 1.
- 1994 - Final version of ISO 5151 was issued.
  - Replaced and canceled ISO R 859
- 1995 - Revised PNS396 - Part 1. Increased the minimum EER requirement.
- 1997 - Deliberation of ISO 5151:1994(E) by BPS/TC-30
- 1998 - Finalized PNS 240:1998, adopted ISO 5151:1994

Test Conditions for the determination of cooling capacity

Parameter	ISO 5151: 1994			PNS 240
	Standard Test Conditions*			
	T1	**T2**	**T3**	**T4**
Tempearature of air entering indoor side (°C)				
dry-bulb	**27**	**21**	**29**	**27**
wet-bulb	**19**	**15**	**19**	**19**
Temperature of air entering outdoor side (°C)				
dry-bulb	**35**	**27**	**46**	**35**
wet-bulb	**24**	**19**	**24**	**27**
Condenser water temperature (°C)				
inlet	**30**	**22**	**30**	**31**
outlet	**35**	**27**	**35**	**37**
Test frequency	Rated frequency			
Test voltage	Rated voltage			
T1- Standard cooling capacity rating conditions for **moderate** climates				
T2- Standard cooling capacity rating conditions for **cool** climates				
T3- Standard cooling capacity rating conditions for **hot** climates				
T4- Standard cooling capacity rating conditions for **Philippine** climate				

Source: Table 1 of ISO 5151:1994 / PNS 240:1998

Performance Rating

Standard Rating	ISO 5151		PNS 240	
	Units	Rounded to	Units	Rounded to
Cooling Capacity *(Total=sensible+latent)*	W	0.1	kJ/h	1
Energy Efficiency Ratio	W/W	0.05	kJ/W-h	0.1

Energy Efficiency Ratio (EER):

- **Should not be less than minimum requirement.**
- **computed value should not be less than 90% of claimed.**

Cooling Capacity:

- **Measured value should not be less than 90% of the rated.**

Power Input:

- **measured value should not be more than 110% of the rated.**

Philippine Minimum EER Requirements from 1995 to 2002

Classification of room air conditioners	1995	1996	1997	1998	1999	2000	2001	2002
With Cooling Capacity below 12,000 kJ/h	8.3 (2.31)	8.3 (2.31)	8.3 (2.31)	8.7 (2.42)	8.7 (2.42)	8.7 (2.42)	9.1 (2.53)	9.1 (2.53)
With Cooling Capacity 12,000 kJ/h and above	7.4 (2.06)	7.8 (2.17)	7.8 (2.17)	7.8 (2.17)	8.2 (2.28)	8.2 (2.28)	8.2 (2.28)	8.6 (2.39)

*Values in parenthesis ( ) are in W/W.

Source: PNS 396-1:1995

LIST OF CERTIFIED ROOM AIR CONDITIONERS
As of September1999

- Number of Local Manufacturers/Assemblers : 10
- Number of Importers : 7
- Number of Models Certified :

Local	:	115
Imported	:	52
		167

ANNUAL SALES VOLUME
Room Air Conditioners (Local)
CY 1988 - CY 1998

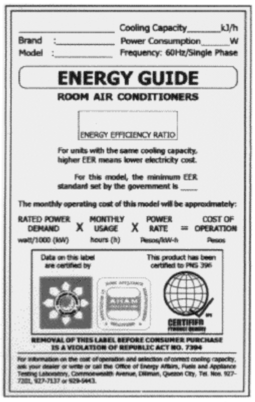
YEAR	TOTAL SALES	% CHANGE
1988	42,556	-
1989	48,926	14.969
1990	55,972	14.401
1991	44,205	-21.023
1992	52,657	19.120
1993	65,778	24.918
1994	90,651	37.814
1995	111,422	22.913
1996	153,597	37.852
1997	191,637	24.766
1998	201,898	5.354

Note: source - AHAM*
* Association of Home Appliance Manufacturers

Status of RAC Energy Efficiency and Labeling

- **Only 50% of models met standard before program started; now 100% meet**
  - **Based on 2nd quarter monitoring: 94% compliance nationwide.**
- **23% increase in average efficiency (1994 – 1998)**
  - **units below 12,000 kJ/h: average EER is 9.9 (2.75)**
  - **units 12,000 kJ/h and above: average EER is 9.4 (2.61)**
  - **overall average is 9.6 (2.67)**

Room Airconditioner Energy Label



Industrial Technology Research Institute
Energy & Resources Laboratories

Energy Efficiency Measurements of Small Air-Conditioning Systems in Chinese Taipei

Robert Yie-Zu Hu, Ph.D

Energy & Resources Lab., Industrial Technology Research Institute,

Hsinchu, Taiwan 310

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Air-Conditioning Product Status in Chinese Taipei

Item	**Room A/C**			**Package A/C**			**Water Chiller**		
Year	Production (unit)	Shipment (unit)	Value (Million NT$)	Production (unit)	Shipment (unit)	Value (Million NT$)	Production (unit)	Shipment (unit)	Value (Million NT$)
91’	981,912	969,145	17,883.5	35,912	33,564	2,548.3	–	7,885	1,417.8
92’	1,036,234	1,073,979	18,920.5	41,629	39,219	2,946.5	–	10,827	1,498.3
93’	1,115,513	1,182,328	22,412.6	36,571	39,981	3,178.0	–	11,153	1,640.5
94’	1,487,543	1,410,763	26,022.8	43,781	41,171	3,506.2	–	13,915	1,335.1
95’	1,584,631	1,600,248	31,390.3	50,955	47,069	3,792.1	9,453	9,519	1,386.9
96’	1,673,176	1,673,995	31,988.3	41,737	42,722	3,469.3	8,385	8,418	1,232.4
97’	1,595,823	1,587,180	29,378.4	50,803	54,074	4,077.4	9,397	8,998	1,344.2
98’	1,384,510	1,566,457	28,559.9	51,074	54,237	3,808.6	8,992	9,518	1,395.1

Source:Industrial production statistics monthly report, MOEA
1 US$ ≅ 33 NT$

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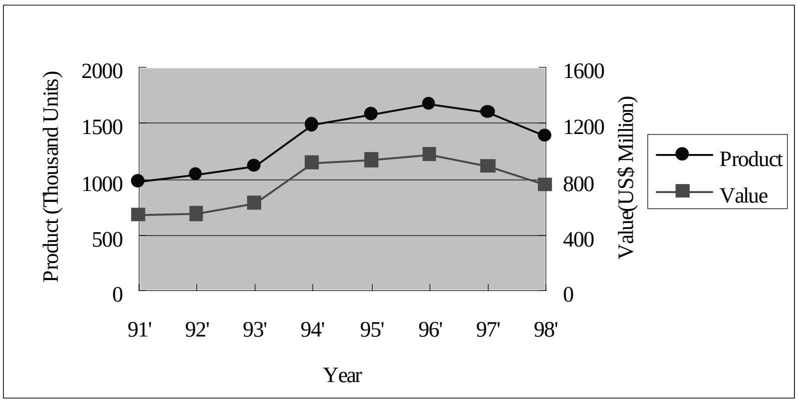

Figure 1 Quantities and values of the small air-conditioning system in Taiwan.

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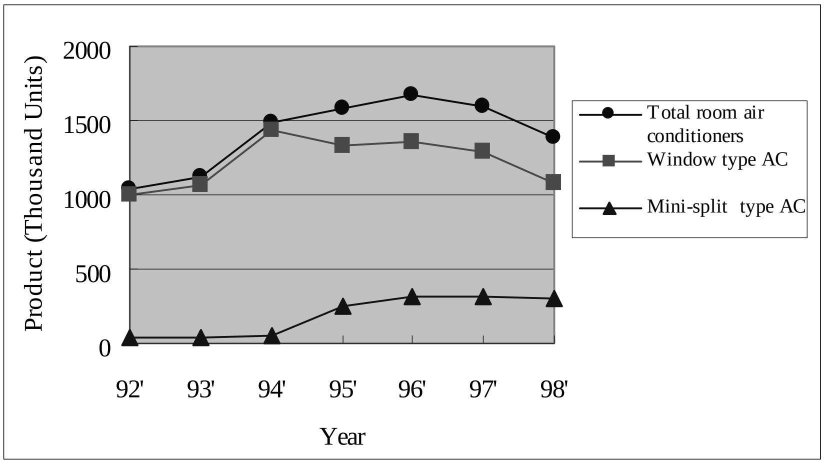

Figure 2 Quantities of the window and split type air-conditioners in Taiwan during 1991~1998.

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Energy & Resources Laboratories

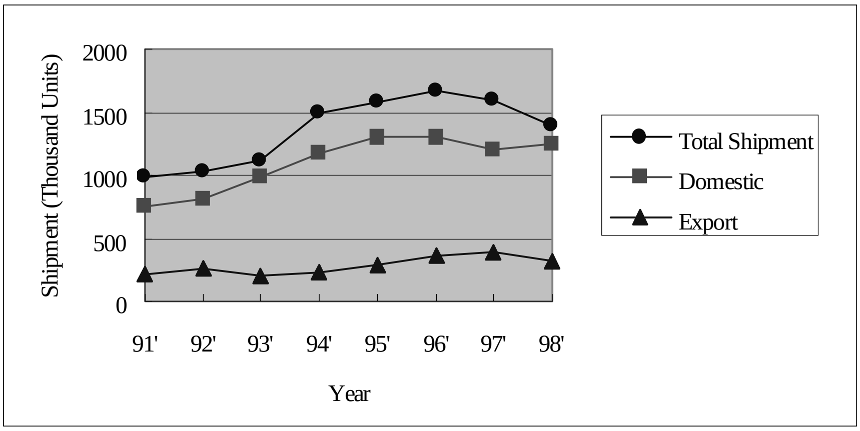

Figure 3 Quantities of the domestic and export for the small air-conditioners in Taiwan during 1991~1998.

