06 ENERGY EFFICIENCY OF APPLIANCES

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Sunil Sinha, a banker in Meerut, remembers when in the 1990s he had a modest four ceiling-fans, six lights, a refrigerator and a colour TV, enough for him to boast about. Since then he has added computers, geysers, a mixer, water purifier, air conditioners, two more TV sets and another fridge. But these conveniences have come at a cost. "Monthly electricity usage hardly ever crossed 250 units. But now, even after our children have moved out, we rarely use less than 1,000 units of power a month," says Sinha.

According to the Consumer Electronics and Appliances Manufacturers Association, consumer electronics and appliances in India is a 45,000-crore-rupee industry. A report prepared by the association this year shows the Indian consumer electronics market grew at a compound annual rate of 13 per cent during 2003-13.

Even though the appliance penetration of India is lower than the global standard, its energy consumption is high and will increase. Indian appliance ownership is where China was two decades ago. Indian families are yet to buy 70 per cent of the appliances they will own by 2030, according to Daljit Singh, senior research fellow at the Pune-based non-profit Prayas, which works on energy and other issues. However, domestic energy consumption in India has increased from 80 terawatt hour (TWh, or a million megawatt hour) in 2000 to 186 TWh in 2012, and constitutes 22 per cent of the total energy consumption as per the 2013 report of the Central Electricity Authority. If the commercial sector, which includes offices, malls and shops, is added, then total domestic and commercial energy consumption goes up to 257 TWh, or 30 per cent of electricity consumed in India. A study by the Ahmedabad-based Centre for Environmental Planning and Technology University for the Global Buildings Performance Network shows that at this rate, with rising incomes and urbanisation, the domestic consumption may increase to 1,600 TWh in 2050 if nothing is done to improve the energy efficiency of appliances.

According to the United Nations Environment Programme, about 40 per cent of energy expenditure and a third of CO_2 emissions in the world are attributed to the operation and maintenance of buildings, with home appliances contributing a major share.

Prayas' 2008 calculations show just nine appliances account for almost all the electricity used in Indian homes. Of these four kinds – lighting fixtures, ceiling fans, TV sets and refrigerators – account for 80 per cent of the electricity consumption. Another estimate in 2010 by the Bureau of Energy Efficiency (BEE), a statutory body under the power ministry, shows that fans use about 34 per cent of the electricity, lighting 28 per cent and refrigerators 13 per cent in a typical house. Air conditioners (ACs) are the biggest energy guzzlers but this is not reflected in national averages because very few houses have them.

The government took the first step towards energy efficiency by notifying the Energy Conservation Act in 2002. The Act sought efficiency measures and a legal framework to implement them throughout the country. In 2006, bee introduced star rating of appliances to influence consumer choice and push the market towards improving the energy efficiency of products. Under its Standards and Labeling programme, bee defined the minimum efficiency performance benchmark for various appliances and decided the bandwidth to award five-star ratings to products. It also made it mandatory for all manufacturers of ACs, refrigerators and tube lights to put bee ratings on the product, which meant that products with efficiency lower than bee's minimum benchmark could not be sold in the market. BEE revises the minimum

TV: Growing on its own steam

The TV market in India has been continuously moving towards efficient technology, from cathode ray tube to LCD to LCD-LED. Star-rating of TV is not mandatory, yet their energy efficiency is likely to improve enough to qualify for the current four- or five-star rating, potentially saving 6 terawatt-hours (TWh) per year in 2020, according to LBNL. An extra 20 per cent additional efficiency in the sector can be achieved cost-effectively by policies interventions.

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benchmark every two years and the last revision happened in January 2014.

While the star rating has encouraged a shift towards more efficient models in some appliances, people still buy less expensive but inefficient models of others. For example, in 2009-10, almost 90 per cent purchases of labelled frost-free refrigerators were in the four- or five-star category, according to a 2010 report of the National Productivity Council, an autonomous body under the commerce and industry ministry. In the case of room ACs, however, only 14 per cent of the purchases were rated four or five stars, while 55 per cent were rated one or two stars. The sale of five-star ACs has not picked up because they are substantially more expensive than ordinary ACs and are not easily available in the market. In contrast, the average efficiency of refrigerators sold in India before the Standards and Labelling programme was already three-star, which meant the higher-efficiency refrigerators were marginally more expensive.

