

DRAFT REPORT

BENCHMARKING OF AIR CONDITIONER EFFICIENCY LEVELS IN FIVE ASIAN COUNTRIES

PREPARED FOR THE AUSTRALIAN GREENHOUSE OFFICE

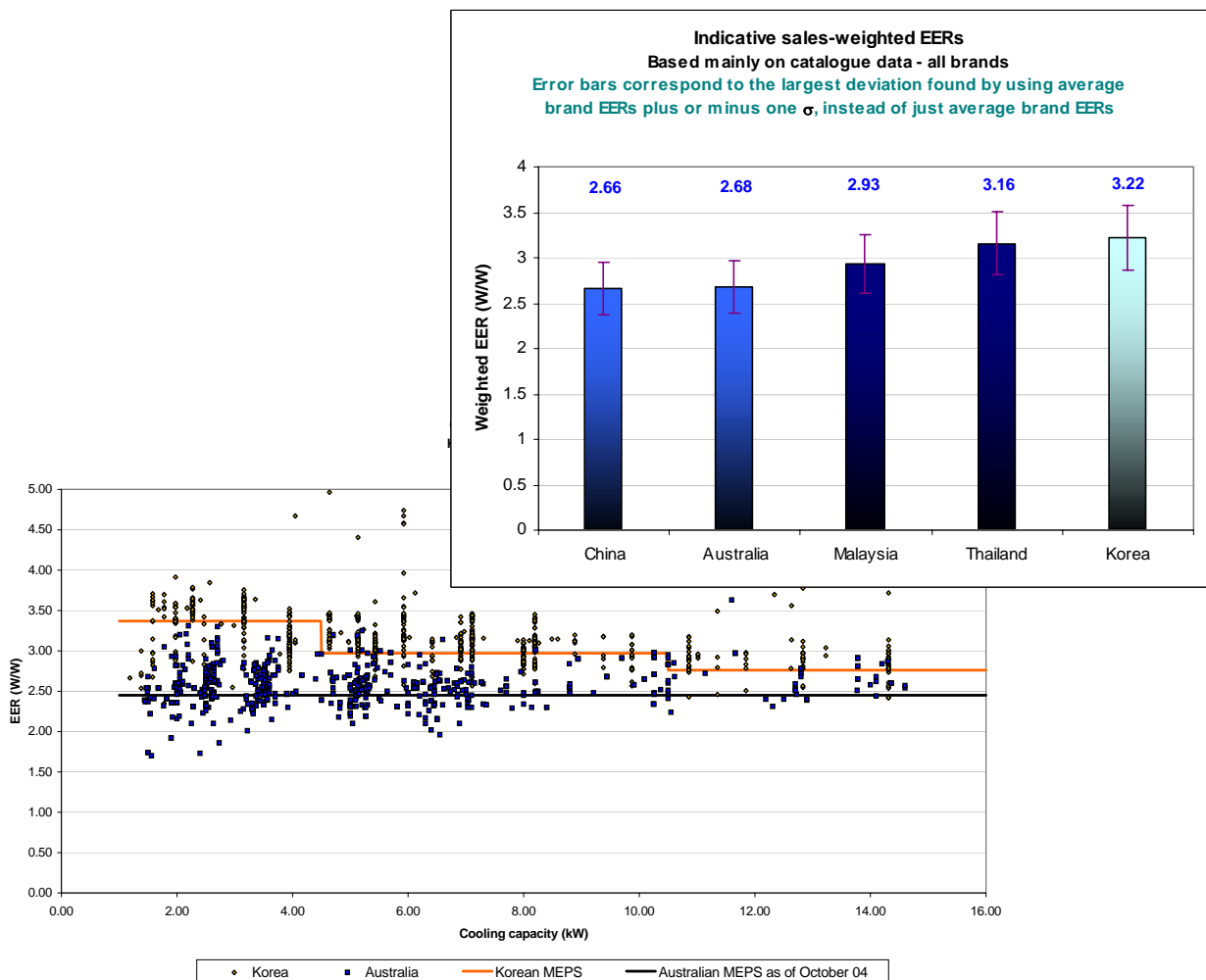


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EXECUTIVE SUMMARY

The Project. Under contract to the Australian Greenhouse Office, Danish Energy Management A/S (DEM) has carried out this study to benchmark the efficiency of room air conditioners (ACs) in five Asian countries: Thailand, Malaysia, China, Korea, and Australia.

The Study Team. DEM assembled a team of local consultants in the five countries. The country consultants were responsible for collecting and gathering available data in their country and supplying it to DEM. DEM carried out the data analyses presented in this report and integrated the data and conclusions across the five countries.

Data Collection. The DEM team carried out market surveys and characterized the room air conditioner market in each of the countries. Teams also reviewed manufacturers' catalogues of models available on the market; carried out shop surveys; and collected available laboratory test data on air conditioner performance. The data collection and analysis focused on air conditioner units with up to 36,000 BTU/hr cooling capacity. A massive amount of data was collected – ranging from 23 to 46 brands per country; and from 224 up to 929 models per country.

Test Procedures. All five countries use the same international test standard (ISO 5151) for measuring energy performance. The test standards for Korea and Thailand use a slightly different indoor wet bulb temperature, which is 0.5 C higher. The team used a correction algorithm developed for APEC to adjust the test results (1.2% for EER and 1.6% for cooling capacity adjustment). However this potential bias is extremely small and is less than 4% error for a calorimeter laboratory.

Catalogue Data Used. Because not all of the countries have comprehensive test data on models available in the market, the team decided to do the primary AC comparisons between the five countries using catalogue data. While there are some potential drawbacks to this approach, the catalogue data is the only common denominator of the available data in each of the countries and thus the only way to ensure that we were comparing “apples with apples.”

EER Comparisons. Of the five countries, Korea has the highest average AC EER (3.22), only slightly higher than that for Thailand (3.16), and within the margin of error. Following Korea and Thailand, Malaysia has the third-highest EER (2.93), with Australia and China having the lowest average EERs (2.68 and 2.66, respectively). The levels for Australia and China are not distinguishable, given the margin of error.

Other Comparisons. The main report presents a number of representative findings from the large dataset. These include comparisons of shop data to catalogue data; comparisons of test data to catalogue data; comparisons of urban and rural AC data within a country; comparisons of brand efficiencies across countries; and comparisons of individual models available in more than one country. Since many of these comparisons are “paired” comparisons between countries, we have included a much more complete set of figures and comparisons on the annexes.

The Benchmarking Initiative. This is one of the first international benchmarking efforts of its kind for appliance and equipment energy efficiency. The results will be used by Australia in implementing its policy of “international regulatory best practice” in the establishment of minimum energy performance standards (MEPS) and labelling grades for its energy labels. They will form the core of a new section on “performance benchmarking” that will be established on the web site of the APEC Energy Standards Information System (www.apec-esis.org) in order to promote international best practice in appliance and equipment efficiency.

INTRODUCTION

Background

Since the mid- to late 1990s, an increasing number of international meetings on energy policy have identified that energy-efficiency standards and labelling programs can deliver cost effective environmental benefits and conserve energy, while also calling for the acceleration and expansion of such programs. Appliances and equipment are internationally traded, policymakers rarely look at international benchmarks when developing thresholds for minimum energy performance standards (MEPS) and labeling. For example, it is extremely rare to find direct, cross-country comparisons of MEPS and labeling tiers.

The Australian government is beginning to take the lead in the area of benchmarking, in line with the country's stated policy of examining "international best regulatory practice" when develop new MEPS and labeling requirements. The Australian approach is that its MEPS levels should not be lower than any other economy – or stated another way, if a product is made in Australia, it should meet the energy and environmental criteria and be able to be sold in any market in the world. AGO's interest in benchmarking energy performance of appliances and equipment is a direct outgrowth of its focus on "best regulatory practice."

Under contract to the Australian Greenhouse Office, Danish Energy Management A/S (DEM) has carried out this study to benchmark the efficiency of room air conditioners (ACs) in five Asian countries: Thailand, Malaysia, China, Korea, and Australia. The results of our data and analyses are provided in this report, and will be posted on the web site of the APEC Energy Standards Information System (APEC-ESIS, www.apec-esis.org). The report will also be presented at an international conference in Sydney, Australia from 7-9 June 2004.

Objectives

The main objective of this study was to compare the energy efficiency of room air conditioners across the five countries.

A secondary objective was to compare the regulated levels (minimum energy performance standards, or MEPS) and labelling categories across the five countries.

An additional objective was to compare, where possible, the accuracy of data reported in manufacturer catalogues against test results carried out by accredited laboratories.

METHODOLOGY AND DATA COLLECTION

Methodology

DEM assembled a team of local consultants in the five countries. Table 1 provides an overview of the research team.

Table 1. Overview of the Study Team

Country	Consultant
Overall	Danish Energy Management A/S
Australia	Paul Ryan, EnergyConsult Pty.
China	China Certification Center for Energy Conservation Products (CECP)
Korea	Korea Testing Laboratory (KTL)
Malaysia	Mensilin Holdings Sdn Bhd
Thailand	Monthon Kumpengsath, Saangsan Consultants Co., Ltd.

The country consultants were responsible for collecting and gathering available data in their country and supplying it to DEM. DEM carried out the data analyses presented in this report and integrated the data and conclusions across the five countries.

Data collection

Initial data on the overall market picture were developed through interviews with several major manufacturers and suppliers in each country. This resulted in a 5-10 page overviews of the room air conditioner market in each of the countries¹. The overviews cover such issues as market size (sales and value), relative importance of import and exports, primary export markets and import sources, market breakdown for window and split type air conditioners, and relative efficiency levels (e.g. MEPS and labelling developments). It also identifies market shares of the largest manufacturers and gives an indication of the total number of manufacturers, assemblers, and distributors in each country.

Primary data collection on AC capacity and efficiency for room air conditioners have been developed through a review of catalogues provided by manufacturers, distributors and retailers². Shop surveys have been carried out in capital and in one or more provincial centres. Apart from the primary purpose of gathering catalogue data, the shop surveys also enable an assessment of whether there are systematic differences in the level of efficiency of ACs in different regions of the countries, and to provide verification that the collected catalogue data is representative of what is actually available to customers. The shops and retailers surveyed have been selected to provide a representative spectrum of outlet types.

To the extent they have been available data from laboratory tests of room air conditioners have also been collected. This is considered a secondary source of data collection on room AC efficiency, since it is recognized that similar test data is not available across all five countries. To the extent possible, the AC test data has been used to (a) cross check the AC performance data provide by the manufacturers in their catalogues; and (b) to provide an overview of the efficiency range of models verified by laboratory testing.

DEM also reviewed and made use of the data on the web site of the APEC Energy Standards Information System (APEC-ESIS, www.apec-esis.org). APEC-ESIS is an internationally recognized database of up-to-date information on technical energy standards for testing, performance, and labeling of appliances and equipment. The APEC-ESIS site provided further information about current efficiency levels for minimum energy performance standards (MEPS) and tier levels for energy labels for room ACs.

Overview of the Data Set

An overview of what data has been collected is given in Table 2. Table 3 provides detail on the data collected, based on type of AC unit, number of brands, and number of models for each country.

¹ I.e. Thailand, Malaysia, Korea, China and Australia

² Information on ACs with cooling capacities in the range 0 - 36,000 BTU/h have been collected.

Table 2. Overview of Data Collected

	Australia	Korea	China	Thailand	Malaysia
Catalogue data	Y ^b	N ^c	Y	Y	Y
Shop data	Y ^b	Y	Y	Y	Y
Test data	Y	Y	Y	Y ^a	N ^d
Market overview	Y	Y	Y	Y	Y

Key: Y= Yes, N = No

Notes:

- a. For Thailand ,the test data received from EGAT is “blind” in that only cooling capacity and EER is given. Brand and model names have not been provided due to concerns by manufacturers about disclosure. Furthermore, the labelling program is voluntary so EGAT only labels AC’s with a performance corresponding to the highest levels, #5 and in some cases #4. Thus the test database becomes naturally upwards biased, since only models that manufacturers expect will pass the #4 and #5 threshold are submitted.
- b. In Australia, only a limited shop survey and catalogue collection was carried out. Since labelling is mandatory, the test dataset contains all models on the market.
- c. In Korea, as in Australia, labelling is mandatory. The local consultant has informed DEM that the test dataset contains all models on the market and that catalogue data are fully equivalent to the test results.
- d. Malaysia has no labelling or MEPS for ACS, and no independent testing has been carried out.

In order to compare information across the five countries, a number of adjustments to the raw data have been required. The present report makes use of SI units, whereas -- as indicated in Table 2 above -- data from some of the countries were actually collected in Imperial units³.

³ I.e. cooling capacities given in BTU/h, and EER in BTU/h/W rather than in kW and W/W.

Table 3. Overview of Data Collected on AC Brands and Models

	Australia	Korea	China	Thailand	Malaysia	Total
DATA ON AC BRANDS						
Catalogue data	NA ¹	NA	5 split 3 window	26 split 2 window	15 split 1 window	NA
Test data	36 Split 29 Window	21 split 7 window	15 split 3 window	NA ²	NA	NA
Shop data	NA ¹	5 split 0 window	20 split 0 window	29 split 0 window	22 split 0 window	NA
Number of AC brands collected in total	46	23	25	36	24	NA
DATA ON AC MODELS						
Catalogue data	37 split < 15 Window	Same as test	402 split 33 window	455 split 15 window	148 split 17 window	NA ⁴
Test data	362 split & 218 window	751 split 40 window	184 split 6 window	1277 split & window ²	NA	NA ⁴
Shop data	NA	175 split 0 window	355 split 0 window	255 split 0 window	137 split 0 window	NA ⁴
Total number of models (split & window)	580	791	929	670 ³	224	NA ⁴

Notes:

NA = not applicable

1. The number of brands and unique models collected in Australia refer only to “non ducted, cooling only, split and windows units”. Brands and models in the limited shop and catalogue survey are the same as in test data, which cover everything. The test data set includes also some packaged ACs, a lot of reverse cycle (heat pumps) units, as well as some portable ACs and other odds and ends. The latter have not been counted in the above table, since these types of ACs are not represented in the datasets for the other countries (and were not part of the scope of this benchmarking exercise).
2. At the request of Thai DSM Office, the Thai test data for air conditioners, which is available on the product labels was provided “blind” – without the brand names and model numbers listed.
3. Does not include number of models in test data.
4. Model numbers in our data do not match in the different countries. It is therefore not possible to determine the total number of different models in the dataset across all countries.

MEPS AND TEST PROTOCOLS

Overview of MEPS

Of the five countries surveyed two have MEPS already in effect, one (Australia) will have MEPS effective as of October 2004, and will aggressively raise the level already in 2005 for single phase ACs below 7.5 kW. Furthermore there is a proposal still under discussion to have yet another raise in

2006 for this category. Thailand has been considering MEPS but the final decision is still pending. Figure No.1 below shows both the MEPS and labelling levels currently in effect and those planned.

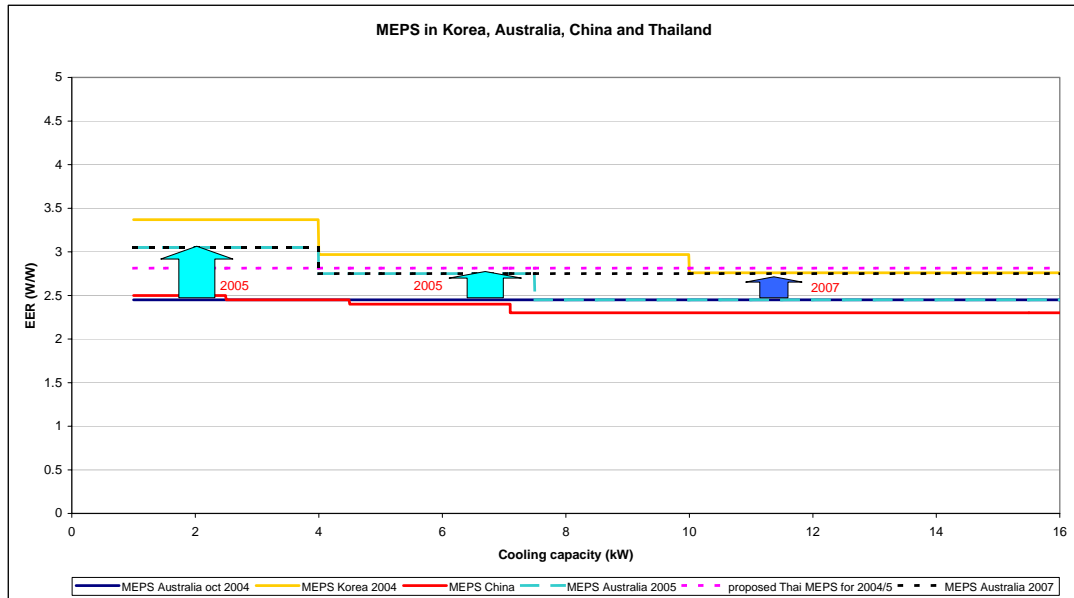


Figure 1. Current and proposed MEPS levels in the Five Countries. The arrows indicate the development of MEPS in Australia over the next couple of years (in 2005 and 2007 respectively)

Ambient test conditions

All of the national test standards for ACs refer to ISO 5151 for the type of ACs being analyzed in this study. However, the various national test standards implement it by using slightly differing test conditions, relating to the ambient conditions used for measuring the AC's performance. As a result, the test procedures employed in some of the countries⁴ differ only slightly from each other; however, for the comparison to be 100% fair it is necessary to recalculate the performance data to correspond to identical test conditions.

Correction for differences in test conditions

A comprehensive treatment of test procedures and differences as implemented in different APEC countries is given in an AC algorithm study commissioned by APEC⁵. Below is a brief review of the main points relating to the present study. Table 4 provides an overview of the testing standards used in the countries concerned. Although all the national test standards refer to ISO 5151, the test standards call for slightly differing test conditions. *The main difference is that indoor wet bulb temperature is 0.5 C higher in the test procedures used in Korea and Thailand.*⁶

This affects the resulting performance of the AC as reported in the test result, and to be able to fairly compare data from all the countries it, is necessary to bring all of them on the same footing.

⁴ Korea and Thailand use slightly different temperature settings in their test procedures as compared to China and Australia.

⁵ Study of Algorithms for Air Conditioners Study 3 of Studies on Algorithm Development for Energy Performance Testing, APEC Energy Working Group, November 2001

⁶ There are also some minor differences related to the tolerances used.

Table 4. Overview of MEPS, Labeling and Test Protocols. Specifications and standards used for room ACs, as well as overview of differences in test conditions.

	Australia	Korea	China	Thailand	Malaysia
MEPS	Y-m, as of October 2004	Y-m	Y-m	U	U
Labelling	Y-m + voluntary endorsement label	Y-m	Y-v	Y-v + voluntary endorsement label	U
Reference test standard	ISO 5151	ISO 5151, JIS B 8616, JIS C 9612	ISO 5151	ISO 5151	ISO 5151 ^a

<i>Test conditions' impact on performance</i>	Australia	Korea	China	Thailand	Malaysia
Similarity of test conditions to ISO 5151 T1	ISO T1	EER \approx 1.2% > than @ T1 Cooling capacity \approx 1.6% > than @T1	ISO T1	EER \approx 1.2% > than @ T1 Cooling capacity \approx 1.6% > than @T1	ISO T1 ^a

Sources: www.apec-esis.org and Study of Algorithms for Air Conditioners Study 3 of Studies on Algorithm Development for Energy Performance Testing, APEC Energy Working Group, November 2001

Notes:

a. Malaysia uses ISO 5151, but it is not clear if it is with T1, or modified T1 settings (similar to what is used in Korea and Thailand according to the Malaysian consultant).

