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APPENDIX 3

TRANSFORMING LIGHTING EFFICIENCY IN INDIA

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This Appendix summarises successive government initiatives to encourage the uptake of energy-efficient lighting across India. It outlines the critical lessons learned from each stage, which eventually helped policymakers steer even the lowest-income households to use more expensive but vastly more efficient LED bulbs, resulting in a host of positive outcomes.

1990-2010: The leap from kerosene to electric lighting

Around 96% of Indian households today are connected to the grid, thanks to successive government electrification policies over the past few decades (Nidhi, et al., 2020). Between 1990 and 2020, the proportion of households using electricity for lighting increased from 35% to 99% (Shalu, et al., 2020), rapidly displacing kerosene, particularly in rural households, and since 2010 electricity consumption in the residential sector has realised an average annual growth rate of more than 6% (MOSPI, 2020).

It is estimated that between 20% and 27% of all household electricity use is for lighting, although this varies greatly between income groups, from 14% in high-income households, to around 60% in low-income households (TERI internal analysis). With both access to electricity and lighting energy demand increasing rapidly, especially among low-income households, India's challenge was to ensure people adopted the most efficient lighting technologies, to minimise not only household bills, but also the need for additional electricity generation, and associated emissions.

Various lighting technologies have been used in India, including incandescent bulbs (ICB), compact fluorescent lamps (CFL), fluorescent tube lights (FTL), and light emitting diodes (LED). Of these, LEDs are the most efficient, consuming around 10% of the energy required by an ICB, for a similar level of light output (Aditya, et al., 2018). In 2005, ICB and FTL together held around 95% of the Indian market. By 2010, more efficient CFLs had captured a 24% share, despite a unit price around six times that of ICBs, due to an ongoing government policy (BEE, 2008). Meanwhile LEDs, which at the time had a price around 13 times more than CFLs, remained largely negligible (ELCOMA, 2013) (Rohan, 2014).

The more energy-efficient lighting options were only gaining traction with large commercial entities, where electricity prices were relatively high and the initial investment could be recouped in as little as 2-3 months. To harness these efficiency gains in the residential sector while meeting its development agenda of enhancing access to electricity, the Government of India (GoI) was faced with the challenge of increasing the take-up of LEDs in the face of high investment cost, particularly for low-income households, and the regulated low electricity price households paid.

Bachat Lamp Yojana: The push to compact fluorescent lamps

The GoI's first programme to promote efficient lighting, in 2008-09, encouraged replacing ICBs with CFLs through the voluntary scheme 'Bachat Lamp Yojana' (Energy Saving Light Scheme). Formulated after extensive consultations with multiple stakeholders, including investors, government departments, distribution utilities and consumers, the scheme was implemented by the Bureau of Energy Efficiency (BEE), along with CFL investors and electricity distribution companies (DISCOMs). Under this scheme, investors procured CFLs from countries listed in Annex I to the Kyoto Protocol (OECD countries, plus 'Economies in Transition' away from 'developing' status), and the DISCOMs were responsible for their distribution. The CFLs procured were distributed to consumers in exchange for old ICBs, and at a cost equivalent to an ICB (i.e. one sixth of the market price of a CFL). The combination of electricity savings and reduced CO_2 emissions from avoided electricity generation accrued to the DISCOMs as Certified Emission Reduction (CER) credits, which could be traded on the global market via the Clean Development Mechanism (CDM)[1], to generate income for investors.

[1] Formulated under Kyoto protocol, the CDM allows Annex II countries to earn CER credits from greenhouse gas abatement projects, which may be traded in the global market to be used by Annex I countries to meet their emission reduction targets

By 2012, about 29 million CFL bulbs were distributed under this scheme, resulting in 415 MW of avoided generation capacity (BEE, 2021), annual energy savings of 1.64 TWh, and 2 million tonnes of CO2 emission avoided (BEE & GIZ, 2019). However, its success was short-lived. The value of a CER plummeted from around $20 per tonne of CO_2 avoided in 2008, to less than $5 in 2012 (Schwieger, et al., 2019), while the cost of manufacturing CFL bulbs increased due to limited availability of key raw materials. These factors led to investors withdrawing from the scheme. Although its success was limited, it provided stakeholders with important insights on the benefits of transitioning to efficient lighting technologies, such as effective demand management and reduction of peak loads. Additionally, the increased consumer awareness helped establish the need for promoting more efficient lighting technologies such as LED. However, barriers such as a lack of technical standards and the high upfront cost remained (Malhotra et al., 2021).

