Evaluating Market Response to the Appliance Standards and Labelling Programme - A Status Report

Final Report Submitted to

SHAKTI SUSTAINABLE ENERGY FOUNDATION

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Alliance for an Energy Efficient Economy

New Delhi

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Abbreviations

AC	Air Conditioner
AT&C	Aggregate Technical & Commercial
BAT	Best Available Technology
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
CAGR	Compounded Annual Growth Rate
CEA	Central Electrical Authority
CEC	Comparative Energy Consumption
CEAMA	Consumer Electronics and Appliances Manufacturers Association
CRGO	Cold Rolled Grain Oriented
DCR	Direct Cool Refrigerator
DT	Distribution Transformer
ECA	Energy Conservation Act
EE	Energy Efficiency
EER	Energy Efficiency Ratio
EESL	Energy Efficiency Services Limited
ELCOMA	Electric Lamp and Component Manufacturers Association
EMI	Equated Monthly Instalments
FFR	Frost Free Refrigerator
GW	Giga Watt
GWP	Global Warming Potential
IEC	International Electrotechnical Commission

IEEMA	Indian Electrical & Electronics Manufacturer's Association
IM	Induction Motor
kWh	Kilo Watt Hour
LBNL	Lawrence Berkeley National Laboratory
MEPS	Minimum Energy Performance Standard
MTEE	Market Transformation for Energy Efficiency
MW	Mega Watt
NMEEE	National Mission for Enhanced Energy Efficiency
R-APDRP	Restructured Accelerated Power Development and Reforms Programme
SDA	State Designated Agencies
S&L	Standards & Labelling
SRB	Star Rating Band
T&D	Transmission and distribution
UNEP	United Nations Environment programme

1. Introduction

According to the report *More Power to India: The Challenge of Electricity Distribution* (Sheoli Pargal and Sudeshna Ghosh Banerjee, 2014) India has a peak deficit of 10.5% and an energy deficit of 7.5%, while 300 million people still lack access to electricity. In order to meet the growing demand for power while minimising the impact on the environment, energy efficiency in power generation, power distribution and appliances and equipment is as critical as increasing energy supply.

The Energy Conservation (EC) Act 2001 was introduced with the aim of reducing the energy intensity of the Indian economy by promoting energy conservation and energy efficiency. The Bureau of Energy Efficiency (BEE) was set up in 2002 under the Ministry of Power and has since introduced several schemes to promote energy efficiency in the residential, commercial and industrial sectors. Schemes such as the Standards and Labelling (S&L) Programme for Appliances and Equipment, the Energy Conservation Building Code (ECBC) and Demand Side Management (DSM) for agriculture, SMEs and industry resulted in 10,836 MW of avoided capacity generation during the Eleventh Plan (2007-2012). Promoting energy efficiency continues to be a strategic initiative of the Government of India in tackling energy demand and climate change. The National Mission for Enhanced Energy Efficiency (NMEEE), introduced during the Eleventh Plan to provide a regulatory and policy framework to promote the market for energy efficiency, has been approved for the Twelfth Plan (2012-2017) as well with an allocation of INR 775 crore. One of the initiatives of NMEEE is Market Transformation for Energy Efficiency (MTEE), which aims to accelerate the shift to energy efficient appliances by making products more affordable.

This report presents the findings of a study conducted by AEEE and sponsored by SSEF to evaluate the market response to BEE's S&L programme for appliances and equipment. The aim of the study was to assess market penetration of S&L products, identify existing gaps in the programme and put forward recommendations to promote BEE's S&L programme.

1.1 The Standards and Labelling Programme in India

The Standards and Labelling (S&L) programme was launched in May 2006 with the objective of reducing the energy intensity of electrical appliances and equipment, leading to energy savings. The labelling of appliances is intended to improve consumer awareness about the energy saving potential of appliances and equipment, enabling consumers to make an informed choice when purchasing appliances/equipment. The labelling of appliances is also intended to encourage manufacturers to produce energy efficient products, in addition to continuously improving energy efficiency standards.

The S&L programme directs participating manufacturers to provide information on the energy performance of appliances according to a star rating system which is based on standards issued

by BEE. The star rating ranges from 1-star to 5-star, with 5-star being the most efficient. In an effort to continuously improve energy efficiency BEE revises the standards every few years for all products in the programme.

Central to BEE's S&L scheme is equipment selection, based on key criteria like the size of the product market, share of appliance in energy consumption, share of organised and unorganised market, energy saving potential and ease of implementing the standard. Availability of test procedures and test laboratories are critical in product selection. Additionally, BEE relies on its own baseline studies to conclude whether an appliance or equipment is to be brought under the S&L programme. BEE has established separate technical committees for setting standards for each product. The technical committee constituted by BIS includes manufacturers, test laboratories, consumer organisations, technical experts and consultants who deliberate on various aspects of energy efficiency standards and their implication on implementation before recommending them. BEE periodically raises the Minimum Energy Performance Standard (MEPS) and label levels.

The S&L programme has a mandatory labelling scheme and a voluntary labelling scheme. There are currently four products notified under the mandatory labelling scheme, namely frost free refrigerators, room air conditioners (split and window), distribution transformers and tubular fluorescent lights, applying to all models manufactured, imported or sold in India. There are fifteen products under the voluntary labelling scheme, namely room air conditioners (cassette, floor standing tower, ceiling, corner), direct cool refrigerators, induction motors, agricultural pump sets, ceiling fans, domestic LPG stoves, electric geysers, colour televisions, washing machines, laptops, ballasts, office equipment, diesel monoset pumps for agriculture, solid state inverters and diesel generators.

1.2 Objective and the Scope of the Project

An earlier study sponsored by SSEF, *Energy Efficient Products and Indian Consumers* (Bipul Chatterjee and Suresh P Singh, 2012), provided an assessment of consumer awareness of energy conservation and energy-efficient products, which is crucial to the adoption of energy-efficient products.

The focus of this project is to evaluate the performance of the S&L programme by assessing the market penetration of a few selected appliances and equipment notified under BEE's S&L Programme. This study also contains an analysis of the gaps and barriers impacting the adoption of the S&L programme, and provides recommendations to improve the adoption of the S&L programme. The long term goal of this study is to assist policy makers in identifying strategies for maximizing the benefits from the S&L programme.

2. Methodology

The study selected a mix of mandatory and voluntary products, across home appliances and industrial equipment. Refrigerators, air conditioners and distribution transformers were selected from the mandatory category. Water heaters (electric geysers) and induction motors were selected from the voluntary category. The products have been selected for this study based on the maturity of the labelled market, energy intensity, high energy-saving potential, consumer demand and price sensitivity to higher star-rated models.

Task 1: Market assessment of the S&L programme, based on the selected products

- Share of labelled models as a percentage of the overall market for the product (appliance or equipment)
- Number of products for each label (1-star to 5-star)
- Growth in the number of manufacturers covered under the programme
- Growth in number of products and/or models issued with permission to use labels
- Availability of 4-star and 5-star appliances and equipment at retail level
- Number of manufacturers, Indian/foreign production, kind of appliance, organised/unorganised market, nature of supply chain/retail etc

AEEE collected data from various sources, including IEEMA (Indian Electrical & Electronics Manufacturer's Association), CEAMA (Consumer Electronics and Appliances Manufacturers Association) and BEE. AEEE analysed the information to draw conclusions on the growth rate and penetration of star labelled products.

Task 2: Identification of barriers and gaps to large scale adoption of star labelled products

AEEE analysed quantitative and qualitative data from several sources, including published reports, articles and interactions with various stakeholders.

Task 3: Recommendations to improve the adoption of the S&L programme

AEEE has based its recommendations on the data analysed in tasks 2 and 3 mentioned above.

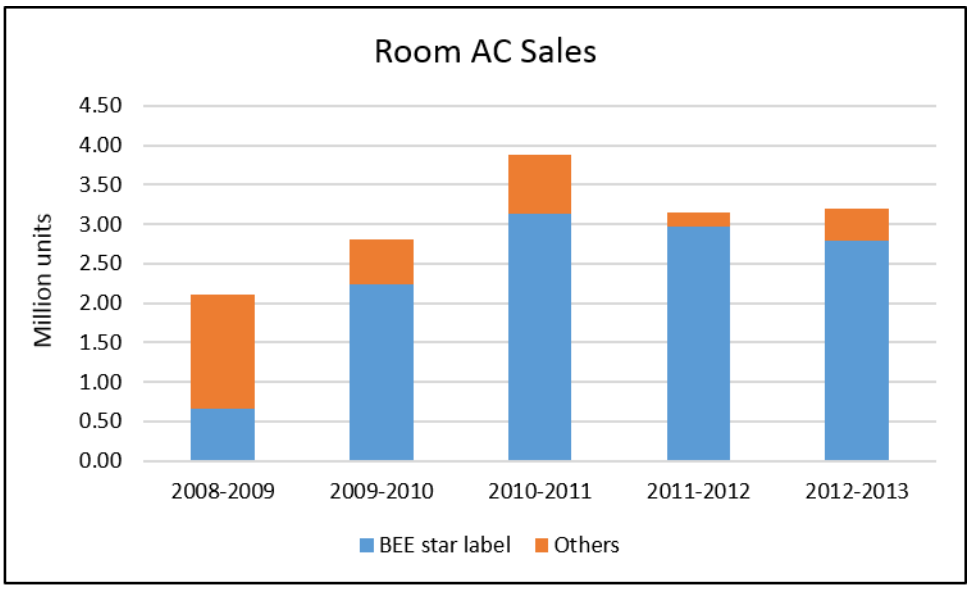
3. Air Conditioners

The air conditioning industry in India is observing a shift from the traditionally dominant commercial sector towards the residential sector. For the year 2011-2012 room air conditioners constituted 50% of the AC market, with 60% of room AC sales in the residential sector. Room AC sales have been growing at 15-20% per year over the last decade and are expected to continue increasing over the next decade. A study by LBNL, *Avoiding 100 New Power Plants by Increasing Efficiency of Room Air Conditioners in India: Opportunities and Challenges* (Amol Phadke, Nikhit Abhyankar, Nihar Shah, 2014), estimates room AC stocks in India to rise to 37 million in 2020 and 116 million in 2030, contributing 46 GW to peak demand in 2020 and 143 GW to peak demand in 2030. The study adds that enhancing the efficiency of room ACs has the potential to save close to 60 GW of peak demand by 2030.

3.1 Labelled Air Conditioners Market in India

BEE launched the voluntary labelling programme for air conditioners in 2006 and made it mandatory for window and split ACs from 2010 onwards. Figure 1 indicates a significant increase in sales for star labelled ACs, while the share of ACs not following the BEE star label scheme reduced from 68% in 2008-2009 to 13% in 2012-2013. BEE's country-wide awareness programmes and promotion schemes during the voluntary stage of the programme played a critical role in pushing the market demand for star labelled ACs. This study did not ascertain the type and/or model of room ACs indicated as "Others" in Figure 1, i.e. not following the BEE star label scheme.

