CDM-MP71-A01

Draft methodological tool

Methodological framework for standardized baseline for energy efficient appliances - refrigerators and air conditioners

Version 01.0

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. The CDM Executive Board at its 85th meeting (EB 85) considered a concept note on the development of standards with a methodological framework for two specific project types to facilitate the development of standardized baselines and approved the identified sectors, i.e. energy-efficient appliances for residential/household application (e.g. air conditioners, refrigerators) and energy efficiency in buildings.

2. Purpose

2. This document proposes a new draft regulatory document in the form of a draft standard with a methodological framework for the development of standardized baselines (SBs) to cover energy-efficient appliances for residential/household application (i.e. air conditioners, refrigerators). The framework can be used to develop SBs to cater to the needs of a wide range of SB developers. A SB before its approval by the Board needs endorsement from the DNA. Once approved, CDM project developers can apply SB, provided eligibility criteria of the SB are met. This standard also addresses additionality.

3. Key issues and proposed solutions

3. This framework provides options to calculate average electricity consumption and average refrigerant emissions from refrigerators and air conditioners in an identified region using various data sources, including energy efficiency labels. The variety of options provided is aimed to facilitate the development of standardized baselines in all eligible countries. This objective requires to consider up to three different sources of data to ensure data used is of acceptable quality, but in cases where reliable data is an available lesser number of sources will be sufficient. The analytical steps are described in the document to help a reader of the framework.

4. Most countries including LDCs have regulations for air conditioners and refrigerators (and many more appliances) that generate sufficient data to calculate the averages values of parameters referred above. Some countries have up-to-date efficiency data of all available air conditioner models which are publicly available online (e.g. China and India), while other countries only issue endorsement labels when manufacturers solicit them. Therefore, this framework includes a variety of calculation options so that the framework is broadly applicable under different data availability conditions.

5. It is difficult to predict which calculation method is the most accurate in a country and the framework requires judgment on the quality of three possible data sources, i.e.:

   (a) National Standard & Labelling (S&L) information (Procel in Brazil for example);

   (b) Commercially available marketing data;

   (c) Data from importers, distributors, and retailers (industry data).

6. All three sources include data for air conditioners and refrigerators based on global test standards such as the ones from ISO and IEC. To make the data comparable, conversion factors for relevant differences between efficiency metrics are also provided in the framework. For example, an overseas manufacturer active in the market in South Africa may be selling models identical to those tested in the manufacturer's home country. Therefore, no new testing would be required for monitoring purposes and no metering either when the relevant values from the home country's metric are converted to the South African metric.

7. With the methods provided in the framework, the average electricity consumption of refrigerators and air conditioners currently being sold and those sold in the immediate past (e.g. past one year) are established allowing estimation of emission reduction from new more efficient models identified for distribution under a proposed mitigation project. There are two types of SB for electricity consumption that can be developed: *replacement* and *new sales*.

8. A refrigerator *replacement* baseline credits the avoided continued use of old refrigerators in use up to the current average efficiency level of refrigerators, and the *new sales* baseline credits electricity savings over and above the current average efficiency level of sold models. In other words, the replacement baseline, when applied on a stand-alone basis, corresponds to project activities removing functioning old refrigerators and replacing them with new high-efficiency refrigerators.

9. The new sales baseline, on the other hand, is the average efficiency of the refrigerators models sold on the market. It may be calculated as the average of the efficiency of all models available on the market and/or it can be the sales-weighted average of the models.

10. Independent of these two types of SBs for electricity consumption, is a *refrigerant* SB that may be developed as the third component. Introducing new efficient models can imply models with *refrigerants* with lower GWP (typically by a factor of 100). A refrigerant baseline reflects the average refrigerant emissions from currently sold refrigerators and air conditioners and allows estimation of emission reduction from new models based on the reduced/avoided release of refrigerants eligible to be considered in the baseline under the CDM.

11. Many countries, from China to Ghana, implement very large scale programmes to remove old refrigerators and air conditioners and speed up the introduction of efficient ones. Some as "Demand Side Management", others through import regulation, and the Montreal Protocol funds refrigerant emissions reductions (esp. Hydrochlorofluorochlorocarbons (HCFC)[1] in air conditioners). The framework seeks to accommodate national policy preferences so that electricity and refrigerant baseline estimations can be credibly established. A conservative baseline set as the average efficiency and the usage of the appliance on the market is also used as the threshold for additionality. All of the calculation options included in the framework reflect national circumstances and reflect the aim to achieve market transformation.

[1] HCFCs are dominant air conditioner refrigerants and dominant refrigerator PUR foam blowing agents. The SB approach accounts only HFCs at present, but anticipates that the Montreal Protocol will be extended to HFCs.

12. A Standard & Labelling database typically contains the following information for each one of the thousands of the refrigerators or air conditioners sold in a country (example from Indian BEE[2] on refrigerator models):

Figure 1. Extract of Standard & Labelling database from Bureau of Energy Efficiency in India

S.No	Brand	Model No	Gross Volume (Litres)	Storage Volume (Litres)	Electricity consumption (unit per year)	Approval Date	Valid Till	Star Rating
1	LG	GN-M702HSHM	546	507	400	23-12-2015	31-12-2018	2
2	LG	GC-B519ESQZ	452	398	360	23-12-2015	31-12-2018	2
3	LG	GN-M602HLHM	511	477	404	23-12-2015	31-12-2018	2
4	GODREJ	RD EDGE ZX 195 PDS 5.2	195	188	210	26-02-2015	31-12-2016	5
5	GODREJ	RD EP210 PD 5.1	210	198	203	18-03-2016	31-12-2016	5

4. Impacts

13. Usually the brand, type, model number, Energy Efficiency Ratio, capacity (power rating), annual electricity consumption, validity of test result and efficiency class (1-5 stars) are included. In a mandatory standard and label (S&L) database, all manufacturers and importers are required to report information for all models produced or sold. Typically, a national energy administration maintains the S&L database and verifies the data. Some countries have voluntary S&L databases, containing only information from companies willing to report. Where all manufacturers do, the averages are correct for the entire market. Where only some manufacturers report, the average reflects a share of the market. In some countries manufacturers and importers are also required to provide annual sales data and then efficiency data of models can be sales-weighted.

14. The second source, marketing data is available in most countries from commercial data companies. Marketing data companies use elaborate survey methods screening all retailers, typically every week or month, collecting model sales numbers, efficiency data and pricing information. This marketing data is usually comprehensive in sales and price

[2] Five randomly extracted brands out of thousands of models in the database for illustration, accessed in October 2016 <www.beestarlabel.com/Home/Searchcompare>.

coverage, however the cost of such marketing data can be very high. Below is an example for three of 1,037 refrigerator models available in a country in 2010 that have been sold:

Figure 2. Extract of a typical marketing data

Model	Brand	First Activity	Net. Liters Total	NoFrost Sy	En.l	Energy Cor	Sales Units	Sales Units
							January 2008 - December	ry 2009 - December
5231 NFY	ARCELIK	September 2009	>400<=450 ltr.	YES	B	657		5,042
BD 4306 ANFE	PROFILO	May 2009	>350<=400 ltr.	YES	A	453		9,133
BK 7121 T	BEKO	July 2008	>100<=150 ltr.	NO	A	235	5,787	15,294

15. The third data source is the industry data where data from companies selling appliances is directly sourced including from importers, wholesalers, distributors and retailers. A Standardised Baseline (SB) developer may approach all such companies and request data on their sales in the previous year or months. In smaller countries with only few appliance importers and sellers, this may be pragmatic and feasible option. It requires assuring that commercially sensitive information is not revealed. In larger countries such data may be collected through sampling approaches applying CDM sampling guidelines.

16. How these three data sources are utilised is case specific. When data is complete, i.e. all models in a market covered, the data is accurate and recent, only one source may be sufficient. In practice, a SB developer can use between these three sources, the primary data and data for cross check. The flexibility to combine data sources allows furthermore to combine efficiency information of various import sources e.g. where Korean S&L data with Indian, Chinese or EU label data is needed to cover a sufficiently large share of sales in a country.

5. Subsequent work and timelines

17. The Meth Panel requested that the secretariat make the draft standard publicly available for global stakeholder consultation. After receiving public inputs on the document, the Meth Panel will continue working on the draft standard with an aim for recommendation to the Board at its next meeting.

6. Questions to the public:

18. The Meth Panel would like to receive inputs from the public on the draft standard as contained in this document. The scope of inputs includes but is not limited to the following issues:

    (a) Refrigerator and air conditioner baselines and additionality thresholds need to reflect market trends in the preceding years. Market shares of dominant manufacturers of air conditioners are considerably higher than those of refrigerator manufacturers. In addition, the number of air conditioner manufacturers is lower than the number of refrigerator manufacturers (often just a fifth). Other factors also make it easier to assemble data for all air conditioner models in a market compared to all refrigerator models. Data coverage of publicly available databases for air conditioners in the US, in China, India, Australia and in Brazil is much higher than for refrigerators. The share of air conditioner models where efficiency data is not available, is often negligible. While these factors make it easier to define a baseline for air conditioners, more precaution is required to determine whether different socioeconomic classes of households are changing their air conditioner purchases.

(b) Responses from the public are invited for suitable indicators of the most important drivers of market trends for refrigerators and air conditioner baselines and additionality thresholds. Indicators for market trends for refrigerators and for air conditioners should enable specifying a range for baseline and additionality threshold in the draft framework to facilitate the selection of specific thresholds in the standardised baselines depending on the data availability and quality.

(c) As currently written, the draft framework in appendix 2 includes guidance to consider models available on the market to arrive at standardized values. It does not detail the procedure to consider respective sales data of the models of the refrigerators or air conditioners. The public are invited to provide inputs on how an option to include sales weighing of the models may be integrated.

7. Recommendations to the Board

19. Not applicable (call for public input).

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1. Introduction

1. This draft standard includes a methodological framework for the development of standardized baselines for energy-efficient appliances for residential/household application, in particular for refrigerators and air conditioners (RAC).

2. If the energy efficient appliances were to be ranked according to the potential for energy savings, different patterns would emerge among LDCs, SIDs, CDM underrepresented countries and the rest. In general, in the case of LDCs, SIDs and underrepresented countries, refrigeration (30-55% of total appliance efficiency potential), lighting (30-40%) and air conditioners (10-20%) ranked according to share of electricity saving potential in 2030[3]. On the other hand, data for Brazil, China, India, Mexico and South Africa show heterogeneity for the ranking, nevertheless lighting, air conditioners, refrigerators, fans, TV, water heaters and washing machine are considered to have the largest potential for energy efficiency and emission reduction in most countries. For instance, in China in 2030[4], 41% of appliance efficiency potential for air conditioners, 18% for refrigerators, whereas for Mexico in 2030, 41% for refrigerators, 22% TVs and 21% air conditioners, or in South Africa in 2030[5], 30% refrigerators, 30% for water heaters and 20% air conditioners.

3. Among the above discussed appliances, RAC equipment are unique in the sense that they offer the opportunity to address multiple components for emission reduction (ER) in an integrated way, i.e. ER on account of energy savings but also due to avoided, and/or reduced leakage of refrigerants used in the cooling circuit of the equipment and/or new insulation foam blowing agents.

4. Efficient lighting methodologies under the CDM have been already standardised on account of work done over last few years. The focus of this standard is therefore on RAC equipment with the greatest potential for GHG emission reductions.

5. A standardised baseline may be potentially applied by several players involved in the value chain of RAC manufacture, retail, use, after-sales/service and scrapping/ replacement. The draft standard therefore aims to be exhaustive to include all of the variables that may need to be considered in these different standardised baselines, however for any given standardised baseline only some of the variables may be relevant.

6. A few methodologies have been approved for RAC applications under the CDM. However number of project and programmes developed with those methodologies have been few compared to the potential. So far very few manufacturers have used the benchmarks of methodology AM0070 to introduce high efficient refrigerators, and very few utilities applied AMS-II.C and AMS-III.X to expand their incentive programmes replacing old refrigerators. A primary reason appears to be that the respective market information required by these methodologies is too costly to obtain or unreliable. In addition, many market transformation efforts such as “Top Runner”, “Energy Star” and many large Demand-Side Management

[3] SE4All country assessments (www.se4all.org).

[4] Zhou et al., 2010, Analysis of Potential Energy Savings and CO2 Emission Reduction of Home Appliances, *Energy Policy,* 39: 4541-4550.

[5] De la Rue du Can et al., 2013, Energy Efficiency Country Study: Republic of South Africa, LBNL Report 6365E.

programmes have not accounted for the GHG impacts. Approaches similar to the deemed savings for lightbulbs (AMS-II.J) with usage hour averages translated to hours of air conditioner and refrigerator use are critically missing. The deemed savings approach is popular for CFL lightbulb distribution project activities but new LED lightbulb distribution projects still shoulder the monitoring with AMS-II.C. This shows that different appliances need different parameter standardization approaches.

7. This framework provides conversions and standardisations so that varied data sources in most countries can be combined and fit together for as many players as possible. In particular, the practice of energy efficiency labelling in all exporter countries can be made comparable so that all imports can be converted to market averages of annual electricity consumption or other efficiency parameters.

8. As some of the refrigerants are controlled substances under the Montreal Protocol (MP), a brief status of the progress under the MP is also included in this note. While Chlorofluorocarbon (CFC) and Hydrochlorofluorocarbons (HCFC) with high ozone depletion potential (ODP) and global warming potential (GWP) are not Kyoto gases (hence ineligible for baselines), Hydrofluorocarbons (HFCs) used as their replacement is a Kyoto gas and hence eligible for the baseline.

