Appliances Guide
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Energy efficient
Air Conditioners (AC)

Country

South Africa

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1 Country-wide saving potential

Air Conditioners (AC)

About **2.6 million** electric AC are in use in South Africa (reference year 2010). The average annual consumption of each of these AC amounts to about **3,100 kWh**. In total, this causes an annual electricity consumption of **8.1 TWh**. As model calculations show, enormous efficiency improvements can be achieved, especially if old inefficient models are replaced by modern efficient ones. The calculations of the efficiency scenario are based on the assumption that every time a new AC is bought, the most efficient "Best Available Technology" (BAT) model is chosen and that the improvements of the most efficient models over the years are taken into account. By this means, even an absolute decoupling of the annual energy consumption and the increasing stock of AC can be achieved. While the stock is expected to grow by 73 % between 2010 and 2020, in the efficiency scenario the energy consumption can be reduced by 7 %. Although the stock is expected to grow significantly by another 120 % until 2030 (following international trends), in the efficiency scenario the increase of energy consumption can be at least mitigated (Figure 1). Thereby, in particular higher living standards (e.g. increasing appliance ownership rates and household numbers) have been anticipated. In contrast, in the baseline scenario with moderate efficiency gains the energy consumption would increase by 27 % by 2020 and 85 % between 2020 and 2030.

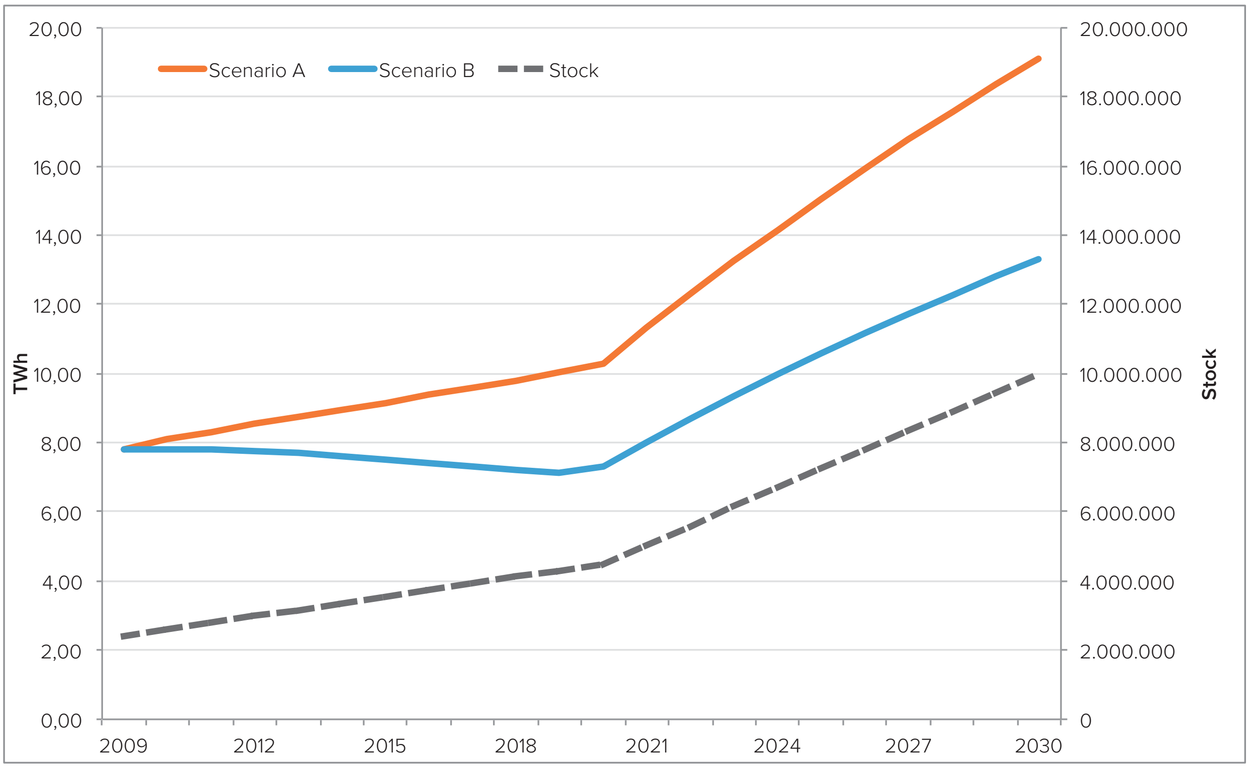

Figure 1: Electricity consumption AC, Baseline Scenario (A) vs. Efficiency Scenario (B)

Source: Wuppertal Institute (2015)

Table 1: Country-wide saving potential 2010 - 2030: AC

Base year 2010	Total energy consumption of AC per year [TWh/year]	8.08
	Stock number AC	2,600,000
	Average annual energy consumption of AC in the stock [kWh/year]	3,109
	Total annual CO_2eq emissions related with AC [Mt/year]	5.46
2020	Energy savings potential in 2020 vs. baseline development [TWh/year]	3.0
	Resulting change in energy consumption 2020 vs. 2010 [TWh/year]	-0.78
	CO_2eq emission reduction potential vs. baseline development [Mio.t/year]	1.98
	Stock number of AC in 2020	4,500,000
	Average annual energy consumption of new AC (all BAT) in 2020 [kWh/year]	1,500
	Total incremental investment costs [not discounted] until 2020 (end-user perspective) [€]	1,498,291,466
	Total incremental investment costs [not discounted] until 2020 (societal perspective) [€]	1,314,290,760
	Total economic benefit until 2020 [not discounted] (end-user perspective) [€] scenario B vs. scenario A	238,993,341
	Total economic benefit until 2020 [not discounted] (societal perspective) [€] scenario B vs. scenario A	-521,792,222

2030	Energy savings potential in 2030 vs. baseline development [TWh/year]	5.79
	Resulting change in energy consumption 2030 vs. 2010 [TWh/year]	5.21
	CO_2eq emission reduction potential vs. baseline development [Mio.t/year]	3.78
	Stock number of AC in 2030	10,000,000
	Average annual energy consumption of new AC (all BAT) in 2030 [kWh/year]	1,200
	Total incremental investment costs [not discounted] between 2021 and 2030 (end-user perspective) [€]	3,078,000,000
	Total incremental investment costs [not discounted] between 2021 and 2030 (societal perspective) [€]	2,700,000,000
	Total economic benefit until 2030 [not discounted] (end-user perspective) [€] scenario B vs. scenario A	1,644,851,428
	Total economic benefit until 2030 [not discounted] (societal perspective) [€] scenario B vs. scenario A	-925,084,293
Lifetime data for AC purchased in the analysed timeframe	Total electricity savings, scenario B compared to scenario A [TWh]	90.55
	Total GHG emission reductions scenario B compared to scenario A [Mt]	59.07
	Total incremental investment costs [not discounted] (end-user perspective) [€] scenario B vs. scenario A	4,576,291,466
	Total incremental investment costs [not discounted] (societal perspective) [€] scenario B vs. scenario A	4,014,290,760
	Total economic benefit [not discounted] (end-user perspective) [€] scenario B vs. scenario A	3,973,113,782
	Total economic benefit [not discounted] (societal perspective) [€] scenario B vs. scenario A	282,730,271

Source: Wuppertal Institute (2015)

2 Subtypes and markets

AC are not a priority appliance in South Africa but in recent years the popularity has grown in high income households, reaching a 40 % penetration rate in the most affluent homes. In addition to households, split ACs are often used in offices without a centralised HVAC system. The AC market was hit hard by the 2008 economic recession and sales bottomed out only in 2011/12. The market started to grow again in 2013 and is expected to grow by a compound annual growth rate of 5 % until 2018. The market in South Africa is dominated by split AC.

