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Energy Efficient Refrigerators

Country

India

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1 Subtypes and markets

Refrigerators have been manufactured in India since the 1950s. Till the 1980s brands like Allwyn, Kelvinator, Voltas and Godrej controlled almost 90% of the market, which was considered as a luxury goods market back then. It was subjected to extensive taxation and licensing. The liberalization of the economy in the early 1990s opened up the market for international players and multi-national corporations (MNCs). Domestic producers like Videocon and BPL also diversified their operations and companies that already had a strong base in the consumer electronics market sought to enter the consumer durables market as restrictions eased. Samsung India began its operations in December 1995 and achieved a sales turnover of $1 billion within a decade due to the massive demand for these products.

Following the economic liberalisation in the 1990s, the growth of this product group has been led by an increase in affordability. An expanding middle class with a higher share of disposable incomes and decreasing prices of durables has made refrigerators affordable to large section of the population. The Government of India's investment in infrastructure has been steadily rising in each consecutive Five year Plan. Investment in infrasturcure has increased from 5.2% of the GDP between 2003 and 2007 to 10% of the GDP between 2013 and 2017 (Bharadwaj, 2013). 31% of the infrastructure spending has been in the power sector which also leads to an increase in the market for durables. The effect of this investment is evident as 43.8% of urban households possessed a refrigerator in 2011-2012 as against 31.9% in 2004-2005 (NSSO, 2014). On the other hand, 9.4% of rural households had refrigerators in 2011-12 compared to 4.4% in 2004-05. The wide gap in urban and rural possession is generally attributed to lack of access to electricity in rural pockets of the country owing to the hinderances in the implementation of rural electrification program. Therefore, despite the massive growth this remains an underpenetrated market. The overall market for refrigerators in India has a 21% penetration rate, which is only about a quarter of the global average of 85% (FICCI, April 2015). The market is set for a rapid growth with increasing reach of power infrastructure, easily available credit and decreasing prices of durables.

The refrigerator market in India is divided into two major segments, the direct cool (DC) refrigerators and the frost free refrigerators (FFR) variants. The frost free variant of refrigerator contains a heating element to prevent the formation of frost in the freezer. This heating element consumes additional energy, resulting in higher power consumption by FFRs than DC refrigerators along with a 30-50% increase in the cost as well. Standalone freezers are virtually non-existent in the Indian domestic market. The FFR variants can be divided into following sub variants (Shakti Foundation, August, 2012):

- **Top mount double door refrigerators**: These refrigerators have separate compartments and doors for the refrigerator and the freezer compartments in a single appliance. The smaller freezer compartment is above the refrigerator section. They constitute 47% of the FFR market.
- **Bottom-mount refrigerators**: These are refrigerators in which the freezer compartment is below the refrigerator compartment. They constitute 2.5% of the FFR market.
- **Multi-door refrigerators**: These type contain an additional compartment for fruits and vegetables, besides the fresh-food and freezer sections. These constitue 4.5% of the FFR market.
- **Side-by-side refrigerators:** These type of refrigerators have two side-by-side doors. They are generally in the higher capacity range of around 500L. They constitute 4.4% of the FFR market.

The latest technology in the FFR segment is the digital inverter compressor technology, which enables the compressor to run at variable capacities. This conserves energy and also helps maintain a constant temperature inside the cooling compartment.

Refrigerators find year-long application in India operating for 24 hours a day and for 365 days a year. Since the refrigerator unit also contains the freezer compartment the entire appliance operates for the through out the year, which is 8,760 hours annually (The World Bank, 2008). For testing purposes the temperature in the refrigerator compartment is maintained at 3°C and the temperature in the freezer compartment is maintained at -15°C (Bureau of Energy Efficiency, 2015).