Table 5 gives an overview of the critical test point temperatures used.

Table 5. Test Point Temperatures Used. (Note: tolerances differ slightly from country to country.)

Country	Degrees C			Test point name
	ODB	IDB	IWB	
Australia	35.0	27.0	19.0	ISO T1
Korea	35.0	27.0	19.5	
Thailand	35.0	27.0	19.5	
China	35.0	27.0	19.0	ISO T1
Malaysia	35.0	27.0	?	

Source: Study of Algorithms for Air Conditioners Study 3 of Studies on Algorithm Development for Energy Performance Testing, APEC Energy Working Group, November 2001

Key:

ODB: Outdoor Dry Bulb temperature

IDB: Indoor Dry Bulb Temperature

IWB: Indoor Wet Bulb Temperature

The APEC air conditioner algorithm study⁷ gives a recommendation on how to compensate for differing test conditions by using an algorithmic approach. The correction algorithm is based on the following equation.

$$X_{ISO_5151} = (\alpha_1 \Delta T_{ODB} + \alpha_2 \Delta T_{IDB} + \alpha_3 \Delta T_{IWB}) \cdot X$$

α_1 , α_2 and α_3 coefficients in % difference per degree difference in test condition [2],

X the property that has to be adjusted to ISO 5151 basis.

Indices:

ODB Outdoor Dry Bulb temperature test condition

IDB Indoor Dry Bulb Temperature test condition

IWB Indoor Wet Bulb Temperature test condition

The numerical values of the coefficients depend on whether it is EER or cooling capacity that is being corrected. The algorithm study shows that the method is generally applicable to small ΔT , and conjectures that it may also be applicable to larger differences in the testing conditions than those considered here.⁸

In the present case, the correction that has to be applied to Korean and Thai performance data in order to be comparable to ISO T1⁹ is about 1.2% for EER and 1.6% for the cooling capacity (i.e. the “raw values” for Korean and Thai data are slightly higher than the Australian and Chinese. Thus the comparisons made in this report are based on Thai and Korean data that are adjusted downwards by 1.2 and 1.6% respectively).

THE DATA ANALYSIS

Paired EER comparisons. The backbone of the analysis is comparisons using scatter plots showing the EER of individual AC models (y axis) as function of cooling capacity (x axis). Each plot compares data collected in two countries, and MEPS levels and labelling tiers are overlain as appropriate.

Five-country scatter plots. Scatter plots showing AC efficiency levels across the five countries¹⁰ have been prepared by calculating a sales-weighted EER for each country. The sales weighting has been done irrespective of the models’ AC cooling capacity¹¹ within the range of data available.

Intra-county regional comparisons. A comparison of the models found in different parts of each country has also been carried out, in order to investigate whether there are signs of significant disparities between, for instance, the capital and smaller regional cities.

⁷ Study of Algorithms for Air Conditioners Study 3 of Studies on Algorithm Development for Energy Performance Testing, APEC Energy Working Group, November 2001

⁸ The study indicates that for larger delta T the linear model for the correction may also be applicable. In the conclusions of the study, it is also noted that “other” aspects should be investigated to further corroborate the correction algorithm.

⁹ E.g. the Australian and Chinese data.

¹⁰ To avoid the plot getting too crowded with data points the overall plot shown in the findings section is displaying the shop survey data. Additional comparisons for each country (in appendix A1) demonstrate that the smaller shop survey dataset match the catalogue dataset in terms of EER and cooling capacities plotted.

¹¹ This is equivalent to assuming that the sales weighted average EER is constant for all cooling capacities. This is quite reasonable on the basis of the scatter plots, and since the market data available is not detailed enough to allow sales weighted average EERs to be calculated for smaller intervals it is also the best possible estimate.

Catalogue vs. test data. We have also investigated whether performance figures (EER and cooling capacity) in manufacturer catalogues are comparable with those in test reports. Finally, we made a cross-comparison of the models sold by manufacturers, in order to see if it possible to discern whether or not the manufacturers tailor the models they sell to the markets they operate in.

Sales-weighted analysis

Ideally the sales weighted EER, \mathbf{E}_w , for a particular market¹² is based on the average EERs, E_i , of each brand “i” for all its available models in the given market. However, data on all models of all brands in a given market is not generally available, and we have therefore used the following approximate calculation methodology instead.

Instead of using the exact brand sales-weighted average EER, E_i , an approximation, ε_i , has been made based on the data on AC models collected from manufacturer catalogues.

Ideally E_i should be calculated using the actual market share of each individual model, s_i . This, however, also requires data so detailed that it is not generally available. Instead, the particular brand’s overall market share¹³, σ_i , is used and applied to ε_i .

A final approximation that we introduce is necessitated by the fact that normally only market shares are only known with sufficient accuracy for the largest brands in the market. We therefore make the assumption that ε_{rest} , the average EER of all remaining models not belonging to any of the dominant brands, is representative of the actual average EER of these minor brands. This is considered a reasonable assumption, since even if it entails a further source of error, its weight in calculation of \mathbf{E}_w will normally be small.

Thus, with market shares¹⁴ σ_i the weighted EER, \mathbf{E}_w can be calculated as follows:

$$E_w = \sum_{j=1}^M [s_j \cdot \tilde{\varepsilon}_j] \approx \sum_{i=1}^N [\sigma_i \cdot \varepsilon_i] + \left(1 - \sum_{k=1}^N \sigma_k\right) \cdot \varepsilon_{rest}$$

Where

\mathbf{E}_w	Sales weighted EER
N	The number of (“dominant”) brands for which the market share σ_i are known.
M	The number of individual models present in the market
$\tilde{\varepsilon}_j$	The j’th individual model’s EER
ε_i	Brand average EER approximation through using only the collected dataset
ε_{rest}	Average EER approximation of all models in dataset not belonging to a brand with a well-determined market share. I.e. the models remaining in the dataset.
s_i	Actual market share of each individual model
σ_i	A particular brand’s overall market share

¹² It is assumed that each country is comprised of a single market.

¹³ This assumption is equivalent to giving all models of a particular brand the same individual market share.

¹⁴ in %

MAIN FINDINGS

Market Overviews

For each of the five countries, the national consultant provided an overview and assessment of the air conditioner market. The market overviews are presented in Annexes A through E. Table 6 below summarizes the information on market share. It is interesting to note that no brand has 10% market in more than two countries (Carrier, LG, and Panasonic each have at least 10% share in two countries).

Table 6. Approximate Market Shares by Brand for Each of the Five Study Countries.

Australia		China		Thailand		Malaysia		Korea	
Brand	Share	Brand	Share	Brand	Share	Brand	Share	Brand	Share
Fujitsu	31.0%	Midea	14.9%	Mitsubishi	20.0%	Panasonic	34.1%	LG	70.0%
Panasonic	16.0%	Gree	14.2%	Carrier	15.0%	York	16.0%	Samsung	
LG	10.0%	Haier	12.2%	Saijo Denki	7.5%	LG	9.9%	remainder	30.0%
Carrier	10.0%	Kelon	4.7%	Daikin	7.5%	Hitachi	8.7%		
Mitsubishi Electric	9.0%	Chunlan	4.4%	National	7.5%	Toshiba	5.0%		
Daikin	7.0%	AUX	4.2%	Hitachi	7.5%	“I”	3.4%		
Samsung	6.0%	Changhong	3.9%	Sharp	7.5%	Remainder	22.9%		
Kelvinator	3.0%	LG	3.0%	Toshiba	7.5%				
remainder	8.0%	remainder	38.5%	Trane	7.5%				
				LG	7.5%				
				remainder	5.0%				
	100.0%		100.0%		100.0%		100.0%		100.0%

Sales weighted average EERs

The sales weighted EER for the five economies have been calculated as described above, and the result confirm the situation seen in the scatter plots of catalogue and shop data. The result is shown in Figure 2.

Our findings suggest that, in descending order of AC model efficiency the country rankings are Korea, Thailand, Malaysia, Australia, and China. Of the five countries, Korea has the highest average AC EER (3.22), only slightly higher than that for Thailand (3.16), and within the margin of error. Following Korea and Thailand, Malaysia has the third-highest EER (2.93), with Australia and China having the lowest average EERs (2.68 and 2.66, respectively). The levels for Australia and China are not distinguishable, given the margin of error.

The two biggest surprises here are that Australia seems to be trailing the others on par with China; and that Malaysia seems to be doing quite well despite having neither MEPS nor labelling.

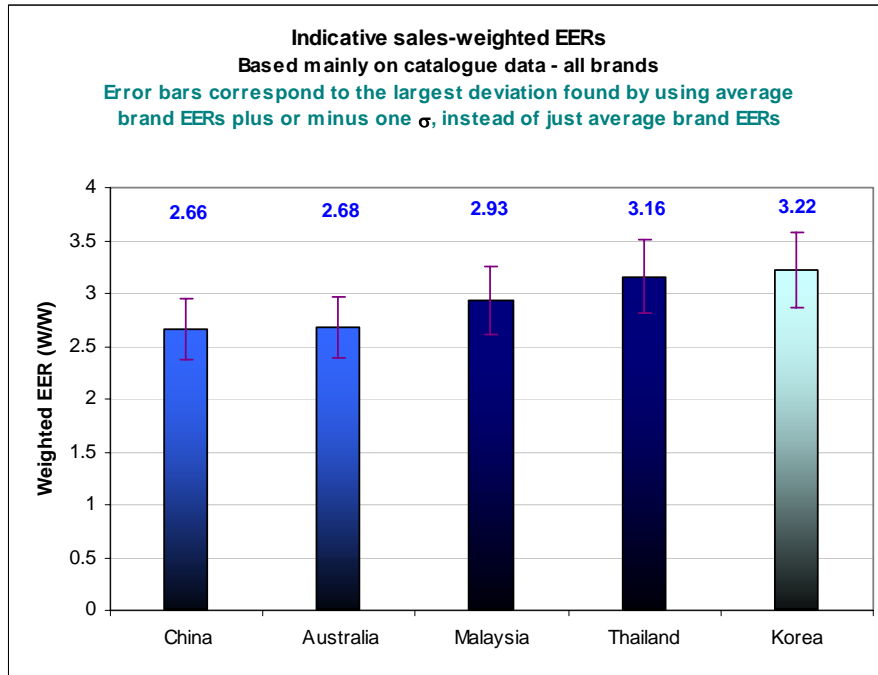


Figure 2. Sales-Weighted Average EER in the Five Countries.

Since the sales-weighted EER is calculated using an approximate method, there is some uncertainty associated with the values obtained. To appreciate the magnitude of this uncertainty a very conservative approach has been employed. To get a reasonable lower limit for the weighted EER, brand averages used in the calculation have been lowered by an amount corresponding to the standard deviation of the brand average. The upper limit is determined similarly.

To develop a reasonable idea of the magnitude of error in the sales-weighted EER figures shown in the chart for each country, we also display an error bar. The error bar shows the upper and lower limits, respectively, resulting from a calculation of the sales weighted EER with plus or minus one standard deviation for each brand average.¹⁵

In the market with the largest difference between the average weighted EER and the lower limit this limit is 11% below the average. The conservative assessment therefore has been to set the uncertainty as $\pm 11\%$ relative to the average. This corresponds to the error bars shown in Figure 1.

Appendix G contains graphs and tables giving frequency distributions for the different brands in each of the countries based on the catalogue data.

Figure 3 shows the normalized frequency distribution of all AC models in Thailand and China, both weighted and non-weighted.¹⁶ Also shown are the average sales-weighted EERs and the upper and lower limits as determined using the above approach.

¹⁵ Furthermore, the error bar shows the largest of the resulting deviations from this procedure -- i.e. the resulting deviation differs from country to country, but 11% is the largest deviation of them all. We used this value to be conservative.

¹⁶ From the collected catalogue data

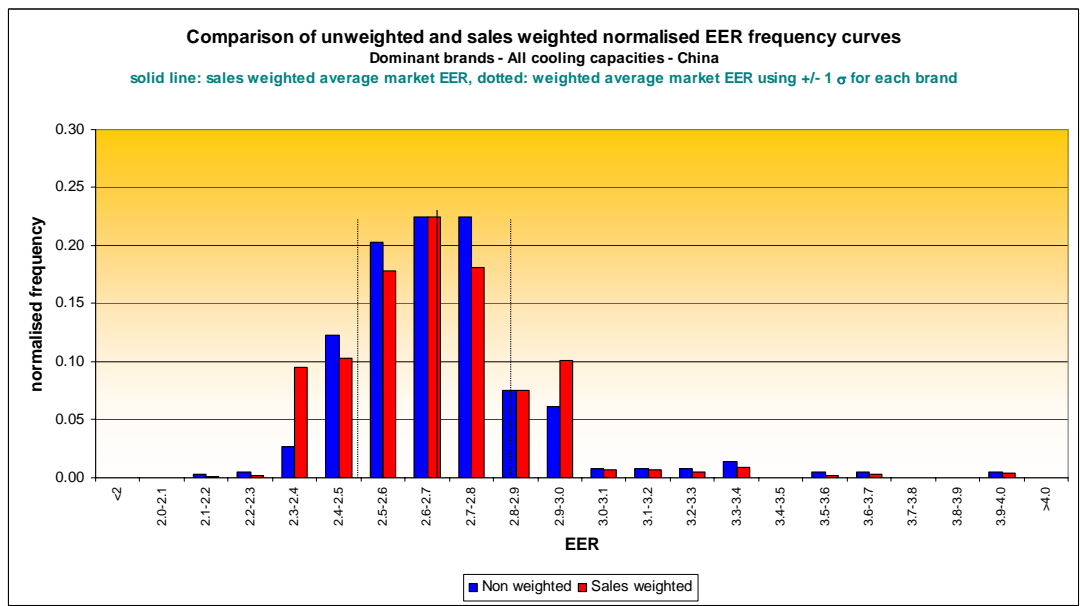
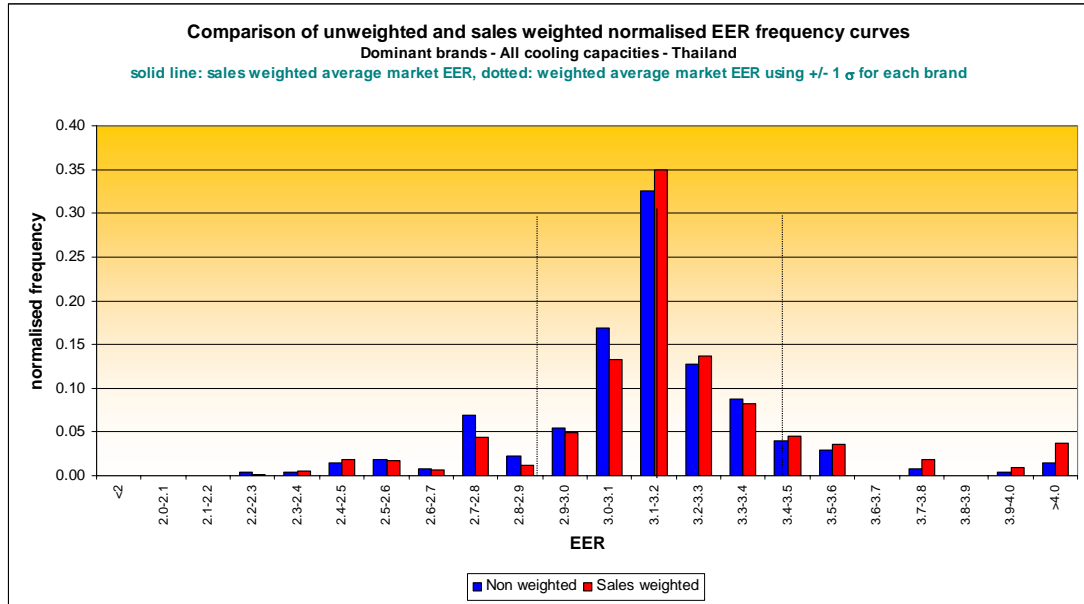


Figure 3. Normalized Frequency Distributions of All Catalogue AC Models in Thailand and In China. Also shown are the average sales-weighted EERs together with upper and lower limits as described in the text.

Other comparisons

Below we display a number of scatter plot comparisons using data adjusted as described above. The figures here are representative of the types of comparison made. A more complete selection of figures and comparisons can be found in the Appendices F, G, and H at the back of the report.

Figure 4 shows compares EER levels for all data collected in all five countries. It is easy to see that Korean and Thai models have higher EERs than the corresponding Australian and Chinese.

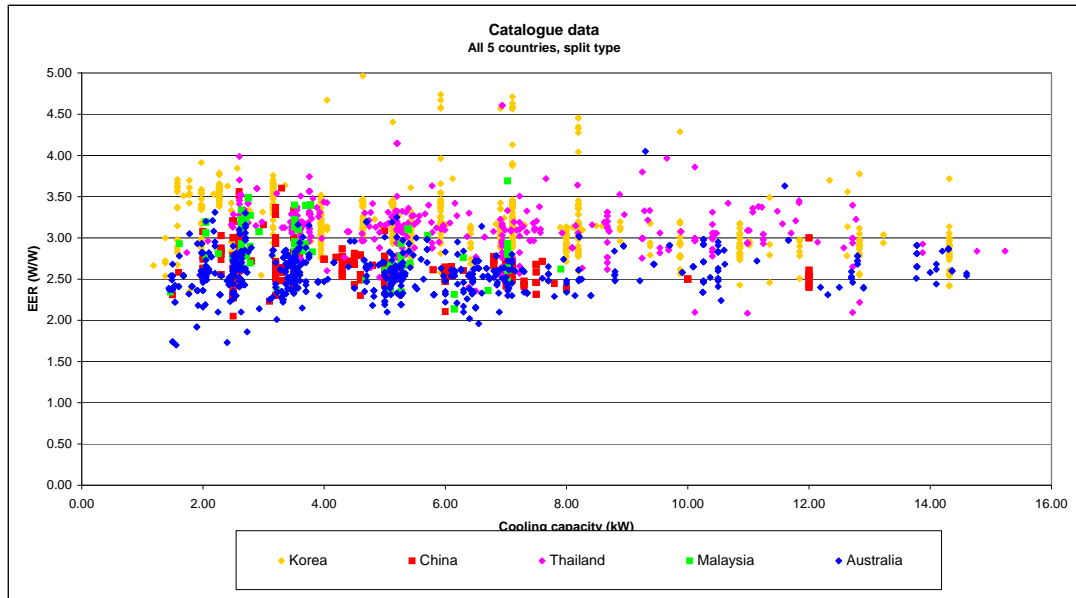


Figure 4. Comparison of Test/Catalogue data in all five surveyed countries.

Figure 5 compares EER levels based on test data from Korea and Australia. Since labelling is mandatory and the test data cover all models in the market, the test data are basically equivalent to the catalogue data¹⁷.