South Africa has a long history of appliance manufacturing and the first large appliances (electric stoves) were manufactured in 1932. Refrigeration came soon after and other domestic appliances such as gas stoves, washing machines, tumble dryers followed. Historically there was a limited number of locally manufactured mass produced appliances available to the middle to lower income groups while the high income groups were traditionally serviced by European imports. With the new democratic Government and the onset of globalisation in the mid-1990s several South African companies have shut down their manufacturing plants but still two remain in 2014. However, there has never been any local manufacture or assembly of AC. These appliances have always been imported due to historically low sales volumes in South Africa and the specialised components required for AC. There is also no incentive amongst local companies to manufacture AC as this sector in general is dominated by imported devices especially from large multinational companies that local companies cannot compete against [1]. AC are also viewed as a luxury item and targeted to the upper income families and commercial properties without a central AC system. All compressor-operated AC with a rated cooling capacity not exceeding 8.8 kW are subject to a 15 % import duty [2].

As recently as the late 1980's the country's electrification rate for residential households was around 35%, whereby almost all white households had electricity and the electrification rate of non-white households was extremely low. An electrification programme was implemented in the early 1990's and by 2001 the electrification rate had increased to 61 % [3] and by 2011 it was 83 % [4]. By the late 1990's the country's electrification programme expanded the market for electrical appliances by an estimated 50 % [5], but this is unlikely to have benefitted the AC market to the same extent as other more essential appliances such as refrigerators, televisions and to a lesser extent washing machines.

The country's significant income inequality means that the middle to lower end of the market chooses appliances almost exclusively based on price and brand. These appliances generally have less functionality and are often higher consumers of electricity. Conversely, upper income households choose their appliances based on functionality, design, brand, guarantees and after sales service, aesthetics and to a lesser extent and only more recently on their energy consumption.

This income inequality also means that the middle to lower income groups categorise their appliances as ‘essential’ and ‘non-essential’.

Market Characteristics

All AC sold in South Africa must comply with the South African National Standard (SANS) 54511-3:2010. This standard conforms to the International Electrotechnical Commission Standard IEC 14511-3:2007. The market is characterised by two types of systems – split and packaged units. A split AC system is made up of two units - an outside unit including the compressor, and an inside air outlet unit, often also referred to as the “wall hung head unit”. The two units are connected by pipes that carry refrigerant. A packaged terminal AC (PTAC) is a self-contained heating and air conditioning system. This report covers units, which are used in residential houses and small commercial properties and thus does not consider units exceeding 7.1 kW of cooling capacity as defined in the VC9008 [6].

The AC market is unique in many respects in that it was originally dominated by a small set of specialist companies, who did not manufacture other household appliances such as refrigerators, ovens and washing machines (e.g. Carrier and Daikin). In recent years Korean appliance manufacturers added more and more AC to their appliance portfolios. This prompted also South Africa’s biggest manufacturers of appliances to introduce a range of residential AC units, but these are actually all imported units. In addition there are many small and no-name brands, which enter the South African market in the form of direct imports. According to interviews held with industry experts, the market in SA is clearly split between the established local companies and direct imports. Thereby it was also suggested that container loads of no-name products enter the country and once the respective products are sold, the direct import sellers frequently close their shops, leaving the customers without any support [7]

In its 2014 appliance report, Euromonitor states that AC continue to be supported by high income earners who continue to buy AC despite the tough economic conditions being experienced in the country since 2008. The report goes on to note a peculiarity of the local market being that although most AC units have dual functionality, consumers typically do not use AC to heat their homes as they prefer to use heating specific appliances. This behaviour may change in the future as consumers are expected to opt increasingly for more energy efficient heating options [8].

With the high electricity tariff increases experienced since 2007 and the uncertainty of electricity supply in South Africa, major global brands put significant effort into making consumers aware of the innovative functionality and features their AC products offer, with a major focus being energy efficiency. An example of this is ‘Smart Invertor’ technology, which claims to use less energy than conventional models. The energy efficient technology is thereby often bundled with additional comfort features such as Wi-Fi or air purifier functionality, which however may also push up the price of units significantly. Split models dominate the market due to advantages concerning their size, noise levels and energy efficiency performance relative to the PTAC models [8].

As the Government’s water and electrification programme continues to develop coupled with increasing household income it is expected that also the general penetration rates of appliances will experience further growth. But with electricity tariffs increasing by as much as 300 % since 2007 and growing national concern regarding security of electricity supply and water availability in a water scarce country, Euromonitor (2014) reports that increasingly manufacturers and consumers are generally moving towards more energy and water efficient appliances as the economy continues to remain subdued and the price of water and electricity continue to rise. This is certainly the case for AC where sales plummeted from a high of 398,500 units in 2006 to reach a low point of 268,000 units in 2012 before the market started to experience growth once again.

Penetration Rates and Sales

A phenomenon, which has emerged in South Africa over the last 20 years as a result of new zoning policies is the conversion of former residential houses into office buildings. This is especially prevalent near to main arterial roads with high traffic volumes making them easily accessible but undesirable to live in. Once converted, e.g. what was formerly a four-bedroom house may serve as many as a dozen employees, with multiple smaller offices and meeting rooms, with each one commonly fitted with a dedicated AC unit. This could result in six or more units installed in a single location. These units may be sourced from suppliers who sell direct imports (often older generation, inefficient but cheaper units) or from agents who supply products from one of the major brand names. Figure 2 shows the annual sales of AC by category type for the period 1999 to 2013. Figure 3 shows the penetration rate of AC generally, which is as high as 20 % and Figure 4 shows the penetration rate of AC in residential households only, which is just 4 % but in Figure 4 it can be also seen that the penetration rate is as high as 40 % in the highest income households. The Life Style Measure (LSM) categorises households on a scale between 1 and 10, with 1 being indigent or lowest income and 10 representing the highest.