The tocal stock of refrigerators across different segments was estimated to be 33.3 million in 2006 and registered a massive growth in 5 years taking the stock to approximaltey 57.6 million units by the year 2010 (The World Bank, 2008). The stock of frost-free segement in 2010 was 13.8 million units. According to the Bureau of Energy Efficiency this would expand to 18.8 million units by 2020-21. The sales of FFRs stood at 1.5 million units in 2010-11 and 1.7 million units in the consecutive year, with a predicted CAGR of 31.7% from 2012 to 2015. By 2013 the refrigerator market in India had grown to $1.2 billion.

The market-share of FFRs increased in the year 2009 to 34% from 12% in 1998. The remaining 66% of the market was occupied by the DC variant due to the lower price point (Shakti Foundation, 2012). Although the price remains a sensitive point, consumers in the middle class are willing to pay for innovation. Energy efficiency, super cooling and better technology are the main factors pushing the growth in the FFR segment. In the DC segment the capacity range of 165-225 litres occupies the highest percentage of sales among all available capacities accounting for 91% of all DC refrigerator sales. Whereas in FFR segment the capacity range 240-270 Litres occupies 61% of the sales. The minimum capacity available in the FFR segment is 240 litres.

Refrigerators in India consumed an estimated 14.75 TWh of energy in 2011, including all segments and all volumes while the energy consumption of the FFR segment stood at 6.42 TWh in 2010-2011.This was one of the highest amongst all white appliances, namely refrigerators, washing machines, electric ovens, toasters and microwaves. On an average annual energy consumption for the below 300L capacity models is approximately 320 kWh, for the above 300L capacity modles is 370 kWh (The World Bank, 2008).

2 Efficiency range and user savings

The most popular capacity range in the frost free refrigerator (FFR) segment is 226-270L, which accounts for 60% in the refrigerator market (TV Veopar Journal, 2013). FFRs falls under the mandatory category of the Standard & Labelling program in the country. All the FFRs sold in the market adhere to minimum performance standards and displays a star rating label prominently which indicates the level of energy efficiency of the particular model.

Table 1: Efficiency range and user savings of refrigerators

Level	**Typical appliance in the stock (over all appliances in use)**	**Typical Inefficient appliance. If MEPS is implemented: Appliance just complying to minimum requirement (MEPS)**	**Typical appliance purchased (BAU – Business As Usual)**	**Best Available Technology (BAT)**	**Expected future BAT (Best not yet Available Technology)**
Typical Capacity / Size	226 - 270 Litre				
Category	**Frost free refrigerator**	**Frost free refrigerator**	**Frost free refrigerator**	**Frost free refrigerator**	**Frost free refrigerator**
Type	Top mount refrigerator	Bottom top refrigerator	Top mount refrigerator-Double door	Top mount refrigerator with inverter compressor	Top mount refrigerator with inverter compressor
Lifetime (years)	13	13	13	13	13

Qualitative classification of the provided service (e.g.: washing performance /etc.)	☐ Poor ☐ Low ☒ Average ☐ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☒ Average ☐ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☒ Average ☐ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☐ Average ☒ Good ☐ Excellent ☐ No information	☐ Poor ☐ Low ☐ Average ☒ Good ☐ Excellent ☐ No information
Yearly energy consumption: electricity (kWh)	397	318	254	165	95
Yearly energy cost (INR) (PHD RESEARCH BUREAU, February 2013)	2184	1749	1397	908	523
Purchase cost in (currency) INR	14,000	21,000	23,000	30,000	NA
Operation & Maintenance cost	2000 (lifetime)	2000 (lifetime)	2000 (lifetime)	2000 (lifetime)	2000 (lifetime)
Labelling class (for the aforementioned labels)	no star	2 star	3 star	5 star	-

3 Performance and information requirements

The Bureau of Energy Efficiency (BEE) was constituted by the Government of India, under the Ministry of Power on 1st March 2002 to assist in developing policies and strategies towards the objective of decreasing India's energy intensity. As a medium and long run measure to achieve this objective in the residential sector BEE launched the Standards and Labelling (S&L) program for home appliances in May 2006 . The S& L scheme has been implemented in India for 21 appliances, out of which 4 are under the mandatory scheme and 17 are under the voluntary scheme. Direct Cool refrigerators are currently under the voluntary scheme, whereas FFRs are under the mandatory scheme.