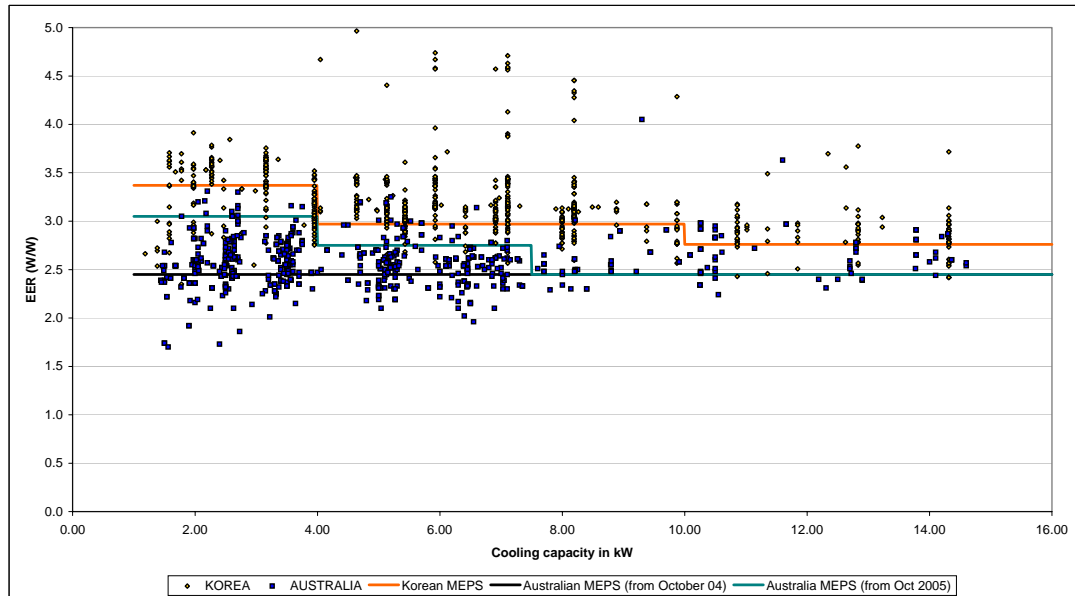


Figure 5. Comparison of Korean and Australian Test/Catalogue data. The Korean and (planned) Australian MEPS levels (from 2004 and 2005) are superimposed as lines.

¹⁷ As we will note, there are in fact in some instances a small discrepancy between the test data and data given in manufacturers' catalogues. This will be discussed in a later section in more detail.

It is noteworthy is that so many Korean models do not appear to comply with the Korean MEPS. This, however, is an illusion. Since the dataset plotted covers the years 1997-2003, and since the MEPS shown took effect in January 2004, many of the models shown are actually no longer on the market (and could not be sold in any event post-January 2004). This is demonstrated in Figure 6, which shows data from shop surveys carried out in January 2004: models now found in shops do – for the most part -- comply with the new MEPS.¹⁸

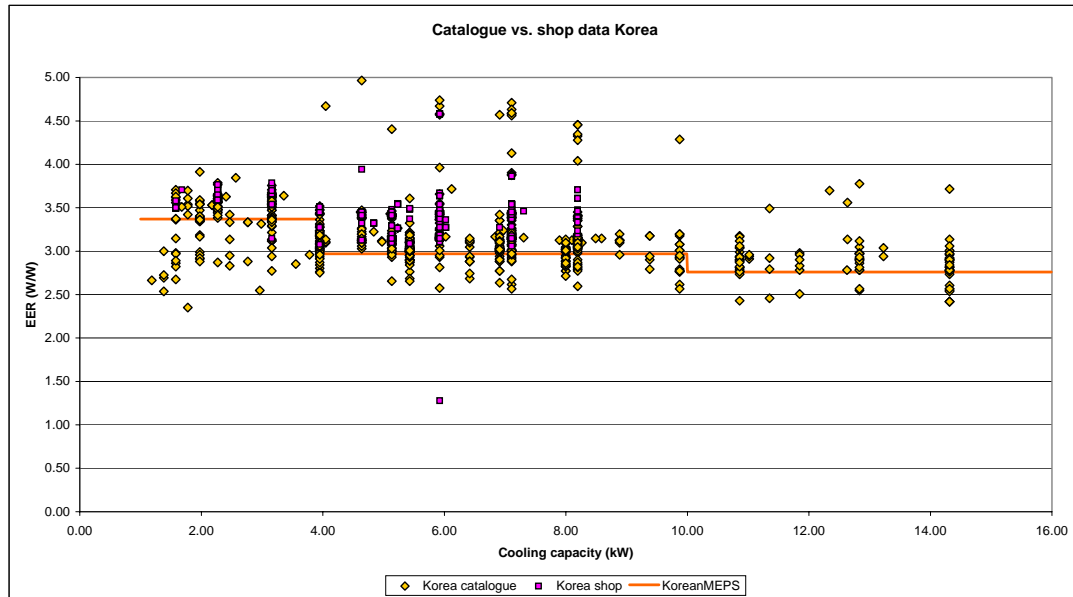


Figure 6. Korean Shop Survey Data and Test Data, Compared to the January 2004 MEPS.

Scatter plots of catalogue data taken solely from the biggest brands on the market show the exact same picture. Graphs with scatter plots of catalogue and test data for all the five countries are found in the appendices (where they also appear on a larger scale than shown here). The overall picture that emerges is that models in Korea have a higher average EER than in the other countries. In a head-to-head comparison of Thai/Korean data, it looks as if the models present in the two markets are roughly equivalent; however, it is important to keep in mind that Korea has just taken a leap ahead due to its aggressive new MEPS.

Figure 7 compares the spread of cooling capacities and EER of ACs from the largest brands in each market, and it is clear to see that for similar sized ACs model EERs are clearly differentiated as also shown by the sales weighted analysis and scatter plots above.

¹⁸ 1,6% (6 out of 384) of the models found in shops are below the MEPS. The Korean data were all collected in December 2003/January 2004 so strictly speaking they would have been in compliance at the time of the data collection.

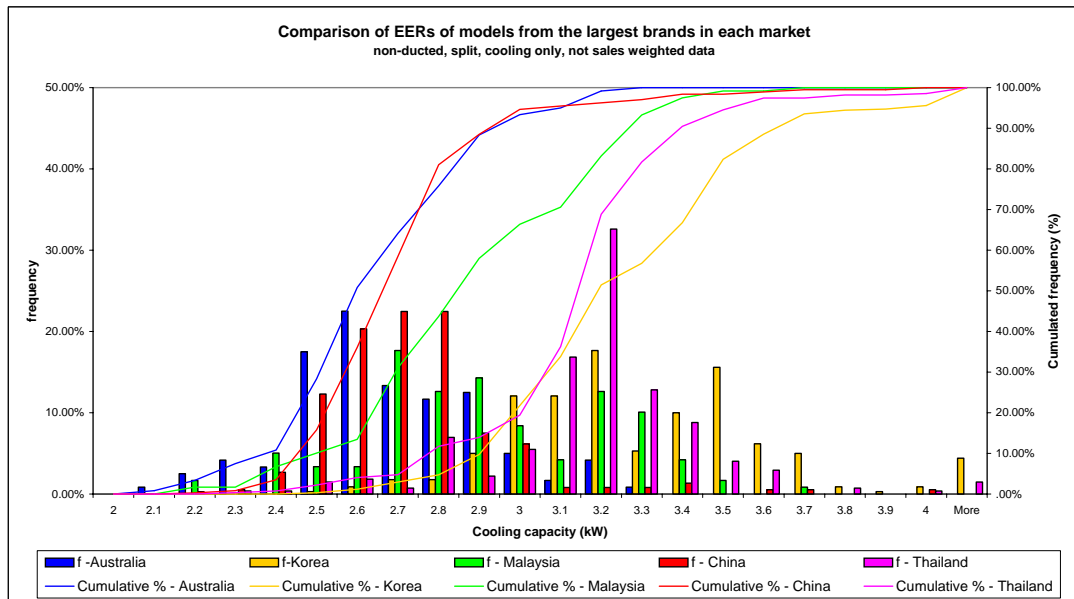
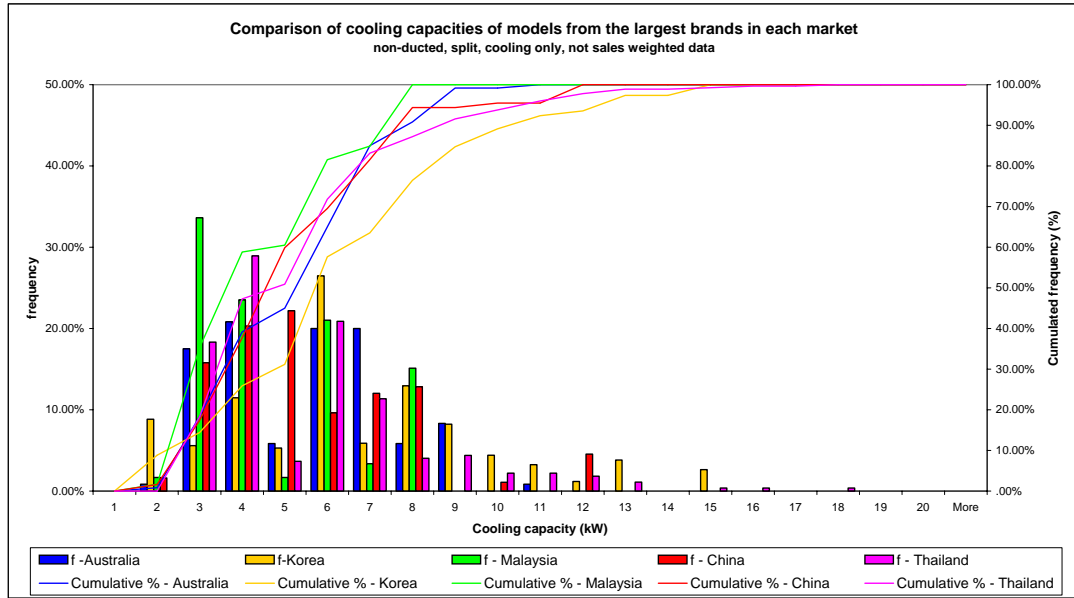


Figure 7. Comparison of the spread of cooling capacities and EERs of ACs from the largest brands in each market.

Figure 8 shows Australian and Malaysian catalogue data together, with the calculated sales weighted EER for each market (more on the sales weighting below).

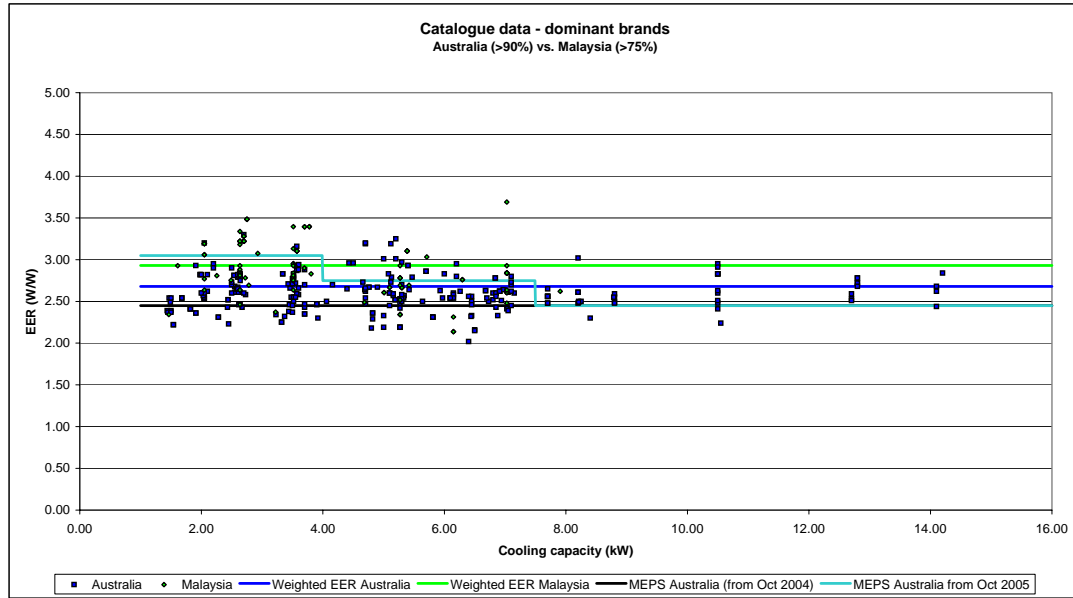


Figure 8. Australian and Malaysian Catalogue Data and Sales Weighted EERs. Overlain lines show Australian planned MEPS for 2004 and 2005.

Comparison of shop and catalogue data

The comparison of shop data was done mainly to confirm that the catalogue data reflect the AC models actually found in shops. In general this is conformed, with the exception of Korea where the shop data clearly show the recently implemented increase in MEPS requirements (see Figure 4 above). Since this change only serves to further emphasize the overall situation already seen, it has been decided to keep the Korean catalogue data as is without filtering out the older models. This overall situation is also illustrated by the scatter plot in Figure 9 below. Scatter plots of all shop data comparisons to catalogue data, as well as shop data comparison between countries are found in Appendix F.

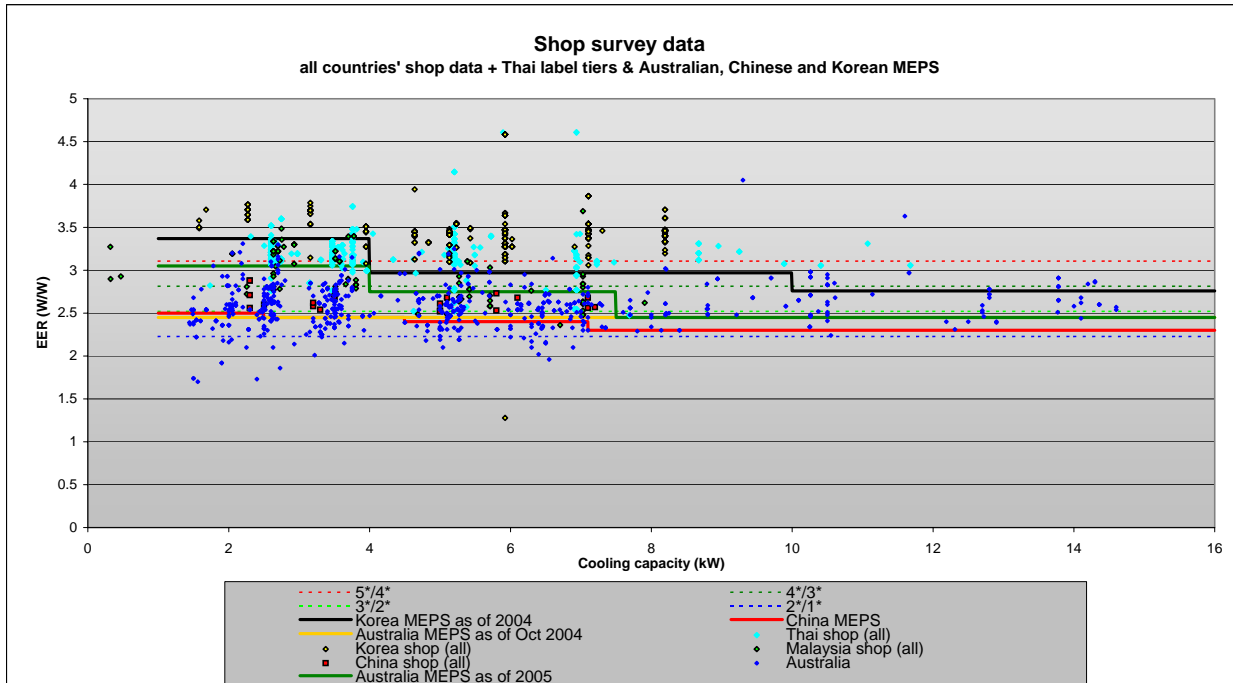


Figure 9. Shop Data from All Five Countries, Compared to Korean, Chinese and (coming) Australian 2004 and 2005 MEPS, and Thai Label Tiers.

Comparison of capital and regional data

The shop data is also used to compare the situation in different cities in each country. The overall finding is that there is no significant difference in the models available. The market overviews indicate that there could be differences if a sales weighted comparison could be made¹⁹. This, however, is not possible to quantify, since the available sales data are not detailed enough to allow a regional disaggregation. Furthermore, Thailand may be a special case as it is probably more heterogeneous -- when comparing the capital to regional centres -- than is the case in the other countries. Figure 10 shows the Korean shop data from Seoul, Incheon and Busan, and it is clear that there is no apparent difference in efficiency levels of the models available. Figure 11 shows the situation in Thailand in Chiang Mai, Hat Yai and Bangkok respectively.

¹⁹ In Thailand for instance the shop interviews hint that there are relatively fewer label #5 ACs sold in Chiang Mai and Hat Yai than in Bangkok.

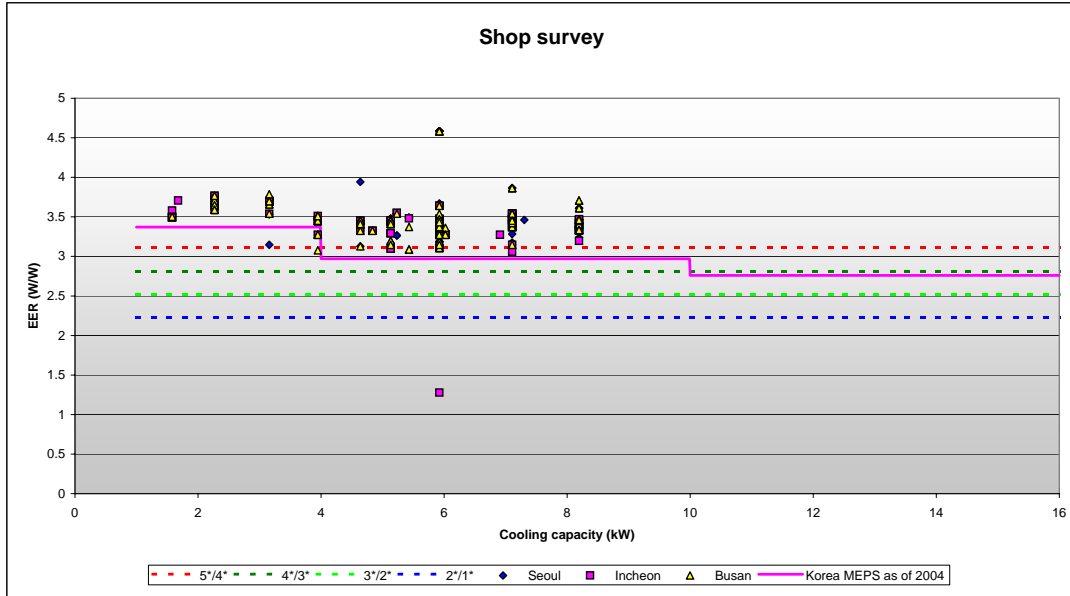


Figure 10. Shop Data from Seoul, Incheon and Busan in Korea

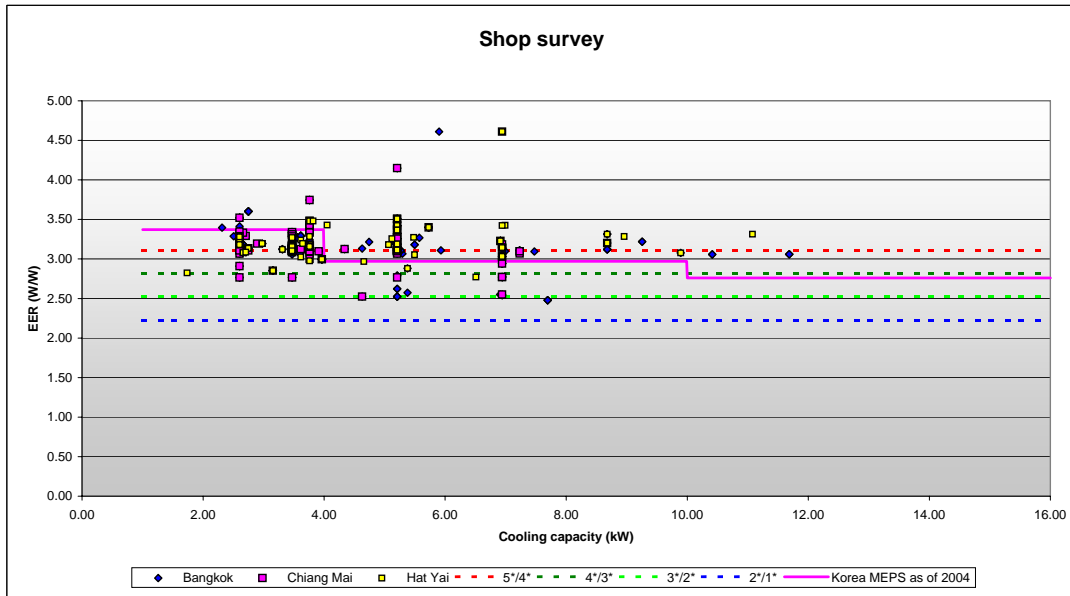


Figure 11. Shop Data from Bangkok, Chiang Mai, and Hat Yai in Thailand. Also shown are the Thai label tiers and Korean MEPS for comparison.