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Table 1 Rating Condition for Room Air-Conditioners

Unit: °C

Condition	Indoor Condition		Outdoor Condition			
			Air Cooling		Water Cooling	
	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb	Water inlet Temperature	Water Outlet Temperature
Standard Rating for Cooling	27±1	19.5±0.5	35±1	24±1	30±0.5	35±0.5
Standard Rating for Heating (Heat Pump)	21±1	¡ Ð	7.0±1	6.0±0.5	15.5±0.5	Identical to the cooling condition and same water flowrate
Standard Rating for Heating (Electric)	21	¡ Ð	¡ Ð	¡ Ð	¡ Ð	¡ Ð
Over Load	32±1	22.5±0.5	43±1	25.5±1	35±0.5	Identical to the cooling condition and same water flowrate
Freeze up	27±1	24±0.5	27±1	24±0.5	¡ Ð	27±0.5
Low Temperature	21±1	15.5±0.5	21±1	15.5±0.5	¡ Ð	21±0.5
Heating defrost	21±1	15.5±0.5	1.5±1	0.5±0.5	¡ Ð	¡ Ð

Note: 1. CNS-3615 Conditions
2. Power consumption ≤ 3kW

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Table 2 Minimum EER Requirements for the Room Air-Conditioners

Type of Air-conditioner			E.E.R kCal/W-hr¡]BTU/W-hr¡ ^ Starting from 1993
Window Type	Cooling Capacity less than 2000 kCal/ hr		2.22¡]8.8¡ ^
	Cooling Capacity between 2000 kCal/ hr And 3550 kCal/ hr		2.27¡]9.0¡ ^
	Cooling Capacity more than 3550 kCal/ hr		2.07¡]8.2¡ ^
Split Type	Cooling Capacity less than 3550 kCal/ hr	normal	2.43¡]9.6¡ ^
		Inverter	2.27¡]9.0¡ ^
	Cooling Capacity more than 3550 kCal/ hr		2.18¡]8.6¡ ^

Table 3 Noise Level for the Room Air-Conditioners

Unit: dB

Rating Cooling Capacity ¡]kCal/hr¡ ^	Indoor	Outdoor
Less than 2240	53	58
Between 2500 and 3550	58	63
More than 4000	63	68

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Table 4 Rating Condition for Package Unit Air-Conditioners

Unit: °C

Condition		Indoor Condition		Outdoor					
				Air Cooling		Water Cooling		Water Cooling ,Heat Pump	
		Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb	Water inlet	Water Outlet	Water inlet	Water Outlet
Cooling	Cooling	27±1	19.5±0.5	35±1	24±0.5	30±0.5	35±0.5	18±0.5	29±0.5
	Over Load	32±1	22.5±0.5	43±1	25.5±0.5	32±0.5	¡ Ð	24±0.5	¡ Ð
	Frost	27±1	24±0.5	27±1	24±0.5	¡ Ð	27±0.5	¡ Ð	27±0.5
	Low Temperature	21±1	15.5±0.5	21±1	15.5±0.5	¡ Ð	21±0.5	¡ Ð	21±0.5
Heating Heat Pump	Heating	21±1	¡ Ð	7.0±1	6.0±0.5	¡ Ð	¡ Ð	15.5±0.5	¡ Ð
	Over Load	24±1	¡ Ð	21±1	15.5±0.5	¡ Ð	¡ Ð	21±0.5	¡ Ð
	Defrost	21±1	¡ Ð	1.5±1	0.5±0.5	¡ Ð	¡ Ð	¡ Ð	¡ Ð
Heating of Electric Heater		21	¡ Ð	¡ Ð	¡ Ð	¡ Ð	¡ Ð	¡ Ð	¡ Ð
Identical Static Pressure Condition		20±2	15.8±1	¡ Ð	¡ Ð	¡ Ð	¡ Ð	¡ Ð	¡ Ð

Note: 1. CNS-2725 Conditions
2. Power consumption > 3kW, capacity ≤ 22400 Kcal/hr

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Table 5 Minimum EER Requirements for the Package Unit Air-Conditioners

Air Conditioner Type	E.E.R Value kCal/W-hr¡]BTU/W-hr¡^
	Starting from 1993
Air Cooling Type	2.22¡]8.8¡^
Water Cooling Type	2.88¡]11.43¡^

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Table 6 Noise Level for the Package Unit

Unit: dB

Rating Capacity ¡]kCal/ hr¡ ^	Indoor	Outdoor
Below 11200	Below 63	Below 68
Below 22400	Below 66	Below 71

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Energy & Resources Laboratories

Air Conditioners Regulatory Measure in Chinese Taipei

I. Products Certified Registration

This is a mandatory requirement for every A/C product to apply and certify by the Bureau of Standard and Testing, MOEA, in order to sale on the market. The certified or testing items include:

(a) Product structure, (b) Cooling, Heating capacities or both, (c) Electricity consumption
(d) Air volume, (e) Auto defrost characteristic, (f) Over load characteristic
(g) Temperature senor, (h) Condensation characteristic, (i) Low temperature
(j) Voltage variations, (k) Starter characteristic, (l) Insulated resistance
(m) Electricity leakage, (n) Isolation cartelistic characteristic, (o) Noise level,
(p) EER Values, (q) Name plates for mechanical functions, (r) Others.

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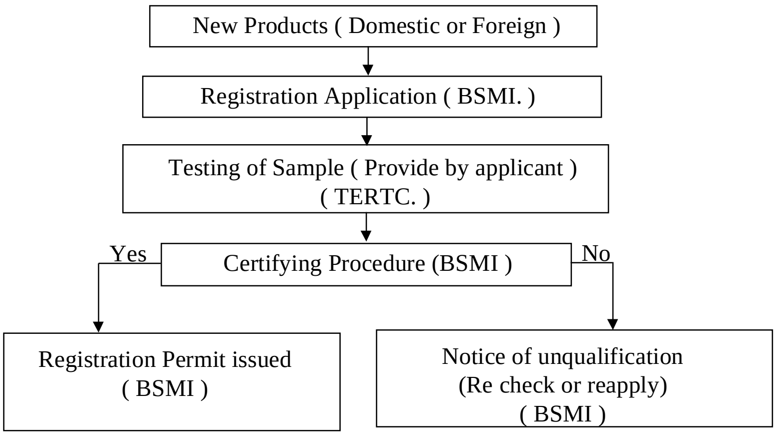
Industrial Technology Research Institute
Energy & Resources Laboratories

II. Product Registration: (Mandatory)



BSMI: Bureau of Standards, Metrology & Inspection
TERTC: Taiwan Electric Research and Testing Center

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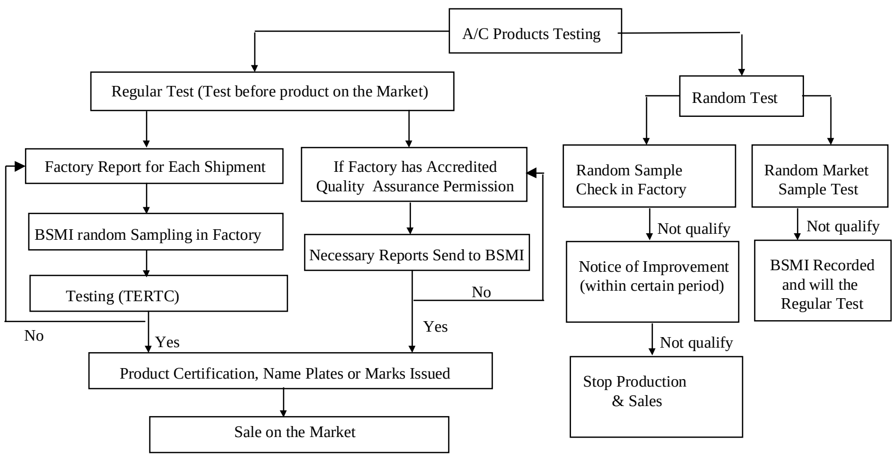
Industrial Technology Research Institute
Energy & Resources Laboratories

III. Product Testing: (Mandatory)



BSMI: Bureau of Standards, Metrology & Inspection
TERTC: Taiwan Electric Research and Testing Center

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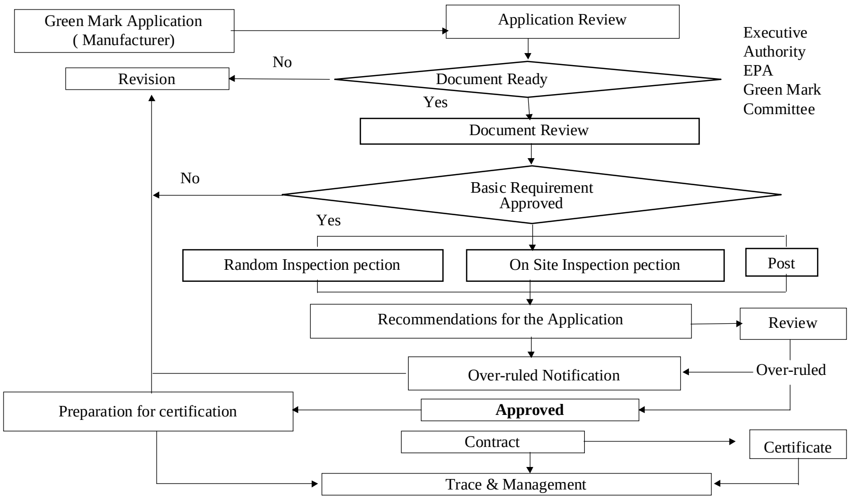
Energy & Resources Laboratories

IV. Green Mark or S Mark Program (Voluntary)



Flow Chart of Green Mark Application

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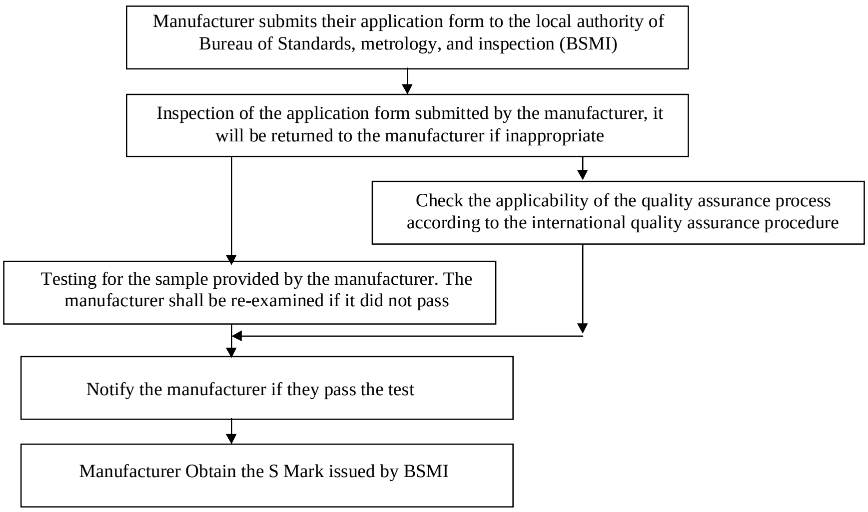
Flow Chart of S-Mark Application