From a relatively small base, sales of ACs are increasing and are quickly becoming an 'essential' item for high income households and small businesses which do not have centrally installed AC, but for now this is only the case in 6 % of all households.

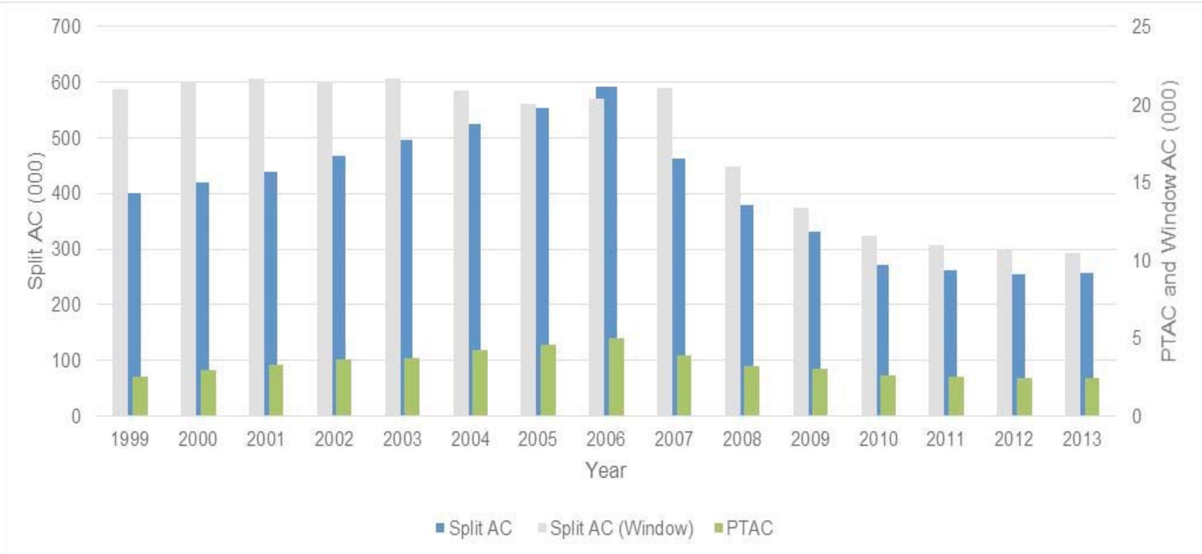

Figure 2: Annual sales of AC by type 1999 - 2013

Source: Euromonitor (2014)

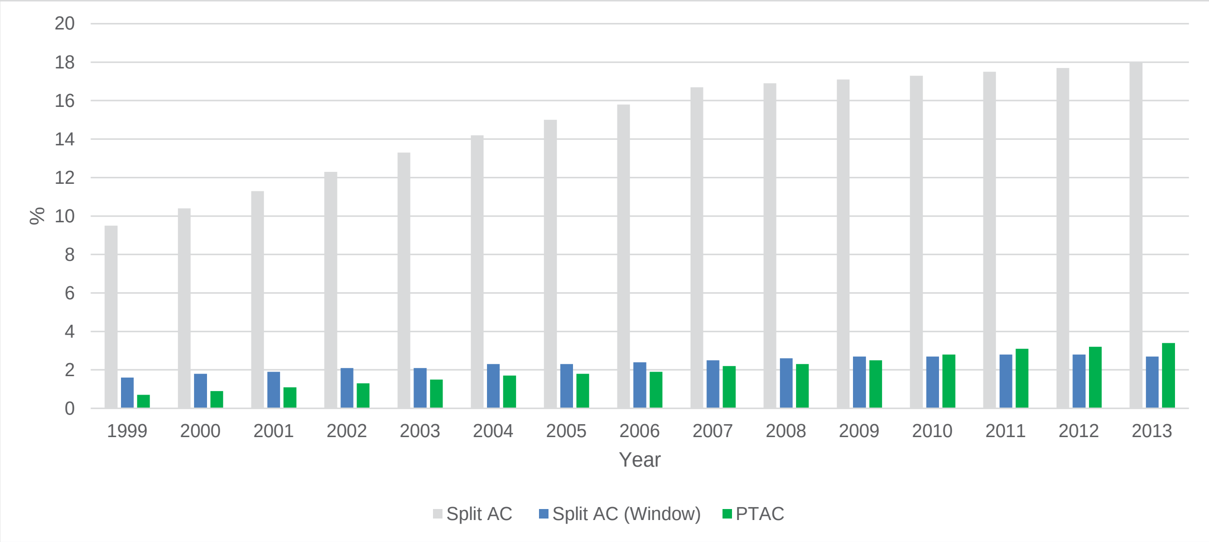

Figure 3: Penetration rates of AC by type 1999 - 2013

Source: Euromonitor (2014)