OTHER FINDINGS

Comparison of catalogue and test data

While the samples are rather small, a comparison of test and catalogue data shows a tendency for some catalogues to exaggerate performance figures. Figure 12 shows the result of comparisons carried out on Australian and Chinese datasets.

trend one way or the other, as the differences between catalogue data are small – on the order of 1-2%, and go in both directions.

The samples are small, and it is hard from these small comparisons to make any conclusive observation about the extent to which catalogue data are validated by test data.

Comparison of brands between markets

We also investigated whether manufacturers sell models with different efficiency levels in different country markets. Figure 13 shows two plots – one for LG and one for Mitsubishi. The plots show the efficiency (EER) of models sold for each brand at different cooling capacities. Additional plots can be found in Appendix H.

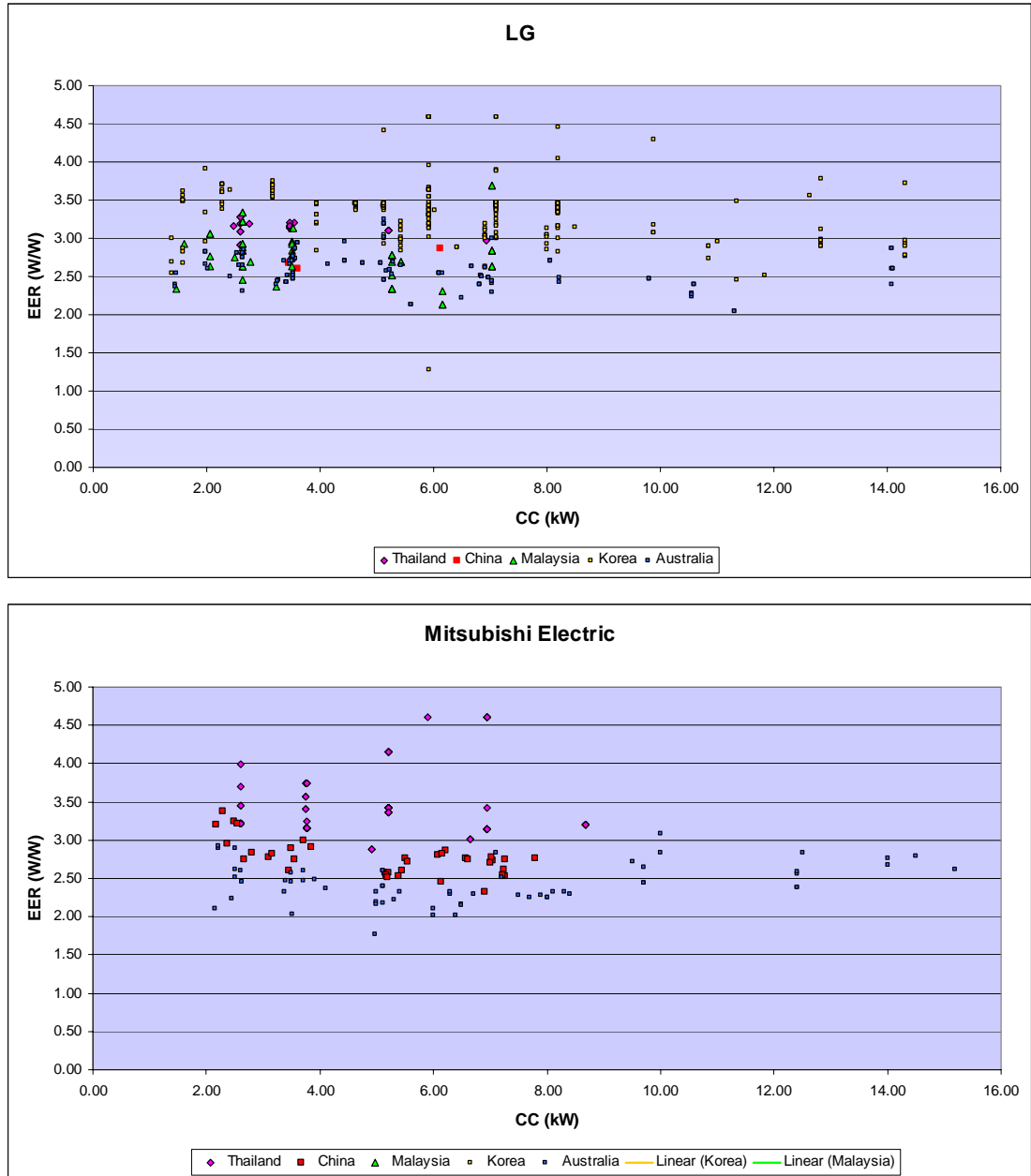


Figure 13. Catalogue data scatter plots of LG and Mitsubishi models found in different countries.

As can be seen, the efficiency of the model sold for a particular brand appears to vary widely depending on the market

Comparison of models across markets

We also investigated potential differences in the efficiency of a single model number sold in different markets. In practice, we found that the model numbers do not correspond very well across country,

and were able to find only seven exact matches across country border of the same model (from the same brand). The available small sample of data do not show any significant differences between the rated cooling capacities.²⁰

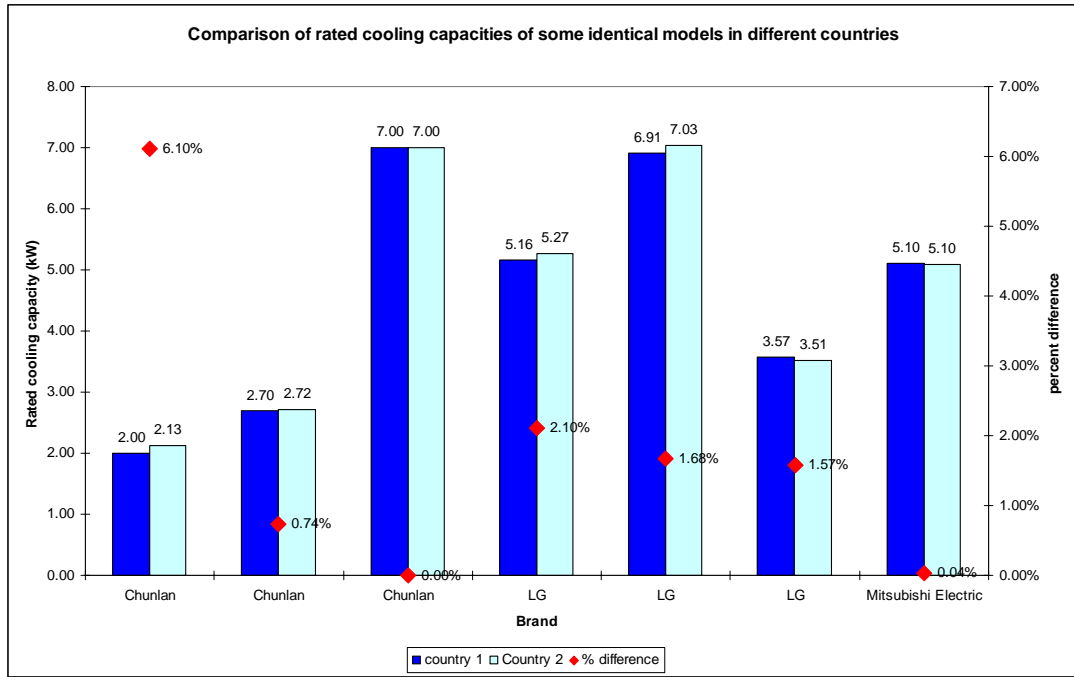


Figure 14. Comparison of rated cooling capacity for identical models in different countries. The first paired bar is a window type AC, whereas the rest are non-ducted split units for cooling only functionality

AC trade flows

Related to the above comparison between brands and models in different markets it is interesting to consider the mix of ACs imported to Australia and the actual average sales weighted EER. From Annex A it is clear that the vast majority of all ACs imported into Australia are from the countries surveyed in this report²¹. If, for the sake of argument, one assumes that the average EER of the models exported are equal to the sales weighted EER in the country of origin²² it is easy to calculate that the average sales weighted EER in Australia should be around 2.9. However, detailed model and sales data from Australia results in an actual sales weighted EER of 2.68. The conclusion therefore appears to be that, for whichever reason, the models exported have a lower average EER than what is generally sold in those countries. This is overall in conformance with what was seen in the comparison of brands between the countries.

This is quite interesting since it strongly hints that rapidly increasing MEPS levels in Australia is not only feasible, but also that such a move is likely to push average EER levels in other countries without MEPS up²³. This observation supports the notion that e.g. Malaysia's average sales weighted EER is relatively high due to large volumes of export to countries with high EER requirements, and that this tends to spill over to the domestic market.

²⁰ Note: we plotted cooling capacities instead of EERs, since there was not enough data in several cases to calculate the EER for all models.

²¹ I.e. Korea, China, Thailand and Malaysia cover some 87% of the total imports

²² This assumption is strictly hypothetical. It could be argued that a value corresponding to e.g. MEPS in the predominant export market is more realistic, but that is beside the point of the argument since the comparison made is with these particular countries' average level of efficiency.

²³ Since the manufacturers will have to increase the output of higher EER models this will increase the viability of those models elsewhere by way of improved economies of scale.



Figure 15. Country of origin composition of imported AC to Australia. Other countries include the small Australian manufacturing (less than 5% overall).

It could be mentioned in passing perhaps, that the country of origin composition shown in figure 15 above was part of the rationale for selecting the five countries covered by the present investigation.

Another noteworthy observation from the trade statistics included in annexes A to E is that of the five countries, Australia is almost exclusively relying on imported equipment (about 95-98 % imported), whereas all the other four countries are major exporters²⁴. This implies that increasing MEPS levels in Australia will also increase viability of higher EER in those countries, with the exception of Korea which already have higher MEPS than Australia, by way of increasing the economy of scales for the exporters that also to a large extent supply the home markets.

We could insert the table with the export/import data here, and add some more text.

²⁴ Korea importing only about 14%, Malaysia about 7.5%, Thailand some 2% and China about 1% of ACs sold.

Possible Biases in the Analysis

Our initial intent was to compare models on catalogue data across the 5 countries. Due to the long-time prevalence of test data for energy labelling in Australia and Korea, and the assumed equivalence of test data and catalogue data, we relied primarily on test data for these two countries. In contrast, we relied on catalogue data, supplemented with shop data, for our analysis of Malaysia, Thailand and China.

In our comparison of test and catalogue data, the comparison were small. For Australia the catalogue data appeared to slightly overstate the EER compared to test data. The data for China were inconclusive.

In general, the differences found between catalogue data and test data were small, and were only found for certain brands. In our comparison of the sales-weighted EERs across the five countries, it is possible the Australian EERs are actually slightly lower than shown in the analysis. But the bias, if it exists would be quite small – on the order of just a few percent.

Questions Raised by the Data and Analysis

The comparison of data raises a number of questions for possible further inquiry:

Malaysian EER levels. What is the reason for Malaysia's unexpectedly high average sales-weighted EER? Malaysian ACs appear to be more efficient than Australia (and China), despite having neither MEPS nor labelling. Are the performance data stated in Malaysian catalogues more exaggerated than elsewhere due to the lack of testing and hence verification? Or could the EERs be relatively high in Malaysia due to the fact that most of the AC models are manufactured for export to countries with high MEPS and labelling requirements – and that this trend toward higher efficiency “rubs off” on models sold in Malaysia's domestic market?

Australian EER levels. Why does Australia trail the other countries in terms of models available and average sales-weighted EER? Even the brand comparisons across countries indicate that models sold in Australia are less efficient than models of the same brand sold in Korea or Thailand.

Performance parameters. Are EER and CC really the only important parameters in assessing AC performance? If not, then is it possible that Australian models display better characteristics in other respects? Better controls? Better service and maintenance? Better installation? Etc.?

CONCLUSIONS

Data Collected. The DEM team carried out market surveys and characterized the room air conditioner market in each of the countries. Teams also reviewed manufacturers' catalogues of models available on the market; carried out shop surveys; and collected available laboratory test data on air conditioner performance. The data collection and analysis focused on air conditioner units with up to 36,000 BTU/hr cooling capacity. A massive amount of data was collected – ranging from 23 to 46 brands per country; and from 224 up to 929 models per country.

Test Procedures. All five countries use the same international test standard (ISO 5151) for measuring energy performance. The test standards for Korea and Thailand use a slightly different indoor wet bulb temperature, which is 0.5 C higher. The team used a correction algorithm developed for APEC to adjust the test results (1.2% for EER and 1.6% for cooling capacity adjustment). However this potential bias is extremely small and is less than 4% error for a calorimeter laboratory.

Catalogue Data Used. Because not all of the countries have comprehensive test data on models available in the market, the team decided to do the primary AC comparisons between the five countries using catalogue data. While there are some potential drawbacks to this approach, the

catalogue data is the only common denominator of the available data in each of the countries and thus the only way to ensure that we were comparing “apples with apples.”

EER Comparisons. Of the five countries, Korea has the highest average AC EER (3.22), only slightly higher than that for Thailand (3.16), and within the margin of error. Following Korea and Thailand, Malaysia has the third-highest EER (2.93), with Australia and China having the lowest average EERs (2.68 and 2.66, respectively). The levels for Australia and China are not distinguishable, given the margin of error.

Other Comparisons. The main report presents a number of representative findings from the large dataset. These include comparisons of shop data to catalogue data; comparisons of test data to catalogue data; comparisons of urban and rural AC data within a country; comparisons of brand efficiencies across countries; and comparisons of individual models available in more than one country. Since many of these comparisons are “paired” comparisons between countries, we have included a much more complete set of figures and comparisons on the annexes.

The Benchmarking Initiative. This is one of the first international benchmarking efforts of its kind for appliance and equipment energy efficiency. The results will be used by Australia in implementing its policy of “international regulatory best practice” in the establishment of minimum energy performance standards (MEPS) and labelling grades for its energy labels. They will form the core of a new section on “performance benchmarking” that will be established on the web site of the APEC Energy Standards Information System (www.apec-esis.org) in order to promote international best practice in appliance and equipment efficiency.

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- [1] APEC-ESIS web site – <http://www.apec-esis.org>
- [2] Study of Algorithms for Air Conditioners Study 3 of Studies on Algorithm Development for Energy Performance Testing, APEC Energy Working Group, November 2001
- [3] Personal communication from Ir. Lalchand Gulabrai, Malaysian Energy Commission & Mensilin Holdings Snd. Bhd.

APPENDIX A: AUSTRALIA MARKET OVERVIEW

INTRODUCTION

This report covers the initial data on the overall market picture of household and small commercial air conditioner in Australia. This report is only for single phase air conditioning units up to 7.5kW nominal cooling capacity.

CLIMATE OVERVIEW

Australia has the land mass of the USA, the population of New York and an economy smaller than California. The island continent of Australia features a wide range of climatic zones, from the tropical regions of the north, through the arid expanses of the interior, to the temperate regions of the south. Widely known as the “Dry Continent”, the land mass is relatively arid with 80% having a median rainfall less than 600mm per year and 50% less than 330mm. Seasonal fluctuations can be large, with temperatures ranging from above 50 degrees C to well below zero.

MARKET OVERVIEW

Market size (sales and value)

The Australian market is one of the world’s largest markets with estimated current sales of over 600,000 units estimated to be worth over AUD\$500 million despite its small population of 20 million people.

Some two thirds of the market by volume is minisplits. Research completed in January 2002 indicated annual growth in excess o 10% per annum, with residential market penetration set to grow from 30-35% to 50-60% within the next 5 years.

The majority of the market is larger units > 4kW but < 7.5kW in view of bigger house designs, with heat pumps contributing to over 70% of sales. Residential type multisplits have now risen to some 10,000 units but VRF systems remain modest. Wall hung types totally dominate the Australian market with an estimated share of over 85%.

Window/Wall style units have been a major but diminishing market in Australia with some 98% of sales via retail outlets, making final end user analysis difficult. The residential market accounts for less than 35% of the Window/Wall unit as consumers switch to more popular split systems. The majority of window unit sales are for smaller commercial applications, motels and portable building used in construction, industrial and mining sites.

Primary sales channels where residential and small commercial air conditioning is sold

Channel	Market Share
Retail Stores	60%
Specialist AC Dealers	20%
Department Stores	< 1%
Utilities	5%
AC Contractors	15%

Relative importance of import and exports

The Australian single phase AC market is dependant on imported equipment to satisfy approximately 95% of consumer demand.

Primary export markets and import sources

Australia imports single phase AC units from 9 countries according to manufacturer's data from the Australian Greenhouse Office (AGO). China, Korea and Thailand account for a majority (83%) of these imported items. A table of brands exported by country is provided below.

Country of Origin	Number of Brands Imported	Estimated Market Share
China	64	48%
Korea	11	20%
Thailand	11	15%
Japan	4	5%
Malaysia	3	4%
Taiwan	1	< 2%
Israel	1	< 2%
Singapore	1	< 2%
New Zealand	1	< 2%

Brands imported and country of origin

Country of Origin *Brands Imported*

China	Admiral, Aeon, Agean, Ager, Airwell, Alpine, Arlec, Aux, Blueway, Celestial, Celsius, Centrex, Chigo, Chunlan, Cleardrop, Conia, Daewoo, Davinci, Dec, Degree, Derby, DL, Econair, Electrolux – Kelvinator, Enigma, Enviro Master, Fonko, Fedders, Fujita, Fujitsu, Galanz, Genaire, General Electric, Gree, Haier, Heller, Hoffwal, Hualing, JBS, Jet-Air, Krana, Laguna, Lakes, Midea, Milano, Misake, Mistral, Nobel, Omni, Pacific Air, Panasonic, Quick Air, Rank Arena, Rowa, Roxland, Samsung, Sanyo, Starway, TCL, Teco, Uzay, Vacu-Maid, Versaire
Korea	Hyundai, Kelvinator, LG, NEC, Oasis, Samsung, Weathermaker, Winia, Streamline, Carrier, Executive
Thailand	Amena, Benson, Carrier, Daikin, Derby, Fujitsu, MHI, Mitsubishi Electric, Roland, Sharp, Toshiba
Malaysia	Hitachi, Panasonic, Fujiaire
Japan	Daikin, Sanyo, Toshiba, MHI
Taiwan	Teco
Israel	Carrier
Singapore	Sanyo
New Zealand	Tempzone

Market breakdown for window and split type air conditioners

Market data is provided for annual sales in Australia for the period May 2001 to April 2002. The parameters for this data are single phase air conditioning units with a total nominal cooling capacity of 7.5kW or below. While there are several brands that carry items that are single phase and greater than this capacity, the quantity is insignificant and not considered for this report.

