


COOLING BENCHMARKING STUDY

Part 1: Mapping Component Report

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BY

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in Partnership with
The Collaborative Labeling and Appliance
Standards Program (CLASP)

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ABBREVIATIONS AND ACRONYMS

4E	**Programme on Efficient Electrical End-Use Equipment**
AC	**Air Conditioning**
AHRI	**Air Conditioning, Heating and Refrigeration Institute**
AHU	**Air Handling Unit**
APF	**Annual Performance Factor**
BSMI	**Bureau of Standards Metrology and Inspection**
CAC	**Central Air Conditioners**
CC	**Cooling Capacity**
CEE	**Consortium for Energy Efficiency**
CLASP	**Collaborative Labeling and Appliance Standards Program**
CNIS	**China National Institute of Standardization**
CO_2	**Carbon Dioxide**
COP	**Coefficient of Performance**
CQC	**China Quality Certification Centre**
DB	**Dry Bulb**
ECCJ	**Energy Conservation Center for Japan**
EE	**Energy Efficiency**
EER	**Energy Efficiency Ratio**
EU	**European Union**
HVAC	**Heating, Ventilating and Air Conditioning**
IEA	**International Energy Agency**
ISO	**International Standards Organization**
ITRI	**Industrial Technology Research Institute**

kW	**Kilowatt**
LBNL	**Lawrence Berkeley National Laboratory**
MEPS	**Minimum Energy Performance Standards**
RAC	**Room Air Conditioner**
RCC	**Rated Cooling Capacity**
S&L	**Standards and Labels**
SEER	**Seasonal Energy Efficiency Ratio**
USA	**United States of America**
VSD	**Variable Speed Drive**
WB	**Wet Bulb**

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INTRODUCTION

Context of the Study

As part of its efforts to support transitioning to a world in which appliances, equipment and lighting are built for maximum Energy Efficiency (EE) and minimal contribution to global climate change, the Collaborative Labeling and Appliance Standards Program (CLASP) funded a study to provide tools and procedures allowing an international comparison of the EE performance and policy measures for air conditioners with a cooling capacity of 19 kW or less used in the residential and commercial sectors. CLASP is an international organization that promotes EE Standards and Labeling (S&L) in commonly used appliances and equipment.

Air Conditioning (AC) systems represent a major energy end-use in several countries, and contribute to the growth of energy consumption and peak load in the commercial and residential sectors. This trend is recently increasing due to rising living standards in several countries combined with a cost reduction of AC products. This tendency is contributing to an increase in greenhouse gas emissions across the world.

This study covered AC products offered in the global market as well as testing procedures and regulatory or voluntary initiatives introduced in different economies. In support of this study, information was collected for Australia, China, the European Union (EU), Japan, India, Korea, Taiwan and the United States (US). The main objective was to provide a meaningful comparison of the effectiveness of air conditioner models sold in major economies. This has been done through an analysis of the market characteristics, Minimum Energy Performance Standards (MEPS) levels and EE classes used for labeling schemes. In addition, conversion functions were developed allowing comparison of different efficiency metrics used across the world.

The project team included Econoler acting as team leader and experts from Navigant, CEIS and ACEEE. CLASP experts were also closely involved in work supervision and provided direction and advice to the project team. Several external experts and country representatives provided market information, advice and views on different issues related to the international comparison of AC equipment efficiencies.

This report is the first of three reports prepared as part of this global study on air conditioner energy efficiency. It presents a review of AC products offered in different economies and some market characteristics. Other reports prepared as part of this project include:

- Report 2: Benchmarking component. This report presents an analysis to develop a series of conversion functions for metrics used in different economies around the world as well as a comparison of the relative stringencies of different MEPS and labeling schemes.

- Report 3: Testing component. This report presents the conclusions from a comparison of the testing of air conditioners under test procedures of various countries, and the actual testing of a limited sample of products under different test procedures.

Scope of the Study

In this study, the term Room Air Conditioner (RAC) includes:

- RAC products with a cooling capacity of up to 19 kW;
- Electrically driven vapor compression units. Absorption units are excluded;
- Cooling only units and the cooling function of reverse cycle (heating and cooling) units.

The scope of the study includes the following RAC sub-categories:

- Non-ducted single split units (mobile or fixed split units);
- Non-ducted single split unit heat pumps;
- Ducted single split units;
- Multi-split units;
- Single-packaged AC units;
- Single and double duct units (portable air conditioners);
- Central AC units (rooftop units).

Purpose of the Mapping Component

The mapping study was designed to determine air conditioner performance in selected countries by comparing market trends and performance as well as existing S&L initiatives and their characteristics.

1 Data Collection Overview

Some of the data initially requested for the mapping analysis could not be gathered. The following table provides an overview of the data collection in countries covered by the study.

Table 1: Overview of Data Collected in Countries Covered by the Study

Economy	AC Market Data	MEPS	Label	Testing Procedures
Australia	Data could not be collected: Lack of agreement with a national contact	Data collected through internet search	Data collected through internet search	Part of the data related to the testing procedures could be collected through internet search
China	Y	Y	Y	Y
European Union	Y	Y	Y	Y
Japan	Y	Y	Y	Y
India	Y	Y	Y	Y
Korea	Data could not be collected: Lack of agreement with a national contact	Data collected through internet search	Data collected through internet search	Part of the data related to the testing procedures could be collected through internet search
Taiwan	Only the list of AC models covered by the S&L scheme could be collected	Y	Y	Y
United States of America	Y	Y	Y	Y
Note: Y = Data successfully collected				

2 International Reference Test Procedures

ISO 5151 is used very widely around the world. The standard defines the following parameters for testing purposes: Definitions; Determination of capacity and energy efficiency; A range of performance tests in cooling and heating mode; and Uncertainties and tolerances.

For the determination of capacity, 3 possible combinations of indoor and outdoor conditions are defined as shown in Table 2. Condition T1 is used almost universally for cooling capacity determination and efficiency claims. T2 (mild conditions) and T3 (very hot conditions) are rarely specified.

Condition "high" for heating is most commonly used, although "low" is sometimes specified for colder climates. Condition "extra-low" is not used widely for rating (climates with sub-zero temperatures tend to opt for other technologies like ground source heat pumps).

Table 2: Cooling and Heating Conditions in ISO5151

Cooling Conditions	T1	T2	T3
Indoor	27°C DB, 19°C WB	21°C DB, 15°C WB	29°C DB, 19°C WB
Outdoor	35°C DB, 24°C WB	27°C DB, 19°C WB	46°C DB, 24°C WB
Heating Conditions	**High**	**Low**	**Extra Low**
Indoor	20°C DB, <15°C WB	20°C DB, <15°C WB	20°C DB, <15°C WB
Outdoor	7°C DB, 6°C WB	2°C DB, 1°C WB	-7°C DB, -8°C WB
Note: DB = dry bulb; WB = wet bulb			

Importantly, ISO5151 defines a range of performance tests that check whether the air conditioner is fit for purpose. For cooling these include maximum cooling, minimum cooling, enclosure sweat and condensate disposal tests and a freeze up test. For heating these include maximum heating, minimum heating and an automatic defrost test. Some of these tests are mandated within some testing regimes. Not all tests are relevant for all users.

In terms of efficiency the standard defines Energy Efficiency Ratio (EER) as the ratio of cooling output (W) to electrical input (W) – this variable is dimensionless (W/W). It also defines the Coefficient of Performance (COP) for heating in a similar fashion.

ISO5151 specifies both calorimeter and air enthalpy test setups for energy and capacity determination. ISO5151 does not address non-operating power.

The standard ISO 13253 is limited to systems which use a single refrigeration circuit and have one evaporator and one condenser. The procedure applies to air conditioners of any capacity and type, provided they are ducted, including cooling-only and reversible, single-phase and three-phase, and air-cooled or water-cooled units. The test procedure excludes single duct room air conditioners and multi-split systems. Water-cooled heat-pumps are not included.

Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

3 Mapping for Australia

3.1 AC Market Characterization

3.1.1 Supply of New AC Products

No data on the supply of new AC products was available.

3.1.2 Stock of AC Products

No data on the stock of AC products was available.

3.2 Standards and Labeling Framework

3.2.1 Minimum Energy Performance Standards

Since October 2001, three-phase air conditioners with a cooling capacity of up to 65 kW manufactured in or imported into Australia must comply with MEPS requirements. MEPS cover three-phase non-ducted or ducted room air conditioners of the vapor compression type with a cooling capacity of up to 65 kW (commercial or residential). Also, since October 2004, all single-phase air conditioners manufactured in or imported into Australia must comply with MEPS requirements. The MEPS cover single-phase non-ducted or ducted room air conditioners of the vapor compression type (commercial or residential). Hence, the MEPS in Australia cover AC systems with one or more refrigeration systems with one outdoor unit and one or more indoor units controlled by a single thermostat/controller. They cover equipment utilizing single, multiple and variable capacity components.

The MEPS and energy labeling requirements for air conditioners with a cooling output of up to 65 kW were revised and became effective on April 1, 2010 with transitional arrangements commenced in October 2009. Other changes are expected in April 2011. Thereafter, the upgraded MEPS levels for all AC products will be based on the annual Energy Efficiency Ratio (EER) and the annual Coefficient of Performance (COP) with the inclusion of standby and other non-operational energy consumption and a mandatory power factor requirement.

The MEPS levels are shown in Table 3 and Table 4 below.

Table 3: MEPS Levels for Air Conditioners in Australia[1]

RAC Product Description	MEPS 2006 - 2007	MEPS 2010*	MEPS 2011*
Unitary – all types, <10 kW, all phases	2.75	2.84	2.84
Unitary – all types, 10 kW to <19 kW, all phases	2.75	2.75	2.75
Split systems – all types, <4 kW, all phases	3.05	3.33	3.33
Split systems – all types, 4 kW to <10 kW, all phases	2.75	2.93	2.93
Split systems – all types, 10 kW to <19 kW, all phases	2.75	2.75	2.75
Ducted systems – all types, <19 kW, single-phase	2.50	2.75	2.75
Ducted systems – all types, <10 kW, three-phase	2.50	2.75	2.75
Ducted systems – all types, 10 kW to <19 kW, three-phase	2.75	2.75	2.75
All configurations, all types, 19 kW to 39 kW, all phases	3.05	3.05	3.05
All configurations, all types, <39 kW to 65 kW, all phases	2.75	2.75	2.75
*The 2010 EER levels are based on operating EER, while the 2011 levels will be based on Annual EER/COP (AEER/ACOP). Note: Unitary are mostly window wall units or packaged systems. Types refer to cooling only or reverse cycle. Air source only – separate MEPS levels are specified for water source heat pumps.			

Table 4: MEPS Requirements for Water Source Heat Pumps and Air Conditioners at Rated Capacity

Cooling and / or Heating Capacity	MEPS (EER and/or COP) April 1, 2010	MEPS (AEER and/or ACOP) April 1, 2011
< 39.0 kW	3.50	3.50
≤ 39.0 kW	3.20	3.20
Note: This table includes requirements for air conditioners with water-cooled condensers and water source heat pumps.		

[1] http://www.energyrating.gov.au/pubs/factsheet-trans-ac.pdf

It is worth nothing that MEPS do not apply to the following air conditioner types:

- Close controlled air conditioners within the scope of AS/NZS 4965 and chillers within the scope of AS/NZS 4776.
- Multi-split systems (i.e., more than one indoor unit with an independent control for each indoor unit). However, MEPS levels are under consideration for multi-split systems.
- Evaporative coolers or any other cooling systems which are not of the vapor compression type.
- Ground water or ground loop source heat pumps within the scope of AS/NZS 3823.1.3 (ISO 13256-1). Note that water-loop heat pumps are not exempt; these are covered by AS/NZS 3823.1.3.
- Unbalanced air conditioners and spot coolers (including some portable types). Regulatory requirements for these types are under consideration.
- Air conditioners powered by main electricity specifically designed and sold for installation in end-use mobile applications of caravans, mobile homes, camper vans and rail cars.
- Single-phase models that are designed for commercial applications, and where the requirements of (i), (ii) and (iii) below are met, must be registered but are not required to display an energy rating label:
  i) designed for and used only in non-residential applications; and
  ii) not on display for sale through retail outlets; and
  iii) not promoted in any catalogue or advertising material that could be interpreted as suitable for some residential applications.
- Models that have been granted exemption by the relevant Australian/New Zealand regulatory authority due to their specific design for application such as process heating or cooling, or for heating or cooling of spaces to conditions that are not intended for human comfort.

3.2.2 Labeling Scheme

The mandatory energy efficiency labeling scheme for air conditioners was first introduced in Australia in 1987. The label has been updated twice, in 2000 and 2010. The label uses a comparative approach. There are five levels (5-star scale), with more stars representing higher efficiency.

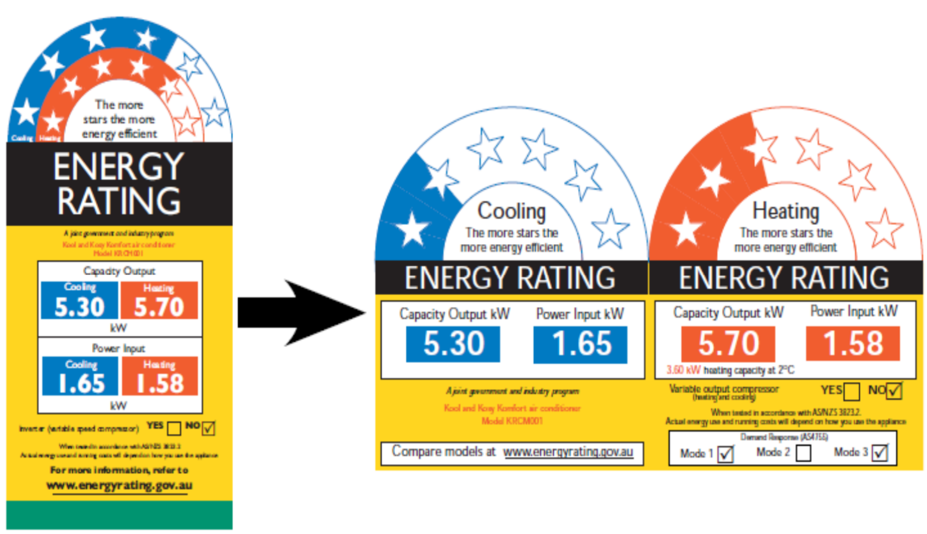
Table 5 gives the current and past levels defining the star rating criteria.

Table 5: Star Rating for EER

Star Rating	EER (after 2010)	EER (From 2000 - 2010)	EER (Before 2000)
1	2.75	2.00	1.90
1.5	3.00	2.15	2.00
2	3.25	2.30	2.10
2.5	3.50	2.45	2.20
3	3.75	2.60	2.30
3.5	4.00	2.75	2.40
4	4.25	2.90	2.50
4.5	4.50	3.05	2.60
5	4.75	3.20	2,70
5.5	5.00	3.35	2.80
6	5.25	3.50	2.90

The figure below presents a picture of the label in force for RACs in Australia.

Figure 1: Label for RACs in Australia[2]



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2 http://www.energyrating.gov.au/pubs/factsheet-trans-ac.pdf

Like MEPS, energy labeling does not apply to AC products listed in section 3.2.1.

The Department of Climate Change and Energy Efficiency under the Prime Minister Cabinet has the responsibility to implement EE standards and labeling programs.

3.2.3 Testing Procedures

Air conditioners in Australia are tested according to AS/NZS 3823 with ISO 5151 and ISO 13253[3] as reference test standards. The standard is applicable to non-ducted and ducted room air conditioners of the vapor compression type with a single or multiple refrigeration circuit.

The cooling and heating capacity and energy consumption are determined under AS/NZS 3823.1.1 or AS/NZS 3823.1.2[4].

The Government of Australia has established a system to verify compliance with the MEPS and label regulations by RAC distributors and manufacturers. Regulatory authorities have commissioned external contractors to undertake regular ongoing audits of retail outlets to ensure that products are correctly labeled and are registered for MEPS with one of the Australian states or New Zealand. Independent National Australian Test Authority accredited laboratories commissioned by regulators carry out the verification testing (check tests). The check test process comprises an initial screen test, paid for by the government. If the unit complies with MEPS no further action is taken. If the unit fails, the supplier has the option of (i) choosing to request cancellation of the registration; or (ii) performing verification testing of up to three randomly selected units at the supplier's cost.

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[3] ISO 5151- Non-ducted air conditioners and heat pumps -- testing and rating for performance and ISO 13253 - Ducted air-conditioners and air-to-air heat pumps - Testing and rating for performance

[4] http://www.energyrating.gov.au/rac1.html#rac1a

4 Mapping for China

4.1 AC Market Characterization

4.1.1 Supply of new AC products

Share of AC products by Sub-Category

There is little data on the evolution of market share by room AC type except that in 2009 it is reported that out of total domestic sales of 30.3 million units, some 30 million were for single split AC, 0.3 million for multi-split AC and that sales of windows and moveable AC units were very few (CNIS 2011). In addition, inverter unit sales are reported to be rising and to have attained 18% of total sales by 2009 (CNIS 2011).

Cooling Capacity

According to data presented in the International Energy Agency (IEA) 4E study[5] the product-weighted average cooling capacity was 4.3 kW in 2008. An analysis of Chinese air conditioner catalogue data done for this study has found that the product-weighted average cooling capacity is 3.33 kW in 2011. It is also reported that 89% of the market is in the range of 0-4.5 kW, 8% in the range 4.5-7.1kW and 3% in the range 7.1-14kW (CNIS 2011).

Previous studies have estimated that the sales-weighted average cooling capacity is lower again at 2.8kW (IEA 2007).

Trends in EER of Most and Least Efficient Products

The key trends for room air conditioner energy efficiency are shown in Table 6.

Table 6: Room AC Product Offer-weighted Trends[6]

	2005	2006	2007	2008	2009	2010
EER of Worst Product (W/W)	2.3	2.36	2.4	2.4	N/A	2.9
Product Weighted Average EER (W/W)	2.78	2.83	2.83	2.96	N/A	3.23
EER of Best Product (W//W)	3.97	3.97	3.97	4.75	N/A	7.56

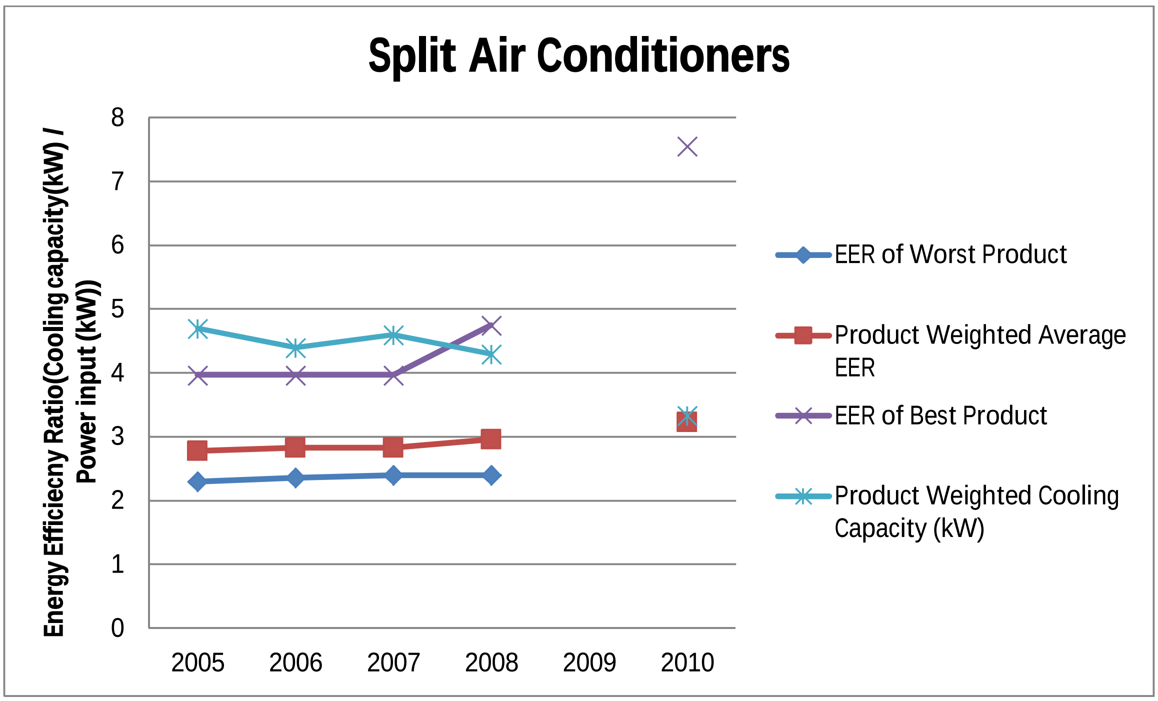
[5] The study report was released in February 2011. It looks at both unitary (packaged) and split air conditioners sized up to 14kW and makes a range of observations on the differences in performance of these products between countries. 4E is an IEA energy technology collaborative program.

[6] Data source: IEA 4E (Eurovent) to 2008. For 2010 data it is a mix of CNIS (2010) and analysis done for this study.

The best EER figure for 2010 was reported by CNIS; however, it is not clear if this is an EER or SEER figure. The best EER value found in a sample of 245 models in on-line catalogue data carried out for this study was 6.14 W/W. The product weighted-average value for 2010 is also an estimate based on assumptions regarding continuing movement between labeling classes and a presumption that the 2010 MEPS are fully respected. The product-weighted average EER from a sample of on-line catalogue data conducted for this study was 3.33 W/W.

The same data is shown graphically in Figure 2. Data is not available for other room AC types although their market shares are thought to be very small.

Figure 2: Split Air-Conditioner Product Offer-weighted Trends[7]



Additional information regarding the Chinese RAC market is given in Appendix 1 to this report. The information covers the Chinese RAC market volumes in terms of production and export in Table 48, the product offer-weighted shares by energy label class for split in Table 49, and unitary AC units in Table 50.

4.1.2 Stock of AC products

It is estimated that there are about 230 million room AC units in use in Chinese households, of which 212 million are in urban households and 18 million are in rural households. In 2005, the number of room AC units in stock was estimated at 160 million (see Figure 3 below). Average ownership is just above one room air conditioner per urban household at present (see Figure 4 below) and a typical household is thought to use the room air conditioner for about 700 hours per year[8].

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[7] Data source: IEA 4E (Eurovent) to 2008. For 2010 data it is a mix of CNIS (2010) and analysis done for this study.

[8] CNIS (2011) Personal communication with program manager of Chinese National Institute for Standardization

Figure 3: Air-conditioner Stocks in China[9]

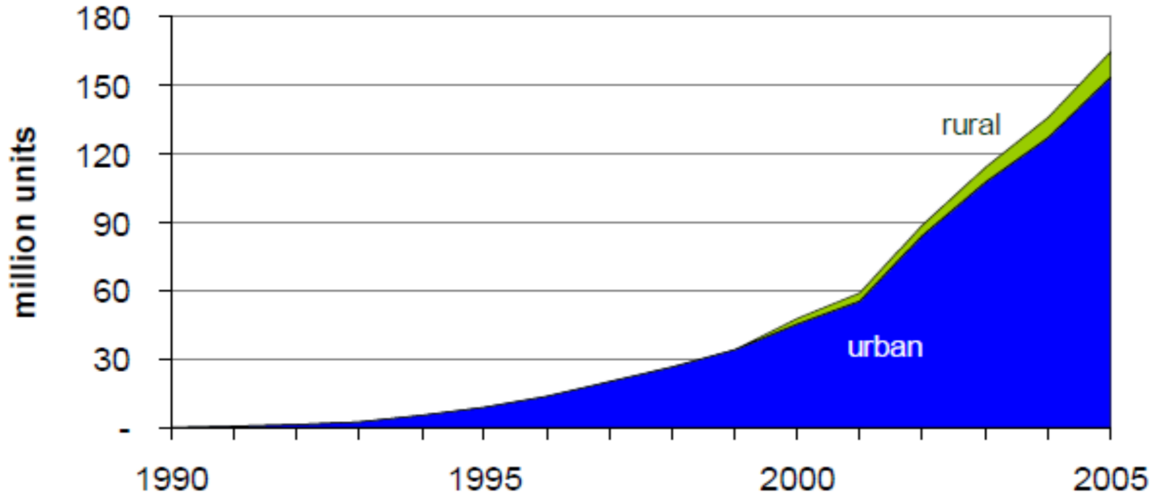
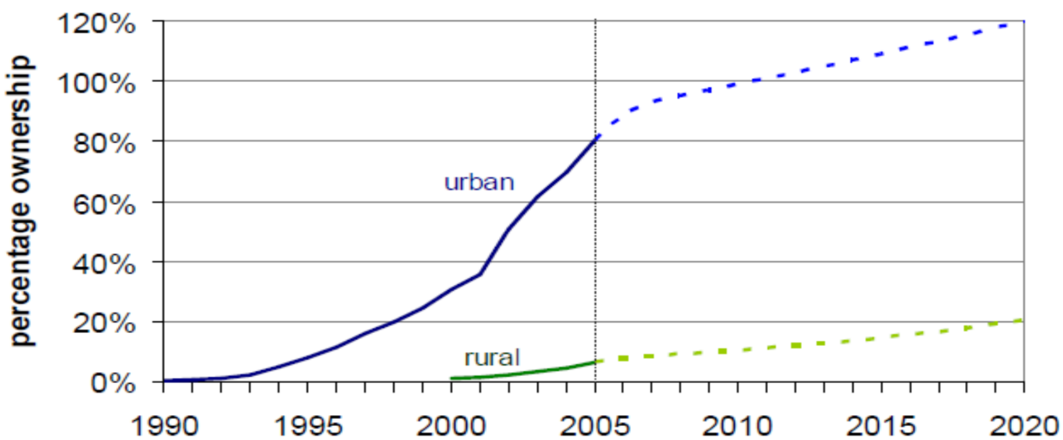


Figure 4: Historical and Projected Air-Conditioner Ownership in China[10]



If the current stock is 230 million operating at an average of 700 hours a year and with a mean cooling capacity of 2.8kW at a rough average in situ EER of 2.2 W/W, the total national final electricity consumption of RACs would be 214 TWh/year. This unofficial and impromptu estimate is substantially higher than those produced in earlier studies,[11] and reflects that the stock of room air conditioners has grown even faster than expected and that the latest average hours of use data are higher than previously reported.

[9] CNIS (2011) Personal communication with program manager of Chinese National Institute for Standardization

[10] Source: LBNL 2007 from National Bureau of Statistics data

[11] See LBNL, 2007, **Impacts of China's Current Appliance Standards and Labeling Program to 2020**, Report no. LBNL 62802, Lawrence Berkeley National Laboratory, USA

4.2 Standards and Labeling Framework

4.2.1 Minimum Energy Performance Standards

China has had MEPS for room air conditioners since 1989. These were revised in 2004 and then again in 2010. In addition, separate MEPS and labeling requirements for variable speed units were introduced in 2008, as shown in Table 7. The requirements apply to all room air conditioners (defined as units with cooling capacity of ≤ 14kW). Separate requirements are specified for split units and for integrated units, where the latter include windows or through the wall units and moveable AC. Although separate requirements were issued for variable speed units in 2008, the 2010 MEPS supersede the 2008 MEPS for all room AC types including variable speed units.