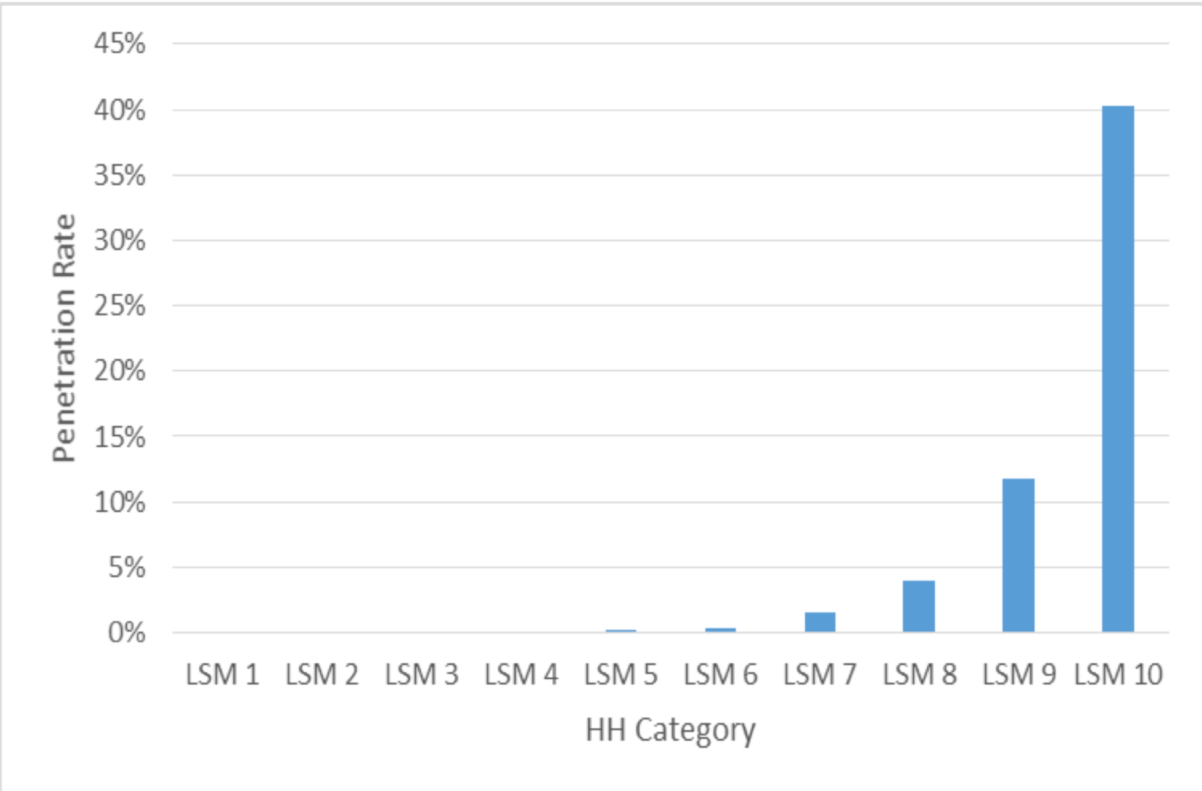

Figure 4: Penetration rates of AC by household categories (1999 - 2013)

Source: Euromonitor (2014)

Table 2 provides a breakdown of sales by AC sub-category type:

Table 2: Unit sales by format ('000 units)

		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
AC	Split	496	524	553	593	462	379	332	272	261	255	256
	Window	22	21	20	20	21	16	13	12	11	11	11
	PTAC	4	4	5	5	4	3	3	3	3	2	2
		521	**550**	**578**	**619**	**488**	**399**	**348**	**286**	**275**	**268**	**269**

Source: Euromonitor (2014)

AC Market – 1995

First interest in energy efficient appliances in South Africa dates back to 1995, when a cost benefit analysis was undertaken by the Department of Minerals and Energy [9]. The study grouped space heating and AC into one category and stated the following:

[Energy efficient] '*Air conditioners can make a large contribution to reduce energy used but [currently] there are only a few units used in the homes. The units will be bought from suppliers and they may have energy labels in the country of origin hence they are included on a voluntary basis. Air conditioners use about 600 kWh per month and here energy efficiency labels could result in savings of 5 %. Existing electric space heaters and air conditioners would be replaced after 15 years*'. [10]

AC Market – 2010

A study undertaken by the Department of Trade and Industry [7] in 2011 surveyed the Top 7 distributors of ACs in South Africa. Jointly, these companies accounted for more than 60 % of annual sales in 2010 and 2011. Only some of the AC companies agreed to participate in the study in the form of interviews and although some data was provided it was limited with almost no information regarding each unit's energy performance. It was therefore not possible to develop a profile of the AC units available in the South African market. The study thus relied on the BSRIA 2010 report [11] to overcome the lack of direct market data. Table 3 shows the derived market breakdown.

Table 3: Efficiency market shares and corresponding UEC for split unit air conditioners (2010)

	Split unit AC	
Energy class	**Market share**	**Unit energy consumption (UEC)**
	(%)	(kWh)
A++	0	390
A+	0	413
A	0	439
B	**75**	**468**
C	25	501
D	0	540
E	0	585
Average		**476**

Please note: Cooling only, UEC according to standard

AC Market – 2014

Figure 5 shows the percentage of models available in the South African market in 2014 by energy class. The data was sourced from popular online shopping websites, manufacturer websites and data supplied by manufacturers themselves. 70 models were identified in total. As in 2010, AC distribution companies did not participate in the data enquiry to the full extent. For this reason it is not a complete list, but it is believed to represent the market serviced by the major distributors.

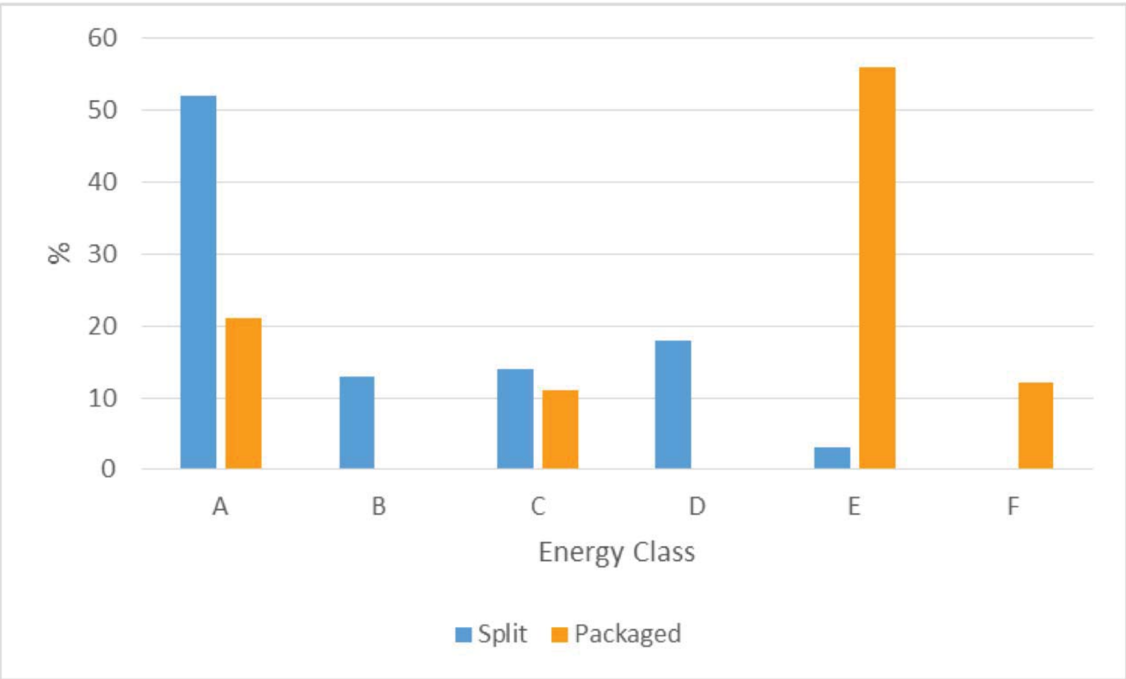

Figure 5: Percentage of AC models by Energy Class and product category (2014)

Source: Euromonitor (2014)

Market Trends

South Africa has been in an economic downturn since 2008 and continues to experience sluggish growth. In October 2014 the Minister of Finance revised annual economic growth down to 1.4 % from a forecast of 2.7 % in February 2014 [12]. The duration of these tight economic conditions and the steep rise in electricity tariffs over the same period has had a significant impact on household disposable income. Electricity tariffs more than tripled over the four-year period 2008 - 2012 and will continue to rise at an average of 12 % per year from 2014 to 2018. Sales of ACs were hit particularly hard and dropped by 48 % over a three-year period. Euromonitor (2009) [13] attributed this to the following:

- The building market in South Africa slowed down and went into decline. AC rely on a positive building market development and on consumers having disposable income;
- Until 2007 most AC were purchased on credit. The introduction of the National Credit Act (2008), which regulates the credit market in South Africa more strictly to protect consumers, was expected to impact on sales significantly; and
- Tight economic conditions meant that ACs dropped down in the list of ‘essential’ appliances.