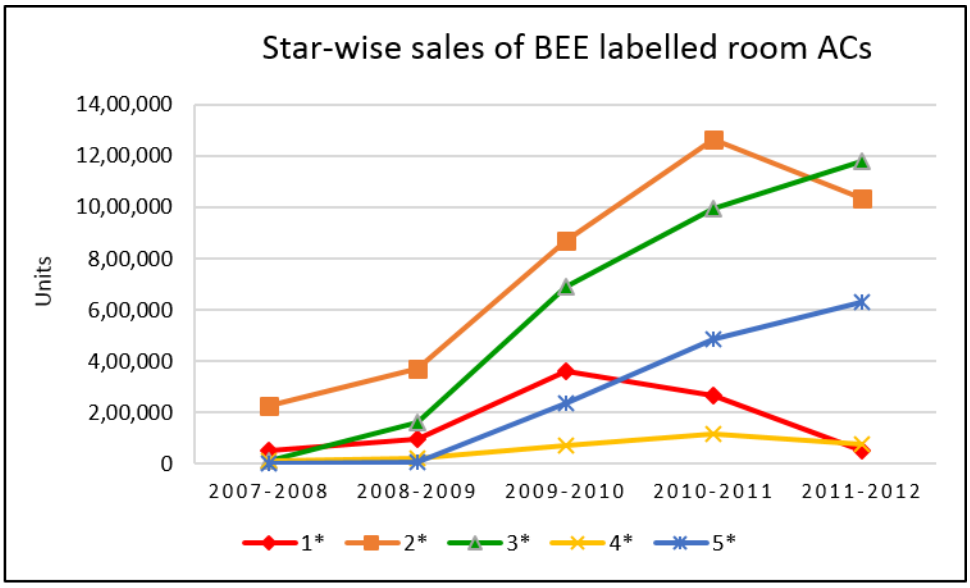
Figure 1. Room AC Sales



Source: CEAMA, BEE

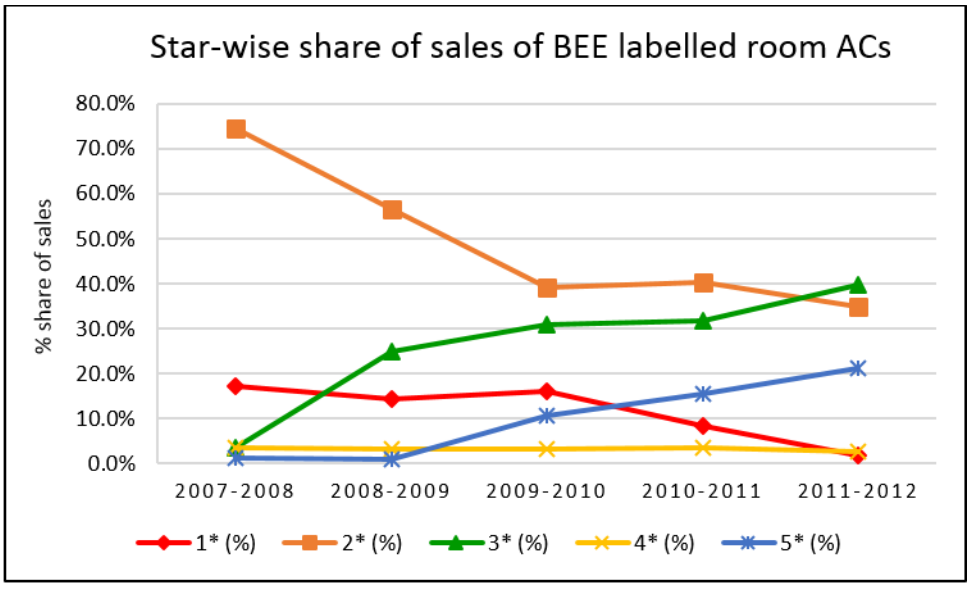
The star-wise sales of labelled ACs is shown in Figure 2 and the % share of sales for each star category is shown in Figure 3. In terms of absolute volume of sales, the market is dominated by 2-star and 3-star ACs, followed by 5-star ACs. However, Figure 3 shows that the market share of 1-star and 2-star ACs has been decreasing whereas the market share of 3-star and 5-star ACs has been increasing. 4-star sales have remained flat in the same period.

Figure 2. Star-wise Sales of BEE Labelled Room ACs



Source: BEE

Figure 3. Star-wise Share of Sales of BEE Labelled Room ACs



Source: BEE

A key observation is that buyers find it worthwhile spending the additional amount to purchase ACs of a higher star-rating. Based on inputs from various stakeholders it appears that the dominance of 2-star and 3-star ACs is primarily due to cost, retailers' margins and pushing through EMI schemes. Consumers prefer to buy higher star-rated ACs provided the price differential is reasonable. Therefore, between 2-star and 3-star ACs, the preferred choice is 3-star as the incremental price difference is not significant. However, this is not the case between 3-star and 5-star. Penetration of ACs of higher rating (particularly 5-star) has been increasing primarily among consumers who use air conditioners for longer hours. Even though the market share of 5-star ACs has been increasing since 2010, it is still significantly lower than the market share of 2-star and 3-star ACs. The key market drivers for higher star-rated ACs are energy savings, easy financing and growing middle class income levels. Besides BEE's nationwide efforts, manufacturers and retailers have started educating consumers on energy efficient products, as well as providing easy financing schemes for higher star-rated appliances. However, the high initial cost of 5-star ACs is still observed to be a hurdle for majority of consumers to invest in them.

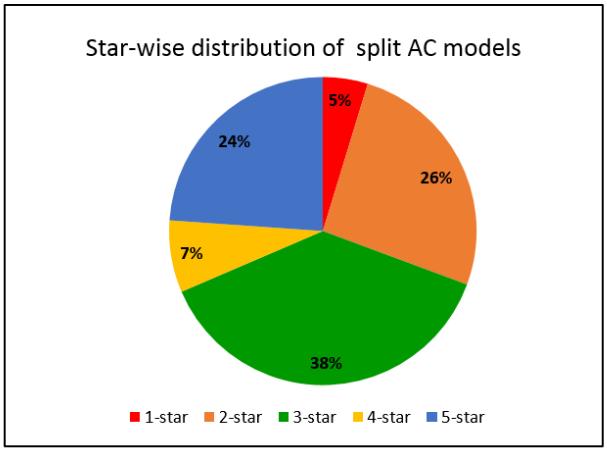
Inverter ACs made an entry into the Indian market in 2012 and now have a market share of 4-5%. Section 3.4 gives a brief overview of inverter ACs.

The major companies in the room AC market are Voltas and LG which together had 40% market share in the first half of 2014, followed by Samsung with 13.7% of market share. Other major companies are Blue Star, Hitachi, Panasonic, Daikin, Godrej and Carrier.

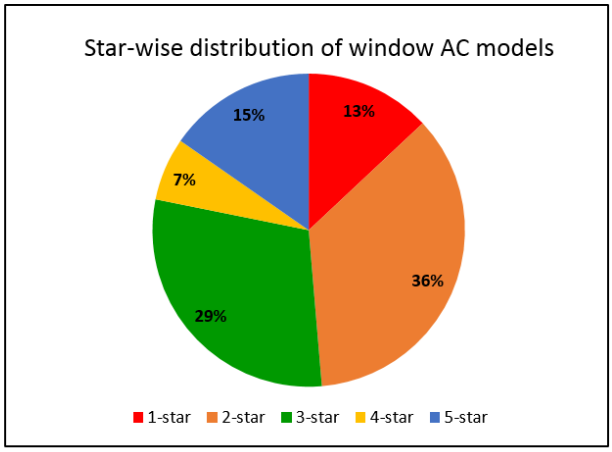
3.2 Manufacturers' Participation

From 12 manufacturers in 2009, the list of registered manufacturers increased to more than 70 in 2014 with more than 1500 registered models. Figure 4 shows the star-wise distribution of registered split and window AC models. The star-wise distribution of registered models more or less mirrors the star-wise sales share. While split and window ACs were notified under the mandatory scheme from 2010 onwards, other room AC models such as cassette, floor standing tower, ceiling and corner AC models are still under the voluntary scheme. Further, BEE is yet to define the labelling standards for inverter ACs, which had 4-5% of market share in 2014.

Figure 4. Star-wise Distribution of Registered AC Models



Source: BEE



Source: BEE

Type of room AC	1-star	2-star	3-star	4-star	5-star	Total
Split AC	65	357	522	104	329	1377
Window AC	34	93	77	17	40	261

3.3 Efficiency Standards for ACs

BEE revises its energy rating for ACs every two years by increasing its energy efficiency ratio (EER). Figure 5 shows the efficiency standards published by BEE for the years 2012-2015. BEE's primary reason for raising efficiency standards at regular intervals is aimed at achieving parity with global AC energy efficiency standards, while giving the industry sufficient bandwidth to keep pace. Every EER revision also affects the cost of new 5-star ACs, influenced by the cost of technology improvements and raw material. Stakeholders point out that there was 8 to 15% increase in retail level cost due to revisions in BEE ratings.

Figure 5. BEE Efficiency Standards Revision for Room ACs

Star level for Window ACs 01-01-2012 to 31-12-2013

	Energy Efficiency Ratio (Watt/Watt)	
Star level	Minimum	Maximum
1 Star *	2.30	2.49
2 Star **	2.50	2.69
3 Star ***	2.70	2.89
4 Star ****	2.90	3.09
5 Star *****	3.10	

Star level for Window ACs 01-01-2014 to 31-12-2015

	Energy Efficiency Ratio (Watt/Watt)	
Star level	Minimum	Maximum
1 Star *	2.50	2.69
2 Star **	2.70	2.89
3 Star ***	2.90	3.09
4 Star ****	3.10	3.29
5 Star *****	3.30	

Star level for Split ACs 01-01-2012 to 31-12-2013

	Energy Efficiency Ratio (Watt/Watt)	
Star level	Minimum	Maximum
1 Star *	2.50	2.69
2 Star **	2.70	2.89
3 Star ***	2.90	3.09
4 Star ****	3.10	3.29
5 Star *****	3.30	

Star level for Split ACs 01-01-2014 to 31-12-2015

	Energy Efficiency Ratio (Watt/Watt)	
Star level	Minimum	Maximum
1 Star *	2.70	2.89
2 Star **	2.90	3.09
3 Star ***	3.10	3.29
4 Star ****	3.30	3.49
5 Star *****	3.50	

3.4 Inverter AC

An inverter AC uses a variable-speed drive to control the speed of the motor and compressor in response to temperature changes. This is in contrast to conventional non-inverter ACs in which the motor and compressor operate at a constant speed, stopping and restarting in response to temperature changes.

The core benefits of inverter technology are as follows

- 30%-50% less energy consumption
- Better at maintaining a constant temperature
- More reliable in extreme temperatures
- Quieter operation
- Less wear and tear (leading to longer life span)

Inverter ACs were introduced into the Indian market in 2012 and now have a market share of 4-5%, which is expected to increase. In Japan the market share of inverter ACs is 100% and in China it is 50%.

The estimated savings of inverter ACs are 20-25% more than a 5-star rated AC and 35-40% more than a 3-star rated AC. The average cost of a 1.5 ton inverter AC is INR 50,000-60,000 versus INR 35,000-45,000 for a 1.5 ton 5-star AC.

BEE is yet to formalise the efficiency standard for inverter ACs. In formulating these standards it would be important to also include standards for efficient, environment-friendly refrigerants.

3.5 Barriers and Gaps Impacting S&L Programme Adoption

BEE has been working extensively towards the promotion of the Star Labelling Programme to capture the appliance value chain: manufacturers with higher efficiency criteria and product differentiation are selling their product as a premium product. By offering energy-saving appliances to consumers, the programme hoped the payback would be within 1-2 years. BEE had recognised that the crux to achieving the above payback period was extensive awareness programmes and steady improvement of appliance standards, eventually being on par with international appliance ratings and achieving higher energy savings. Some of the key awareness programmes included BEE's partnership with Emerson Climate Technologies and International Copper Promotion Council (India) for nationwide training programmes for appliance showroom salesmen. BEE aims to achieve an EER of 6-8 (from the current 3.5) by 2030. In this context, AEEE held stakeholder dialogues to identify how opportunities fructified and what barriers still exist in the star-labelling programme. Table 1 lists the barriers and gaps impacting the star-labelled market for ACs.

Table 1: Barriers to Star Labelled AC Market in India

Barriers & Gaps	Priority	Stakeholder Comments / AEEE Observations
Frequency of standards revision (every two years)	High	All manufacturers interviewed conveyed that standards stringency revisions done every two years do not let them recover the cost of investment to adhere to the prescribed standard. Hence they are forced to keep AC prices high, which negatively impacts consumer adoption.
High cost of EE technology	High	The price differential for 5-star ACs is high because of additional raw material and technology upgrades. This could also be a barrier to the adoption of the more efficient inverter technology and more efficient low-GWP refrigerants.
Payback period	High	Consumers understand the relevance of 5-star ACs in saving more energy, but the penetration of 5-star ACs is still low because the financial payback is not significant for usage of less than 8 hours/day, which is the case for most consumers.
Testing issues	High	A report on capacity assessment and building of labs in India (2012) says that there are primarily four AC labs with a total capacity of testing 695 units per year, whereas there are more than 1,000 models registered annually.

Barriers & Gaps	Priority	Stakeholder Comments / AEEE Observations
Label distribution	Moderate	Labelling is self-declared by manufacturers, but the lack of sufficient testing facilities could impact labelling by manufacturers.
Different standards for window & split ACs	Low	Room ACs are tested with IS 1391 with all amendments.
Unorganised market	Low	In spite of mandatory labelling for room ACs, Figure 1 indicates that there are still room ACs in the market that do not follow the BEE S&L programme.

3.6 Recommendations

BEE analysis shows that prioritising improvement in the efficiency of ACs at 3% per annum would help achieve an EER of 6 by 2030, enabling a savings of 40 GW. If the energy efficiency criteria were aggressively improved to 8% per annum, the EER could be increased up to 8 and an impressive saving of 60 GW would be possible. Equally important is the adoption of energy-efficient appliances and equipment by consumers. BEE has acknowledged that it needs to prioritise the review of the best available technology, cost benefit analysis, review of challenges in implementation of policy initiatives and defining of a future roadmap for market transformation. The lessons from current market analysis are critical indicators of policy and deployment gaps, which need to be addressed in order to accelerate the adoption of energy-efficient appliances and equipment.