Table 7: Minimum energy performance requirements for room air conditioners[12]

RAC Products Description	*MEPS 2010 (EER- W/W)*	*MEPS 2004 (EER- W/W)*	*MEPS- VSD levels 2008 (EER- W/W)*
Integrated type, CC≤14000	2.9	2.3	2.9
Split type, CC≤4500	3.2	2.6	3.0
Split type, 4500<CC≤7100	3.1	2.5	2.9
Split type, 7100<CC≤14000	3.0	2.4	2.8

Test standards GB/T 7725-2004, GB 12021.3-2010, GB 21455-2008 and GB/T 7725 are used, and are equivalent to the ISO 5151 T1 condition and hence are directly comparable with the EU, US, and Japanese steady state requirements.

4.2.2 Labeling Scheme

China has applied a mandatory energy label for room air conditioners since 2005. Different requirements were introduced for variable speed split AC units in 2008, and wholly revised labeling requirements came into effect in 2010. Under the 2004 scheme there were five label classes, ranked from grade 1 (most efficient) to grade 5 (least efficient) as set out in Table 8 and Figure 5 below.

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[12] Sources: GB12021.3—2010 the limited values of energy efficiency and grading criteria for room air conditioners. GB12021.3—2004 the limited values of energy efficiency and grading criteria for room air conditioners. GB21455-2008 the limited values of energy efficiency and grading criteria for room air conditioners (variable speed (VSD)).

Table 8: Former Energy Labeling Thresholds for Room Air Conditioners (from 2004-2010)[13]

RAC Products Description	Label Class 5 (EER-W/W)	Label Class 4 (EER-W/W)	Label Class 3 (EER-W/W)	Label Class 2 (EER-W/W)	Label Class 1 (EER-W/W)
Integrated type, CC≤14000	2.30	2.50	2.70	2.90	3.10
Split type, CC≤4500	2.60	2.80	3.00	3.20	3.40
Split type, 4500<CC≤7100	2.50	2.70	2.90	3.10	3.30
Split type, 7100<CC≤14000	2.40	2.60	2.80	3.00	3.20

Figure 5: China's Room Air Conditioner Energy Label

The requirements for fixed speed units were specified in GB/T 7725-2004 and GB 12021.3-2010, and the requirements for variable speed units were specified in GB 21455-2008 GB/T 7725. In 2010 the labeling requirements were revised when new MEPS were introduced and the number of grades reduced from five to three as presented in Table 9 below.

[13] Source: GB12021.3—2004 the limited values of energy efficiency and grading criteria for room air conditioners

Table 9: Current Energy Labeling Thresholds for Room Air-Conditioners (from 2010 Onwards)[14]

RAC Products Description	Label Class 3 (EER-W/W)	Label Class 2 (EER-W/W)	Label Class 1 (EER-W/W)
Integrated type, CC≤14000	2.90	3.10	3.30
Split type, CC≤4500	3.20	3.40	3.60
Split type, 4500<CC≤7100	3.10	3.30	3.50
Split type, 7100<CC≤14000	3.00	3.20	3.40

The requirements for variable speed units are set out in Table 10. For these it seems that a seasonal energy efficiency ratio is used, although the details of how this is applied are not yet known.

Table 10: Energy Labeling Thresholds for Variable Speed Room Air-Conditioners (from 2008 Onwards)[15]

RAC Products Description	Label Class 5 (SEER-W/W)	Label Class 4 (SEER-W/W)	Label Class 3 (SEER-W/W)	Label Class 2 (SEER-W/W)	Label Class 1 (SEER-W/W)
Split type, CC≤4500	3.00	3.40	3.90	4.50	5.20
Split type, 4500<CC≤7100	2.90	3.20	3.60	4.10	4.70
Split type, 7100<CC≤14000	2.80	3.00	3.30	3.70	4.20

In addition to the mandatory energy label, China also operates the CQC Mark Certification. This is a voluntary label and applies to split and variable speed type air conditioners. CQC stands for China Quality Certification Centre, a professional certification body. The CQC Mark can be applied to over 500 products in a number of categories, and shows that the product conforms to specific quality, safety, environmental and performance standards. Test standards GB 21455-2008 and GB/T 7725 are used under this certification.

4.2.3 Testing Procedures

Chinese room air conditioners are tested according to GB/T 7725-2004. This standard applies to home use and similar type of air conditioners, with air cooling and/or water cooling condenser, completely sealed electric motor compressor, and cooling capacity lower than 14kW. The requirements are essentially harmonized with those in ISO 5151 - Non-ducted air conditioners and heat pumps -- Testing and rating for performance (see section 2 for details about ISO 5151).

[14] Source: GB12021.3—2010 the limited values of energy efficiency and grading criteria for room air conditioners

[15] Source: GB 21455-2008 the limited values of energy efficiency and grading criteria for room air conditioners (variable speed)

In the case of speed controllable split room AC units, a different set of requirements apply as set out in *GB 21455-2008 the limited values of energy efficiency and grading criteria for room air conditioners (variable speed)*[16].

Speed controllable and room air conditioners cooling season energy consumption efficiency (SEER) should be based on the requirements of Chapter 7 test and its experimental values of SEER calculations.

[16] Reference: http://test.energylabel.gov.cn/UserFiles/转速可控型房间空气调节器标准摘要.pdf

5 Mapping for European Union

5.1 AC Market Characterization

5.1.1 Supply of new AC products

Share of AC Products by Sub-Category

The Eurovent database contains performance data on all AC units certified under the Eurovent AC scheme. This covers the large majority of AC units sold in the EU (over 95%), with the exception of single- or twin-duct (mobile) AC units which are not eligible for inclusion. The share of models by sub-category (product-weighted) in the database in January 2011 is presented in Table 11 below:

Table 11: Share of Air Conditioning Products by Sub-Category (As of January 2011)[17]

Air Conditioner Type	Market Share
Non ducted split packaged AC systems (fixed)	9%
Non ducted split packaged AC systems (heat pump)	59%
Multi split packaged units	31%
Window unit	1%
Total	100%

Actual sales data by sub-category is reported in the EuP study as presented in Table 12 below:

Table 12: Actual Sales Data by Sub-Category[18]

Air Conditioner Type	2005	2006	2007	2008	2009	2010
Non ducted split packaged AC systems (cooling only)	669,639	739,888	628,475	481,571	228,421	31,853
Non ducted split packaged AC systems (heat pump)	3,579,402	3,996,954	4,607,392	5,302,262	5,719,708	6,148,833
Window units (unitary)	220,590	241,323	227,968	214,678	214,678	214,678
Single duct unit (Portable unit)	629,017.02	603,164	625,272	648,265	853,488	1,064,988
Total	5,098,649	5,581,328	6,089,107	6,646,775	7,016,295	7,460,353

[17] Data source: Eurovent, 2011

[18] Data source: BSRIA 2005, EuP 2011

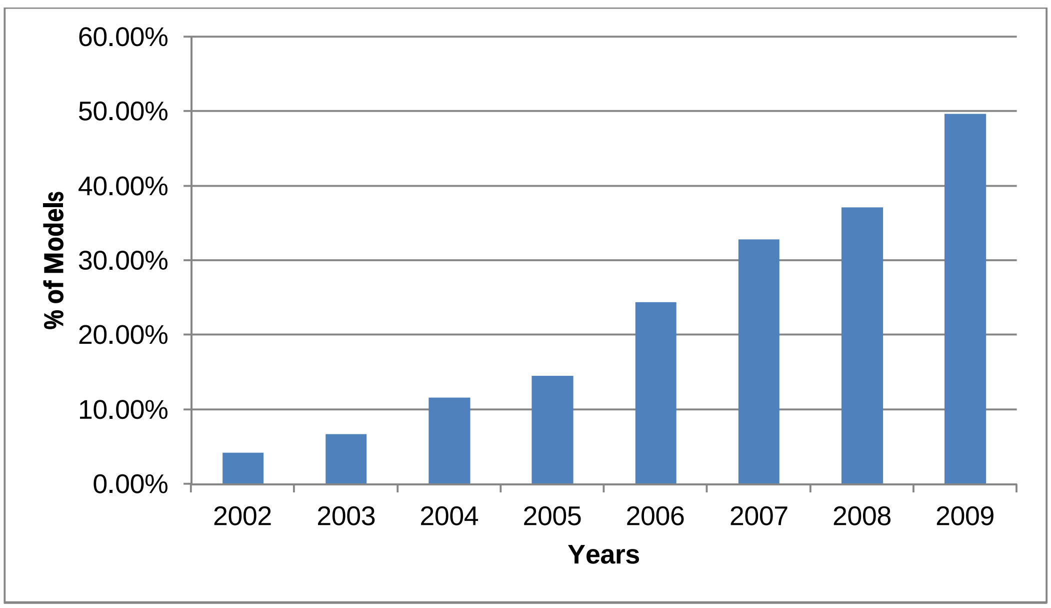
Based on this data, in 2010 split AC (cooling only and reversible units, including multi-splits) accounted for 83% of room air conditioner sales, window units for 3% of sales, and single duct units for 14% of sales. In addition to these product types, there is a very small market in US-style central ducted air conditioners. The most recent data is from 2004 (BSRIA, 2005) at which time the total market size of these products was less than 60 000 units with only about 20 000 units having a cooling capacity of under 12 kW. The market share of room air conditioner sales for 2008, for units with and without inverters, is reported in Table 13 below.

Table 13: The Market Share of Room Air Conditioner Sales for Units with and without Inverters (2008)[19]

	Western EU	Eastern EU
With inverter	36.2%	26.0%
Without inverter	60.9%	71.9%
Unknown/ N/A	2.9%	2.1%

In addition, a time series of model-weighted data derived from the Eurovent database is reported in the IEA 4E study and presented in Figure 6 below.

Figure 6: Percentage of Models with Variable and Multi Speed Compressor



From the figure above, it seems likely that models with variable and multi speed compressors accounted for about 50% of the market in 2009 and their share was continuing to grow strongly.

More details on sales, trade, and production data on ACs in the EU-27 member countries are provided in Appendix 2.

[19] Data source: Stöckle 2009

Market Share of AC Sales by End-User Type

Room air conditioners are sold to both residential and non-residential end-users. In Europe the latter dominate the market, and 63% of room air conditioner sales (when weighted by the share of total cooling capacity) are installed in the non-residential sector and 37% in the residential sector (EuP 2011). The sales share of room AC units is somewhat different between the two sectors. In the residential sector, single split AC accounts for 84% of sales, moveable AC (single ducts) for 11%, multi-splits for 4%, and windows for 1%. In the non-residential sector, single split AC accounts for 78% of sales, moveable AC (single ducts) for 5%, multi-splits for 15%, and windows for 2% (EuP 2011).

Cooling Capacity

The average product-weighted cooling capacity by sub-category in the 2011 Eurovent database is presented in Table 14 below.

Table 14: Average Product-Weighted Cooling Capacity by Sub-Category 2011[20]

Air Conditioner Type	Average Cooling Capacity (kW)
Non ducted split packaged AC systems (cooling only)	6.19
Non ducted split packaged AC systems (heat pump)	5.66
Multi split packaged units	6.09
Windows unit (unitary)	5.62

The trends in product-weighted cooling capacity are shown in Table 15 below, which combines the above data with earlier Eurovent data.

Table 15: Product-Weighted Cooling Capacity (kW) by Sub-category[21]

	2002	2005	2009	2011
Unitary AC with Cooling Capacity under 12kW	4.3	3.8	3.7	5.6
Split AC with Cooling Capacity under 12kW	5.4	5	5.3	5.7
Multi Split AC with Cooling Capacity under 12kW	5.8	5.9	6.4	6.1

[20] Eurovent, 2011

[21] Data source: IEA 4E (Eurovent) to 2009 and this study for 2011

As is the case in many other markets, it is thought that the sales of room air conditioners in Europe is more heavily weighted to smaller capacity units than the product offer data would imply. The EuP (2011) study estimates that the sales-weighted average cooling capacity is 3.5 kW for split AC units and 2.2 kW for moveable (single-duct) units.

Trends in EER of Most and Least Efficient Products

A time series of the trends in the EER of the highest efficiency products is shown in Table 16 below.

Table 16: Time Series of Trends in the EER of the Highest Efficiency Products[22]

	2002	2005	2009	2011
Unitary AC with Cooling Capacity under 12kW	3.03	4.17	3.23	3.07
Split AC with Cooling Capacity under 12kW	3.97	4.55	5.71	5.55
Multi Split AC with Cooling Capacity under 12kW	4.04	4.64	4.78	5.08

A time series of the trends in the EER of the lowest efficiency products is shown in Table 17 below.

Table 17: Time Series of Trends in the EER of the Lowest Efficiency Products[23]

	2002	2005	2009	2011
Unitary AC with Cooling Capacity under 12kW	2.14	2.15	2.37	2.10
Split AC with Cooling Capacity under 12kW	2.28	2.29	2.54	2.21
Multi Split AC with Cooling Capacity under 12kW	2.27	2.39	2.64	2.28

It can be seen from the tables above that the EER of the highest efficiency AC products (split and multi split AC) with a cooling capacity under 12 kW has improved between 2002 and 2011. As far as the EER of the highest unitary AC with a cooling capacity less than 12 kW is concerned, it has decreased from 4.17 in 2005 to 3.07 in 2011.

However, the EER of the lowest efficiency products have not really improved over the 2002-2011 period. From 2002 to 2009 the EER of the lowest efficiency products (unitary AC, split and multi split AC) with a cooling capacity under 12 kW have slightly increased from 2.14 to 2.37 for unitary AC, 2.28 to 2.54 for split AC, and 2.27 to 2.64 for multi split AC. Thereafter, the EER of the same AC products have decreased to 2.10 for unitary AC, 2.21 for split AC and 2.28 for multi split AC. Table 51 to Table 54, in Appendix 2 to this report, show

[22] Idem

[23] Idem

detailed information on the highest and lowest EER by AC type and by Eurovent Product Classification Categories.

Sales-Weighted EER Trends

The sales-weighted average energy efficiency of split AC room air conditioners with a cooling capacity less than 12 kW in the European Union is reported in Table 18 below.

Table 18: Sales-Weighted Average EER (kW/kW) in EU10[24]

	2005	2006	2007	2008	2009
Split AC with Cooling Capacity under 12kW	2.72	2.79	2.97	3.13	3.28

As can be seen from the table above, the sales-weighted average EER of split AC was reported to be 3.28 in 2009. It is important to note that the sales-weighted average EER constantly increased from 2005 to 2009.

Product Offer-Weighted EER Trends

Like the sales-weighted average EER of the split AC products mentioned above, the product offer-weighted EER of split and multi split AC has constantly increased from 2005 to 2009. The product offer-weighted EER reported by the IEA study for 2011 is 3.22 and 3.34 for split and multi split AC respectively. As far as unitary AC products are concerned, the product offer-weighted EER has slightly decreased from its highest value of 2.9 in 2005 to 2.68 in 2011. These trends are summarized and shown in Figure 7 to Figure 9 below.

[24] Data source: IEA 4E, 2010 (from GfK)

Figure 7: Split Air-Conditioner Product Offer-weighted Trends

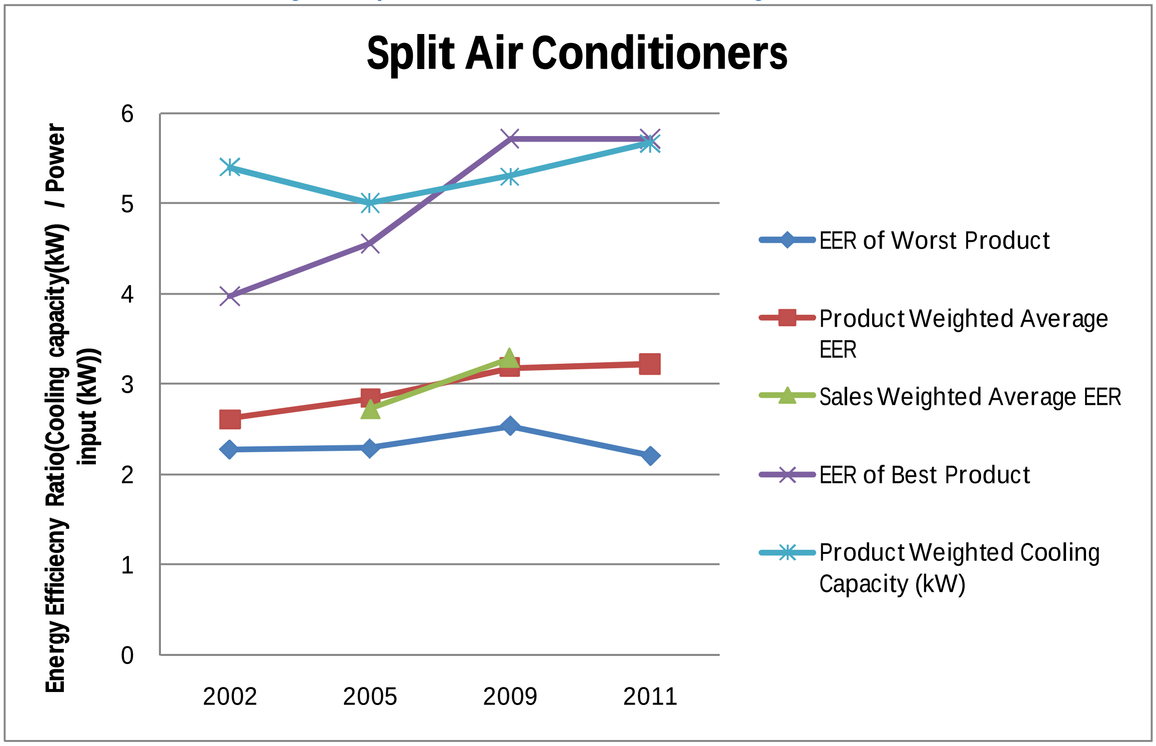


Figure 8: Multi-split AC Product Offer-Weighted Trends

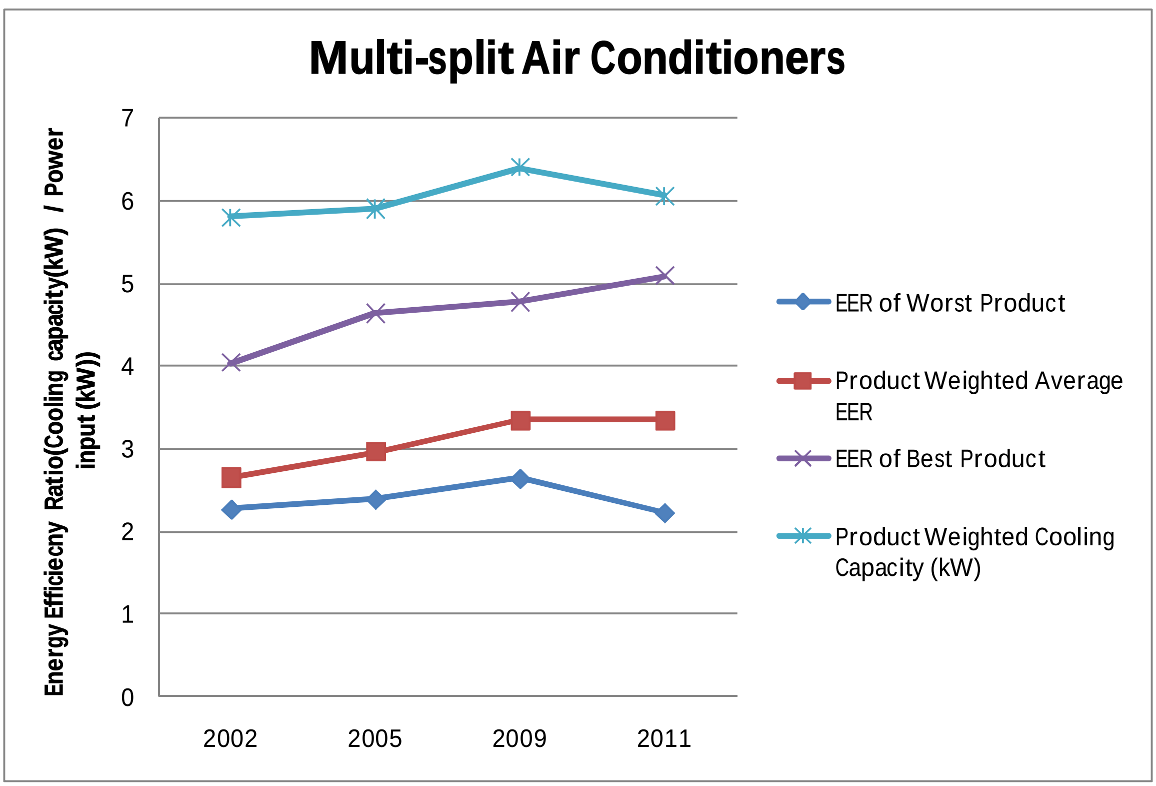
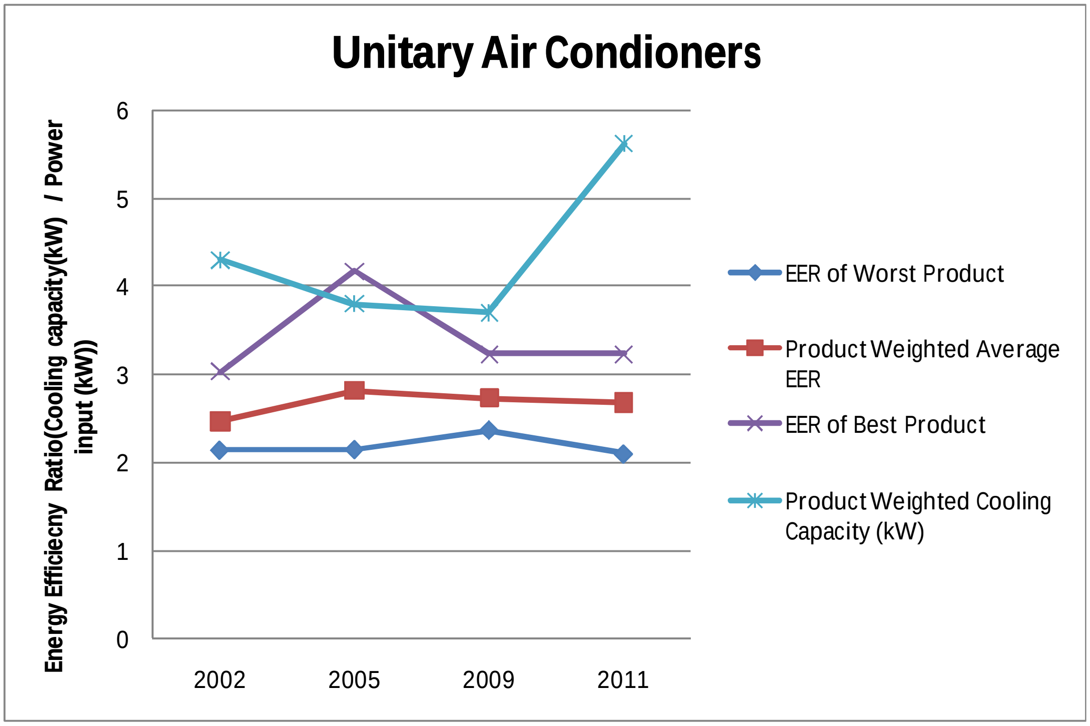


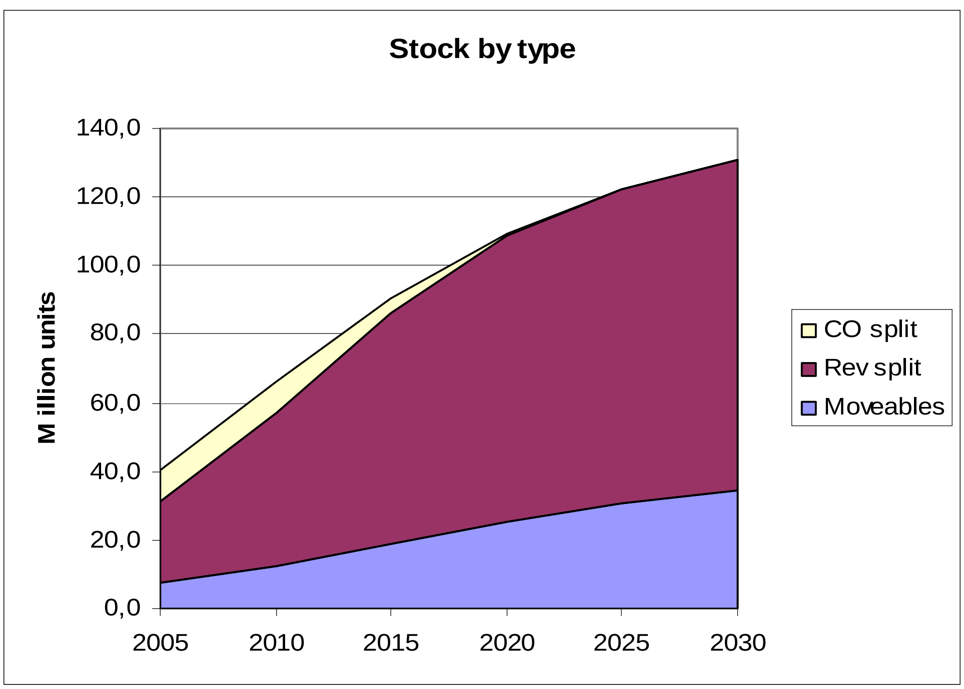
Figure 9: Windows (Unitary) AC Product Offer-Weighted Trends



5.1.2 Stock of AC products

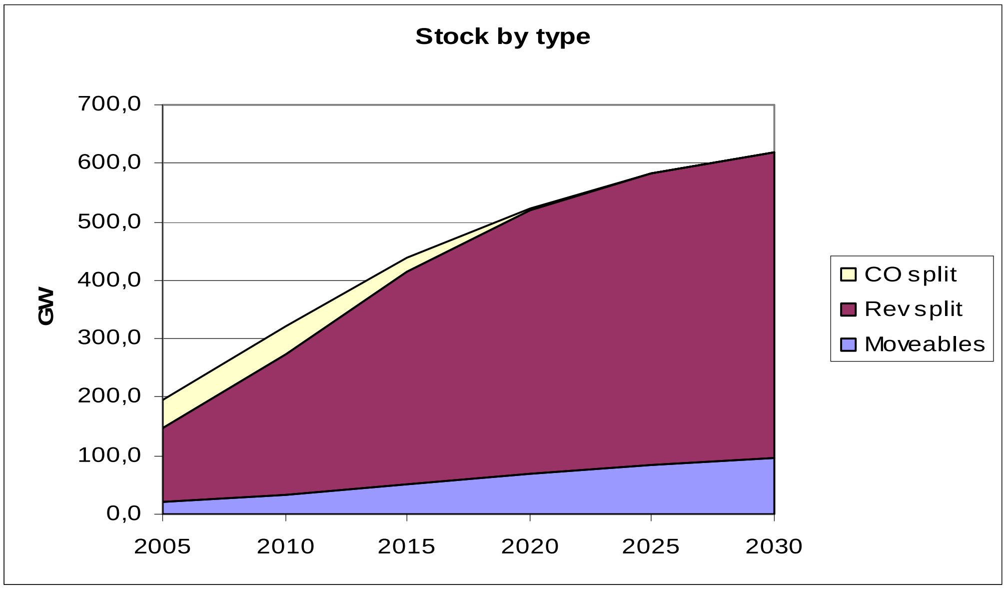
The installed stock of room air conditioners in the EU has been rapidly growing as shown below in Figure 10 and Figure 11.