At the top end of the market consumers were still able and willing to spend on AC units, which are becoming a standard feature in high-end households and small offices. Distribution companies have also increased their marketing efforts and above the line advertisements, such as magazines, billboards and television, is growing. Strong messages about lifestyle, innovation and energy efficiency are communicated. Direct importers continue to sell their products on the market competing on price rather than functionality and energy performance. Nevertheless, the middle and lower end of the market still opt by tendency for cheaper alternatives such as ceiling and desktop fans (please see bigEE South Africa reports on other appliance groups for details).

The combination of the Government’s intention to introduce a mandatory Standards & Labelling (S&L) programme (for ACs in 2016) and manufacturers realising that consumer awareness and understanding of energy efficiency is growing has elicited a response. Manufacturers surveyed have confirmed that for the appliances that are to be included in the Government’s S&L programme their products meet the MEPS and that they would like to see the programme to come into effect as soon as possible’[1]. It is with the retailers where the major uncertainty continues as the delayed implementation of the mandatory S&L programme means that stores, where there is very limited understanding of how S&L programmes are applied, remain unclear on what labelling is required and where. This has resulted in a situation where it is left up to the individual store managers to decide as to whether appliances labels are displayed and how to best deal with appliances where the energy efficiency rating is not supplied by the manufacturer.

As split unit AC require professional installation the majority of these units are not sold through retail stores but via authorised dealers. It is common practise for these vendors to manage several brands to meet the broad range of their customers needs. For this reason, marketing campaigns by the major companies focus on selling the ‘concept of AC’ rather than directly selling a specific single product.

[1] Discussion held with technical manager of Defy appliances September, 2014

Detailed product information is typically provided on the company websites and the dealership. For AC, energy efficiency and innovation are strong marketing tools with the major brands. But as an interviewed senior manager from one of the major brands stated: 'Energy efficiency is a strong marketing tool but ultimately when it is time to place the order 80 % of the decision still relates to price and availability'. More recently some of the major appliance retailers have also started the stocking lower end split AC units, as shown in Figure 6 below. Portable units are also distributed through major retailers as shown in Figure 7. During on-site visits in 2014, no energy labels were found on any AC products (split or PTAC) in major retail stores. The marketing focus is clearly on credit terms and the refrigerant used.

Figure 6: Split AC units in retail store – no energy labels (2014)

Source: Photos taken by Theo Covary (2014)

Figure 7: Portable (PTAC) units in retail appliance store – no energy labels (2014)

Source: Photos taken by Theo Covary (2014)

It is unclear as to why manufacturers and retailers are not putting already more effort into placing energy efficiency information on their AC products given that they are included in the mandatory S&L programme which comes into effect as of 2016.

Summary of the AC market in South Africa:

- Electricity tariffs in South Africa were amongst the lowest in the world in 1995, thus there was little demand for energy efficient appliances. However, tariffs have tripled over the four years period 2008 - 2012 and households paid EUR 0.10/kWh in 2014. The South African electricity regulator has also agreed to a further annual 12 % tariff increase for the period 2014 - 2018.

- During the 1990's South Africa had low electrification rates. A priority of the new Government was to electrify all households, which it has largely achieved. The percentage of households that used electricity for lighting went from 58 % (1996) to 80 % (2007). This programme created a new market for manufacturers of electric appliances and the growth rates were high for the initial period 1995 - 2005. It is unlikely that these growth rates are sustainable for the period 2014 - 2030.

- Historically, South African households did not make relevant use of AC for cooling, but this is starting to change in high-income households where they have become desirable products. The most likely time that an AC will be installed is when a house is being built or renovated and thus the market relies strongly on building cycles and applicable general building energy efficiency standards.

- All AC units in South Africa are imported and thus the introduction of more stringent MEPS will have no impact on the local appliance manufacturing industry.

- Replacement cycles of AC are estimated to be every 10 years.

3 Efficiency range and user savings

The AC market in South Africa is dominated by split unit ACs, with window and PTAC types controlling only a small percentage. Traditionally, households have not made relevant use of AC for cooling or heating but this is slowly starting to change amongst high-income households. Nevertheless, the biggest application of AC appliances in South Africa remains in small offices (e.g. in rededicated former residential buildings) without central AC system. This main application has also influenced the usage estimation used for efficiency calculations.

The following assumptions were used: AC operated for 5 hours per day throughout the year equalling 1,825 hours in total.

Table 4: Efficiency range and user savings of AC, based on 2010 data

Level	**Typical appliance in the stock (over all appliances in use)**	**Typical inefficient appliance on the market.**	**Typical appliance purchased (BAU – Business As Usual)**	**Best Available Technology (BAT)**	**Expected future BAT (Best not yet Available Technology)**
Typical Capacity / Size	4.5 kW Split AC (Reversible)				
Category	N/A	N/A	N/A	N/A	N/A
Type	Existing inefficient AC	Non-inverter	Non-inverter	Inverter AC with Heat Pump	Inverter AC with Heat Pump
Lifetime (years)	10	10	10	10	10

Qualitative performance classification of the provided service:	☐ Poor ☐ Low ☒ Average ☐ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☐ Average ☒ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☐ Average ☒ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☐ Average ☐ Good ☒ Excellent ☐ No information	☐ Poor ☐ Low ☐ Average ☐ Good ☒ Excellent ☐ No information
Yearly energy consumption: *electricity (kWh)*	3,500	2,600	2,200	1,800	1,500
Yearly energy cost (ZAR)	5,250	3,900	3,300	2,700	2,250
If applicable: yearly energy consumption for further energy carriers	N/A	N/A	N/A	N/A	N/A
If applicable: yearly water consumption	N/A	N/A	N/A	N/A	N/A
Yearly water cost (ZAR)	N/A	N/A	N/A	N/A	N/A
Purchase cost in (ZAR)	3,000	3,500	4,000	8,000	16,000
Operation & Maintenance cost (ZAR)	1,000 (lifetime)	1,000 (lifetime)	1,500 (lifetime)	2,000 (lifetime)	3,000 (lifetime)

4 Performance and information requirements

South Africa introduced a voluntary energy label for refrigerators and freezers in 2005. The label was based on the EU design and the objective was to extend this to other large appliances, such as washing machines, dishwashers and dryers but this did not materialise. National Standards for appliances were issued in 2009. VC 9008 published by the Minister of Trade and Industry on 28 November 2014 sets a date for the start of a mandatory S&L programme. For AC this is 28 of May 2016 and the MEPS has been set at level B for units not exceeding 7.1 kW (24,000 btu/h).