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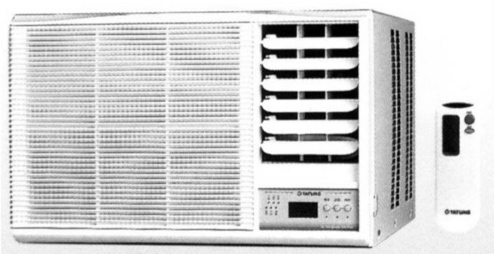
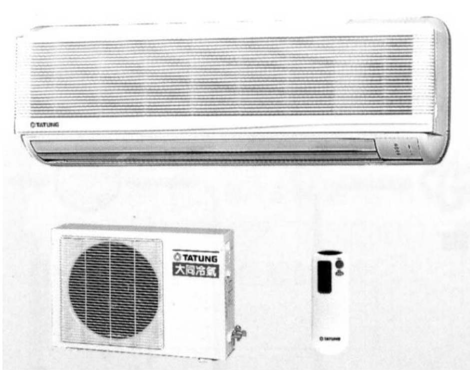


Window Unit



Mini-Split Unit

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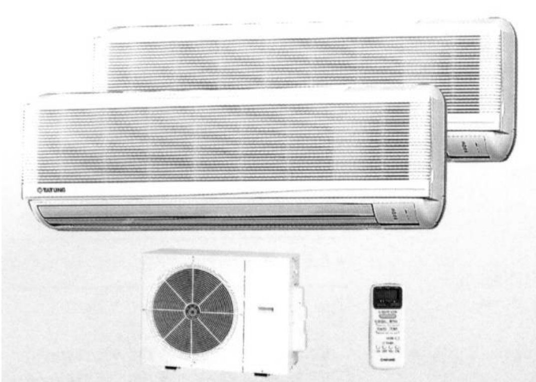

Multi-Mini Split Unit

Package Unit (Air Cooled)

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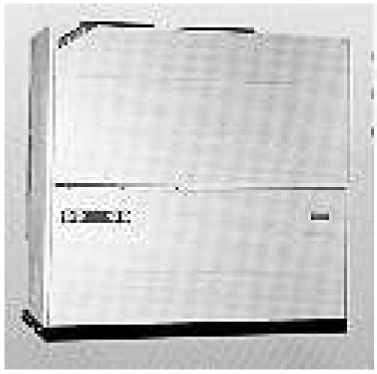
Industrial Technology Research Institute
Energy & Resources Laboratories



Package Unit (Water Cooled)

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Industrial Technology Research Institute
Energy & Resources Laboratories

Suggestions to APEC

1. Accredited or Certified program for testing Labs. within APEC
2. Testing methods (procedures) standardization
   [Not testing conditions]
3. Permission of using each Economies' testing reports as certifications for exporting

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MIMINUM EFFCIENCY PERFORMANCE STANDARD

FOR AIRCONDITIONERS

IN THAILAND

1. CURRENT MARKET SITUATION

1.1 INTRODUCTION

According to the latest official forecast, in 1998 air conditioning accounted for about 23% of residential electricity use and about 68% of commercial sector electricity use. Air conditioning energy use is growing more rapidly than energy use for most other end-uses. For example, by 2010, air conditioning is expected to account for 31% of residential sector electricity use .

1.2 THE THAI ROOM AND WINDOW AIR CONDITIONER MARKET

The latest data indicates that split units account for approximately 95% of the Thai room air conditioner market, while window units account for only about 5% of the room air conditioner market. As of 1997, about 80% of the units sold were in a range of 7,000 – 18,000 BTU/hour (2.05 – 5.28 kW). *Table 1.1* shows the market share of room air-conditioners by cooling capacities and type.

Table 1.1 Market Share of Air Conditioners by Cooling Capacities and Type

Cooling Capacity Btu/hr (kW)	Market Share (%)		
	Split Units	**Window Units**	**Total**
7,000 or less (2.05 or less)	*3*	-	*3*
7,001-9,000 (2.06-2.64)	*29*	*1*	*30*
9,001-13,000 (2.65-3.81)	*32*	*2*	34
13,001-18,000 (3.82-5.28)	*19*	*1*	20
18,001-24,000 (5.29-7.03)	*9*	*0.5*	*9.5*
More than 24,000 (7.03)	*3*	*0.5*	3.5
Total	*95*	*5*	100%

Source: Management Information Services Co., Ltd. (Manager magazine, Oct., 1997)

More recent data (early 1999) collected as part of a manufacturer survey conducted for this project seems to indicate a shift toward larger average air conditioner sizes. With this more recent data, 70% of air conditioners are between 12,001 and 24,000 BTU/hour (3.52 – 7.03 kW). These latter figures are illustrated in *Table 1.2*.

Table 1.2 *Market Share of Split Air Conditioners by Capacity*

Cooling Capacity Btu/hr (kW)	Market Share (%)
Less than 9,000 Btu/hr (2.63 kW)	4
9,000-12,000 (2.64-3.51)	9
12,001-16,000 (3.52-4.68)	33
16,001-20,000 (4.69-5.86)	20
20,001-24,000 (5.87-7.03)	17
24,001-30,000 (7.04-8.79)	7
More than 30,000 (8.79)	10
Total	100%

Note: Figures reported here are the average of responses from five manufacturers, each reporting on their company's sales.
Source: Survey of manufacturers (see *Annex E*).

Nearly all of the air conditioners sold in Thailand are cooling-only units. There are a few units with heating capabilities sold in the north of the country, but these probably account for less than 1% of total sales. However, Thai manufacturers do make units with heat pumps and/or electric heating elements for export.
Most of the split units sold in Thailand have single speed compressors. However, since 1996, a few Split unit with variable speed compressors have been produced.

1.3 *THE EGAT AIR CONDITIONER LABELLING PROGRAM*

The EGAT Air-Conditioner labelling program is similar to the refrigerator labelling program and uses the same 1-5 rating scale. The current rating scale is summarised in *Table 1.3*

Table 1.3 *EGAT Efficiency Level Rating Scale*

Level	Minimum EER	Minimum COP
1	6.6	1.93
2	7.6	2.23
3	8.6	2.53
4	9.6	2.82
5	10.6	3.11

The EGAT air-conditioner labelling program began in September, 1995. Most of the major air-conditioner manufacturers and distributors participate in the program. Under the EGAT program, labelling is voluntary, with the result that manufacturers almost always label units with a 5 rating, sometimes label units with a 4 rating, and seldom label units with lower ratings. As of June, 1998, there were 303 models tested by TISI and classified as level 5, and 16 models classified as level 4. According to EGAT, the weighted average EER of labelled air-conditioners was in a range of 10.85 – 10.99 during the February, 1996 to June, 1998 period. In the first quarter of 1999, the weighted average EER was 11.02 (DSMO 1999).

From the program inception up to March, 1999, a total of 447,455 labels were supplied to manufacturers by EGAT. Of these labels, more than 90% are for units with a 5 rating, and nearly 10% are for units with a 4 rating. It is also interesting to note that the number of labels for 5 rated units has increased steadily each year since the labelling program began, indicating a growing market share for these high-efficiency units (see *Table 3.3*). Looked at another way, EGAT distributed 170,000 labels in 1998, including 156,000 for level 5. Thus, the total number of labels distributed in 1998 were roughly one-third of annual electricity sales of 400,000 (366,000 residential units as estimated above plus some commercial units) and level 5 labels were approximately 30% of total air conditioner sales (see *Table 1.4*).

Table 1.4 ***Number of Air Conditioner Labels Sent to Manufacturers since 1996***

Period	Efficiency Level 4		Efficiency Level 5		Total by Period
	# of Label	% of Total	# of Label	% of Total	
1996	18,209	17.15	87,951	82.85	106,160
1997	9,067	7.64	109,547	92.36	118,614
1998	14,557	8.53	156,157	91.47	170,714
Jan.-Mar., 1999	-	-	51,967	100.00	51,967
Grand Total	41,833	9.35	405,622	90.65	447,455

Remark: As of March 31, 1999

1.4 REFRIGERANTS

The refrigerant that is currently universally used worldwide in room and window air conditioners is HCFC-22. Because of environmental concerns, this refrigerant will be phased out by international agreements in accordance with the following schedule.

In the United States:

January 1, 2010 Can no longer be used in new air conditioners

January 1, 2020 Can no longer be produced

In developed countries other than the United States (for example, Japan):

January 1, 2020 Can no longer be used in new air conditioners

January 1 2030 Can no longer be produced

In developing countries (for example, Thailand):

January 1, 2016 Freeze consumption at 2015 levels
January 1, 2040 Can no longer be produced

Significant research has been underway for over 10 years to develop alternative refrigerants that are not subject to regulation as replacements for HCFC-22. The most promising replacements are the following:

HFC-410A: a 50/50 blend of HFC-32 and HFC-125
HFC-407C: a 23/25/52 tertiary blend of HFC-32, HFC-125 and HFC-134a

These are not drop-in replacements for HCFC-22, so some redesign of system components is required. However, it has been demonstrated that air conditioners utilising these HFC refrigerants can match the cooling capacity, efficiency levels, and physical dimensions of products that use HCFC-22. Products with the HFC refrigerants are currently being extensively field tested in the United States. Many manufacturers have indicated that the change to the alternatives may be made well in advance of the imposed deadline.

As indicated above, HCFC-22 will be permitted for use in the production of air conditioners in Thailand for many years after the deadline imposed on the United States and other developed countries, so the existing time schedule should not create a sense of urgency for Thai manufacturers. Furthermore, initial indications are that when HCFC's are phased-out, there are acceptable substitutes that can be used while providing equivalent (or even enhanced) performance relative to current refrigerants.