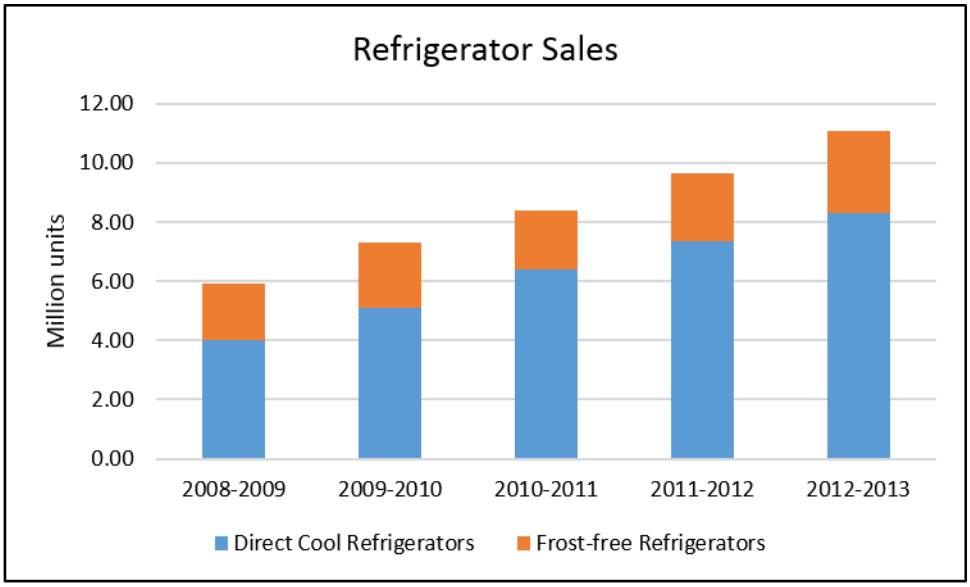
- Address the issue of the cost of technology and longer payback period for higher star-rated ACs, both for manufacturers and consumers
    - Study the application of inverter technology and energy-efficient low-GWP refrigerants for ACs. Given that the technology has already captured 100% of the Japanese market and 50% of the Chinese market, it is worthwhile analysing the market in those countries to apply similar strategies in India.
    - The government could incentivise manufacturers to use more energy efficient technology, especially for technology that can be used across various appliances and equipment, e.g. compressors and refrigerants, thereby bringing down the cost of appliances. As can be seen from Figures 2 and 3, customers are willing to pay more for more efficient appliances provided the price differential is not that much.

    - Manufacturers and retailers could provide customers with attractive financing / EMI schemes.
- Ensure more accurate, comprehensive and timely testing & verification of star labelled ACs
    - Develop a formal standardised procedure for check testing and challenge testing
    - Include all AC models in the star rating scheme
    - Build and/or certify more laboratories and testing facilities
    - Ensure the accountability of all the stakeholders in the process: Enhance the role of the Standards & Labelling Implementation Committee
- Continue with consumer awareness: Empower SDAs as identified in EC Act to promote S&L programme

4. Refrigerators

The domestic market for refrigerators grew from sales of 5.9 million units in 2008-2009 to 11.1 million units in 2012-2013, with direct cool refrigerators (DCR) comprising 70-75% of the market. According to the study *Energy Efficient Products and Indian Consumers* (Bipul Chatterjee and Suresh P Singh, 2012), household penetration of refrigerators in 2012 was 50% overall, ranging from 32% in households with monthly incomes less than INR 10,000 to 96% in households with monthly incomes more than INR 75,000. Figure 6 indicates refrigerator sales for the years 2008-2009 to 2012-2013, split by direct cool and frost-free. It appears that consumers are driven more by the lower price and lower energy consumption of direct cool refrigerators rather than the convenience of frost-free refrigerators. However, there is a growing demand for higher capacity frost-free models. A study by GfK reported that almost two-thirds of the new models introduced in 2014 were frost-free models. The LBNL study *Estimate of Technical Potential for Minimum Efficiency Performance Standards in 13 Major World Economies* (Virginie Letschert, Louis-Benoit Desroches, Jing Ke, Michael McNeil, 2012) estimates a 50% reduction in energy consumption in refrigerators by using the Best Available Technology (BAT), such as variable-speed compressors, larger heat exchange area and vacuum-insulated panels, among others.

Figure 6. Refrigerator Sales



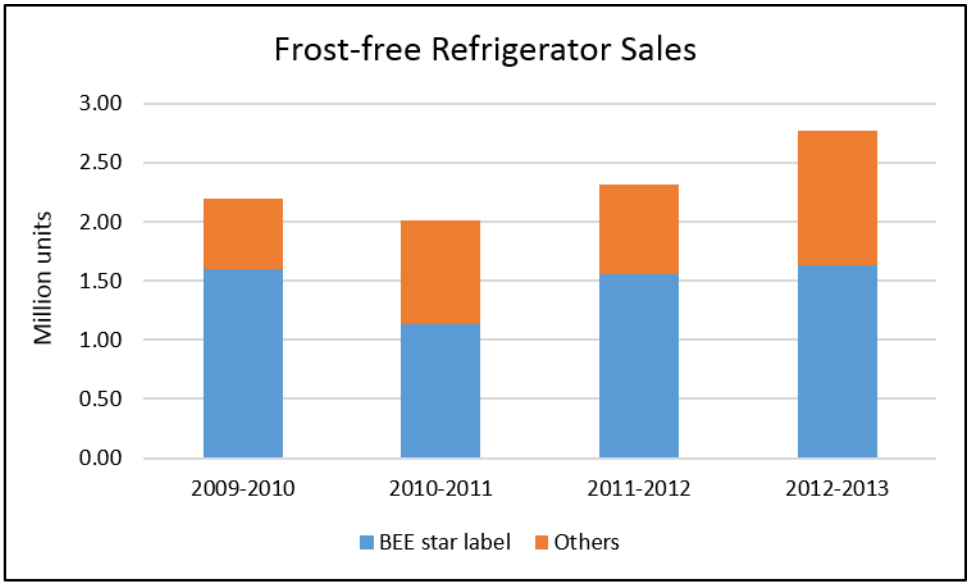
Source: CEAMA

4.1 Labelled Refrigerators Market in India

Both frost-free and direct cool refrigerators were notified under BEE's voluntary labelling scheme in 2006. However, mandatory labelling was introduced for frost-free refrigerators in 2010 and is expected to be introduced for direct cool models in 2015. Figure 7 indicates the growth of

labelled frost-free refrigerators from 2009-2010 to 2012-2013. Though BEE labelling for frost-free refrigerators was made mandatory in 2010 close to 40% of the sales in 2012-2013 was from models not following BEE's star labelling scheme. This study has not looked into details of the sales of units not following BEE's star labelling scheme.

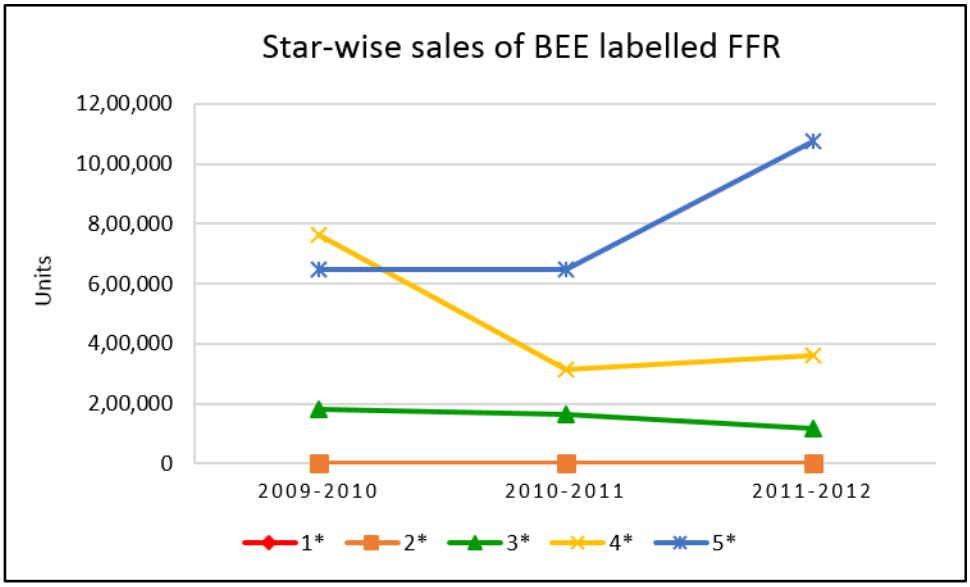
Figure 7. Frost-free Refrigerator Sales



Source: CEAMA, BEE

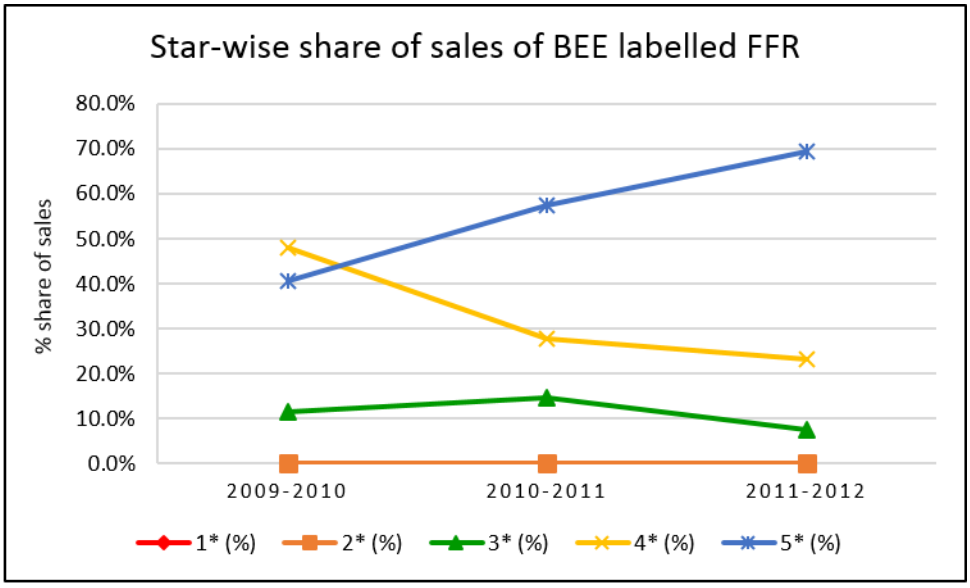
Figures 8 and 9 indicate the star-wise sales volume and star-wise % share of sales for frost-free refrigerators for the years 2009-2010 to 2011-2012. Sales of 5-star rated FFR's clearly outstrip sales of 3-star and 4-star FFRs, rising from 40% in 2009-2010 to 70% in 2011-2012. Sales of 1-star and 2-star models are negligible.

Figure 8. Star-wise Sales of BEE Labelled Frost-free Refrigerators



Source: BEE

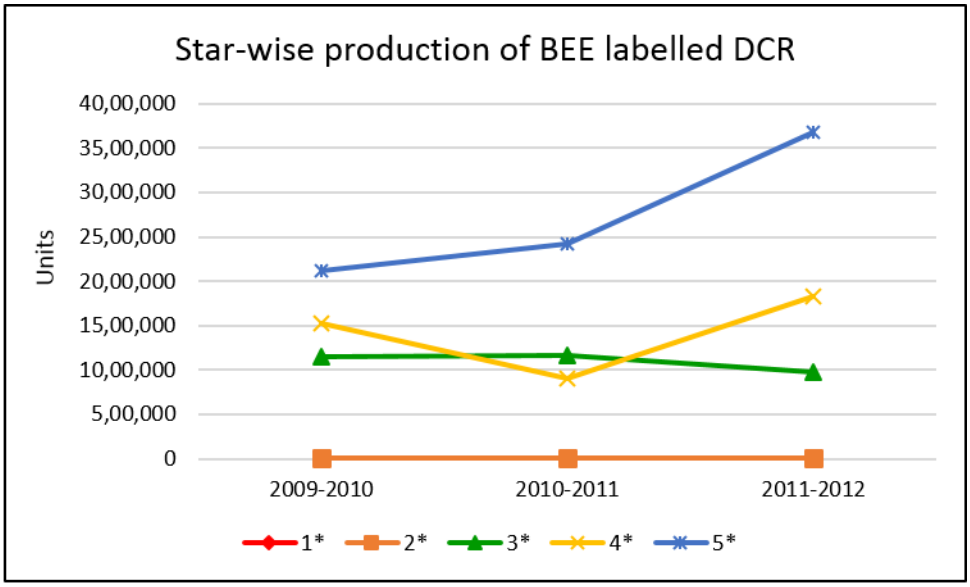
Figure 9. Star-wise Share of Sales of BEE Labelled Frost-free Refrigerators



Source: BEE

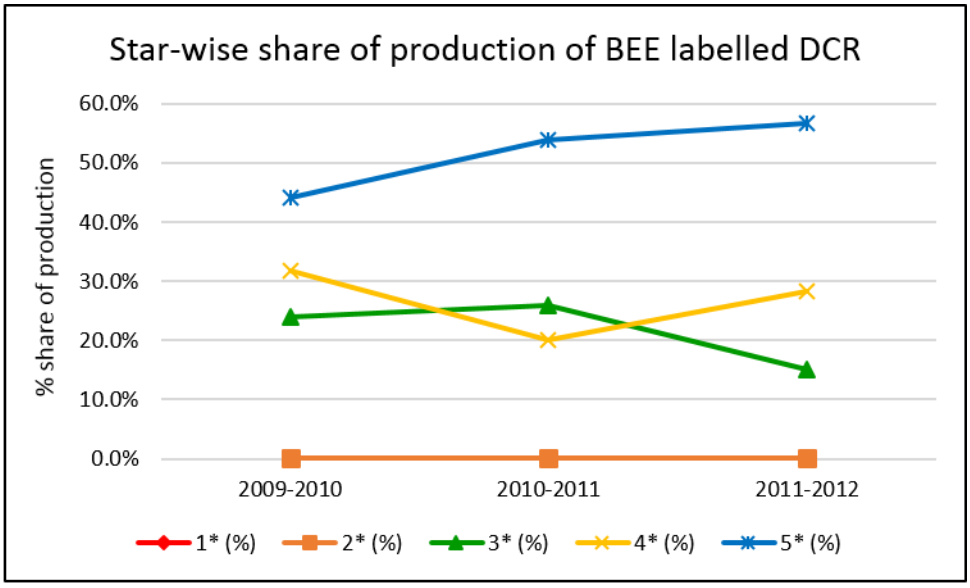
Figures 10 & 11 indicate the star-wise production volume and star-wise % share of production volume for direct cool refrigerators for the years 2009-2010 to 2011-2012. Based on the production data for direct cool refrigerators there seems to be an increasing demand for 4-star and 5-star rated refrigerators. 5-star DCRs constitute 56% of production volume and 4-star DCRs constitute 28% of production volume for the year 2011-2012.