Figure 10: Stock of Air-Conditioning Units by Type: 2005 to 2030 – EU 27



These figures suggest that the total installed stock of RACs in the EU-27 is over 70 million units in 2011, which represent more than 350 GW of installed capacity. Also, the figures suggest that reversible split units dominate the stock of AC installed in the EU-27. In fact, currently more than 65% of the AC in terms of units installed is reversible. This is followed by moveable AC, which represents approximately 20% of installed units, and cooling only units that represent 12% of the total installed AC.

Figure 11: Stock of Air-Conditioning in GW by Type: 2005 to 2030 – EU 27[25]



Moreover, as shown by the figure above, the projection of installed stock of RAC reveals that by 2030 there will no cooling only split units in use in the EU-27. Therefore, the reversible split units will represent approximately 75% of the total installed AC in the EU-27.

For more details on the installed stock of AC in the EU-27 member countries in terms of units and GW, refer to Table 57 and Table 58 in Appendix 2 to this report.

5.2 Standard and Labeling Framework

5.2.1 Minimum Energy Performance Standards

The EU does not currently have MEPS regulations for Room Air Conditioners; however, the Commission is currently considering such measures under the auspices of the Eco-design for Energy Using Products Directive (2005/32/EC of the European Parliament and of the Council of 6 July 2005) and a full investigative study has been commissioned and completed in draft form to assemble evidence to inform the decision (EuP 2011).

In addition the trade association Eurovent, whose members account for ~90% of the EU room AC market, operates a voluntary certification system for air conditioning products including room air conditioners. This scheme is mandatory for all Eurovent members, and a condition for inclusion is that the product energy

[25] **CO split** = Cooling only split units; **Rev split** = Reversible split units; **Moveable** = Moveable splits

efficiency must be better than class G of the mandatory energy label. This thus serves as a de facto minimum standard for a large proportion of the EU market.

5.2.2 Labeling Scheme

A mandatory energy label for room air conditioners is in place in Europe under Commission Directive 2002/31/EC of 22 March 2002 implementing Council Directive 92/75/EEC with regard to energy labeling of household air conditioners. The label must display the following information:

- Supplier's name or trade mark.
- Supplier's model identifier. For split and multi-split units, the model identifier of the indoor and of the outdoor elements of the combination.
- The energy efficiency class of the model, or combination, determined, in accordance with Annex IV.
- A copy of the eco-label, if applicable.
- The indicative annual energy consumption calculated with the total input power as defined in the harmonized standards referred to in Article 2 multiplied by an average of 500 hours per year in cooling mode at full load, determined in accordance with the test procedures of the harmonized standards referred to in Article 2 (conditions T1 'moderate').
- The cooling output defined as the cooling capacity in kW of the appliance in cooling mode at full load, determined in accordance with the test procedures of the harmonized standards referred to in Article 2 (conditions T1 'moderate').
- The EER (energy efficiency ratio) of the appliance in cooling mode at full load, determined in accordance with the test procedures of the harmonized standards referred to in Article 2 (conditions T1 'moderate').
- The type of appliance: cooling only, cooling/heating.
- The cooling mode: air cooled, water cooled.
- Only for appliances with heating capability (label 2): the heat output defined as the heating capacity in kW of the appliance in heating mode at full load (conditions T1 + 7C).
- Only for appliances with heating capability (label 2): the heating mode energy efficiency class, expressed on a scale of A (higher) to G (lower) (conditions T1 + 7C). If the appliance heating capability is provided by a resistive element then the COP (coefficient of performance) shall have the value of 1.
- Where applicable, noise during standard function.

The current European energy labeling classes for cooling mode are shown in Table 19 below.

Table 19: Current European Energy Labeling Classes for Cooling Modes

Cooling: Air-Cooled			
Energy Efficiency Class	Split and Multi-Split Appliances	Packaged (through the wall)	Single Duct and Double Ducts
A	3.2 < EER	3.0 < EER	2.6 < EER
B	3.2 ≥ EER > 3.0	3.0 ≥ EER > 2.8	2.6 ≥ EER > 2.4
C	3.0 ≥ EER > 2.8	2.8 ≥ EER > 2.6	2.4 ≥ EER > 2.2
D	2.8 ≥ EER > 2.6	2.6 ≥ EER > 2.4	2.2 ≥ EER > 2.0
E	2.6 ≥ EER > 2.4	2.4 ≥ EER > 2.2	2.0 ≥ EER > 1.8
F	2.4 ≥ EER > 2.2	2.2 ≥ EER > 2.0	1.8 ≥ EER > 1.6
G	2.2 ≥ EER	2.0 ≥ EER	1.6 ≥ EER

In 2011, these labeling requirements are currently undergoing a revision. The current Working Document on possible Eco-design Requirements for air conditioning appliances and comfort fans (November 2010[26]) sets out a scheme wherein the rating of split, multi-split and single packaged (window) room air conditioners is treated consistently, whereas moveable units have a separate scale (as at present). Seasonal performance will be rated for split systems. Ten ratings from A+++ to G are proposed, with separate ratings for the cooling and heating modes for reversible units. The SEER of the heating function will be calculated based on different climate zones, but for cooling it will be based on a single climate zone.

Table 20: Proposed New Energy Labeling Requirements

Cooling: Air-Cooled			
Energy Efficiency Class	Room Air Conditioners	Double Duct	Single Duct
A+++	≥7 SEER	≥4.1 EER	≥4.1 EER
A++	≥6.1 SEER	≥3.6 EER	≥3.6 EER
A+	≥5.6 SEER	≥3.1 EER	≥3.1 EER
A	≥5.1 SEER	≥2.6 EER	≥2.6 EER
B	≥4.6 SEER	≥2.4 EER	≥2.4 EER

[26] Latest working document can be downloaded from: http:/env-ngo.eup-netowekr.de/product-groups/draft-adopted-measures/

Cooling: Air-Cooled			
Energy Efficiency Class	**Room Air Conditioners**	**Double Duct**	**Single Duct**
C	≥4.1 SEER	≥2.1 EER	≥2.1 EER
D	≥3.6 SEER	≥1.8 EER	≥1.8 EER
E	≥3.1 SEER	≥1.6 EER	≥1.6 EER
F	≥2.6 SEER	≥1.4 EER	≥1.4 EER
G	<2.6 SEER	<1.4 EER	<1.4 EER

5.2.3 Testing Procedures

Room air conditioners are currently tested according to EN 14511-3:2007 which is directly equivalent to the ISO 5151 test procedure. A new test procedure is under development in 2011 which will include a seasonal energy efficiency rating and measure standby and crank case heater loads within the overall efficiency rating.

Self-declaration is applied for the energy performance of room air conditioners sold on the EU market; however, about 90% of the products are certified under the Eurovent industry certification scheme. Compliance testing is the responsibility of each EU member state but must be conducted in accredited laboratories if a legal challenge is to be sustained.

6 Mapping for India

6.1 AC Market Characterization

6.1.1 Supply of New AC Products

Share of AC Products by Sub-Category

Two types of RACs are typically available in the Indian market. They are window air conditioners (normally used for cooling individual rooms) and split-system air conditioners, which consist of an outdoor metal cabinet that contains the condenser, condenser fan and compressor as well as an indoor cabinet that contains the evaporator and air handler.

Most of the current AC manufacturers in India are foreign corporations with local offices and potentially domestic manufacturing facilities. As of now, in the domestic sector, the Indian market is mainly dominated by constant-speed air conditioners. However, the introduction of inverter types has begun. In order to shift the market towards energy-efficient AC, the Government of India, through the Bureau of Energy Efficiency (BEE), developed and implemented an energy efficiency rating system for some AC models. Therefore, the BEE maintains a database of all AC units qualified under the mandatory scheme in force in India. Table 21 below presents the sales data by sub-category and size.

Table 21: Sales Data of Fixed (on/off) AC by Sub-Category and Size in India[27]

Residential Air Conditioners	Cooling Capacity (CC)	Sales Volume		
		2007	2008	2009
Non-Ducted Split-Packaged AC Systems (fixed)	Less than 3 kW	3,746	36,300	32,084
	From 3 kW to 4.4 kW	17,761	208,832	426,991
	From 4.4 kW to 6.1 kW	101,253	571,075	831,724
	From 6.1 kW to 14 kW	14,057	96,671	216,376
Window Units	Less than 3 kW	22,12	23,967	42,397
	From 3 kW to 4.4 kW	30,914	75,817	107,022
	From 4.4 kW to 6.1 kW	114,325	243,547	560,107
	From 6.1 kW to 14 kW	3,378	-	18,567

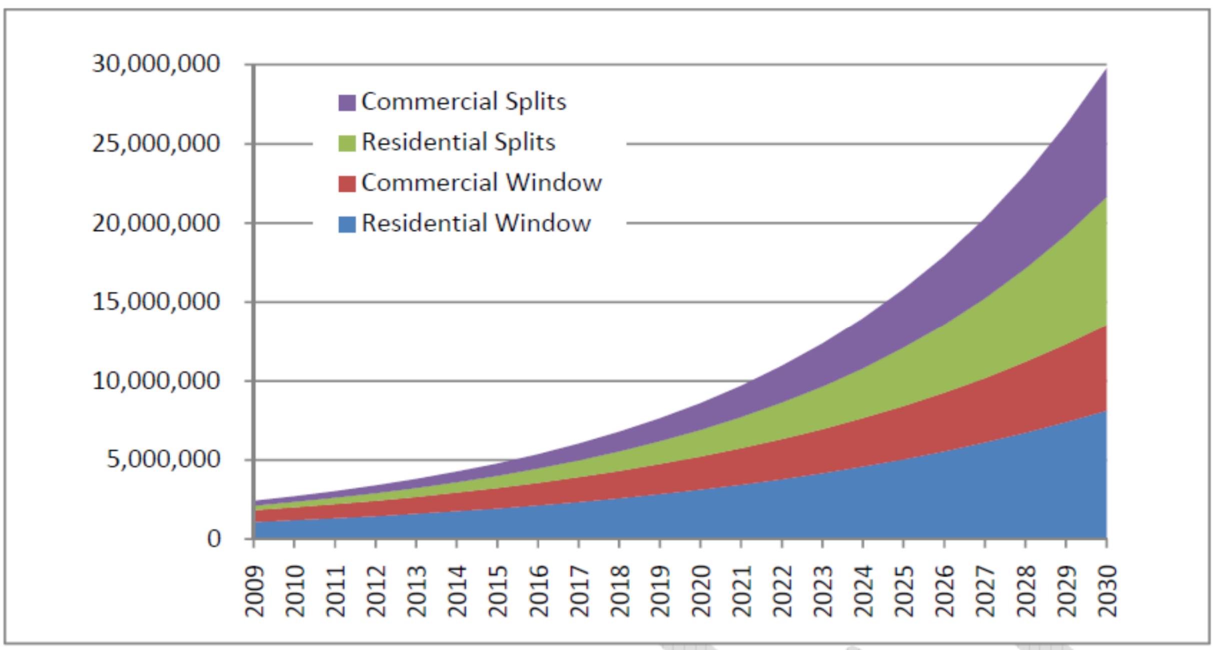
[27] Data Source: BEE, 2011

An important observation that can be made from the table above is that the split and window RAC sales grew rapidly over the 2007-2009 period with a higher growth rate for non-ducted split AC systems. However, the sale trend of the split AC unit with a CC less than 3 kW shows a decrease in 2009 compared to 2008 sale data. Based on these 2009 data, non-ducted split AC systems (4.4 kW to 6.1 kW) account for approximately 38% of RAC sales in India. These are followed by window units with the same CC and non-ducted split AC systems (3 kW to 4.4 kW). The table also shows that the least sold AC units are non-ducted split AC systems (less than 3 kW) and window AC systems (6.1 kW to 14 kW) which contribute to 1.44% and 0.83% of RAC sales respectively.

Furthermore, according to India's air conditioning trade organization, the Refrigeration and Air Conditioning Manufacturers Association (RAMA), 372,000 window and split residential AC units were sold in the first quarter of 2009 (1/3 were ductless splits and 2/3 were window units). India is one of the few international markets where ductless split sales were expected to increase in 2009 with over 600,000 units sold[28].

According to projections from an update of a Lawrence Berkeley National Laboratory (LBNL) study using more recent data from the Refrigeration and Air Conditioning Manufacturers Association (RAMA), the AC market in India will continue to grow and reach almost 30 million AC units by 2030 versus 2.5 million in 2009. The forecast, which is shown in Figure 12 below, assumes a fixed growth rate of 10% of window unit sales and 17% for split units.

Figure 12: AC Unit Forecast for India[29]



[28] Natural Resources Defense Council, ***India Air Conditioners and Power Use: Fact Sheet February 2011,*** p.10.

[29] Idem

EE Analysis by Year and by Sub-product

Average nominal EER values for each AC category qualified under the labeling scheme are given in Table 22 below.

Table 22: Minimum, Average and Maximum Performance on the Indian Fixed (on/off) AC Market[30]

Residential Air Conditioners	Size	EER		
		Min	Average	Max
Non-Ducted Split-Packaged AC Systems (fixed)	Less than 3 kW	2.44	2.87	3.5
	From 3 kW to 4.4 kW	2.37	2.89	3.59
	From 4.4 kW to 6.1 kW	2.35	2.83	3.6
	From 6.1 kW to 14 kW	2.43	2.78	3.42
Window Units	Less than 3 kW	2.35	2.67	2.88
	From 3 kW to 4.4 kW	2.34	2.62	2.89
	From 4.4 kW to 6.1 kW	2.39	2.56	2.89
	From 6.1 kW to 14 kW	2.35	2.46	2.65

The table above shows that in the AC market, non-ducted splits with a capacity ranging from 3 kW to 4.4 kW have the highest average EER (2.89) while window AC units (6.1 kW to 14 kW) have the lowest EER (2.46).

Sales-Weighted Average EER

The sales-weighted average EER of non-ducted split and window units can only be estimated from the label class and are reported in Table 23 below.

Table 23: Sales-Weighted Average EER in India[31]

Residential Air Conditioners	EER per label class	Sales Volume		
		2007	2008	2009
Non-Ducted Split-Packaged AC Systems	More than 3.1 (Class 5)	1,716	45,346	239,299
	Between 2.9 and 3.1 (Class 4)	6,782	44,486	70,496

[30] Authors, based on data collected from BEE, 2011

[31] Idem

Residential Air Conditioners	EER per label class	Sales Volume		
		2007	2008	2009
(fixed)	Between 2.7 and 2.9 (Class 3)	21,959	237,722	612,025
	Between 2.5 and 2.7 (Class 2)	67,289	559,001	567,595
	Between 2.3 and 2.5 (Class 1)	39,071	22,364	17,760
Window Units	More than 3.1 (Class 5)	0	0	0
	Between 2.9 and 3.1 (Class 4)	0	0	0
	Between 2.7 and 2.9 (Class 3)	1,660	24,462	80,457
	Between 2.5 and 2.7 (Class 2)	132,023	130,297	303,693
	Between 2.3 and 2.5 (Class 1)	37,054	188,572	343,943

Calculating a weighted average from the sales numbers presented above, we can estimate an average EER of 2.8 for non-ducted split unit and 2.5 for windows unit. Also from the table above, we can observe that sales of non-ducted split units grew in each label class between 2007 and 2009 except for the lowest efficiency class. In fact, these figures indicate that the sales of these AC systems decreased by 55% over the same period. The figures further indicate that class 5 and class 4 window AC units were not sold on the Indian market. Nonetheless, the sale of window AC units also grew between 2007 and 2009 regardless of the label class.

6.1.2 Stock of AC Products

The installed stock of RACs in India has been growing rapidly. According to a market study quoted by the Natural Resources Defense Council[32], India had approximately 1 million residential AC units in 2000. In 2007, LBNL estimated that by 2020 there would be 61 million residential AC units installed.

6.2 Standards and Labeling Framework

6.2.1 Minimum Energy Performance Standards

Because of concerns that many of the AC units manufactured and imported into India are not optimized for the local climate and are essentially based on imported designs, government authorities established MEPS for AC. MEPS are mandatory and became effective in January 2010. MEPS apply to single-phase split and unitary air conditioners of the vapor compression type for household use up to a rated cooling capacity of 11 kW being manufactured, imported or sold in India. All the AC units subject to these MEPS should have a minimum EER

[32] See Natural Resources Defense Council, ***India Air Conditioners and Power Use: Fact Sheet February 2011,*** p.10.

(W/W) of 2.30 between January 7, 2010 and December 31, 2011. In addition, the current EER will be updated according to the schedule below:

- January 1, 2012 to December 31, 2013, Energy Efficiency Ratio (W/W) = 2.50;
- January 1, 2014 to December 31, 2015, Energy Efficiency Ratio (W/W) = 2.70.

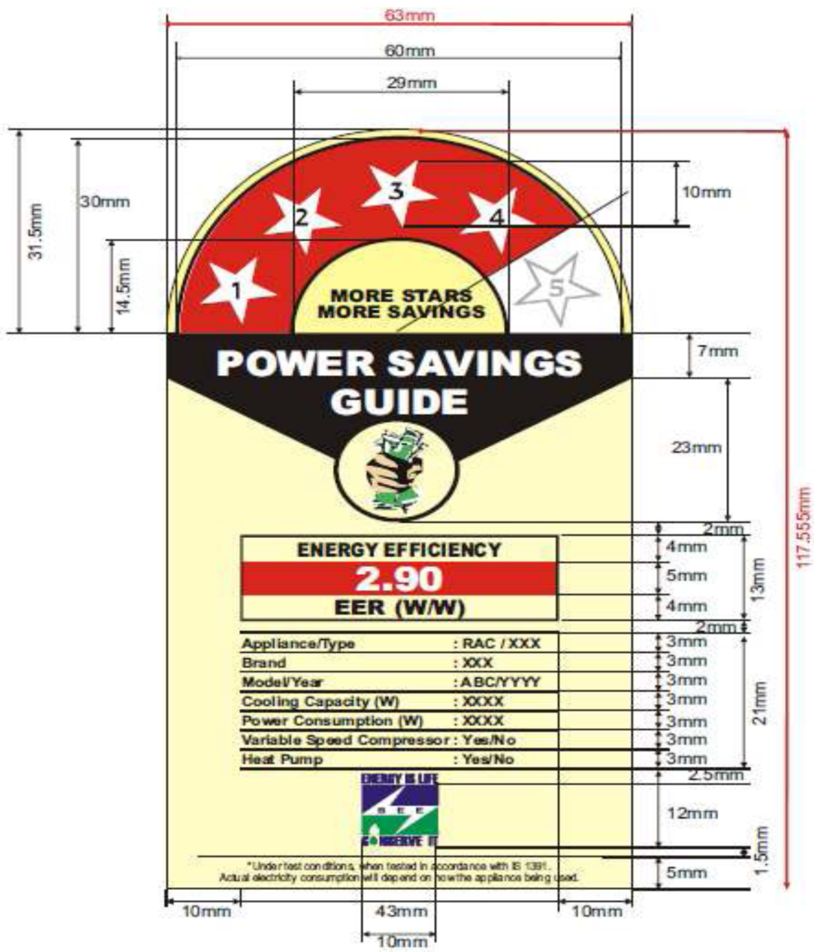
6.2.2 Labeling Scheme

In May 2006, the BEE launched a voluntary S&L program for electrical home appliances, including air conditioners. Under this program, for the benefit of the general public, appliance manufacturers could voluntarily affix a star label to appliances showing their level of energy consumption, both in terms of absolute values and the equivalent number of stars (from one to five), in accordance with the labeling scheme. In this scheme, a greater number of stars on the label represents better energy efficiency. Affixing a BEE star label, which is comparative, was made mandatory for RACs in January 2010.

The label, shown in Figure 13 below, indicates the following information:

- Appliance/Type;
- Brand/Model Name/Number/Year of Manufacturing;
- Capacity (kW) (Actual Tested);
- Power (Watts);
- EER (W/W);
- Variable Output Compressor (Yes/No);
- Heat Pump (Yes/No).

Figure 13: Label for Room Air Conditioners



The star rating criteria and the proposed update are presented in Table 24 below.

Table 24: Existing and Proposed EER Update of the Labeling Scheme in India

Period	January 7, 2010 to December 31, 2011		January 7, 2012 to December 31, 2013		January 7, 2014 to December 31, 2015	
Star Rating	Min	Max	Min	Max	Min	Max
1-Star	2.30	2.49	2.50	2.69	2.70	2.89
2-Star	2.50	2.69	2.70	2.89	2.90	3.09
3-Star	2.70	2.89	2.90	3.09	3.10	3.29
4-Star	2.90	3.09	3.10	3.29	3.30	3.49
5-Star	3.10		3.30		3.50	

6.2.3 Testing Procedures

In India, RACs are currently tested for energy consumption and cooling capacity according to the testing code and procedure for air conditioners referred to as IS 1391 with all amendments. The Bureau of Indian Standards (BIS) is responsible for the development or the transposition of international testing procedures of equipment in the country. Currently, IS 1391 is undergoing revision and the transposition of international procedures pertaining to test standards for AC into national standards is under consideration.

Self-declaration is applied to the energy performance of RACs distributed on the Indian market by manufacturers. Compliance testing is the responsibility of the BEE but must be conducted in accredited laboratories.

To verify the compliance of AC product manufacturers and distributors, the BEE, or its designated agency for testing, picks up the samples as per the following sampling plan: (i) one sample will be picked up at random from the manufacturing facility or warehouse; (ii) one sample will be picked from a retail outlet. Three units of each type are picked up for each test. The tests are conducted on two of the three units, and the third is kept as an alternative in case one of the units is damaged or cannot be tested properly for any other reason.

Furthermore, for each unit tested, the measured capacity must be > 0.95 of the rated value, the measured energy consumption must be < 1.05 of the rated value, and the measured EER must be > 0.95 of the rated EER. In addition, there is no tolerance for the Star Rating Band – the average of products tested must be equal to or better than the label threshold.

7 Mapping for Japan

7.1 AC Market Characterization

7.1.1 Supply of new AC Products

Share of AC Products by Sub-Category

The Japanese market for residential air conditioners is mature, unlike the rapidly growing European market.

The Japanese room air conditioner market is dominated by reversible split AC units, which were invented there. The sales of room AC by cooling only and reversible is shown in Table 25 below. Windows (unitary) and single duct sales are thought to be minimal or non-existent. Among the split units, sales of cooling only units have declined steadily and seem to have been almost completely substituted by reversible units. Data on the sales of multi-split units as a share of the total were not available for this study but a review of manufacturers catalogues suggests that they are much less common place than single split units. Similarly, ducted units are very rare in Japanese households (national sales were just 3.5 thousand units in 2004[33]).

Table 25: Residential AC Sales[34]

Air Conditioner Type	2004	2005	2006	2007	2008	2009
Residential air conditioners	6,931,026	7,481,272	7,520,394	7,390,038	7,749,477	6,775,383
Cooling only	90,599	89,770	113,103	-	-	-
Reversible	6,840,427	7,391,502	7,407,291	-	-	-

To assess the status of the current market, Navigant collected data on 307 room air conditioners available on the Japanese market via on-line catalogue data. These data reveal that cooling-only room air conditioner units seem to have disappeared from the Japanese market[35], and the entire residential room air conditioner market is comprised of single-split heat pumps. Single-packaged (window) units have been unpopular in Japan for many years and are not able to reach the high Annual Performance Factor (APF) required by the Top Runner requirements. Multi-splits seem to be largely reserved for non-residential use.

Furthermore it is thought that all the models on the market use inverters. Even when this is not made explicit in the on-line product literature, the minimum APF values are too high for single speed models and it is known

[33] ECCJ, 2008

[34] Data source: JRIA 2011

[35] The only exception appears to be for cooling only dehumidifiers, but these are not classified as room air conditioners in the current study.

that inverters are the cheapest and most practicable means of reaching the higher APFs required by the 2010 Top Runner requirements. An analysis of the ratio of the APF to EER values confirms this assessment as practically all models have a ratio in excess of 1.1, which single speed compressor units are not able to attain.

Since 2009, most if not all Japanese room air conditioners are thought to have switched to R410A for the refrigerant.

Cooling Capacity

The average product-weighted cooling capacity by sub-category in the 2011 on-line catalogue data is presented in Table 26 below.

Table 26: Average Product-Weighted Cooling Capacity by Sub-category 2011[36]

Air Conditioner Type	Average Cooling Capacity (kW)
Non ducted split packaged AC systems (cooling only)	NA
Non ducted split packaged AC systems (heat pump)	3.67
Multi split packaged units	NA
Windows unit (unitary)	NA

Trends in Energy Efficiency

The last publically available national investigation into the energy efficiency of Japanese air conditioners reported efficiency information up to 2006. It is reported that the most energy efficient air conditioners on the Japanese market are smaller capacity split system heat pumps, which are also comfortably the products with the highest sales in the Japanese domestic market (ECCJ 2006).

SEER ratings are not applied in Japan, but a new Annual Performance Factor is in use, which uses a similar approach to produce more accurate annual average efficiency and combines both cooling and heating efficiencies at full and part loads. The test points and annual average hours of use at each point applied in Japan are designed to be representative of typical usage and environmental conditions there and hence are not directly comparable with US SEER or EU SEER ratings; however, the full capacity EER and COP ratings are consistent with those used in ISO 5151 and hence are directly comparable with the values reported for other economies.

For products with a 2.2 kW cooling capacity, the highest efficiency unit in 2006 had:

- APF of 6.6 W/W;

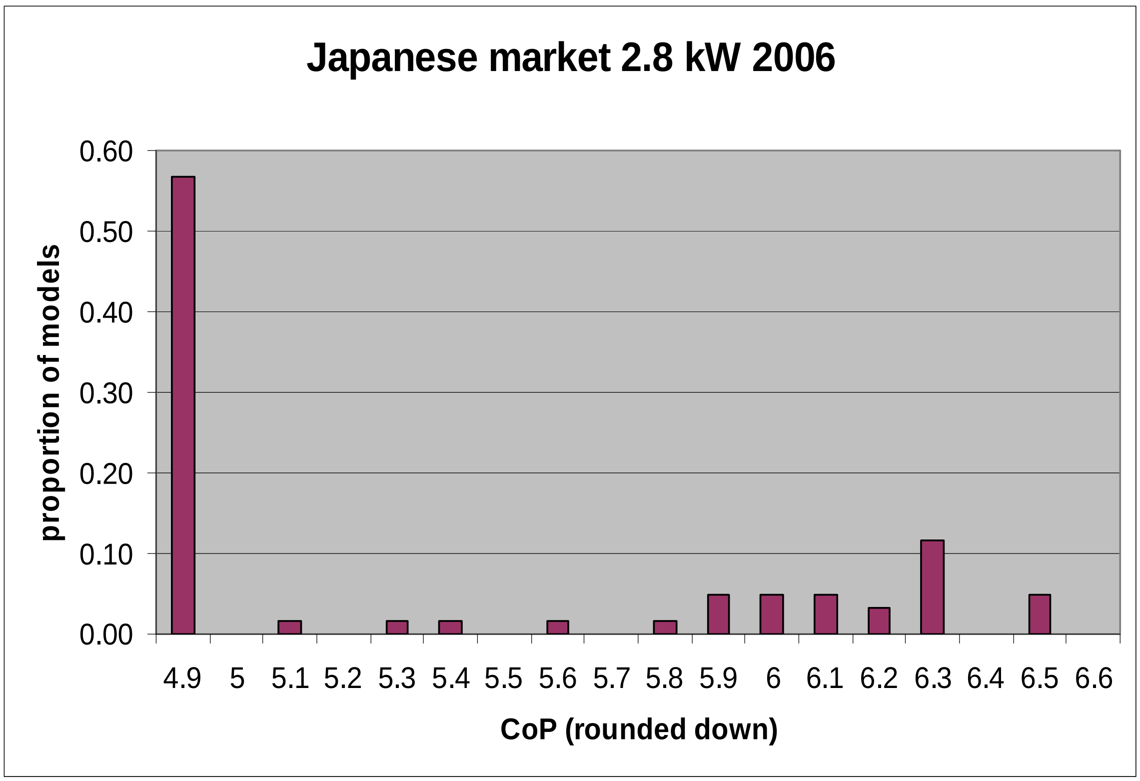
[36] Data source: Navigant survey of 307 models in on-line catalogues, 2011

- COPc (EER) of 6.38 W/W;
- COPh of 6.85 W/W;
- COPave of 6.62 W/W.