9. HFCs are used in air conditioning, refrigeration, foams and aerosols as replacements for many ozone-depleting substances that are being phased out under the MP. Under the MP, control measures to phase out 50 per cent of a group of five CFCs and freeze production & consumption of three halons were implemented. Over the years MP had been amended and adjusted to cover the phase-out of around 100 substances, including methyl bromide and HCFCs, and to accelerate the previously agreed phase-out schedule for HCFCs. A dedicated financial mechanism under MP[6] provided financial resources to cover the incremental costs of implementing the Protocol in Article 5 parties and the work of its assessment panels.

10. HFC emissions are growing rapidly, at a rate of about 7 per cent annually. HFC phase-down would avoid the equivalent of 100 billion tonnes of carbon dioxide and more than 0.5°C of warming by 2050, according to a report by the Lawrence Berkeley National Laboratory (LBNL-1003671).

11. The most recent work under the MP is the “Dubai Pathway for HFC phase out”, agreed in November 2015, where the parties to MP agreed to work together, within the MP, towards an HFC amendment in 2016 by first “resolving challenges and generating solutions in the contact group on the feasibility and ways of managing HFCs at MP meetings”.

2. Scope, applicability, and entry into force

2.1. Scope

12. This framework covers methods to standardise the parameters for baseline for household refrigerators and/or air conditioners with a view to facilitate development of standardised baselines (SBs). Project activities applying the SB need to define only the number of new appliances, volume / capacity and efficiency of these appliances and with that done, can

[6] “Multilateral Fund” (MLF) for the MP has spent over 3.5 billion US$.

directly estimate the emission reductions. The framework is comprised of four components:

(a) Methods to standardise baseline for greenfield or new sales refrigerators and air conditioners (RAC) appliances (new sales SB);

(b) Methods to standardise baseline for activities that replace existing RAC appliances with efficient ones (replacement SB);

(c) Methods to standardise baseline emissions from the refrigerant circulating in the RAC equipment (refrigerant SB);

(d) Methods to standardise baseline emissions from the blowing agents used in the insulating foam of the RAC equipment (blowing agent SB)[7];

13. The new sales SB, the replacement SB, the refrigerant SB and the blowing agent SB-may be developed as four different SBs or may be combined under one SB.

2.2. Applicability

14. This standard covers energy-efficient appliances for residential/household application (i.e. air conditioners, refrigerators). The framework can be used to develop several standardised baselines to cater to the needs of a wide range of SB developers. The framework provides options to calculate average electricity consumption and average refrigerant emissions from refrigerators and air conditioners in an identified region using various data sources, including energy efficiency labels. The variety of options provided is aimed to facilitate development of standardized baselines in all eligible countries. This objective requires to consider up to three different sources of data to ensure data used is of acceptable quality, but in cases where reliable data is available lesser number of sources will be sufficient.

3. Definitions

15. The definitions contained in the Glossary of CDM terms shall apply.

16. For the purpose of this framework, the following definitions apply:

(a) **Inventory** - collection of records for all appliances sold in a given time period in a country. An inventory can be developed from one or multiple data sources with the aim of completing the coverage;

(b) **Marketing channel** - on route from the producer (a manufacturer) to the final consumer (e.g. a household), an appliance is traded between importers, wholesalers, retailers, department stores and increasingly Internet-based retailers;

(c) **Refrigerator model** - refers to a refrigerator series or type produced by one manufacturer. Refrigerators with different storage volume or different rated electricity consumption are considered as different models. Each model has an identifier code of letters and numbers from the manufacturer. This code is included on the nameplate and appears in Standard & Labelling databases and marketing data;

[7] The method for blowing agent SB is not currently included but will be appended in a future revision

(d) **Energy Efficiency Index** (EEI) - this index is the ratio between the actual annual electricity consumption of an appliance to a standard value of annual electricity consumption for its size. Calculations methods for standard annual electricity consumption and the efficiency classes are defined in many national energy efficiency standards for many different appliances. For example, EU energy ratings for refrigerators are determined using an index, which compares energy consumption with the appliance’s internal volume, to show how efficient it is for its size. This means two different-sized fridges could still carry the same energy rating. To determine the standard annual electricity consumption, energy consumption is calculated with a linear equation defined in national efficiency metrics. For example, the EU efficiency class "A" is between EEI 42 and 55 and the label indicates to a buyer the efficiency level of the model. Manufacturers are obliged to get their refrigerator models tested by an independent laboratory and the laboratory certifies the annual electricity consumption and the Energy Efficiency Index;

(e) **Cooling capacity** - the total amount of cooling provided to an enclosed area with a specified unit of time specified in thermal Watts W_{th};

(f) **Fixed speed air conditioner** - the compressor of the air conditioner runs only at one speed, a certain number of rotations per unit time. The air conditioner can only be switched on or off to maintain a room temperature. In many countries there are separate Standard & Labelling systems for fixed speed air conditioners and they tend to be less efficient than others;

(g) **Inverter air conditioner** - have an inverter allowing variability and reduced speed of the compressor, so that the cooling output can be varied across a wide range. Inverter air conditioners are more expensive and efficient and have rapidly gained market share in many countries;

(h) **Energy Efficiency Ratio (EER)** - the ratio between the cooling capacity and total power input of an air conditioner model, specified in W_{th}/W_{elec}. The purpose of this ratio is the same as for the Energy Efficiency Index, to allow comparing the efficiency of different appliance sizes. This ratio EER is used to define efficiency classes, for example the EU class "A" is between EER 5.2 and 5.9. EER is also tested in laboratories as legally demanded by manufacturers. All EER information refers to a test standard ISO 5151. Minimum energy performance standards (MEPS) in most countries use an EER value as a mandatory minimum;

(i) **Seasonal Energy Efficiency Ratio (SEER)** - is derived from the EER by weighing for different part load periods of a year. It is a better indicator of electricity consumption than EER. It is a legally required parameter in many countries, reported in Btu/hr per Watt or in Watt per Watt. For example, in the US federal efficiency standards impose both SEER: 14 and EER: 12.2, and utilities differentiate rebate programmes for SEER levels. The EU's SEER definition reflects average climate conditions in Europe, the Indian SEER definition reflects the Indian climate, each national SEER metric has specific factors. Most efficiency labels on air conditioners show both the EER and the SEER and the latter corresponds to the country where the air conditioner is sold. While EER and SEER correlate, it is not possible to estimate one from the other based on a conversion factor;

(j) **Coefficient of performance (COP)** - for refrigerators, the ratio of the refrigeration effect to the heat of compression. For air conditioners, in heating mode, the COP is the ratio of the heating capacity to the effective power input in Watt/ Watt. In the EU air conditioner label COP refers to heating and EER to cooling and in the Japanese label the average of COP and EER is cited. Appliances with higher COP are more efficient and more expensive because the compressor and the heat exchanger are more advanced and use more expensive materials;

(k) **Refrigerant** - chemicals circulating in a thermodynamic process in refrigeration or air conditioning equipment. GWP of refrigerants currently used vary between 10,000 for CFCs, 700-1,900 for HFCs and 1-10 of Hydrocarbons and Hydrofluoroolefins. An average air conditioner contains about one litre of refrigerant and an average refrigerator 0.1 litre. Refrigerants leak slowly out of the appliance so it needs to be refilled periodically. Air conditioners need this maintenance every one or two years, while refrigerators leak so little that they run for 10 or 15 years before the refrigerant needs to be refilled;

(l) **Charge volume** - the amount of refrigerant filled in an appliances during manufacturing, smaller units can be hermetical sealed (with optimized brazing technology and automatic leak detection by the manufacturer), others need to be refilled with refrigerant periodically, some up to 30% refilling per year;

(m) **Blowing agent** - chemical injected into Polyurethane (PUR) foam during the manufacturing of a refrigerator. The blowing agent stays in fine bubbles inside the insulating foam until the foam is mechanically destroyed when the refrigerator is disposed. Refrigerator manufacturers buy blowing agents and other PUR components from specialized suppliers. The manufacturing equipment used in a refrigerator plant is designed for one chemical and changing the blowing agent requires new investment in equipment. Many blowing agents currently used have high GWP and new blowing agents available have lower GWP by a factor of 100;

(n) **CFC** - chlorofluorocarbons, CFC-11 and CFC-12 were dominant refrigerant and blowing agent in the 1970s and 1980s but were the main cause of the ozone hole. CFC-11 and CFC-12 are phased out under the Montreal Protocol since 2010, their production or sale is illegal. Hundreds of millions of old refrigerators still in operation in the world still contain CFCs and continue to emit them;

(o) **HCFC** - hydrofluorochlorocarbons, main application of this class of chemicals is as HCFC-22 as refrigerant in air conditioners and as HCFC-141b as blowing agent in refrigerators. The Montreal Protocol was amended in 2007 to fund so-called HCFC-Phaseout Management Plans (HPMP) to replace this class of chemicals because HCFC-22 and HCFC-141b are ozone-depleting. HCFCs will be banned in OECD countries in 2020 and in developing countries in 2030;

(p) **HFC** - hydrofluorocarbons, main CFC replacement chemicals in the 1990s with many diverse uses. At present, the Montreal Protocol negotiates an amendment to fund also phase-out of HFCs in a similar step-wise phase-out as currently for HCFC.

Table 1. Overview of parameters to be standardized

Refrigerator parameters		**Source**	**Comments**
$SEC_{avr,y}$ kWh/l/yr	average specific annual electricity consumption per litre of refrigerator volume	nameplate has kWh/yr and litre, ratio of these averaged across all refrigerator models	• Combining SEC and EEI allows to compensate for data gaps, cross-check and verify differences between sources • Allows to account for imports from different regions • allows to compare all refrigerator sizes
$EEI_{avr,y}$ no dimension	average Energy Efficiency Index (EEI) (lower is better)	S&L database and each model's label have EEI as required in national regulation	
Air conditioner parameters:			
$EER_{avr,y}$ no dimension	average Energy Efficiency Ratio (higher is better)	S&L database or manufacturers, reported on labels, average for full market or capacity segment	not possible to convert one to the other, some S&L databases have both, even where one is regulated, both allow data for all imported models
$SEER_{avr,y}$ no dimension	average Seasonal EER (higher is better)		
hrs_y	average annual usage hours	publications, survey, utility load curves	defaults avoid monitoring costs
Refrigerant parameters:			
$SREF_y$ $tCO_2e/kW/yr$ or $tCO_2e/l/yr$	average specific refrigerant charge per kW or liter	S&L database or manufacturers, reports to Montreal Protocol	assembles data not otherwise tracked in most countries
L_{avr} %	average annual leakage	manufacturers	avoids monitoring

4. Methodology procedure

4.1. Refrigerators new sales

17. Three options (i.e. approach 1 to 3) are provided to determine the baseline emissions in a given year based on the number of appliances introduced by the project activities in that year. Approach 1 is based on average annual electricity consumption of the baseline refrigerators. Approach 2 is based on average specific annual electricity consumption per unit volume of the refrigerators. Approach 3 is based on average Energy Efficiency Index of the refrigerators.

18. **Approach 1.** This applies when the baseline and project refrigerators have the same or similar (+/-10%) volume. Baseline emissions are calculated as:

$$BE_y = \sum_i EF_{grid} \times n_{P,i,y} \times AE_{avr,i,y} \qquad \text{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2 /yr)
EF_{grid}	=	Emission factor of a grid determined using “Tool to calculate emission factor of electricity system” (tCO_2/kWh)
$n_{P,i,y}$	=	Number of appliances *i* introduced by the project activity in year *y*
$AE_{avr,i,y}$	=	Average annual electricity consumption of the baseline refrigerators (kWh/yr) (as per Data/Parameter Table 1)

19. **Approach 2.** When the baseline and project refrigerators have different volumes, either the average specific annual electricity consumption (SEC) or the average Energy Efficiency Index (EEI) may be applied to calculate the baseline emissions. When a baseline is defined for a narrower project activity group e.g. for a specific volume class, amount of data required is reduced. Whether to apply SEC or EEI and whether to use averages for the entire market or a segment can be decided to accommodate data availability.

$$BE_y = \sum_i EF_{grid} \times n_{P,i,y} \times V_{avr,p} \times SEC_{avr,y} \qquad \text{Equation (2)}$$

Where:

$V_{avr,p}$	=	Average volume of appliances *i* introduced by the project activity in year *y* (L)
$SEC_{avr,y}$	=	Average specific annual electricity consumption per unit volume (kWh/l) in year *y*. SEC can reflect the entire refrigerator market or a volume segment (as per procedure determined under Data/Parameter Table 4)

20. **Approach 3.** When Energy Efficiency Index (EEI) information is available for all models in a market or a market segment, the baseline emissions can be calculated with the standard annual electricity consumption (SAE) of the refrigerators introduced by the project activity. The EEI and SAE must use the same efficiency metric, for example the EU directive 2003/66/EC, or the Chinese GB12021.2-2008, or any other efficiency metric. The EU and China have the same metric and it is included below since they are the most widely used. EEI is reported in S&L databases and on efficiency labels. SAE has to be calculated for the specific refrigerators introduced by the project activity.

$$BE_y = \sum_i EF_{grid} \times n_{P,i,y} \times \frac{EEI_{avr,y}}{100} \times SAE_{avr,P} \qquad \text{Equation (3)}$$

Where:

$EEI_{avr,y}$	=	Average Energy Efficiency Index for all refrigerators in a market or a volume segment (no dimension) (as determined under Data/Parameter Table 5)
$SAE_{avr,P}$	=	Standard annual electricity consumption of the refrigerators introduced by the project activity, (as determined under Data/Parameter Table 6)

21. EEI_{avr} and SEC_{avr} may be weighted average values based on sales data from any one of the three data sources as available. It may also be based on an average of all models offered in a market. Sales-weighing of EEI data typically modifies the average EEI value by only one or two percent and this correction will be smaller where the total number of models available in a market is higher. In general, in a market with more than a thousand refrigerator models, sales-weighing can be neglected. When individual model data for at least 300 models are available, the average EEI can be established by summing up individual model data.