Figure 10. Star-wise Production of BEE Labelled Direct Cool Refrigerators



Source: BEE

Figure 11. Star-wise Share of Production of BEE Labelled Direct Cool Refrigerators



Source: BEE

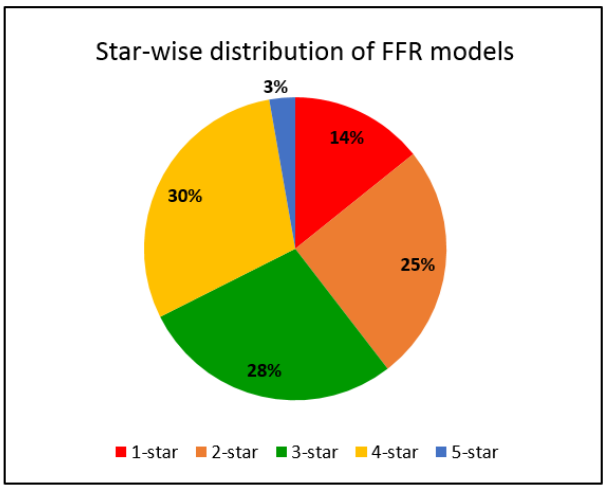
Refrigerators using inverter technology were introduced a few years ago but these are primarily higher capacity models. Since inverter refrigerators were introduced recently, this study did not analyse the sales volume or market share of the inverter technology models.

LG, Videocon, Whirlpool, Godrej and Samsung are the major players in the refrigerator market, with a combined market share of 95%.

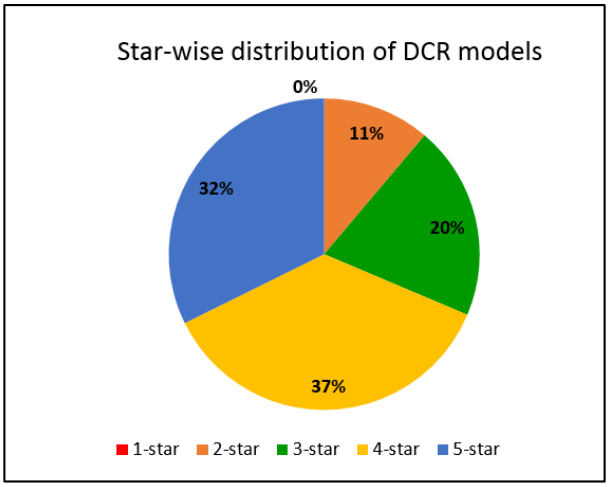
4.2 Manufacturers' Participation

The number of registered manufacturers for BEE's labelling program for frost-free refrigerators is 24 and for direct cool refrigerators is 17. Figure 12 indicates the star-wise share of registered models for frost-free and direct cool refrigerators. Close to 70% of direct cool models are 4-star and 5-star rated, probably indicating the demand for these models among consumers. However, for frost-free refrigerators only 3% of models are 5-star rated even though 5-star rated models constituted close to 70% of frost-free refrigerator sales in 2011-2012. BEE is yet to define labelling standards for refrigerators using inverter technology.

Figure 12. Star-wise Distribution of Registered Refrigerator Models



Source: BEE



Source: BEE

Type of room AC	1-star	2-star	3-star	4-star	5-star	Total
Frost-free (FFR)	62	110	122	129	12	435
Direct Cool (DCR)	0	36	65	117	104	322

4.3 Efficiency Standards for Refrigerators

Efficiency Standards for Frost-free Refrigerators

The star rating for frost-free refrigerator models is based on the Comparative Energy Consumption (CEC) for the model, measured in kWh/year. The Star Rating Band (SRB) is calculated using the formula given below:

$$SRB_{nf} = k_{nf} * V_{adj\_tot\_nf} + c_{nf}$$

where,

k_{nf} = constant multiplier (kWh/litre/year)

$V_{adj\_tot\_nf}$ = total adjusted storage volume for no frost (litre)

c_{nf} = constant fixed allowance (kWh/year)

BEE revises the efficiency standard for frost-free refrigerators every 2 years. Tables 2, 3 and 4 give the star rating bands for each 2-year period from January 2010 to December 2015. As can be seen from the table, with each revision the efficiency standard for the 5-star rating is set at a higher level, and the SRB's 1-star, 2-star, 3-star, 4-star move up a level to the previous 2-year period's standard for 2-star, 3-star, 4-star, 5-star respectively.

Table 2. Star Rating Band for Frost-free Refrigerators 07 January 2010 to 31 December 2011

Star Rating Band (SRB)	Comparative Energy Consumption (CEC) Criteria
1 Star *	$0.6973 * V_{adj\_tot\_nf} + 607 \leq CEC < 0.8716 * V_{adj\_tot\_nf} + 759$
2 Star **	$0.5578 * V_{adj\_tot\_nf} + 486 \leq CEC < 0.6973 * V_{adj\_tot\_nf} + 607$
3 Star ***	$0.4463 * V_{adj\_tot\_nf} + 389 \leq CEC < 0.5578 * V_{adj\_tot\_nf} + 486$
4 Star ****	$0.3570 * V_{adj\_tot\_nf} + 311 \leq CEC < 0.4463 * V_{adj\_tot\_nf} + 389$
5 Star *****	$< 0.3570 * V_{adj\_tot\_nf} + 311$

Table 3. Star Rating Band for Frost-free Refrigerators 01 January 2012 to 31 December 2013

Star Rating Band (SRB)	Comparative Energy Consumption (CEC) Criteria
1 Star *	$0.5578 * V_{adj\_tot\_nf} + 486 \leq CEC < 0.6973 * V_{adj\_tot\_nf} + 607$
2 Star **	$0.4463 * V_{adj\_tot\_nf} + 389 \leq CEC < 0.5578 * V_{adj\_tot\_nf} + 486$
3 Star ***	$0.3570 * V_{adj\_tot\_nf} + 311 \leq CEC < 0.4463 * V_{adj\_tot\_nf} + 389$
4 Star ****	$0.2856 * V_{adj\_tot\_nf} + 249 \leq CEC < 0.3570 * V_{adj\_tot\_nf} + 311$
5 Star *****	$< 0.2856 * V_{adj\_tot\_nf} + 249$

Table 4. Star Rating Band for Frost-free Refrigerators 01 January 2014 to 31 December 2015

Star Rating Band (SRB)	Comparative Energy Consumption (CEC) Criteria
1 Star *	$0.3570 * V_{adj\_tot\_nf} + 311 \leq CEC < 0.4463 * V_{adj\_tot\_nf} + 389$
2 Star **	$0.2856 * V_{adj\_tot\_nf} + 249 \leq CEC < 0.3570 * V_{adj\_tot\_nf} + 311$
3 Star ***	$0.2285 * V_{adj\_tot\_nf} + 199 \leq CEC < 0.2856 * V_{adj\_tot\_nf} + 249$
4 Star ****	$0.1828 * V_{adj\_tot\_nf} + 159 \leq CEC < 0.2285 * V_{adj\_tot\_nf} + 199$
5 Star *****	$< 0.1828 * V_{adj\_tot\_nf} + 159$

Efficiency Standards for Direct Cool Refrigerators

The star rating for direct cool refrigerator models also is based on the Comparative Energy Consumption (CEC) for the model, measured in kWh/year. The Star Rating Band (SRB) is calculated using the formula given below:

$$SRB_{dc} = k_{dc} * V_{adj\_tot\_dc} + c_{dc}$$

where,

k_{dc} = constant multiplier (kWh/litre/year)

$V_{adj\_tot\_dc}$ = total adjusted storage volume for direct cool (litre)

c_{dc} = constant fixed allowance (kWh/year)

BEE revises the efficiency standard for direct cool refrigerators every 2 years. Star labelling for direct cool refrigerators will be made mandatory in January 2015. Tables 5, 6 and 7 give the star rating bands for each 2-year period from January 2010 to December 2015. In the case of direct cool refrigerators too, with each revision the efficiency standard for the 5-star rating is set at a higher level, and the SRB's 1-star, 2-star, 3-star, 4-star move up a level to the previous 2-year period's standard for 2-star, 3-star, 4-star, 5-star respectively.

Table 5. Star Rating Band for Direct Cool Refrigerators 01 Nov 2006 to 31 Dec 2014

Star Rating Band (SRB)	Comparative Energy Consumption (CEC) Criteria
1 Star *	$0.516 * V_{adj\_tot\_dc} + 432 \leq CEC < 0.645 * V_{adj\_tot\_dc} + 541$
2 Star **	$0.413 * V_{adj\_tot\_dc} + 346 \leq CEC < 0.516 * V_{adj\_tot\_dc} + 432$
3 Star ***	$0.33 * V_{adj\_tot\_dc} + 277 \leq CEC < 0.413 * V_{adj\_tot\_dc} + 346$
4 Star ****	$0.264 * V_{adj\_tot\_dc} + 221 \leq CEC < 0.33 * V_{adj\_tot\_dc} + 277$
5 Star *****	$CEC < 0.264 * V_{adj\_tot\_dc} + 221$

Table 6. Star Rating Band for Direct Cool Refrigerators 01 January 2015 to 31 December 2016

Star Rating Band (SRB)	Comparative Energy Consumption (CEC) Criteria
1 Star *	$0.413 * V_{adj\_tot\_dc} + 346 \leq CEC < 0.516 * V_{adj\_tot\_dc} + 432$
2 Star **	$0.33 * V_{adj\_tot\_dc} + 277 \leq CEC < 0.413 * V_{adj\_tot\_dc} + 346$
3 Star ***	$0.264 * V_{adj\_tot\_dc} + 221 \leq CEC < 0.33 * V_{adj\_tot\_dc} + 277$
4 Star ****	$0.211 * V_{adj\_tot\_dc} + 177 \leq CEC < 0.264 * V_{adj\_tot\_dc} + 221$
5 Star *****	$< 0.211 * V_{adj\_tot\_dc} + 177$

Table 7. Star Rating Band for Direct Cool Refrigerators 01 January 2017 to 31 December 2018

Star Rating Band (SRB)	Comparative Energy Consumption (CEC) Criteria
1 Star *	$0.264 * V_{adj\_tot\_dc} + 221 \leq CEC < 0.33 * V_{adj\_tot\_dc} + 277$
2 Star **	$0.211 * V_{adj\_tot\_dc} + 177 \leq CEC < 0.264 * V_{adj\_tot\_dc} + 221$
3 Star ***	$0.169 * V_{adj\_tot\_dc} + 141 \leq CEC < 0.211 * V_{adj\_tot\_dc} + 177$
4 Star ****	$0.135 * V_{adj\_tot\_dc} + 113 \leq CEC < 0.169 * V_{adj\_tot\_dc} + 141$
5 Star *****	$< 0.135 * V_{adj\_tot\_dc} + 113$

Table 8 gives the mandated CEC range for a 250 litre frost-free refrigerator for the BEE efficiency standards in each 2-year period. There is a 20% improvement from 2010-2011 to 2012-2013 and a 36% improvement from 2012-2013 to 2014-2015.

Table 8. CEC (kWh/year) for 250L Frost-free Refrigerator

Star Rating Band	2010-2011 Standard	2012-2013 Standard	2014-2015 Standard
3 Star ***	501 - 625	400 – 501	256 - 320
4 Star ****	400 – 501	320 – 400	205 - 256
5 Star *****	< 400	< 320	< 205

Table 9 gives the mandated CEC range for a 250 litre direct cool refrigerator for the BEE efficiency standards up to December 2014 (voluntary phase) and the 2-year periods 2015-2016 and 2017-2018. There is a 20% improvement from 2006-2014 to 2015-2016 and a 36% improvement from 2015-2016 to 2017-2018.