For appliances for which labelling is not mandatory, a large fraction of purchases is of unlabelled models, which are energy-inefficient. Further, the energy consumption thresholds for labelled products have not been raised at a desired pace. Experts say one reason for this is the resistance from manufacturers, particularly in the unorganised sector, who may find it difficult to improve manufacturing technologies.

As a result, even eight years after the launch of the star-rating programme, Indian efficiency standards lag behind global levels. Saurabh Diddi, energy economist at BEE and project officer for the programme, thinks the comparison is unfair because the conditions for testing efficiency vary among countries, leading to different results. "We cannot push the minimum standards drastically higher overnight as it will make the products unaffordable and force many local manufacturers to shut shop," he says. "We have to be considerate towards the local industry and the purchasing power of the average Indian when deciding the efficiency standards." Nikit Abhyankar, senior scientific engineering associate at the California-based Lawrence Berkeley National Laboratory (LBNL), which has an India-specific energy programme, does not agree. "The spike in prices is momentary. We have analysed the Indian market and found that prices of ACs and TV sets in India in absolute terms have fallen since the introduction and subsequent tightening of minimum efficiency standards," he says. He adds that cost sensitivity of the Indian market and stiff competition have a way of making manufacturers adjust and innovate to keep prices low.

Room for super efficiency

Industry is already ready with several super-efficient products, which use much less power than even five-star-rated ones. These products, which can easily be called seven- or eight-star, can go a long way in improving the energy security of the country. To get a measure of what super-efficient products can do, take the government's rural electrification scheme. Under this, the government is providing families with power. "Today we can operate an LED colour TV, a table fan, two LED light fixtures, a phone charger and a digital radio-cum-watch with 40 watts (W) of electricity, which is the same power a single incandescent bulb consumes," says Abhyankar. "All the products are commercially available in major markets, including those in Africa, but not in India as policies are not pushing for them." The challenge is to create incentives for super-efficient products, while quickly upgrading the star- rating system to push the baseline. This will remove inefficient appliances from the market and encourage long-term energy savings. This can also be achieved with the cross subsidy mechanism, under which lower efficiency products can be charged higher and the differential utilised to subsidise higher efficiency products, suggests Delhi-based non-profit Centre for Science and Environment (CSE). "For the manufacturers the excise duty should be made inversely proportional to the star rating of the product," adds Piyal Sengupta, product manager, air conditioners, Godrej Appliances.

Let us look at how three major appliance markets – ceiling fans, lights and air-conditioners – can make the transition.

Fans

Almost all electrified houses in the country have at least one ceiling fan. Yet they are rarely mentioned in discussions on energy efficiency. BEE has a rating programme for fans – the five-star-rated fans use 50 W as compared to the conventional 75-90 W. A 2012 report by Pune-based energy policy group Prayas found that although 70 per cent of this appliance market is in the organised sector, five- star-rated fans have not taken off. The bulk of the 25 million ceiling fans sold in the country in a year remain inefficient. Since fans are rarely replaced, this 'locks' in options and drains energy for decades.

The opportunity then lies in phasing out inefficient fans and ensuring that new fans are even more efficient than the five-star rated. In January 2014, the Union Cabinet cleared a programme to provide incentives for the production of 35 W ceiling fans, which are twice as

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efficient as the conventional fan. The Super-Efficient Equipment Programme (SEEP) is designed to provide upstream benefits to manufacturers, who meet the BEE technical specifications for superefficient fans. There is a two-way process: the star rating of fans would be made mandatory to push up the floor of performance, while SEEP will provide financial incentives to companies so that they can pull up the ceiling level.