22. The following equation applies in all efficiency metrics for refrigerators. It can be used to calculate EEI for models that are not included in a Standard / Labelling database to increase EEI data coverage.

$$EI = \frac{AE}{SAE} \times 100 \qquad \text{Equation (4)}$$

23. The definitions of standard annual electricity consumption in national efficiency metrics varies. The following is used in EU and China.

$$SAE = V_{eq} \times M + N \qquad \text{Equation (5)}$$

Where:

V_{eq}	=	Equivalent volume of a refrigerator
M, N	=	Factors for calculating the standard annual electricity consumption for each category of refrigerators, listed in Table 2

24. Many efficiency metrics have similar equations[8]. The US has 18 instead of 9 categories, in Japan JIS C9801:2006 has 11 categories, all with a constant and a factor for compartment volumes. *SAE* serves the same purpose in all metrics but the formula for parameter V_{eq} are different. SAE of the appliances introduced by the project activity is calculated using the following equation, used in EU and China standards.

$$V_{eq} = \left(\sum V_i \times TF \times FF\right) \times CC \times BI \qquad \text{Equation (6)}$$

Where:

V_i	=	Volume of compartment *i* typically a fresh food or a freezer compartment (L)

[8] For example US, E = 0.21 x av + 248.4, in Japan, E = 0.774 x Vadj + 220, for South Korea, P = 0.667 x AV + 30.15, Thailand, E = 0.74 x AV + 278

TF	=	Thermodynamic factor for the design temperature in the compartment *i*, Table 2
FF	=	Frost-free 1.2, otherwise 1.0
CC	=	Climate class, for T class 1.2, for ST class 1.1, otherwise 1.0
BI	=	Built-in refrigerators under 58cm width 1.2, otherwise 1.0

Table 2. M and N values for refrigerators in the EU and China S&L

	Category	**EU regulation no 1060/2010**		**China GB12021.2-2008**	
		M	N	M	N
One or more fresh food compartments	1	0.233	245		
Refrigerator-cellar, cellar and wine storage	2	0.233	245		
Refrigerator-chiller with 0-star compartment	3	0.233	245	0.221	233
Refrigerator with a one-star compartment	4	0.643	191	0.611	181
Refrigerator with a two star compartment	5	0.450	245	0.428	233
Refrigerator with a three-star compartment	6	0.777	303	0.624	223
Refrigerator-freezer	7	0.777	303	0.697	272
Upright freezer	8	0.539	315	0.530	190
Chest freezer	9	0.472	296	0.657	205

Table 3. EU and China Energy Label Classes

	EU EEI			**China**
A++	22 – 33			
A+	33 – 42			
A	42 – 55		grade 1	η ≤ 55%
B	55 – 75		grade 2	55%≤ η ≤65%
C	75 – 95		grade 3	65%≤ η ≤80%
D	95 – 110		grade 4	80%≤ η ≤90%
E	110 – 125		grade 5	90%≤ η ≤100%
F	125 - 150			

Table 4. Thermodynamic Factor Freezer Compartment of Refrigerator/freezer

	India			**South Korea**			**US Energy Star**		
TF in V_{eq}	1.62			1.78			1.63		
	EU 2010/30/EU			**Japan Top Runner after 2010**			**Brazil PBE**		
TF in V_{eq}	*	**	***	*	**	***	*	**	***

	India			South Korea			US Energy Star		
	1.55	1.85	2.15	1.54	1.87	2.20	1.41	1.63	1.85

25. All national efficiency metrics use linear equations with the adjusted volume of refrigerators and the adjusted volume is defined with different compartments (volumes and temperatures). Therefore, conversion factors between different metrics can be calculated at linear mid-points of the efficiency class, across the volume range of 100 l to 500 l. The conversion factors for China efficiency classes to EU classes and Brazilian efficiency classes to EU classes in Appendix 1 Table 3 reflect the mid-value of each class, to be used to convert EEIavr between metrics. When such EEI conversion factors are used, they apply to averages only between 100 and 500 litre volume. These conversion factors can be used to combine EEI data where different importers provide EEI information according to S&L data in the countries where the refrigerators are produced.

26. Using the mid-value of EEI in an efficiency class when converting EEI between efficiency metrics adds conservativeness because appliances are often designed to be just below the efficiency class limit, for example label class "A" for EU is between 55 - 42 and most models in this class have EEI 53 to 54. Using the mid-value EEI of each class when calculating the average EEI of the market typically adds 10-12% of efficiency to the actual average EEI. In the EU metric, the mid-points for refrigerators are at:

(a) EU grade A++avr = EEI 27.5;

(b) EU grade A+avr = EEI 37.5;

(c) EU grade Aavr = EEI 48.5;

(d) EU grade Bavr = EEI 65;

(e) EU grade Cavr = EEI 85;

(f) EU grade Davr = EEI 102.5;

(g) EU grade Eavr = EEI 117.5,

(h) EU grade Favr = EEI 137.5.

27. Appendix 1 provides guideline for collecting/determining data parameters required to establish baseline emissions using one of the approaches provided above.

4.1.1. Data and parameters

Data / Parameter table 1.

Data / Parameter:	$AE_{avr,y}$
Data unit:	kWh/yr
Description:	Average annual electricity consumption of the baseline refrigerators
Source of data:	Survey or data from Standard & Labelling database or manufacturers specifications

Measurement procedures (if any):	No measurements are required. Average is calculated for all models sold in a market or a segment of a market. Data used should not be older than three years. Data is sourced from Standard & Labelling database, marketing data or manufacturer specifications when these are reported according to national test standard or IEC 62552 or equivalent. Conversion factors Appendix 1 Table 2 apply. Refer to Appendix 2 Baseline Options and Additionality Determination[9]
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	$n_{P,i,y}$
Data unit:	Number
Description:	Number of refrigerator appliances *i introduced* by the project activity year *y*
Source of data:	Project activity monitoring and documentation
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	$V_{avr,P}$
Data unit:	Litres
Description:	average volume of the refrigerators introduced by the project activity
Source of data:	Project activity monitoring and documentation, model specifications from manufacturers
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	$SEC_{avr,y}$
Data unit:	kWh/l/yr
Description:	average specific annual electricity consumption of refrigerators available in a market or a segment of the market
Source of data:	Calculated from Standard & Labelling database or manufacturers specifications

[9] Public are invited to provide inputs on thresholds for additionality and baseline to include in this document

Measurement procedures (if any):	No measurements are required. Average is calculated for all models sold in a market or a segment of a market. Data used should not be older than three years. Data is sourced from Standard & Labelling database, or manufacturer specifications when these are reported according to national test standard or IEC 62552 or equivalent. Conversion factors in Appendix 1 Table 2 apply. Refer to Appendix 2 Baseline Options and Additionality Determination[10]
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	$EEI_{avr,y}$
Data unit:	Energy efficiency index
Description:	Average energy efficiency index in year *y*
Source of data:	As reported in Standard & Labelling database, or manufacturers or retailers' information, or as reported on the refrigerator efficiency label
Measurement procedures (if any):	No measurements are required. Average is calculated for all models sold in a market or a segment of a market. Data used should not be older than three years. Data is sourced from Standard & Labelling database, or manufacturer specifications when these are reported according to national test standard or IEC 62552 or equivalent and the national efficiency metric. Conversion factors in Appendix 1 Table 3 apply to China, India, EU and Brazilian metrics and similar conversion factors for other efficiency metrics can be used. When the exact EEI numbers of models are not known, the values at mid-points of efficiency classes shall be used for all models in an efficiency class[11]. Refer to Appendix 2 Baseline Options and Additionality Determination
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	$SAE_{avr,y}$
Data unit:	Standard annual electricity consumption kWh/yr
Description:	Standard annual electricity consumption of the project refrigerators in kWh/yr
Source of data:	Manufacturers data for compartment volumes and compartment temperatures
Measurement procedures (if any):	No measurements required. Calculated with equations 5 and 6 with the Vequivalent factors of the efficiency metric applied in the EEIavr calculation in Data/Parameter Table 5, as used in equation 3, baseline emissions
Any comment:	-

[10] Public are invited to provide inputs on thresholds for additionality and baseline to include in this document

[11] For example, when 8,000 refrigerators are imported and it is only known that they have class "A", then an average EEI calculation uses EEI 48.5 for these 8,000 units.

4.2. Air conditioners new sales

28. The baseline emissions from a number of air conditioners introduced by the project activity can be calculated as:

$$BE_y = \sum_i EF_{grid} \times n_{P,i,y} \times hrs_y \times \beta_L \times \frac{P_{Bl,i}}{EER_{avr,y}}$$ Equation (7)

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2/yr)
$n_{P,i,y}$	=	Number of air conditioners the project activity introduced
hrs_y	=	Annual average operating hours or usage, optional a national or regional default or a monitored sample (as described in Data/Parameter table 8)
β_L	=	Part load factor, 0.75 for fixed speed air conditioner and EER data, 0.88 for inverter and EER data, 0.85 for fixed speed air conditioners and SEER data, and 1.0 for inverter and SEER data (Data/Parameter table 9)
$P_{Bl,i}$	=	Cooling capacity of the project air conditioners i (as determined in Data/Parameter Table 10)
$EER_{avr,y}$ or $SEER_{avr,y}$	=	Average EER or SEER for the baseline air conditioners for a segment or the whole market (as determined under Data/Parameter Table 11)

29. All national testing standards use ISO 5151, except the one from South Korea and USA with a small variation of in a parameter related to ambient temperature. The following correction factors[12] are valid for this variation for all types of air conditioners:

    (a) $EER_{ISO}= EER_{NAFTA}$ / 1.0096 $EER_{ISO}= EER_{Korea}$ / 1.012;

    (b) To convert EER and SEER from US data in Btu/Wh to SI-units in W/W: multiply by 0.2931.

30. EER data is more widely reported than SEER and in many S&L databases both are listed. SEER data can be more accurate than EER data but SEER contains household behaviour variation and climate variation. Equation 7 applies to only EER or only SEER.

31. In Japanese and Korean standards three alternatives for SEER are used, CSPF, HSPF and APF which are relevant to consider.

    (a) CSPF Cooling Seasonal Performance Factor – the ratio of the total cooling capacity to the total energy consumption;

    (b) HSPF Heating Seasonal Performance Factor – the ratio of the total heating capacity to the total energy consumption for the winter period (W/W);

[12] Source: Waide P, Rivère P and Watson R, 2011, Cooling Benchmark Study Part 2: Benchmarking Component Report, CLASP, p. 36.

(c) APF Annual Performance Factor – weighted average of the CSPF and HSPF.

32. The tables 1 and 2 in the Appendix 3 include conversion factors for all versions of SEERs (US, Japan, South Korea, China and EU)[13], separate for fixed speed and inverter air conditioners. These factors can allow to convert all SEER data and establish a SEER threshold based on all data reported in a market. Irrespective of the policy chosen in a country, with EER or with SEER for minimum requirements and using EER or SEER for efficiency class definitions, the efficiency parameters can be combined. Policy choices are often the result of consumer habits and a standardized baseline can be calculated with the efficiency parameter in operation as this automatically leads to the standardized baseline reflecting consumers' habits.

33. Air conditioner models have a wide range of sizes and efficiency classes, however typically 15 manufacturers cover more than two thirds of the market. Some markets are concentrated with one or two manufacturers having >70% market share and in such cases average EER or SEER only from these major brands is sufficient so that the average are representative. Data coverage of all brands is itself not an improvement.

34. Sales data is required to show the main models in a given country. Efficiency of all main models is available which makes it possible to establish the actual efficiency distribution. An air conditioner market inventory can comprise the following variables:

(a) P – cooling capacity (kW) of a model;

(b) EER – energy efficiency ratio, cooling capacity/effective power input (W/W);

(c) SEER – seasonal energy efficiency rating (W/W)[14];

(d) COP – coefficient of performance;

(e) FS/V – fixed-speed, inverter (variable speed drive);

(f) Split – split system with internal and external unit ducted, Window-type unit.

35. The limited number of air conditioner brands, often between 20 to 40, allows a higher market coverage than for other appliances.

4.2.1. Step 1. Determine Standard and Labelling and Marketing Data

36. All air conditioner standard and labelling (S&L) refer to the same test standard ISO 5151[15], and the main producer countries have mandatory S&L so that at least 70% of models sold in a market have publicly available efficiency data (either EER or SEER). Therefore, an air conditioner SB can always be established based on efficiency indicators and can avoid using efficiency class or label classes. S&L authorities such as CNIS, Kemco, BEE or INMETRO publish their air conditioner databases and update them frequently. These authorities can offer to apply ETL software tools ("Extract, Transform and Load") to extract all data automatically. Many open source and commercial ETL tools are available. The

[13] US: ARI 210/240, Japan: JRA-4046, Korea: KSC 9306-2010, China: GB 21455-2008, EU: regulation 626/2011. Differences among these standards reflect consumer habits and also industry interests.

[14] Different part load conditions and temperature bins in US, China, Japan, Korean and EU standards.

[15] Also integrated in ISO 13253, ISO 15042 and ISO 16358.

total number of models in the market (often 300-600) typically allows to process the data manually.