Table 9. CEC (kWh/year) for 250L Direct Cool Refrigerator

Star Rating Band	2006-2014 Standard	2015-2016 Standard	2017-2018 Standard
3 Star ***	360 – 449	287 – 360	183 - 230
4 Star ****	287 – 360	230 – 287	147 - 183
5 Star *****	< 287	< 230	< 147

The LBNL study *Estimate of Technical Potential for Minimum Efficiency Performance Standards in 13 Major World Economies* (Virginie Letschert, Louis-Benoit Desroches, Jing Ke, Michael McNeil, 2012) and the SSEF-sponsored study *Techno-economic analyses of the Incremental Cost of Super Efficiency for Refrigerators in India* (August 2012) suggest several technologies that can improve efficiency of refrigerators. It would also be worthwhile to study how inverter technology captured 100% of the market in Japan and 50% of the market in China, also a developing economy.

4.4 Barriers and Gaps Impacting S&L Programme Adoption

The share of 4-star and 5-star models in the refrigerator market is much higher than that in the AC market. In order to further improve S&L programme adoption AEEE met with various stakeholders to get inputs on barriers and gaps that need to be addressed.

Table 10. Barriers to Star Labelled Refrigerator Market in India

Barriers & Gaps	Priority	Stakeholder Comments / AEEE Observations
Label distribution	Moderate	Labelling is self-declared by manufacturers. Though manufacturers are subject to check testing and challenge testing, there is still scope for non-uniformity and/or non-compliance to testing methods and conditions.

Barriers & Gaps	Priority	Stakeholder Comments / AEEE Observations
Unorganised market	Low	Based on the sales data from CEAMA and BEE, in spite of mandatory labelling for frost-free refrigerators there still seem to be sales of non-labelled units.

4.5 Recommendations

- Given the significant household penetration of refrigerators and the consumer preference for 4-star and 5-star models, both BEE and the manufacturers should accelerate the use of the best available technology and drive for more stringent efficiency standards. In doing so, it would be worthwhile to study the adoption of inverter technology in Japan and China, so that similar strategies can be applied to the Indian market.
- In order to address the stakeholders' concern about labelling it's recommended to revisit the labelling process to fix gaps in uniformity and/or conformance when it is applied by various manufacturers, testing and verification labs and standards organisations.

5. Water Heaters

A study conducted by TVJ in 2012 pegged the water heater market in 2010 at 1.7 million units, with a total value of INR 600 crore. Of the market value of INR 600 crore, electric water heaters had a share of 75%, followed by solar water heaters at 15% and gas water heaters at 10%. In 2014, as stated in Business Wire, the annual market for water heaters was pegged at INR 1200-1300 crore, with electric water heaters accounting for INR 800-900 crore. According to the study *Energy Efficient Products and Indian Consumers* (Bipul Chatterjee and Suresh P Singh, 2012), household penetration of water heaters in 2012 was only 6%. However, the same study also noted that the penetration in households with monthly incomes of more than INR 40,000 was 36%, suggesting that as incomes rise there is likely to be more demand and, therefore, increased sales and household penetration.

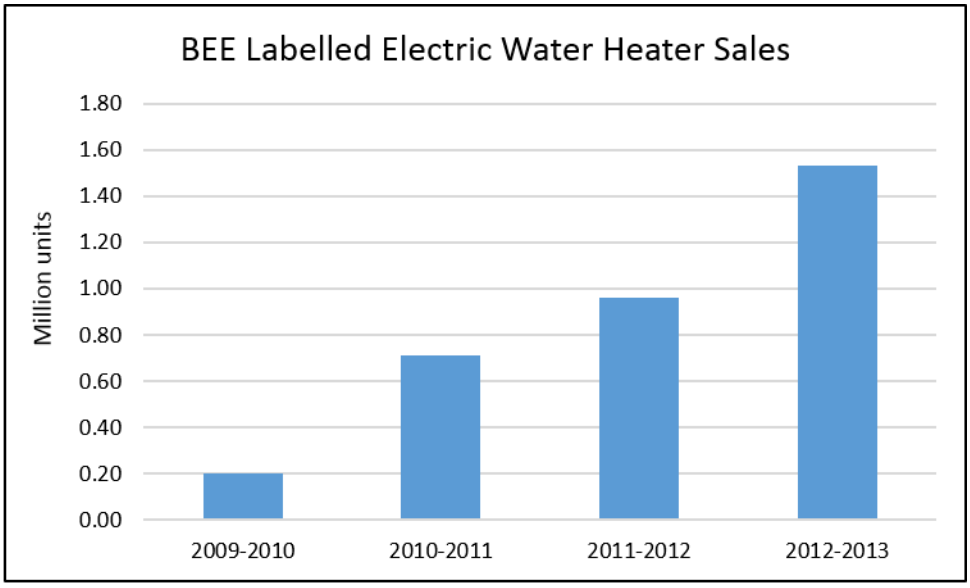
Though solar water heaters and gas water heaters command 25%-30% of the market, BEE's labelling program is currently only for electric water heaters. This study focussed on labelled electric water heaters.

5.1 Labelled Electric Water Heater Market in India

Electric water heaters are currently under BEE's voluntary labelling scheme. BEE will introduce mandatory labelling for electric water heaters in July 2015. Figure 13 indicates the sales volume of BEE labelled electric water heaters. Figures 14 and 15 show the star-wise sales volume and star-wise share of sales respectively. The demand is clearly for 4-star and 5-star models at 50% and 40% market share in 2011-2012. However, while the share of 4-star heaters has been decreasing, the share of 5-star heaters has been increasing in the same period.

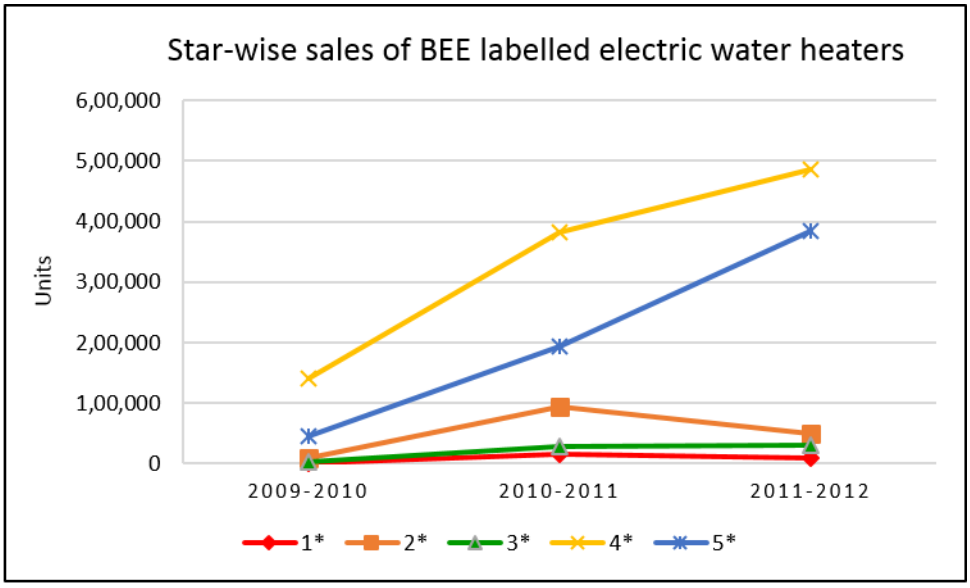
The major players in the market are Racold, Bajaj, Venus, V-guard, Crompton Greaves, Haier, Usha, Havells, Kenstar, Symphony and AO Smith.

Figure 13. BEE Labelled Electric Water Heater Sales



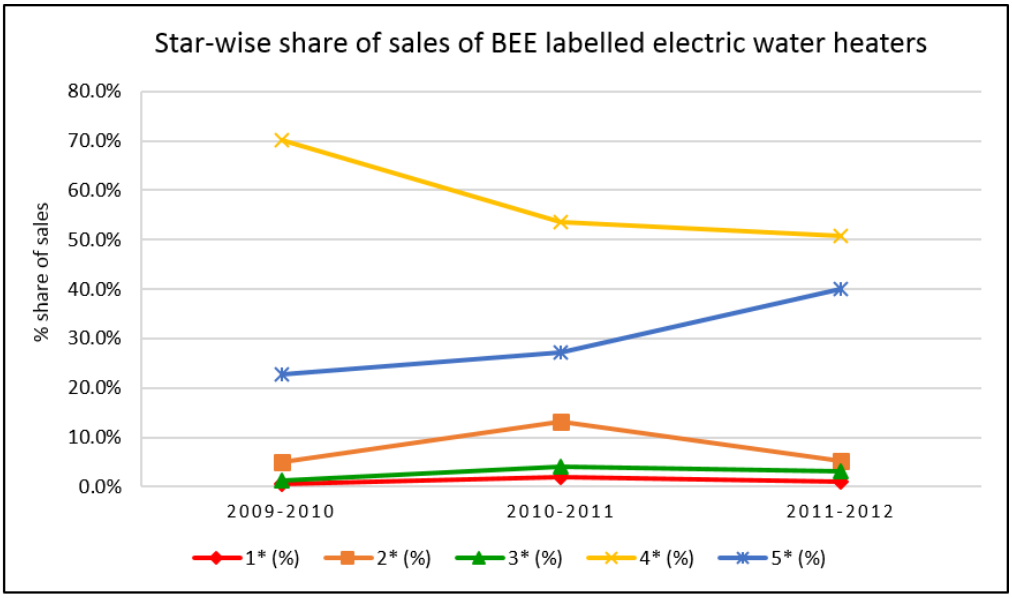
Source: BEE

Figure 14. Star-wise Sales of BEE Labelled Electric Water Heaters



Source: BEE

Figure 15. Star-wise Share of Sales of BEE Labelled Electric Water Heaters

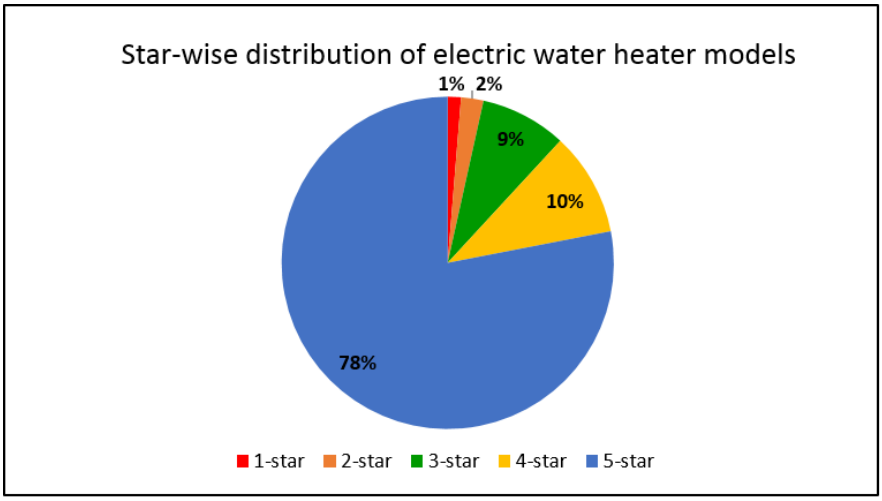


Source: BEE

5.2 Manufacturers' Participation

As of 2014 there were 210 manufacturers registered with BEE. The star-wise distribution of registered models is given in Figure 16. The majority have capacities of 25 litres (362), 15 litres (336), 10 litres (203) and 6 litres (142). 90% of the models have a power rating of 2kW.

Figure 16. Star-wise Distribution of Registered Electric Water Heater Models



Source: BEE

1-star	2-star	3-star	4-star	5-star	Total
16	27	104	125	967	1239

5.3 Efficiency Standards for Electric Water Heaters

BEE's star rating plan for electric water heaters is based on Standing Losses (kWh/24hour/45°C) calculated as per IS 2082:1993. BEE's standard is defined for heater capacities from 6 litres to 200 litres. Tables 11, 12 and 13 list the star rating plans for heater capacities in the range of 6 to 35 litres, the majority of labelled models, for the periods up to June 2014, July 2014 to June 2015 and July 2015 to June 2017 (mandatory labelling phase).