2 CRITERIA FOR STANDARDS

2.1 TESTING AND RATING

Most of the world has already adopted, or is in the process of changing to, International Organisation of Standardisation (ISO) testing procedures and terminology for air conditioning products. ISO provides three sets of temperature condition options for standard ratings of full-load performance. See *Table 2.1*

Table 2.1 ISO Test Procedures

	Moderate Climate	Hot Climate	Cool Climate
Indoor air temperature			
dry-bulb	27/C (80.6/F)	29/C (84.2/F)	21/C (69.8/F)
wet-bulb	19/C (66.2/F)	19/C (66.2/F)	15/C (59.0/F)
Outside air temperature			
dry-bulb	35/C (95.0/F)	46/C (114.8/F)	27/C (80.6/F)
wet-bulb	24/C (75.2/F)	24/C (75.2/F)	19/C (66.2/F)

ISO rating procedures state that cooling capacity and efficiency shall be expressed in terms shown in *Table 2.2*

Table 2.2 ISO Test Terms

	Term	Abbreviation
Cooling Capacity	Kilowatts	kW
Efficiency	Coefficient of Performance	COP (W/W)

Currently, TISI conducts its tests to the ISO 'Moderate Climate' indoor and outdoor temperature conditions and TISI test results are recorded on the calorimeter room data sheets in the ISO terminology. However, Thailand currently provides cooling capacity in terms of British Thermal Units per Hour (Btu/h) and efficiency in Energy Efficiency Ratio (EER), which is the Btu/h capacity divided by the Watt Input.

The proposed plan is based on the premise that Thailand may at some future date adopt ISO rating terminology. Therefore, this report is presented in both ISO terminology and the current Thailand terminology.

Framework

Minimum Energy Performance Standards (MEPS) should be established at a level that can be achieved from a technology standpoint and are also cost-effective to the consumer. That is, the higher efficiency air conditioner should provide future savings in operating costs (discounted to present value) that exceed the increased cost of the air conditioner to the purchaser.

In addition to establishing a MEPS, efficiency levels at steps above the MEPS should be established that are also achievable and cost effective. A minimum of two efficiency levels above the MEPS should be established that provide an approximately 10% additional reduction in operating cost for each step. The proposal achieves this by classifying the product offerings into the EGAT Efficiency Levels 3, 4, and 5 categories for marketing purposes and possible introduction of incentive programs to encourage consumers to move up to higher efficiency products. Having three levels of products available to the consumer preserves the three-tier concept so essential to retail marketing.

An upper limit to the range of cooling capacities that can be included in the program must comply with the capability of the calorimeter room test facility at TISI (or other test facility) that will be necessary to monitor compliance.

Technology Options

The following types of approaches are available for achieving high efficiency air conditioners in a cost-effective manner.

- higher efficiency rotary compressors;
- higher efficiency reciprocating compressors;
- scroll compressors (available for air conditioners with rated cooling capacity greater than 5 kW (17,000 Btu/h)) ;
- heat exchangers (condensers and evaporators) with rifled tubing;
- heat exchangers (condensers and evaporators) with slit fins;
- increased physical size of heat exchangers (condensers and evaporators);
- high-efficiency permanent split-capacitor fan motors; and
- subcool liquid refrigerant with evaporator condensate.

These approaches are available to manufacturers regardless of size and design capability.

Also, while probably not cost-effective, but will reduce energy consumption and may have other benefits, such as improved comfort and reduced sound levels during periods of reduced cooling need, are:

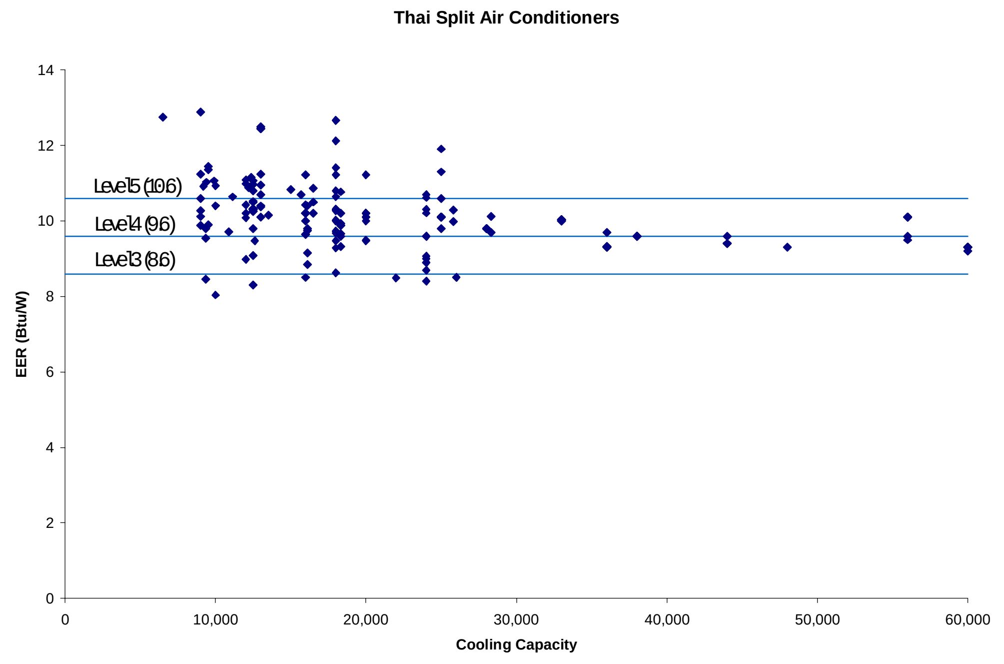
- multiple compressors, variable-speed compressors, multi-speed compressors; and
- compressors with unloading capability

Many of these improvements increase cooling capacity as well as COP. For example, the heat exchanger improvements reduce the pressure difference across which the compressor must operate. The lower pressure differential results in an increase the delivered cooling capacity, so additional increases in efficiency along with lower cost can be obtained by a change to a compressor of less displacement that returns the cooling capacity to the baseline level.

Possible Standard Levels

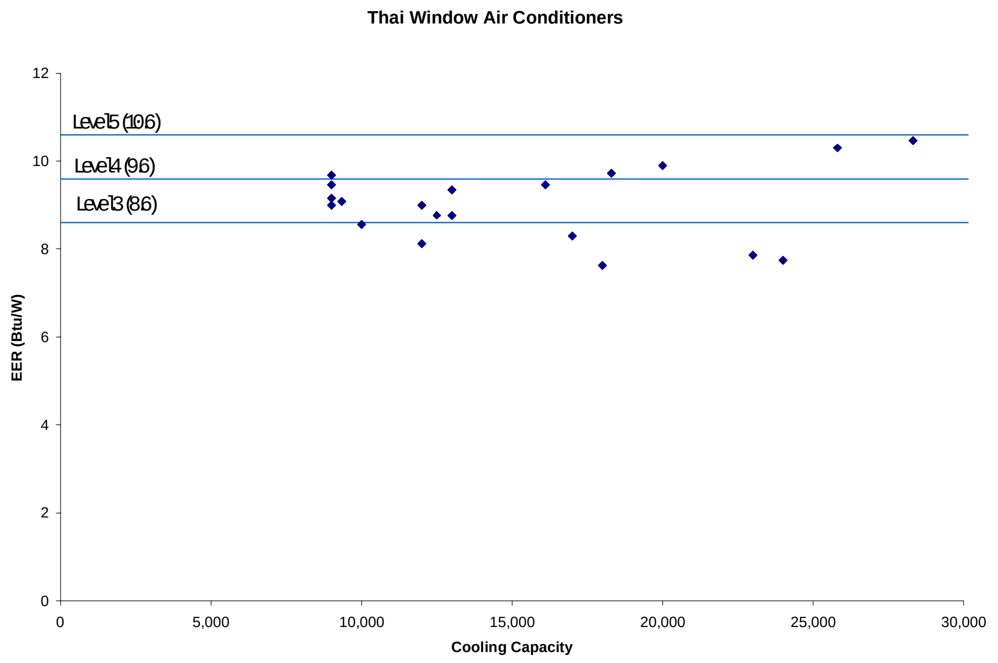
For purposes of analysis a finite number of possible standard levels needs to be selected. As a first step in this process, we prepared a database of the air conditioners that are presently being sold in Thailand. This database was compiled from manufacturer's catalogues including units that have been tested by TISI, units that have been tested elsewhere, and calculated efficiency values. In some cases catalogues did not list efficiency but we could calculate an EER based on cooling capacity and power input. We used catalogue data in order to include a full range of units, from the least to the most efficient.[1] TISI data covers primarily the most efficient units (because these are the ones that participate in the EGAT labelling program) and does not provide a good picture of the rest of the Thai market. All told, our database contains 245 different units. *Figure 2.1* and *Figure 2.2* summarise the information in the database in terms of EER as a function of cooling capacity for split and window units respectively.

Figure 2.1 Split-Type Air Conditioners Sold in Thailand as a Function of Cooling Capacity and EER.



In the Thai air conditioning industry there has been a lot of focus in recent years on the levels used in the EGAT air conditioner labelling program. As noted above, the EGAT program has five levels as listed in *Table 1.3*.

Figure 2.2 *Window-Type Air Conditioners Sold in Thailand as a Function of Cooling Capacity and EER.*



However, as shown in *Figure 2.1*, there appear to be no Level 1 air conditioners on the Thai market at present and very few Level 2 air conditioners. Therefore, we selected Level 3 (COP 3.53, EER 8.6) as our baseline unit and chose also to examine Levels 4 and 5 (COP 2.53 and 2.82, EER 9.6 and 10.6) as possible standard levels.

The current EGAT levels were developed in terms of EER and the COP values are calculated. As discussed above, at some point in the future Thailand is likely to want to convert to the ISO standard and use COP as the primary efficiency metric. When this change is made, it would be easier to manufacturers and consumers if the EGAT levels correspond to COP numbers rounded to the nearest tenth. Given the current products on the market, we could see a future progression including COP 3.0, and 3.3. These COP values correspond to approximately Level 4.6, and 5.6 on the current EGAT scale (equivalent to EER 10.24, and 11.26). Since Thailand is likely to switch to the COP unit of measure over the next few years, we elected to examine these COP-based levels as possible standards as well.