Energy Label

The South African Energy Strategy of 1998 identified residential appliances as an effective means to achieve energy savings in the residential sector in South Africa. In 2005 the country's first National Energy Efficiency Strategy (NEES) was developed and in the same year the Department of Minerals and Energy (now Department of Energy) introduced a voluntary labelling scheme, which was a precursor to a mandatory Standards and Labelling (S&L) Programme.

The voluntary scheme targeted refrigerators but encouraged manufacturers to extend it to all their appliances. It was decided to use the EU designed label, largely because historically the majority of South Africa's appliances were imported from Europe. A South African label was designed (Figure 8), which included some minor changes to the EU label being used at the time, most notably a star with the colours of the South African national flag. The label was registered with all the relevant national and international authorities.

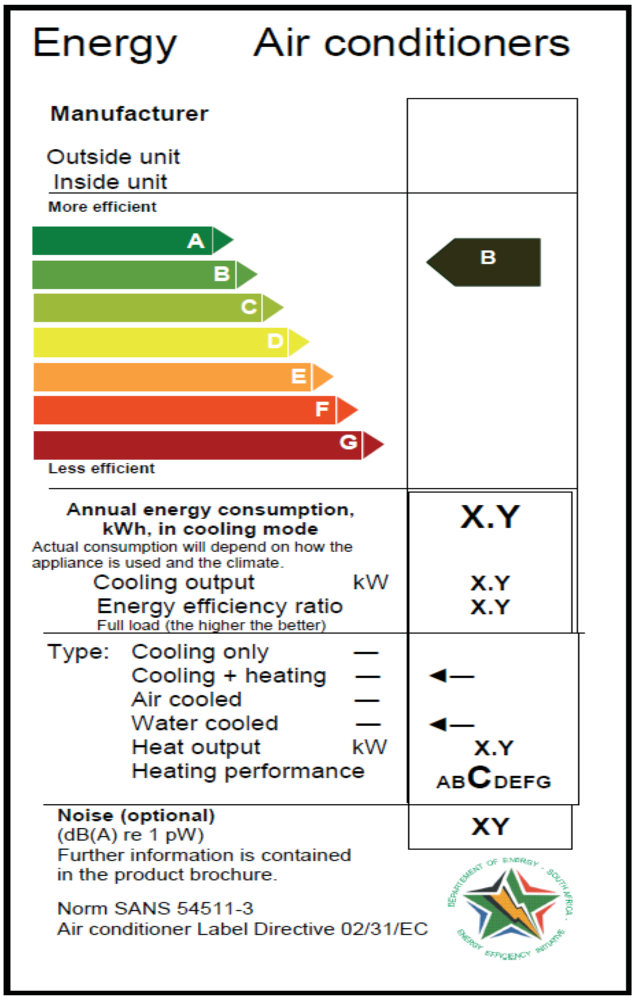

Figure 8: Energy Label for AC (SANS 54511-3:2011)

Source: South Africa Bureau of Standards

The voluntary programme had limited impact. With no support or signals from Government on the implementation of a mandatory programme it was soon forgotten and abandoned by manufacturers and retailers. In 2007 the South African Department of Energy (DOE) and the United Nations Development Programme (UNDP) country office agreed to submit a joint application to the Global Environment Facility (GEF) for financial support in order to implement a mandatory S&L programme [14]. In 2008, the South African Bureau of Standards (SABS) formed the Working Group 941 (WG941) who was mandated to develop the South African National Standard "SANS 941 - Energy Efficiency for Electrical and Electronic Apparatus". SANS 941 identified energy efficiency requirements, energy efficiency labelling, measurement methods and the maximum allowable standby power for a set of appliances. SANS 941 created the basis for the development of national testing standards in South Africa, which adopted the existing International Electrotechnical Commission (IEC) standards. The derived testing standard for AC is SANS 54511-3:2011 "Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling – Part 3: Test methods" (based on IEC 14511-3:2007). The proposal for the GEF funded S&L programme (submitted in 2010 and approved in 2011) selected the appliances based on SANS 941, but does not cover all the appliances listed in SANS941.

The South African energy label in its current format has certain shortcomings. These include:

- The label designed in 2005 is obsolete, and e.g. does not go beyond A. The standard states 'the indicators for A+ / A+++ shall be placed at the same level as for class A';
- Focus Groups undertaken 2012 found that all consumers viewed the programme would benefit them and supported its implementation. However, reported issues concerning the label included confusion regarding the words used for descriptions on the label. For example, why does it say energy and not electricity? As South Africa has many languages (11 official) so this also means that certain words may be misunderstood; and
- Including extra information was also questioned. For example, why were noise levels included if it is an energy label?

Based on the above listed findings, a review and re-design of the South African label is recommended to incorporate the issues identified locally and in the EU (which has almost eliminated all text in favour of pictograms). The South African S&L project team is currently (2015) deliberating whether to make changes to the existing label in line with the upgrades made to the EU label, which makes greater use of symbols (pictograms) rather than text. Exemplarily, potential changes to the label for refrigerators (as discussed in meanwhile) are shown in Figure 9 below:

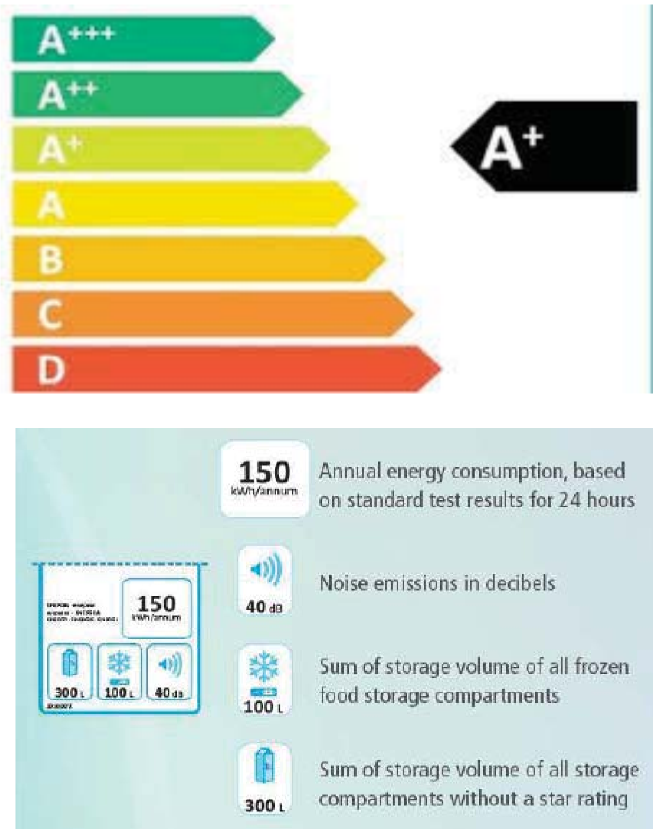

Figure 9: Draft for a new South African Energy Label (Example for Refrigerators)