The highest EER for a room air conditioner on the Japanese market in 2006 was 6.38 W/W, which was 45% higher than the highest on the US market in 2010, which was 4.4 W/W.

Figure 14 below shows the number of models of the popular 2.8 kW cooling capacity size by their average COP (average of the EER and heating COP) in 2006. At that time the performance of the majority of the models was close to the minimum Top Runner requirements then applicable, although about half had significantly higher performance.

Figure 14: COP of Split Air-Conditioners with 2.8kW Capacity in 2006



In order to get a picture of the current Japanese room air conditioner market, on-line catalogue data was collected for 307 air conditioner models offered by a wide variety of manufacturers. An analysis of this data showed that the highest efficiency model had an APF of 7.2 W/W and the highest efficiency model at full load had an EER of 6.7W/W. Details are reported in Table 27 below.

Table 27: Product with the Highest EER by AC Type[37]

	APF (W/W)	EER (W/W)	Brand and Model
Non ducted split packaged AC systems (cooling only)	NA	NA	NA
Non ducted split packaged AC systems (heat pump)	7.20	6.67	Panasonic CS-HX220C
Multi split packaged units	NA	NA	NA
Window unit	NA	NA	NA

A time series of the trends in the energy efficiency of room air conditioners sold in Japan is shown in Table 28. The results only concern reversible single split units which dominate the Japanese market. Mean data up to 2006 is sales-weighted but afterwards (for 2011) is product-weighted.

Table 28: Time Series of Trends in the COP or APF (W/W) and EER (W/W) of Japanese Room Air Conditioners[38]

	2002	2005	2006	2011
Mean COP or APF	4.6	5.25		6.29
Highest COP or APF			6.60	7.20
Lowest COP or APF				4.50
Mean EER				4.10
Highest EER			6.38	6.67
Lowest EER				2.37

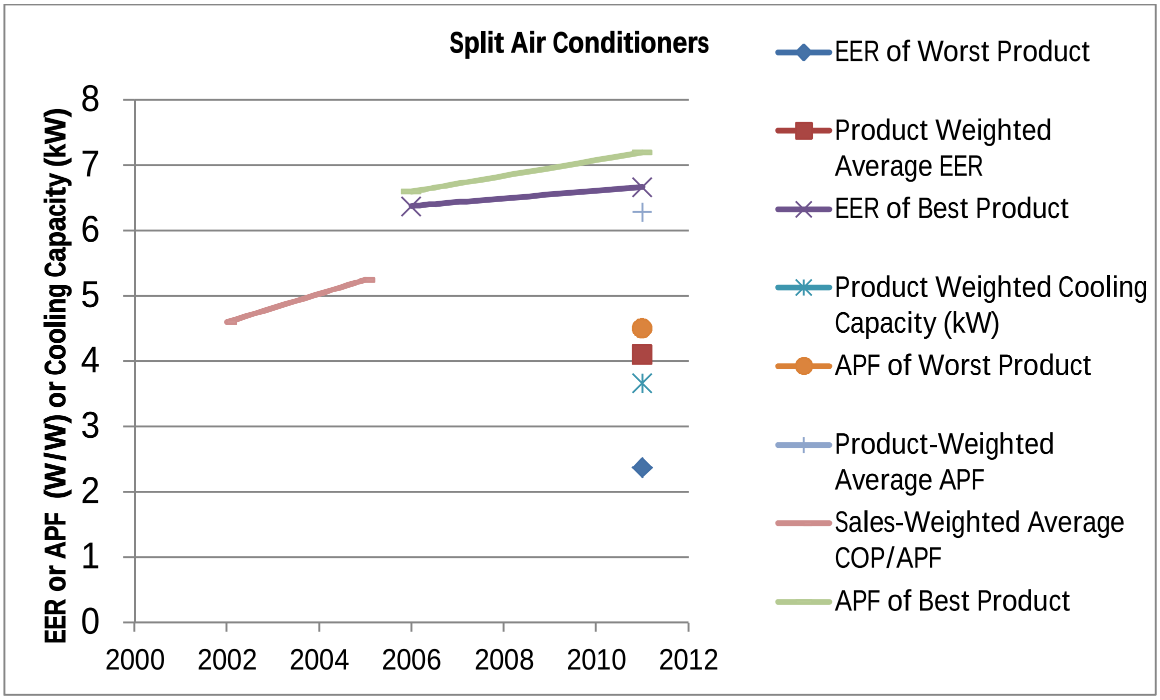
The least energy efficient products in the on-line catalogue data of January 2011 was for a unit with an APF of 4.5 W/W. The lowest EER was 2.37 W/W.

Figure 15 below summarizes the AC market and efficiency trends aforementioned for Japan.

[37] Data source: Navigant survey of 307 models in on line catalogues, 2011

[38] Data source: EECJ (2008) and Navigant survey of 307 models in on line catalogues, 2011

Figure 15: Split Air-Conditioner Efficiency Trends



7.1.2 Stock of AC Products

There were an estimated 124 million room air conditioners in Japanese households in 2010, which corresponds to an average of 2.63 room air conditioners per household (ECCJ 2010). This is an increase of 35% since 2000.

7.2 Standards and Labeling Framework

7.2.1 Minimum Energy Performance Standards[39]

Japan has applied fleet average minimum energy performance requirements for room air conditioners since 1997 under the auspices of the Top Runner program.

Target Scope

The scope of room air conditioners under the Top Runner program includes cooling-cum-heating air conditioners and dedicated cooling air conditioners, except units with the following characteristics:

- cooling capacity of over 28 kW;
- water-cooling type;
- without compressors;
- using any energy other than electricity as a heat source for heating;

[39] The source for the information in this section is Top Runner (2010).

- having temperature control function or dust control function for maintenance of machine operations or food hygiene;
- mainly cool outside air and send it into indoors;
- spot air conditioners;
- designed for vehicles and other transports;
- having a duct at suction/exhaust outlet of a heat-exchanger of an outdoor unit;
- having a thermal storage tank dedicated for cooling (including cooling-cum-heating);
- designed for highly gas-tight/heat-insulating housing, and which send air to multiple rooms through a brunched duct and operate coupled with ventilation devices;
- with compressors, air blowers and other main components that are powered by electricity generated from a dedicated solar cell module;
- having floor heating function or hot-water supply function.

Energy Consumption Efficiency

Air Conditioners whose Target Fiscal Year is 2004 Freezing Year[40] or 2007 Freezing Year

For cooling air conditioners, energy consumption efficiency is cooling energy consumption efficiency (COP). It is a numeric value obtained from dividing cooling capacity (as measured in the manner stipulated by Japanese Industrial Standards (JIS) 88615-1 or 88615-2) by cooling power consumption (measured in the same way). For cooling-cum-heating air conditioners, it is cooling-heating average energy consumption efficiency (cooling-heating average COP). This is a numeric value obtained from dividing the sum of cooling energy consumption efficiency and heating energy consumption efficiency (measured in the same way as for cooling energy efficiency) by 2.

Air Conditioners whose Target Fiscal Year is 2010

Energy consumption efficiency is annual performance factor (APF), which is a numeric value calculated with the method stipulated in JISC 9612 (2005), Appendix 3.

Category, Target Values

In the target fiscal year and each subsequent fiscal year, energy consumption efficiency in each category must be at or greater than the target standard value. Target values and energy consumption efficiency levels are shown in Table 29 through Table 32 below.

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[40] The Japanese government use the term “freezing year” to mean the cooling season.

Table 29: Target Values

Residential Air Conditioners	Target
Air conditioners of wall-hung type among the non-duct types (excluding the multi-types that control operation of indoor unit separately), and whose cooling capacity is 4.0 kW or less (limited to cooling-cum-heating types)	2004 freezing year and each subsequent freezing year (until "the period from October 1, 2009 through March 31, 2010"): compliance with the target standard value for (1). FY 2010 and each fiscal year after that: compliance with the target standard value for (2).
Other	2007 freezing year and each freezing year after that: compliance with the target standard value for (1).
Service Air Conditioners	**Target**
Air conditioners of wall-hung type among the non-duct types (excluding the multi-types that control operation of indoor unit separately), and whose cooling capacity is 4.0 kW or less (limited to cooling-cum-heating types).	2004 freezing year and each freezing year after that: compliance with the target standard value for (1).
Other	2007 freezing year and each freezing year after that: compliance with the target standard value for (1).
Note: (1) Air conditioners whose target fiscal year is 2007 freezing year and each freezing year after that; (2) Air conditioners whose target fiscal year is 2010	

Table 30: Air conditioners whose target fiscal year is 2007 and each freezing year after that

Category			Standard Energy Consumption Efficiency (COP)
Unit Type	Cooling Capacity	Category Name	
Non-ducted window/ wall-installed type		A	2.85
Non-ducted wall-mounted type (except multi-type operating indoor units individually)	Up to 2.5kW	B	5.27
	Over 2.5kW up to 3.2kW	C	4.9
	Over 3.2kW up to 4.0kW	D	3.65
	Over 4.0kW up to 7.1kW	E	3.17
	Over 7.1kW	F	3.1
Other non-ducted type (except multi-type operating indoor units individually)	Up to 2.5kW	G	3.96
	Over 2.5kW up to 3.2kW	H	3.96
	Over 3.2kW up to 4.0kW	I	3.2
Ducted type	Over 4.0kW up to 7.1kW	J	3.12

Category			Standard Energy Consumption Efficiency (COP)
Unit Type	**Cooling Capacity**	**Category Name**	
(except multi-type operating indoor units individually)	Over 7.1kW	K	3.06
	Up to 4.0kW	L	3.02
Multi-type operating indoor units individually	Over 4.0kW up to 7.1kW	M	3.02
	Over 7.1kW	N	3.02
	Up to 4.0kW	O	4.12

Table 31: Cooling Air Conditioners

Category			Standard Energy Consumption Efficiency (COP)
Unit Type	**Cooling Capacity**	**Category Name**	
Non-ducted window/ wall-installed type		A	2.67
Non-ducted wall-mounted type (except multi-type operating indoor units individually)	Up to 2.5kW	B	3.64
	Over 2.5kW up to 3.2kW	C	3.64
	Over 3.2kW up to 4.0kW	D	3.08
	Over 4.0kW up to 7.1kW	E	2.91
	Over 7.1kW	F	2.81
Other non-ducted type (except multi-type operating indoor units individually)	Up to 4.0kW	G	2.88
	Over 4.0kW up to 7.1kW	H	2.85
	Over 7.1kW	I	2.85
Ducted type (except multi-type operating indoor units individually)	Up to 4.0kW	J	2.72
	Over 4.0kW up to 7.1kW	K	2.71
	Over 7.1kW	L	2.71
Multi-type operating indoor units individually	Up to 4.0kW	M	3.23
	Over 4.0kW up to 7.1kW	N	3.23
	Over 7.1kW	O	2.47

Note: "Ducted type" indicates systems connected to ducts at the outlet. "Multi-type" indicates a type that has two or more indoor units connected to an outdoor unit.

Table 32: Air Conditioners Whose Target Fiscal Year is FY 2010 and Each Subsequent Fiscal Year

Category			Standard energy consumption efficiency (APF)
Cooling capacity	Dimension type of indoor units	Category Name	
Up to 3.2 kW	Dimension-defined type	A	5.8
	Free-dimension type	B	6.6
Over 3.2 kW up to 4.0 kW	Dimension-defined type	C	4.9
	Free-dimension type	D	6.0
Note: "Dimension Type of Indoor Unit" means that air conditioner models whose indoor unit has a horizontal width of 800 mm or less and a height of 295 mm or less shall be defined as a dimension-defined type. Air conditioners other than those of dimension-defined type shall be free-dimension type.			

Target Fiscal Year

- 2007 freezing year (October 1, 2006 through September 30, 2007) and each subsequent freezing year (until "the period from October 1, 2009 through March 31, 2010")
- For non-ducted wall-mounted type cooling-cum-heating air conditioners whose cooling capacity is up to 4kW, it is 2004 freezing year (October 1, 2003 through September 30, 2004) and each subsequent freezing year after that.
- For non-ducted wall-mounted type cooling-cum-heating air conditioners which are covered by the Household Good Quality Labeling Law, enforcement order, appendix no. 3, it is FY 2010 and each subsequent fiscal year after that.

Energy Saving Effects

- For non-ducted wall-mounted type cooling-cum-heating air conditioners whose cooling capacity is up to 4 kW, its target year was 2004 freezing year, and energy efficiency was improved by approximately 67.8% compared to that of 1997 freezer year (October 1, 1996 to September 30, 1997).
- For air conditioners whose target year is 2007 freezing year, energy efficiency is assumed to be improved by approximately 63% for the cooling-cum-heating type and approximately 14% for the cooling type from 1997 freezing year.
- For air conditioners whose target year is FY 2010, energy efficiency is assumed to be improved by approximately 22.4% from FY 2005.

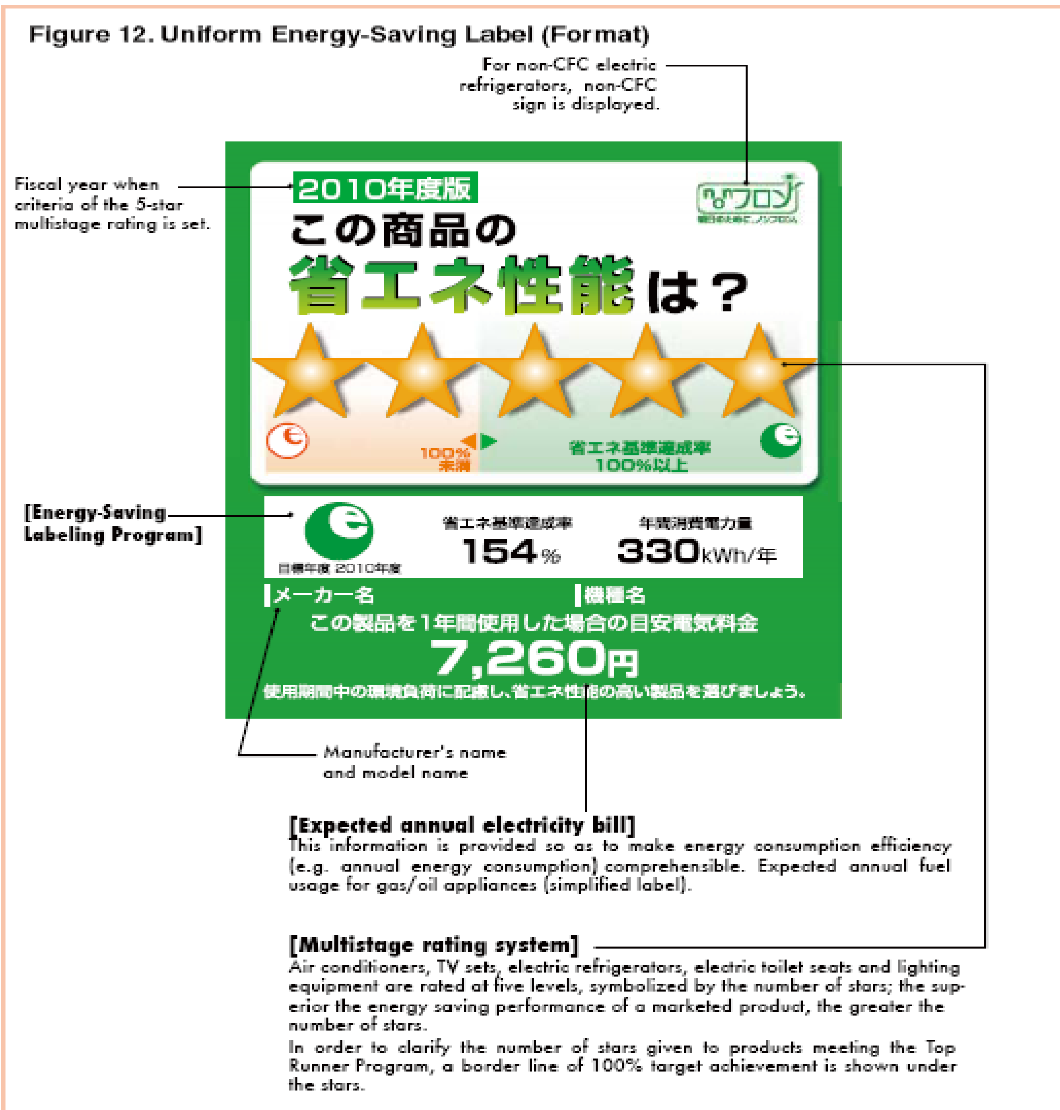
Display Items

Information displayed on Top Runner products include product name and type, cooling capacity, cooling power consumption, cooling energy consumption efficiency, heating capacity (heating units only), heating power consumption (restricted to heating systems), heating energy consumption efficiency (heating units only), average cooling/heating energy consumption efficiency (heating units only), and the manufacturer's name.

7.2.2 Labeling Scheme

Japan applies a mandatory "uniform" energy label for room air conditioners as shown in Figure 16 below. Under this scheme, more stars represent greater appliance efficiency. The label also incorporates the older energy label which shows what percentage of the Top Runner efficiency target the model achieves. If the percentage is above 100, the model is more efficient than the current Top Runner threshold.

Figure 16: Japan's "Uniform" Energy Label



7.2.3 Testing Procedures

Japan used to rate air conditioners using the "COP" values, noted hereafter COP_J to avoid misunderstandings: $COP_J = (COP + EER) / 2$

Nevertheless, inverter split air conditioners were introduced in the early 1990s in Japan, and a seasonal performance metric was adopted in 2004 for residential air conditioners[41] (JRA, 4046) and in 2006 for commercial air conditioners. Both standards are similar except the load and temperature conditions differ to take into account the specific use of commercial equipment depending on the specific installation.

In the residential sector, i.e., up to 10 kW thermal capacity (according to the JRA, 4046 standard), the metric available to the consumer is the APF (Annual Performance Factor), defined as the weighted average of the CSPF (Cooling Seasonal Performance Factor) and of the HSPF[42] (Heating Seasonal Performance Factor). Nevertheless, the CSPE and the HSPF are directly available to the consumer via the cooling energy consumption and the heating energy consumption. For cooling only split air conditioners, the APF equals the CSPE, simplifying the calculation. On the other hand, most dwellings in Japan use reversible VSD mini-split for their primary heating needs, and hence virtually all air conditioners are reversible in Japan. This means that to usefully benchmark the seasonal performance APF requirements in Japan, it is necessary to translate the APF value. Because of this specificity, it is necessary to consider here both heating and cooling modes.

Scope of the Residential Standard (JRA, 4046)

This standard specifies room air conditioners to be sold in the Japanese market, which are classified as single-package type or split-system type with a rated cooling capacity not exceeding 10 kW and a rated electric power consumption not exceeding 3 kW. Moreover only air conditioners with single speed compressor or variable speed compressor are in the scope of this standard, as units with two speed compressors or two capacity stages are not sold on the Japanese market.

Scope of the Commercial Standard (JRA, 4048)

This standard specifies package air conditioners with a cooling capacity less than 28 kW primarily intended for commercial use. This standard includes multi-split units, two step units, and variable capacity units. Specific conditions are specified for different buildings and climate. In what follows, we do not address these climates and focus on the residential segment.

Temperature and Load Conditions

The standard APF value is computed for Tokyo mild climate, although 17 other Japanese climates are available in the standard.

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[41] It can be noticed that previous Japanese Top Runner targets in COP do apply to new products. They simply have been completed with APF requirements.

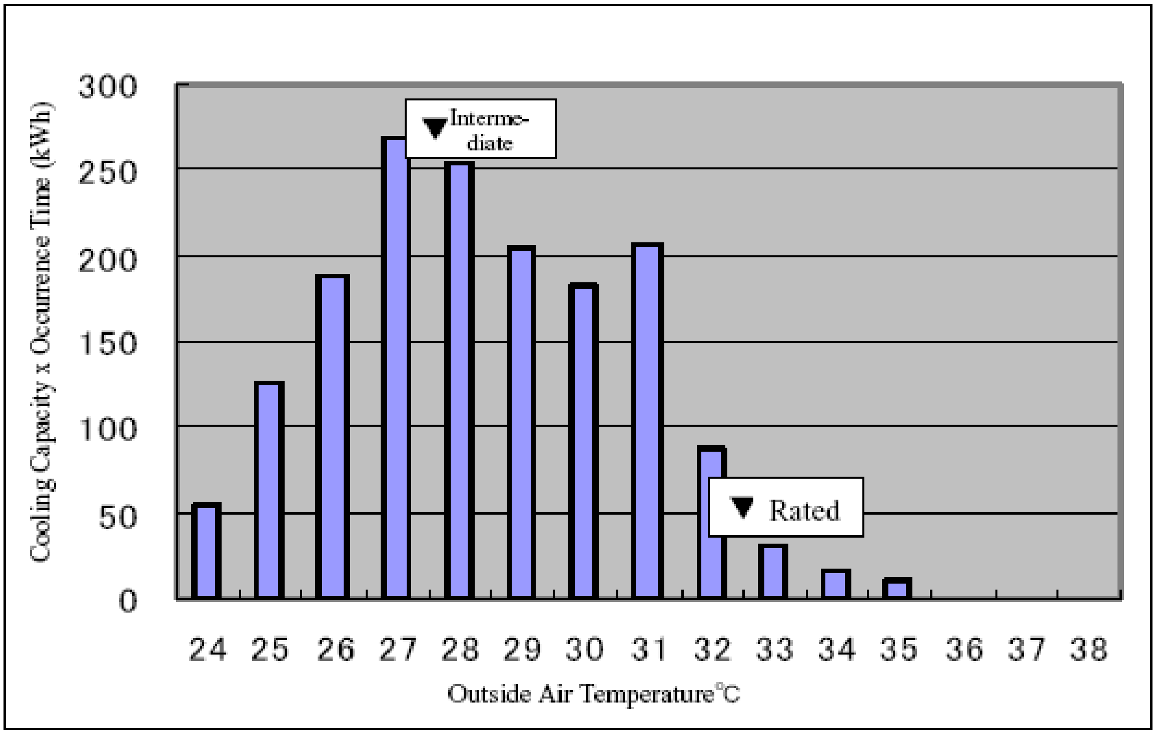
[42] Distinct from the US HSPF discussed earlier.

The cooling and heating building load curves are straight lines, defined by the following formulas for cooling and heating mode.

The rated cooling capacity, Φ_{BL} , is supposed to be equal to the load for an outdoor air temperature of 33 °C and the load is zero for an outdoor air temperature of 23 °C; cooling capacity is then supposed undersized by a few percent at 35 °C.

$$BL_c(T_j) = \frac{T_j - 23}{33 - 23}.\Phi_{BL}$$

Figure 17: Distribution of Cooling Energy as a Function of Outdoor Air Temperature, (ECCJ, 2008b)

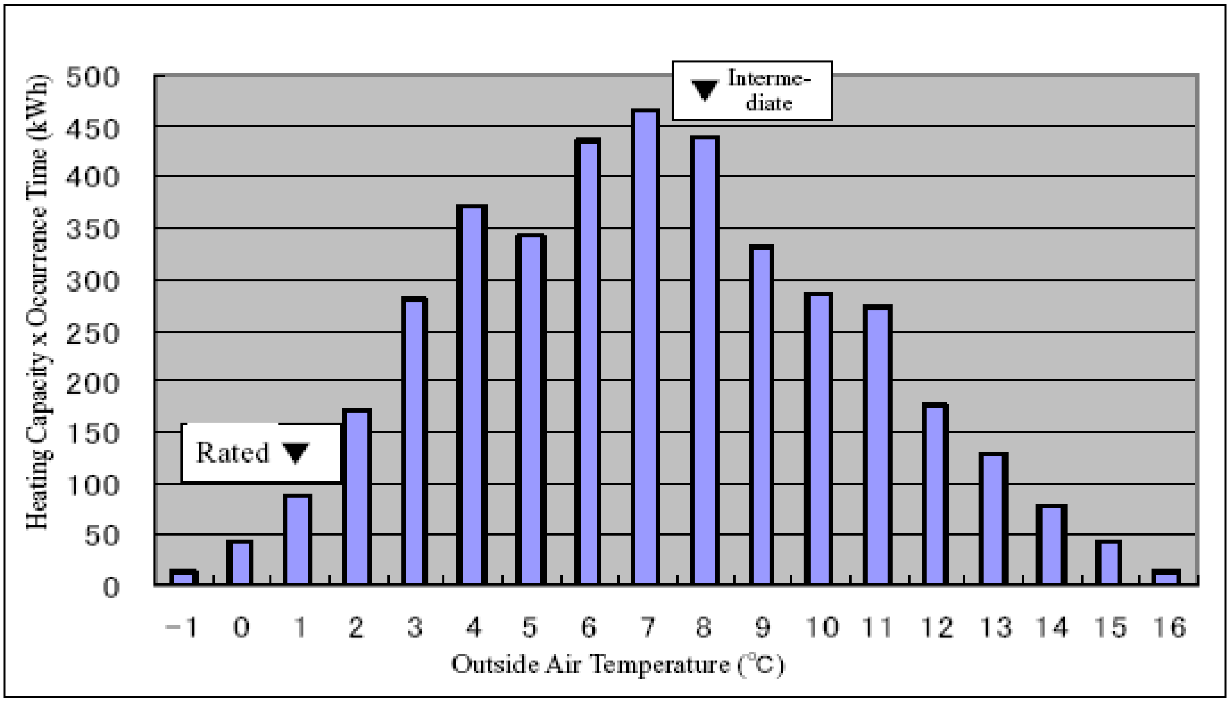


To compute a number of hours of use, the cooling season is set as June to September in Tokyo, and hours when outdoor temperature exceeds 24°C are binned as a function of outdoor air temperature. The product of the number of hours and of the building load by temperature bin is represented in Figure 17 above for the cooling season. The distribution average point is (54 % load, 28.4 °C).