Table 11. Star Rating Plan Valid up to 30 June 2014

Rated Capacity (litres)	Standing Losses (kWh/24 hours/45°C)				
	1 Star *	2 Star **	3 Star ***	4 Star ****	5 Star *****
6	≤0.792 & > 0.634	≤0.634 & > 0.554	≤0.554 & > 0.475	≤0.475 & > 0.396	≤ 0.396
10	≤0.990 & > 0.792	≤0.792 & > 0.693	≤0.693 & > 0.594	≤0.594 & > 0.495	≤ 0.495
15	≤1.138 & > 0.910	≤0.910 & > 0.797	≤ 0.797 & > 0.683	≤0.683 & > 0.569	≤ 0.569
25	≤1.386 & > 1.109	≤1.109 & > 0.970	≤0.970 & > 0.832	≤0.832 & > 0.693	≤ 0.693
35	≤1.584 & > 1.267	≤1. 267 & > 1.109	≤1.109 & > 0.950	≤0.950 & > 0.792	≤ 0.792

Table 12. Star Rating Plan Valid from 1 July 2014 to 30 June 2015

Rated Capacity (litres)	Standing Losses (kWh/24 hours/45°C)				
	1 Star *	2 Star **	3 Star ***	4 Star ****	5 Star *****
6	≤0.521 & > 0.474	≤0.474 & > 0.431	≤0.431 & > 0.392	≤0.392 & > 0.356	≤ 0.356
10	≤0.654 & > 0.594	≤0.594 & > 0.540	≤0.540 & > 0.491	≤0.491 & > 0.446	≤ 0.446
15	≤0.750 & > 0.681	≤0.681 & > 0.620	≤0.620 &> 0.563	≤0.563 & > 0.512	≤ 0.512
25	≤0.914 & > 0.831	≤0.831 & > 0.755	≤0.755 & > 0.686	≤0.686 & > 0.624	≤ 0.624
35	≤1.044 & > .949	≤.949 & > 0.864	≤0.863 & > 0.784	≤0.784 & > 0.713	≤ 0.713

Table 13. Star Rating Plan Valid from 1 July 2015 to 30 June 2017

Rated Capacity (litres)	Standing Losses (kWh/24 hours/45°C)				
	1 Star *	2 Star **	3 Star ***	4 Star ****	5 Star *****
6	≤0.469 & > 0.426	≤0.426 & > 0.387	≤0.387 & > 0.352	≤0.352 & > 0.320	≤ 0.320
10	≤0.587 & > 0.534	≤0.534 & > 0.485	≤0.485 & > 0.441	≤0.441 & > 0.401	≤ 0.401
15	≤ 0.675 & > 0.614	≤0.614 & > 0.558	≤ 0.558 & > 0.507	≤0.507 & > 0.461	≤ 0.461
25	≤0.823 & > 0.748	≤0.748 & > 0.680	≤0.680 & > 0.618	≤0.618 & > 0.562	≤ 0.562
35	≤0.940 & > 0.855	≤0.855 & > 0.777	≤0.777 & > 0.706	≤0.706 & > 0.642	≤ 0.642

In an article in the magazine *MGS Architecture*, dated November 2013, manufacturers said that energy efficiency is a key criterion for consumers purchasing water heaters. Some of the features incorporated to increase energy efficiency are improved insulation to reduce standing losses, better thermostats, latest thermal cut out technology and energy meters. Some manufacturers raised concerns about different standards from BIS and BEE.

5.4 Barriers and Gaps Impacting S&L Programme Adoption

With a combined market share of 90%, 4-star and 5-star electric water heaters already dominate the labelled water heater market. Given the level of adoption of higher star-rated appliances, it's a good opportunity to improve standards. In order to further improve S&L programme adoption AEEE met with various stakeholders to get inputs on barriers and gaps that need to be addressed.

Table 14. Barriers to Star Labelled Water Heater Market in India

Barriers & Gaps	Priority	Stakeholder Comments / AEEE Observations
Difference between BIS and BEE standards	High	Most manufacturers pointed out that BEE and BIS have different standards for water heaters. This could lead to confusion among manufacturers and consumers, who may not be able to compare models and choose the best option.
Gas and solar water heaters not included in BEE standards	High	Given that gas and solar water heaters constitute 25-30% of the market it is important to include them in a comprehensive standard for all domestic water heaters. This would help the consumer make a choice as to the best option for their needs, based on utility, energy efficiency and cost.
Performance degradation	High	Heating efficiency is affected by the hardness of water, so unless there is periodic maintenance the consumer may not get efficiency levels as per the star rating. This could impact consumer trust in the labelling scheme.
Review of international best practices and standards	Moderate	Other than using better insulation, there don't seem to be studies or analyses on different technologies for improving energy efficiency of water heaters.

5.5 Recommendations

The main recommendations to improve S&L programme adoption for water heaters are in the areas of standards and technology.

- Establish a uniform standard for all domestic water heaters
    - Phase 1: Establish a common energy efficiency standard for electric water heaters taking the best criteria from BIS and BEE, while also taking into account international best practices and standards, and the best available technology.
    - Phase 2: Incorporate efficiency standards for solar water heaters and gas water heaters, along with that for electric water heaters, in a common energy efficiency standard. Build consumer awareness on the feasibility & utility of each type of water heater, along with the energy efficiency rating and cost.
- Provide an industry forum for periodically reviewing the best available technology to enable manufacturers and BEE to work towards improving efficiency standards in India and the adoption of more energy efficient products.
    - Review of best available technology worldwide
    - Ways to promote the use of the best available technology, such as incentives for manufacturers, retailers and consumers, consumer awareness programmes

6. Distribution Transformers

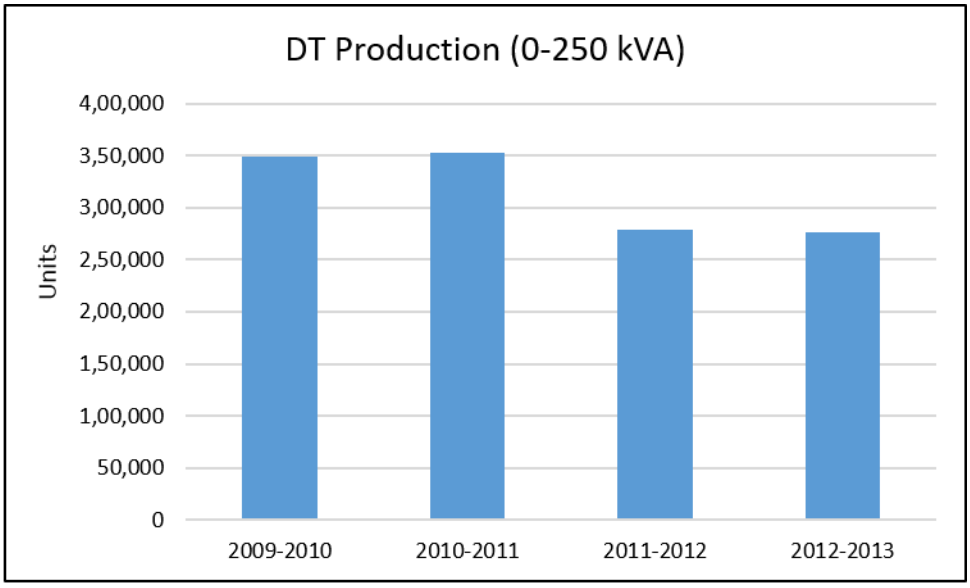
With a peak deficit of 10.5% and an energy deficit of 7.5%, India can ill afford transmission and distribution (T&D) losses. Distribution losses have fallen from 32% in 2003 to around 21% in 2011, but are still well above international best practice. Further, not being paid for a fifth of the power that they generated and/or purchased puts financial pressure on utilities, many of which already suffer huge losses. The Ministry of Power, Government of India, launched the Restructured Accelerated Power Development and Reforms Programme (R-APDRP) in July 2008 to improve accountability and reduce AT&C losses by strengthening and upgrading the sub-transmission and distribution network. The scope of R-APDRP includes the renovation, modernisation and strengthening of 11kV substations and transformers.

Distribution losses can be attributed to under-pricing, under collection and physical losses of energy. Energy efficient distribution transformers (DT) are critical to reducing physical losses of energy. The LBNL study *Estimate of Technical Potential for Minimum Efficiency Performance Standards in 13 Major World Economies* (Virginie Letschert, Louis-Benoit Desroches, Jing Ke, Michael McNeil, 2012) estimates a 50% reduction in energy losses in distribution transformers by using the Best Available Technology (BAT), such as amorphous metal cores and hexaformer geometries.

As per CEA guidelines the standard ratings for 11kV/433-250V distribution transformers are 10, 16, 25, 63, 100, 160, 200, 250, 315, 400, 500, 630, 1000, 1250, 1600, 2000 and 2500 kVA. This study looked into 11kV/433-250V DT's in the range 0-250 kVA, since those are the models that are notified under BEE's mandatory labelling scheme.

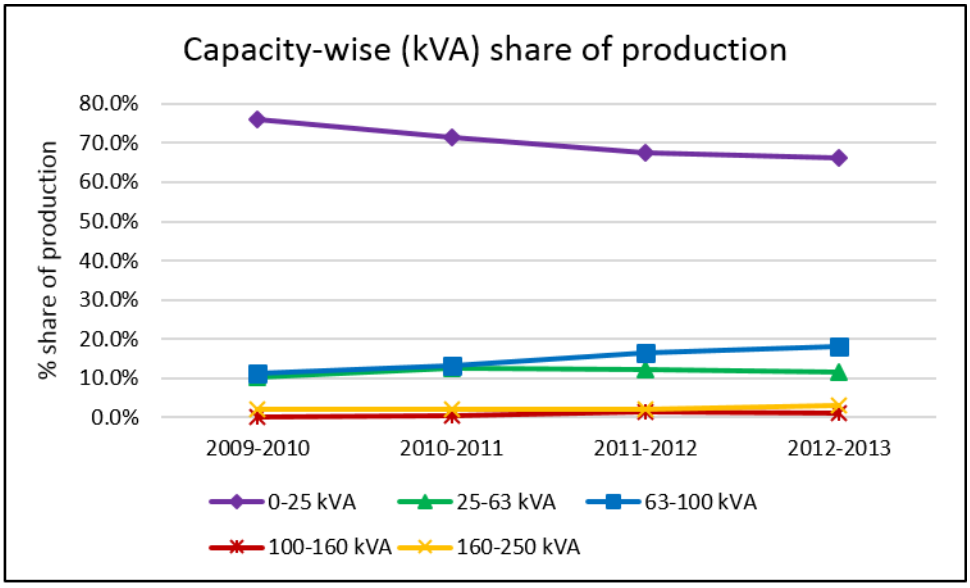
Since distribution transformers are produced based on order bookings, this study used production data from IEEMA (Indian Electrical and Electronics Manufacturers' Association) to gauge the market size for DT's. Figure 17 indicates the production volumes for DTs in the range of 0-250 kVA and Figure 18 shows the capacity-wise share of production for the same period, 2009-2010 to 2012-2013.

Figure 17. DT Production Volumes (0-250 kVA)



Source: IEEMA

Figure 18. Capacity-wise Share of Production of DT



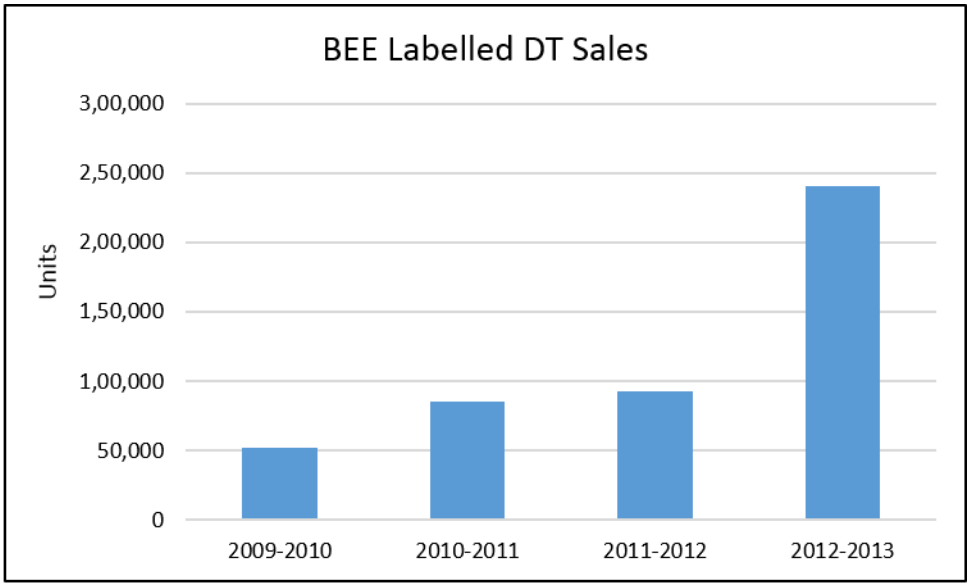
Source: IEEMA

6.1 Labelled Distribution Transformer Market in India

BEE introduced mandatory labelling for 11 kV/433-250V distribution transformers in the range of 16-200 kVA in July 2009. The labelling scheme includes the standard ratings 16, 25, 63, 100, 160, 200 kVA and non-standard ratings from 16-200 kVA. Figure 19 shows the absolute sales volume of BEE labelled DT's in the years 2009-2010 to 2012-2013. BEE's sales figures are only for

DT's in the range 16-200 kVA, whereas the production data in Figure 17 is for DT's in the range 0-250 kVA. All the same, viewing Figure 19 (Labelled DT sales) in conjunction with Figure 17 (DT production volumes), seems to indicate an increasing share of star-rated DT's in the overall market for DT's in the range 0-250kVA. For example, in the year 2012-2013 DT production stood at 2,76,404 units and sales of BEE labelled DTs stood at 2,40,389 units, about 86% of market share.