The primary energy demand in India has grown rapidly, from 450 million tons of oil equivalent (mtoe) in 2000 to about 770 mtoe in 2012, and is further expected to reach about 1,500 mtoe by 2030, as predicted by the Integrated Energy Policy Report by the Planning Commission in August 2006 (PIB, 2016). To manage the growing energy need on the demand side the Energy Conservation Act was passed in 2001. Under this Act the Bureau of Energy Efficiency was formed as the statutory body with the aim of reducing the energy intensity of the country. The energy efficiency labelling programme under BEE, implemented in 2006, is intended to reduce the energy consumption of appliances without diminishing the services it provides to consumers. Further, the standards and label for refrigerators and air-conditioners are periodically revised so that the least-efficient products are removed from the market and more efficient ones are introduced.

The formula for determining the energy labasel of an appliance is shown below (Bureau of Energy Efficiency, 2015):

Star Rating Band (SRB) nf = knf * Vadj_tot_nf + cnf

Where,

knf = Constant Multiplier (kWh/Litre/Year)

Vadj_tot_nf = Total Adjusted Storage Volume for No Frost (Litre)

cnf = Constant Fixed Allowance (kWh/Year)

Total Adjusted Volume for Frost Free refrigerator (**Vadj_tot_nf**) = Fresh Food Storage Volume + 1.62 * Freezer Storage Volume

The Star Rating corresponding to the band whose lower rating is less than the comparative energy consumption (CEC) and upper limit is greater than or equal to CEC will be assigned to the model. Lower

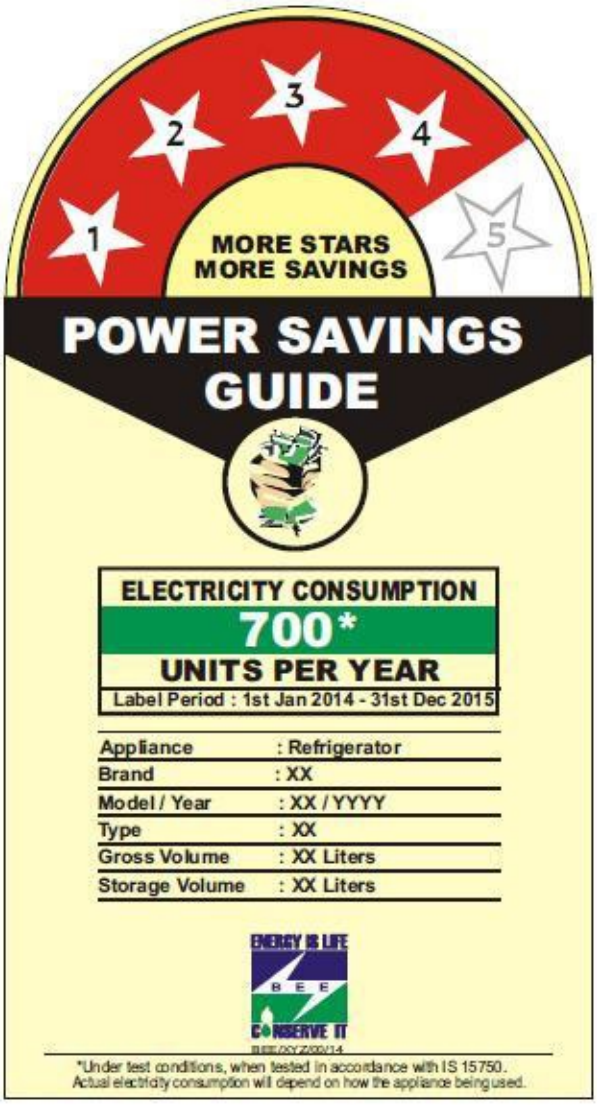
Limit of **SRB < CEC ≤** Upper Limit of **SRB.** Further, the CEC is based on the predicted annual energy consumption (PAEC) which is given as:

PAEC = E_t * (365/1000)

Where E_t = tested energy consumption expressed in Wh per 24 hours, rounded to the nearest whole number. CEC cannot be less than the average PAEC, which is the average PAEC of the three tested units, rounded to the nearest whole number.