Heating load is zero at 17 °C outdoor and is equal to 1.025 times the rated cooling capacity at 0 °C outdoor (1.025 is the average ratio between heating capacity at 0 °C and the rated cooling capacity). Hence, the heat pump is sized for 0 °C outdoor.

$$BL_h(T_j) = 1.25.\Phi_{BL}.0.82\frac{17 - T_j}{17}$$

Figure 18: Distribution of Heating Energy as a Function of Outdoor Air Temperature, (ECCJ, 2008b)



To compute a number of hours of use, the heating season is set as November to mid-April in Tokyo and hours when outdoor temperature falls below 17 °C for heating (and above 24 °C for cooling) are binned as a function of outdoor air temperature. The product of the number of hours and of the building load by temperature bin is represented in Figure 18 above for the heating season. The average of the distribution is around (60 % load, 7 °C). Interestingly, the sizing hypothesis is compatible for heating and cooling modes.

Computing the APF

$$APF = \frac{(CSTL + HSTL)}{(CSTE + HSTE)}$$

With the default climate set as that of Tokyo, CSTL (the Cooling Seasonal Total Load) and HSTL (the Heating Seasonal Total Load) are default values so that the sum of the cooling and heating electric consumption can be deduced directly from the knowledge of the APF.

With 583 hours of cooling and 1421 hours of heating, the CSTL and HSTL in Figure 19 below are used as default values.

Figure 19: Testing and Modeling to Compute Performances for Different (Load, Outdoor Temperature) Couples

Table 8 Annual total load (both cooling and heating type) (in Tokyo)

Rated cooling capacity		kW	1.0	1.1	1.2	1.4	1.6	1.8	2.0
Tokyo	Total	kWh	2004	2204	2405	2805	3206	3607	4008
	Cooling season	kWh	583	641	700	816	933	1050	1166
	Heating season	kWh	1421	1563	1705	1989	2273	2557	2842

Rated cooling capacity		kW	2.2	2.5	2.8	3.2	3.6	4.0	4.5
Tokyo	Total	kWh	4408	5010	5611	6412	7214	8015	9017
	Cooling season	kWh	1283	1458	1633	1866	2099	2332	2624
	Heating season	kWh	3125	3552	3978	4546	5115	5683	6393

Rated cooling capacity		kW	5.0	5.6	6.3	7.1	8.0	9.0	10.0
Tokyo	Total	kWh	10019	11222	12624	14227	16031	18035	20038
	Cooling season	kWh	2915	3265	3673	4140	4665	5248	5831
	Heating season	kWh	7104	7957	8951	10087	11366	12787	14207

The number of testing points is reduced as compared to the ARI 210/240 test standard. In addition, as opposed to the USA standard, exact ISO test conditions are used based on ISO 5151 T1, H1, and H2.

Cooling Mode

In cooling mode, **for single speed units**, the default C_D^C coefficient is set to 0.25 with no challenging test available. The performance curve of full load cooling capacity and power variation with outdoor air temperature is standardized by the following two relationships, amounting to an 18% increase in EER or 3% increase by °C of outdoor temperature decrease.

$P_c(29\ °C)/P_c(35\ °C) = 1.077$ — P_c: cooling capacity

$P_e(29\ °C)/P_e(35\ °C) = 0.914$ — P_e: cooling power

Hence APF of these units is directly proportional to ISO 5151 full load EER with a 13.5% increase.

For **variable speed units**, only two tests are required: the ISO 5151 test and the "intermediary cooling capacity" test, whose percentage of reduced capacity is let free to manufacturers, providing manufacturers with an optimization option. Indeed, lower intermediary capacity lowers the impact of cycling, but then intermediary efficiency may be lower than the maximum efficiency at reduced speed. As in the ARI 210/240 standard, performance curves are drawn by capacity stage (intermediary and full capacity).

In both cases, performance curves are straight lines with the same laws of variation as for the single speed unit. EER increases by about 3% for 1 °C outdoor dry bulb temperature decrease.

8 Mapping for Korea

8.1 AC Market Characterization

8.1.1 Supply of New AC Products

No data on the supply of new AC products was available.

8.1.2 Stock of AC Products

No data on the stock of AC products was available.

8.2 Standards and Labeling Framework

8.2.1 Minimum Energy Performance Standards

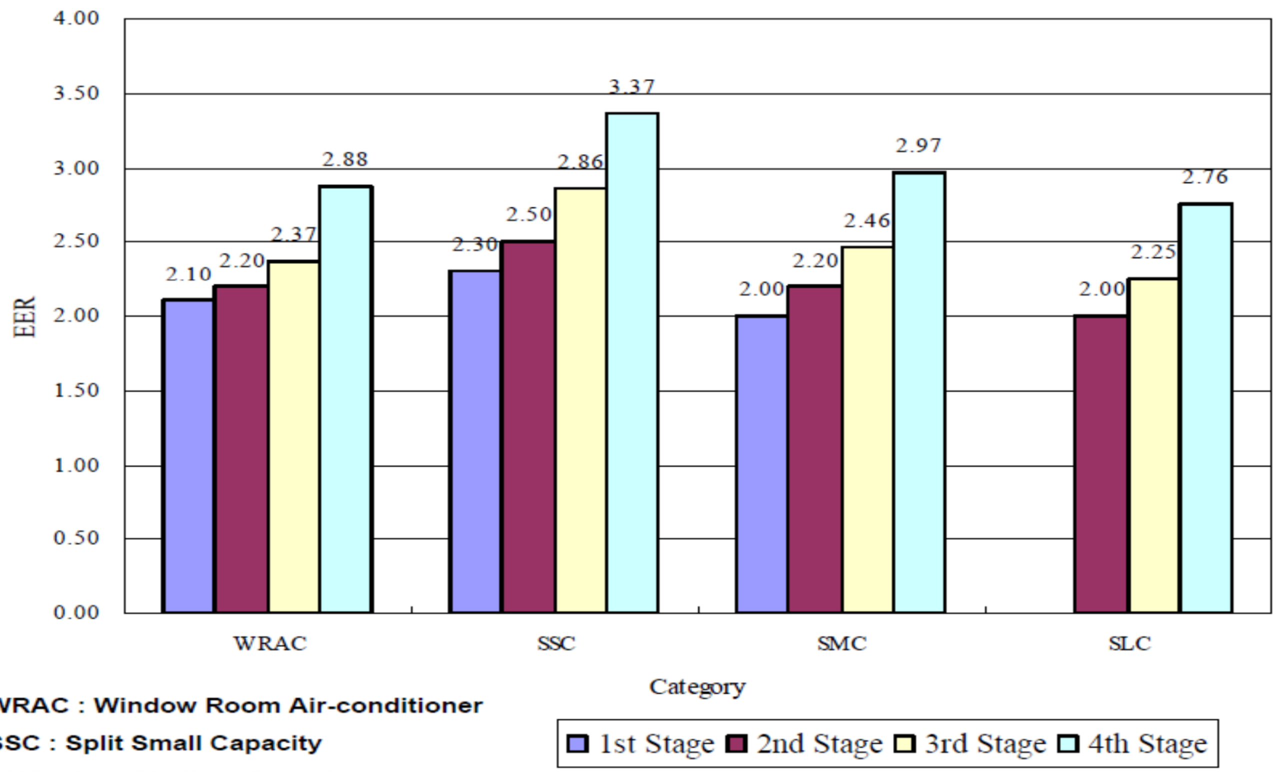
In Korea, mandatory MEPS regulations were published in 2002 and became effective in 2004 for window and split AC units up to 23 kW. The mandatory minimum energy efficiency standard bans the production and sale of low energy efficiency products that fall below MEPS. Table 33 gives the current MEPS level in the country.

Table 33: Specification of MEPS in Korea

Type		MEPS (From January 2010 Onwards)
Room Air Conditioner		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
	17.5.0 kW < RCC < 23.0 kW	2.63

Figure 20 below shows the evolution of MEPS for RACs in Korea. It suggests that MEPS were very stringent from 1994 to 2004 in Korea.

Figure 20: MEPS Trend from 1994 to 2004[43]



WRAC : Window Room Air-conditioner
SSC : Split Small Capacity
SMC : Split Medium Capacity
SLC : Split Large Capacity

8.2.2 Labeling Scheme

Published in 1992, the labeling scheme became effective in 1993 and is currently mandatory in Korea. In 2004, an improvement of the labeling requirement was introduced. Energy labeling is comparative and consists of five scales from one to five, with one being the most efficient and five the least efficient. A sample of the label is given in Figure 21 below. It is worth noting that from January 2010, CO_2 emission reduction is represented in the energy label for RACs.

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[43] http://www.asiapacificpartnership.org/pdf/batf/hvac/Korea%20S_H_Hong.pdf

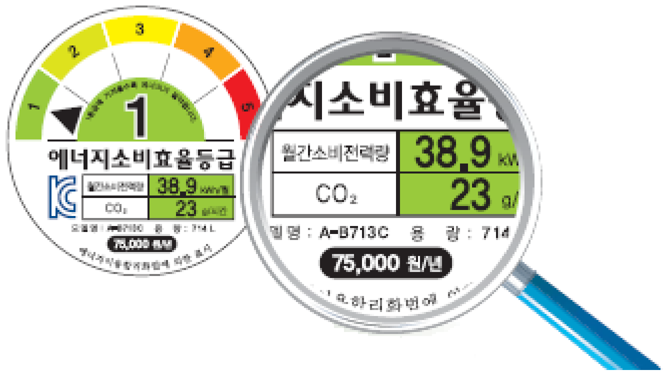
1st Stage: effective date from January 1994

2nd Stage: effective date from January 1997

3rd Stage: effective date from January 2001

4th Stage: effective date from January 2004

Figure 21: Sample Label for RACs in Korea



The Table 34 below presents the EER per label class for RACs in Korea.

Table 34: EER per Label Class and RCC in Korea

Label Level	Non-Ducted and Ducted Unitary (including window type)	Split Type (RCC< 4 kW)	Split Type (4 kW RCC< 10 kW	Split Type (10 kW RCC< 23 kW
1	More than 3.20	More than 4.00	More than 3.80	More than 3.20
2	2.90 – 3.20	3.60 – 4.00	3.40 – 3.80	2.90 – 3.20
3	2.60 – 2.90	3.20 – 3.60	3.00 – 3.40	2.60 – 2.90
4	2.30 – 2.60	2.80 – 3.20	2.60 – 3.00	2.30 – 2.60
5	2.00 – 2.30	2.4 – 2.80	2.20 – 2.60	2.00 – 2.30

The Ministry of Commerce Industry and Energy (MOCIE) and the Korea Energy Management Corporation (KEMCO) are the key organizations implementing Korea's S&L program. MOCIE drafts policies and regulations on energy efficiency S&L based on the Rational Energy Utilization Act of 1980. KEMCO implements and operates the program.

8.2.3 Testing Procedures

Air conditioners in Korea are tested according to KS C 9306, which is derived from ISO 5151. So far, KS standards have been used as measurement techniques for Korea's Energy Efficiency S&L program. The test procedure consists of the following cooling tests:

- Cooling capacity;
- Cooling power consumption;
- Cooling overload performance;

- Enclosure sweat and condensate disposal tests;
- Freezing test and the following heating tests;
- Heating capacity;
- Heating power consumption;
- Power consumption of electric heater (if there is a separate resistance heater);
- Heating overload performance;
- Automatic defrosting test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity: either the calibrated or balanced-ambient room-type calorimeter. Korean room air conditioner rating conditions are almost harmonized with the ISO 5151 T1 condition except for a half-degree difference in the indoor side wet-bulb temperature and wider tolerances for all measurements.

The cooling capacity must not be less than 92% of their rated values while the electrical power consumption in the cooling or heating mode must not be more than 115% of the rated power consumption. The EER must be within ± 10 of their rated values, which implies a maximum permitted deviation of 20% in the EER.

9 Mapping for Taiwan

9.1 AC Market Characterization

9.1.1 Supply of New AC Products

No data on the supply of new AC products was available.

9.1.2 Stock of AC Products

No data on the stock of AC products was available.

9.2 Standards and Labeling Framework

9.2.1 Minimum Energy Performance Standards

The first mandatory MEPS were effective in 1991 for split RACs and in 2002 for window and packaged terminal RACs. The current MEPS in force in Taiwan and future changes are presented in Table 35 below:

Table 35: Current MEPS and Update Proposal for Window RACs

Type		Cooling Capacity (kW)	EER (1) (W/W)	
			First Phase	Second Phase
			January 1, 2011 to December 31, 2015	From January 1, 2016
Air-Cooled	Unit	> 2.2	3.15	3.40
		> 2.2 <4.0	3.20	3.45
		> 4.0 , <7.1	3.00	3.25
		> 7.1 <10	2.95	3.15
	Split	<4.0	3.45	3.85
		> 4.0 <7.1	3.20	3.55
		>7.1 (2)	3.15	3.40
Water-Cooled and Steam-Cooled		All types(2)	4.25	4.80

Notes: (1) EER of no-duct RAC should be in accordance with No-Duct Air Conditioner and Heat Pump Testing Standard in CNS 14464. The ratio of total cooling capacity (W) to effective input power (W) under T1 standard testing conditions should not be smaller than the values in the above table, and must be more than 95% of the labeled value. (2) Only products whose capacity is less than 70 kW will be tested.

Table 35 gives the minimum EER for the different window AC units based on the cooling capacity load as well as the EER for water- or steam-cooled AC systems. These MEPS are expected to be increased by the year 2016, as indicated in the same table. The increase from 2011 to 2016 varies from 6.5% to 8.6% according to the type of product. Moreover, the performance indicator is expected to switch from EER to SEER in 2016.

9.2.2 Labeling Scheme

In June 2009, the revised law of the Energy Management and Implementation policy in Taiwan stated that manufacturers and importers of energy equipment and appliances must put clear labels on their products stating their energy consumption and efficiency levels. Products such as refrigerators, air conditioners, washing machines and automobiles must state explicitly their energy consumption and efficiency numbers for the benefit of consumers. Therefore, RACs which are packaged terminal, split, and window units are subject to mandatory labeling.

The labeling scheme in Taiwan provides a five-level comparative label, an energy conservation label, and the Green Mark label. Both the energy conservation and Green Mark labels are voluntary while the five-level comparative label remains mandatory.

Implementation for RACs (packaged terminal) became effective in 2001 while implementation for window RACs became effective July 1, 2010. The revision of split RACs was promulgated in August 10, 2009.

RAC products (packaged and split) qualify for the endorsement label if they have an EER which is at least 15% higher than national standard EER values.

Table 36 gives the EER criteria for window air conditioners while Table 37 gives the EER criteria for box type AC units.

Table 36: Criteria for Energy Efficiency Rating of Window/Wall Type Air Conditioners

Type	Cooling Capacity (kW)	EER (W/W)				
	Class	Class 5	Class 4	Class 3	Class 2	Class 1
Integrated	less than or equal 2.2	less than or equal to 2.95	> 2.95, less than or equal to 3.10	> 3.10, less than or equal to 3.25	> 3.25, less than or equal to 3.40	> 3.40
	> 2.2, less than or equal 4.0					
	> 4.0, less than or equal 7.1					
	> 7.1, less than or equal 10.0					
Split Type	less than or equal 4.0	less than or equal 3.45	> 3.45, less than or equal 3.69	> 3.69, less than or equal 3.93	> 3.93, less than or equal 4.17	> 4.17
	> 4.0, less than or equal 7.1	less than or equal 3.20	> 3.20, less than or equal 3.42	> 3.42, less than or equal 3.65	> 3.65, less than or equal 3.87	> 3.87
	> 7.1	less than or equal 3.15	> 3.15, less than or equal 3.37	> 3.37, less than or equal 3.59	> 3.59, less than or equal 3.81	> 3.81

It is worth noting that the above criteria are applicable to integrated or split type window/wall type air conditioners with a power rating of less than 3 kW.

Table 36 above shows that the energy efficiency ratio for window/wall integrated systems is less than or equal to 2.95 for class 5 and greater than 3.40 for class 1. With split type systems, the energy efficiency ratio for a 7.1 kW or greater capacity is less than or equal to 3.15 for class 5 and greater than 3.81 for class 1.

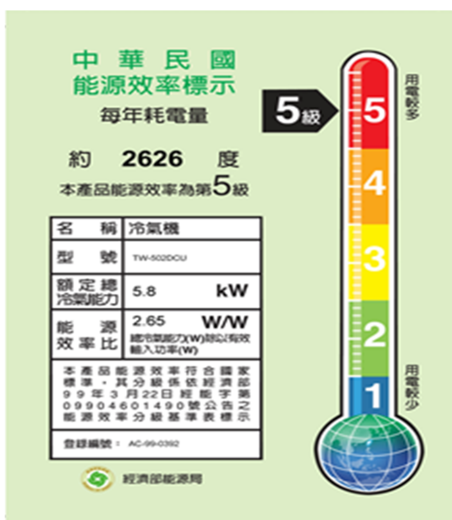
Table 37: Criteria for Energy Efficiency Rating of Box Type Air Conditioners

Type	Energy Efficiency Class				
	Class 5	Class 4	Class 3	Class 2	Class 1
Air-Cooled	less than or equal to 3.15	> 3.15, less than or equal to 3.37	> 3.37, less than or equal to 3.59	> 3.59, less than or equal to 3.81	> 3.81
Water-Cooled	less than or equal to 4.25	> 4.25, less than or equal to 4.55	> 4.55, less than or equal to 4.85	> 4.85, less than or equal to 5.14	> 5.14

It is worth noting that the above criteria are applicable to air-cooled or water-cooled box type air conditioners with a power rating of less than 26 kW.

Figure 22 below presents a sample mandatory label used in Taiwan.

Figure 22: Mandatory Label Used in Taiwan[44] for AC



[44] CLASP at http://www.clasponline.org/clasp.online.worldwide.php?rc=260|1.

9.2.3 Testing Procedures

In Taiwan, RACs are currently tested in accordance with the testing procedures for air conditioners referred to as CNS 3615, with ISO 5151 as the reference standard. The Bureau of Standards, Metrology and Inspection (BSMI) of the Ministry of Economic Affairs is responsible for the transposition of international testing procedures for equipment in the country. Therefore, some international procedures and standards (e.g., ISO or IEC for AC testing) have already been transposed into national standards in the country. The test conditions satisfy T1 conditions and the uncertainty reported by laboratories on rating or compliance is about 5%.

To enforce the S&L regulation, there is also a compliance checking program for new AC systems. Only two government-approved testing laboratories are allowed to perform the testing, and about 120 to 130 AC units are being tested every year. The selection of the products to be tested is based on the total sale of each manufacturer (i.e., one unit out of every ten thousand AC units sold). The Industrial Technology Research Institute (ITRI) gets annual funding to help the Bureau of Energy implement and inspect the S&L scheme. Inspections were scheduled to start in 2011. The Ministry of Economic Affairs is responsible for overseeing the program.

10 Mapping for United States of America

10.1 AC Market Characterization

10.1.1 Supply of new AC products

Share of AC Products by Sub-Category

Residential air conditioners in the USA fall into the two broad categories of "room air conditioners" and "central air conditioners". These are regulated differently and treated differently in the manner in which they are tested; however, the distinctions used do not correspond to those used outside of North America. Room air conditioners in the USA refer solely to single packaged window/wall units (unitary types). By contrast, the term central air conditioners includes split and multi-split packaged non-ducted AC units which would be classified as room air conditioners in other parts of the world. Moveable air conditioners do not appear to be present in the US market and hence are not treated here. The major difference, however, is that most US homes use comparatively large ducted air-to-air whole house AC systems and these dominate the market in terms of energy use and preponderance. These systems are sold in a variety of forms but are all classified within the rubric of central air conditioners. They are therefore treated within the same regulatory and testing/rating framework as are the less common single and multi-split systems that are preponderant in markets outside North America. In the rest of this report a distinction is therefore made between the treatment of the central and window/wall air conditioners.

Residential Window/Wall Air Conditioners: Market Size and Shipments[45]

The historical shipments of room air conditioners[46] (defined as purely window/wall types) are shown in Table 38.

Table 38: Room Air Conditioner Shipments in the USA (Million units)

Year	All	Residential Sector	Commercial Sector
2000	6.496	5.74	0.75
2001	5.576	4.93	0.65
2002	6.153	5.44	0.71
2003	8.216	7.26	0.95
2004	8.082	7.14	0.94
2005	8.032	7.10	0.93

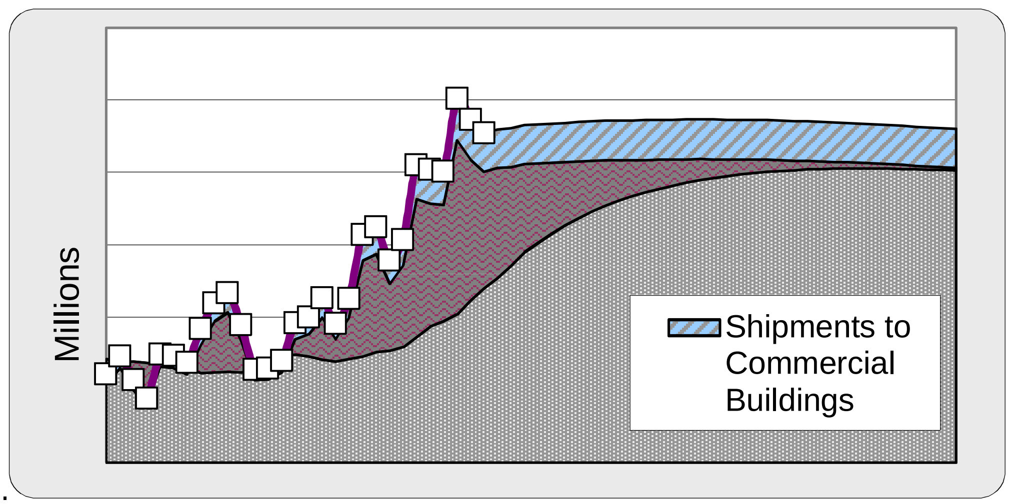
[45] Source: http://www.ahrinet.org/Content/CentralAirConditionersandAirSourceHeatPumps_604.aspx)

[46] US energy efficiency regulations distinguish between 16 sub-types of window/wall room air conditioner.

Year	All	Residential Sector	Commercial Sector
2006	10.055	8.89	1.17
2007	9.460	8.36	1.10
2008	9.086	8.03	1.05
Source: DOE 2010 RAC rulemaking			

The figures in the table above suggest that RAC shipments grew rapidly between 2000 and 2003, demonstrating an increase of 26% (from 6.496 to 8.216 million units). Thereafter, the figures slightly decreased to 8.032 million units in 2005. In 2006, the shipment volume increased to more than 10 million units which later decreased to 9.086 million units in 2008. Over the same period, the trend observed for all RAC shipments is consistent with the trend observed in each of the residential and commercial sectors. However in 2010, a US Department of Energy projection (see Figure 23 below) predicted that the shipment volume will remain almost constant at approximately 9.5 million RAC units over the next three decades.

Figure 23: Historic and Projected Room Air Conditioner Shipments (million units)[47]



Residential central air conditioners: market size and shipments[48]

In June 2010, the US shipments of central air conditioners and air-source heat pumps totaled 808,394 units, an increase of 2 percent upon the previous year. The US shipment of air conditioners was 565,322 (up 2% upon previous year) and of air-source heat pumps was 243,072 (up 6% upon previous year).

For the Year-to-Date (YTD), the collective shipments for both residential central air conditioners and air-source heat pumps are 2,949,141 units, which are up by 6% from the June 2009 figures. The YTD shipments for central

[47] Source: DOE 2010 RAC rulemaking

[48] Source: http://www.ahrinet.org/Content/CentralAirConditionersandAirSourceHeatPumps_604.aspx)

air conditioners was 1,959,845 units and for heat pumps was 989,296, which are up 5% and 8% respectively for the same time period in 2009.

The following figures (see Figure 24 to Figure 26), extracted from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) industry statistics website, represent the US manufacturer shipments for central air conditioners and air-source heat pumps between 1995 and 2005.

Figure 24: U.S. Manufacturer Shipments of Central Air Conditioners and Air-Source Heat Pumps[49]

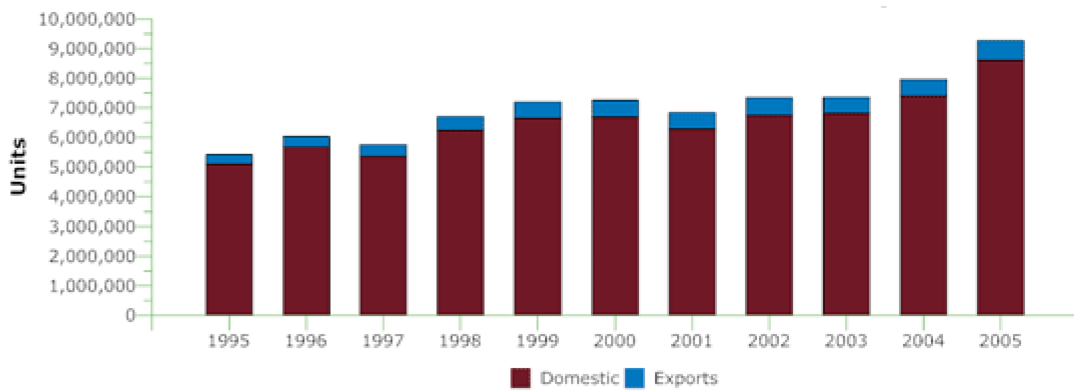
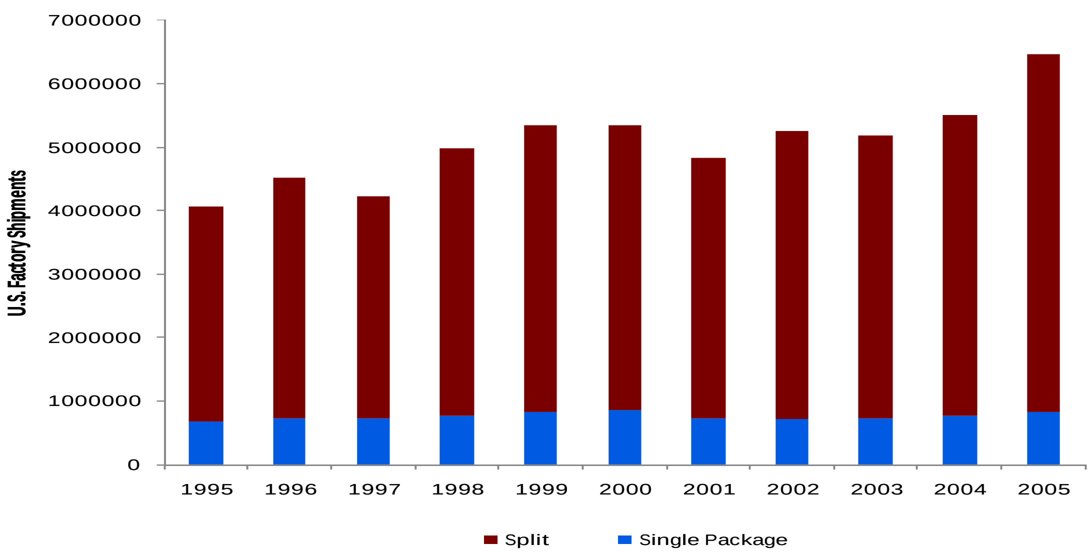


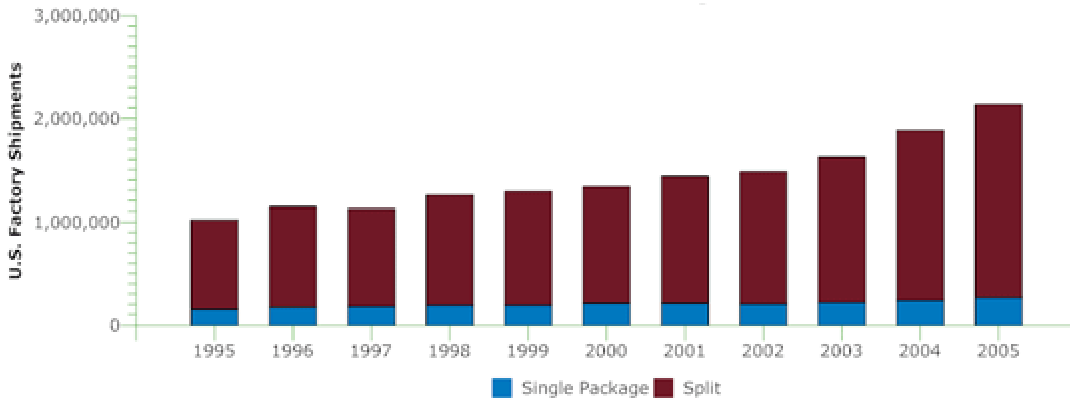
Figure 25: US Shipments of Central Air Conditioners[50]



[49] Source: Air-Conditioning, Heating, and Refrigeration Institute, Industry Statistics

[50] Idem

Figure 26: US Shipments of Air-Source Heat Pumps[51]



From this data it is clear that shipments of central AC and central air-source heat pumps in the US roughly doubled from 1995 to 2005. In 2005, total annual sales were about 6.5 million and 2.2 million units respectively. Most of these units were destined for residential applications of up to 65,000 Btu (19.04kW) of cooling or heating capacity. The domestic market for all such equipment reached 8.61 million units in 2005 while 0.67 million units were exported, mostly to Canada. Of this, domestic shipments of unitary AC equipment reached 6.47 million units in 2005, of which 5.6 million were split system air conditioner condensing units and 0.8 million single packaged air conditioners of all types. Some 2.1 million unitary air source heat pumps were shipped in the US in 2005 of which 1.9 million were split system heat pumps and 0.3 million were single packaged heat pumps.