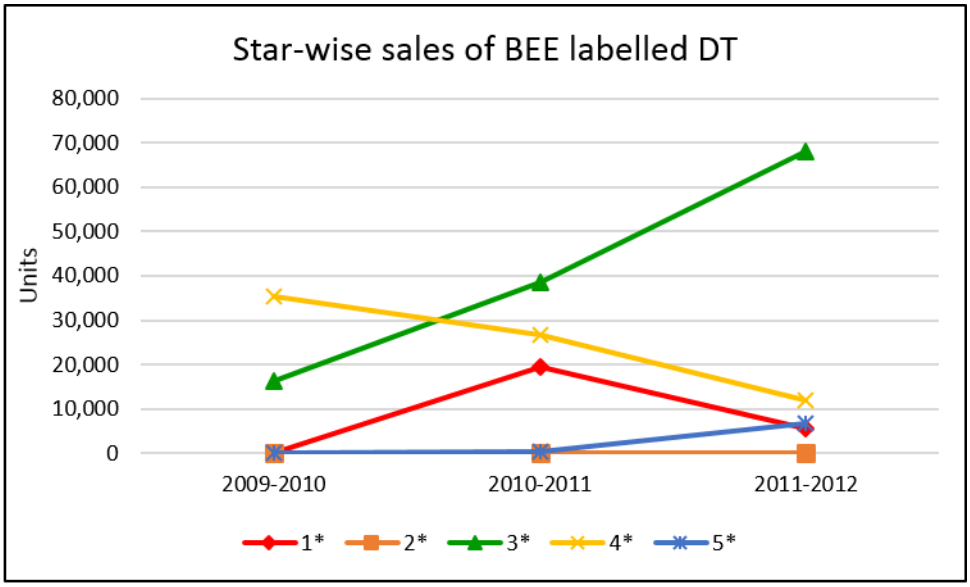
Figure 19. BEE Labelled Distribution Transformer Sales



Source: BEE

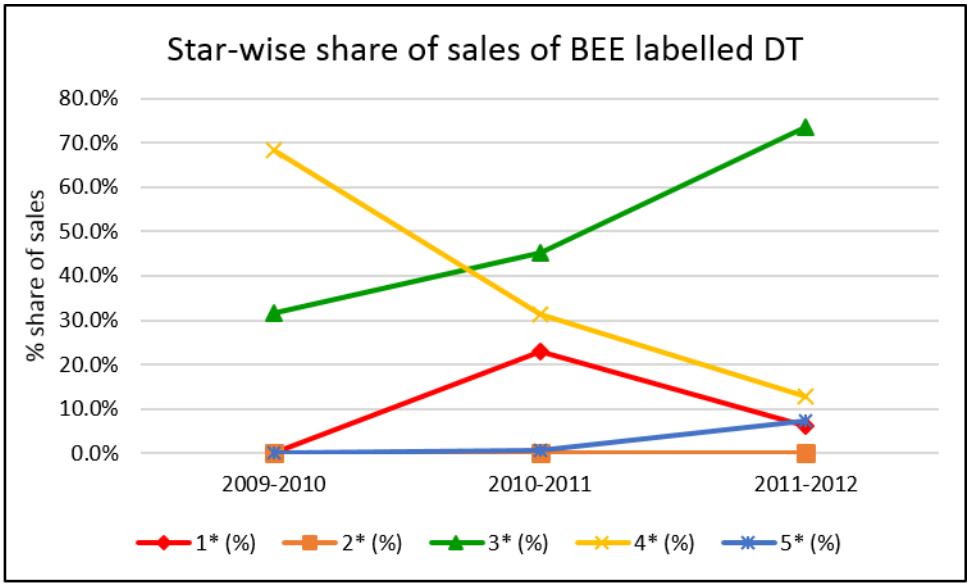
Figures 20 and 21 show the star-wise sales volume of BEE labelled DT's and the star-wise share of sales of BEE labelled DT's, respectively. For the 3-year period shown in Figure 21 sales were dominated by 3-star and 4-star DT's, probably because the Central Electricity Authority guidelines stipulate that utilities use DT's rated 3-star or higher, and the main customers for DT's are utilities. However, there has been a significant decline in the market share of 4-star DT's while that of 3-star DT's has increased. It's interesting to note that there was a spurt of sales of 1-star DT's in 2010-2011, though it's not clear in which market segment this was.

Figure 20. Star-wise Sales of BEE Labelled Distribution Transformers



Source: BEE

Figure 21. Star-wise Share of Sales of BEE Labelled Distribution Transformers

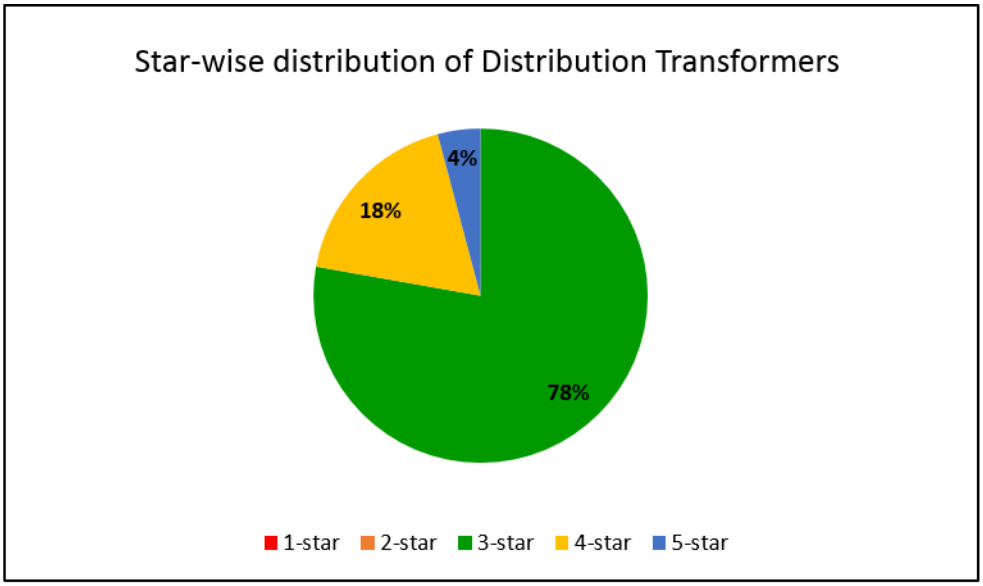


Source: BEE

6.2 Manufacturers' Participation

In 2014 there were 572 manufacturers registered with BEE. The star-wise distribution of registered models is shown in Figure 22. 3-star models make up the bulk of registered models. There are no 1-star and 2-star models. In terms of capacity rating, 25 kVA, 63 kVA and 100 kVA DT's make up 75% of registered models.

Figure 22. Star-wise Distribution of Registered DT Models



Source: BEE

1-star	2-star	3-star	4-star	5-star	Total
0	0	1110	258	59	1427

6.3 Efficiency Standards for Distribution Transformers

BEE's rating plan for distribution transformers is based on energy losses at 50% load and at 100% load. The highest loss segment is rated as 1-star and the lowest loss segment is rated as 5-star. Table 15 lists the star rating plan for 11kV/433-250V distribution transformers in the range 16-200 kVA. This star rating plan was made mandatory in July 2009. At the time of writing this report there was no further revision of the standard. The efficiency of DT's is affected by the materials used, especially the material used for the core. The material most frequently used for the core is Cold Rolled Grain Oriented (CRGO) steel. The use of amorphous metal cores can significantly reduce the energy losses in DT's. Though BIS has a standard for the use of CRGO steel, it is yet to establish a standard for the use of amorphous metal cores. However, manufacturers are also using amorphous cores for DT's in India.

Table 15. BEE Star Rating Plan for Distribution Transformers

Rating	1 Star *		2 Star **		3 Star ***		4 Star ****		5 Star *****	
(kVA)	Max losses at 50% load (W)	Max losses at 100% load (W)	Max losses at 50% load (W)	Max losses at 100% load (W)	Max losses at 50% load (W)	Max losses at 100% load (W)	Max losses at 50% load (W)	Max losses at 100% load (W)	Max losses at 50% load (W)	Max losses at 100% load (W)
16	200	555	165	520	150	480	135	440	120	400
25	290	785	235	740	210	695	190	635	175	595
63	490	1415	430	1335	380	1250	340	1140	300	1050
100	700	2020	610	1910	520	1800	475	1650	435	1500
160	1000	2800	880	2550	770	2200	670	1950	570	1700
200	1130	3300	1010	3000	890	2700	780	2300	670	2100

6.4 Barriers and Gaps Impacting S&L Programme Adoption

Compared to the consumer appliances analysed in this report, the adoption of labelled DT's seems less, in spite of DT's having been notified under mandatory labelling since 2009. Additionally, there doesn't seem to be a roadmap for improving efficiency standards as there is for the consumer appliances studied in this report.

Table 16. Barriers to Star Labelled DT Market in India

Barriers & Gaps	**Priority**	**Stakeholder Comments / AEEE Observations**
Presence of unorganised market	High	There is a significant unorganised market in DT's, especially when it comes to refurbishment and maintenance. Due to the use of inferior materials in the unorganised market, the efficiency of DT's is impacted.
Cost of core material	High	Though BIS has a standard for CRGO cores, lower grade cores are still in use due to the cost of BIS-certified cores. Further, amorphous cores are even more expensive, which could impact the drive towards more efficient DT's.
Revision of Standards	Moderate	The current BEE star rating plan was introduced in July 2009. There is no roadmap for improving the efficiency standards.

6.5 Recommendations

The main recommendations are to remedy non-compliance and to improve efficiency standards.

- Include repair and refurbishment of DT's in BEE's star rating plan. Given the preference for repair and refurbishment of DT's, bringing these activities under a mandatory energy efficiency standard will improve the adoption of energy efficiency standards, especially where cost of a new DT is critical factor.
- Incentivise manufacturers to use the best available technology. Given that the R-APDRP is aimed at reducing AT&C losses, the program could be used to bring in the best available technology for Indian manufacturers.
- BIS, CEA and BEE could look into providing a roadmap for energy efficiency standards for DT's, with a periodic improvement in efficiency standards.

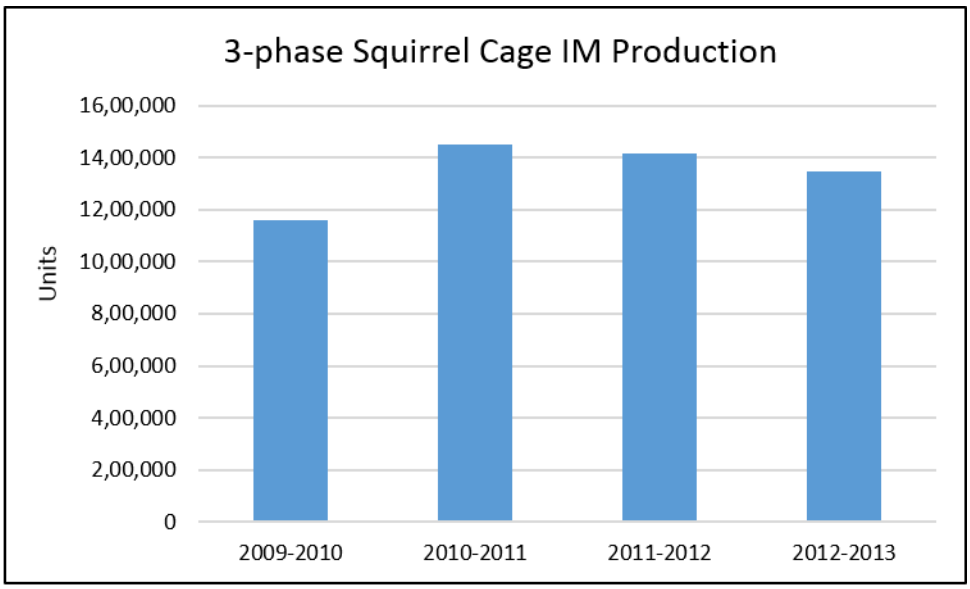
7. Motors

Electric motors have a wide range of applications in industrial, transport, commercial, agricultural and residential sectors. The IEA report *Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems* (Paul Waide, Conrad U. Brunner, 2011) estimates that 46% of global electricity demand is from electric motors, and 69% of electrical energy used in the industrial sector is by electric motors. In India electric motors account for 45% of electricity demand.

AC induction motors are very common in industry, being a cheap and cost-effective way to continuously operate pumps, fans, compressors, conveyors and other motive loads typical in industrial applications. This study looks at 3-phase squirrel cage induction motors (IM), which have been notified under BEE's voluntary labelling scheme.