Source: South Africa Bureau of Standards

Minimum Energy Performance Standards (MEPS)

On 7 February 2014, the “Compulsory specification for energy efficiency and labelling of electrical and electronic apparatus, VC9008” [15] was published by the South African government, which confirmed the MEPS as:

- AC not exceeding 7.1 kW (24,000 btu/h) cooling capacity, of the wall mounted split, window and portable types; and heat pumps for space cooling and heating: **Label class B**

The intention to introduce the above energy class allowed for a mandatory two-month period for public comments. After this time had elapsed and comments were dealt with, the Minister introduced the regulations at his / her discretion. On the 28 November 2014 the Department of Trade and Industry published notification that the VC 9008 will come into effect for AC eighteen months after publication of the notice i.e.: 28 May 2016 [16].

The MEPS levels were based on the findings of preceding impact assessment studies as well as consultations with manufacturers, retailers and consumer groups.

5 Test procedures and standards

All AC sold in South Africa must comply with the South African National Standard (SANS) 54511-3:2010 “Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling.” This standard conforms to the International Electrotechnical Commission Standard IEC 14511-3:2007.

Definitions

The following terms and definitions given in EN 14511-1:2007 apply:

- **Effective power input (P_E):** Average electrical power input, expressed in Watt, of the unit within the defined interval of time obtained from:
    - o Power input for operation of the compressor and any power input for defrosting;
    - o Power input for all control and safety devices of the unit; and
    - o Proportional power input of the conveying devices (e.g. fans, pumps) for ensuring the transport of the heat transfer media inside the unit.
- **Heating capacity (P_H):** Heat given off by the unit to the heat transfer medium per unit of time, expressed in Watt.
- **Total cooling capacity (P_C):** Heat given off from the heat transfer medium to the unit per unit of time, expressed in Watt.
- **Energy efficiency ratio (EER):** Ratio of the total cooling capacity to the effective power input of the unit, expressed in Watt/Watt. The EER value indicates the energy efficiency of the **cooling** performance.
- **Coefficient of performance (COP):** Ratio of the heating capacity to the effective power input of the unit, expressed in Watt/Watt. The COP value is an indicator of the energy efficiency of the **heating** performance.
- **Heat transfer medium:** Any medium (water, air, etc.) used for the transfer of the heat without change of state, for example cooled liquid circulating in the evaporator, cooling medium circulating in the condenser, heat recovery medium circulating in the heat recovery heat exchanger.
- **Operating range:** Range indicated by the manufacturer and limited by the upper and lower limits of use (e.g. temperatures, air humidity, voltage) within which the unit is deemed to be fit for use and has the characteristics published by the manufacturer.

Overview

The purpose of defining a COP/EER ratio is to provide a relative indicator to evaluate the performance of an air conditioning system in terms of the *energy input* by the user or operator and the *useful energy output generated by the system*.

Both the EER and COP ratios are determined by the amount of heating and cooling generated by the air conditioning compared with 1 kilowatt (kW) of electricity it consumes. An air conditioner that generates 3.6 kW of heating when using 1 kW of electricity has a COP value of 3.6. Therefore the air conditioning that generates most useful heat out of 1 kW of electricity is the most efficient, hence the higher the COP the more efficient is the air conditioning. Likewise, the higher the EER, the more energy efficient the cooling system. An air conditioner that generates 3.6 kW of cooling when using 1 kW of electricity has an EER of 3.6.

To determine the ratio, the total useful energy output is divided by the total input energy that must be supplied in order to make the system function properly. For example, in the case of COP, the ratio may be expressed by the following equation:

COP = $\frac{P_H}{P_E}$ **Watt/Watt** **(1)**
Where
P_H = heating capacity (Watt)
P_E = effective power input (Watt).

AC may also be rated by the number of British Thermal Units (Btu) of heat that the system can remove per hour. An air conditioner's energy-efficiency rating lists how many Btu's per hour are removed for each watt of power it draws. If expressed in Btu/hr, EER is defined as the net **cooling capacity (in Btu/hr)** divided by the **total electrical power input (in Watt).** EER is calculated at a single very specific operating point; i.e. the EER is a measure of how efficiently a cooling system operates when the *outdoor temperature is at a specific level*.

To illustrate, EER can be expressed as:

EER = $\frac{q_c}{P}$ **(2)**
Where
q_c = cooling energy (Btu/hr)
P = power consumption (Watt).

1 Btu = 2.931 x 10^{-4} kWh or alternatively 1 Btu/hr = 2.931 x 10^{-4} kW.

An air conditioner with cooling energy = 9,000 Btu/hr and input energy = 820 W will result in an EER of 10.98 $\frac{Btu/hr}{W}$ or 3.22 (Watt/Watt).

Generally the recommendation is that in mild climates air conditioners with an EER of at least 9.0 should be selected whereas in hotter climates air conditioners with an EER over 10 are preferable.

Types of AC

The categorization according to SANS 54511-3:2010 states that the energy efficiency class depends on the type of AC. These are classified* as follows:

- Split- & Multi-split air cooled
- Packaged air cooled
- Single duct air cooled
- Split- & Multi-split water cooled
- Packaged water cooled

**As the bulk of residential systems in South Africa are split and packaged air cooled systems only these categories are covered in this document.*

Energy Efficiency Class: Depending on whether the air conditioner is operating in cooling or heating mode, the energy efficiency class is based on respectively the EER or COP value.

Cooling Mode: The energy efficiency class of air conditioners in *cooling mode* must be determined in accordance with the appropriate equation, depending on the type of air conditioner (see Table 5 for data applicable for split and multi-split air-cooled AC in cooling mode).

Table 5: Energy Efficiency Class of split and multi-split air-cooled AC in cooling mode

Energy Efficiency Class	EE ratio at full load, at conditions T1
A	EER > 3.20
B	3.20 ≥ EER > 3.00
C	3.00 ≥ EER > 2.80
D	2.80 ≥ EER > 2.60
E	2.60 ≥ EER > 2.40
F	2.40 ≥ EER > 2.20
G	2.20 ≥ EER

<u>Heating Mode:</u> The energy efficiency class of air conditioners in *heating mode* shall be determined in accordance with the appropriate tables AA.6 to AA.10 of the standard, relevant to the respective type of air conditioner (see Table 6 for data applicable for split and multi-split air-cooled AC in heating mode).