Table 39 provides historic (to 2009 inclusive) and forecast shipment estimates for central air conditioners and air-source heat pumps. These projections are based on data provided by the AHRI. The shipment data from AHRI has a gap between 2005 and 2009, and the subsequent years are forward projections based on historical trends and calibrated using the YTD figures for June 2009/2010.

Table 39: Shipment Estimate for Central Air Conditioners and Air-Source Heat Pumps for the US Market[52]

Years	Central A/C	Air-Source HP	Total Market
1995	4,063,176	1,024,885	5,088,061
1996	4,522,837	1,147,828	5,670,655
1997	4,229,140	1,130,718	5,359,858
1998	4,980,283	1,259,695	6,239,978
1999	5,353,676	1,293,395	6,647,071

[51] Source: Air-Conditioning, Heating, and Refrigeration Institute, Industry Statistics

[52] Source: Air-Conditioning, Heating, and Refrigeration Institute, Industry Statistics Profile, Accessed 06/09/2010

Years	Central A/C	Air-Source HP	Total Market
2000	5,346,046	1,339,435	6,685,481
2001	4,835,425	1,442,355	6,277,780
2002	5,262,727	1,483,599	6,746,326
2003	5,180,897	1,626,365	6,807,262
2004	5,514,967	1,886,100	7,401,067
2005	6,470,976	2,136,525	8,607,501
2006	5,815,980	2,167,853	7,983,834
2007	5,154,490	2,205,677	7,360,167
2008	4,484,250	2,252,249	6,736,499
2009	3,735,348	1,834,920	5,570,268
2010	3,919,690	1,978,592	5,898,282
2011	4,238,496	2,275,467	6,513,963
2012	4,060,081	2,376,621	6,436,702
2013	3,869,441	2,490,000	6,359,441
2014	3,664,214	2,617,966	6,282,180
2015	3,441,394	2,763,525	6,204,919

The historic and projected breakdown of shipments by CAC and HP type is shown in Table 40 below. This data is taken from the DOE rulemaking process and seems to exclude some of the product types reported in the AHRI shipment data of Table 39 above, as the total shipments are about 15% less.

Table 40: Estimated and Forecast Shipments of Residential Central Air Conditioners and Air-Source Heat Pumps in the USA (millions of units)[53]

Year	CAC Split - Coil Only	CAC Split - Blower Coil	CAC Packaged	Heat Pump Split	Heat Pump Packaged	Total CAC	Total HP
2005	4.57	0.51	0.42	1.68	0.20	5.50	1.88
2006	3.38	0.38	0.31	1.68	0.18	4.06	1.86
2007	3.00	0.33	0.31	1.46	0.18	3.65	1.65
2008	3.24	0.36	0.38	1.42	0.19	3.99	1.61
2009	3.25	0.36	0.38	1.36	0.18	3.99	1.55
2010	3.22	0.36	0.37	1.46	0.19	3.95	1.65
2011	3.47	0.39	0.40	1.62	0.21	4.25	1.84
2012	3.62	0.40	0.41	1.72	0.23	4.44	1.94
2013	3.74	0.42	0.42	1.79	0.24	4.58	2.03
2014	3.80	0.42	0.43	1.84	0.24	4.66	2.08
2015	3.87	0.43	0.44	1.89	0.25	4.74	2.14
2016	3.95	0.44	0.44	1.94	0.25	4.83	2.20
2017	4.00	0.44	0.45	1.99	0.26	4.90	2.25
2018	4.06	0.45	0.45	2.03	0.27	4.96	2.30
2019	4.11	0.46	0.46	2.08	0.27	5.03	2.35
2020	4.15	0.46	0.46	2.11	0.28	5.07	2.39

From Table 40 above, it is apparent that cooling-only CAC accounted for 71% of the market and reversible heat pumps for 29% of the market in 2009. The share taken by heat pumps has been growing over time. Among the cooling-only CAC market the split coil-only CAC dominate sales with approximately 81% of the market and split CAC with blower coils and packaged CAC each comprise about 9% of the market. Among heat pumps the split systems account for 88% of shipments and the packaged for 12%.

[53] Source: "Residential Central Air Conditioners and Heat Pumps Analytical Spreadsheets", U.S. Department of Energy, March 2010. http://www1.eere.energy.gov/buildings/appliance_standards/residential/cac_analytical_spreadsheets.html

The sales-weighted average cooling capacity of central air conditioners in the USA is 35200 Btu/h (10.3 kW) as shown in Table 41 below. Mini-splits, with a capacity of up to 16500 Btu/h and which dominate sales in Japan, Europe and elsewhere, only account for 2% of US sales.

Table 41: U.S. Manufacturers' Shipments of Central Air Conditioners and Air-Source Heat Pumps as a Function of Cooling Capacity[54]

Cooling capacity ranges		Market Share
Btu/h (1000s)	kW	
0- 16.5	2.6	2%
16.5-21.9	5.6	7%
22-26.9	7.2	20%
27-32.9	8.8	17%
33-38.9	10.5	24%
39-43.9	12.1	9%
44-53.9	14.3	12%
54-64.9	17.4	10%

Trends of Energy Efficiency of Window/Wall Air Conditioners in the USA

AHRI maintains a directory of AHRI-verified residential and small commercial HVAC equipment. This directory (www.ahridirectory.org) catalogues thousands of HVAC systems that are 19,500 btu/h or less. Table 42 below presents a time series of the energy efficiency and cooling capacity characteristics of models in this database.

Table 42: Energy Efficiency Trends of Window/Wall (unitary) Air Conditioners

	2006	2007	2008	2009	2010
EER of Worst Product (W/W)	2.78	2.93	2.93	2.93	2.93
Product Weighted Average EER (W/W)	3.02	3.03	3.04	3.04	3.04
EER of Best Product (W/W)	3.52	3.52	3.52	3.96	3.96
Product Weighted Cooling Capacity (kW)	3.36	3.38	3.39	3.39	3.36

[54] Source: Air-Conditioning, Heating, and Refrigeration Institute, Industry Statistics Profile to 2009

Residential Central Air Conditioners: The Most Efficient Air Conditioners in the USA

The Consortium for Energy Efficiency (CEE) maintains a directory of AHRI-verified, energy-efficient residential and small commercial HVAC equipment. This directory[55] catalogues thousands of HVAC systems that are 65,000btu/h or less and that meet CEE's specification levels.

The CEE/AHRI Verified Directory identifies a list of products that manufacturers represent as meeting energy performance tiers established by CEE as a part of the Residential Air Conditioner and Heat Pump initiative and the High Efficiency Commercial Air Conditioning Initiative. These initiatives make use of tiers to differentiate equipment on the basis of energy performance, with a higher tier representing a higher level of claimed performance. The directory subdivides these products based upon certain defining characteristics, such as single package or split system and coil only or coil and blower combinations[56].

The most efficient air conditioners or heat pumps currently available in each category are:

(i) RCU-A-CB: Split System: Air-Cooled Condensing Unit, Coil with Blower;

(ii) RCU-A-CB-O: Split System: Air-Cooled Condensing Unit, Coil with Blower, Free Delivery;

(iii) HRCU-A-CB: Split System: Heat Pump with Remote Outdoor Unit-Air-Source; and

(iv) HRCU-A-CB-O: Split System: Heat Pump with Remote Outdoor Unit-Air-Source.

Among these, the SEER can be up to 26 Btu/h/W (7.6 W/W) and the EER can be up to 15.8 Btu/h/W (4.6 W/W). The highest efficiency levels tend to be for smaller capacity units of about 1 ton (12000 Btu/h). In the two ton range the highest SEERs are 24.5 Btu/h/W (7.2 W/W). In the three to four ton range the highest SEERs are 22.0 Btu/h/W (6.45W/W). In most cases these are for the RCU-A-CB: Split System: Air-Cooled Condensing Unit, Coil with Blower product class.

In the case of the other major CAC types, the maximum SEER performance levels found in the CEE/AHRI database are:

(i) Coil-only split-systems: max-tech estimate = 18.0 SEER (for the RCU-A-C product category);

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[55] See www.ceedirectory.org

[56] Some AHRI AC and HP product definitions:

SP-A: Single-Package Air-Conditioner, Air-Cooled
RCU-A-C: Split System: Air-Cooled Condensing Unit, Coil Alone
RCU-A-CB: Split System: Air-Cooled Condensing Unit, Coil with Blower
RCU-A-CB-O: Split System: Air-Cooled Condensing Unit, Coil with Blower, Free Delivery
SDHV-SP-A: Small-duct, High-velocity Air Conditioner, Single Package, Air-Cooled
SDHV-RCU-A-C: Small-duct, High-velocity Air Conditioner, Condensing Unit, Coil Alone, Air-Cooled
SDHV-RCU-A-CB: Small-duct, High-velocity Air Conditioner, Condensing Unit, Coil and Blower, Air-Cooled
SDHV-RCUY-A-CB: Small-duct, High-velocity Air Conditioner, Year-Round, Condensing Unit, Coil and Blower, Air-Cooled
HSP-A: Single-Package Heat Pump, Air-Source
HRCU-A-CB: Split System: Heat Pump with Remote Outdoor Unit-Air-Source
HRCU-A-CB-O: Split System: Heat Pump with Remote Outdoor Unit-Air-Source, Free Delivery
HRCU-A-C: Split System: Heat Pump with Remote Outdoor Unit with No Indoor Fan-Air-Source
HORCU-A-C: Split System: Heat Pump with Remote Outdoor Unit with No Indoor Fan-Air-Source, Heating Only

(ii) Split-system heat pumps: max-tech estimate = 22.0 SEER (for the HRCU-A-CB product category); and

(iii) Single-packaged air conditioners: max-tech estimate = 18.0 SEER (for the SP-A product category).

Detailed information on the most efficient AC products is given in Appendix 4 (Table 17 to Table 68) to this report.

10.1.2 Stock of AC products

Residential Central Air Conditioners: Stock and Energy Consumption

Table 43 below shows how the estimated stock of installed CAC is expected to evolve to 2020 if the sales estimates of Table 40 materialize. It should be noted that these sales trends are not fully consistent with a max-tech scenario, as the most efficient split with blower-coil units are more efficient than the most efficient split coil-only units currently on the market. Therefore, a max-tech scenario would imply greater market share for the more efficient solutions. Table 43 also shows the historic and projected final electricity demand for US residential CAC and HP operating in the cooling mode under a business as usual scenario.

Table 43: Installed Stock of Residential Central Air Conditioners and Heat Pumps in the USA (millions of units) and Cooling Electricity Consumption (TWh) for Business as Usual[57]

Year	CAC Split - Coil Only	CAC Split - Blower Coil	CAC Pack-aged	Heat Pump Split	Heat Pump Pack-aged	Total CAC	Total HP	Final Electricity Consumption (TWh)
2005	48.4	5.4	5.7	13.4	1.9	59.5	15.3	189
2006	49.8	5.5	5.7	14.4	2.0	61.1	16.4	196
2007	50.7	5.6	5.8	15.1	2.0	62.1	17.1	201
2008	51.8	5.8	5.9	15.7	2.1	63.4	17.8	206
2009	52.7	5.9	6.0	16.2	2.2	64.6	18.4	211
2010	53.5	5.9	6.1	16.8	2.3	65.6	19.0	215
2011	54.5	6.1	6.2	17.4	2.3	66.8	19.8	221
2012	55.6	6.2	6.3	18.2	2.4	68.1	20.6	226
2013	56.7	6.3	6.4	19.0	2.5	69.4	21.5	232

[57] Source: Source data used as input for analysis to produce the figures above comes from “Residential Central Air Conditioners and Heat Pumps Analytical Spreadsheets”, U.S. Department of Energy, March 2010 http://www1.eere.energy.gov/buildings/appliance_standards/residential/cac_analytical_spreadsheets.html

Year	CAC Split - Coil Only	CAC Split - Blower Coil	CAC Pack-aged	Heat Pump Split	Heat Pump Pack-aged	Total CAC	Total HP	Final Electricity Consum ption (TWh)
2014	57.8	6.4	6.5	19.7	2.6	70.8	22.4	238
2015	58.9	6.5	6.6	20.5	2.7	72.1	23.2	244
2016	60.0	6.7	6.8	21.3	2.8	73.5	24.1	251
2017	61.1	6.8	6.9	22.1	2.9	74.8	25.0	255
2018	62.2	6.9	7.0	22.9	3.0	76.1	25.9	260
2019	63.3	7.0	7.1	23.6	3.1	77.4	26.7	264
2020	64.3	7.1	7.2	24.4	3.2	78.7	27.6	268

There is tremendous uncertainty about the potential savings from a shift to max-tech energy efficiency levels, largely because of the unknowns regarding the full applicability of the highest efficiency technologies to all market segments and hence of the overall adoption rates.

It is estimated that full adoption of max-tech technologies within each CAC product class would eventually lower future CAC energy use in the US by between 29% and 36%. If there was a migration away from the less efficient product classes to the most efficient the energy savings would be up to 56%, but this may imply some degree of service change or inconvenience.

All these savings are derived through improvements in the efficiency of the equipment used, and none consider the potential to reduce cooling demand by improvements in the building fabric or the improved operation of the AC equipment. Furthermore, these options do not include high efficiency cooling technology solutions which are locally but not universally applicable. Such options were briefly discussed in the body of the report and could produce significant additional savings through appropriate deployment.

10.2 Standards and Labeling Framework

10.2.1 Minimum Energy Performance Standards

The MEPS applies to a consumer product, other than a “packaged terminal air conditioner,” which is powered by a single phase electric current and which is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating (split and window type room air conditioners). The MEPS became effective in 2000 and is implemented by the Department of Energy. The test standard used can be found in the US Code of Federal Regulations (CFR), Title 10, Part 430, Appendix F to Subpart B, where the reference test standard is ANS Z 234.1-1972.

Window/Wall Air Conditioners

The program covers single-phase air conditioners that are not packaged terminal air conditioners. Products with and without louvered sides are defined as distinct categories. The product is required to be tested in accordance with Federal test procedures to meet mandatory efficiency standards. The current standard level was published in the Federal Register (FR), 62FR50121, 24 September 1997 and became effective from 1 October 2000 (See Table 44); the original standard was published in 1987 and was effective from 1 January 1990.

Table 44: US MEPS Requirements for Window/Wall Air Conditioners

Products Class	Cooling (Heating) Power in Btu/h (kW)	EER Btu/h/W (W/W)
Cooling Only		
With louvered sides	Less than 6000 (1.76)	9.7 (2.84)
	6000 (1.76) to 7999 (2.34)	9.7 (2.84)
	8000 (2.34) to 13 999 (4.10)	9.8 (2.87)
	14 000 (4.10) to 19 999 (5.86)	9.7 (2.84)
	20 000 (5.86) and over	8.5 (2.49)
Without louvered sides	Less than 6000 (1.76)	9.0 (2.64)
	6000 (1.76) to 7999 (2.34)	9.0 (2.64)
	8000 (2.34) to 13 999 (4.10)	8.5 (2.49)
	14 000 (4.10) to 19 999 (5.86)	8.5 (2.49)
	20 000 (5.86) and over	8.5 (2.49)
Cooling and Heating		
With louvered sides	Less than 20 000 (5.86)	9.0 (2.64)
	And 20 000 (5.86) or more	8.5 (2.49)
Without louvered sides	Less than 14 000 (4.10)	8.5 (2.49)
	And 14 000 (4.10) or more	8.0 (2.34)
Casement - Only		8.7 (2.55)
Casement - Slider		9.5 (2.78)

Central Air Conditioners

Central air conditioners and heat pumps manufactured on or after January 23, 2006, must have Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF) not less than the values indicated in Table 45.

Table 45: US MEPS Requirements for Central Air Conditioners

Products	SEER Btu/h/W (W/W)	HSPF (Zone IV) Btu/h/W (W/W)
Split system air conditioners	13 (3.8)	-
Split system heat pumps	13 (3.8)	7.7 (2.3)
Split package air conditioner	13 (3.8)	-
Split package heat pumps	13 (3.8)	7.7 (2.3)
Through-the-wall air conditioners and heat pumps-split system	10.9 (3.2)	7.1 (2.1)
Through-the-wall air conditioners and heat pumps-single package	10.6 (3.1)	7.0 (2.1)

It should be noted that there is no direct relation between EER and SEER. Attempts to establish a relationship may well translate on-off control unit performances but cannot cover all types of control modes, multiple compressor speeds, inverters, etc. Nonetheless, building on the analysis of the ARI 210/240 standard and assuming a 2% increase in EER for each 1°C outdoor air temperature decrease, a minimum SEER of 3.8 W/W would roughly translate to a minimum EER of 3.4 W/W (for a single speed compressor, CD C=0.1) or to an EER of 2.7 W/W for a variable speed unit with average 20% performance improvement at part load. In the heating mode, and assuming a 3% decrease in COP per unit outdoor air temperature decrease, a minimum HSPF of 2.3 W/W would roughly translate to a minimum COP of 2.9 W/W (for a single speed compressor, CD H=0.1) or to 2.3 W/W for a variable speed unit with an average 20% performance improvement at part load.

10.2.2 Labeling Scheme

There are mandatory labels for split and window type room air conditioners. The label, EnergyGuide, has been effective since 1980 with a minor update in 2007 and is implemented by the Federal Trade Commission (FTC). The labeling standards are described within Title 16 – Commercial Practices, Chapter I – Federal Trade Commission, Subchapter C--Regulations under specific acts of congress, Part 305--rule concerning disclosures regarding energy consumption and water use of certain home appliances and other products required under the energy policy and conservation act ("appliance labeling rule"). The label must include information on the model's energy efficiency rating and estimated annual operating costs. The same test standard is used for the labeling scheme as for the MEPS.

ENERGY STAR runs a voluntary label for split and window type room air conditioners, effective since 1996. The EER of the selected products must be equal to or above the levels in the Table 46 below. Only models without a reverse cycle and with louvered sides are considered for the label at present. The same test standard is used for the ENERGY STAR label as for the mandatory label and MEPS.

Table 46: ENERGY STAR Criteria for RAC (Window and Split Types)

	EER
Less than 6,000 Btu	10.7
6,000 to 7,999 Btu	10.7
8,000 to 13,999 Btu	10.8
14,000 to 19,999 Btu	10.7
20,000 Btu or greater	9.4

ENERGY STAR products are displayed on a website which helps consumers find the most efficient products for their requirements.

Note on the ENERGY STAR Program for Air Conditioners

Increasing SEER minimum thresholds is not a guarantee of improved peak power performance as it is mostly achieved via the use of inverters. As a consequence, the ENERGY STAR program, in addition to specifying a minimum SEER of 14 Btu/h/W (4.1 W/W), also requires a minimum EER of 11 Btu/h/W (3.2 W/W) for central air conditioners.

10.2.3 Testing Procedures

Room air conditioners are a global commodity for which there is widespread international trade. There are generally only small differences in product design at a regional level. North America treats split systems as central units, which means they have to be tested in a different fashion, but the product is otherwise the same as elsewhere. North America also has a product type called a packaged terminal air conditioner which appears to be limited to the US – this is effectively a unitary non-ducted system.

The testing procedures follow the international standard ISO 5151, which is already described in section 2 of this report.

The most significant variation to the fundamental test requirements is in North America where split systems have to be tested to the requirements for central air conditioners, which requires the determination of a SEER. This requires test data at four different test conditions which are then combined to reflect an overall annual efficiency for a specified average North American climate. One of the test points is equivalent to condition T1. The other points have the same indoor conditions with reduced (milder) outdoor conditions.

Table 47: North American SEER Test Conditions for Room Air Conditioners

Condition	Indoor	Outdoor
Condition A (equivalent to ISO T1)	27°C DB, 19°C WB	35°C DB, 24°C WB
Condition B	27°C DB, 19°C WB	28°C DB, NS - WB
Condition C	27°C DB, 14°C WB	28°C DB, NS – WB
Condition D	27°C DB, 14°C WB	28°C DB, NS – WB

Testing to conditions "C" and "D" are optional in that if the tests are not done, a value of 0.25 is assigned for the degradation co-efficient CD. Only four tests are required for single speed compressors. Where there is a two speed compressor, tests at condition "A" and "B" are to be done for each speed. For variable speed compressors, up to seven tests are required as follows:

- "A" and "B" wet coil tests at maximum compressor speed;
- "B" wet coil is tested at minimum speed;
- Low temperature wet coil test is conducted at minimum speed (indoor and outdoor 19.4/13.9oC dry/wet); and
- Final wet coil test is conducted at an intermediate speed if a value for CD of 0.25 is not used, dry coil tests "C" and "D" at minimum speed.

CONCLUSION

The study has established the mapping of RAC characteristics in selected countries by comparing the market sizes and trends as well as the EE performance of the RAC products offered. The mapping component also reviewed the existing S&L initiatives and their characteristics. The main findings are summarized as follows:

- In most of the studied countries, the RAC market is dominated by split units. One notable exception is India, where window and split units almost equally share the RAC market. Moreover, inverter units are widely available in mature RAC markets such as the EU, Japan, and the US, and inverter unit sales in China are also growing rapidly. The Japanese market is dominated by reversible RAC units that provide both cooling and heating functions. Despite the variation of the RAC market characteristics according to the economy, the market has been on an upward trend over the last 10 years in the EU and the last five years in the US and India. Unlike these countries, the Japanese RAC market has been constant with a slight decrease in 2009.

- There is variation in the trend of the EER level of the most efficient RAC products across the studied economies. In most countries analyzed, the EER of the most efficient AC products has been on an upward trend over the last decade. However, we can observe a reverse trend in products that are losing market share. This is notably the case in the EU where the EER level of the most efficient unitary (window type) RAC products with a cooling capacity under 12 kW has decreased between 2005 and 2011 after an increase over the 2002-2005 period. As far as the least efficient RAC products are concerned, there is also variation in the trend of the EER levels across the studied economies. In fact, the EER level of the least efficient unitary, single, and multi-split RAC units with a cooling capacity of 12 kW or less has decreased in the EU between 2009 and 2011 after an increase between 2002 and 2009. Flat and upward trends have been observed in the US and China, respectively, over the last years.

- The sales-weighted average EER of window AC products has remained almost constant between 2006 and 2011 in the US while it has decreased in the EU over the same period. On the other hand, the sales-weighted average EER of single and multi-split AC products has experienced an upward trend in the countries analyzed over the past decade.

- The RAC stock grew rapidly in the studied countries with 75% and 44% increases in the EU and China, respectively, over the 2005-2010 period. Growth has been moderate in Japan and the US with 15% and 10%, respectively, over the same period of time.

- In some of the studied economies, such as China and Australia, the RAC MEPS levels established and implemented have become more stringent after one or several rounds of updates. In the coming years, India and Taiwan have planned MEPS levels that are more stringent than the current levels in force within these economies.

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APPENDIXES

APPENDIX 1: Additional Information on Chinese RAC market

Chinese RAC Market Volumes (million units)

The sales and production of RACs in China has grown dramatically since the 1990s. Table 48 shows that imports of RACs into China are negligible

Table 48: Chinese room air conditioner market volumes (million units)[58]

Title	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Production	18.3	23.3	31.4	48.2	63.9	67.6					109.3
Export	3.2	5.6	9.2	18.9	26.7	28.3	22.9	27.7	28.7	21.5	
Implied home market	15.1	17.7	22.2	29.3	37.2	39.3				30.3	

The share of sales by label class (under the former mandatory labeling scheme) is shown in Table 49 and Table 50.

Table 49: Product Offer-weighted Shares by Energy Label Class for split AC units[59]

	2005	2006	2007	2008
Grade 1	3%	4%	4%	5%
Grade 2	5%	7%	11%	24%
Grade 3	4%	9%	7%	7%
Grade 4	18%	15%	21%	20%
Grade 5	70%	65%	57%	43%

[58] Source: Source: LBNL-62902 (from China Statistical Yearbook) from 2000 to 2005; Comtrade database for export data from 2006 to 2009; CNIS personal communication for domestic market size in 2009; http://www.stats.gov.cn/english/statisticaldata/monthlydata/t20101221_402691892.htm for 2010 production data.

