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Energy efficient Lighting Technologies

Country

India

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Index

1 Subtypes and markets

Power for lighting accounts for 18% of all power consumption in India, as against 10-12% in developed countries (Indiastat, n.d.). The lighting market landscape in India is divided into incandescent bulbs, fluorescent lighting in the forms of tubular fluorescent lamps (TFLs) and compact fluorescent lamps (CFLs), and light emitting diode (LED) lamps. Incandescent bulbs, even though highly energy inefficient as compared to even fluorescent lighting, still enjoy a significant market share in India's lighting market. According to the 2011 Census of India there were still 1.1 million households in India with no source of lighting. Just over half the rural households used electricity for lighting. This means that the market is hugely underpenetrated and the potential for energy saving in lighting is also massive.

The market trend is rapidly changing in favour of fluorescent lighting and LED lamps. For example, due to the growth in market for CFL lighting the manufacturing capacity of these lamps has gone up from 19 million units in 2002 to 730 million pieces per annum in 2011, in India (Electric Lamp and Component Manufacturers Association of India, 2013). The LED market is expected to show a CAGR of almost 30% between 2016 and 2021 (TechSci Research, 2016), reaching a size of almost USD s1,457.8 million by 2019 (Research and Markets, 2014). The government is also taking significant steps to reduce energy consumption in India due to lighting, like BEE's S&L programme for TFLs and LEDs, the Bachat Lamp Yojna etc. Under the Bachat Lamp Yojana scheme, implemented by the Bureau of Energy Efficiency (BEE), power distribution companies (DISCOMs) distribute CFLs to residential consumers in exchange for incandescent bulbs and INR1 5 (around 20 EUR cents), which are procured from certain suppliers. In return these suppliers are awarded saleable certified emission reduction credits (Bijli Bachao Team, 2015).

Light sources are available in various wattages ranging from 5W to more than 100W. The market share, however, is staggered in favour of lower wattages, with wattages up to 60W having a 70% market share in the industry. Wattages between 60W and 100W have a 25% share while wattages above 100W have a mere 5% market share (Indiastat, n.d.).

The lighting technology market in India can be segregated into incandescent bulbs, CFLs, TFLs and LEDs. The LED lighting market has shown the maximum growth in recent years, registering a CAGR of 57.31%. The CFL market was estimated to be worth INR8 billion in 2006 and by 2008 it had grown to be worth INR18 billion. The demand for CFLs has increased by almost 40-50% in the past three years, while that for incandescent bulbs has more or less stagnated. In the fluorescent lighting segment TFLs

also have a large share, with a market worth INR 13 billion in 2008 (Indiastat, n.d.). Further, according to lighting experts, this segment is dominated by 4 ft. 36W fixtures with a colour temperature of 6,500K.

The most relevant parameter for lighting technologies is the luminous efficacy, which is the amount of lighting a fixture provides for each watt of electrical energy consumed, measured in Lumens per Watt. The energy efficiency performance of TFLs and LED lamps by the Bureau of Energy Efficiency in India is based on this parameter's value after a defined number of hours of operation, like at 100 hours of operation, at 2,000 hours of operation, at 3,500 hours of operation etc. To calculate the amount of energy a lighting appliance will consume in a year The World Bank, in its report 'India: Strategies for Low Carbon Growth', assumes an operating time of 913 hours a year (The World Bank, 2008).

In 2014-15 the market volume for CFLs was 667.3 million units. In the same year the market volume for fluorescent tubes was 340 million units (Indiastat, n.d.). In 2015 the market size of the LED market in India was estimated to grow to about INR 40 billion and by 2016 this was estimated to grow to almost INR50 billion (Electric Lamp and Component Manufacturers Association of India, 2013). Almost 51% of the orders for LED lamps are made up by Government. Due to a huge unorganized sector operating in the lighting appliances market (almost 40% of the market according to some sources) estimating the exact number of appliances in use across the country is a very precarious task. The only estimates available in the public domain are the market volumes and sales of lighting appliances. Estimates however, can be made using data of total energy consumed by lighting per annum and the average annual consumption of electricity by a single fixture.

Due to slightly higher prices of fluorescent lighting fixtures as compared to incandescent bulbs and the limited success of government initiatives to promote energy efficient lighting, incandescent bulbs still had the largest market share in India at 60% in the year 2012. Fluorescent lamps, or TFLs, had the next largest market share at 23%. CFLs only had a 16% share in the overall market. Other lamps, like high intensity discharge lamps (HIDs), LEDs etc. had shared the remaining 1% of the market (Electric Lamp and Component Manufacturers Association of India, 2013).