37. Marketing data from commercial providers[16] can be used to establish sales-weighted efficiency average. The variations between S&L and marketing data arise because of the survey methods in marketing data and also differences in market coverage. It is possible to identify the cause of coverage differences, but in most cases it is not necessary to compensate for it because the spread of efficiencies (and prices) is similar across all cooling capacities. For example, Korean S&L have led to a similar average EER for the entire range of capacities, whereas Australian S&L led to a small decrease for higher capacity EER[17]. In most countries, it is preferable to decide whether to use average EER for all capacities or use average EER for capacity ranges depending on the data availability. Marketing data is generally reported in EER and capacity for each model but manufacturers often provide EER and SEER data because they export for various markets with various mandatory requirements. Therefore, using marketing data often allows to choose EER or SEER for the baseline calculation.

38. When the costs of marketing data are too high, it can be helpful to request the marketing data provider to remove the model codes and only provide EER and sales for each model. Some marketing data providers offer such reduced datasets at a much lower price, since it cannot be used to elaborate commercial strategies. Without model codes, the marketing data cannot be verified with other sources, but it is acceptable to rely on the accuracy of marketing data alone to calculate average EER or SEER.

39. When available S&L data includes the market shares of each air conditioner capacity, weighing EER or SEER for these market shares is equivalent to weigh EER or SEER with sales per model.

40. Comparing S&L and marketing data allows to verify recent changes in the type of models. Especially increasing shares of inverter air conditioners can lead to an increase in EER averages that has to be accounted for. If recent changes in the number of models in a market cannot be ascertained, a possible solution is to specify an SB for fixed speed air conditioners, or to separate wall type from split types. In a market with rapidly changing consumer habits and changing market shares of air conditioner types, an SB for all types is effective because there are no particular efficiency levels of any type of air conditioner[18]. A decision to produce an SB for all types or for one type can therefore be based on the data availability and data coverage. When sales information is available, the sales-weighted averages can be representative for broader household groups. In order to verify if market shares of types are changing or not, price information can be used as evidence since inverters are 50-100% more expensive so when prices remained the share of inverters remained as well. Efficiency levels cannot be separated for refrigerant types and therefore a separate SB for one refrigerant type is misleading.

[16] Such as the Nielsen Company, IMS Health, TNS, GfK, The Kantar Group, BSRIA or IPSOS.

[17] IEA 4E, 2011, 4E Benchmarking Document Residential Air conditioners, Figures 7 and 8.

[18] In one market preferences can be determined by climate (shorter hot periods) and less by price, in another market preference are more determined by the economics.

4.2.2. Step 2. Combining S&L and/or Marketing Data with Industry Data

41. When sales numbers from marketing data are not available, more aggregate sales data from commerce can be used. Wholesalers and importers are often fewer through channel concentration and Internet retailers. It can be more effective to collect industry data from wholesalers than to cover all manufacturers. Refrigerant charge and refrigerant leakage can be combined from wholesalers, importers and manufacturers. When all importers or wholesalers in a country provide detailed efficiency information for all models they sell, the efficiency average is accurate even where there is not labelling.

42. Where S&L or marketing data is complete, still industry data might be required for air conditioner refrigerant volume information. Frequently retailers also provide maintenance services because air conditioners need regular refilling with refrigerant. So refrigerant charge and refrigerant leakage data can be combined from wholesalers, importers and manufacturers. Retailers' information about refrigerant leakage can be more accurate than the manufacturers' leakage information because the quality of the maintenance over the years cannot be predicted. Large manufacturers often have their own retail chains focusing on particular market segments and their data can be combined with the wholesalers covering all manufacturers. Even though manufacturers might have no retail outlets, some provide maintenance for their air conditioners that customers got from independent retailers.

43. Wholesalers and manufacturers can provide sales-weighted or product-weighted average EERs when commercial confidentiality allows. The price and cooling capacity ranges need to be verified when different average EERs are combined. Dominant manufacturers in a market with together more than 70% of the market can be used as sole bases of producer-weighted or sales-weighted averages. When requesting data from wholesalers, importers and retailers it is necessary to do so with the same conditions for all, clarifying what level of feedback they get and that all will receive the same. When importers do not provide EER and SEER for all models they import, these shall be obtained from manufacturers and provided to all importers so that these then calculate sales-weighted averages. Models from manufacturers unwilling or unable to provide EER and SEER can be excluded from the baseline calculation, since these are the lower efficient models and their exclusion increases conservativeness.

4.2.3. Step 3. Establishing Average Annual Operating Hours

44. **Option 1.** In a country where average operating data is published, these can be assessed for representativeness. Survey, especially whether they account for annual cooling degree day differences. Published survey results related to census data or from utilities' household surveys can be compared to calculated averages in energy models[19].

45. **Option 2.** The operating hours of the baseline air conditioners can be determined using surveys by continuous measurement of usage hours for a minimum of 90 days. For a large population of baseline air conditioners: (a) use a representative sample (sampling determined by a minimum 90% confidence interval and 10% maximum error margin); (b) ensure that sampling is statistically robust and relevant.

[19] For example, the BUENAS model used in the Int. Energy Studies Group of Lawrence Berkeley Nat. Laboratory uses national Cooling Degree Days to determine annual operating hours, see Shah N, Wei M, Letschert V and Phadke A, 2015, Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning, LBNL-1003671, p. 19-20.

46. **Option 3.** Utility companies often use peak load analysis and air conditioners are a major component of demand during peak hours. This analysis can provide an accurate range of average operating hours across a year as it reveals the outcome of all air conditioner usage instead of an approximated sample.

4.2.4. Step 4. Air conditioner New Sales SB Calculations

47. Average EER or average SEER is the main SB parameter. Generally the full range of efficiency (and prices) is available for the full capacity range, 2 – 14 kW. In many countries, small capacity segments dominate the market and average EER or SEER can be established for these segments. In China for example, 25% of all sales have 3.5 kW and 15% at 2.5 kW cooling capacity. To reduce the data requirements, an average EER can be established for the dominant market capacity segments covering 50% of all sales in a year, and this average EER value is accurate for the whole capacity range present in a market.

48. EER_{avr} and $SEER_{avr}$ can be sales-weighted with sales data from the three data sources as available. Sales-weighting can be limited to a market segment for which sales data is available. When more than 300 models are available for one capacity, sales-weighing these models does not affect the average significantly[20].

49. The level of aggregation is important in determining an SB for efficient air conditioners. It can be effective to establish an average EER or SEER for a capacity segment and determine respective average annual operating hours that corresponds to a household type or class using this capacity segment. Limiting the capacity range to a market segment can be used to accommodate efficiency data availability or operating hour data availability or SB user orientations such as utilities targeting household classes or distributors seeking to expand marketing channels or manufacturers pursuing new market channels.

4.2.5. Data and parameters monitored

Data / Parameter table 7.

Data / Parameter:	$n_{P,i,y}$
Data unit:	Number
Description:	Number of air conditioners introduced in year *y*
Source of data:	Project activity monitoring and documentation
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 8.

Data / Parameter:	hrs_y
Data unit:	Hours
Description:	Annual hours air conditioner usage in a country or a climatic zone
Source of data:	Published data, survey or grid load curve analysis

[20] Appendix 5 has an example for sales-weighing the average EER per cooling capacity.

Measurement procedures (if any):	Where a survey is applied, sampling should be as per Guidelines for sampling and surveys for CDM project activities and programme of activities
Any comment:	-

Data / Parameter table 9.

Data / Parameter:	β_L
Data unit:	Load factor
Description:	Number of hours per year during the cooling periods of the year when air conditioners operate at full capacity.
Source of data:	Fixed speed air conditioner with EER data β_L= 0.75 Fixed speed air conditioner with SEER data β_L= 0.85 Inverter air conditioner with EER data β_L= 0.88 Inverter air conditioner with SEER data β_L= 1.00
Measurement procedures (if any):	No measurement required.
Any comment:	If all SEER temperature bin and their operation hours per year are accurate the load factor is 1.00, however the SEER standards are simplifications with 8, 12 and 15 temperature bins and the EER is measured only at 2 or 4 load points and extrapolated in between[21]

Data / Parameter table 10.

Data / Parameter:	$P_{Bl,i}$
Data unit:	kW
Description:	Average cooling capacity of the air conditioners introduced by the project activity in year *y*
Source of data:	Manufacturer information from manufacturer or retailer information or reported as per efficiency label
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 11.

Data / Parameter:	$EER_{avr,y}$
Data unit:	Energy efficiency ratio W/W
Description:	Average energy efficiency ratio of all air conditioners sold in a market or a segment of a market in year *y*
Source of data:	Average calculated from manufacturer specifications, reported in manufacturer documentation, in Standard & Labelling database or by retailers in efficiency labels

[21] McNeil et al, 2008, Potential benefits from improved energy efficiency of key electrical products: The case of India, *Energy Policy*, 36: 3467-3476, or, Sachs et at. 2007, Improving Central Air Conditioner Performance Ratings: a Review of SEER, ACEEE Report A071.

Measurement procedures (if any):	No measurements required. Manufacturers or retailers information or reported on efficiency label or in Standard & Labelling database. Conversion factors for South Korean and US air conditioner models in para 27 apply. All versions of ISO5151 can be used and EER data from different ISO5151 versions combined. When equation 7 is used with SEER data, the conversions in Appendix 3 Tables 1 and 2 apply. Average calculated for all models sold in a market or a segment of a market. Data used should not be older than three years. Refer to Appendix 2 Baseline Options and Additionality Determination[22]
Any comment:	-

4.3. Refrigerator replacement

50. This baseline accounts for replacements of existing, functional domestic refrigerators, either with more efficient new units or with market average new units.

51. More efficient new units comprise refrigerators with refrigerants and PUR foam blowing agents with no ODP and low GWP. The baseline comprises options to calculate the electricity consumption of the old units as these would continue to be used in households. Refrigerants and blowing agents can only be Hydrofluoroolefins or Hydrocarbons (since GWPs<10).

52. The replacement baseline credits the avoided continued use of the old refrigerators up to the current average efficiency level of refrigerators sold in a market and the new sales baseline credits electricity savings over and above the current average efficiency level. A PP applying the replacement baseline can support the replacement with incentivizing the households to do so in any form a PP chooses, for example providing support via the electricity price paid by the household or by offering a rebate for the purchase of a new refrigerator. The new sales baseline is relevant when the rebate is sufficient to motivate a household to buy a higher efficient model than it otherwise would.

53. The baseline is applicable when neither replacement of refrigerators nor recovery of refrigerants is required by laws or regulations. The average volume of the new units is at least 80% of the average volume of the baseline refrigerators. The baseline scenario is the continued use of the existing refrigerators until they would reach their average end-of-life usage. Normal replacement (without the project activity) can be with new refrigerators or second hand refrigerators.

54. The replaced refrigerators are collected and recycled in material components either manually or in automatised recycling installations. GHG reduction from the recycling of materials is not reflected in the baseline and can be credited in a subsequent project activity. The electricity consumption savings are credited independently of the degree or type of recycling and the savings are validated only because the recycling assures that the replaced refrigerator cannot be re-used as refrigerator elsewhere. The recycling operation includes the recovery of refrigerants and the vacuum pump of the recovery equipment must attain a pressure of 0.3 bar (absolute) or a lower value. CFC-12 can be treated with Montreal Protocol funded destruction, or with GHG crediting from bilateral emissions trading such as the Californian “Climate Action Reserve”, the “Swiss Charter”

[22] Public are invited to provide inputs on thresholds for additionality and baseline to include in this document

or the "American Carbon Registry" and from voluntary crediting with VCS[23], or according to national regulation for hazardous waste (for example destruction in cement kilns). Any treatment of recovered Isobutane and HFC-134a and any treatment of PUR insulation foam is possible for the applicability of this SB.

4.3.1. Calculation of the replaced refrigerators electricity consumption baseline

55. One of the following three approaches may be applied. Contrary to new sales baselines, the replacement baseline is the average of the old (replaced) units without a margin for market transformation or to ascertain conservativeness.

56. **Approach 1.** During the arrival of the replaced old refrigerators at a recycling facility, approximately 100 refrigerators are randomly selected for testing following the test protocol in the Appendix 5. Subsequently every 100th refrigerators is tested. The test result shall be statistically valid, defined as being within ±10% error of the actual value with a 90% confidence interval. The baseline for refrigerator replacement is calculated with

$$BE_y = EF_{grid} \times n_{P,i,y} \times AEC_{Bl,avr} \div 1000 \quad \text{Equation (8)}$$

Where:

$n_{P,i,y}$	=	Number of refrigerators replaced in year *y*
$AEC_{Bl,avr}$	=	Average annual electricity consumption of the tested refrigerators in kWh/y (as determined under Data/Parameter Table 13)

57. Any recycling facility can provide an average efficiency baseline (applying the Appendix 5 Test protocol) for the whole country as long as all recycling facilities document the average volume of the replaced refrigerators and the average volume of these refrigerators treated in the recycling facility providing the baseline is within 10% of the national average volume of replaced refrigerators.

58. When all replacement refrigerators at baseline end-of-life are second hand refrigerators, the baseline scenario is the one of AMS-III.X, where only through the project activity, the replacement refrigerator can be new refrigerators and the baseline remains the average second hand refrigerator efficiency. This scenario is established with verifying that all households buy only second hand refrigerators and that >80% of households have the lowest electricity tariff. When replacement refrigerators at baseline end-of-life are new refrigerators (the replacement refrigerator without the project activity), the average age of the replaced refrigerators in the project case has to be established and the replacement baseline is valid for the remaining period between the average age until 17 years, as normal end-of-useful life[24]. The average age of the replaced refrigerators shall be established by recording the age of those refrigerators with nameplates among all refrigerators arriving at the recycling facility.

[23] Voluntary Carbon Standard.