[59] Data source: CNIS 2009

Table 50: Product Offer-weighted Shares by Energy Label Class for unitary AC units[60]

	2005	2006	2007	2008
Grade 1			18%	8%
Grade 2			14%	25%
Grade 3			28%	23%
Grade 4			24%	33%
Grade 5			16%	11%

[60] Data source: CNIS 2009

APPENDIX 2: Additional Information on the EU RAC Market

Sales Weighted EER Trends

The most energy efficient products in the Eurovent database in January 2011 were as follows:

Table 51: Product with the Highest EER by AC Type

	EER (W/W)	Brand and Model
Non ducted split packaged AC systems (cooling only)	4.55	DAIKIN RKS25G (outdoor), FTXS25G (indoor)
Non ducted split packaged AC systems (heat pump)	5.71	Mitsubishi SRC20ZJX-S (outdoor) SRK20ZJX-S (indoor) Mitsubishi SRC20ZIX-S (outdoor), SRK20ZIX-S (indoor)
Multi split packaged units	5.09	Mitsubishi MXZ-2B30VA (outdoor), MSZ-CGE22VA(x2) (indoor) and MSZ-GE22VA(x2) (indoor)
Window unit	3.23	LG - S12AHP LG - K12AH

Data source: Eurovent, 2011

Table 52: Product with the Highest EER by Eurovent Product Classification Categories

	EER (W/W)	Brand and Model
AC1 ASR - Split reversible	5.71	Mitsubishi SRC20ZJX-S (outdoor) SRK20ZJX-S (indoor) Mitsubishi SRC20ZIX-S (outdoor), SRK20ZIX-S (indoor)
AC1 ASC - Split cooling only	4.55	DAIKIN - RKS25G and FTXS25G
AC1 APR - Window/wall reversible	3.23	LG - S12AHP LG - K12AH
AC1 APC - Window/wall cooling only	2.63	LG - W07AC
AC1 AMR - Multi-split reversible	5.09	Mitsubishi MXZ-2B30VA (outdoor), MSZ-CGE22VA(x2) (indoor) and MSZ-GE22VA(x2) (indoor)
AC1 AMC - Multi-split cooling only	4.21	Daikin 4MKS58E (outdoor), FTXS20G + FTXS20G (indoor) Daikin 3MKS50E (outdoor), FTXS20G + FTXS20G (indoor)
AC1 WPR - Water-cooled packaged reversible	3.45	CIATESA - IXH-25

Data source: Eurovent, 2011

The least energy efficient products in the Eurovent database in January 2011 were as follows:

Table 53: Products with the Lowest EER by AC Type

	EER (kW/kW)	Brand and Model
Non ducted split packaged AC systems (cooling only)	2.21	CIATESA (35K & 35D)
Non ducted split packaged AC systems (heat pump)	2.21	DAIKIN (RZQ71DV1 &FCQ71C8) LG (UU30 UED & UV30 NBD) LG (UU30 UED & UT30 NPD) LG (UU30 UEC & UV30 NBC) LG (UU30 UEC & UT30 NFC) LG (UU30 UEC & UB30 NGC) CIATESA (35HK & 35D) CARRIER (38BZ042 & 40BZ042)
Multi split packaged units	2.23	CARRIER - 38GL3M21H
Window unit	2.1	CIATESA - RHA-35 CIATESA - IHA-35

Data source: Eurovent, 2011

Table 54: Products with the Lowest EER by Eurovent Product Classification Categories

	EER (kW/kW)	Brand and Model
AC1 ASR - Split reversible	2.21	DAIKIN (RZQ71DV1 &FCQ71C8) LG (UU30 UED & UV30 NBD) LG (UU30 UED & UT30 NPD) LG (UU30 UEC & UV30 NBC) LG (UU30 UEC & UT30 NFC) LG (UU30 UEC & UB30 NGC) CIATESA (35HK & 35D) CARRIER (38BZ042 & 40BZ042)
AC1 ASC - Split cooling only	2.21	CIATESA (35K & 35D)
AC1 APR - Window/wall reversible	2.1	CIATESA - IHA-35
AC1 APC - Window/wall cooling only	2.1	CIATESA - RHA-35
AC1 AMR - Multi-split reversible	2.28	HAIER (H2SM-18HA03(B)-R2 & H2SM-18HA03CB)-R2(x2))
AC1 AMC - Multi-split cooling only	2.23	CARRIER - 38GL3M21H
AC1 WPR - Water-cooled packaged reversible	2.93	CIATESA - IXV-30 CIATESA - IXH-30

Data source: Eurovent, 2011

Sales in Italy and France account for about 55% of the entire market, and sales of RACs by energy label class have evolved in the following manner for these markets:

Table 55: RAC Sales in Italy and France by Energy Label Class[61]

	2002	2005	2009	2011
A	16.9%	22.0%	44.2%	61.0%
B	4.7%	3.3%	7.4%	6.0%
C	8.9%	8.4%	7.5%	4.2%
D	28.3%	21.5%	9.0%	3.9%
E	0.6%	1.0%	1.0%	0.5%
F	0.5%	0.4%	0.7%	0.3%
G	0.6%	0.4%	0.2%	0.1%
unknown	39.5%	43.0%	30.0%	24.0%

RAC sales in EU-5 (Germany, France, United Kingdom, Italy, Poland) in 2007 by efficiency class (sales weighted) are reported to be as follows:

Table 56: RAC Sales in EU-5 by Efficiency Class[62]

	2007
A	63%
B	19.5%
C	11.5%
D	5%
E	1%
F	0%
G	0%

AC Stock in Use in the EU – 27 and its Member Countries

The installed stock of room air conditioners in the EU has been estimated to be as follows for 2005.

[61] Data source: Stöckle (2009)

[62] Data source: JRC 2009 (from GfK)

Table 57: Installed Stock of Air Conditioners in 2005, EU-27 in Numbers of Units

Number of standards units	Moveables			Reversible split units			Cooling only split units		
	Residential	Office	Retail	Residential	Office	Retail	Residential	Office	Retail
Austria	116641	15274	6943	2651	15404	8137	895	5202	2748
Belgium	147558	19323	8783	34293	199290	105272	11581	67302	35551
Bulgaria	148407	74203	74203	249971	472278	70390	83768	164947	24584
Cyprus	2537	0	134	145112	28608	28435	53242	13516	13434
Czech Republic	46827	42144	4683	2512	62962	18602	985	24684	7293
Denmark	75887	9938	4517	17636	102492	54140	5956	34612	18284
Estonia	19674	2576	1171	4572	26572	14036	1544	8974	4740
Finland	74119	9706	4412	6498	41075	21697	3487	17236	9105
France	862860	112994	51361	214450	1246270	658324	72421	420875	222321
Germany	425484	382935	42548	2722	66497	21691	15505	378811	123566
Greece	35201	0	1853	1542482	304088	302248	565938	143670	142801
Hungary	23871	21484	2387	10652	255190	65906	3850	118889	30705
Ireland	58736	7692	3496	5150	32550	17194	2763	13659	7215
Italy	1031315	515657	515657	3653700	1889974	538334	1274703	686982	195678
Latvia	32322	4233	1924	8806	51175	27032	2974	17282	9129
Lithuania	47781	6257	2844	11104	64532	34088	3750	21793	11512
Luxembourg	7027	920	418	1633	9490	5013	551	3205	1693
Malta	7709	3855	3855	12986	24534	3657	4352	8569	1277
Netherlands	230471	30181	13719	53562	311273	164425	18088	105119	55528
Poland	49863	6530	2968	11473	60459	36652	5364	29347	17791
Portugal	20	0	779	54814	301241	85661	20343	116390	33097
Romania	416310	208155	208155	701218	1324832	197458	234984	462707	68964
Slovakia	104077	52039	52039	175305	331208	49365	58746	115677	17241

Number of standards units	Moveables			Reversible split units			Cooling only split units		
	Residential	Office	Retail	Residential	Office	Retail	Residential	Office	Retail
Slovenia	38547	19274	19274	64928	122670	18283	21758	42843	6386
Spain	6992	0	0	3443506	1404838	318208	1264387	663841	150366
Sweden	127261	16665	7575	11158	70525	37254	5987	29594	15633
UK	848872	111162	50528	108847	687999	363425	58407	288701	152502
Total EU-27	4986367	1673196	1086225	10551739	9508025	3264929	3796329	4004428	1379142
PER TYPE	7745788			23324694			9179900		

Source: EuP (2011)

The EU AC stock will grow as follows by 2030:

Table 58: Projected Installed Stock of RAC in 2030, EU-27 in Numbers of Units

Number of standards units	Moveables			Reversible split units			Cooling only split units		
	Residential	Office	Retail	Residential	Office	Retail	Residential	Office	Retail
Austria	524991	68749	31249	15462	89855	47464	0	0	0
Belgium	664146	86971	39532	200041	1162532	614091	0	0	0
Bulgaria	722336	361168	361168	716483	1369263	204081	0	0	0
Cyprus	4555	0	240	370596	79072	78593	0	0	0
Czech Republic	53822	48439	5382	10991	275480	81392	0	0	0
Denmark	341561	44728	20331	102878	597874	315818	0	0	0
Estonia	88553	11596	5271	26672	155004	81879	0	0	0
Finland	446427	58461	26573	42264	245614	129742	0	0	0
France	3883670	508576	231171	1250963	7269936	3840238	0	0	0
Germany	902864	812578	90286	43631	1066006	347725	0	0	0
Greece	63200	0	3326	3939294	840502	835416	0	0	0
Hungary	18708	16837	1871	45544	1180612	304910	0	0	0
Ireland	353772	46327	21058	33492	194638	102815	0	0	0

Number of standards units	Moveables			Reversible split units			Cooling only split units		
	Residential	Office	Retail	Residential	Office	Retail	Residential	Office	Retail
Italy	4513107	2256554	2256554	14687648	7685484	2189108	0	0	0
Latvia	145480	19051	8659	51368	298522	157690	0	0	0
Lithuania	215057	28162	12801	64775	376439	198848	0	0	0
Luxembourg	31626	4141	1882	9526	55359	29242	0	0	0
Malta	37524	18762	18762	37220	71131	10602	0	0	0
Netherlands	1037332	135841	61746	312445	1815765	959151	0	0	0
Poland	47238	6186	2812	53821	287292	174165	0	0	0
Portugal	19	0	731	192513	1070479	304401	0	0	0
Romania	2026293	1013147	1013147	2009874	3841050	572486	0	0	0
Slovakia	506573	253287	253287	502469	960262	143121	0	0	0
Slovenia	187620	93810	93810	186099	355653	53008	0	0	0
Spain	13099	0	0	13595519	6004055	1359969	0	0	0
Sweden	766506	100376	45625	72566	421715	222765	0	0	0
UK	5112851	669540	304336	707907	4113984	2173152	0	0	0
Total EU-27	22708928	6663286	4911611	39282061	41883576	15531875	0	0	0
PER TYPE	34283826			96697512			0		

Figure 27: Stock of Air-conditioning Units by Country: 2005 - 2030 – EU

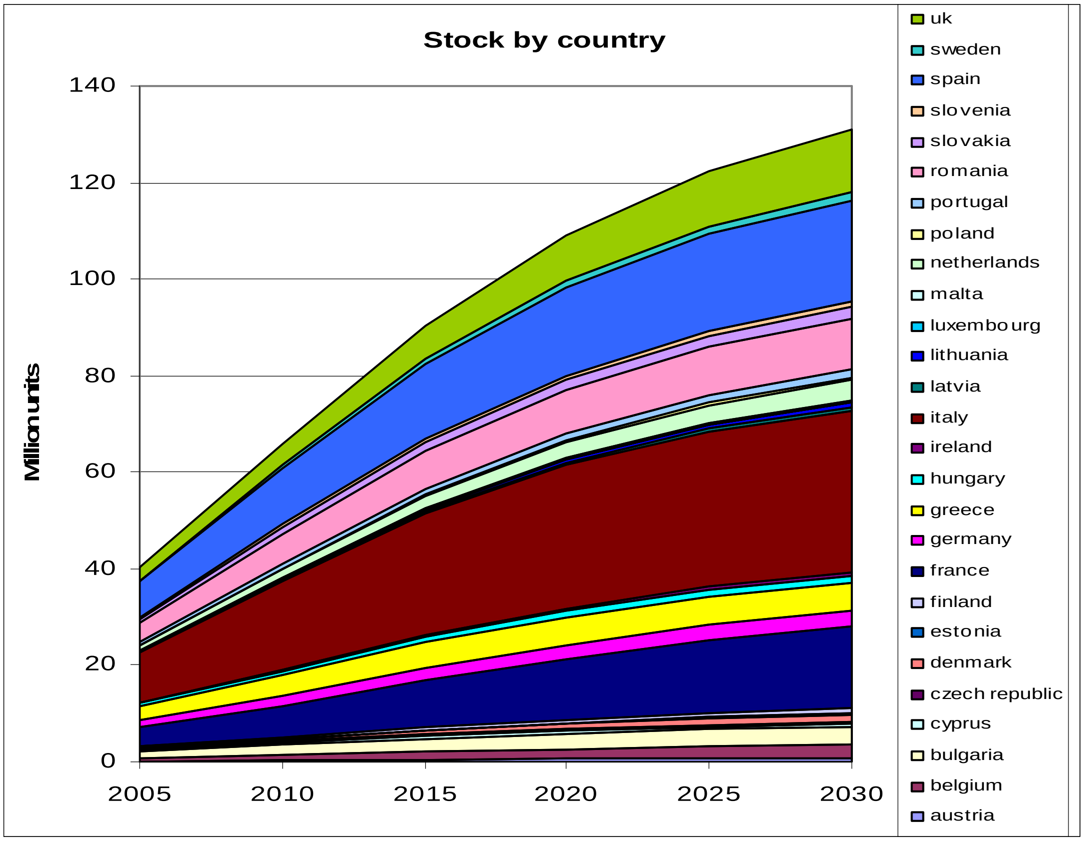


Figure 28: Stock of Air-conditioning Units by Sector: 2005 to 2030 – EU 27

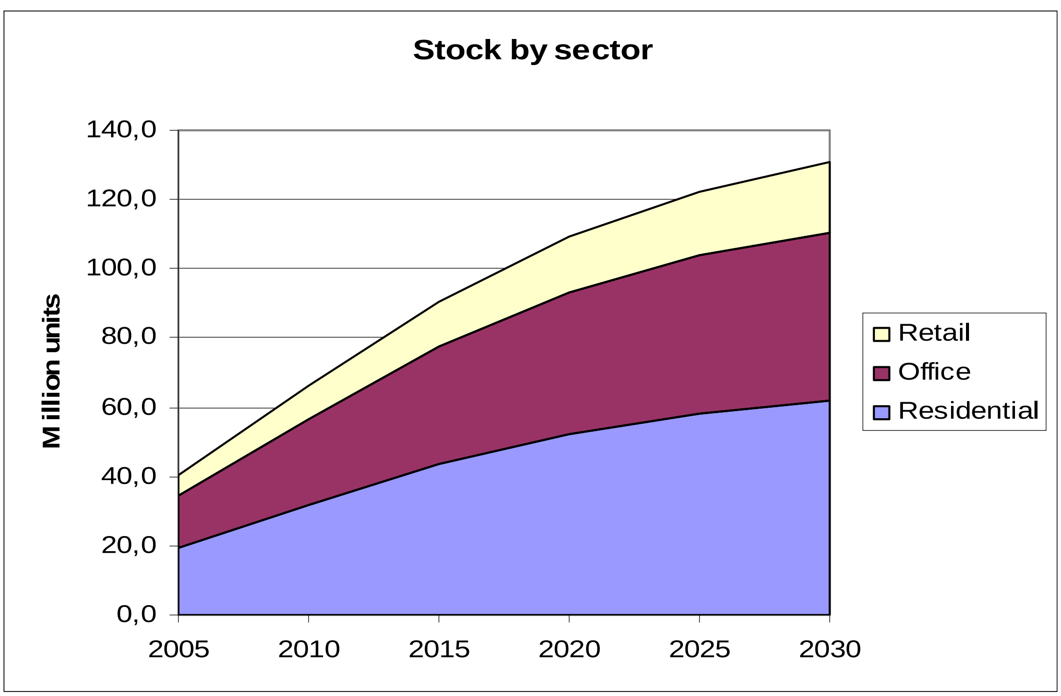


Figure 29: Stock of Air-conditioning in GW (Cooling Capacity) by Type: 2005 to 2030 – EU 27

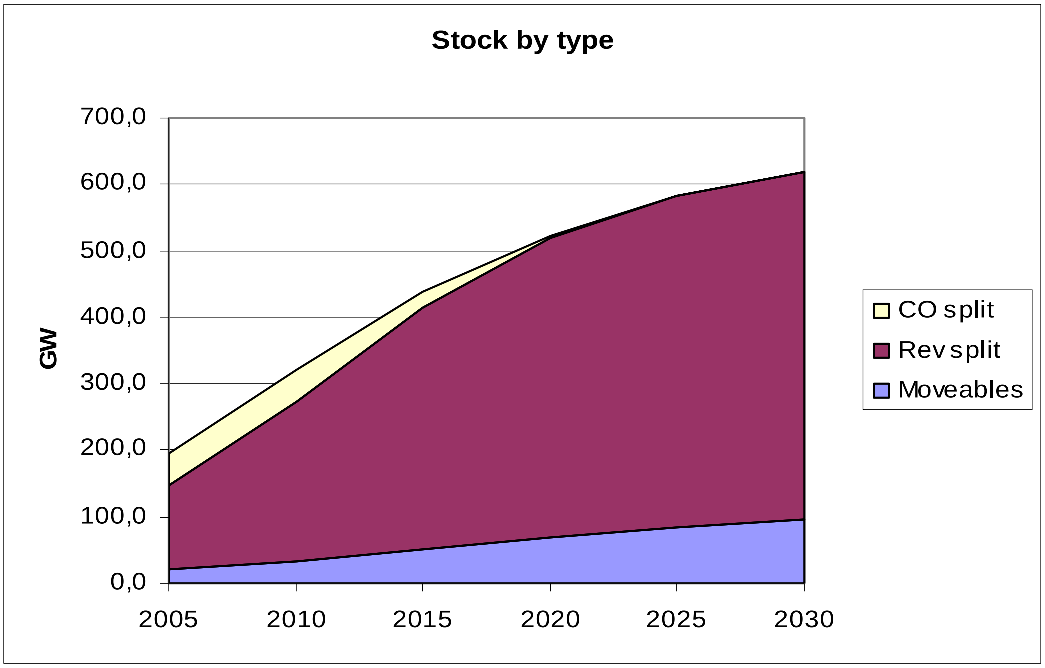


Figure 30: Stock of Air-Conditioning in GW (Cooling Capacity) by Country: 2005 to 2030 – EU 27

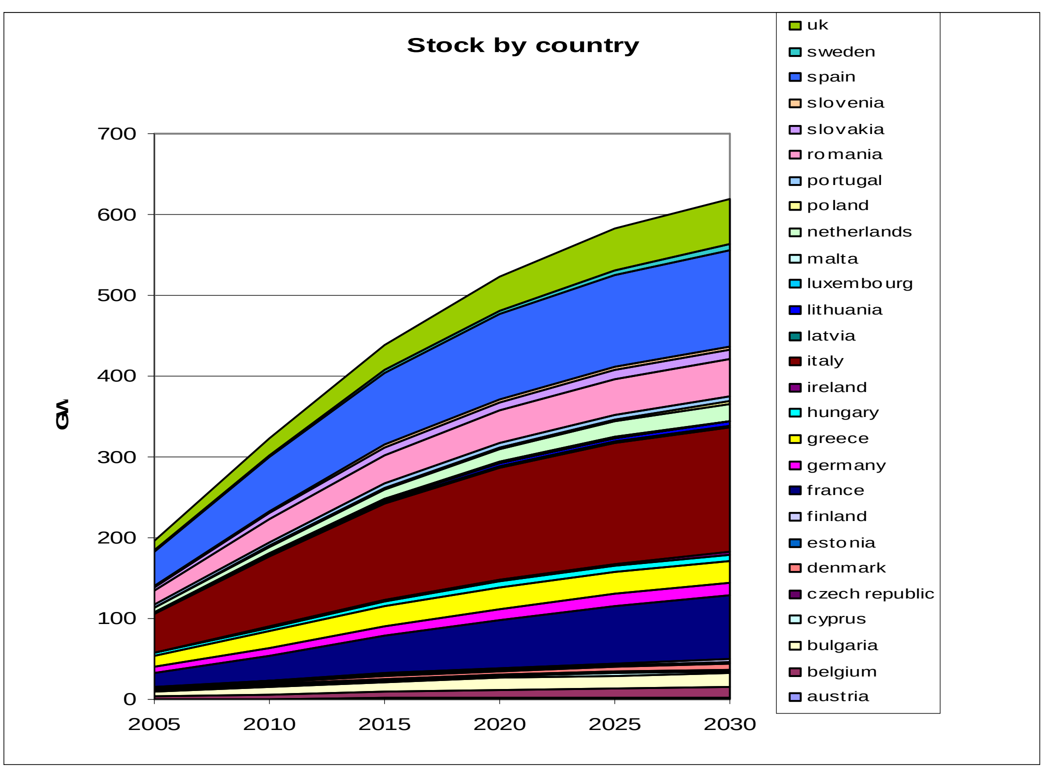
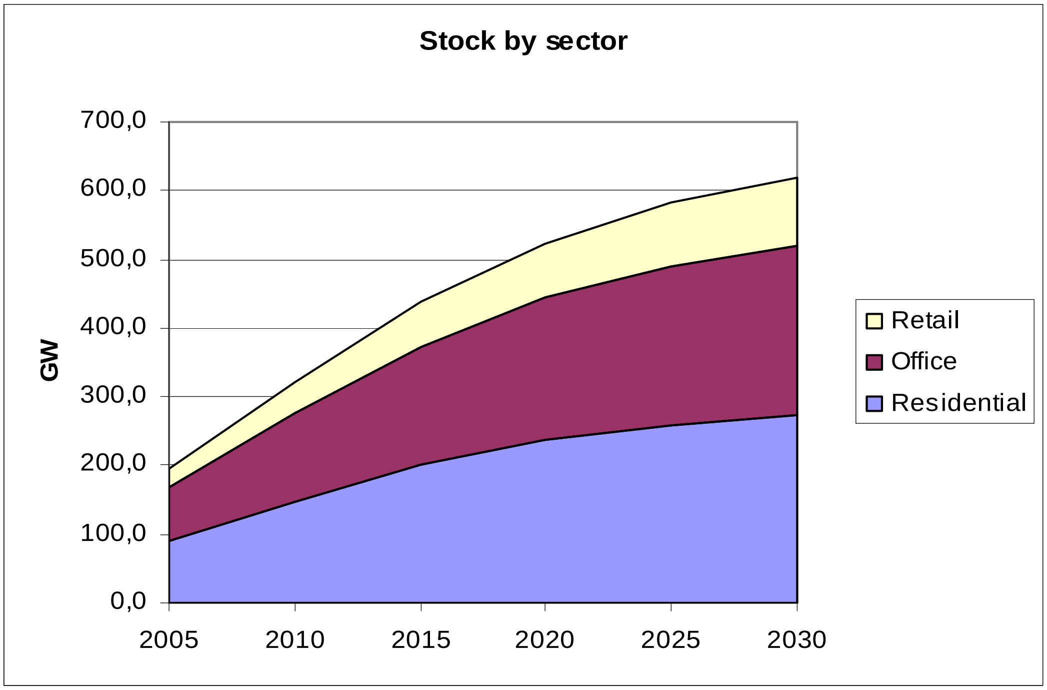


Figure 31: Stock of Air-Conditioning in GW (Cooling Capacity) by Sector: 2005 to 2030 – EU 27



Sales, Trade and Production Data in the EU – 27 and its Member Countries

Table 59: Air Conditioner Window/Wall and Split Types, Self-Contained (841510) International Import Data for EU27

Period	Trade Flow	Trade Value $	Trade Quantity	Av. Price per Unit $
2005	Import	1,147,214,340	4,239,144	270.62
2006	Import	1,147,328,791	4,239,567	270.62
2007	Import	1,869,198,727	7,318,002	255.42
2008	Import	1,848,665,269	6,924,712	266.97
2009	Import	930,212,175	2,878,378	323.17

Data source: UN Comtrade

Table 60: Air Conditioner Window/Wall and Split Types, Self-Contained (841510) International Export Data for EU27

Period	Trade Flow	Trade Value $	Trade Quantity	Av. Price per Unit $
2005	Export	122,231,652	526,514	232.15
2006	Export	182,582,945	786,478	232.15
2007	Export	238,066,598	1,012,164	235.21
2008	Export	225,949,009	902,923	250.24
2009	Export	166,279,950	691,153	240.58

Data source: UN Comtrade

Table 61 shows the production of AC units (Window or wall air conditioning systems, self-contained or split-systems) in the EU-27 as reported in the Eurostat, Prodcom database (accessed January 2011) (Thousands of units).

Table 61: Production of AC units

2002	2003	2004	2005	2006	2007	2008	2009
1208	1293	1592	1863	2811	2489	2578	2460

The following figures show historic and projected sales and stock data for the EU room air conditioner market from the EuP study (EuP 2011).