The mandatory comparative labelling scheme is called the Standards and Labelling Program. In case of refrigerators it is invoked for electric mains powered frost-free (No-Frost) refrigerating appliance of the vapour compression type intended for household and similar use, being manufactured, imported, or sold in India. A sample label to be displayed on refrigerators is shown below.

Figure 1: Sample energy rating label for refrigerators



(Source: Bureau of Energy Efficiency, 2015)

The label provides the following information:

1. Appliance (type): Refrigerator
2. Energy Consumption per Year (CEC)
3. Model Name/Number, Year of Manufacturing
4. Brand
5. Type
6. Gross Volume
7. Storage Volume
8. Label Period

Direct Cool refrigerators have been placed by the BEE under the list of appliances for which the labelling scheme is voluntary. Manufacturers may or may not choose to obtain an energy rating for these appliances. In case of refrigerators FFRs have been placed in the mandatory scheme due to their higher energy consumption as compared to DC refrigerators. FFRs may consume as much as double the energy a DC refrigerator consumes due to an extra heating coil which prevents frosting. The increasing market share of FFRs over time suggested a massive increase in the domestic energy consumption. Hence, BEE has chosen to include FFRs in the mandatory scheme.

4 Test procedures and standards

The BEE schedule for rating frost-free refrigerators use the IS 15750:2006 standard for calculating the tested energy consumption in Watt-hour (Wh) per 24 hours for the appliance, which is then further used to calculate the predicted annual energy consumption (PAEC). This forms the basis of further calculation for rating the appliance. The standards specify the test conditions for calculating the energy consumption.

The standard used by BEE to define test procedures of appliances for energy star rating is the IS 15750:2006. As stated in this standard's document, assistance while preparing IS 15750:2006 was derived from ISO 15502:2005 (E) and AS/NZS 4474.1: 1997. Three models of an appliance are tested to determine their power consumption in 24 hours in Wh. The aggregate is then multiplied by 365 to calculate the annual power consumption in kWh, which forms the basis of further calculation and is indicated on the label. The energy star bands are defined as follows:

Star rating band	Minimum CEC	Maximum CEC
1 Star *	≥ 0.3570 * Vadj_tot_nf +311	0.2856 * Vadj_tot_nf +249
2 Star * *	≥ 0.2856 * Vadj_tot_nf +249	0.2285 * Vadj_tot_nf +199
3 Star * * *	≥ 0.2285 * Vadj_tot_nf +199	0.1828 * Vadj_tot_nf +159
4 Star * * * *	≥ 0.1828 * Vadj_tot_nf +159	0.146 * Vadj_tot_nf +127
5 Star * * * * *	≥ 0.146 * Vadj_tot_nf +127	

Table 2: Star Rating Band of FFR from 01.01.2016 to 31.12.2018

The Indian Standard IS 15750:2006 specifies the test conditions for the testing of the appliance, under the 'Energy Consumption Test' as follows:

- The ambient temperature should be 32 ˚C and to be controlled within specified tolerances.
- The appliance is to be operated under no-load condition, with all internal fittings in position and all compartments in simultaneous operation.
- If anti-condensation heaters are provided which can be switched on and off by the user but are not necessary to withstand the water vapour condensation test, they shall not be switched on.
- If the appliance includes a cellar compartment and the volumes of this compartment and of the fresh food storage compartment are adjustable in relation to one another by the user, the cellar compartment shall be adjusted to its minimum volume.

- The temperatures to be maintained for the duration of the test are:
  - Fresh food refrigerator compartment : +3 ˚C
  - Freezer compartment : -15 ˚C
- For products where separate compartments like cellar or chiller are also defined only the temperatures in the refrigerator and the freezer are to be used for testing purpose.