[24] Welch, C and Rogers B, 2010, Estimating the Remaining Useful Life of Residential Appliances, Proceedings of ACEEE summer study on energy efficiency in buildings, August.

59. **Approach 2.** Among the replaced refrigerators with brand and model information but without electricity consumption information, top five most common brands can be used to verify the design annual electricity consumption of the respective models when they are based on information available from the manufacturers. When nameplate data on electricity consumption for the model is available for 25% or more of replaced refrigerators, the average specific electricity consumption can be used to represent average specific electricity consumption of all replaced units. To identify the design electricity consumption S&L databases for refrigerators such as CNIS, BEE or INMETRO can be used or the data obtained from the manufacturers. When the design electricity consumption of a model is known but refrigerator compartment volumes not, an estimated and not measured overall volume is sufficient to establish the specific consumption (kWh/l).

$$BE_y = \sum_i EF_{grid} \times n_{P,i,y} \times V_{avr} \times SEC_{Bl} \times (Lt_{avr} - 14) \div 1000 \qquad \text{Equation (9)}$$

Where:

V_{avr}	=	Average volume of the all replaced refrigerators in (L)
SEC_{Bl}	=	Average specific electricity consumption of replaced refrigerators in kWh/l/y (as determined under Data/Parameter Table 14)
Lt_{avr}	=	Average age of the replaced refrigerators in years (as determined under Data/Parameter table 15)

60. This approach requires recording the average age of those replaced refrigerators where this information can be found on the nameplates (as in Approach 1). When replacement refrigerators in the baseline scenario end-of-life are new refrigerators, the replacement baseline is valid for the remaining period until 17 years, as normal end-of-useful life. Nameplates found on old refrigerators can show the model code but not the year of production. So the number of replaced refrigerators where age is recorded can be different from the number of replaced refrigerators for which the specific electricity consumption has been calculated.

61. **Approach 3.** When a refrigerator inventory has been established in the preceding five years in a region of the country, the average specific annual electricity consumption of all refrigerators in use (kWh/l/y) can be applied as a baseline for replaced refrigerators[25] and equation 9 applied with this value. When this inventory also recorded the age of refrigerators in use and when this inventory has shown a statistically significant correlation between refrigerator age and refrigerator efficiency, then the average efficiency at the average retirement of refrigerators can be used as baseline for replaced refrigerators. The average age of the replaced refrigerators (established at the recycling site) can be used to determine the annual electricity consumption of these replaced refrigerators with the age – efficient correlation shown in the inventory. The same average age value is used to establish the remaining useful lifetime until 17 years, as normal end-of-life in the baseline scenario.

62. Appendix 4 provides guideline for collecting/determining data parameters required to establish baseline emissions using one of the approaches provided above.

[25] Instead of SEC, a replacement baseline can also be derived with EEI information, but this would not result in more realistic applications.

4.3.2. Data and parameters monitored

Data / Parameter table 12.

Data / Parameter:	$n_{P,i,y}$
Data unit:	Number
Description:	Number of refrigerators replaced in year *y*
Source of data:	Project activity monitoring and documentation
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 13.

Data / Parameter:	$AEC_{Bl,avr}$
Data unit:	kWh/y
Description:	Annual electricity consumption of the tested replaced refrigerator sample in year *y*
Source of data:	24h measurements of the old refrigerators according to the test protocol performed at the recycling facility
Measurement procedures (if any):	See Appendix 5 for test protocol
Any comment:	-

Data / Parameter table 14.

Data / Parameter:	SEC_{Bl}
Data unit:	kWh/l/y
Description:	Average specific annual electricity consumption of the replaced refrigerators, Standard & Labelling database or manufacturers specifications
Source of data:	No measurements required. Manufacturer specification obtained with the model code or from a Standard & Labelling database, or noted from the nameplate. Calculated for all models sold in a market or a segment of a market. Data for all models from Standard & Labelling database, or manufacturer specifications when these are reported according to national test standard or IEC 62552 or equivalent. Conversion factors in Appendix 1 Table 2 apply
Measurement procedures (if any):	
Any comment:	When the annual electricity consumption can be found on the nameplate or in an S&L database the respective refrigerator volume information is also available so that the ratio between the two can be calculated

Data / Parameter table 15.

Data / Parameter:	Lt_{avr}
Data unit:	years
Description:	Average age of the replaced refrigerators
Source of data:	Nameplates of replaced refrigerators
Measurement procedures (if any):	Arithmetic average of all replaced refrigerators as recorded from the nameplates in the recycling facility
Any comment:	-

4.4. Refrigerant emissions from new sales of refrigerators and air conditioners

63. This baseline reflects the refrigerant emissions of new refrigerators and air conditioners occurring in the absence of the project activity. This baseline represents the share of KP eligible refrigerants currently offered in a market, typically and HFC-134a for refrigerators and for air conditioners R410a, HFC-134a and HFC-32. Ideally the market inventories for new sales refrigerators and air conditioners established for the electricity savings SB can be used to establish the total number of refrigerators and air conditioners sold in a year per type of refrigerant. Mandatory S&L databases for refrigerators and air conditioners often contain the amount of refrigerant charges used in each model.

64. A refrigerant SB may be used as standalone or is applied in conjunction with the new sales electricity savings SBs. A refrigerant SB credits the introduction of lower GWP refrigerant in appliances and the introduction of lower refrigerant leaking appliances (either because the charge is smaller or the leakage smaller), but does not credit the recovery of refrigerants. A refrigerant SB includes all types of refrigerants occurring in new sales, HFCs, HCFCs, Hydrocarbons and future HFOs. Only avoided emissions of HFCs are eligible under the CDM. Avoided HCFC emissions are ineligible under the CDM. A refrigerant SB accounts for all eligible refrigerants according to emissions and GWPs during the appliance use phase.

65. Most project activities are likely to include the introduction of Hydrocarbons and Hydrofluoroolefins (HFOs) as refrigerants in air conditioners and refrigerators because their GWP is smaller by a factor ~100. But they can also imply introducing lower GWP refrigerants such as HFC-32 and many new mixtures of HFCs and HFOs currently being developed for air conditioners as replacements of HCFC-22. Project activities can also comprise preventing the introduction of more R410a (a mixture of HFCs) air conditioners.

66. **Step 1.** The inventory of refrigerants in the current market comprises the total number of appliances sold in a year, their average charge volume and the average leakage of the respective appliance type. Only design data is required to assemble such inventories. The design data can be obtained from manufacturers, from wholesalers, from S&L databases and from inventories reported under the Montreal Protocol.

67. **Step 2.** Calculate the average specific charge per appliance unit per refrigerator volume and per air conditioner cooling capacity.

68. For refrigerators:

$$SREF_y = \frac{\sum^{j}\left(REF_{i,j,y} \times n_{i,y} \times GWP_j\right)}{\sum n \times V_{avr}}$$ Equation (10)

Where:

$SREF_y$	=	Specific refrigerant charge per volume of refrigerators sold in year *y* in tCO2e/l
$REF_{i,j,y}$	=	The charge volume of refrigerant *j* in the refrigerator model i sold during year *y* (as determined under Data/Parameter table 17)
$n_{i,y}$	=	Number of refrigerator model i sold in year *y*
n	=	Number of all refrigerators sold in year *y*
V_{avr}	=	Average volume of refrigerators sold in year *y*
GWP_j	=	Global warming potential of the refrigerant *j* according to the latest IPCC assessment

69. The refrigerator types included in SREF shall comprise all types of refrigerator models that are introduced by the project activity. SREF shall contain all types of eligible refrigerants currently sold in a country, such as HFC-134a.

70. For air conditioners:

$$SREF_y = \frac{\sum^{j}\left(REF_{i,j,y} \times n_{i,y} \times GWP_j\right)}{\sum n \times CC_{avr}}$$ Equation (11)

Where:

$SREF_y$	=	Specific refrigerant charge per cooling capacity in air conditioners in year *y* in tCO_2e/kW
$REF_{i,j,y}$	=	The charge volume of refrigerant *j* in the air conditioner model i sold during year *y* (as determined under Data/Parameter table 17)
$n_{i,y}$	=	Number of air conditioner model i sold in year *y*
n	=	Number of all air conditioners sold in year *y*
CC_{avr}	=	Average cooling capacity of air conditioners sold in year *y* in kW

71. **Step 3.** Calculate the baseline for refrigerants in new sales of refrigerators and air conditioners.

72. For refrigerators:

$$BE_{REF,y} = \sum_{i,j} n_{P,i,j} \times SREF_y \times V_{avr} \qquad \text{Equation (12)}$$

Where:

$n_{P,i,j}$	=	Number or refrigerators introduced by the project activity in year
V_{avr}	=	Average volume of the project refrigerators in liters

73. For air conditioners:

$$BE_{REF,y} = \sum_{i,j} n_{P,i,j} \times \left(SREF_y \times CC_{avr} \times \left[1 + \frac{L_{avr}}{100}\right]^{Lt} \right) \qquad \text{Equation (13)}$$

Where:

$n_{P,i,j}$	=	Number or air conditioners introduced by the project activity in year *y*
CC_{avr}	=	Average cooling capacity of the project air conditioners in kW
L_{avr}	=	Average leakage of all air conditioners sold in the year *y* in a market in percent, applying one of the following three options.
Lt	=	Average lifetime of air conditioners in a country, a default of 10 years or a surveyed average number of years

74. Options for the air conditioner refrigerant leakage during the lifetime:

(a) **Option 1.** Global air conditioner refrigerant leakage default of 5% annually, for all types of refrigerants.

(b) **Option 2.** Average leakage of 70% of all air conditioners models in operation in a country, applying manufacturer data on leakage of each model, the 70% of air conditioners can comprise those brands most popular in a country.

4.4.1. Data and parameters monitored

Data / Parameter table 16.

Data / Parameter:	$n_{P,iy}$
Data unit:	Number
Description:	Number of appliances introduced in year *y*
Source of data:	Project activity monitoring and documentation
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 17.

<table>
<tr><td>Data / Parameter:</td><td>$REF_{i,j,y}$</td></tr>
<tr><td>Data unit:</td><td>kg</td></tr>
<tr><td>Description:</td><td>Charge of refrigerant j in appliance i in year y</td></tr>
<tr><td>Source of data:</td><td>Manufacturer specifications.</td></tr>
<tr><td>Measurement procedures (if any):</td><td>No measurements required.
Charge and refrigerator volume (air conditioner capacity) correlate[26] and one charge value can be used for each volume and each refrigerant, for example:
<table>
<tr><td>Volume</td><td colspan="3">140l</td><td colspan="2">170l</td><td colspan="3">190l</td></tr>
<tr><td>Refrigerant</td><td>CFC-12</td><td>Isob</td><td>HFC-134a</td><td>CFC-12</td><td>Isob</td><td>CFC-12</td><td>Isob</td><td>HFC-134a</td></tr>
<tr><td>Charge in gr.</td><td>100</td><td>27</td><td>73</td><td>120</td><td>40</td><td>135</td><td>55</td><td>87</td></tr>
</table>

For air conditioners a similar cooling capacity to refrigerant charge can be used for each refrigerant.
When charges for half of all models in the market are known, an approximation equation can be derived and then applied to all models. When the share of models with charge data available is representative for the refrigerator volume variation (air conditioner capacity) across the market, the SREF for this share can be applied.</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter table 18.

Data / Parameter:	V_{avr}
Data unit:	Liters
Description:	Average volume of refrigerators type i in year *y*
Source of data:	For refrigerators introduced by the project activity: Project activity monitoring and documentation, model specifications from manufacturers. For all refrigerators in the market: Data for all models from Standard & Labelling database, commercial database, importers, retailers or manufacturer specifications
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 19.

Data / Parameter:	$CC_{avr,y}$
Data unit:	kW
Description:	Average cooling capacity of air conditioners introduced in year *y*

[26] Because the number of compressor manufacturers worldwide is much smaller than the number of refrigerator manufacturers (or air conditioner manufacturers) most refrigerators models of the same volume have the same charge as they use similar compressors.

Source of data:	For air conditioners introduced by the project activity: Project activity monitoring and documentation, model specifications from manufacturers. For all air conditioners in the market: Data for all models from Standard & Labelling database, commercial database, importers, retailers or manufacturer specifications
Measurement procedures (if any):	
Any comment:	-

Data / Parameter table 20.

Data / Parameter:	*Lt*
Data unit:	Years
Description:	Average lifetime of air conditioners in a country
Source of data:	Default of 10 years or survey as per Guidelines for sampling and surveys for CDM project activities and programme of activities
Measurement procedures (if any):	
Any comment:	-

Appendix 1. Steps for collecting/determining data parameters required to establish baseline emissions (new sales refrigerators)

1. A refrigerator market inventory ideally comprises the following parameters (variables) for all refrigerator models sold in a year:

   (a) V - volume of refrigerator;

   (b) Vc - volume per compartment;

   (c) AE - annual electricity consumption;

   (d) REF - chemical used as refrigerant;

   (e) REFc - refrigerant charge volume;

   (f) BA - chemical used as Polyurethane Foam blowing agent;

   (g) Sales - total number of a refrigerator model sold through all marketing channels.

2. An inventory can combine and/or compare Standards and Labelling (S&L) data, marketing data from commercial provider and industry data from the manufacturers, importers or retailers depending the quality and coverage of these sources.