This information indicates that some 480,000 units are sold into the residential light commercial market each year. Product sold is split into Window Wall, Ducted Split and Wall hung Split styles and is further categorized by 'Heat Pump and 'Cool Only' functionality.

	QLD	NSW/ACT	VIC	TAS	SA	NT	WA	TOTAL
Window Wall Style (WWS)	79,003	32,606	20,031	86	19,740	1,993	13,150	166,609
Heat Pump up to 7.5kW	20,933	20,571	7,813	69	11,418	129	5,556	66,489
Cool Only up to 7.5kW	58,070	12,035	12,218	17	8,322	1,864	7,594	100,120
Ducted Split System (DSS)	1,075	2,790	861	87	1,703	9	823	7,348
Heat Pump up to 7.5kW	1,060	2,781	825	87	1,695	5	822	7,275
Cool Only up to 7.5kW	15	9	36	-	8	4	1	73
Wall Hung Split System (WHS)	89,848	100,944	53,257	4,153	23,488	4,953	28,892	305,535
Heat Pump up to 7.5kW	65,749	97,014	44,719	4,088	19,472	721	25,414	257,177
Cool Only up to 7.5kW	24,099	3,930	8,538	65	4,016	4,232	3,478	48,358

Notable aspects of product distribution relating to the Australian market are:

- 30% of all units sold are 'Cool Only'
- Over 60% of all units sold are in Queensland/New South Wales/Australian Capitol Territory due to ambient temperature and humidity
- Window Wall Style units account for 35% of sales and are typically used in portable homes, hotels, communication huts, industrial site sheds. The trends towards this product type are diminishing and are being replaced by Wall Hung Split Systems.
- Increase in Ducted Split system market as a total cooling/heating system due to fuel substitution – i.e. gas heating vs. reverse cycle heating.
- Annual consumer spend is estimated at:
 - i. Window Wall Style – AUD\$118 million per annum with the volume and average cost trend decreasing
 - ii. Ducted Split System – AUD\$13 million per annum with volume trend increasing and average cost trend decreasing
 - iii. Wall Hung Split System – AUD\$380 million per annum with significant increases in volume trend and average cost trend decreasing

Relative efficiency levels

From 1 October 2004, all single phase air conditioners manufactured in or imported into Australia must comply with Minimum Energy Performance (MEPS) requirements which are set out in AS/NZS 3823.2-2003.

MEPS covers single phase non-ducted or ducted room air conditioners of the vapour compression type (commercial or residential). It covers only those units with a single compressor with a single indoor control such as single packaged units, packaged ducted units, double and triple split systems and single split systems.

MEPS requirements for single phase and air conditioners are will be revised in 2007 as detailed below.

Cooling Capacity/Type	After Oct 2001	After Oct 2004	After Oct 2007
All capacities – cooling only, non ducted	n/a	2.45	2.75/3.05*
All capacities – cooling only, ducted	n/a	2.45	2.50
All capacities – reverse cycle, non ducted	n/a	2.30	2.75/3.05*
All capacities – reverse cycle, ducted	n/a	2.30	2.50

* After October 2007, a MEPS level of 3.05 is applicable to non ducted systems of less than 4.0 kW nominal cooling capacity.

Market share of the largest manufacturers

The Australian market is dominated by a combination of well recognised international brands that currently hold an 80% market share with a secondary range of brands sharing the remaining market. Information that provides detailed market share is not available; however this estimate has been made on interviews with key industry operatives.

The market is divided into three tiers of product supply; Tier One – main brands with dominant market share; Tier Two – known brands with approximately a 15% market share; Tier Three – lesser known or new brands with approximately a 5% market share.

The following list is a brief summary of typical brands within this informal tier structure.

Tier One		
Airwell	LG	Kelvinator
Daikin	Mitsubishi Electric	Carrier
Panasonic	Hitachi	Fujitsu
Tier Two		
Samsung	Temperzone	Sanyo
Mitsubishi MLA	General Electric	
Tier Three		
Sharp	Admiral	Celestial
Teco	Mistral	NEC

Re-badging for other major brands is also significant with complex inter-trade arrangements. A further market squeeze is now taking place as major Chinese brands appear in the Australian market.

Total number of manufactures, assemblers, and distributors in each country

Although the vast majority of the market is imported, there is still some 100,000 room and packaged units manufactured in Australia per annum by four manufacturers (Carrier, Actron Air, Aircommand, Pioneer). Half of these locally manufactured units are exported for applications that exceed standard residential or light commercial ambient condition standards.

APPENDIX B: CHINA MARKET OVERVIEW

INTRODUCTION

It all began with the economic reforms of 1978 – China began commercially producing air conditioners, with a total of 223 puzzled together that year. In 1990's, especially during the recent years, the industry of household air conditioners has undergone such a dramatic expansion that the total production soared to 0.22 million in 1990, and reached 26 million to 33 million (double-shift level) currently. Accordingly the gross industrial output and the sales income of China's air conditioners industry have also experienced an uninterrupted development and growth. The gross industrial output and the sales income in 2002 were respectively 105.5 and 69.6 billion RMB. The products have also grown in their type from the pure window-type air conditioners to split air conditioners, floor-standing air conditioners, central household air conditioners and others. Today, the production of air conditioners in China has approximated one third of the global total and China has ensured a worthy title as the air conditioner manufacturing giant.

Prices have recently been slashed dramatically by a myriad of manufacturers: data from the National Bureau of Statistics shows that the average price for air conditioners stood at 4,200 RMB (\$507) in 2000 but fell to 3,200 RMB in 2001 – a discount of roughly 25%. In 2002 the average price even fell to 2,500 RMB – a drop of more than 20% as compared with that in 2001. For the coming years, prices are bound to fall even more.

The penetration rate (ownership per number of inhabitants) on the mainland is still quite low as compared with that for other household appliances like refrigerators, washing machines, and TVs: the National Bureau of Statistics said there were 35.7 air conditioners per 100 people in urban areas in 2001– up from 16.3 in 1997, but only half as high as the figure for refrigerators. In rural areas, the rate rose from a mere 0.2% in 1997 to 1.5% in 2001. Penetration is highest for the wealthier eastern area (52.5%), followed by central-southern China (46.5%). Sticky warm Guangdong leads the pack with a rate of 107.7%, followed by Shanghai (99.4%), Beijing (98.5%), and Chongqing (85.5%).

This overview, based on a combined method of qualitative and quantitative analyses, presents those factors involved in China's air conditioners industry such as market size, export and import status, market breakdown, chief manufacturers, primary sales channels and relative efficiency levels.

MARKET SIZE

In the past several years, the industry of household air conditioners has expanded so much that the total production soared to 18.27 million in 2000, to 23.13 million in 2001, and to 31.35 million in 2002, during which the annual increase has remained above 20%. The domestic sales volume from 1998 to 2001 jumped accordingly, however in 2002 the domestic sales volume was only 14.00 million, dropping a little compared with that of the previous year. (See Figure B-1). Given the export volume in 2002 was 9.79 million, the stocks of air conditioners that year was over 7 million, a tremendous stock never seen in this industry before. In other words, the air conditioner industry is faced with a harsh situation of supply over demand.

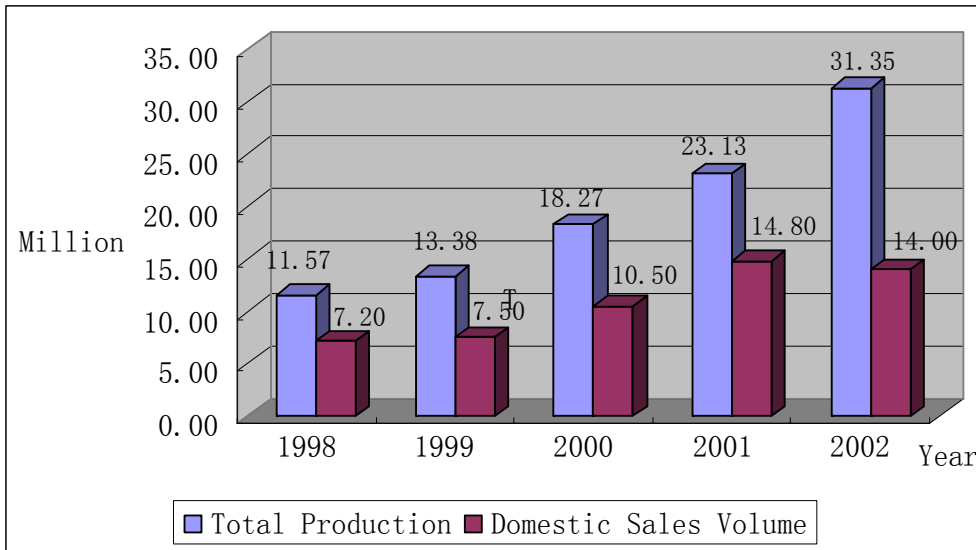


Figure B-1. Total Production and Domestic Sales Volume of ACs in China, 1998-2002

Source: Data of All China Marketing Research Co., Ltd.

The gross industrial output and the sales income of China's air conditioners industry have also experienced an uninterrupted development and growth. The most prominent rise has happened to the year 2001, in which the gross industrial output and sales income jumped by 53.7% and 60.5% separately compared to 2000. China's sales income in 2001 makes up 17% of the global market, third only to the United States and Japan. In 2002, however, the sales income just increased by 0.9% compared to 2001 although the gross industrial output still jumped by 36.5% compared to 2001. Figure B-2 shows the gross industrial output and the sales income for each year of the period 1998-2002.

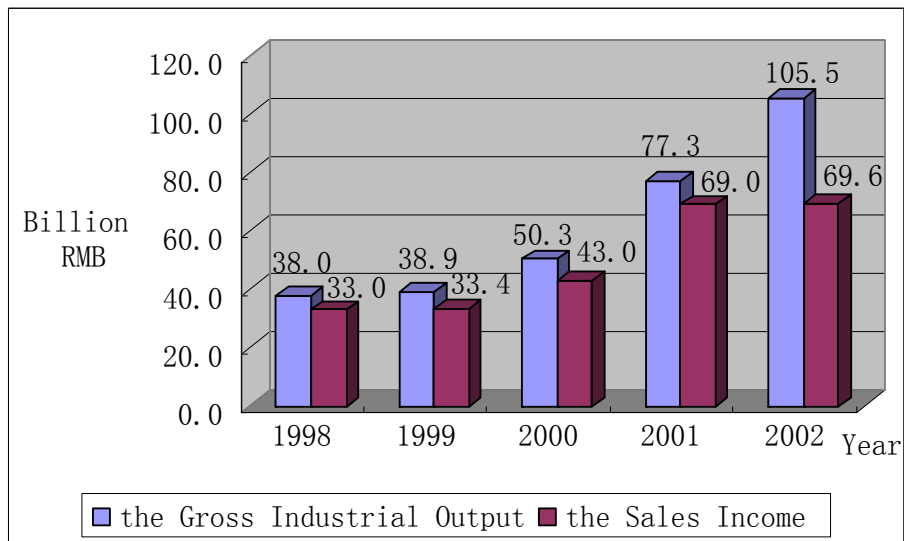


Figure B-2. Gross Industrial Output and Sales Income for China's AC Industry, 1998-2002

Source: Data of All China Marketing Research Co., Ltd.

EXPORT AND IMPORT²⁵

Export Status

Coupled by the ceaseless expansion of our domestic market, the export of Chinese air conditioners has never desisted from a continual increase at a large rate annually. The export volume of air conditioners totalled 2.017 million in 1999, 3.870 million in 2000, 6.502 million in 2001 and 9.788 million in 2002, whose export volume saw a rise of 50% over 2001. The export value rose up to \$ 0.485 billion in 1999, \$0.797 billion in 2000, \$1.129 billion in 2001 and \$1.428 billion in 2002, whose export value experienced a jump of 26.5% over 2001. The export value of air conditioners has been witnessing an ever-increasing share of the total export value of those household appliances. Figure B-3 shows the export volume and export value for each year of the period 1998-2002.

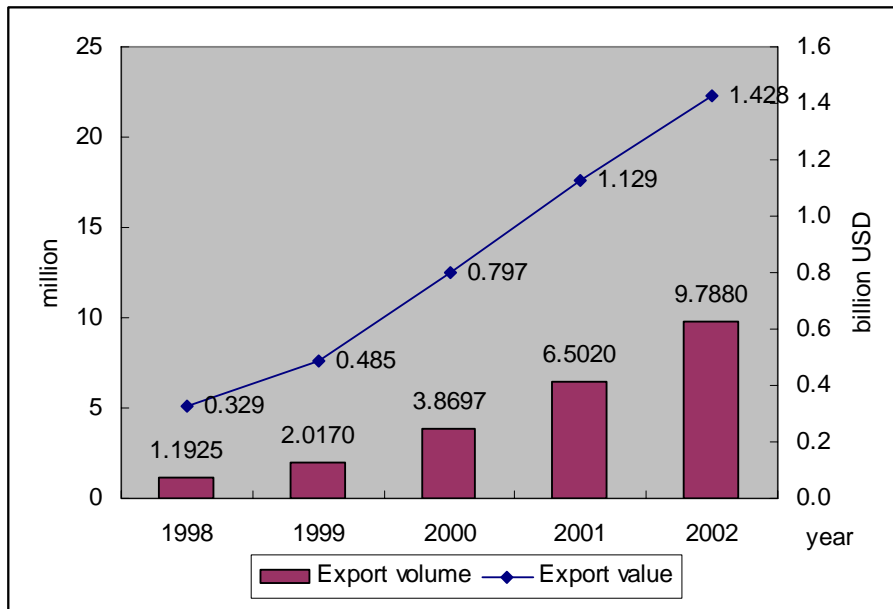


Figure B-3. Export Volume and Value for China ACs, 1998-2002

Source: Data of All China Marketing Research Co., Ltd.

In 2002 single-packaged air conditioners (window or wall types), with an export volume of 4.49 million which accounts for 45.86% of the total export volume of air conditioners, played a main role in Chinese air conditioner export. Table B-1 show the export volume and export value of various types of air conditioners in 2002.

²⁵ The original data for this section is from China Custom Annual Statistics, in which fan heaters are included. So fan heaters have also been incorporated in this section. Please note this statistical difference between this section and the rest of the report.

Table B-1. Export Volume and Export Value for Chinese ACs in 2002

Products		export volume		export value	
		Quantity (million)	percentage	Quantity (billion \$)	percentage
Cooling Only	Single-packaged	4.4886	45.86%	0.533	37.32%
	Split	1.6329	16.68%	0.35	24.51%
With Cooling-Heat Valve		1.4124	14.43%	0.318	22.27%
Other Air Conditioners		0.5436	5.55%	0.099	6.93%
Fan Heaters		1.7104	17.47%	0.128	8.96%
Total		9.7879	100%	1.428	100%

Source: Data of All China Marketing Research Co., Ltd.

Chinese air conditioners export mainly boxed their way into Europe, America and Southeast Asia, among which the U.S. and Japan were the most important export markets. Figure B-4 describes the details.

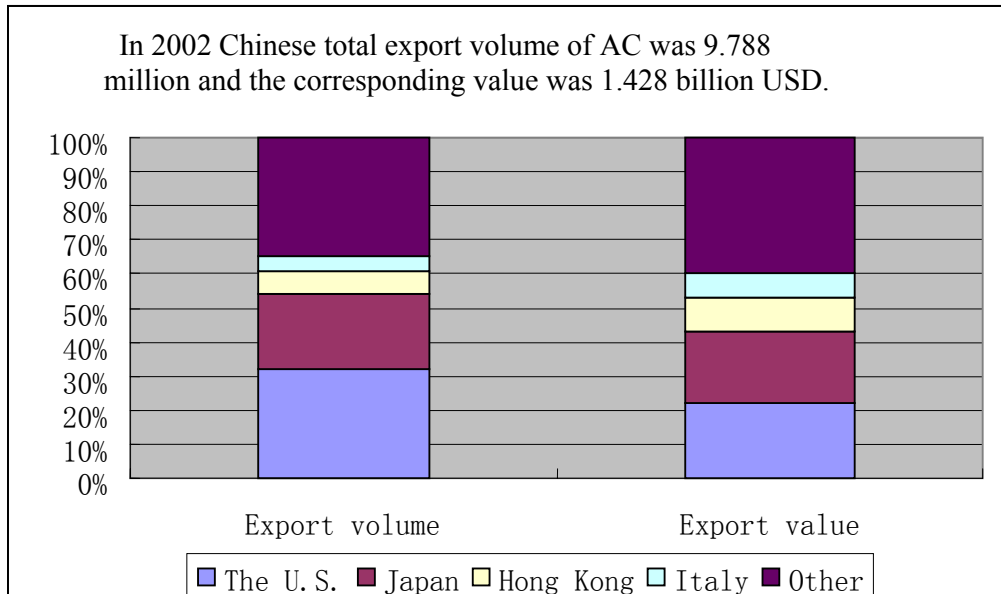


Figure B-4 Main Export Markets for Chinese Air Conditioners, 2002

Source: Data of All China Marketing Research Co., Ltd.

Import Status

There has come a corresponding rise in the demand for import while the domestic market has an inflated demand for the air conditioners. The demand for import reached its summit in 1999 and experienced a gradual decline since then. The import value of the air conditioners rose by 77% in 1999 when compared to 1998, but dropped by 5.9% in 2000 when compared to 1999. The import value totalled \$0.128 billion in 2001 and \$0.136 billion in 2002. It's estimated that the recent years to come won't see any huge variation in the air conditioners import of China. Figure B-5 shows the import volume and import value for each year of the period 1998-2002.