In 2011 lighting appliances consumed an estimated 57,786 GWh of energy (The World Bank, 2008), forming a 20% share of India's total energy consumption. A typical incandescent bulb used in the household sector is a 60W bulb, which, at 913 hours of annual operation, would consume 54.78 kWh of energy annually. The market dominant 36W TFL consumes 38.87 kWh of energy for the same operating time. For the similar amount of lighting the typical wattage of a CFL would be 15W, consuming 13.67 kWh of energy annually. A 12W LED would consume only 10.95 kWh per annum in comparison.

2 Efficiency range and user savings

The typical lighting appliance purchased in India is still the highly inefficient incandescent bulb, primary due to its extremely low upfront purchase cost as compared to other more efficient options. Within this type bulbs below the wattage of 60W are the ones with the highest demand volume (Indiastat, n.d.). Its life is also very low as compared to other lighting appliance options in the market. The BEE has launched S&L programs for TFLs and LEDs, hence, if MEPS were to be made mandatory in the current scenario a 1 star TFL would be the least efficient model in the market. The best available technology currently is the LED lamp with the longest life and highest efficacy. It's cost has come down significantly due to government initiatives and large scale orders. This technology is expected to improve considerably by 2020, with decreasing luminous efficacy (lumens provided per Watt of power consumed), and decreasing prices due to government initiatives.

Table 1: Efficiency range and user savings of washing machines

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	60W				
Category	**Incandescent bulb**	**Tubular fluroscent**	**Incandescent bulb**	**LED lamp**	**LED lamp**

		lamp			
Type	60W	36W	60W	12W	4W
Lifetime (hours)	1,200	8,000	1,200	50,000	50,000
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 (kWh)	54.78	32.87	54.78	10.95	3.65
Yearly energy cost (INR)	301,3	180,8	301,3	60,2	20
Purchase cost in (currency) INR	10	100	10	400	NA
Operation & Maintenance cost	0	0	0	0	0
Labeling class (for the aforementioned labels)	NA	1 star	NA	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 in May 2006 BEE launched the Standards and Labeling (S&L) program for home appliances. 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. Tubular Fluorescent Lamps fall under the mandatory scheme of energy efficiency labeling. LED lamps currently fall under the voluntary scheme but are soon to be included in the mandatory scheme as well.

About 20% of global energy consumption is made up by lighting requirements. This accounts to about 1.9 billion tons of CO_2 emissions every year (Samal, 2013). This is as much emission as 70% of the world's passenger vehicles. Therefore reducing the share of lighting in total energy consumption is a rather important step towards reducing overall emissions.

Considering this and the ease of simply replacing inefficient lighting technologies with more efficient ones, the Bureau of Energy Efficiency has set in place a mandatory labeling program for energy rating of TFLs and a voluntary program for energy ratings of LED lamps. For LED lamps the program is voluntary till 31st December 2016. Starting from 1st January 2017 the rating criteria for LEDs will also become mandatory.

The parameter based on which lighting appliances are rated is the luminous efficacy, measured in lm/W. The criteria are different for LED lamps and TFLs.

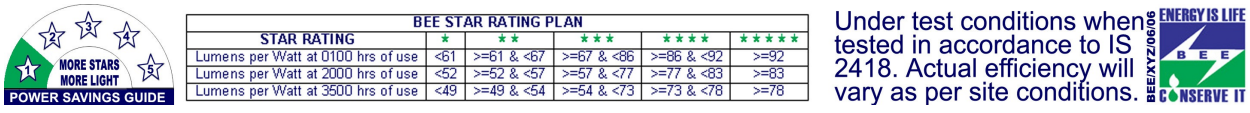
For TFLs the criteria of rating is given in table 1.

Table 2: BEE Star Rating Plan for TFLs

STAR RATING	1 star	2 star	3 star	4 star	5 star
Lumen per Watt at 100 hours of use	<61	>=61 & <67	>=67 & <86	>=86 & <92	>=92
Lumen per Watt at 2,000 hours of use	<52	>=52 & <57	>=57 & <77	>=77 & <83	>=83
Lumen per Watt at 3,500 hours of use	<49	>=49 & <54	>=54 & <73	>=73 & <78	>=78

The mandatory comparative labeling scheme for lighting technologies is called the Standards and Labeling Program. For TFLs it is invoked for 4 feet tubular lamps with wattages up to 40W, covering 6,500K colour temperature for halo-phosphates and 6,500K, 4,000K & 27,00K for tri-phosphate category.