1. Step 1. Extract data from Standard & Labelling database and/or commercial database

3. Databases of national agencies responsible for Standards and Labelling usually include the information on model and energy consumption or energy efficiency class of appliances. Where available S&L data shall be used. Voluntary S&L data can be as useful as mandatory S&L data, where it can be demonstrated that there is systematic efforts to maintain and update a database, i.e. adequate QA/QC procedures are in place. For baseline estimation, parameters to extract and elaborate from S&L refrigerator databases are:

   (a) MN - number of models in volume classes;

   (b) AEavr,vc - average annual electricity consumption in volume class;

   (c) SECavr,vc - average specific electricity consumption (kWh/l) in volume class;

   (d) Cov - percentage of models without electricity consumption data;

   (e) EEI - energy efficiency class of model (for example A+++ - F, classes 1 – 5, or class K – N).

4. When market data from commercial providers (such as The Nielsen Company, IMS Health, TNS, GfK, The Kantar Group, BSRIA or IPSOS[1]) is used, the results extracted can be:

   (a) MN - number of models offered in the market in year *y*;

   (b) SNvc - number of models sold in volume class;

   (c) Vvc - average volume of models offered in volume class;

   (d) AEavr,vc - average annual electricity consumption in volume class;

   (e) SECavr,vc - average specific electricity consumption (kWh/l) in volume class;

   (f) AESWavr,vc - average sales weighted annual electricity consumption in volume class;

   (g) Cov - percentage of models without electricity consumption data;

   (h) EEI - energy efficiency class of model (A+++ - F, classes 1 – 5, or class 1 - 3);

   (i) SNeei - number of models sold in energy efficiency class.

2. Determine the coverage of S&L and commercial data

5. Variations between the two data sources referred under step 1 may arise from the survey methods used. Extent and type of variation can provide further market insights, for example:

   (a) AEavr,vc - difference are / are not similar in each volume class;

   (b) AESWavr,vc - biases in sales channels covered.

6. Most relevant are differences between AEavr,vc and AESWavr,vc. When these differences are less than 10% they are considered of similar reliability, when these have more than 10% variation, indicators for discarding one of the data sources can be necessary to proceed.

7. When a S&L database contains annual electricity consumption while commercial database includes energy efficiency class data (EEI), or vice versa, these should be converted with the respective energy efficiency metric. The annual electricity consumption data is converted with the standard annual electricity consumption (SAE) into EEI or vice versa, the EEI information can be converted into annual electricity consumption. This allows to assess the variation between data sources.

3. Step 3. Combining S&L and/or commercial data with industry data

8. Information extracted from a S&L database and commercial database should be verified/confirmed/completed with data requested from manufacturers, importers, wholesalers and retailers (the latter is termed as industry data in this document). High quality and Internet-accessible public databases such as CNIS (China) and high quality (but expensive) commercial data yield statistically equivalent results. The objective for

[1] Acronyms are company names; the list is only an illustration.

combining these sources is to ascertain the representativeness of either the average specific annual electricity consumption for a volume class and/or the average energy efficiency class for a market segment. Many industry associations such as European Committee of Domestic Equipment Manufacturers (CECED) provide refrigerator stock model data.

9. Any variations between S&L and commercial data discovered under the previous step is the basis for the need for and extent of industry data to be considered in an inventory. Such industry data can be requested from all manufacturers, all importers and all wholesalers. Extrapolation from the data obtained to the entire market may be permissible depending on the quality of the data. In the data request made, it shall be documented how all manufacturers, importers and wholesalers are equally approached. Acknowledging commercial confidentiality, the following data request formats can be useful:

    (a) SNvc and SNEEC - total sales for a volume class or energy efficiency class;

    (b) AESWavr,vc - sales weighted annual electricity consumption in volume class.

10. Total sales numbers and sales per volume class obtained from commercial database and obtained from industry can be compared. This comparison may be separated for models with electricity consumption data (e.g in the nameplate or energy efficiency class) from models sold without this data. Such a comparison is important to verify the coverage of a voluntary S&L database.

4. Step 4. Options to determine SB parameters under data gaps

11. A SB may require to standardise SECavr,vc or AESWavr,vc or AEavr,vc. In this regard with more data coverage of the market the higher the certainty and the lower the required conservativeness. However, data gaps may still persist in some cases. The following table includes options to compensate for and fill data gaps.

Table 1. Cross-verification of Refrigerator Data Sources

S&L database	commercial data	Industry information
Coverage of models limited or uncertain	- Add manufacturers missing in S&L - Add volume classes missing in S&L - estimate models in S&L data that are not offered any more in year *y*	- Verify the extent of coverage limits - Add manufacturers or brands - Remove models not offered any more
Energy consumption data coverage is limited	- Verify if limited coverage affects the average in a volume class - select a volume class or efficiency range that is better represented in the S&L - Use commercial marketing data company to verify average AE value	- Complete data by using data on models that manufacturer provided to other S&L systems - Use total sales per energy efficiency class and EEI to estimate average AE
Volume data available is limited	Verify energy efficiency class	Verify energy efficiency

S&L database	commercial data	Industry information
Refrigerant data missing	Verify brand market shares	- Total sales per refrigerant - Total number of models with refrigerant in volume class - Average charge of refrigerant per volume class
Blowing agent data not included	- Verify brand market shares average refrigerator volume	- Total sales per blowing agent - Number of models with each blowing agent - Design blowing agent per kg of insulating foam - Volume of insulating foam per model

12. Table 2 below provides conversion factors that reflect only temperature differences in test standards and need to be adapted when the electricity consumption is related to adjusted refrigerator data. They are suitable for test results under ISO 15502, EN 153, IEC 62552, AS/NZS 4474.

Table 2. Conversion Factors for Refrigerator Test Standards[2]

	AS/NZS	ANSI/AHAM	ISO	JISC
AS/NZS		1.0081	0.9046	0.7520
ANSI/AHAM	0.9919		0.8973	0.7460
ISO	1.1055	1.1144		0.8313
JISC	1.3297	1.3405	1.2029	

13. The columns represent the numerator while row represents the denominator of the ratio (e.g. for $E_{ISO}/E_{AS/NZS}$= 0.6787).

14. Where only efficiency class information is available and these refer to different efficiency metrics (for instance some refrigerator class information comes from Indian energy star rating and other refrigerator class information from the Brazilian PBE label), the EEI averaging should use the following conversion factors. Similar conversion factors can be established for all efficiency metrics that use linear equations for adjusted volume or Vequivalent, using mid-points across the volume range. These conversion factors can be used to combine EEI data where different importers can provide EEI information from the S&L data in the countries where the refrigerators are produced.

Table 3. Conversion factors for EEI values between efficiency classes

(i) China Grade 1: EU class A;
(ii) China Grade 2 : EU class B * 1.08;

[2] Source: bigEE, 2012, Test procedures, measurements and standards for refrigerators and freezers, Wuppertal Institute, p.7.

(iii)	China Grade 3: EU class C * 1.11;
(iv)	China Grade 4: EU class D * 1.21;
(v)	China Grade 5: EU class E * 1.24;
(i)	India Grade 1: EU class E / 1.1
(ii)	India Grade 2: EU class D / 1.07
(iii)	India Grade 3: EU class C / 1.05
(iv)	India Grade 4: EU class B / 1.02
(v)	India Grade 5: EU class A
(i)	Brazil Grade A: EU class A
(ii)	Brazil Grade B: EU class B / 1.2
(iii)	Brazil Grade C: EU class C / 1.4
(iv)	Brazil Grade D: EU class D / 1.6
(v)	Brazil Grade E: EU class E / 1.8
(vi)	Brazil Grade F: EU class F / 2.0

15. When all parameters of all models sold in a year and the complete sales numbers for each of these models are known and are current, then the required conservativeness only reflects residual operational variations for example that refrigerator doors are opened more frequently. If parameters for only half of all models or less are known from any of the three data sources, then it has to be established if the known models are the more efficient part of all which is frequently the case since manufacturers declare the efficiency parameters of their better products and do not reveal the inefficiency of the cheaper models. This is a continuum with many graduations.

5. Sampling Approaches when no S&L or commercial Data Exists

16. The representativeness of a sampling approach can be established via an inventory of marketing channels when 70% of all refrigerator sales can be identified to a channel and when 70% of retailers are identified. Of the total number of retailers known, the geographic coverage shall be determined and for a minimum of 10 retailers, the distribution of refrigerator sizes determined. Of the dominant size classes, a statistically valid sample of refrigerators shall be tested with the test protocol included in Appendix 5 or any other nationally regulated or international testing standard such as IEC62552. Only where no S&L data, no commercial data and not importer data is available the tested average can be used to establish a new sales baseline.

Appendix 2. Baseline options and additionality determination

1. The benchmark level chosen for the baseline and the threshold for additionality shall be determined for the country context. Baseline level and additionality threshold should also reflect the availability and quality of data. In an ideal case, where all models sold in a market are known and all parameters are known, then baseline level and additionality threshold can be less stringent because conservativeness and integrity of the standardised values are certain. When part of the data is not available, then baseline level and additionality threshold shall be more conservatively set. In an ideal case, when an inventory of all models in the market is analysed (not a sample of models), baseline parameters values based on average shall be used.

2. The range of additionality thresholds is smaller and reflects the impact on the decision making of average appliance buyers and the market transformation ambition that the SB shall exert. In an ideal case, where data of models available is complete and where past Standard & Labelling programmes or MEPS have already removed the least efficient models, then the additionality threshold shall be at least XX% of most efficient models threshold. Where data is incomplete and\or much slack in the marketing of efficiency remains, then the additionality threshold shall be at XY% most efficient models. The range between XX and XY is continuous and any value can be chosen.

3. The baseline level chosen can ascertain that the average of the baseline appliances is below the emissions credits to project appliances. For mandatory S&L data, the baseline level can reflect the coverage and currentness[1] of the S&L data and the market surveillance ensuring the S&L data. The quality of market data reflects the completeness of energy data for all models sold in a market. Finally for data from commerce, especially importers and retailers, the baseline shall be more conservative since there is some uncertainty in the reporting of the importers and retailers who do not benefit from their efforts in reporting. Ranging from sole use of one data source to using all the three sources, many combinations of data sources may be feasible. Part of the data can come from an S&L database, another part from importers and a third part from marketing data and dependent on the relative role of the three sources, threshold levels for baseline and additionality can be defined for these different situations.[2]

4. Baseline and additionality level shall reflect the specific S&L regulation context, including voluntary and endorsement labelling. Where energy efficiency classes have been updated in the previous five years, additionality can be set in relation to the efficiency class with the highest increase in market share since then. The additionality level shall reflect whether the last S&L update results from an accompanying demand-side programmes or from the updates' impact on consumer awareness and information. The additionality level can anticipate a future S&L update when a date has been announced. Without S&L regulations in a country, the additionality level can reflect energy efficiency classes in the largest import source country. In a country where S&L are not enforced while dominant

[1] For example, the Indian S&L database by BEE contains the approval date and the validity period of each model's parameters.

[2] Public are invited to provide inputs on thresholds for additionality and baseline to include in this document

manufacturers are based in countries with S&L, for example one local manufacturer owned by a European brand and another local manufacturer owned by a US brand, the more demanding energy efficiency classes shall inform the additionality level to create incentive of the foreign owned manufacturer to raise its local manufacturing technology. Countries without S&L, without marketing data, with uncooperative importers and located in Africa can apply baselines and additionality thresholds similar to the most advanced S&L in Africa, currently the S&L in Ghana.

Appendix 3. Steps for collecting/determining data parameters required to establish baseline emissions (new sales air conditioners)

1. Options to Improve Standardized Baseline Parameters under Data Gaps

1. The necessary Energy Efficiency Ratio (EER) and Seasonal Energy Efficiency Ratio (SEER) coverage can be ascertained in all countries. One obstacle can be different model numbers used in different countries by the same manufacturer. In a Standard & Labelling database in China (CNIS) a different model code might exist for a model number that is included with another code in the INMETRO database. Such obstacles can be addressed with respective information from manufacturers.

2. The availability of sales data is typically the main obstacle and generally the solution is to distinguish different marketing channels. When one or several of the importers or one or several of the wholesalers can provide average EER for the air conditioners distributed, this average EER in relation to average cooling capacity can be used to extrapolate for all importers and all wholesalers. In this regard it is important to consider the market share of importers or wholesalers because in a country one of them might exert considerable market power by selling a high share of all air conditioners. Whether this one importer or wholesaler provides average EER data is crucial to determine what form of extrapolation is possible. Frequently when there is one dominant importer or wholesaler it has a long-term agreement with dominant manufacturers and these manufacturers can provide accurate and representative average EER data.

3. Data availability can determine whether to use average EER or average SEER in a SB. The following tables contain conversion factors for the major air conditioner exporter countries so that in all countries, all imported model data can be converted to a common denominator. All SEER data from models sold must be converted to the same SEER standard in order to calculate the average SEER. The highest model share can be the common SEER. While the SEER standards have different temperature profiles, it is not possible to improve the accuracy by using one particular SEER.

Table 1. Conversion of SEER between different SEER standards Fixed Speed AC[1]

To	From	%
Korea	China	99
Japan CSPF	China	104
US SEER non-ducted	China	99
EU SEER non-ducted	China	112
China	Korea	101
Japan CSPF	Korea	105
US SEER non-ducted	Korea	100

[1] Source: Waide P, Rivière P and Watson R, 2011, Cooling Benchmark Study Part 2: Benchmarking Component Report, CLASP, p.46-47.