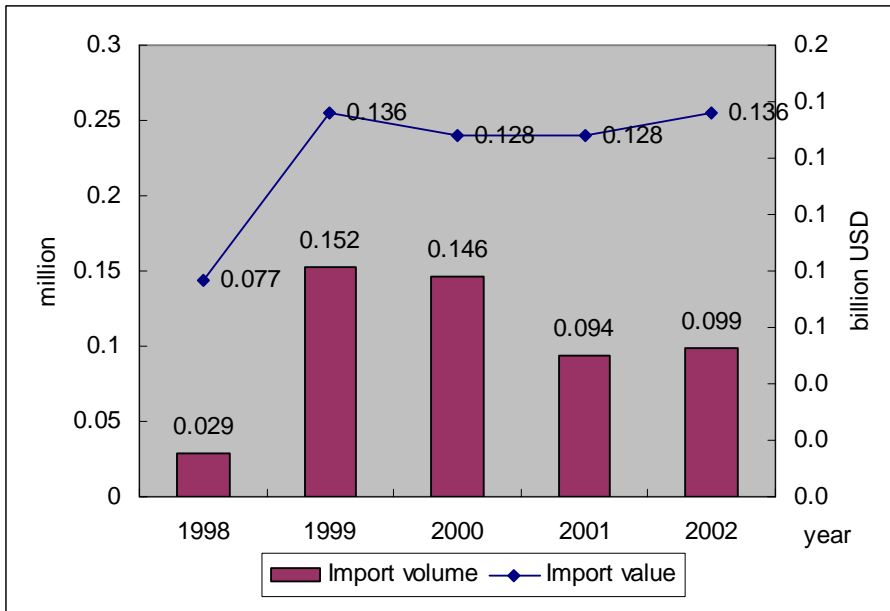


Figure B-5 Import Volume and Value for China ACs, 1998-2002

Source: China Custom Annual Statistics

Table B-2 Import Volume and Import Value of Various Types of Chinese ACs in 2002

Products		import volume		import value	
		Quantity	percentage	Quantity (million \$)	percentage
Cooling Only	Single-packaged	763	0.77%	0.717	0.53%
	Split	8631	8.75%	11.632	8.53%
With Cooling-Heat Valve		18671	18.93%	51.668	37.91%
Other Air Conditioners		12480	12.65%	44.445	32.61%
Fan Heaters		58098	58.90%	27.842	20.43%
Total		98643	100%	136.304	100%

Source: Data of All China Marketing Research Co., Ltd.

Chinese mainland mainly imported air conditioners from Japan, the U.S. and China Hong Kong, from which the import volume accounted for 67% of the total import volume. Figure B-6 describes the details.

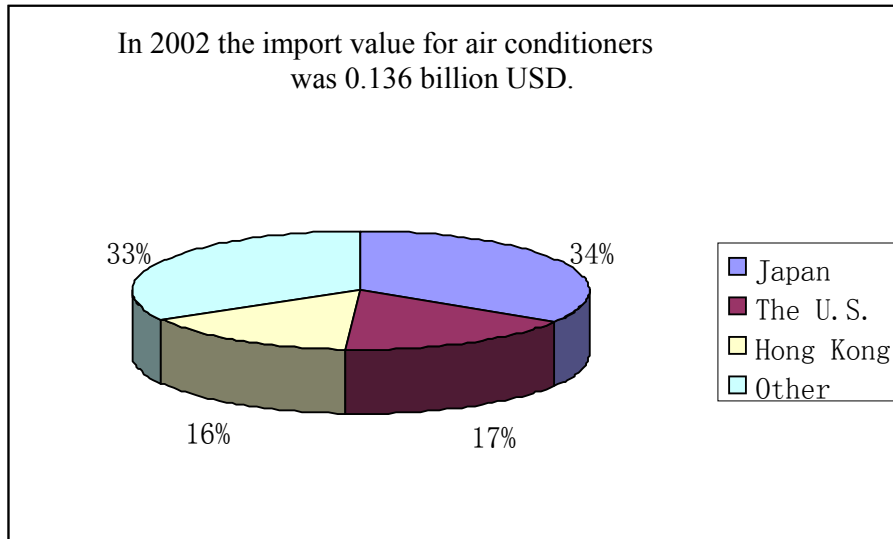


Figure B-6. Main Sources of China's AC Imports, 2002

Source: Data of All China Marketing Research Co., Ltd.

MARKET BREAKDOWN

The air conditioners in China market have grown in their type from the pure window-type air conditioners to split air conditioners, floor-standing air conditioners, central household air conditioners and others. Based on an investigation and analysis of market breakdown on various types of air conditioner sales in China market (see Figure B-7), wall-mounted split air conditioners still controlled over half of the market with a market share of about 67% in the total household air conditioner sales. Cabinet air conditioners' market share is continuously increasing by entering into common families. While Window air conditioner has only a shrunk market share of 10%, which indicates its retreating from the market. In contrast, China's sales of central air conditioners increased quickly and totalled \$846 million in 2002, according to the official Xinhua news agency, and the figure is expected to increase by more than 15% annually in the coming years.

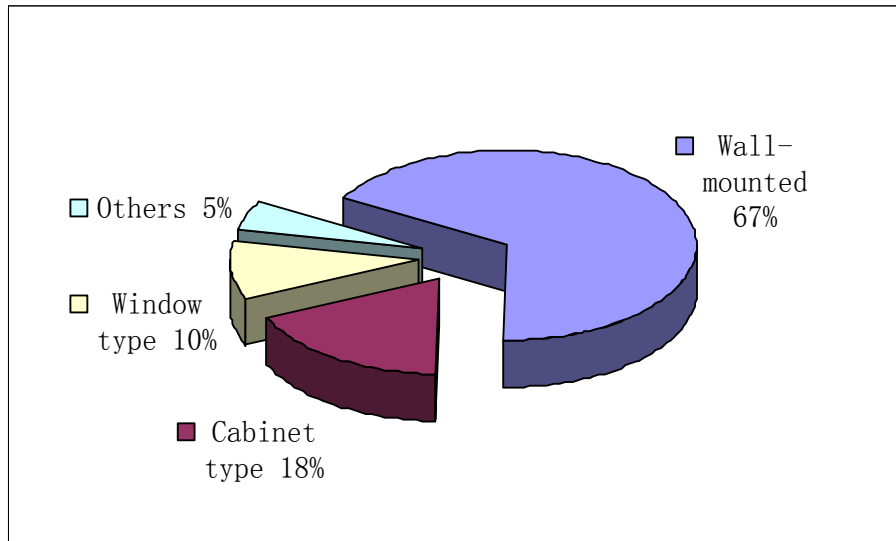


Figure B-7 Market Breakdown of China AC Sales, 2000

Source: the State Council Development and Research Center

The recent years have seen several changes, as indicated below, on the demand of various types of air conditioners:

- demand for window air conditioners is shrinking;
- demand for wall-mounted split air conditioners is steadily rising;
- demand of cabinet air conditioners is small in absolute terms, but rapidly increasing; and
- demand for household central air conditioners is going up quickly, which will no doubt become a new focus in near future.

According to the China Household Electric Appliance Association (CHEAA), Chinese overall market capacity for air conditioners in 2001 was 14.8 million. The market share by brand categories that year are presented in Figure B-8. there were 3 well-known brands controlling over 40% of the market: Gree 格力, Midea 美的, and Haier 海尔. A wave of other domestic brands also stood important positions, with Kelon 科龙, Chunlan 春兰, AUX 奥克斯, Hisense 海信, Changhong 长虹 and Xinke 新科 piling onto the market in a race for the large but dwindling profit margins.

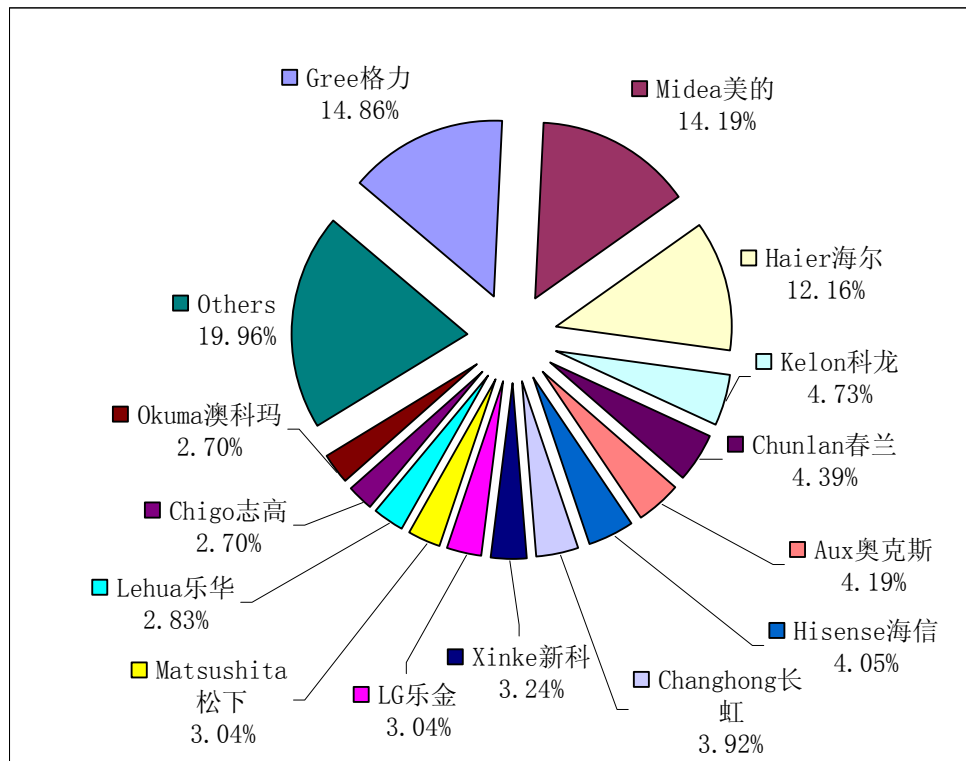


Figure B-8 Market shares by brand categories

Source: the China Household Electric Appliance Association (CHEAA)

Primary Manufacturers

According to an incomplete statistic there are now nearly 400 manufacturers having officially registered for air conditioners production in China, among which over 130 manufacturers mainly produce large industrial or commercial air conditioners equipments and units, and the others focus on producing household air conditioners. Of all the air conditioner manufacturers nearly 70% are new built in recent years, among which nearly 70% are assemblers.

The tremendous increase enjoyed by the air conditioners industry in 2001 can be attributable mainly to an expansion in the manufacturing volume of this industry as a whole. According to the National Statistic Bureau, within no more than two years all the state-owned enterprises of this industry as well as the enterprises of other categories with an annual sales income of more than RMB 5 million have rocketed up from 195 in 2000 to 248 in 2001 and to 259 in 2002. Of these air conditioners manufacturers, the large-sized enterprises with an annual sales income of more than RMB 50 million have risen up to 102 in number. In the meantime, those foreign-funded enterprises have also expanded. Given the geographical distribution of all these 259 enterprises, most of the air conditioners manufacturers are found in Guangdong Province and East China, and the new enterprises are chiefly concentrated on Guangdong, Zhejiang and Jiangsu.

Of the top ten air conditioner manufacturers (see Table B-3) in terms of sales income in 2002, domestic brands occupy five positions and the others are joint venture brands. In 2001 domestic brands just occupied 3 positions, which also show an increasing importance of domestic manufacturers in the Chinese air conditioner industry.

Table B-3. Top Ten Chinese AC Manufacturers in 2002

No.	Manufacturer Name	Sales income (Thousand RMB)
1	Guangdong Midea Holding Co., Ltd.	13189680
2	Gree Electric Appliances, Inc. of Zhuhai	6603089
3	LG Electronics Tianjin Appliances Co., Ltd.	5111519
4	Guangdong Chigo Air-conditioning Co., Ltd.	2667451
5	Guangzhou Matsushita Air conditioner Co., Ltd.	2542067
6	Ningbo AUX Air Conditioner Co., Ltd.	1965962
7	Shanghai Sharp Electrics Co., Ltd.	1857126
8	Jiangsu Chunlan Refrigeration Co., Ltd.	1660060
9	Matsushita-Wanbao (Guangzhou) Compressor Co., Ltd.	1602009
10	Guangdong Midea Holding (Wuhu) Air Conditioner Co., Ltd.	1507816

Note: Only the manufacturers with main business of air conditioner production are included here.

Source: Data of All China Marketing Research Co., Ltd.

In the year 2001, since OEM suppliers of the joint ventures claimed an increase in their volume of production and sales, their concentration of production dropped to some degree. Of all the air conditioners manufacturers, those top five enterprises shrank in percentage from 52.5% in 2000 to 49% in 2001. Over half of the total export of air conditioners was secured by the production bases that have been established in China by those multinationals.

PRIMARY SALES CHANNELS

The primary sales channels for air conditioners in China market are shown in Figure B-9. These channels are (1) large-sized department store, (2) single-brand store, (3) departmentalized specialty store for electric appliances, (4) electric appliance chain store, and (5) air conditioner specialty store.

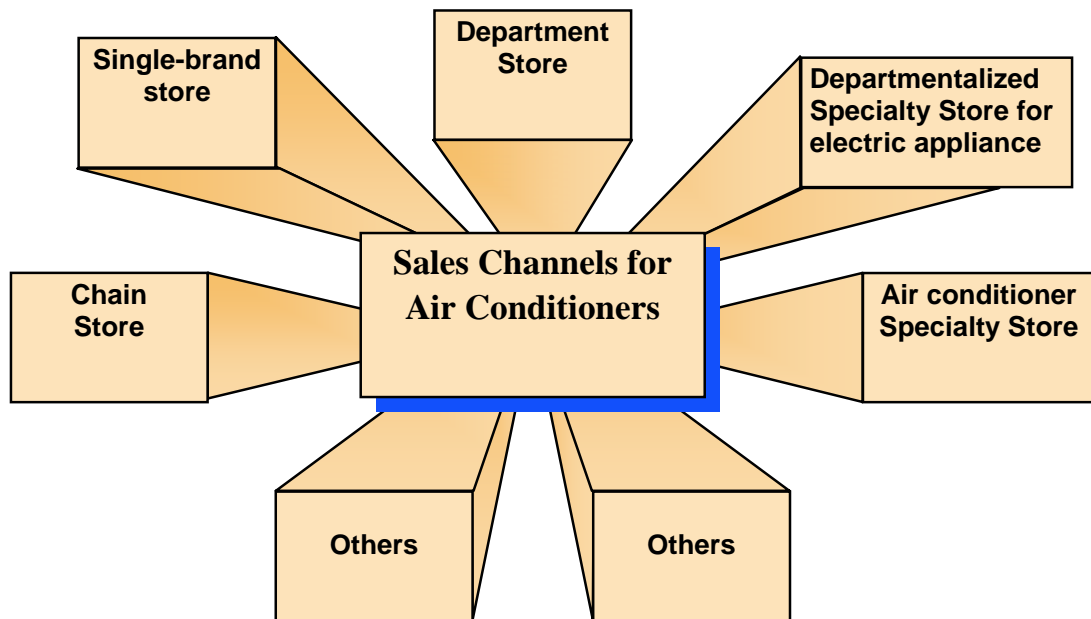


Figure B-9. Primary Sales Channels for Air Conditioners in China

A large-sized department store usually owns large customer flow and high credit standing, which facilitate brand promotion. Some department stores have retreated from the business of household electric appliances for a reason of low profit margin, however some other department stores have strengthened the business in order to increase the total sales income and improve their influence. Generally the household electric appliances sold in a department store are organized into separate departments due to different brands. In each separate department some sales promotion persons assigned from the corresponding manufacturer will be working there.

A single-brand store is helpful to fully demonstrate brand products, improve brand image, and promote brand sales. Now a single-brand store has been the biggest sales channel for many large domestic air conditioner manufacturers. For example, Chunlan 春兰, Gree 格力, Midea美的, Kelon 科龙, Huabao 华宝, Changhong 长虹, and etc have all gradually retracted from department stores and in stead invested much to build their own sales and distribute network in central cities over the whole country so as to strengthen their brand power.

An investigation conducted by Beijing Research Center for Chinese Enterprisers shows that the general gross profit margin of a single-brand specialty store is about 3%-10%, while that of a department store is about 10%-18%, which may contribute the most important reason for manufacturers to entrust single-brand specialty stores to sell their brand products. The investigation also shows that not only domestic famous brands but also imported brands as well as joint venture's brands prefer to such a sales channel.

Departmentalized specialty stores for electric appliances exist in China in two different forms: one is that the store is an independent unit with unitary promotion activities and organized in the same way as a department store but just handing a business of electric appliances; the other one is that the store is

comprised of over 20 separate electric appliance departments and the store itself is just responsible of rent charging and logistic management. Now such a type of store has been built all over the country and has strong sales power.

Electric appliance chain store system is a group of retail stores of essentially the same type, centrally owned and with some degree of centralized control of operation, which only focus on the sales business of electric appliances. Guomei 国美 and Suning 苏宁 are examples of this type. Electric appliance chain stores usually promise a sales base so that manufacturers will offer them the most preferential prices. Generally customers can find relatively low prices in chain stores. So electric appliance chain stores have the strongest competitive price compared with other sales channels for air conditioners.

An air conditioner specialty store usually has a mall size and runs an exclusive business. It only caters to narrowly defined core customers who are interested in purchasing air conditioners.

The Economic Research Institute of the State Council Development and Research Center has conducted an investigation which shows that large-sized department stores, single-brand stores as well as electric appliance chain stores, have become the most important channels for customers to purchase air conditioners. The sales share of each is presented in Table B-4.

Table B-4 Sales Share of Each Primary Sales Channel in China

Sales Channels	Sales share (%)
Large-sized department stores	41.1
Single-brand stores	31.2
Electric appliance chain stores	20.9
Total	93.2

Source: the State Council Development and Research Center

The investigation also show that the primary sales channels for air conditioners over the whole country are similar, all focusing on the three types mentioned above, although in the east of China, large-sized department stores have the most encouraging sales income which account for over 50% of the total regarding air conditioner products, while in the southwest of China single-brand stores play a most arresting role. Table B-5 describes the details.

Table B-5 Sales Share of Each Primary Sales Channel in China, by Area

Areas	The sales share of each primary sales channel by areas (%)			
	Department Store	Chain Store	Single-brand store	others
Northeast	46.9	17.6	30.4	5.1
North	44.8	20.4	30.7	4.1
East	51.3	20.5	22.8	5.4
Central South	37.8	23.7	30.6	7.9
Northwest	40.7	15.7	37.4	6.2
Southwest	25.3	27.2	35.6	11.9

Source: the State Council Development and Research Center

RELATIVE EFFICIENCY LEVELS

Many countries in the present-day world all have their own regulations for energy efficiency. The air conditioner enterprises in China which are now joining up with the world must follow the road of high-efficiency, energy-saving and environment protection. In 1989, China's State Bureau of Technical Supervision issued the first set of standards related to energy efficiency. They developed minimum efficiency standards for 8 types of products, in which air conditioners are included. As a result, by the March of 2001 such a minimum efficiency standard for air conditioners has eliminated nearly 15% of the low efficiency products off the market, and energy efficiency of air conditioner increased by 10% (Cheng Jianhong and Li Aixian, China National Institute of Standardization (CNIS), 2001).

The revised Chinese minimum efficiency standard for room air conditioners became effective in 2001. Table B-6 summarizes the efficiency requirements by product categories. For the most popular product category with a cooling capacity between 2500 to 4500 watts, the revised standard raised the minimum EER from 2.26 to 2.45, a gain of 8%. This is a very modest improvement. It is known from the China National Institute of Standardization (CNIS) that the minimum EER will be justified and improved in 2004 given a combination of available technical options, such as more efficient compressors and improved fin and tube design for the heat exchangers, are being adopted in the air conditioner industry.

Table B-6 Efficiency Requirements in China, by Product Category

Type	Cooling Capacity (W)	EER (W/W)	
		Cooling Only	Heat Pump
Single-Package	CC ≤4500	2.20	2.15
	CC >4500	-	-
Split	CC ≤2500	2.50	2.40
	2500 < CC ≤ 4500	2.45	2.35
	4500 < CC ≤ 7100	2.40	2.30
	CC > 7100	2.30	2.25

Besides the minimum energy efficiency standards, China also developed Voluntary Endorsement Labeling Programs for air conditioners. China Certification Center for Energy Conservation Products

(CECP) formalized a comprehensive system of certification requirements and procedures, under which an endorsement label would be granted to products that meet both the quality assurance and energy performance specifications²⁶. From 2000 until now, CECP has granted its energy efficiency label to 554 models of air conditioners from 25 manufacturers. According to CECP's estimate, labeled air conditioners consume 10%-20% less electricity on average than non-labeled products.