At present, two manufacturers, Versa Drives in Coimbatore and Luxaire in Bengaluru, supply super-efficient fans in India. But these fans are much more expensive, so consumers do not buy them. SuperFan of Versa Drives is four times as expensive as unlabelled fans.

"The primary objective of SEEP is to achieve rapid market transformation to super-efficient variants of appliances. The aim is not to simply introduce the most efficient ceiling fan, but to strike best balance between cost and efficiency," says Daljit Singh, senior research associate at Prayas who co-authored the 2012 report on the development of SEEP for fans.

The programme is now ready to take off. "BEE has finalised the commercially feasible efficiency performance parameters with the corresponding costs. The proposed timeline for the project is three years and the number of fans covered in the first phase would be about 2 million," says Ashok Kumar, BEE economist and project incharge for SEEP. "A 70 per cent market penetration of 35 W fans would be more desirable than a 1 per cent penetration of 10-watt fans, so specifications for these fans were framed keeping in mind the manufacturing capabilities of producers in India," he says.

BEE has also addressed the problem of "air delivery" in its specifications for the super-efficient fans. One of the reasons people have not switched to five-star fans is they find the air delivered by them is less than what conventional ones deliver. Conventional fans have an air delivery of 250 cubic metre per minute (cum m) against five-star fans, which have air delivery of 210 cum m.

In its specifications for super-efficient fans BEE has proposed that they must provide a higher air delivery at 230 cumm, which will increase acceptability among users. In addition, the fans have to have low noise and must be suitable to Indian conditions and the Indian pocket.

Better technologies are available. Induction motor improves performance, while brushless DC technology and improved blade design give greater efficiency. And with just eight brands – Bajaj, Crompton-Greaves, Havells, Khaitan, Orient, Ortem, Polar and Usha – controlling 70 per cent of the market, it should be possible to bring about a rapid improvement in efficiency.

Lightings

Lighting provides the biggest scope for saving energy as it accounts for nearly a third of the electricity consumed by appliances in Indian houses. Today, tube lights and incandescent bulbs dominate Indian homes, with CFLs (compact fluorescent lamps) slowly gaining a foothold, thanks to a government scheme.

In February, 2009, the BEE launched Bachat Lamp Yojana for replacing incandescent bulbs with CFLs. It raised consumer awareness of energy savings from CFLs through an aggressive campaign, spurring sales to cross 340 million units in 2011. In comparison, 755 million units of incandescent bulbs were sold that year, according to industry estimates. The scheme also subsidised the price of CFL (Rs 80-100), bringing it on a par with an incandescent bulb (Rs 15) in project areas.

The lighting fixture market in India is likely to grow at the compound annual growth rate of 17 per cent during 2013-18, according to Reportlinker, a global market research organisation. It is already witnessing an influx of energy-efficient products like LED (light emitting diode). There are 400 million lamps in Indian houses, mostly incandescent bulbs, consuming 70 million MWh annually. The penetration of super-efficient lights in this sector can reduce household electricity demand for lighting by 30 per cent, according to BEE.

There seems to be a linear progression from incandescent lamps to CFLs to LEDs but the transition to a more efficient future is not going to be as straightforward.

Which one is the most efficient?

Picking up the best option from available and emerging technologies requires weighing them on a number of parameters. One is wattage, which denotes the amount of energy a lamp uses, and another is lumen (lm) per watt, which indicates the amount of light produced by a lamp for every watt of electricity it consumes. Lumen per watt is a better tool for comparison because the light output of lamps with same wattage can vary. Life and cost are other parameters.

Incandescent bulbs produce 10-17 lumen per watt

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(lm/W), which is much less than what other technologies that are now readily available give. However, technologies are evolving both in terms of efficiency and cost. The lumen-per-watt range for linear fluorescent lamps is 30-110 lm/W, but as one goes towards the higher end of the range the cost rises. CFLs and LEDs both begin at 40 lm/W and go up to 70 lm/W and 100 lm/W respectively. LEDs are expected to have the longest life. Some laboratory tests show their life could be as high as 50,000 hours but such claims have not been proven yet. It is also clear that the actual life of the led bulb will be affected by other components as well, especially the quality of the AC-DC transformers. The more specialised companies, which offer LED bulbs in the Indian market, run lighting directly on DC power to give better life and quality. For instance, Alien Lighting, the company which supplied light fixtures for the Planning Commission building in Delhi, claims a life of 50,000 hours for its product and offers a 'limited lifetime' warranty. Its product is expensive.