In the case of appliances with heating capability, the heating output (heating capacity), in kilowatt, in heating mode at full load, is determined at conditions T1 + 7°C. If the appliance heating capability is provided by a resistive element, the coefficient of performance (COP) shall have a value of 1. The energy efficiency class is based on the COP value.

Table 6: Energy Efficiency Class of split and multi-split air-cooled AC in heating mode

Energy Efficiency Class	Coefficient of Performance, at full load, at conditions T1 + 7°C (COP)
A	COP > 3.60
B	3.60 ≥ COP > 3.40
C	3.40 ≥ COP > 3.20
D	3.20 ≥ COP > 2.80
E	2.80 ≥ COP > 2.60
F	2.60 ≥ COP > 2.40
G	2.40 ≥ COP

6 Application of the Standard

The SANS 54511-3 formulas to derive the energy class are complicated and the practical application is difficult to understand for non-experts. To provide a reference point, a selection of ACs for which actual data was publicly available was chosen and used to determine annual energy consumption for each of the energy classes.

The calculations were done by the electrical engineering department of the University of Stellenbosch.

Data obtained for the South African market [19] revealed the following information:

- Types: split, portable, window and floor standing units;
- Classes: Based on the EER values, classes A to E are represented;
- Performance ratios: since only EER values are given and cooling capacity in Btu/hr, cooling mode operation is generally implied.
- No market data was available for air conditioning units indicating heating mode operation

Cooling Performance

According to the standard [18], an energy label shall provide the following information:

- The indicative annual energy consumption calculated for total input power at an average annual use of 500 h in cooling mode at full load;

- The cooling output (cooling capacity), in kW, and the energy efficiency ratio (EER), in cooling mode at full load, determined in accordance with this standard (conditions T1, “moderate”).

The annual consumption (in kWh/yr) for the publicly available datasets [19] indicate that the covered number of hours in operation is approximately 2,556 hours. Table 7 and Table 8 provide a summary of the publicly available actual market dataset:

Table 7: Actual market dataset of split and multi-split AC with EER >3.20 (Class A)

Type	Input_Power (W)	Annual consumption (kWh/yr)	Cooling Capacity (Btu/hr)	Energy Class	EER (Watt/Watt)
Split	No data	5,373.83	23,000	No data	3.21
Split	No data	1,985.98	8,500	No data	3.21
Split	No data	3,971.96	17,000	No data	3.21
Split	No data	8,411.21	36,000	No data	3.21
Split	No data	2,562.11	11,000	No data	3.22
Split	820	2,096.27	9,000	A/B	3.22
Split	No data	4,192.55	18,000	A/B	3.22
Split	No data	2,795.03	12,000	No data	3.22
Split	No data	2,096.27	9,000	No data	3.22
Split	No data	11,180.12	48,000	No data	3.22
Split	No data	4,192.55	18,000	No data	3.22
Split	No data	13,975.16	60,000	No data	3.22
Split	1,090	2,786.38	12,000	A/B	3.23
Split	No data	8,333.33	36,000	No data	3.24
Split	No data	13,384.62	58,000	No data	3.25
Split	No data	13,636.36	60,000	No data	3.3
Split	No data	3,958.94	18,000	No data	3.41
Split	No data	2,639.30	12,000	No data	3.41

Table 8: Actual market dataset of split and multi-split AC with EER ≤ 3.20 (Class B and worse)

Type	Input_Power (W)	Annual consumption (kWh/yr)	Cooling Capacity (Btu/hr)	Energy Class (as stated)	EER (Watt/Watt)	Energy efficiency class (calc.)
Split	No data	8,437.50	36,000	No data	3.2	B
Split	No data	11,250.00	48,000	No data	3.2	
Split	No data	5,625.00	24,000	No data	3.2	
Split	No data	6,382.98	24,000	No data	2.82	C
Split	No data	12,765.96	48,000	No data	2.82	
Split	No data	6,405.69	24,000	No data	2.81	
Split	No data	6,405.69	24,000	C/D	2.81	
Split	No data	12,996.39	48,000	No data	2.77	D
Split	No data	9,818.18	36,000	No data	2.75	
Split	No data	3,296.70	12,000	No data	2.73	
Split	No data	13,284.13	48,000	No data	2.71	
Split	No data	10,112.36	36,000	No data	2.67	
Split	No data	16,917.29	60,000	No data	2.66	
Split	No data	17,175.57	60,000	No data	2.62	
Split	No data	8,620.69	30,000	No data	2.61	
Split	No data	2,586.21	9,000	No data	2.61	
Split	No data	5,273.44	18,000	No data	2.56	E
Split	2,060.0 W	5,273.44	18,000	No data	2.56	
Split	No data	17,786.56	60,000	No data	2.53	
Split	No data	11,020.41	36,000	No data	2.45	
Split	No data	7,468.88	24,000	No data	2.41	

Based on an assumption of 2,556 hours p.a. the input power P_E, in Watt can be calculated which was done for Table 7 and Table 8, covering classes A to E, and the EER values were verified to be correct.

Consumption Reference Table

The central tendency values of the cooling capacity for the available market data set for split units (classes A to E) are summarised as follows (Table 9):

Table 9: Cooling Capacity

	Cooling capacity (in Btu/hr)
Average	26,575.47
Mode	12,000
Median	23,000

In order to generate a consumption comparison reference table for air conditioning split-type units operating in cooling mode, it is essential to fix the cooling capacity parameter by constraining it to a realistic and representative value such as the *mode value* = 12,000 Btu/hr. (The *mode value* is the value that occurs most frequently in the data set).

Using the available actual dataset as guideline and equation (2), a consumption reference table (Table 10) for split air conditioners in classes A to E was developed based on the following specifications:

- Type: split unit;
- Operating mode: cooling;
- Operating conditions: at full load under conditions similar to the standard (T1);
- Duration: annual consumption is based on 2,556 hours;
- Cooling capacity: 12,000 Btu/hr, which is the mode value for the available actual data set for products in classes A to E.

From equation (2) it is clear that EER and *P* are inversely proportional hence ≥ and > (as in the EER expression) become ≤ and < (in the power consumption expression).

$$\textbf{EER} = \frac{q_c}{P} \qquad \textbf{(2)}$$

Where

q_c = cooling energy (Btu/hr)

P_E = power consumption (Watt).

Table 10: Reference table for split type AC in cooling mode with cooling capacity 12,000 btu/hr

Energy Efficiency Class	EER (at full load, T1 conditions)	Power consumption P (in Watt)
A	EER > 3.20	P < 3,750
B	3.20 ≥ EER > 3.00	3,750 ≤ P < 4,000
C	3.00 ≥ EER > 2.80	4,000 ≤ P < 4,285
D	2.80 ≥ EER > 2.60	4,285 ≤ P < 4,615
E	2.60 ≥ EER > 2.40	4,615 ≤ P < 5,000

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