Chinese current average EER of air conditioners is only 2.6, which is far below that of developed countries. There exists a great potential to improve it in the near future.

As learned recently from a workshop on the air conditioners in China organized by the Chinese Consumers Association some air conditioner enterprises began to put forward a conception for updating the EER, advocating that the development of air conditioner should toward environment protection, energy-saving and comfortableness. They are now vying with one another in optimizing the design of refrigerating and heating system by adopting new technology and workmanship in order to update the level of efficiency and performance quality of air conditioner as a whole.

²⁶ Tailored to China's appliance market conditions, CECP has added stringent requirement for quality assurance for manufacturers that is similar to internationally compatible standards (such as ISO 9000), in addition to product efficiency specification, as part of its certification requirement.

APPENDIX C: KOREA MARKET OVERVIEW

INTRODUCTION

This report covers the initial data on the overall market picture of household and small commercial air conditioner in Korea. It includes market overview, shop survey, Collect Catalogue data, and Collect test data as DEM requested. All data were collected from recent reports, recent statistics and direct interviews.

MARKET OVERVIEW

Primary sales channels (including types of stores where ACs are sold)

There are three primary sales channels:

- Department Store (25%)
- Electronic Specialty Store (35%)
- Hypermart (30%)
- Others (10%)

MARKET SIZE (SALES AND VALUE);

The domestic total market (exclude car air conditioner) from 2000 to 2002 is shown in Figure C-1. From 2000 to 2002 the total domestic market has increased apparently every year, the domestic market has recovered after economic crisis. In 2002 it was 1.08 million units, and US\$ 37.4 M (KRW 452,593 M). Tables C-2 to C-4 also show production, and export by each manufacture; however, these tables do not include the small manufactures, because their market share is under 2% in total market.

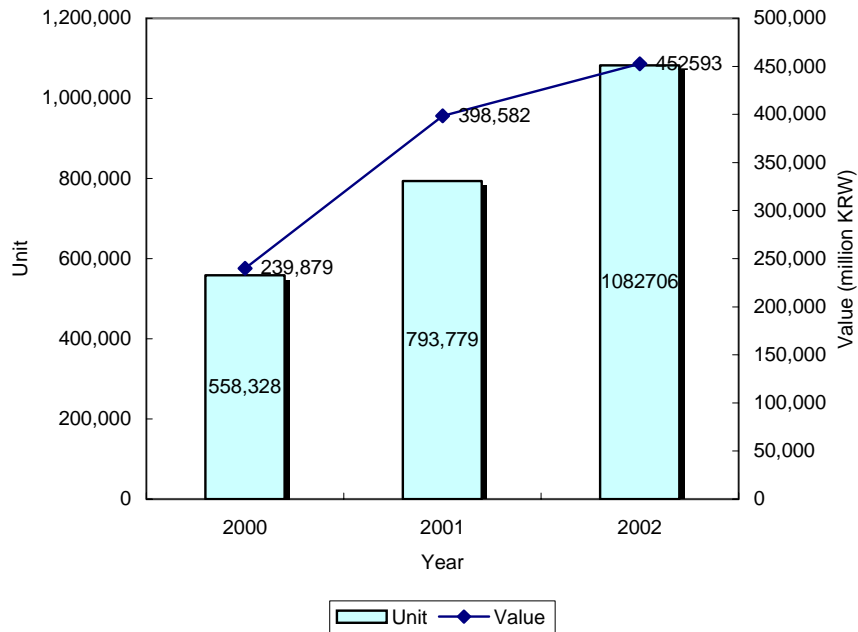


Figure C-1. Air conditioner Sales and Value for Korean Domestic Market

Manufacture and Distribution of ACs in Korea

Table C-1 lists manufacturers, assemblers, and distributors, active in Korea.

In Korea there are two big manufactures, LG and SAMSUNG, which occupy over 70 % of the domestic market, and others(DAEWOO, Carrier, Winia Mando, Bumyang, Century, and imported) occupy the rest. It is very interesting thing that the imported products have very weak competition in Korean market, even large Japanese manufacturers (see Tables C-2 to C-4).

Table C-1. List of Korean AC Manufacturers, Assemblers, and Distributors

Manufacturer	Assemblers	Distributor
Daewoo Electronics	Daehan HVAC	Hanchang
Winia Mando Inc.	Hankook Metal Co., LTD	Hi-Mart (Mitsubish)
Bumyang Air-Conditioning Co.	Bumyang World Airconditioning	Trane Korea
Samsung Electronics Co.	Hebsiba	Doosan
Carrier	Human tech	
LG Electronics Inc.	Namji	
Ranee Corp.	Rinnai Korea Corp.	
Tempia	NaNa Ref.	
<i>8 Manufacturers</i>	<i>8 Assemblers</i>	<i>4 and more</i>

Relative importance of import and exports

Korea air conditioner manufactures export over 80% of their production in 2002, because a small domestic market is not enough to satisfy their production capability. Tables C-2 to C-4 show export by each manufacturer from 2000 to 2002. Compared with export import is very small, it is under 10% of export, which means Korean manufactures have a strong competition in air-conditioner market.

Primary export markets and import sources

Table C-5 and Table C-6 show primary export market and import source. The United States is the biggest export market, they are over 34% of all export, and china is the primary import source, which a lot of part of import come from Korean manufactures to produce in China.

Table C-2. Korean AC Production, Shipment, and Exports in 2000

< 1US\$ = 1210 KRW >

Model	Manufacturer	Production		Shipment (Domestic)		Export	
		Unit	Value (million KRW)	Unit	Value (million KRW)	Unit	Value (million KRW)
RAC	Total	6,385,462	1,678,080	558,328	239,879	5,326,554	1,293,220
Window RAC	Sub Total	3,494,302	641,769	41,201	9,825	3,385,604	606,277
	Daewoo Electronics	45,028	13,081	15	4	41,715	12,152
	Carrier	203,274	48,343	5,186	1,264	98,889	21,525
	Samsung Electronics Co.	1,013,000	179,345	13,000	3,157	987,000	171,500
	LG Electronics Inc.	2,233,000	401,000	23,000	5,400	2,258,000	401,100
Split RAC	Sub Total	2,789,160	972,611	488,127	217,054	1,878,950	644,643
	Winix	500	212	500	250	0	0
	Daewoo Electronics	25,578	8,454	15,554	5,687	5,341	2,452
	Carrier	834,082	145,008	60,073	13,141	410,609	98,906
	Winia Mando Inc.	66,000	50,400	36,000	38,400	30,000	16,800
	Samsung Electronics Co.	796,000	312,837	177,000	74,876	586,000	222,385
	LG Electronics Inc.	1,067,000	455,700	199,000	84,700	847,000	304,100
RAC (Both heating and cooling)	Sub Total	0	0	0	0	0	0
	Daewoo Electronics	0	0	0	0	0	0
	Samsung Electronics Co.	0	0	0	0	0	0
	LG Electronics Inc.	0	0	0	0	0	0
Multi RAC	Sub Total	102,000	63,700	29,000	13,000	62,000	42,300
	LG Electronics Inc.	102,000	63,700	29,000	13,000	62,000	42,300

Table C-3. Korean Production, Shipments, and Exports in 2001

< 1US\$ = 1210 KRW >

Model	Manufacturer	Production		Shipment (Domestic)		Export	
		Unit	Value (million KRW)	Unit	Value (million KRW)	Unit	Value (million KRW)
RAC	Total	6,036,427	2,042,728	793,779	398,582	4,758,998	1,540,796
Window RAC	Sub Total	3,175,494	675,222	56,819	13,314	2,816,709	624,741
	Daewoo Electronics	29,293	7,324	2,529	643	40,534	10,123
	Carrier	51,769	30,429	1,787	854	51,787	30,075
	Samsung Electronics Co.	615,000	152,329	19,000	4,548	645,000	157,116
	LG Electronics Inc.	2,479,432	485,140	33,503	7,269	2,079,388	427,427
Split RAC	Sub Total	2,282,902	1,041,479	664,961	327,439	1,448,699	653,337
	Daewoo Electronics	32,126	12,211	28,498	10,181	5,190	2,624
	Carrier	216,084	104,121	34,696	13,941	189,789	92,088
	Winia Mando Inc.	277,000	196,659	142,000	119,322	135,000	77,337
	Samsung Electronics Co.	416,000	181,617	218,000	89,915	217,000	85,458
	LG Electronics Inc.	1,341,692	546,871	241,767	94,080	901,720	395,830
RAC (Both heating and cooling)	Sub Total	336,439	143,020	0	0	356,479	153,928
	Daewoo Electronics	11,439	5,596	0	0	11,479	5,615
	Carrier	0	0	0	0	0	0
	Samsung Electronics Co.	325,000	137,424	0	0	345,000	148,313
	LG Electronics Inc.	0	0	0	0	0	0
Multi RAC	Sub Total	241,592	183,007	71,999	57,829	137,111	108,790
	Sewon-Giyeon Co.	14	472	14	472	0	0
	Century	24	14	24	14	0	0
	Daewoo Electronics	3,200	1,475	0	0	3,200	1,475
	Samsung Electronics Co.	23,000	24,274	16,000	16,965	6,000	7,257
	LG Electronics Inc.	215,354	156,772	55,961	40,378	127,911	100,058

Table C-4. Korean Production, Shipment, and Export in 2002

< 1US\$ = 1210 KRW >

Model	Manufacturer	Production		Shipment (Domestic)		Export	
		Unit	Value (million KRW)	Unit	Value (million KRW)	Unit	Value (million KRW)
RAC	Total	6,472,678	2,082,420	1,047,606	452,593	5,316,257	1,539,011
Window RAC	Sub Total	3,209,025	675,238	23,583	34,180	3,116,135	648,316
	Daewoo Electronics	51,145	14,460	2,314	515	55,860	16,208
	Samsung Electronics Co.	488,000	125,996	14,000	3,482	491,000	126,808
	Carrier	69,880	20,334	3,369	735	69,275	20,300
	LG Electronics Inc.	2,600,000	514,448	3,900	29,448	2,500,000	485,000
Split RAC	Sub Total	3,074,653	1,207,114	929,023	322,600	2,100,122	825,383
	Daewoo Electronics	48,291	19,920	34,547	10,646	13,675	7,566
	Winia Mando Inc.	205,504	145,900	138,652	81,400	90,852	40,500
	Bumyang Air-Conditioning Co.	2,600	1,250	2,600	1,250	0	0
	Samsung Electronics Co.	872,000	370,929	312,000	111,494	551,000	225,853
	Carrier	546,258	119,115	101,224	18,810	444,595	100,464
	LG Electronics Inc.	1,400,000	550,000	340,000	99,000	1,000,000	451,000
	RAC (Both heating and cooling)	Sub Total	0	0	0	0	0
Multi RAC	Daewoo Electronics	0	0	0	0	0	0
	Samsung Electronics Co.	39,000	60,068	25,000	40,813	10,000	10,312
	LG Electronics Inc.	150,000	140,000	70,000	55,000	90,000	55,000
	Sub Total	189,000	200,068	95,000	95,813	100,000	65,312

Table C-5. Primary Korean Export Markets in 2002

Rank	Economy	Export	
		Unit	Value (US\$ 1,000)
1	United States	1,844,463	256,796
2	Australia	306,703	73,108
3	Italy	276,863	54,401
4	Spain	259,165	53,730
5	Hong Kong	178,439	29,497
6	Japan	92,848	8,001
7	Germany	73,517	18,418
8	France	43,721	12,806
9	China	20,599	2,040
11	United Kingdom	13,278	6,228

Table C-6. Primary Sources of Korean AC Imports in 2002

Priority	Economy	Export	
		Unit	Value (US\$ 1,000)
1	China (Korean manufacture)	24,290	2,423
2	Japan	20,481	17,870
2	United States	723	1,111
3	Italy	180	136
4	Hong Kong	164	65
5	Germany	103	41
6	Australia	102	147

Market breakdown for window and split type air conditioners

As shown in Tables C-2 to C4, we can find a tendency Korean market is fully oriented to split type air conditioners, window type is only 2.3% of the total market (unit) in 2002. On the other hand split type air conditioner is over 88% in 2002, and new type air conditioner, multi system air conditioner which has one outdoor unit and several indoor units has come out the market, its production has increased dramatically

Relative efficiency levels

Table C-7 shows the new MEPS on air conditioner from 2004, it is much stronger than before, and also one of the highest level in APEC economies.

Table C-7. Korean MEPS Levels for ACs

Type	MEPS (kW/kW)	
Window type	2.88	
Split type	RCC < 4.0 kW	3.37
	4.0 kW ≤ RCC < 10.0 kW	2.97
	10.0 kW ≤ RCC < 17.5 kW	2.76

Remark : RCC = Rated Cooling Capacity

SHOP SURVEY

Retail data are collected through a survey of 20 stores that sell AC in Korea. Data of 10 stores in Seoul and 5 each in two big cities, Busan and Incheon are collected from 5 Jan. 2004 to 14 Jan. 2004. They are collected through 7 Department stores, 11 Electronic specialty stores, and 2 Hypermarts totally. All data are coming from direct interview and survey in all stores.

Unfortunately it is a winter season in Korea, we found only a few models in each stores. If it is in summer season, we can collect more data from all stores. It is not easy to find a window type air conditioner in winter season, all data from shop survey are split type.

Incheon

Introduction

A gateway to Northeast Asia with both international port and international airport in its hand, Incheon is located in the mid-west Korea peninsula abutting the Yellow Sea. A city located 28km from the nation's capital, Seoul, lies at 126° 37' of east longitude and 37° 28' of north latitude. San Francisco, Washington, Madrid, and Teheran are found on the same latitude. The local GNP for Incheon is 25 trillion 517.7 billion, 4.7% of the national GNP. More than 1.2 million people in the region are participating in various economic activities. Incheon was then changed to a metropolitan city on January 1, 1995. On the following March 1, the entire area of Ganghwa-gun County and Ongjin-gun County as well as Geomdan-myeon of Gimpo-gun County was added to the Incheon Metropolitan City.

The current administrative unit covers a total area of 986.45km², or 0.98% of the entire South Korea. It is made of eight districts, two counties, and 137 smaller units, including eup, myeon, and dong. As of December 2002, the city has a total population of 2,596,000 with more than 872,000 households. Incheon is now rapidly developing into the third largest city in Korea, with Seoul and Busan being the first and the second largest, respectively.

Survey Stores

Survey was conducted from 5 stores, 1 hypermart, 1 department store, 3 Electronic specialty stores. Survey stores are

- E-mart Hypermart, 3-1, Gusan-dong, Bupyeong-gu, Incheon
- Lotte Department Store, Kuwol-dong, Namdong-gu, Incheon
- Songnae Hi-mart Electronic Specialty Store, 3-1, Gusan-dong, Bupyeong-gu, Incheon
- Kesan Hi-mart Electronic Specialty Store, 1066-2, Kesan-dong, Keyang-gu, Incheon
- Jooan Hi-mart Electronic Specialty Store, 1523-2, Jooan-dong, Nam-gu, Incheon

Seoul

Introduction

As the capital of Korea Seoul is the center of South Korea, the hub of the nation's government, economy, education and culture. Thus, it's where everyone wants to be, and the city's population has grown from less than 1 million shortly before World War II to nearly 10 million today. That growth helped Seoul become a major player in the world economy, but its rapid expansion hasn't come without a price. The Gross Regional Domestic Product (GRDP) of Seoul in 1996 was about 92 tril. won, which accounts for some 23.7% of the GNP of 388 tril. won. The per capita GRDP of Seoul citizens is about 8.5 million won.

Seoul has a population of 10,280,523 as of the end of 2002. This accounts for about a quarter of the total national population. As for the proportion of male to female excluding foreigners, men (5,108,964) slightly outnumber women (5,098,331).

Survey Stores

Survey was conducted from 10 stores ; 1 hypermart, 4 department stores, 5 Electronic specialty stores. Survey stores are

- Kyungbang-phil Department store, 441-2, 4ga, Youngdeungpo-dong, Youngdeungpo-gu, Seoul
- Bongcheon Hi-mart Electronic Specialty Store, 869-7, Bongcheon 4-dong, Kwanak-gu, Seoul
- Shinrim Hi-mart Electronic Specialty Store, 1428-9, Shinrim-dong, Kwanak-gu, Seoul
- Shinchon Hyundai Department store, Shinchon30-33, changcheon-dong, Seodaemuin-gu, Seoul
- Chamsil Lotte Department store, 40-1 Chamsil-dong, Songpa-gu, Seoul
- Kumcheon Hi-mart Electronic Specialty Store, 1055-21, Doksan-dong, Kumcheon-gu, Seoul
- Sadang Hi-mart Electronic Specialty Store, 1007-46, Sandang-1dong, Dongjak-gu, Seoul
- Samsung Hi-mart Electronic Specialty Store, 168-12, Samsung-dong, Kangnam-gu, Seoul
- Kurogongdan E-mart Hypermart, 188-26, Kuro-3dong, Kuro-gu, Seoul
- Shinsegae Department store, 434-5, 4ga, Youngdeungpo-dong, Youngdeungpo-gu, Seoul

Busan

Introduction

Busan, a bustling city of 4 million residents, and the second largest city, is located on the Southeastern tip of the Korean peninsula, and on the southeastern tip of the Korean Peninsula at 128° east longitude and 35° north latitude. It is an international city linking the continent and the sea. Busan is located on the same latitude as Tokyo, Kabul, Los Angeles, Memphis, Beirut and Algiers. Busan is about 8 hours and 37 minutes ahead of World Standard Time, and about 24 minutes behind Korean Standard Time.

The total budget of Busan for the 2000 fiscal year, including budgets for autonomous Gu (district) and Gun (county), was 4.234 trillion won. This includes general accounts of 2.821 trillion won and special accounts of 1.423 trillion won. The budget for the operation of city headquarters was 3.02 trillion won. The budget for self - governing Gu (district) was 1.16 trillion won and that for autonomous Gun (county) was 500 billion won.

Survey Stores

Survey was conducted from 5 stores ; 2 department stores, 3 Electronic specialty stores. Survey stores are

- Lotte Department Store, 503-15, Bujeon-dong, jin-gu, Busan
- Hyundai Department store, 62-5, Bumil-dong, donggu, Busan
- Suyoung Electro Land 21 Electronic Specialty Store, 1071-7, Kwangan-3dong, Suyoung-gu, Busan
- Dongrae Hi-mart Electronic Specialty Store, 1250-1, Oncheon-dong, Dongrae-gu, Busan
- Yeonsan Hi-mart Electronic Specialty Store, 105-51, Yeonsan-dong, Yeonje-gu, Busan

COLLECT TEST DATA

The consultants collected all testing data of air conditioner in Korea from 1997 to 2003, it includes all data with AC test data collection form provided by DEM. Data from 1997 to 2003 covered a total of 790 models. Data for 2003 alone covered a total of 88 models. Over 90% of all data come from KTL (Korea Testing Lab.), and others are provided by other testing lab.

All test data have to be registered, by reporting to KEMCO (Korea Energy Management Corporation) immediately after testing.