Most other companies, like market-leader Philips, offer lower-end and cheaper options. But as the Bureau of Indian Standards (BIS) and BEE have not set standards for LED, companies are getting away with vague information of their product. For instance, Philips claims its product have a 'long life of 15 years with 15,000 hours life', while Wipro touts 'long life up to 10 years'. The disclaimer in the case of Philips, however, reads: "Life in years is calculated based on 1,000 hours of usage per year, which is about 2.7 hours per day across 365 days."

Only the Electric Lamp and Component Manufacturers Association (ELCOMA) of India has developed specifications, which set the rated life of the complete LED fixture for focus lights at 35,000 hours, for the regular led lamps at 25,000 hours and for street lights at 50,000 hours. Yet ELCOMA specifications require manufacturers to provide only a two-year warranty on their 'long-life' products.

Overcoming barriers to LED

A BEE report of 2010 identified the key barriers to the market penetration of LEDs in India as: limited product availability in the country; high initial cost; absence of national technical standards for LEDs leading to the import of substandard devices; lack of testing protocols and laboratories; and lack of incentives for major LED firms to make them in India.

Shyam Sujan, secretary general, ELCOMA, says the government should actively support LED. "Government is the biggest consumer of luminaries. If it undertakes bulk purchase and retrofitting, there will be good demand and prices will decrease. It also has to reduce duties and VAT," he says.

BEE has worked out a model for promoting LED bulbs together with the Energy Efficiency Services Limited (EESL) – a joint venture of four Central power sector PSUs – and electricity distribution companies. Under this model, EESL procures LED bulbs in bulk and sells them to families at Rs 10 rather than the market price of Rs 400. The electricity distribution companies then repay EESL over a period of five to eight years from the savings that accrue due to the use of energy-efficient lights. "We have projected that the electricity distribution companies will save 85 per cent electricity consumed in household lighting. They will pass on 30 per cent of that saving to EESL every year for the next five to eight years," says Saurabh Kumar, managing director, EESL.

EESL has completed several projects to retrofit streetlights with energy-efficient LED lights as well as a 750,000-LED-bulb-replacement project for houses in Puducherry. This bulk purchase reduced the cost of an LED bulb from Rs 400 to Rs 310. Recently, after signing an agreement with the Andhra Pradesh government,

LED streetlights

The Ministry of Urban Development has sent an advisory to all state governments to replace all streetlights with LED bulbs. This follows a survey by BEE that showed about 80 per cent of street lights in India are haphazardly installed. BEE has also prepared a guideline for municipalities to understand the right way of installing streetlights. The Central Electricity Authority of India reports that 1 per cent of the total electricity consumption in India, or 6.7 TWh, in fiscal year 2010-11 went into providing public lighting. Energy Efficiency Services Limited (EESL) replaced 200 halide lamps of streetlights on the East Coast Road in Puducherry with LED fixtures. This saved energy up to 50-55 per cent, says Saurabh Kumar, managing director, EESL. A 2014 study by Lawrence Berkeley National Laboratory found the savings potential for currently available technologies is 36 per cent, or 4.8 TWh, in 2020 with LEDs. With efficient tube lights savings could be 38 per cent, or 5 TWh.

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EESL completed the process for procuring 2 million LED bulbs. "Almost the entire lighting industry participated in the bid and the lowest quoted price was Rs 204 per LED bulb," says Kumar.