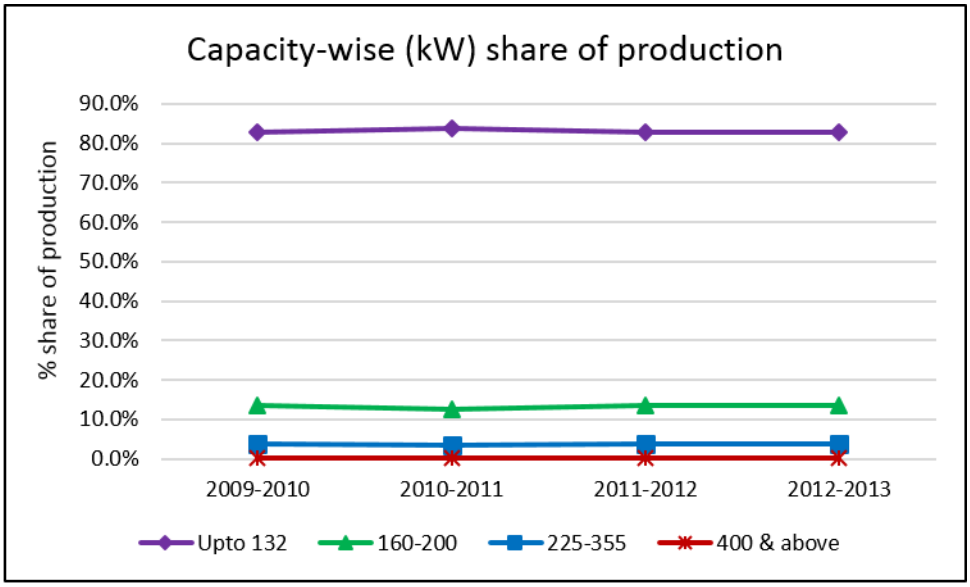
Figure 23 indicates the production volumes for 3-phase squirrel cage induction motors and Figure 24 shows the capacity-wise share of production for the same period, 2009-2010 to 2012-2013. More than 80% of the production is for smaller motors (up to 132 kW).

Figure 23. 3-phase Squirrel Cage Induction Motor Production Volumes



Source: IEEMA

Figure 24. Capacity-wise Share of Production of 3-phase Squirrel Cage IM



Source: IEEMA

7.1 Labelled Induction Motors Market in India

There was no data available with IEEMA or BEE on the sales of star-labelled 3-phase squirrel cage induction motors. Some of the bigger companies that follow BEE labelling are Siemens, Crompton Greaves and Bharat Bijlee.

7.2 Manufacturers' Participation

There was no data available with BEE regarding manufacturers' participation in BEE's star labelling scheme for induction motors. Comments from stakeholders suggest that there is still a significant unorganised market and that some manufacturers follow IE ratings as per IEC 60034-30:2008.

7.3 Efficiency Standards for Induction Motors

BEE has adopted the standard IS 12615:2011 which was revised on 14th May'2013. Efficiency classes are based on IS 12615:2011, namely IE2, IE2(+), IE3, IE3(+) and IE3(++), in which IE2 is the least efficient and IE3(++) is the most efficient. The selected range of motors under the star labelling programme is 0.37-375kW 3-phase squirrel cage induction motor in 2, 4, 6 pole used for continuous duty operation. Table 17 represents BEE's star rating plan under the voluntary scheme. IE2 and IE3 values are based on IS 12615:2011. IE2 (+) is the intermediate value between IE2 and IE3. IE3 (+) is the intermediate value between IE3 and IE3 (++). IE3 (++) is the value equivalent to IE4 based on the guideline given in IEC 60034-31. IE2 specified in IS 12615:2011 would be the minimum entry level for labelling as per this schedule.

Table 17. BEE Star Rating Plan for 3-phase Squirrel Cage Induction Motors

Star Rating	Motor Efficiency class
1 Star *	≥ IE2 & < IE2(+)
2 Star **	≥ IE2(+) & < IE3
3 Star ***	≥ IE3 & < IE3(+)
4 Star ****	≥ IE3 (+) & < IE3(++)
5 Star *****	≥ IE3(++)

7.4 Barriers and Gaps Impacting S&L Programme Adoption

The main barriers and gaps identified by stakeholders are listed in Table 18.

Table 18. Barriers to Star Labelled Motors Market in India

Barriers & Gaps	Priority	Stakeholder Comments / AEEE Observations
Presence of unorganised market	High	There is a significant unorganised market in motors. It is estimated that out of the 2000 manufacturers in India only 8-10% are in the organised sector. Smaller manufacturers find it difficult to upgrade to higher efficiency standards.
Relevance of BEE Star Label	High	There is already a BIS standard for motors based on the IEC standard. The BEE star rating is mapped to the IEC standard.

7.5 Recommendations

- Based on stakeholder inputs on barriers and gaps, the first step should be to consult with small manufacturers and others in the unorganised sector to identify the key issues in following efficiency standards for motors, whether it is the cost of raw materials or costs associated with testing and verification.
- Given the significant unorganised market it's recommended to build consumer awareness on the benefits of energy-efficient motors for industry.

8. Conclusions

Some of the barriers and gaps impacting S&L programme adoption are common across the five products included in this study. Table 19 lists the most common barriers and gaps and provides recommendations to address them. These recommendations aim to improve the overall Energy Efficiency standards framework in order to increase the adoption of energy-efficient appliances and equipment, while continuously improving energy efficiency standards and striving for newer, more energy-efficient technologies.

Table 19. Recommendations to Address Barriers to S&L Programme Adoption

Barriers & Gaps	Priority	Recommendation
Lack of uniformity in EE standards • BIS vs BEE standards • Some technologies not included in BEE standards, e.g. solar water heaters, inverter technology • Differences in frequency of standards revisions	High	It's recommended to have only one standard framework for Energy Efficiency of appliances and equipment. This framework should specify the energy efficiency parameters for each appliance, as well as standard procedures for testing and certification. It should be reviewed and revised periodically to keep up with newer, more energy-efficient technologies and to improve EE standards. There should be periodic conferences and workshops on upcoming technologies so that manufacturers and standards bodies can proactively develop standards for new technologies before products are introduced into the market.
Insufficient infrastructure and lack of uniformity in testing and labelling • Insufficient test facilities • Self-labelling by manufacturers	High	It's recommended that the government set up more testing and certification centres and/or certify independent third-party organisations to test products and provide certification labels.

Barriers & Gaps	Priority	Recommendation
Cost of EE technology	High	It's recommended that the government provide incentive schemes to manufacturers to reduce the cost of adopting the latest, most energy-efficient technology.
Presence of unorganised market	Moderate	It would be worthwhile to study the unorganised market and address issues to bring these players into the EE standards regime. Unless the unorganised market is flushed out the true potential of achieving an energy efficient economy will be unrealised.

In the consumer appliance sector there is clearly a demand for more energy-efficient products. This is something to be capitalised on to push for even higher efficiency standards with the introduction of newer, more energy-efficient technologies, as well as bringing more consumer appliances within the EE standards regime.

However, based on the market assessment of the industrial equipment in this study, it appears that the adoption of energy-efficient equipment is relatively lower, probably due to the cost of technology and the lack of clarity on energy efficiency standards. It would be worthwhile doing more in-depth studies on energy efficiency for industrial equipment, especially among small and medium manufacturers and industries, to better understand the barriers and gaps to adopting energy-efficient equipment. Additionally, this study could analyse the unorganised market to identify its main issues and provide recommendations to bring the unorganised market into the standards regime.

Bibliography

1. More Power To India: The Challenge of Electricity Distribution (Sheoli Pargal and Sudeshna Ghosh Banerjee, 2014) - http://elibrary.worldbank.org/doi/book/10.1596/978-1-4648-0233-1
2. EC Act 2001 - http://powermin.nic.in/upload/pdf/ecact2001.pdf
3. IEA Energy Efficiency Market Report 2013 - https://www.iea.org/publications/freepublications/publication/EEMR2013_free.pdf
4. Ministry of Power, GoI: Energy Efficiency - http://powermin.nic.in/Energy-Efficiency
5. BEE Standards and Labelling - http://beestarlabel.com/
6. Details of Schemes for EE labelling (BEE) - http://beestarlabel.com/Content/Files/Scheme%20of%20energy%20efficiency%20labelling.pdf
7. Avoiding 100 New Power Plants by Increasing Efficiency of Room Air Conditioners in India: Opportunities and Challenges (Amol Phadke, Nikit Abhyankar, Nihar Shah, 2014) - https://ies.lbl.gov/sites/all/files/lbnl-6674e.pdf
8. India AC Efficiency Policy Opportunities and Current Activities (Saurabh Diddi , 2014) - http://www.beeindia.in/documents/Presentations/Day1/Mr%20Saurabh%20Diddi%20Space%20Cooling%20India.pdf
9. http://timesofindia.indiatimes.com/business/india-business/Voltas-topples-LG-to-be-No-1-in-AC-business/articleshow/45391642.cms
10. BEE Search and Compare tool of registered models of appliances and equipment http://beestarlabel.com/Home/Searchcompare
11. BEE S&L Schedule 3A - http://beestarlabel.com/Content/Files/Schedule3A-RAC9jun.pdf
12. http://indianexpress.com/article/technology/technology-others/how-to-select-the-right-ac-for-your-home-this-summer/
13. http://www.business-standard.com/article/companies/consumers-switch-to-inverter-acs-as-energy-efficiency-gains-ground-113091900866_1.html
14. http://www.thehindu.com/business/Industry/inverter-ac-market-picks-up-momentum/article5867888.ece
15. http://www.beeindia.in/documents/Presentations/Day1/Mr%20SANJAY%20GOYAL%20DAIKIN%20PRESENTATION%20ON%20IMPROVING%20AC%20EFFICIENCY.pdf
16. http://www.currentforce.com.au/blog/index.php/inverter-air-conditioners/
17. http://compareindia.ibnlive.com/products/acs-split/21
18. BEE (2012), India's Energy Efficiency Standards & Labelling Programme, Vineeta Kanwal, BEE 23/April/2012
19. Garnaik (2012) Standard &Labelling Programme in India: An Overview
20. http://www.gfk.com/in/news-and-events/press-room/press-releases/pages/consumers-in-india-spent-usd1-8billion-on-refrigerators-in-first-eight-months-of-2014-gfk.aspx

21. Estimate of Technical Potential for Minimum Efficiency Performance Standards in 13 Major World Economies (Virginie Letschert, Louis-Benoit Desroches, Jing Ke, Michael McNeil, 2012 - http://www.superefficient.org/en/Resources/~/media/Files/BUENAS%20BAT%20Scenario-%20LBNL-5724E.pdf
22. Techno-economic analyses of the Incremental Cost of Super Efficiency for Refrigerators in India (August 2012) – http://shaktifoundation.in/wp-content/uploads/2014/02/techno-economic%20feasibility%20study%20-%20super%20efficiency%20in%20refrigerators.pdf
23. BEE S&L Schedule 1 for Frost-free refrigerators - http://beestarlabel.com/Content/Files/Schedule1_FFR.pdf
24. BEE S&L Schedule 5 for direct cool refrigerators - http://beestarlabel.com/Content/Files/Schedule5-DCRefrigerator.pdf
25. http://www.adi-media.com/PDF/TVJ/annual_issue/012-Water-Heaters.pdf
26. http://businesswireindia.com/news/news-details/the-ferroli-group-sets-new-standards-water-heater-market/41283
27. Energy Efficient Products and Indian Consumers - http://shaktifoundation.in/report/energy-efficient-products-and-indian-consumers/
28. BEE S&L Schedule 10 for electric water heaters - http://beestarlabel.com/Content/Files/Schedule_10.pdf
29. http://mgsarchitecture.in/articles/others/276-hot-demand-for-hot-water
30. R-APDRP - http://www.apdrp.gov.in/
31. Guidelines for R-APDRP - http://www.apdrp.gov.in/OrderSGuidelines/Mop%20Order%2822.12.08%29%20-%20Guidelines%20for%20R-APDRP.pdf
32. CEA Guidelines for DT 2008 - http://www.cea.nic.in/reports/articles/god/guidelines_spec_1n3phase_tfs.pdf
33. BEE Schedule 4 for DT - http://beestarlabel.com/Content/Files/Schedule4_DT.pdf
34. BIS presentation on standards for DT - http://www.ieema.org/FileAccess/LFE_Prakash_Bachani.pdf
35. IEEMA Transformer Division - http://www.ieema.org/Contents/DivisionServices/Division_Show.aspx?k=22
36. Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems (IEA 2011) - https://www.iea.org/publications/freepublications/publication/EE_for_ElectricSystems.pdf
37. BEE Schedule 6 - http://beestarlabel.com/Content/Files/Schedule6-InductionMotors.pdf
38. BIS Implementation of IS 12615:2011 "Energy Efficient Induction Motors - 3 phase squirrel cage and STI - http://www.bis.org.in/qazwsx/cmd/CMD-III_IS-12615-30112014.pdf