In sum, we examined five possible standard levels as listed in *Table 2.3*

Table 2.3 ***Possible Standards Examined in This Study***

EGAT Level	EER	COP
3	8.60	2.53
4	9.60	2.82
5	10.60	3.11
'4.6'	10.24	3.00
'5.6'	11.26	3.30

3 COST-EFFECTIVENESS

3.1 BASIC ANALYSIS

To examine the cost effectiveness to consumers of more efficient air conditioners, we constructed a spreadsheet model that compares the costs and benefits to consumers of different efficiency air conditioners. If the added benefits of moving to higher efficiencies exceed the incremental retail prices, then higher efficiencies will be cost-effective to consumers.

Examples for the retail price change projected for a 3.5 kW (12,000 Btu/h) baseline air conditioner improving from EGAT Level 3 to EGAT Level 4 and from EGAT Level 4 to EGAT Level 5 are tabulated below.

Example 1:

Start with a baseline unit of 3.5 kW (12,000 Btu/h) cooling capacity with efficiency at the EGAT Level 3 [COP = 2.53 (EER = 8.60)] and introduce a series of changes to improve the efficiency to the EGAT Level 4 [COP = 2.82 (EER = 9.60)]. Details can be found in *Table 3.1*

Table 3.1 ***Example 1***

	AEER	**EER**	**Add'l Btu/h**	**Btu/h**	**Add'l Baht**	**Cumulative Add'l Baht**
Baseline		8.60		12,000		0
Add slits to evap. & cond. Fins	0.30		370		380	
		8.90		12, 370		380
Change to PSC fan motor	0.40		0		360	
		9.30		12,370		740
Decrease compressor size by 5.5%	0.30		-370		-215	
to return cooling capacity		9.60		12,000		525
to the baseline level						

For this example, the increase in the cost to the consumer to move the MEPS from an EGAT Level 3 to an EGAT Level 4 for a 3.5 kW (12,000 Btu/h) air conditioner is 525 Baht or 150 Baht per kW of cooling capacity.

Example 2:

Start with a baseline unit of 3-5 kW (12,000 Btu/h) cooling capacity with efficiency at the EGAT Level 4 [COP = 2.82 (EER = 9.60)] and introduce a series of changes to improve the efficiency to the EGAT Level 5 [COP = 3.11 (EER = 10.60)]. Details can be found in *Table 3.2*.

Table 3.2 ***Example 2***

	AEER	EER	Add'l Btu/h	Btu/h	Add'l Baht	Cumulative Add'l Baht
Baseline		9.60		12,000		0
Add rifling to tubing	0.20		537		280	
		9.80		12,537		280
Increase coil face area by 11%	0.26		132		980	
		10.06		12,669		1260
Decrease compressor size by	0.54		-669		-385	
10% to return cooling capacity to the baseline level		10.60		12,000		875

For this example, the increase in the cost to the consumer to move the MEPS from an EGAT Level 4 to an EGAT Level 5 for a 3.5 kW (12,000 Btu/h) air conditioner is 875 Baht or 250 Baht per kW of cooling capacity.

In addition to estimating the increase in price this way, we also employed two other methods. First, we surveyed several stores in Bangkok, Korat and Hat Yai and collected prices on air conditioners now being sold. Air conditioners were classed by EGAT level and average prices per Btu of cooling capacity were calculated for each class. Results are shown in *Table 3.3*

Table 3.3 ***Average Retail Prices of Split Air Conditioners in Thailand***

	Avg. Retail Price		Incremental		Number of Models
EGAT Level	(Baht/kW)	(Baht/Btu)	Price Baht/kW)	Price (Baht/Btu)	in Sample
2	7575	2.22	-	-	7
3	7233	2.12	-	-	6
4	8359	2.45	1126	0.33	27
5	8837	2.59	478	0.14	42

The price increment currently in the market for going from Level 3 to Level 4 and from Level 4 to Level 5 is higher than the estimate based on detailed engineering. Based on discussions with manufacturers and other air conditioning experts we believe that the current difference in market price between Level 3 and Level 4 air conditioners is due primarily to feature and quality differences between these products, and that efficiency plays a relatively minor role. Even the difference between Level 4 and Level 5 prices in the current market is partially explained by differences in quality and product features.

Second, we surveyed manufacturers and asked them how much their costs would increase if they upgraded a Level 3 unit to Level 4, and a Level 4 unit to Level 5. Six manufacturers answered this question and the averages are shown in *Table 3.4*

Table 3.4 ***Manufacturer Estimates of Incremental Prices for More Efficient Air Conditioners***

	Split Units			**Window Units**		
		Cost Increment			Cost Increment	
Increment	(Percent)	(Baht/kW)*	(Baht/Btu)	(Percent)	(Baht/kW)*	(Baht/Btu)
Level 2 -> 3	9.6	727	0.21	10.0	757	0.22
Level 3 -> 4	4.8	364	0.11	13.6	1030	0.30
Level 4 -> 5	9.1	689	20	8.3	629	0.18

Note Based on baseline consumer price of 7575 Baht/kW per analysis discussed above. As discussed below, manufacturers expect that retail prices will increase by the same percentage as manufacturer costs.

These manufacturer cost estimates tend to be roughly in the same vicinity as the current prices in the market, and significantly higher than the estimates in the engineering analysis. Our experience with standards in other countries is that this is commonly the case with air conditioner manufacturers, and that when the standards ultimately take effect the incremental cost is lower than manufacturers first predict. Therefore, for the subsequent analyses we will use the engineering analysis as our primary data source, but will also use the manufacturer estimates for a high incremental-cost scenario.

Results

Results of the basic analysis are summarised in *Table 3.5*. This basic analysis uses estimates of incremental costs from our engineering analysis and average annual compressor operating time of 2424 hours per year (e.g. assuming residential systems run for 50% of the cooling load hours). This analysis shows that each of the efficiency increments examined are highly cost-effective to consumers - all of the increments examined have a benefit-cost ratio of more than three, indicating the benefits are more than three-times greater than costs.

Table 3.5 Cost-Effectiveness of Air Conditioner Efficiency Improvements

Base Assumptions:

Discount Rate	8%
Annual Electricity Increase	0%
Electricity Price (Baht)	2.40
Annual Compressor Operating Hours	2424
Incremental costs	Per engineering analysis

Description of Option	**Lifetime**	**Annual kWh Saved**	**Increase In Retail Price**	**Lifetime NPV**	**Benefit Cost Ratio**
9,000 Btuh window unit					
Level 3 --> level 4	12	264	396	4,779	12.08
Level 4 --> level 5	12	214	659	3,878	5.88
Level 4 --> level 4.6	12	134	211	2,418	11.46
Level 4.6 --> level 5.6	12	208	976	3,766	3.86
12,000 Btuh split unit					
Level 3 --> level 4	12	352	528	6,372	12.08
Level 4 --> level 5	12	286	879	5,170	5.88
Level 4 --> level 4.6	12	178	281	3,224	11.46
Level 4.6 --> level 5.6	12	278	1,301	5,021	3.86
24,000 Btuh split unit					
Level 3 --> level 4	12	705	1,055	12,745	12.08
Level 4 --> level 5	12	572	1,758	10,340	5.88
Level 4 --> level 4.6	12	356	563	6,447	11.46
Level 4.6 --> level 5.6	12	555	2,603	10,042	3.86

Notes:
1) Average lifetime from 1/99 survey of Thai manufacturers.
2) kWh saved based on units just meeting each of the levels.
3) 2424 operating hours assume residential units operate 50% of cooling load hours and commercial units operate 6 days/week on average.
4) Incremental engineering cost per ERM engineering analysis.

4 RECOMMENDATIONS FOR PROPOSED STANDARDS

4.1 PRODUCTS COVERED

The existing facility at TISI is capable of testing air conditioners up to 8.5 kW (29,000 Btu/h) capacity. In a calorimeter room test facility, as the cooling capacity of the product being tested approaches the upper limit of it's capability, the accuracy of the results starts to diminish. Therefore, a reasonable upper cooling capacity limit for this program would be 8.0 kW (27,300 Btu/h). This capacity limit could be raised if the TISI capability is increased to higher capacity levels in the future.

We considered whether standards should vary as a function of unit size. However, a review of the data on available unit efficiencies (as summarised in *Figures 3.1* and *3.2*) indicates that there is no significant variation in the range of efficiency levels for units less than 8.0 kW of capacity, hence we do not recommend that separate standards be set for different air conditioner capacities. Options for meeting the recommended efficiency standards for larger capacity units (24,000-27,300 Btu/h; 7.03-8.0 kW) are also reviewed and discussed in section 3.4.3. If standards are extended in the future to cover units larger than 8.0 kW, the question of whether to have separate standards for units above 8.0 kW will need to be reconsidered.

4.2 RATING PROCEDURE

We recommend that current Thai practice be continued and that the ISO moderate climate test procedure continue to be used. This is the international standard and TISI and Thai manufacturers are very experienced in its use. As noted above and consistent with ISO, we recommend that Thailand transition from use of Btus and EERs to their metric equivalents - kW and COP. The international market is increasingly moving in this direction, and as a metric country it will benefit Thailand to follow this international trend.

4.3 MANDATORY STANDARDS

Based on the economic analysis, it is clear that all of the levels analysed are cost-effective to consumers. However, a look at *Figures 2.1* and 2.*2* indicate that setting a minimum standard at EER 10.6 (COP 3.11) or EER 11.26 (COP 3.30) could be disruptive to manufacturers because the majority of their products would need to be redesigned. This finding is further illustrated in *Table 4.1*. As can be seen, not until Level 4 for split units (COP 2.82, EER 9.6) and Level 3 for window units (COP 2.53, EER 8.6) do more than half of the existing units on the market comply. ***Therefore, based on the current market development, we recommend that the initial minimum standard be set at COP 2.82 (EER 9.6) for split units and COP 2.53 (EER 8.6) for window units.*** This would retain up to 85% of existing split units and 74% of existing window units (we use the term 'up to' since it is unclear to what extent manufacturer efficiency ratings are exaggerated; the proportion of existing models meeting the proposed standards is probably somewhat lower than the figures reported above). While many air conditioners meet these levels, we recommend that two years be provided for this standard to go into effect from the time it is announced. This timeframe is probably generous as manufacturers said they would need 1-12 months (average of 4.7) to bring higher efficiency models to market once a decision to develop these models is made. In other countries lead times for room air conditioners have varied from one year (in China) to three years (in the U.S.), although the amount of lead time needed generally increases as the stringency of the standard increases. Since the proposed Thai standard is only modestly stringent, we believe a two-year lead time will be sufficient. Assuming the standard is finalized 2002, the new standard should take effect around January 1, 2004.