A sample label to be displayed on the appliance is shown below:



The label displays the table according to which the fixture is rated and the energy rating of the fixture. The label also include a disclaimer which states that the rating is given to the appliance when tested under lab conditions in accordance to IS 2418, and actual efficiency of the fixture may vary according to the conditions at the site.

Due to high prices of LED fixtures as compared to fluorescent lights and incandescent bulbs LED lamps have not gained a significant market share in the Indian lighting market. But due to large government subsidies and orders the prices have come down from around INR1,200 to INR400 (nearly EUR 5). Also, due to a large unorganized sector and absence of any standards earlier, sub-standard products widely circulated in the market.

Due to this BEE chose to launch an S&L scheme which is voluntary for the first one and a half years from launch date, i.e. from July 7 2015 to December 31 2016, and becomes mandatory for two years after that, i.e. January 1 2017 to December 31 2018.

BEE has released a schedule for each appliance under the S&L scheme, describing the rating system and test procedures. The BEE rating scheme for LED lamps is described in Schedule 20 (Bureau of Energy Efficiency, 2015). The parameter based on which lighting appliances are rated is the luminous efficacy, measured in lm/W. Since till the end of 2016 the rating program for LEDs is voluntary the re-

quirements for this are included in the voluntary section. Post 2016 this program will become mandatory for LEDs.

For LEDs the schedule specifies two tables. Table 2 is to be referred from the date of launch till December 31, 2016. The parameters to be referred for the rating from January 1 2017 to December 31 2018 are the same, the difference being that the 1 star and 2 star rating criteria have been already frozen while the 3, 4 and 5 star rating criteria may still be changed.

Table 3: BEE Star Rating Plan for LED Lamps

STAR RATING	Lumen per Watt
1	>=68 & <79
2	>=79 & <90
3	>=90 & <105
4	>=105 & <120
5	>=120

This schedule specifies the energy labeling requirements for self-ballasted non directional general service LED lamps for general lighting services that work on single phase AC supply up to and including 250V, 50Hz, being manufactured, imported or sold in India. However, this schedule does not covers self-ballasted LED-lamps that intentionally produce tinted or coloured light neither does it cover OLEDs (Bureau of Energy Efficiency, n.d.).

To qualify for obtaining a BEE energy star rating LED lamps must first meet certain pre-qualification criteria. These are:

a. LED lamps must conform to safety requirements of IS 16102.
b. The lamps must meet harmonics requirements as of IS 14700 and power factor requirements as of IS 16102.
c. Lamps must conform to photo-biological safety as per IS 16108.
d. The lamp must have at least 95% lumen maintenance at 1000 hours of operation at the time of application.

To qualify for BEE Star label during voluntary period, all the tested LED lamps shall meet the minimum luminous efficacy of 79lm/W. During mandatory period, all the tested LED lamps shall meet the minimum luminous efficacy of 90lm/W.

A sample label to be displayed on an LED lamp is shown below:

Apart from the Star rating the label specifies the following information:

a. Appliance type
b. Brand
c. Model/Year
d. Rated Power
e. Rated luminous flux

4 Test procedures and standards

Testing procedures and rating schemes are for TFLs and LEDs are described in documents released by the BEE, schedules 2 and 20 of BEE star rating appliances, respectively. Both of these standards draw mostly on Indian Standards for testing procedures of lighting fixtures, with one or two international code references. Both types of lamps are rated based on their luminous efficacy.

The BEE energy efficiency rating scheme is described in BEE's Schedule-2 for mandatory appliances. For methods of testing the schedule refers to IS 2418 (part I and part II) – 1977. Energy efficiency rating is awarded to lamps based on its efficacy values after 100, 2,000 and 3,500 hours of usage. A star rating is awarded after each period of consumption. The final rating is the average of these three ratings, rounded off to the nearest integer.

For LED lamps schedule-20 of voluntary appliances describes the scheme for star rating. The schedule refers to a number of other standards for testing. These are IS16102:2012 part I and part II, IS 16106:2012, IS 14700 (Part 3/Sec 2):1999, IS 16108 and IEC 62612. Same as the schedule for TFL, the energy efficiency rating for LEDs is also done according to the efficacy (lm/W). But unlike the label for TFL, LED lamps display the lm/W rating for the specific lamp on the label, along with its star rating.