Design challenge

"We have estimated that there will be a demand worth Rs 5,442 crore for LED in the retrofitting sector in 2013-16, almost a quarter of the estimated demand for LED luminaries in India," says Sujan. But simply retrofitting current lighting fixtures with LEDs might not give the desired visual comfort. William Sullivan, a retired social worker in Puducherry, noticed the difference in the quality of light when he replaced all lighting fixtures in his room with LEDs a couple of years ago. "The light was drastically less. The light from LED just does not illuminate the areas of the room where I wanted it," he says. "I was forced to use multiple lights to get the same visual comfort which negated the savings."

LED light is focused and does not spread like light from other sources. It is best suited for task lighting, such as spotlights, to produce concentrated light. It is not a good choice for general or ambient light as was Sullivan's requirement. To effectively utilise LEDs for interior lighting one needs to redo the interior layout to facilitate task-lighting. "The most unfortunate thing happening with LED products is that they are being modelled to mimic existing bulbs and tube lights so as to facilitate retrofitting," says Sahiba Hameed, a designer with real estate firm Emaar-MGF in Gurgaon. "The biggest drawback of tube lights is they throw half the light they produce on the wall on which they are mounted, which is outright an waste. The same is happening with LEDs."

LED, like CFL, requires careful handling. While CFL contains mercury, researchers at the University of California have found the presence of heavy metals like lead, arsenic and nickel in LEDs. "Very few municipalities are equipped to deal with this dangerous waste," says Krishna Rao Jasim, a green architect in Bengaluru.

Different functions require different types of technology. Policies should set ambitious minimum efficacy levels for light fixtures which should be met by all the technologies.

Air conditioning

An air conditioner is the most energy-intensive appliance a family can own. When all the devices in a house – two ceiling fans, two incandescent bulbs, four tube lights, one TV and one refrigerator – are switched on, a one-tonne AC alone will still consume twice as much electricity as all the others put together.

India is still not a big AC consumer but with growing prosperity, aspirations and the need for comfort, this will change. Since 2004, room AC sales have grown at an average annual growth rate of 17 per cent, as per official data. The annual electricity demand from ACs may increase to 239 TWh by 2030, almost 30 per cent more than the electricity consumed by the entire domestic sector in 2012, projections by California-based Lawrence Berkeley National Laboratory (LBNL) show. This will translate into a peak demand contribution of about 143 GW by 2030. It is also clear that India, being hot and humid in most parts, has a high need for space cooling. The Lawrence Berkeley National Laboratory (LBNL) in a paper, titled 'The 100 power plant question', has estimated that there is a 40 per cent difference in the afternoon peak and 60 per cent difference in the evening peak in cities like Delhi because of electricity demand by ACs. In other words, these cities would use 40-60 per cent less power if they did not have ACs. There is, therefore, no question that improvement in efficiency standards for this sector will be a game changer for the country.

Since 2010, a star rating for energy efficiency has been made mandatory for ACs in India. The standards are set in terms of the energy efficiency ratio (EER). The higher the ratio the less the energy use.

Beginning in 2012, the one-star-labelled machine had an EER of 2.5, which was revised to 2.7 in January 2014. Under this rating scheme, all ACs with EER of 3.5 and above are labelled five star.

These levels are significantly lower than that of other countries, including China, points out Nikit Abhyankar, senior scientific engineering associate at LBNL. He has found that India's current average is equivalent to China's minimum EER requirement.

China's highest-rated AC has an EER of over 6 and the best commercially available technology currently sold in Japan has even higher EER of 6.67.

The question is: Why can't India move faster to better technology? The key answer is cost. Energy analysts are quick to point out that people do not buy even the current five-star ACs because they are expensive. New standards that drive up price will only mean fewer sales. The technology for super-efficient ACs is not commercially available in India.

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But this reasoning does not reflect the reality. First, with the price of electricity going up, people look to save money through efficiency. The question for them is how long will it take to pay back the extra cost. Secondly, technology is available because global players, who make more efficient ACs for other markets, dominate the Indian AC scene. Today LG and Samsung together hold nearly 60 per cent of the Indian market share. In fact, only five companies are responsible for almost 90 per cent of the ACs sold in India.