However, because the economics of Level 4 (COP 2.82, 9.6 EER) window units are essentially the same as the economics of similar efficiency split units, we believe it is entirely feasible to raise the minimum standard for window units to Level 4 in a few years. If both standards are established now, manufacturers can consider the second-tier standard as they make their design decisions for the first-tier standard, allowing manufacturers to design products so that modifications needed for the second-tier standard are easy to make and low in cost. In this way the total impact on manufacturers of two tiers can be reduced. We also note that the new U.S. window air conditioner standard that goes into effect next year requires that most window units have an EER of 9.7 or 9.8, slightly more efficient than EGAT's current Level 4. Therefore, for window units we recommend that the minimum standard be increased to Level 4 (COP 2.82, 9.6 EER) three years after the initial standard takes effect (i.e., January 1, 2007). However, two years prior to this effective date we recommend that the Thai government review the functioning of the first tier standard and activity to meet the second tier standard, in order to see whether any modifications to the second tier standard (either in timing or stringency) should be considered.

Table 4.1 *Proportion of Existing Models that Meet or Exceed Different Prospective Standard Levels*

Current EGAT Level	COP	EER	Split Units	Window Units
3	2.53	8.60	95%	74%
4	2.82	9.60	85	21
4.6	3.00	10.24	49	5
5	3.11	10.60	25	0
5.6	3.30	11.26	8	0

Source: Based on analysis of data in Figures 3.1 and 3.2.

Notes:
1) Only includes units up to 8.0 kW cooling capacity (27,300 Btu/hour).
2) These data are very consistent with the manufacturer estimates of market share as a function of efficiency as reported in *Table 3.6*.
3) Only some manufacturer efficiency ratings are supported by test results at independent test laboratories. Some ratings are based on manufacturer testing and some based on manufacturer calculations. In some cases, manufacturer ratings of unit efficiency may be exaggerated.
independent test laboratories. Some ratings are based on manufacturer testing and some based on manufacturer calculations. In some cases, manufacturer ratings of unit efficiency may be exaggerated.

4.4 *VOLUNTARY LABELLING PROGRAM*

The EGAT labelling program has been a key component of efforts to increase the efficiency of Thai air conditioners. We strongly recommend that this program be continued. In fact, we recommend that labelling of all units become mandatory, just like refrigerator labels are now mandatory. By making labelling mandatory, the integrity of ratings is enhanced, and it will encourage manufacturers of less efficient products to voluntarily upgrade their products so that they can achieve a higher label rating, achieving additional energy savings. Making labels mandatory also makes it easier to enforce the standards because the label allows consumers and government officials to recognise some models that clearly do not meet the standards (e.g., are rated below the minimum standard level).

4.5 *RATING TOLERANCES*

Rating tolerances vary widely throughout the world. In many countries, a 5% tolerance is allowed on cooling capacity, and a 10% tolerance is allowed on power input (watts) which results in a 15% tolerance in calculated COP (EER).

In the United States, manufacturers self-certify the cooling capacity and efficiency of their air conditioner product. To enforce compliance, a sampling of approximately 30% of the manufacturer's air conditioner models are selected at random each year and subjected to test by an independent laboratory. A 5% tolerance is allowed on cooling capacity and efficiency before rerating is required. If either parameter fails to achieve 95% of rating, the air conditioner must be rerated to the tested values.

The current practice in Thailand is between these extremes. Self-certification of performance by manufacturers with follow-up random testing by TISI should be considered to alleviate possible delays in introducing new improved products. Tightening the tolerance on tested values to 5% is also recommended so that consumers can be better assured of receiving reasonable value for their investment. Experience in other countries is that 5% tolerance is workable in practice and helps to keep manufacturer ratings honest.

Ballasts Current Market Situation

- energy use in lighting accounts for approximately 24% of commercial sector, 8% of residential sector, and 10% of industrial sector;
- roughly 70-80% is for fluorescent lighting.
- most ballasts manufactured are simple choke ballasts which operate one fluorescent lamp;
- As of June, 1998, 18 models of low-loss ballasts, from nine manufacturers, have been tested by TISI. However, discussions with manufacturers also indicate that the program has not led to significant increases in sales of low-loss ballasts.

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Manufacturer Capabilities

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- there are 25 ballast manufacturers in Thailand with production ranging from 7.1 million ballasts per year, to the smallest which produces some 10,000 ballasts per year;
- all produce regular high-loss ballasts. All but one of the large and medium-sized manufacturers produces both regular and low-loss magnetic ballasts;
- of the eight small-sized manufacturers that produce magnetic ballasts, only two are currently producing low-loss ballasts;
- all of the manufacturers would be little or no problem in transferring production from a standard ballast to a low-loss ballast; and
- overall, sales of ballasts peaked in 1996 at approximately 32 million ballasts, with 1998 sales expected to be around 30 million on an annualised basis.

Market Share of Ballast by Type

	% Market share
Regular Magnetic Ballast	*90 – 95*
Low-loss Ballast	*4 – 8*
Electronic Ballast	*1 – 2*

Source: Final Report on Ballast Market Study (Prepared for Copper Development Centre), 1997
Foresight Research Co., Ltd.

ERM

Options for Standards

- a standard capping ballast losses at 6 Watts is the primary option for a magnetic ballast standard;
- electronic ballasts, capping losses at 4 Watts per lamp controlled (eg, for a two-lamp ballast, maximum losses would be 8 Watts) would allow all but some poor-quality electronic ballasts to pass;
- After discussion, the Lighting Subcommittee chose the lamp efficacy approach. Using this approach, and based on a 2740 lumen 40 watt reference lamp, for a ballast maximum losses of 6 watts, the minimum efficacy is 59.6 lumens/watt (2740/[40+6]).
- For electronic ballasts, after discussion, the Lighting Subcommittee chose the efficacy approach since the watt loss approach does not take account of the impact of high-frequency operation on lamp light output.

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Economics of Low-Loss Ballasts

Description of Option	*Lifetime*	*Annual kWh Saved*	*Increase In Retail Price*	*Lifetime NPV*	*Benefit-Cost Ratio*
Commercial use					
Standard --> low-loss					
Manufac. Estimates	13	21	54	326	6.09
Current retail prices	13	21	88	326	3.71
Residential use					
Standard --> low-loss					
Manufac. Estimates	13	9	54	146	2.73
Current retail prices	13	9	88	146	1.66

Source: ERM 1999 The favourable benefit-cost ratio also applies to a sensitivity analysis in which we assumed electricity prices decline by 10% from current values.

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Sensitivity of Impacts of Ballasts to Natural Rate of Improvement

	0.25 % natural	**0.5 % natural**	**1.0 % natural**	**MEPS**
NPV at 2003 bn Baht	1.4	2.8	5.5	6.5
MW (2011)	35	70	136	194
GWh (2011)	162	321	625	893
kt CO_2 (2011)	85	168	328	468

Source: ERM, 1999

ERM

Performance Indicators for All MEPS (MER)

	Consumer NPV (bn Baht)	B/C	GWh	MW	Fuel cost savings NPV (bn Baht)	CO_2 (kt)
Refrigeration	7.7	3.4	961	134	0.8	504
Air Conditioning	3.8	11.6	342	68	0.3	194
Motors	5.9	7.7	677	143	0.6	383
Lighting	11.3	4.4	1526	357	1.4	883
GRAND TOTAL	***29.4***	***4.7***	***3436***	***702***	***3.1***	***1963***

Source: ERM, 1999

Air Conditioning Current Market Situation (1998)

- 23% of residential electricity use and about 68% of commercial sector electricity use;
- air conditioning energy use is growing more rapidly than energy use for most other end-uses;
- by 2010, air conditioning is expected to account for 31% of residential sector electricity use;
- it is estimated that room and window units account for about 95% of residential air conditioning energy use;
- roughly one-third of commercial air conditioning energy use, for a total of about 9100 GWh in 1998; and
- this project focuses on these latter units because they are mass-market products that are already the subject of an EGAT labeling program.

Market Share of Air Conditioners by Cooling Capacities and Type

ERM

COOLING CAPACITY	Market Share (%)		
	SPLIT UNITS	*WINDOW UNITS*	**Total**
Btu/hr (kW)			
7,000 or less (2.05 or less)	3	-	3
7,001-9,000 (2.06-2.64)	29	1	30
9,001-13,000 (2.65-3.81)	32	2	34
13,001-18,000 (3.82-5.28)	19	1	20
18,001-24,000 (5.29-7.03)	9	0.5	9.5
More than 24,000 (7.03)	3	0.5	3.5
Total	95	5	100%

Source: Management Information Services Co., Ltd. (Manager Magazine, Oct., 1997)

Market Share of Split Air Conditioners by Capacity

ERM

Cooling Capacity Btu/hr (kW)	*Market Share (%)*
Less than 9,000 Btu/hr (2.63 kW)	4
9,000-12,000 (2.64-3.51)	9
12,001-16,000 (3.52-4.68)	33
16,001-20,000 (4.69-5.86)	20
20,001-24,000 (5.87-7.03)	17
24,001-30,000 (7.04-8.79)	7
More than 30,000 (8.79)	10
Total	100%

Note: Figures reported here are the average of responses from five manufacturers, each reporting on their company's sales.

Source: Survey of manufacturers

Split-Type Air Conditioners Sold in Thailand as a Function of Cooling Capacity and EER.