For TFLs IS 2418 (part I)-1977 describes the following tests for general lighting service of LED lamps:

1. Visual examination and checking for marking: visual test and test for following marking requirements: name and trademark of manufacturer, rated wattage, colour temperature, starting temperatures and country of manufacture.
2. Torsion test: The lamp is put in a torsion testing machine where torsion is applied suddenly and increased gradually, and tested for failure. This test is done both during inspection tests and after the life test.
3. Insulation resistance test: Insulation resistance between the shell and the contacts of the cap are tested before ageing the lamp for 100 hours for inspection tests.
4. Burning test: The lamp is supplied with rated voltage and tested for burning, i.e. it should burn and give out light.
5. Starting characteristics test.
6. Test of electrical, colour and luminous characteristics
7. Life test: After 2000 hours of operation the lumen maintenance shall not be less than the one specified in the lamp data sheet.

For LEDs:

Table 4: List of testing procedures and standards for LED lamps

S.NO	TEST PARAMETER	TEST STANDARD
1	Wattage	IS 16102 Part 2
2	Initial Luminous Flux	IS 16102 Part 2 and IS 16106
3	Colour chromaticity and colour rendering index	IS 16102 Part 2
4	Life	IS 16102 Part 2
5	Harmonics	IS 14700 (Part 3/Sec2)
6	Limits and methods of measurement of radio disturbance characteristics: Part 5 Electrical lighting and similar equipment	IS 6873 (Part 5): 1999
7	Lamp Efficacy	The lamp efficacy shall be derived from the measured value of lumen output and the wattage at the rated voltage and frequency

5 References

Bijli Bachao Team, 2015. *Bachat Lamp Yojana (BLY)-A scheme by BEE to promote energy efficient lighting.* [Online]
Available at: http://www.bijlibachao.com/government-programs/bachat-lamp-yojna-bly-a-scheme-by-bee-to-promote-energy-efficient-lighting.html
[Accessed 31 August 2016].

Bureau of Energy Efficiency, 2015. *Bureau of Energy Efficiency: Voluntary Scheme.* [Online]
Available at: https://beeindia.gov.in/sites/default/files/ctools/LED%20schedule%2020.pdf
[Accessed 31 August 2016].

Bureau of Energy Efficiency, n.d. *Bureau of Energy Efficiency: Mandatory Scheme.* [Online]
Available at: https://beeindia.gov.in/content/mandatory-appliances
[Accessed 27 July 2016].

Electric Lamp and Component Manufacturers Association of India, 2013. *Global Lighting Association: Library.* [Online]
Available at: http://www.globallightingassociation.org/library
[Accessed 27 July 2016].

Electric Lamp and Component Manufacturers Association of India, 2013. *Lighting Industry in India,* s.l.: s.n.

Indiastat, n.d. *Indiastat Statistical Information: Lighting Products.* [Online]
[Accessed 22 July 2016].

Indiastat, n.d. *Indiastat Statistical Information: Washing Machines and Vacuum Cleaners.* [Online]
[Accessed 22 July 2016].

Research and Markets, 2014. *India LED Lighting Market (2014-2019): Market Forecast by Applications.* [Online]
Available at:
http://www.researchandmarkets.com/reports/2760420/india_led_lighting_market_20142019_market
[Accessed 20 July 2016].

Research and Markets, 2015. *Research and Markets: India LED Lighting Market Overview - Philips, Osram, Bajaj & Havells are the Leading Players.* [Online]
Available at: http://www.businesswire.com/news/home/20151006005985/en/Research-Markets-India-LED-Lighting-Market-Overview
[Accessed 20 July 2016].

Samal, P., 2013. *Policy and Programs Supporting Energy Efficient Lighting in India.* s.l.:s.n.

TechSci Research, 2016. *LED Lighting Market in India to Grow at 30% Until 2021: TechSci Research Report.* [Online]
Available at: http://www.prnewswire.com/news-releases/led-lighting-market-in-india-to-grow-at-30-until-2021-techsci-research-report-580811611.html
[Accessed 20 July 2016].

The World Bank, 2008. *Residential Consumption of Electricity in India: Documentation of Data and Methodology,* s.l.: The World Bank.

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