To	From	%
EU SEER non-ducted	Korea	113
China	Japan CSPF	96
Korea	Japan CSPF	95
US SEER non-ducted	Japan CSPF	95
EU SEER non-ducted	Japan CSPF	107
Korea	US SEER non-ducted	100
Japan CSPF	US SEER non-ducted	105
China	US SEER non-ducted	101
EU SEER non-ducted	US SEER non-ducted	113
Korea	EU SEER non-ducted	89
Japan CSPF	EU SEER non-ducted	93
US SEER non-ducted	EU SEER non-ducted	89
China	EU SEER non-ducted	90

Table 2. Conversion of Inverter air conditioner SEER standards[2]

To	From	Slope	
Japan APF	US SEER	0.865	0.733
EU SEER	US SEER	1.080	0.286
China SEER	US SEER	0.998	-0.258
Korea SEER	US SEER	1.014	0.559
US SEER	Japan APF	1.101	-0.521
EU SEER	Japan APF	1.187	-0.265
China SEER	Japan APF	1.102	-0.798
Korea SEER	Japan APF	1.111	0.062
Japan APF	EU SEER	0.799	0.556
US SEER	EU SEER	0.919	-0.216
China SEER	EU SEER	0.910	-0.425
Korea SEER	EU SEER	0.946	0.240
US SEER	China SEER	0.993	0.310
EU SEER	China SEER	1.064	0.668
Japan APF	China SEER	0.861	0.987
Korea SEER	China SEER	0.989	0.969
US SEER	Korea SEER	0.954	-0.338
EU SEER	Korea SEER	1.047	-0.189
Japan APF	Korea SEER	0.822	0.446
China SEER	Korea SEER	0.937	-0.491
Japan CSPF	China SEER	1.032	0.773
China SEER	Japan CSPF	0.926	-0.464

[2] 1st column = constant + slope x 2nd column unit.
Source: Waide P, Rivière P and Watson R, 2011, Cooling Benchmark Study Part 2: Benchmarking Component Report, CLASP, p.65-66.

To	From	Slope	
Japan CSPF	US SEER	1.051	0.384
US SEER	Japan CSPF	0.938	-0.273
Japan CSPF	EU SEER	0.975	0.088
EU SEER	Japan CSPF	1.024	-0.081
Japan CSPF	Korea SEER	1.025	-0.119
Korea SEER	Japan CSPF	0.972	0.141

Appendix 4. Steps for collecting/determining data parameters required to establish baseline emissions (replacement of refrigerators)

1. Step 1. Establish the nameplate data of the replaced refrigerators

1. At all recycling sites, the replaced refrigerators are connected to an electricity supply to ascertain that they are functional, irrespective of the cooling they achieve. The brand and volume of the refrigerator, the refrigerant gas type is documented, and the nameplate model number and annual electricity consumption is recorded where these are visible on the nameplate.

2. The refrigerant is removed by means of a vacuum pump that achieves a vacuum of 0.3 bar or less and the refrigerants, Isobutane, HFC-134a and CFC-12 are collected separately for subsequent treatment. CFC-12 can be treated with Montreal Protocol funded destruction, or with GHG crediting from bilateral emissions trading", or according to national regulation for hazardous waste (for example destruction in cement kilns). Any treatment of recovered Isobutane and HFC-134a and any treatment of PUR insulation foam is possible for the applicability of this SB.

2. Step 2. Establish the share of refrigerators with nameplate data

3. Calculate the percentage of:

   (a) Replaced refrigerators with brand;

   (b) Replaced refrigerators with brand but not model information;

   (c) Replaced refrigerators with brand, model information but no electricity consumption data;

   (d) Replaced refrigerators with brand, model code, electricity consumption data and age.

4. A typical outcome can be half or up to 80% of all replaced refrigerators have brand data, less than half with model information and less than a quarter with electricity consumption data. The replacement baseline is applicable irrespective of the level of nameplate data.

Appendix 5. Test Protocol for Used Refrigerators

1. The following description is a simplified version of refrigerator test standards which permits to measure the electricity consumption of used refrigerators with sufficient accuracy for a Replacement Standardized Baseline. The simplification is sufficient so that a non-accredited laboratory or a refrigerator maintenance workshop can perform the test.

1. Background

2. During the recycling process the old refrigerators taken back will go first through a routine of statistical analysis and testing. The specification here is for a typical round of some 100 refrigerators. The definitive specification will be updated based on these preliminary results. The tests should be reproducible but need not be accurate to the level of a laboratory test for new refrigerators to comply with a national label or EU Directive 2003/66/EC nor EN 513 (2006) and EN ISO 15502:2005.

2. Room for testing

3. At the recycling plant a room (circa 20m2, 3m height) will be used for the tests. It should be directly accessible from the transport vehicle in order not to load/unload the refrigerators more than necessary.

4. The room has to be equipped with sufficient electrical outlets to test circa 5 to 10 refrigerators in parallel and to maintain the necessary testing temperature. The line Voltage should be within ±5% of nominal Voltage.

5. For the subtropical climate class SN Zone the required reference ambient temperature is 32°C. The room temperature should be measured 1.5 m above ground on a shaded place not directly in contact with external partitions and 2 m away from the test refrigerators.

6. The relative humidity should be between 40% and 75%.

3. Sample

7. From all of the refrigerators taken back a statistical report should be kept.

8. Description of refrigerator:

    (a) Measured external size (length/width/height);

    (b) Number of doors;

    (c) Estimated internal volume (liters): total, internal freezer compartment, separate freezer compartment;

    (d) Technical description (if possible): Brand, year of production, size of compressor, type of refrigerant, defrosting;

    (e) General status of refrigerator: door, seals, internal/external intact/defective.

9. From these refrigerators a typical sample of some 100 refrigerators should be chosen for measuring tests. This sample should represent the major types, sizes, brands.

4. Test

10. In order to achieve a stable and reproducible test result the test should be run in two phases:

    (a) Start phase (2 hours):

        (i) Check of functionality (compressor starts, cooling works), internal temperature depending on thermostat setting;

        (ii) Goal for normal volume: to reach 5 °C internal temperature (if not possible: set thermostat to max.);

        (iii) Goal for freezer volume: to reach -12°C (internal ** compartment) and - 18°C for separate *** freezer compartment) internal temperature (if not possible: set thermostat to max.).

    (b) Run phase (24 hours):

11. Measure and record electronically or manually:

    (a) Electricity consumption (Wh/24h);

    (b) Peak load during 5 minutes (W);

    (c) Average and max/min voltage (V);

    (d) Average and max/min internal temperature of main volume and separately for freezer compartment (° C);

    (e) Average and max/min ambient temperature (°C).

5. Accuracy

12. The test chamber temperature should be kept within ± 1 K of the nominal testing room temperature. The thermometer should be accurate to ± 0.1 K.

13. The internal refrigerator temperature (main volume) should be kept within ± 5 K of the nominal refrigerator temperature. The average refrigerator temperature in 24 hours should be 5° C ±1 K. The thermometer should be accurate to ± 0.1 K.

14. The internal temperature of the freezer volume should be kept within ± 5 K of the nominal freezer temperature. The thermometer should be accurate to ± 0.1 K.

15. The Watt meter should be accurate to within 0.1 W (range 1 W to 200 W).

16. The Voltage meter should be accurate to within 1 V (range nominal line ± 30%).

6. Results

17. Document (1 page A4) with descriptive results:

    (a) Place, date and time of test;

    (b) Name and signature of responsible testing person;

(c) Description of refrigerator;

(d) Test results.

Appendix 6. New sales air conditioner parameter standardization example

1. Data coverage in China is exceptionally good because China has 175 Standard & Label regulations for all appliances which are strictly enforced. Furthermore, the S&L authority, China National Institute of Standardization CNIS, uses many different means to follow market trends and improve the transparency of efficiency criteria for consumers. China uses QR Codes on appliance energy labels allowing consumers to use their smartphones to check criteria for each air conditioner model in a shop. QR user statistics show, for example, that in the first half year of 2015, 340,000 such data queries to the CNIS database came in, concerning 4,092 models in shops in 372 cities. This allows CNIS to measure in real-time the decision-making concerning air conditioner purchases.

2. CNIS provides data to CLASP (Collaborative Labelling and Appliance and Standards Program) and TopTen China to monitor trends and started the MACEEP, “Market Analysis of Energy Efficient Products” in 2012. MACEEP uses several data sources including retailers, independent market research companies and labelling data combined into one database. The energy related data such as the energy consumption, capacity, energy efficiency tier and index comes from manufacturers’ declaration for the products such as nameplates, product instructions and energy labels.

3. The air conditioner data in China is exceptionally good for mandatory S&L programmes that are strictly adhered to and continuously improved. In 2010, an energy efficiency standard for fixed speed air conditioners and inverters was introduced with Energy Efficiency Ratio (EER) as performance indicator. In 2013, a new standard was created for inverter air conditioners using Seasonal Energy Efficiency Ratio (SEER) as indicator. Each standard has three efficiency tiers for three capacity ranges.

4. The market inventory for MACEEP shows 1,000 fixed speed air conditioners models available and 815 inverter type air conditioners in 2013. The share of inverter type models increases annually by around 10%. Whereas the distribution of models among energy efficiency tiers changes much slower. From 2012 to 2013, the share of tier 1 fixed speed air conditioner decreased from 3.8 to 1.5% and share of tier 1 for inverter types from 7.3 to 6.3 %. This reduction of higher efficiency models is explained in the MACEEP study with the end of a large subsidy programme for higher efficiency air conditioners that had been implemented by the National Development and Reform Commission in 2009 and 2012 (with allocated RMB 16 bn and RMB 26 bn). The MACEEP conclusions affirm that without new policy interventions, market forces alone are unlikely to move air conditioners to higher efficiency levels and recommends that tier 1 should be further differentiated so that households have more gradual choices.

5. To calculate an average EER for a SB, three options are appropriate in such a context:

   (a) Use a weighted average EER for shares of available model capacity separately;

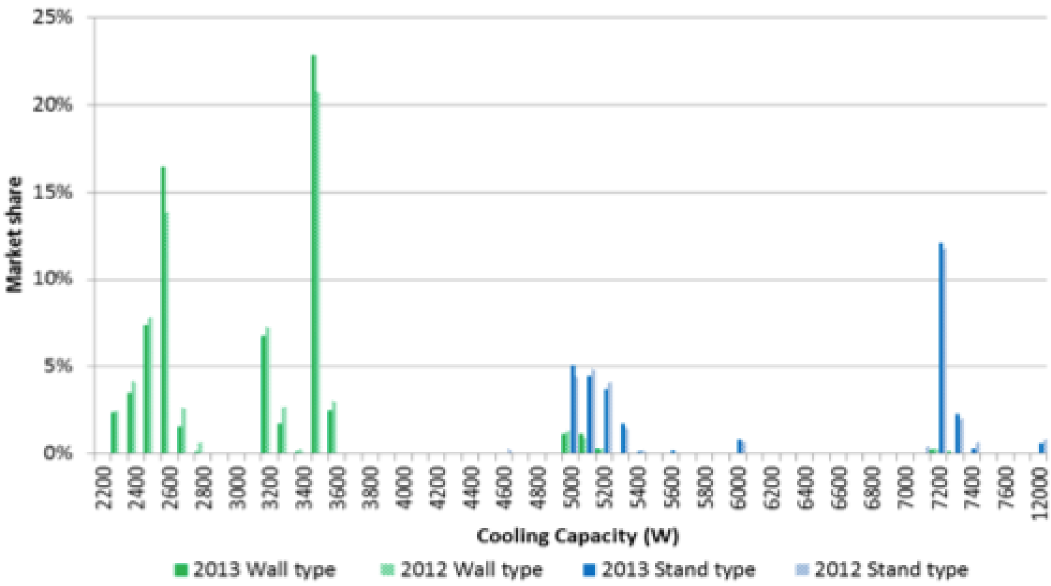
   (b) For fixed speed and inverter air conditioners;

   (c) Split the market in the three size segments used in the Chinese S&L; and

   (d) Calculate an average EER for each segment;

(e) Use the higher end of the average EER range as a conservative baseline.

Figure 1. Distribution of all models available in the market according to cooling capacity



SOURCE: CLASP 2016, Figure 7

Total market share of models <4.5 kW: 66.7%
4.5 to 7.1 kW: 18.6%
> 7.1 kW: 14.7%

6. The MACEPP results (Figure 2) show the variation of average EER for different cooling capacity with a small decrease of EER for higher capacity. Within each capacity range the average EER does not vary. That average EER for hundreds of models on the market are the same value as the regulated energy tiers reflects the size of the Chinese markets. All producers are large enough to target their models according to the S&L energy classes.

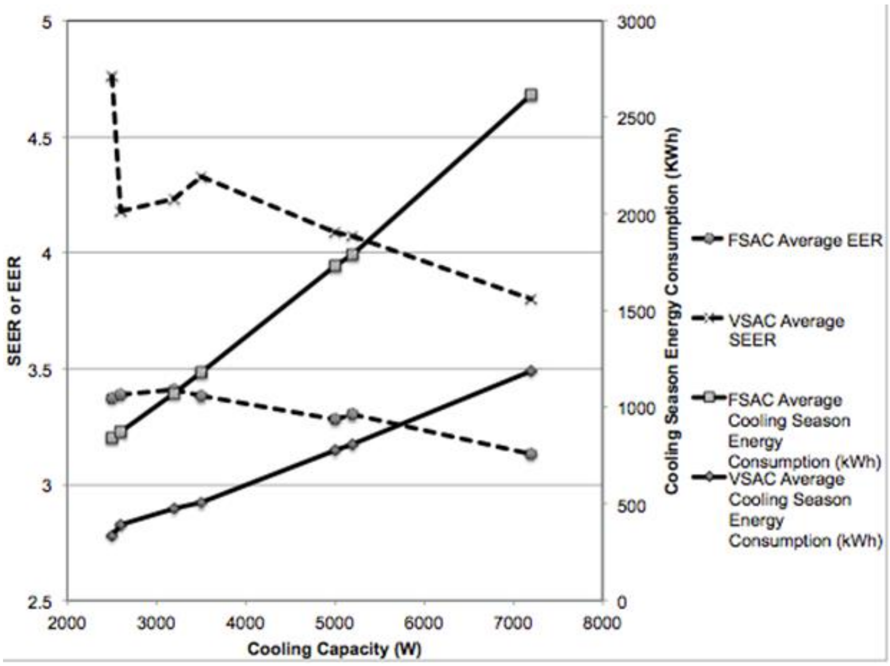
7. Weighing EER for products available in the market rests on the premise that overall model availability is focused on the capacities with the highest sales. Product-weighted averages provide an indicator of the overall sales patterns. Product-weighted average is the only solution without purchasing commercial marketing data containing sales numbers of individual models. Such marketing data is available for China but it is too costly (even for the authors of MACEEP).