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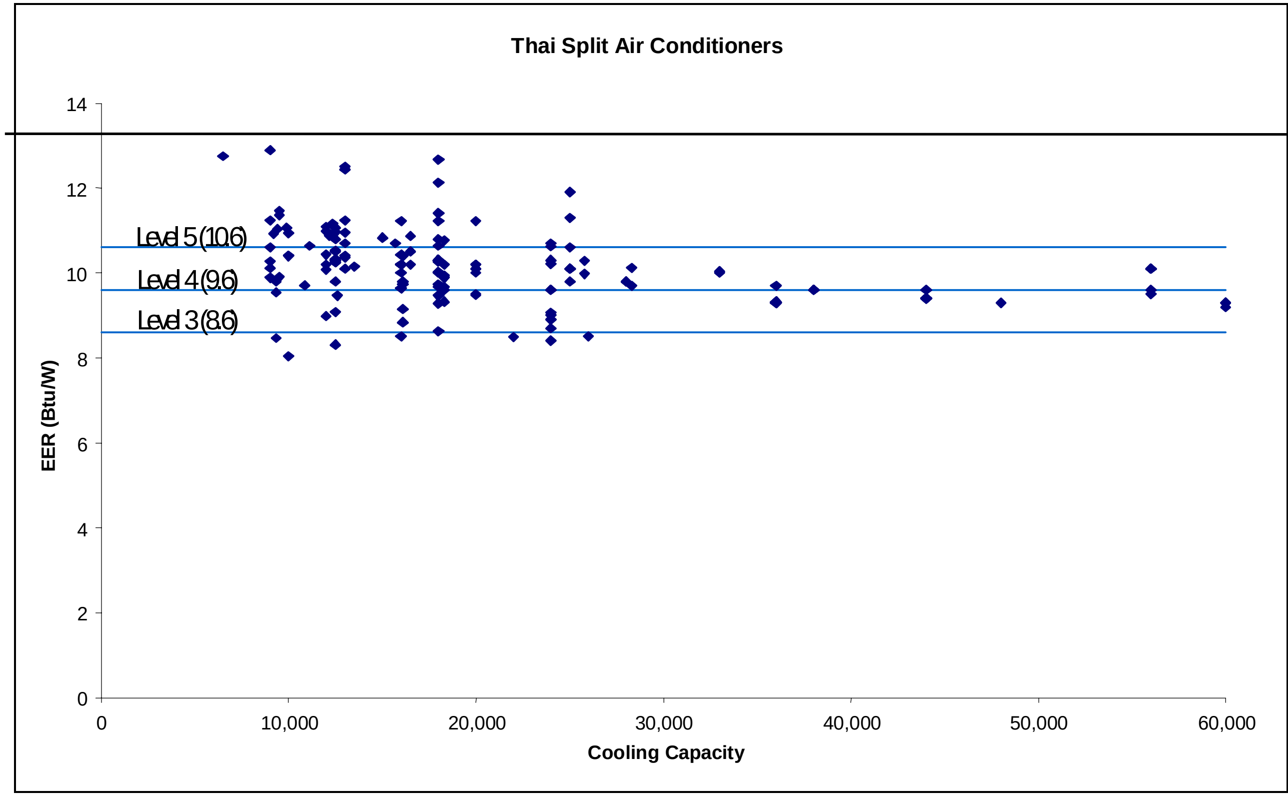
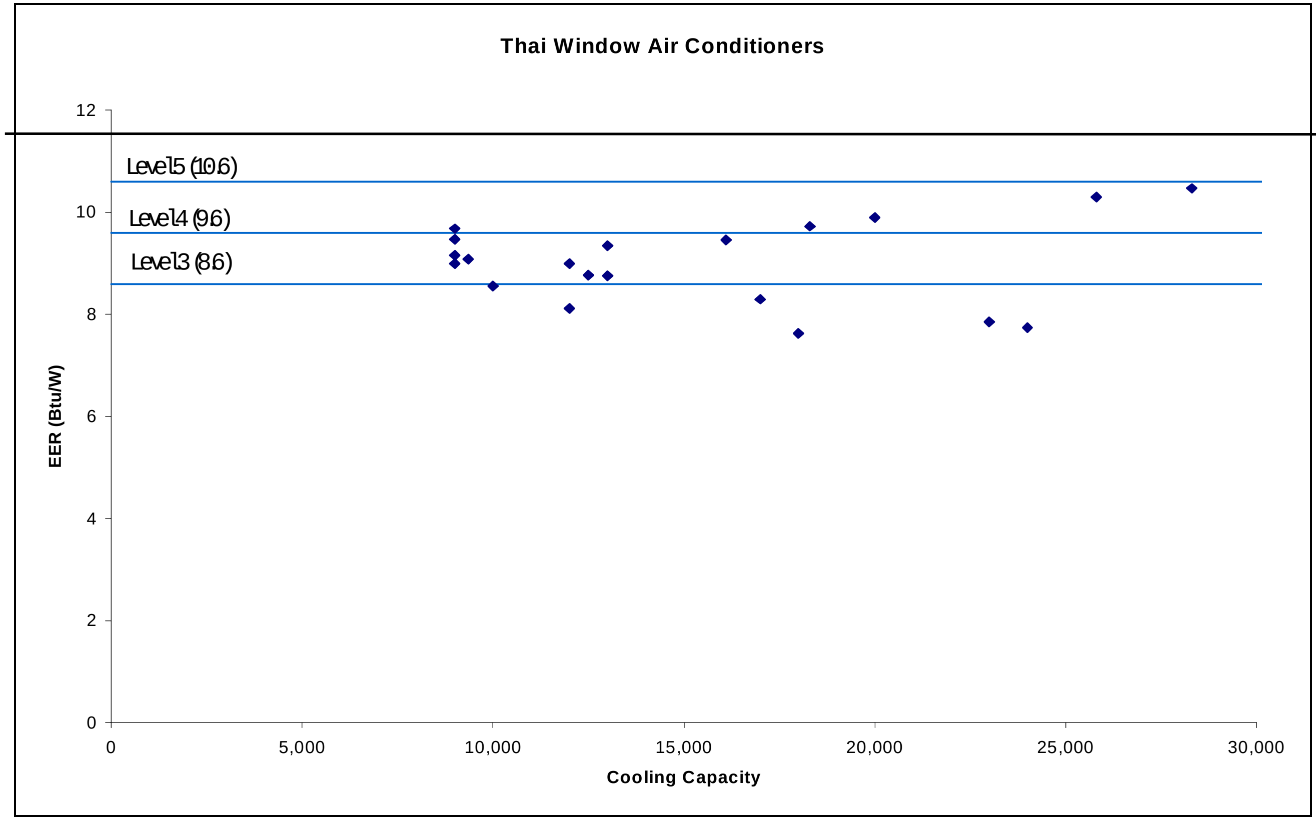


Sources: TISI, 1998-1999

Window-Type Air Conditioners Sold in Thailand as a Function of Cooling Capacity and EER.

ERM



Sources: TISI, 1998-1999

Manufacturer Capabilities

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- there are at least 48 Thai air conditioner manufacturers;
- production capacity ranging from just a few thousand units per year to as many as one million units per year (the latter primarily serves an export market);
- the larger manufacturers tend to be technically sophisticated and produce many models at EGAT levels 4 and 5, staff with excellent test facilities along with state-of-the-art quality control procedures; and
- the smaller manufacturers tend to emphasise less efficient machines, but even many of the smallest manufacturers produce level 5 units using high-efficiency compressors and heat exchangers purchased from outside suppliers.

Recommended Standards

- cover units up to 8.0 kW (27,300 Btu/h) ;

- use the ISO moderate climate test procedure;
- the initial MEPS to be set at Level 4 (COP 2.82, EER 9.6) for split units and Level 3 (COP 2.53, EER 8.6) for window units, take effect around January 1, 2004;
- a second-tier standard should be set for window air conditioners, raising the standard to level 4, effective Jan. 1, 2007; and
- continued labelling of all units made mandatory, just like refrigerator. We recommend that the EGAT levels be upgraded to set level 3 at the minimum standard (2.82 COP, 8.6 EER), level 4 at the current level 5 (COP 3.1, EER 10.6) and level 5 at a level to be determined later but possibly around 3.3 COP (11.26 EER).

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Testing and Rating

- Thailand currently provides cooling capacity in terms of British Thermal Units per Hour (Btu/h) and efficiency in Energy Efficiency Ratio (EER);
- currently, TISI conducts its tests to the ISO 'Moderate Climate' indoor and outdoor temperature conditions;
- TISI test results are recorded on the calorimeter room data sheets in the ISO terminology; and
- the proposed plan is based on the premise that Thailand may at some future date adopt ISO rating terminology; and
- The allowed tolerance on tested values for cooling capacity and efficiency should be tightened from the present 10% to 5% so that consumers can be better assured that equipment will perform as rated.

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ISO Testing Condition

ISO provides three sets of temperature condition options for standard ratings of full-load performance.

	Moderate Climate	Hot Climate	Cool Climate
Indoor air temperature			
dry-bulb	27/C (80.6/F)	29/C (84.2/F)	21/C (69.8/F)
wet-bulb	19/C (66.2/F)	19/C (66.2/F)	15/C (59.0/F)
Outside air temperature			
dry-bulb	35/C (95.0/F)	46/C (114.8/F)	27/C (80.6/F)
wet-bulb	24/C (75.2/F)	24/C (75.2/F)	19/C (66.2/F)

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Residential Air Conditioners in the USA: Market, Test Procedures, and Efficiency Standards