APPENDIX D: MALAYSIA MARKET OVERVIEW

INTRODUCTION

This report contains the findings from the air conditioner's market survey in Malaysia. The survey was carried out in December 2003 – January 2004 and includes data gathered from manufacturers and retail outlets by interviews and collection of catalogues, technical specifications and statistics.

MARKET OVERVIEW

Primary sales channels

All air-condition manufacturer and distributor uses the same channel of sales such as electrical stores, independent electrical outlets, air-condition specialists/contractors, department stores and hyper marts. However the largest players in this business are independent or chain electrical stores and air-condition specialists. Table D-1 below shows the percentage of distribution for air-condition market in Malaysia.

Table D-1. Primary Sales Channels in Malaysia

Primary sales channel	Type	Percentage
A	Electronic store, Department store, Hyper mart	78%
B	Specialists	22%
C	Others	-
Total outlets	2,200	100%

Source: Manufacturer interviews

Market Size

The total annual sales in the period July 2002 to June 2003 was around 200,000 in all Malaysia. More than 80% of the sales are in the in the range from 8000-15000 BTU, which is a common size for households. The annual turnover for the AC market was more than RM 68 million

Table D-2. Annual Sales of ACs in Malaysia, by Size (2002-2003)

Size (BTU)	Units	Percentage	Value	Percentage
0 – 7999	551	0.3	68,400	0.1
8000 – 10999	142,806	70.8	42,447,300	62.0
11000 – 14999	37,160	18.4	13,644,400	19.9
15000 – 19999	13,100	6.5	6,780,500	9.9
20000+	8,082	4.0	5,391,500	7.9
Unidentified	63	0.0	119,800	0.2
Total	201,762	100	68,452,200	100

Source: Manufacturer interview

Relative importance of import and exports

The majority (87.5%) of the AC's sold in Malaysia is of a brand with foreign origin. However a number of local manufacturers and assemblers of foreign brands exists and therefore the import of ACs are less than the figures for the origin of brand.

Table D-3. Origin of Malaysian AC Brands (2002-2003)

Country	Units	Percentage
Japan	106,428	52.7
Korea	30,122	14.9
Malaysia	25,158	12.5
China	10,189	5.1
China	10,189	5.1
US/Aust./NZ	29,158	14.8
China	10,189	5.1
Others	47	0.1
Total	201,762	100

Source: Manufacturer interview

As it can be seen from the import/export statistics only a few number of AC's are actually imported into the country. Thailand is the number one country of import, but the brands imported from Thailand are not of Thai origin, but e.g. Korean.

Table D-4. Air Conditioner Imports into Malaysia (1999)

Country	Units
Thailand	10,325
Rep. of Korea	1,215
Japan	785
Singapore	620
Peoples Rep. of China	466
Others	1,071
Total	14,482

Source: Dep. of Statistics, Malaysia – Malaysia Trade Statistics, 1999

More than 1.2 million ACs was exported in year 1999, where more than half was within the Asian region.

Table D-5. Air Conditioner Exports from Malaysia (1999)

Country	Units
Hong Kong	226,226
Singapore	131,591
Japan	111,165
Australia	87,128
Vietnam	85,929
Italy	68,625
United States of America	65,867
Finland	45,190
Greece	44,858
Rep. of Indonesia	32,506
Others	324,238
Total	1,223,323

Source: Dep. of Statistics, Malaysia – Malaysia Trade Statistics, 1999

Market breakdown for window and split type of air conditioners

The most popular AC type is Wall Mounted single split-type. This can easily be identified in all shops included in the survey. Every outlet displays this type of air-condition while other types has to be ordered by the outlet.

Table D6. Annual AC Sales in Malaysia, by Type (2002-2003)

Type	Units	Percentage
Window type	3,172	1.6
Single split type	193,940	96.1
Multi split type	8	0
Standing type	6	0
Ceiling type	4,636	2.3
Others	-	-
Total	201,762	100%

Another additional feature of air-condition is remote control. This feature also influenced the number of sales of air-condition in Malaysia.

Table D-7. Malaysian AC Sales, with without Remote Control (2002-2003)

Feature	Units	Percentage
With remote control	196,860	97.6
Without remote control	4,314	2.1
Unidentified	588	0.3

Market share of the largest manufacturers

A wide range of brands and models of air-conditioners exists on the Malaysian market. The biggest market players are Panasonic, formerly known as Panasonic and Nasional, York and LG. These three brands form 50% of the market. Panasonic alone has a market share around one-third of the total market.

Table D-8. Market Share of Largest Brands in Malaysia

Brand	Percentage
Panasonic	34.1
York	16.0
LG	9.9
Hitachi	8.7
Toshiba	5.0
I	3.4
Others	22.9
Total	100

Source: Manufacturer interviews

Relative efficiency levels

There are no rating and labelling scheme in place in Malaysia, and air conditioners are not so-called controlled items and no tests are required. Therefore data on efficiency are only available if the manufacturers prepare them voluntarily.

However most of the catalogues from the manufacturers includes some efficiency levels.

Table D-9 below shows the result of the Malaysian sample of air conditioners for which sales data and EER is stated or can be calculated.

Table D-9. Approximate AC Market Share in Malaysia, by Efficiency Level

Catalogue EER	Number of models	Market share
$EER < 10$	49%	24%
$10 \leq EER < 11$	19%	23%
$EER \geq 11$	32%	53%

Source: Manufacturer survey

Total number of manufacturers, assemblers and distributors

Table D-10. Malaysian AC Manufacturers

Brand	Manufacturer	Address
Panasonic	Matsushita Industrial Corporation Sdn Bhd (MAICO)	Lot 2, Persiaran Tengku Ampuan, Seksyen 21, Shah Alam Industrial Site, 40300 Shah Alam, Selangor
Hitachi	Hitachi Air-Condition Products (M) Sdn Bhd	10, Jalan Kemajuan, Kaw. Perindustrian Bangi, 43650 B. Baru Bangi, Selangor.
I	i-Berhad	3, Jalan Astaka U8/84, Section U8, Bukit Jelutong, 40150 Shah Alam, Selangor.
Carrier	Carrier (Malaysia) Sdn. Bhd.	Lot 877, Jalan Subang 9 Taman Perindustrian Subang, 47610 Subang Jaya Selangor
Topaire	Dunham-Bush Industries Sdn Bhd	Lot 8, Jalan P/7, Seksyen 13, Kaw. Perusahaan Bangi, 43650 B. Baru Bangi, Selangor.
MEC		

Table D-11. Malaysian AC Assemblers

Brand	Manufacturer	Address
York	OYL Manufacturing Company Sdn Bhd	Jalan Pengapit 15/19, P.O. Box 7072, 40702 Shah Alam, Selangor Darul Ehsan
Acon	OYL Industries Berhad	Level 8, Wisma Hong Leong, 18 Jalan Perak, 50450 Kuala Lumpur.

Table D-12. Malaysian AC Distributors

Brand	Manufacturer	Address
Sanyo	Sanyo Sales & Service Sdn Bhd	No.2, Lorong 19/1A, 46300 Petaling Jaya, Selangor Darul Ehsan.
Trane	TM Sales & Service Sdn Bhd	Lot 3 & 5, Jalan PJS 11/1, Bandar Sunway, 46150 Petaling Jaya, Selangor.
Mitsubishi	Antah Melco Sales & Services Sdn Bhd	6, Jalan 13/6, P.O. Box 1036, 46860 Petaling Jaya, Selangor
Daewoo	Daewoo Electronics Sales & Services (M) Sdn Bhd	Lot 886, Bay B3-B5, Jalan Subang 9, Taman Perindustrian Subang, Batu 14, Jalan Puchong-Hicom, 47100 Puchong, Selangor
Samsung	S. Marina Sales & Services Sdn Bhd	No. 14, Lorong Keluli 1C, Kawasan Perindustrian Bukit Raja Selatan, Seksyen 7, 40100 Shah Alam, Selangor
Sharp	Sharp-Roxy Sales&Service Co. (M) Sdn Bhd	No. 1A, Persiaran Kuala Langat, Section 27, 40400 Shah Alam, Selangor
Haier	Haier Electrical Appliances (M) Sdn Bhd	No. 886, Sub-Lot C-5, Jalan Subang 9, Taman Industri Subang, Batu 14, 47100 Puchong, Selangor
Panasonic		

METHODOLOGY FOR AC MARKET OVERVIEW

Information on the air conditioner’s market in Malaysia has been obtained from interviews with main manufacturers and importers in Malaysia. Namely two main market players have been contributing to the market overview through their market insight and knowledge. These are Scott & English Electronics, who imports LG air conditioners and represents the third biggest brand on the market. The other is Matsushita Industrial Corporation, who manufactures the number one brand in Malaysia – Panasonic.

Scope of question asked during the interview session including the market size of the company, relative import and exports details, market breakdown and other question related to this survey.

The market study is also based on statistics and market research reports to validate the information given in the interview sessions.

AC SHOP SURVEY

A total of 19 outlets of electrical shop and specialist have been approached in order to collect the data for this survey. Physical visits to the shop were made and the AC models displayed was identified and technical data gathered. Furthermore the salesperson was approached for additional information on other models available in the shop by ordering etc. and catalogues for the available models. Furthermore the consultants asked about the sales figures for the ACs – however the information given by the salesperson was normally limited to what models were top sellers,

Eleven shops were located in and around the capitol Kuala Lumpur (Selangor and Klang Valley). Eight shops were selected in and around Georgetown, Penang – the second most populated area in Malaysia (see Figure D-1).



Figure D-1. Sites of the Malaysia Shop Surveys around Kuala Lumpur and Georgetown, Penang.

The selection of the two areas in Malaysia has been based on the criteria of having the highest population.

Table D-12 shows the number of residents and area for each area in the survey.

Table D-12. Districts Covered in in Malaysia Shop Survey

Area	District	Area (km ²)	Total Residents
Danau Kota & Pandan Jaya	Kuala Lumpur	243.0	1,400,000
Subang Jaya	Subang Jaya	161.80	446,800
Shah Alam	Shah Alam	290.30	372,637
Petaling Jaya	Petaling Jaya	97.20	480,000
Bangi	Hulu Langat/Kajang	787.61	395,000
Penang	Pulau Pinang	292.64	591,200

Reference : <http://www.kpkt.gov.my/statistik/perangkaan2000/4-2.pdf>

Except Penang, which is an island and located approximately 450km away from Kuala Lumpur, all the other areas of survey have the same geographical preference such as temperature, geographical surface, weather and traffic.

Through the sales representative of each shop, information was gathered by asking questions to the sales staff and through information on product displayed and catalogues. The questions covered aspects such as comparison between models in term of performance, price and popularity; availability of other models not being displayed and information on Chinese air-condition products.

All the information was then compiled and entered into the shop survey form provided by DEM. The shops and specialists approached can be seen in the *Shop Survey Data*.

Collection of AC Catalogues

Almost all catalogues was collected during interview with manufacturer and visit to shop outlets. The catalogues were usually limited to few copies in each outlet and only available for the most popular models. Catalogue data has also been obtained from shop and manufacturers web sites on the Internet. The collected catalogues are compiled together with this report in the appendix section.

APPENDIX E: THAILAND MARKET OVERVIEW

INTRODUCTION

The energy efficiency of the Thai air-conditioners has been developed steadily since the establishment of labeling program. The Demand Side Management Office (DSMO) of the Electricity Generating Authority of Thailand (EGAT) started the labeling program in the early 1990's. In the beginning, there was less than 30 manufacturers participated in the program. Since then the program has been expanded and there are over 140 brand names participating and over 1.9 million # 5 labels had been issued by the DSMO in 2003. It is estimated that the market share of label # 5 now is about 40% as compare to 21% in 1998.

This report will look at the overall picture of AC market under 36,000 BTU/hr (3 TR) and their ranges of efficiency.

PRIMARY SALES CHANNELS

Primary sales channels of the manufacturers are:

- Wholesaler
- Dealers (Shop houses)
- Department stores
- Contractors
- Directly to owners (normally for big projects and/or big split-type units)

MARKET SIZE (SALES AND VALUE)

Almost 5 million units are produced in 2003. Table E-1 shows production, domestic sale and values.

Table E-1 Thailand Domestic AC Market, 2000 to 2003

Year	2000	2001	2002	2003
Production	3,441,330	4,129,600	4,170,000	4,881,600
Domestic Sales	165,200	399,300	375,000	412,500
Value (million Baht)	2,370	4,320	8,500	9,350

Note: 1 Thai baht = 40 USD

RELATIVE IMPORTANCE OF IMPORT AND EXPORTS

Thailand exports about 80-90% of the total production to about 100 countries all over the world. Most of exported units have EER not over 10.6 because export market does not require high EER units but instead it requires quality standard, such as, ISO 9000 and must comply with recycling law. Thailand also imported small value of complete AC units and parts from other countries.

PRIMARY EXPORT MARKETS AND IMPORT SOURCES

In 2003 from January to August (8 months), Thailand exported complete AC units worth about 25,334 million Baht or about \$633 million (1\$= 40 Baht), a substantial increased from 2002 which was 25,384 M. Baht for the whole year. Table 2 shows export and import statistics during 2001-2003.

Table E-2 Export and Import Statistics 2001-2003

Year	Export				Import			
	Complete Units		Parts		Complete Units		Parts	
	Qty.	Value F.O.B (Million Baht)	Qty	Value F.O.B (Million Baht)	Qty.	Value C.I.F (Million Baht)	Qty	Value C.I.F (Million Baht)
2003	3,379,591 (Jan.-Aug.)	25,334	92,072	17.20	69,916 (Jan.-Nov.)	363.60	37,870	12.09
2002	3,753,016	25,384	30,697	7.0	67,255	395.27	19,864	3.33
2001	4,028,061	21,255	17,517	5.59	9,837	62.53	4,137	0.88

Source: Customs Department
Exchange rate: 1 USD = 40 Baht

Major importing regions from Thailand in 2003 are:

% Of Export

EU	39.0
Asian	11.2
Japan	10.1
USA	6.3
Others	33.4

MARKET BREAKDOWN FOR WINDOW AND SPLIT TYPE AIR-CONDITIONERS

Most of AC units are split type. About 10% of the total AC production is window units and most of them are for export market.

RANGE OF EFFICIENCY LEVEL

Most large and small manufacturers produce at least one model of high EER >10.6 unit or label # 5. Major manufacturers and well-known brands produce a few models of high efficiency AC units and most of them also produce units with a minimum EER of 9.6.

MARKET SHARE OF THE LARGEST MANUFACTURERS

Mitsubishi has a largest market share, 20%, Carrier about 15%, Saijo Denki, Daikin, National, Hitachi, Sharp, Toshiba, Trane and LG each has about 5-10% market share. Table E-3 shows list of top 20 best selling models in stores according to the interview with several stores.

Table E-3. Top-20 Best-Selling Models in Thailand Shop Survey

Range	Brand	Model	BTU/h	EER
1	Mitsubishi Electric	MS-S09WV	9,000	12.86
2	Mitsubishi Heavy Duty	SRK 09CB	9,000	-
3	Mitsubishi Electric	MS-S13WV	13,000	12.38
4	Daikin	FT/R-09BV1LS	9,000	11.04
5	Panasonic	CS/CU-XC9CKT	9,110	12.23
6	Daikin	FTKE/RKE-09BVMS	4,400-10,900	9.90
7	Samsung	ASK09F6VE	9,000	11.03
8	Panasonic	CS/CU-C9CKT	9,040	12.22
9	Saijo Denki	SWA/SOD-12UP	12,510	11.10
10	Panasonic	CS/CU-XC12CKT	12,290	11.59
11	Saijo Denki	SHW/SOR-13UP	13,200	12.08
12	Daikin	FT/R-13BV1LS	14,000	11.90
13	Daikin	FTKE/RKE-12BVMS	4,800-13,700	10.40
14	LG	HS-R0960CH	9,000	10.98
15	Sharp	AH/AU-MP10	8,662	11.41
16	Samsung	ASK13F6VE	12,000	10.77
17	Sharp	AH/AU-MP13	11,442	10.85
18	LG	HS-R1260CH	12,000	11.15
19	LG	LS-L1060CH	9,500	11.06
20	Mitsubishi Electric	MS-S18UV	18,000	14.40

Source: Interviews with 13 small and large “shophouse” stores and 8 department stores

TOTAL NUMBER OF MANUFACTURERS, ASSEMBLERS, AND DISTRIBUTORS

There are about more than 150 manufacturers and assemblers, and over one thousand distributors all over the country in 2003. Out of the total manufacturers, about 10 are large foreign companies, mainly Japanese, with a combined production capacity of 3,000,000 unit a year. About 50 are major Thai manufacturers with a combined production capacity over 1,500,000 units a year.

OVERVIEW OF SHOP SURVEY IN THAILAND

Chosen mix of representative types of stores

A total of 21 stores were selected for the survey in 3 provinces; Bangkok, Chiangmai and Haadyai. The types of stores and locations are shown in Table E-4.

Table E-4. Overview of Thailand Shop Survey

City	Dept. Store	Shop House		Total
		Big	Small	
Bangkok	4	3	3	10
Chiangmai (North)	2	2	2	6
Haadyai (South)	2	2	1	5
Total	8	7	6	21

A big shop house in general is referred to as a formal registered company and has a show room area around 120-150 m² while a small house has a smaller space, about 40-50 m². Most of big shop houses also sell other electrical appliances, such as, refrigerators, electric fans, washing machines, etc.

Geographical differences observed

All surveyed stores in Bangkok, Chiangmai and Haadyai carry several Japanese brands, most of them represent Mitsubishi. The other Japanese brands represented are such as Daikin, National, Sharp, Hitachi, etc. Most of them also sell Thai brands such as Central Air, Trane, Carrier, Pal, etc. Most of stores in the provinces also sell Korean brands, LG and Samsung.

In Bangkok, consumers are more concerned with AC #5 than in the provinces. Consumers in the provinces are more concerned with the price.

Most shop houses emphasizes in after sale services. Some provide 3-4 times cleaning service in a first year.

Types of air conditioners sold by type of store and location

All surveyed department stores and shop houses sell split type units; floor, wall, and ceiling mounted. No one sells window type unit.

Comments from salespersons/managers

- Most buyers in Bangkok know that AC #5 save energy, so it is not difficult to sell #5. Also the prices are not so high now, about B.1.5/BTU, as compare to 3-4 years ago, about B.2/BTU for a good Thai brand. AC #5 costs about 15-20% higher than lower efficiency units.
- Homebuilders are not interested so much on #5 because they only want low cost units and pass the electricity costs to homebuyers.
- A high amount of sale commission also has influence on salespersons to push the sale some brands.
- There should be more public relation campaigns for #5 in provinces.
- Salespersons normally suggest size of AC for buyers based on the given room areas.

REFERENCES

Interviews

- Link Manufacturing 1999 Ltd. (Carrier)
- Thai Tasaki Engineering Co., Ltd.
- Siam Daikin Sales Co., Ltd.

- Trane Thailand Airco Ltd.
- 13 small and large shop houses and 8 department stores located in Bangkok, Chiangmai (North of Thailand) and Haadyai (South)

Other

- Export and Import Statistics, Customs Department.
- Office of Industrial Statistics, Ministry of Industry
- Research Division, Industrial Financial Corporation of Thailand (IFCT).

APPENDIX F. VARIOUS SCATTER PLOTS USING BASIC DATA

APPENDIX G: BRAND EER FREQUENCY CURVES AND DATA

APPENDIX H. SCATTER PLOTS OF SPECIFIC BRANDS IN DIFFERENT COUNTRIES