8. For the choice EER or SEER data the split between the 2010 standard and the 2013 standard leaves effectively no choice. Since EER data cannot be converted to SEER, the efficiency average must be separated for fixed speed air conditioners and inverter air conditioners.

With the average EER published by MACEEP in the Figure below, the product-weighted average for all fixed speed air conditioner is:

$$3.4 \times 0.667 + 3.3 \times 0.186 + 3.2 \times 0.147 = 3.35 \text{ W/W}$$

Figure 2. Average EER for Air Conditioner Capacity in the Market



SOURCE: Hu et al., 2013, Figure 6.

9. This value can be used in equation 7 to calculate baseline emissions as determined in Data/Parameter Table 11. To apply the Guidelines for the establishment of sector specific standardised baselines it is necessary to determine if the interim value of 80% of the aggregated output of sector can be applied to EER data or to the number air conditioners in efficiency tiers or other indicators of the distribution of installed and running air conditioners in the country.

10. Applying 80% to the spread between best and worst air conditioner sold in 2013 implies:

$$(4.8 - 2.2) \times 0.8 + 2.2 = 4.28 \text{ (W/W)}$$

11. This is physically not correct since it should reflect the best and worst models currently in use and, more importantly, it neglects the influences of brand, functionality and household economics. Since tier 1 starts at EER 3.6 and tier 1 models have only 2% market share, it is conservative.

12. Applying 80% to the available models spread, the distribution among efficiency tiers:

- 52.5 % of all models are tier 3, 45.7% are in tier 2 and 1.8% are in tier 1;
- Puts 80% of the entire market at two thirds of tier 2 and since tier 2 is between EER 3.4 and EER 3.6, the 80% threshold among the models available in the market is 3.53 W/W.

13. A pragmatic judgement is to assess the market transformation impact of the difference between current average purchase at 3.35 W/W and 3.53 W/W by comparing the CER quantity resulting from a high efficiency air conditioner for example with 4.5 W/W for EER and relating the value of this amount of emission credits to the higher price. This can be

compared to empirical studies on the price elasticity of demand for air conditioners. Furthermore, the recent trend in average EER of around 0.09 W/W improvement per annum and the new air conditioner regulations currently prepared should be taken into consideration. It is unlikely that the current average EER improvement trend continues because it is mainly driven by the increasing share of inverter air conditioners and the 50 to 80 % higher price of inverter air conditioners can be beyond the income available of household classes.

1. Literature

14. CLASP, 2016, 2014 Market Analysis of China Energy Efficient Products (MACEEP) version 1,1, <http://clasp.ngo/Resources/Resources/PublicationLibrary/2014/Market-Analysis-of-China-Energy-Efficient-Appliances-2014>.

15. CLASP, 2013, Appliance Energy Efficiency Opportunities: China 2013, <http://clasp.ngo/en/Resources/Resources/PublicationLibrary/2013/Appliance-Energy-Efficiency-Opportunities-China-2013>.

16. Hu Bo, Zheng Tan, Li Jiayang and Zeng Leir, 2013, Market analysis for China energy efficient products, ECEEE Summer Study Proceedings.

Appendix 7. New sales refrigerator SB example

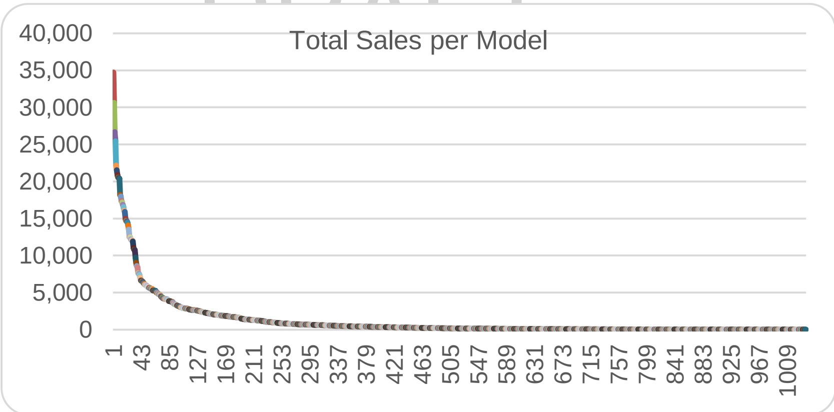
1. Marketing data from a well-known commercial marketing data firm for the country M documents that 1,037 different refrigerator models were sold in 2010, in total 1,315,410 units. The marketing data comprises annual electricity consumption, total volume, efficiency class and sales. It is not possible to calculate the Energy Efficiency Index (EEI) of the models.

Figure 1. Extract of Refrigerator Marketing Data for Country M

Model	Brand	First Activity	Net. Liters Tot	NoF	En.I	Ene	Sales Units	Sales Units	Sales Units
							January 2008 - December	ry 2009 - December	ary 2010 - October 2(
5231 NFY	ARCELIK	September 2009	>400<=450 ltr.	YES	B	657		5,042	34,725
BD 4306 ANF	PROFILO	May 2009	>350<=400 ltr.	YES	A	453		9,133	30,623

2. As is typically the case, only 66 different models were sold in >5,000 units, the majority of models, 727, were sold in <600 models per year. Given the production costs of manufacturers, this implies that on two thirds of their models, manufacturers lose money. The total distribution is shown in the following Figure, ranked (left to right) from highest sold model to lowest sold model. The y-axis is number of sales, highest sold model had 34,725 units and 2.6% of all sales, and the x-axis are the 1,037 models.

Figure 2. Refrigerator Sales in Country M in 2010



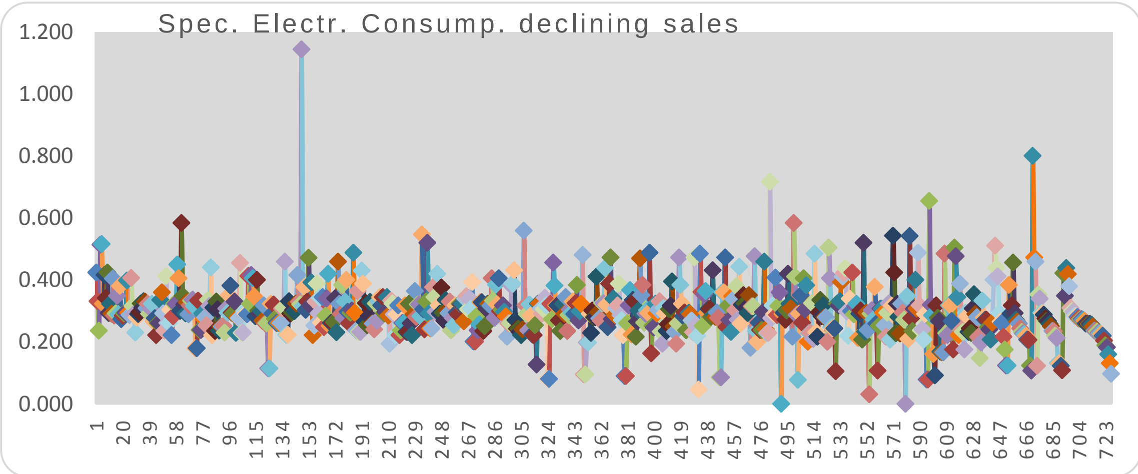
3. 400 models sold less than 100 units. With current transportation costs, most manufacturers ship models globally and offer all sizes, all types and all tastes in all segment of a market. Country M is a major exporter of refrigerators and there are large national manufacturers as well as many Original Equipment Manufacturers (OEM) producing for global brands. The number of models available with 1,037 is comparably lower, many countries of similar size than country M have between 2000 and 4000 refrigerator models offered for sale.

4. The distribution of number of models sold in country M in 2010 per brand was:

(a) AEG 19, Altus 16, Amana 12, Arcelik 111, Beko 85, Bosch 135, Daewo 10, Electrolux 21, Franke 11, Frigidaire 3, GE 4, Gorenje 23, Hitachi 6, Hoover 6, Hotpoint 49, Indesit 22, LG 7, Liebherr 73, Miele 10, Profil 79, Regal 34, Samsung 23, Sharp 7, Siemens 96, TEKA 6, Vestel 140, Westinghouse 23, Whirlpool 22, Zanussi 6.

5. The popularity of a refrigerator model was not related to efficiency. The following Figure 7 shows all refrigerators in the same order on the x-axis from highest to lowest sales as in Figure 6 (1,037 models), with specific annual electricity consumption on the y-axis in kWh/l/yr. The popular models selling >10,000 units per year (those to the left of the x-axis) have similar energy efficiency than the least sold ones (those to the right). The only trend clearly visible is towards the right, the spread is higher, very efficient ones and very inefficient ones sell poorly.

Figure 3. Distribution of efficiency over the sales



6. There is no correlation between brands and efficiency class, all manufacturers produce all levels of efficiency. There is also no correlation between refrigerator volume and efficiency, all efficiency grades are produced over the volume range from very small to very large refrigerators.

1. Step 1

7. This wide spread of specific efficiencies does not appear in the number of models per refrigerator efficiency class, these are in the EU efficiency metric (mandatory in country M):

Table 1. Distribution of Available Models across Efficiency Classes

Class	Number of models	Sales per efficiency class
A++	9	187
A+	174	130436
A	641	858251
B	195	241451
C	18	7120
D	3	7

Table 2. Distribution of Available Models across Volume Classes

volume class	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500	500-550	550-600	>600
MN	26	3	12	47	78	125	267	125	38	38	300
AE_{avr}	211	322	325	312	360	423	474	492	545	477	546
SEC_{avr}	0.463	0.505	0.396	0.310	0.303	0.309	0.306	0.284	0.219	0.260	0.214
$AESW_{avr}$	235	726	368	373	417	460	495	506	592	461	500
sales	55,830	1,714	4,761	17,856	34,011	199,157	513,532	148,733	75,648	44,115	1,329

8. Among 1,037 models, 114 models have no efficiency information, and the sales in that category is 144,220. Unknown models are 11 % of models and 10.9% of sales. This is a high coverage of the whole market. The marketing data does not include volumes for refrigerator compartments and EEI cannot be calculated.

9. Among models without efficiency information, 58 are label A, 18 are label A+, 15 have label B and one label A+. The shares of brands among the models without efficiency information is the same as among models with energy information. Therefore the missing information is most likely not due to manufacturers' not reporting information but due to gaps in marketing survey coverage.

10. The averages in Table 2 indicate that the data is internally consistent esp. because the difference between AE_{avr} and $AESW_{avr}$ is realistic, lower differences in classes with high sales, and $AESW_{avr}$ lower than AE_{avr} only for the 550-600 and >600 l classes.

2. Step 2 and 3

11. The marketing data is likely of good quality, however it is not possible to verify if the surveying by the marketing data company had deficits in some regions or some distribution channels. Comparing a few samples between country M's Standard & Labelling database and the marketing data are sufficient. All models produced in country are mandatorily tested according to IEC 62552. Comparing the number of models per efficiency class is one verification whether the marketing data covers all marketing channel. The Standard & Labelling database probably contains more models and a share is not actually offered in shops any more, but the AE_{avr} of 350-400 and 400-450l should be of similar values.

12. It was not possible to get access to the Standard & Labelling database. The Ministry of Energy and Natural Resources implements mandatory minimum energy efficiency regulations for 26 appliances, mandatory energy labelling for 20 appliances and 31 voluntary energy labels. In this context, it is more realistic to select some variables that are more revealing and also have good sales numbers, $AESW_{avr}$ for 500-550 and 550-600 l for example, and request the industry manufacturers' association to provide these details to control the marketing database. In preparing this case, this verification was not possible.

3. Step 4

13. The average specific electricity consumption across all models is 0.298 kWh/l/yr and the sales weighted average is 0.325 kWh/l/y. This significant difference reflects that less efficient and lower priced models sold in higher numbers. This analysis can be extended by verifying whether the lower prices of well sold models correspond to lower production costs.

14. Ranking the models for specific annual electricity consumption, 80% of the total number of sales is at 0.274 kWh/l/yr. Applying the 80% threshold to the specific annual electricity range between 0.1 and 0.8 kWh/l/y, yields a threshold of 0.24 kWh/l/y. These thresholds can be applied in equation 2.

15. Specific annual electricity consumption at 90% of sales is at 0.240 kWh/l/yr. The number of models below 90 % is 160 and all brands are represented in that bracket.

16. Because of the export orientation of the manufacturers in country M, implying that manufacturers are in intense competition with leading global brands, the 80% threshold can be preferred since these national manufacturers have invested in the latest efficiency improvements and are reaping benefits of the export efforts in the national competitive context as well. In other words, these manufacturers have mastered the technology to be competitive abroad and can apply the most advanced technology also in the national market even so it might not increase their market shares in the national market.

17. In light of the broad range of models, manufacturers and the size of country M sales, using Approach 2 for a new sales SB and threshold on specific annual electricity consumption is both accurate and representative. The 80% additionality threshold would be effective to influence consumer behaviour to react to the supply side advances.

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Document information

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