Indian companies deny they are pulling down the efficiency standards in the country. C Haridas, senior general manager of Indian manufacturer Blue Star, told *Down To Earth* that his company supports ratcheting up of standards as long as a level playing field is provided for Indian makers. But this market leader has no five-star AC model in the category of three- to five-tonne capacity.

LBNL analysis shows that cost is also not a barrier. They have estimated the global average manufacturing cost and retail price against the retail price of ACs sold in India. Their conclusion is that ACs with EER of 4.21 are cost-effective in Indian conditions with a payback period of five years. This is assuming a residential tariff of Rs 4.5 per unit. If the tariff is higher, which is increasingly the case; the payback period would be less.

That is the nub of the matter. India is a price-sensitive market, so it is the price of electricity in houses that will help drive the change towards efficiency. What is needed is an aggressive programme that incentivises manufacturers to leapfrog to the best available technology today. This would need a super-efficient appliance programme for this sector to provide fiscal incentives to manufacturers and simultaneously increase the efficiency standards.

Improve standards, leapfrog

At a BEE workshop on space cooling efficiency enhancement held in June this year, Sanjay Goyal, country head, sales and marketing, Daikin Airconditioning India, said the AC market globally is shifting to super-efficient inverter technology. "All the ACs sold in Japan and half in China are inverter ACs, while in India the share of this technology is just 5 per cent," says Goyal.

What is an inverter AC? The standard fixed-speed AC has a single-speed compressor motor that switches off when the desired temperature is reached and on again when the temperature rises to a set level. Inverter technology uses a variable-speed compressor motor that slows down and speeds up as needed. This provides a more precise room temperature and is, therefore, about 30 per cent more energy efficient than fixed-speed ACs.

The inverter AC technology costs more but the Indian star-rating system does not recognise the extra edge it provides. It awards five stars to all ACs with efficiency higher than 3.5 EER, so there is no way to differentiate that the inverter technology AC, with EER of 4 and above, is better than most others.

Transitioning to a super-efficient appliance future will also require a high order of technical scrutiny by standard-setting organisations. Currently, the Indian rating system is not as rigorous as the rating system in

Refrigerators: Illusion of inefficiency?

The Standard and Labelling programme has been highly successful in pushing refrigerators towards efficiency, with the sales of four- and five-star models dominating the market. The minimum benchmark for refrigerators was hiked by 20 per cent this year, but it still looks weak compared to global standards. One reason could be that India tests refrigerators' performances at a higher ambient temperature than the European Union (EU). So, in India, the refrigerator will have to do more cooling, thereby use more energy, giving the impression of inefficiency. But even after rationalisation Indian standards remain lax.

Standby power vampires

Standby power is the energy used by some products when they are turned off but still plugged into a power outlet. While this power sometimes provides useful functions such as remote control, clock displays and timers, in other cases it is simply wasted. The devices causing this waste are referred to as energy vampires because these products slowly suck energy from homes. Chargers for cell phones, iPods and power tools also use energy when they are plugged into an outlet, even if they are not charging. Non-profit Prayas attributes 2 per cent of household energy consumption in India to standby power. Globally, it is estimated to account for 3 to 10 per cent of home and office electricity use.

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the European Union, USA and even China. In India, appliance efficiency is rated in laboratory conditions but in real life appliances do not function at test conditions, therefore, they always use more energy.

Energy Star, which is the rating followed in the US and Europe, also factors in varying climatic and temperature conditions, bringing the rated values closer to actual. BEE is reluctant to take up the tedious process of changing testing standards. What it is doing is exploring ways to adopt a seasonal metric to measure efficiency in different climatic conditions. "We have collected climatic and performance data from 40 cities, and will hopefully launch this soon," says Saurabh Diddi, energy economist at BEE.

A complementary step in saving energy is lowering the demand for air conditioning. Improve the design of buildings so that they withstand heat and then set higher tariffs for high-energy users.

The solution is clear. Now the question is: what will it take for the government to ensure that India leapfrogs to super efficiency and energy security?