The standard also specifies a number of other tests as well, such as testing of the mechanical properties of the product, ice-making test, water vapour condensation test, test for absence of odor and taste etc. Due to the high number of DC refrigerators in domestic households and their relatively lower power consumption the BEE has included them under the voluntary scheme of energy rating, with a separate schedule specifying the test procedures and rating criteria. Based on this, beginning from 1st January 2015 to 31st December 2016 the rating scheme for DC refrigerators were put in a mandatory phase. The schedule defines a DC refrigerator as " refrigerators with or without crisper and with or without ice making or frozen food storage compartments and are NOT cooled by internal forced air circulation. Cooling is primarily obtained by natural convection only. However, some products may have fans to avoid internal condensation but not to claim as frost free (Bureau of Energy Efficiency, 2015)."

The testing codes and procedures for DC refrigerators, as mentioned in the schedule, shall be as per IS 1476 (Part-I):2000 with all amendments. The method of calculation of the energy star rating of a DC refrigerator remains the same as its frost free counterpart. The parameter to be tested is the energy consumption in 24 h in Watt-hours (Wh), which is then multiplied by 365 to determine the PAEC in kWh. This is done for three samples and the average is calculated as $PAEC_{av.}$. The formula used to determine the star rating bands is:

TABLE 2.2: Star Rating Band valid from 1st January 2015 to 31st December 2016

Star rating band	Comparative Energy Consumption (CEC) Criteria
1 Star *	0.413* Vadj_tot_dc +346 ≤ CEC < 0.516* Vadj_tot_dc +432
2 Star * *	0.33* Vadj_tot_dc +277 ≤ CEC < 0.413* Vadj_tot_dc +346
3 Star * * *	0.264* Vadj_tot_dc +221 ≤ CEC < 0.33* Vadj_tot_dc +277
4 Star * * * *	0.211* Vadj_tot_dc +177 ≤ CEC < 0.264* Vadj_tot_dc +221
5 Star * * * * *	CEC < 0.211* Vadj_tot_dc +177

Table 3: Star Rating Band valid from 1st January 2015 to 31st December 2016

The CEC for a model shall not be less than the average PAEC value i.e., PAECav (the number shall be rounded to the nearest whole number) for the three (or more) units which are tested to determine the label particulars. The CEC shall be an integer in units of kWh/Year.

Total Adjusted Volume for Direct Cool refrigerator (Vadj_tot_dc) = Fresh Food Storage Volume + 1.31 * Freezer Storage Volume
In the direct cool segment the capacity range of 165-225L accounts for the highest percentage of sales among all available capacities with a 91% share. Hence the only difference that exists between the criteris of rating of FFRs and DC refrigerators, in the energy consumption test, is the energy bands.

5 Further information

It is worth noting that almost 70% of the refrigerator market in India is still occupied by the Direct Cool (DC) technology refrigerators. This is due to the price sensitivity of the Indian market and the lower price point of DC refrigerators. With a difference of almost 30%-50% between DC refrigerators and FFRs of identical capacities a major section of the Indian population opts for a DC refrigerator over and FFRs. Prices of FFRs should come down comparable with DCs for enable further growth in FFR market.

The government has taken certain steps to improve the manufacturing scenario of refrigerators.The National Policy on Electronics 2012 was launched with the objective of attracting a $100 billion investment by 2020 in electronics system design and manufacturing (ESDM) and creating employment for 28 million people. Zero duty Export Promotion Capital Goods (EPCG) scheme allows import of capital goods for pre-production, production and post-production processes free of customs duty. The specific export obligation under the EPCG scheme where capital goods are procured from indigenous manufacturers has also been reduced from 90% to 75%. As per some privae sector reports, ease of doing business must also be improved and the inverted duty structure, under which raw materials are taxed at a higher rate than finished products, must also be reduced.

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The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

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