Gregory Rosenquist

E.O. Lawrence Berkeley National Laboratory

Colloquium on the Technical Issues of
Minimum Energy Performance Standards

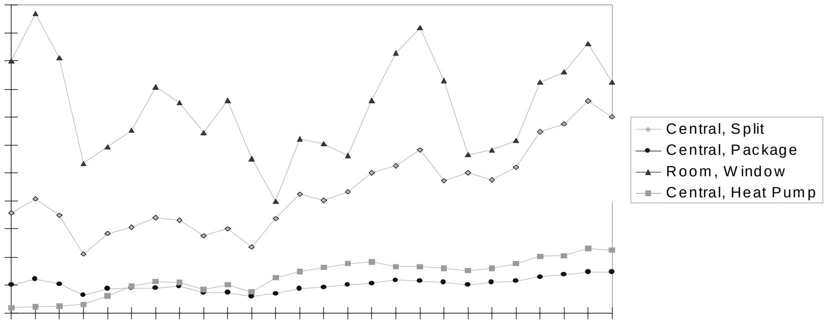
Seoul, Republic of Korea

October 6-8, 1999

Residential Air Conditioner Types

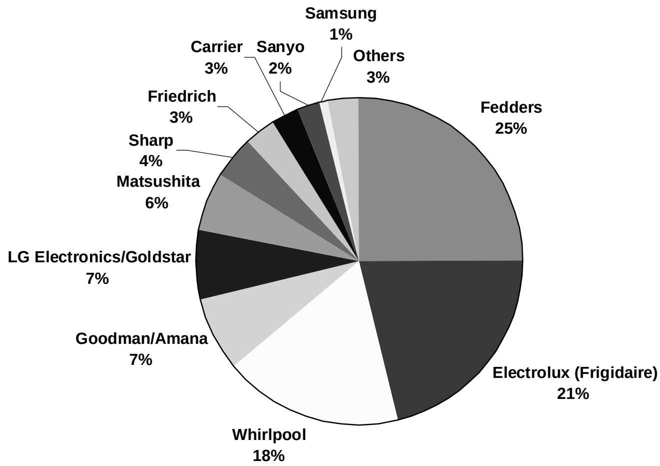
- Room Air Conditoners
  - Window-type
    - Typical cooling capacities range from 1500 to 8800 Watts (5000 to 30000 Btu/hr)
  - Mini-Split
    - Typical cooling capacities range from 2300 to 7100 Watts (8000 to 24000 Btu/hr)
- Central Air Conditioners
  - Ducted-Split
    - Typical cooling capacities range from 5300 to 17500 Watts (18000 to 60000 Btu/hr)
  - Ducted-Single Package
    - Typical cooling capacities range from 8800 to 17500 Watts (30000 to 60000 Btu/hr)

Air Conditioner Shipments

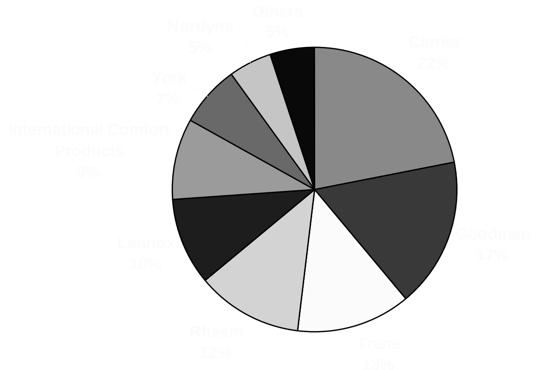


- 47.7% saturation of central air conditioners in 1995
- 27.8% saturation of window-type room a/c in 1995
- Virtually no mini-split air conditioners

Room (Window-type) A/C Market, 1998



Central A/C and Heat Pump Market, 1998



Room (Window-type) A/C Test Procedure

- Cooling capacity measured in Btu/hr
- Input power measured in Watts
- Canadian and Mexican test procedures are identical

Central A/C Test Procedure

- Four operating conditions needed to establish SEER
- Measures benefit due to “cyclic” technologies (e.g. variable-speed)
- Canadian test procedure is identical
- **<u>MINI-SPLIT ROOM A/C MUST BE RATED WITH SEER IN U.S.</u>**

U.S. Energy Efficiency Standards

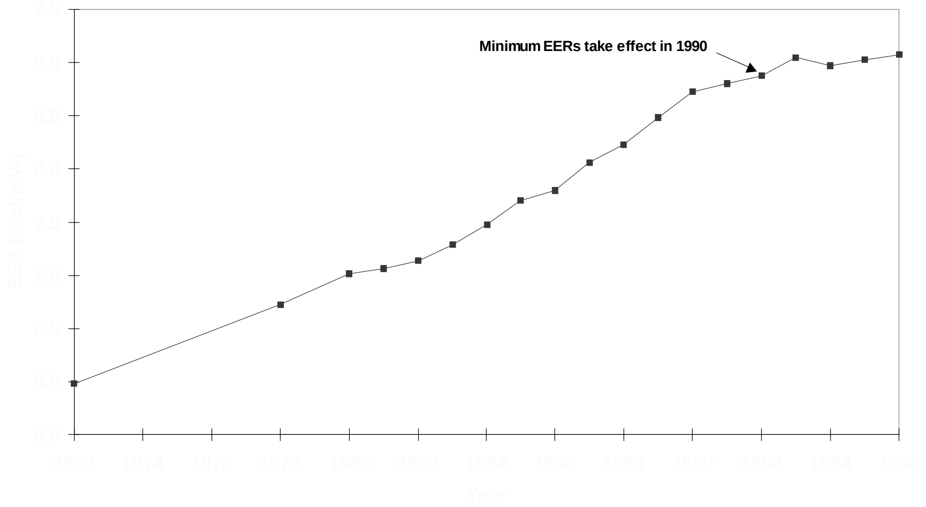
- U.S. National Appliance Energy Conservation Act (NAECA) of 1987 established mandatory standards
- Window-type room a/c
  - EERs of 8.0 to 9.0 Btu/hr/Watt (2.34 to 2.64 W/W) became effective in 1990
  - Canada and Mexico window-type a/c standards harmonized with 1990 U.S. standards
  - NEW U.S. standards to become effective in October 2000
    - EERs of 9.7 to 9.8 Btu/hr/W (2.84 to 2.87 W/W) for room a/c with capacity < 5860 W, with louvered sides, no reverse cycle
- Central air conditioners
  - Split-system: 10 SEER became effective in 1992
  - Single package: 9.7 SEER became effective in 1993

Energy Analysis Department

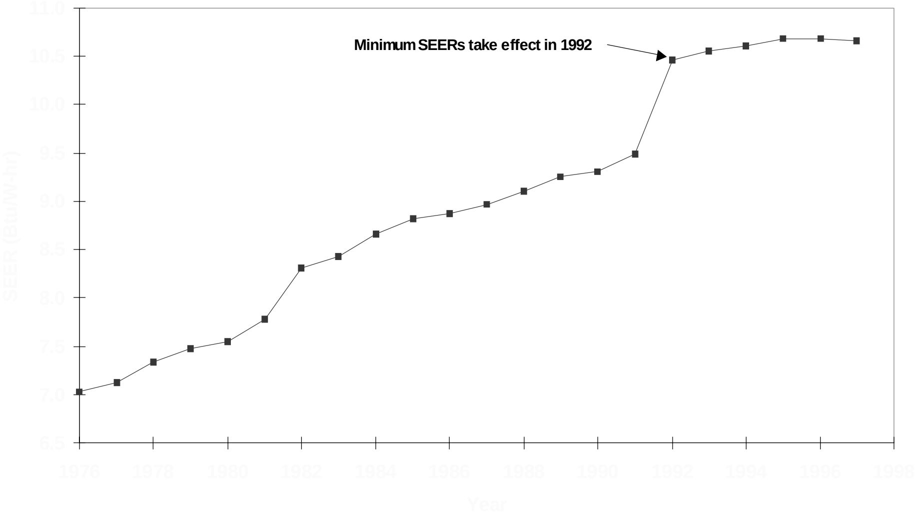
Room (Window-type) A/C Standards

Product Class	EER Jan. 1, 1990 Btu/hr/W (W/W)	EER Oct. 1, 2000 Btu/hr/W (W/W)
Without Reverse Cycle and with Louvered Sides		
Less than 6000 Btu/hr (1758 W)	8.0 (2.34)	9.7 (2.84)
6000 to 7999 Btu/hr (1759 to 2343 W)	8.5 (2.49)	9.7 (2.84)
8000 to 13999 Btu/hr (2344 to 4101 W)	9.0 (2.64)	9.8 (2.87)
14000 to 19999 Btu/hr (4102 to 5859 W)	8.8 (2.58)	9.7 (2.84)
20000 Btu/hr and over (5860 W)	8.2 (2.40)	8.5 (2.49)
Without Reverse Cycle and without Louvered Sides		
Less than 6000 Btu/hr (1758 W)	8.0 (2.34)	9.0 (2.64)
6000 to 7999 Btu/hr (1759 to 2343 W)	8.5 (2.49)	9.0 (2.64)
8000 to 13999 Btu/hr (2344 to 4101 W)	8.5 (2.49)	8.5 (2.49)
14000 to 19999 Btu/hr (4102 to 5859 W)	8.5 (2.49)	8.5 (2.49)
20000 Btu/hr and over (5860 W)	8.2 (2.40)	8.5 (2.49)
With Reverse Cycle and with Louvered Sides		
Less than 20000 Btu/hr (5680 W)	8.5 (2.49)	9.0 (2.64)
20000 Btu/hr and over (5860 W)	8.5 (2.49)	8.5 (2.49)
With Reverse Cycle and without Louvered Sides		
Less than 14000 Btu/hr (4102 W)	8.0 (2.34)	8.5 (2.49)
14000 Btu/hr and over (4102 W)	8.0 (2.34)	8.0 (2.34)
Casement-Slider	NA	8.7 (2.55)
Casement Only	NA	9.5 (2.78)

U.S. Window-type Room A/C Efficiency Trend

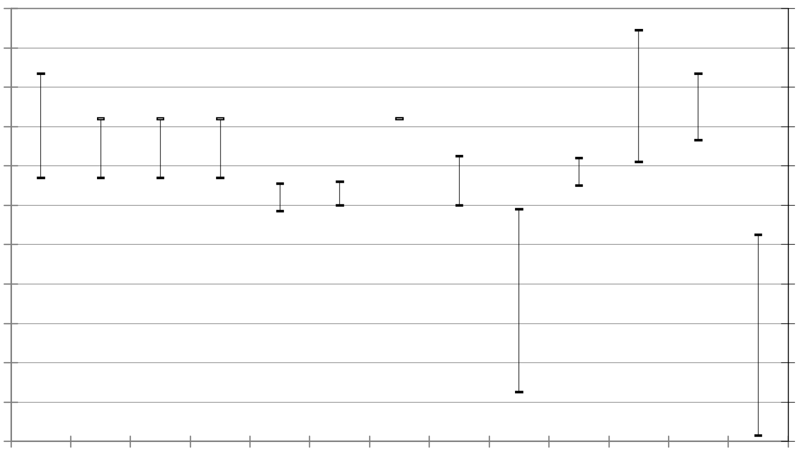


Central A/C Efficiency Trend



Energy Analysis Department

World A/C Efficiency Standards



Energy Analysis Department