Figure 32: Sales of Air-Conditioning Units by Type: 2005 to 2030 – EU 27

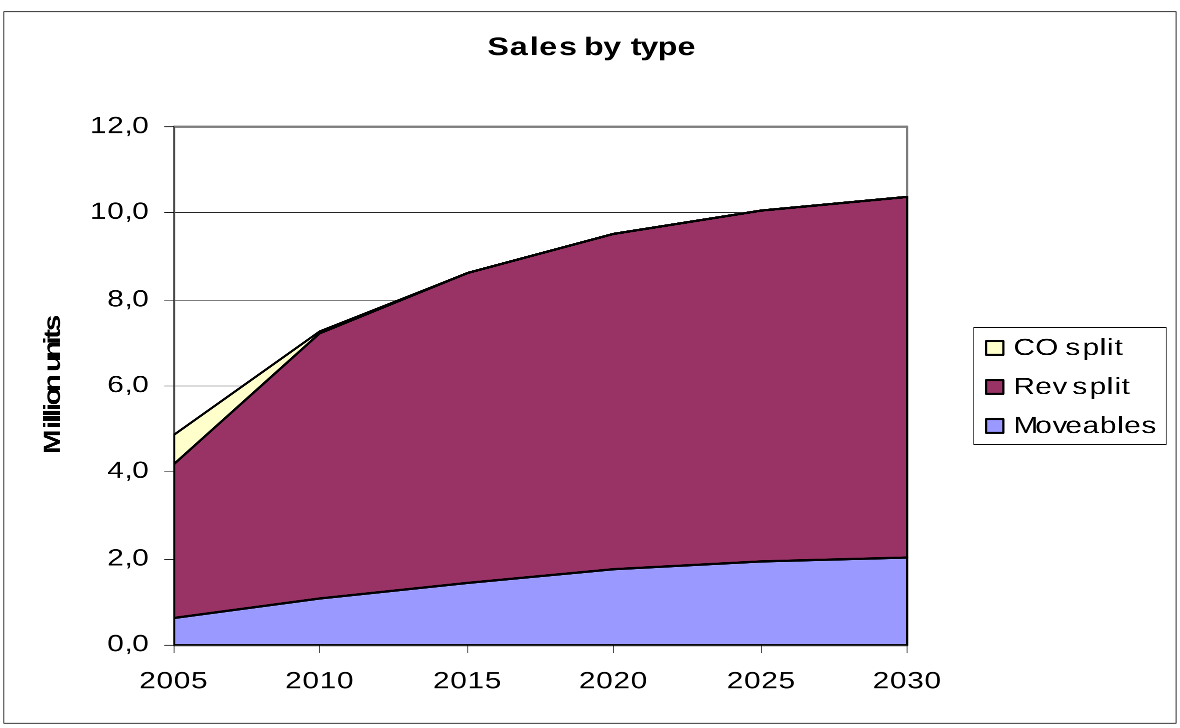


Figure 33: Sales of Air-conditioning in GW (Cooling Capacity) by Country: 2005 to 2030 – EU 27

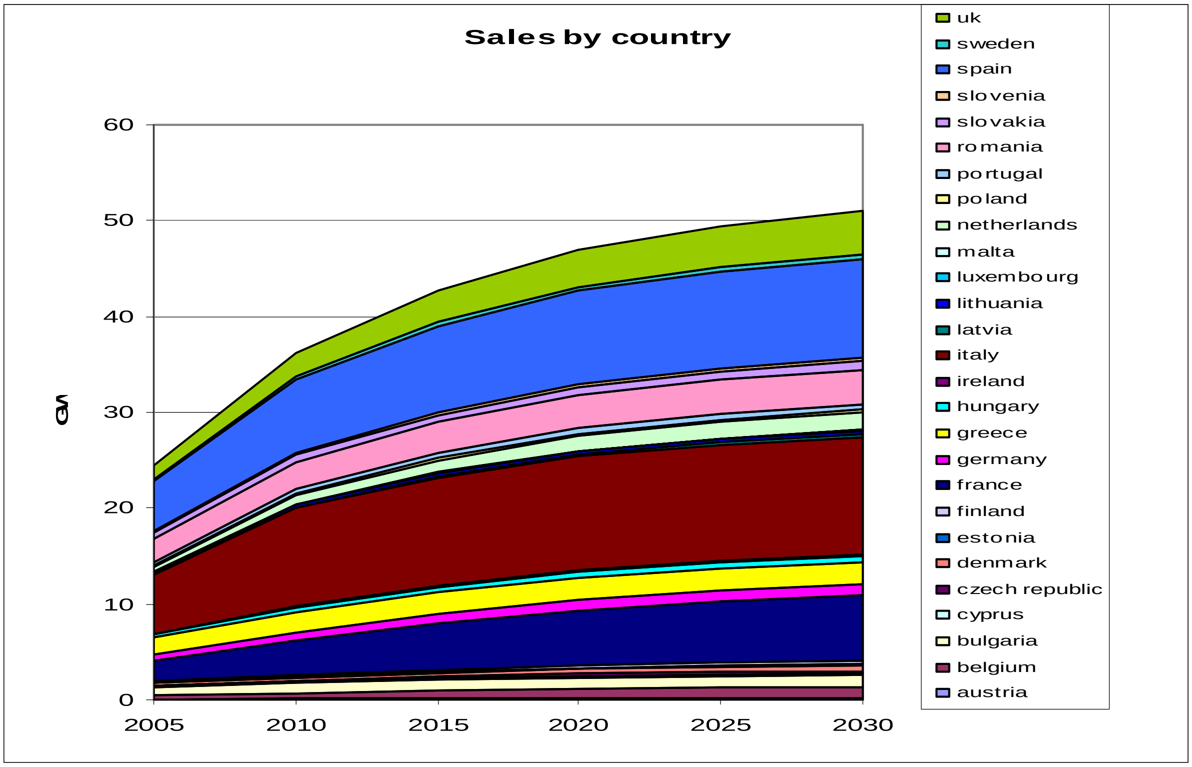
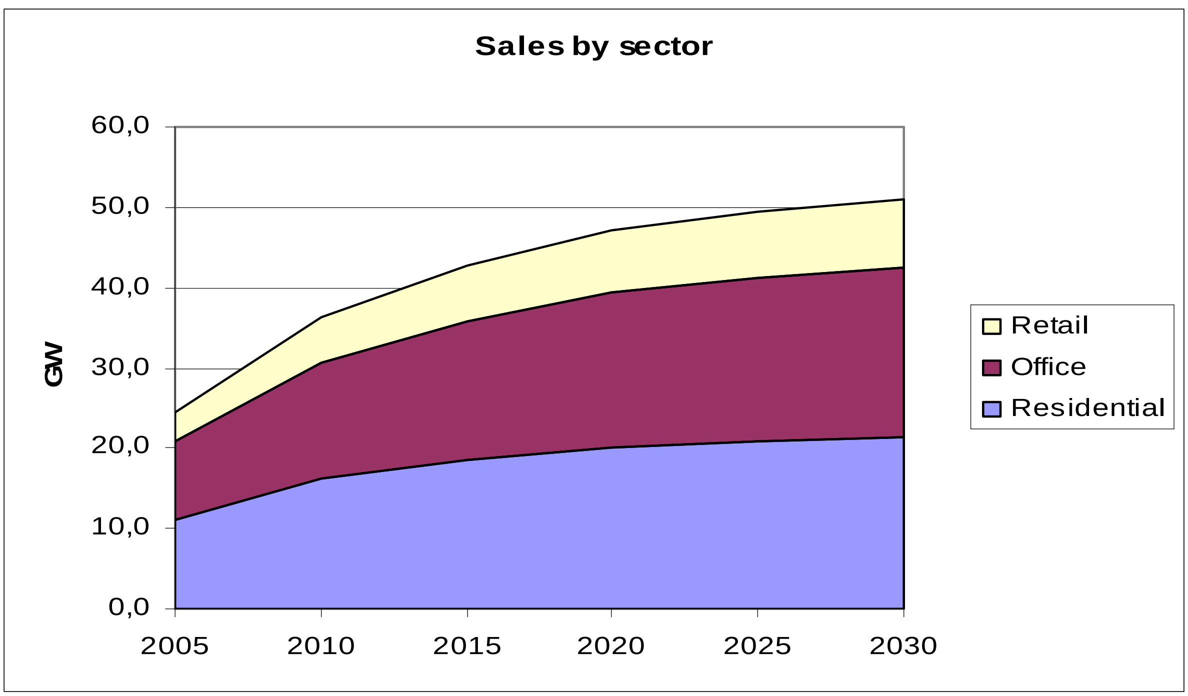


Figure 34: Sales of Air-conditioning in GW (Cooling Capacity) by Sector: 2005 to 2030 – EU 27



APPENDIX 3: Additional Information on the Japanese RAC Market

Residential sales are around 7 million units per annum, and ownership is over 2 units per household with around 85% of households owning at least one unit. (Sales of air conditioners to businesses comprise less than 1 million units per year).

Although there is an overlap in capacities of equipment for residential and commercial use, the markets – and the products offered – are distinct. Typically they are sold through different routes (via stores to households and through agents or distributors to businesses); developed to match the differing customer needs in terms of balancing cost, performance and installation method; and, in the case of at least one manufacturer, are manufactured in separate factories. Residential indoor units are overwhelmingly wall-mounted, while commercial units are predominantly cassette-type. Most residential units are below 3 kW cooling capacity, while most commercial units are over 8 kW but less than 30 kW. About half the commercial units sold have capacities below 12kW.

Product life for residential units is estimated to be about 12 years, based on analysis of recycled products. For commercial units, product life is thought to be about 10 to 15 years. From official figures of household numbers, historical air conditioning ownership, and sales we can estimate that the average product life is about 10 or 11 years.

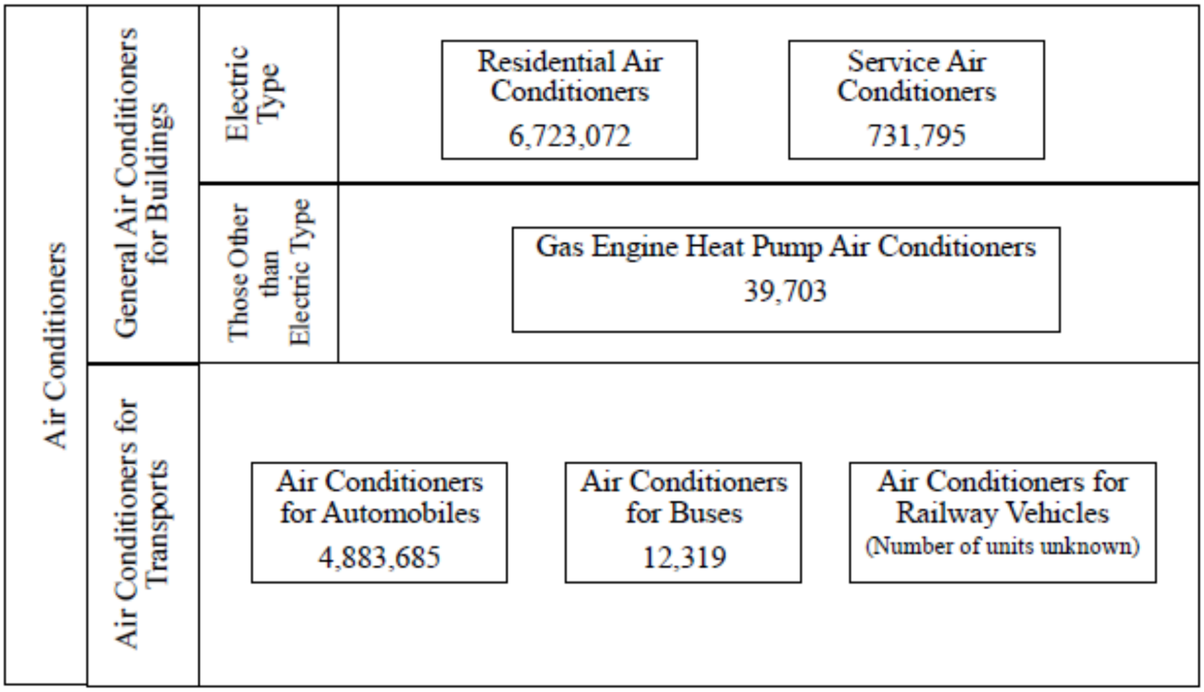
Official statistics show that 62% of replacement purchases are the result of breakdown, 13% are for upgrades, 16% because of moving house, and 10% for other reasons.

Under the influence of the rather demanding Top Runner program, average efficiencies have moved well ahead of those found in other markets.

The market is mature and total shipments have oscillated around 7 million units per year in the residential sector for many years.

Figure 35 shows the general characteristics of the market.

Figure 35: Units sales by sector and AC type in Japan for 2004[63]



Trade and Production Data

Table 62: Air Conditioner Window/Wall and Split Types, Self-Contained (841510) International Import Data for Japan[64]

Period	Trade Flow	Trade Value $	Trade Quantity	Av. Price per Unit $
2005	Import	325857968	1814557	179.58
2006	Import	437571380	2134122	205.04
2007	Import	520399048	2405265	216.36
2008	Import	694705815	2788643	249.12
2009	Import	807082122	3151916	256.06

[63] Data source: ECCJ 2008 from Japan Refrigeration and Air Conditioning Association

[64] UN Comtrade

Table 63: Air Conditioner Window/Wall and Split Types, Self-Contained (841510) International Export Data for Japan[65]

Period	Trade Flow	Trade Value $	Trade Quantity	Av. Price per Unit $
2005	Export	21497108	197718	108.73
2006	Export	40183256	520771	77.16
2007	Export	52410561	331271	158.21
2008	Export	64856802	207688	312.28
2009	Export	25456118	97709	260.53

MEPS: Heating Mode

In heating mode, the frost operation zone is considered to be between –7 °C and 5.5 °C. Outside this interval, performance curves are modeled by using the assumption that the average variation of heating capacity and electric power is the same for all appliances and is given by the following relationship, between H3 and H1 tests:

$P_H(-7\ °C) / P_H(7\ °C) = 0.64$ $\qquad$ P_H: heating capacity

$P_e(-7\ °C) / P_e(7\ °C) = 0.82$ $\qquad$ P_e: heating power

COP decreases by about 1.6% for 1 °C outdoor dry bulb temperature decrease. There is also the possibility to add resistive electric heating. Nevertheless, for standard equipment and for the Tokyo climate, there is no need for electric heating (assuming the following relationship between rated T1 cooling capacity and rated H1 heating capacity: $P_H(H1)=1.08*P_C+0.4$)[66] with balance point at about –3 °C.

For single speed heat pumps, only two tests are performed - the H1 test and H2 test. Full load performance curves in the zone [-7 °C, 5.5 °C] are drawn from the H3 point (deduced from H1) and the H2 point. The default C_D^H coefficient is set to 0.25 with no challenging test available.

For variable speed heat pumps, there is only one supplementary test point at reduced capacity (“intermediate standard heating capacity”) in H1 conditions. The full capacity performance curves are defined in the same manner as for single speed units. At reduced speed, the same coefficients of evolution of performance are used as at full load. The performances in frost conditions H2 at reduced speed are computed using the following relationship:

[65] Data source: UN Comtrade

[66] Regression based on European data 2006, to be recomputed with 2010 data.

$P_{H,intermediate}(2\ °C)/\ P_{H\ intermediate}(7\ °C) = 0.78$ $P_{H\ intermediate}$: heating capacity at reduced speed

$P_{e\ intermediate}(2\ °C)/\ P_{e\ intermediate}(7\ °C) = 0.88$ $P_{e\ intermediate}$: heating power at reduced speed

This relationship translates to a COP decrease of 8% corresponding to the outdoor temperature decrease and a COP decrease of 4% to take into account the impact of frost and defrost cycles. In addition, variable speed reversible air conditioners are supposed to be able to operate at higher than rated speed to face peak heating requirements at low outdoor air temperature. Hence, a third high capacity stage is defined. It is defined by 2 default coefficients that translate heating capacity and power of this stage at –7 °C and 2 °C. Degradation of COP with outdoor air temperature of this stage is a bit higher than for other stages (1.8% versus 1.6%). Performances at 2 °C of this stage are defined as a function of the performances of the full load test in H2 conditions:

$P_{H,high\ speed}(2\ °C)/\ P_{H\ rated\ speed}(H2) = 1.12$ $P_{H\ high\ speed}$: heating capacity at highest speed

$P_{e\ high\ speed}\ (2\ °C)/\ P_{e\ rated\ speed}(H2) = 1.06$ $P_{e\ high\ speed}$: heating power at highest speed

This third stage favors inverter units as compared to single speed units since it enables to lower the balance point before needing addition of resistance heating by a few degrees.

The HSPF calculated with this method does not compare the units with regards to the effect of outdoor air temperature. Since average weighted outdoor air temperature for Tokyo is about 7 °C (7.14 °C), it will not affect HSPF values. Only the effects of frost and part load will be compared, as well as the supplementary heat capacity available for variable speed units (in the case of climates other than the Tokyo climate).

APPENDIX 4: Additional Information on the US RAC Market

Table 64: Highest SEER Split and Packaged Central Air Conditioners on the US Market

Trade/Brand Name	Manufacturer	Model	Model	Capacity (Btu/h)	EER (Btu/h/W)	SEER (Btu/h/W)	Capacity (kW)	EER (W/W)	SEER (W/W)	CEE Qualifying Tie6r	AHRI Type
BROAN FS4BI SERIES	BROAN	FS4BI-024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
FRIGIDAIRE FS4BI SERIES	FRIGIDAIRE	FS4BI-024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
MAYTAG PSA4BI SERIES	MAYTAG	PSA4BI024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
MAYTAG PSA4BI SERIES	MAYTAG	PSA4BI024K	PAH4VME24KB	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
NORDYNE S4BI SERIES	NORDYNE, INC.	S4BI-024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
NUTONE FS4BI SERIES	NUTONE	FS4BI-024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
TAPPAN FS4BI SERIES	TAPPAN	FS4BI-024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB
WESTINGHOUSE FS4BI SERIES	WESTINGHOUSE	FS4BI-024K	B4VM-E24K-B	24000	15	24.5	7.0	4.4	7.2	CEE Tier 3 (Advanced)	RCU-A-CB

Source: AHRI/CEE database

Table 65: Highest EER Split and Packaged Central Air Conditioners on the US Market

Trade/Brand Name	Manufacturer	Model	Model	Furnace Model	Capacity (Btu/h)	EER (Btu/h/W)	SEER (Btu/h/W)	Capacity (kW)	EER (W/W)	SEER (W/W)	CEE Qualifying Tier	AHRI Type
XC21 SERIES	LENNOX INDUSTRIES, INC.	XC21-024-230-05	CBX40UHV-036*+TDR		26800	15.2	20.7	7.9	4.5	6.1	CEE Tier 3 (Advanced)	RCU-A-CB
XC21 SERIES	LENNOX INDUSTRIES, INC.	XC21-024-230-05	CH33-43+TDR+TXV	G71MPP-36C-090*	26400	15.2	21	7.7	4.5	6.2	CEE Tier 3 (Advanced)	RCU-A-CB
XC21 SERIES	LENNOX INDUSTRIES, INC.	XC21-024-230-05	CH33-43+TDR+TXV	SLP98UH090V36C*	26600	15.2	21	7.8	4.5	6.2	CEE Tier 3 (Advanced)	RCU-A-CB
XC21 SERIES	LENNOX INDUSTRIES, INC.	XC21-024-230-05	CH33-43+TDR+TXV	SL280UH090V36B*	26800	15.2	20.7	7.9	4.5	6.1	CEE Tier 3 (Advanced)	RCU-A-CB
XC21 SERIES	LENNOX INDUSTRIES, INC.	XC21-024-230-05	CH33-43+TDR+TXV	G61MPV-36C-090*	26400	15.2	21	7.7	4.5	6.2	CEE Tier 3 (Advanced)	RCU-A-CB
XC21 SERIES	LENNOX INDUSTRIES, INC.	XC21-024-230-05	CH33-43+TDR+TXV	SLP98UH070V36B*	26800	15.2	20.7	7.9	4.5	6.1	CEE Tier 3 (Advanced)	RCU-A-CB

Source: AHRI/CEE database

Table 66: Highest SEER Variable Speed Mini and Multi-split Air Conditioners on the US Market

Trade/Brand Name	Manufacturer	Model	Indoor Type	Model	Capacity (Btu/h)	EER (Btu/h/W)	SEER (Btu/h/W)	Capacity (kW)	EER (W/W)	SEER (W/W)	AHRI Type	Est. National Avg. Annual Operating Cooling Cost ($)	CEE Qualifying Tier
GREE	GREE ELECTRIC APPLIANCES INC. OF ZHUHAI	GWC09AB-A3DNA1B/O	Mini-Splits	GWC09AB-A3DNA1B/I	9000	14.8	23	2.6	4.3	6.7	RCU-A-CB-O	45	CEE Tier 3 (Advanced)
GREE	GREE ELECTRIC APPLIANCES INC. OF ZHUHAI	GWC09MA-A3DNA1A/O	Mini-Splits	GWC09MA-A3DNA1A/I	9000	14.2	22	2.6	4.2	6.4	RCU-A-CB-O	47	CEE Tier 3 (Advanced)
GREE	GREE ELECTRIC APPLIANCES INC. OF ZHUHAI	GWC12AB-A3DNA1B/O	Mini-Splits	GWC12AB-A3DNA1B/I	12000	13	22	3.5	3.8	6.4	RCU-A-CB-O	63	CEE Tier 3 (Advanced)
GREE	GREE ELECTRIC APPLIANCES INC. OF ZHUHAI	GWC12MB-A3DNA1A/O	Mini-Splits	GWC12MB-A3DNA1A/I	12000	12.5	20	3.5	3.7	5.9	RCU-A-CB-O	69	CEE Tier 2
TRANE	TRANE	4TYK8509A1*	Mini-Splits	4MYW8509A1*	9000	14.2	22	2.6	4.2	6.4	RCU-A-CB-O	47	CEE Tier 3 (Advanced)
TRANE	TRANE	4TYK8509A9*	Mini-Splits	4MYW8509A9*	9000	13.6	22	2.6	4.0	6.4	RCU-A-CB-O	47	CEE Tier 3 (Advanced)
TRANE	TRANE	4TYK8512A1*	Mini-Splits	4MYW8512A1*	11800	12.4	20	3.5	3.6	5.9	RCU-A-CB-O	68	CEE Tier 1
TRANE	TRANE	4TYK8512A9*	Mini-Splits	4MYW8512A9*	11800	12	20	3.5	3.5	5.9	RCU-A-CB-O	68	CEE Tier 1

Source: AHRI/CEE database

Table 67: Highest SEER Split and Packaged Central Air Conditioner Heat Pumps and Heat Pump Coils on the US Market (std 210/240-2005)

Trade/ Brand Name	Manufacturer	Model	Model	Furnace Model	Capacity (Btu/h)	EER (Btu/h/W)	SEER (Btu/h/W)	Capacity (kW)	EER (W/W)	SEER (W/W)	Capacity (Btu/h)	HSPF (Btu/h/W)	Capacity (Btu/h)	Capacity (kW)	HSPF (W/W)	(EER+HSPF)/2 (W/W)	CEE Qualifying Tier	AHRI Type
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D34+TDR	Y*(8,L)C*C20	34600	12.5	18	10.1	3.7	5.3	36400	10.5	26600	10.7	3.1	3.4	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D34+TDR	T*(8,L)X*C20	35600	12.5	18	10.4	3.7	5.3	36400	10.5	26600	10.7	3.1	3.4	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D44+TDR	Y*(8,L)C*C20	36000	13	18	10.5	3.8	5.3	37200	10.6	27400	10.9	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D44+TDR	T*(8,L)X*C16	35800	13	17.5	10.5	3.8	5.1	36400	10.6	26200	10.7	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D44+TDR	Y*(8,L)C*C16	36000	13.25	18.5	10.5	3.9	5.4	37200	10.5	27400	10.9	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D44+TDR	T*(8,L)X*C20	36000	13	18	10.5	3.8	5.3	36600	10.6	26800	10.7	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D4G+TDR	T*(8,L)X*C16	35800	13	17	10.5	3.8	5.0	36400	10.6	26200	10.7	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D4G+TDR	T*(8,L)X*C20	36000	13	17.5	10.5	3.8	5.1	36600	10.6	26800	10.7	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D4G+TDR	Y*(8,L)C*C16	36000	13.25	18	10.5	3.9	5.3	37200	10.5	27400	10.9	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)36D4G+TDR	Y*(8,L)C*C20	36000	13.35	18	10.5	3.9	5.3	37200	10.6	27400	10.9	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)42B44+TDR	Y*(8,L)C*C16	36000	13.05	18.5	10.5	3.8	5.4	36600	10.5	27000	10.7	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)42D4G+TDR	Y*(8,L)C*C20	36200	13.4	18	10.6	3.9	5.3	37000	10.5	27200	10.8	3.1	3.5	CEE Tier 2	HRCU-A-CB
ASPEN	YORK, UNITARY PRODUCTS GROUP	YZH03611	C(A,C,D,E)48D4G+TDR	Y*(8,L)C*C20	36200	13.45	18	10.6	3.9	5.3	37200	10.55	27200	10.9	3.1	3.5	CEE Tier 2	HRCU-A-CB
ADP	YORK, UNITARY PRODUCTS GROUP	YZH03611	HD15936	P(C,V)9*C20	35200	13	17	10.3	3.8	5.0	34400	10.7	25000	10.1	3.1	3.5	CEE Tier 2	HRCU-A-CB
ADP	YORK, UNITARY PRODUCTS GROUP	YZH03611	HE36936	P(C,V)9*C20	35200	13	17.5	10.3	3.8	5.1	34400	10.7	25000	10.1	3.1	3.5	CEE Tier 2	HRCU-A-CB

Source: AHRI/CEE database

Table 68: Highest SEER Split and Packaged Variable Speed Mini and Multi-split Heat Pumps on the US Market

Trade/ Brand Name	Manufacturer	Model	Indoor Type	Model	Capacity (Btu/h)	EER (Btu/h/W)	SEER (Btu/h/W)	Capacity (kW)	EER (W/W)	SEER (W/W)	Capacity (Btu/h)	HSPF (Btu/h/W)	Capacity (kW)	HSPF (W/W)	(EER+HSPF)/2 (W/W)	Capacity (Btu/h)	AHRI Type	CEE Qualifying Tier
DAIKIN	DAIKIN U.S. CORPORATION	RXG09HVJU	Mini-Splits	FTXG09HVJU	9000	15.8	22	2.6	4.6	6.4	12000	11	3.5	3.2	3.9	8100	HRCU-A-CB-O	CEE Tier 2
FUJITSU	FUJITSU GENERAL AMERICA, INC.	AOU12RLFW	Mini-Splits	ASU12RLF	12000	12.5	22	3.5	3.7	6.4	16000	11	4.7	3.2	3.4	9900	HRCU-A-CB-O	CEE Tier 2
FUJITSU	FUJITSU GENERAL AMERICA, INC.	AOU12RLS	Mini-Splits	ASU12RLS	12000	14.45	25	3.5	4.2	7.3	16000	12	4.7	3.5	3.9	10100	HRCU-A-CB-O	CEE Tier 2
FUJITSU	FUJITSU GENERAL AMERICA, INC.	AOU15RLS	Mini-Splits	ASU15RLS	14500	12.5	21	4.2	3.7	6.2	18000	11	5.3	3.2	3.4	11900	HRCU-A-CB-O	CEE Tier 2
FUJITSU	FUJITSU GENERAL AMERICA, INC.	AOU9RLFW	Mini-Splits	ASU9RLF	9000	13.8	23	2.6	4.0	6.7	12000	11	3.5	3.2	3.6	8100	HRCU-A-CB-O	CEE Tier 2
FUJITSU	FUJITSU GENERAL AMERICA, INC.	AOU9RLQ	Specific	ASU9RLQ	9000	13.4	21	2.6	3.9	6.2	12000	11	3.5	3.2	3.6	7700	HRCU-A-CB-O	CEE Tier 2
FUJITSU	FUJITSU GENERAL AMERICA, INC.	AOU9RLS	Mini-Splits	ASU9RLS	9000	17.3	26	2.6	5.1	7.6	12000	12	3.5	3.5	4.3	7400	**HRCU-A-CB-O**	**CEE Tier 2**
LG	LG ELECTRONICS, INC.	LSU091HSV	Mini-Splits	LSN091HSV	9000	13.3	20	2.6	3.9	5.9	10800	11	3.2	3.2	3.6	6900	HRCU-A-CB-O	CEE Tier 2
LG	LG ELECTRONICS, INC.	LSU121HSV	Mini-Splits	LSN121HSV	11200	12.5	20	3.3	3.7	5.9	13300	11.3	3.9	3.3	3.5	8300	HRCU-A-CB-O	CEE Tier 2
SUPER DIGITAL INVERTER	TOSHIBA CARRIER	RAV-SP300AT2-UL	Mini-Splits	RAV-SP300UT-UL	32000	14	21	9.4	4.1	6.2	33400	11	9.8	3.2	3.7	19700	HRCU-A-CB-O	CEE Tier 2
SUPER DIGITAL INVERTER	TOSHIBA CARRIER	RAV-SP360AT2-UL	Mini-Splits	RAV-SP360CT-UL	36000	12	20.4	10.5	3.5	6.0	38000	11	11.1	3.2	3.4	25800	HRCU-A-CB-O	CEE Tier 1
SUPER DIGITAL INVERTER	TOSHIBA CARRIER	RAV-SP360AT2-UL	Mini-Splits	RAV-SP360UT-UL	36400	13	21	10.7	3.8	6.2	36000	11.9	10.5	3.5	3.6	23200	HRCU-A-CB-O	CEE Tier 2

Source: AHRI/CEE database

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