UJALA and SLNP: Out with incandescent bulbs, in with LEDs

Drawing inspiration from BLY, the Domestic Efficient Lighting Program (DELP) was launched in 2014 by Energy Efficiency Services Limited (EESL), a joint venture between state-run power companies. It launched initially in Pondicherry, which had a high rate of electrification and was a net importer of electricity, and was later followed by other states.

DELP's objective was to replace household ICBs with LEDs, at the price of a new ICB. EESL shouldered the financial risk and responsibility of cost recovery and developed an innovative approach: a standard offer program (SOP), where EESL bulk-procured LEDs and distributed them to consumers at a minimal cost of Rs10. The utilities treated demand/energy-saving achieved as a resource to purchase at a predetermined (SOP) rate from EESL. The SOP price was fixed relative to the power procurement cost, and the difference between the two prices taken as a benefit by utilities (Shakti Foundation, 2014). More than 46% of households in Pondicherry transitioned to LEDs, resulting in total annual savings of 14GWh (Chunekar, Mulay, & Kelkar, 2017). This success provided a greater impetus for LED deployment and the DELP program was later re-launched at a national level as UJALA.

In January 2015, two countrywide initiatives were introduced by the GOI with an objective of reducing the cost and further increasing the deployment of LEDs. These were:

1. Unnat Jyoti by Affordable LEDs for All (UJALA), which provided LEDs to low-income domestic consumers for an affordable price and promoted their benefits. It set a target to replace 770 million inefficient bulbs by 2019 (EESL(a), 2017).

2. Street Lighting National Programme (SLNP), to replace all 35 million inefficient streetlights with LEDs (EESL(b), 2017).

Since the inception of these initiatives, close to 367 million LED bulbs have been distributed to low-income households, resulting in 47 TWh of energy savings, and approximately 12 million streetlights replaced with LEDs, avoiding around 8 TWh of electricity consumption (EESL, 2021).

By consulting a wide range of stakeholders – including investors, manufacturers, technical experts and end-users – policymakers were able to identify the key factors that would enable acceleration of LED adoption. This led to the following key features: (a) a clear deployment goal; (b) the adaptation of minimum technical standards for LED bulbs/lamps for improved performance and safety, and (c) the creation of a strong institutional framework, including a range of stakeholders including consumers, manufacturers, utilities companies, state regulators, BEE and EESL.

EESL acted as an interface between the government, DISCOMs and LED manufacturers, communicating their various needs. More importantly, it was responsible for developing an innovative business model and taking the required financial risk for enabling a quick transition to LEDs. Both UJALA and SLNP benefited from cost reductions due to bulk procurement programmes, where EESL leveraged economies of scale to reduce LED prices, resulting in an 85% drop between 2014 and 2016.

For UJALA, the LEDs were sold at registered kiosks or vendors at a minimal upfront cost, with the remaining purchase price recovered through instalments on electricity bills. Here too, EESL bore the upfront cost and used the savings monetised over time by consumers to recover the cost. No investment was required from DISCOMs – the only role they played was in distribution of LEDs. This approach made UJALA the world's most extensive zero-subsidy program. The combination of various awareness campaigns and the increased availability of LED bulbs, at minimal upfront cost, greatly accelerated the transition to LEDs in India. It also helped create a parallel market beyond UJALA, as people become more aware of the benefits of LEDs, increasing demand and resulting in a drop in retail prices (UNEP, 2017).

EESL developed an equally innovative service model for the SLNP, entering into a contract with Indian municipalities (or Urban Local Bodies - ULBs) to offer minimum guaranteed energy savings on replacing conventional streetlights with LEDs, and providing free maintenance services for the following seven years. The ULBs repay EESL with the savings accrued from reduced energy consumption and maintenance costs, with no new investment required. This approach encouraged nearly half of all Indian ULBs to sign up for the scheme.

Missed opportunities in the drive to energy-efficient lighting

The UJALA scheme has been instrumental in transforming the efficiency of lighting in Indian households. A survey conducted in 2019 revealed that around 90% of electrified households met their lighting demand using LED bulbs, of which 63% used only LEDs (Agrawal, et al., 2020). Overall, this scheme and the wider demand it initiated resulted in an increase in annual sales of LED bulbs in India from 3 million in 2012, to 670 million in 2018 (TATA power, 2018), with prices reducing from Rs800 in 2010, to Rs400 in 2014, and to just Rs70 in 2019 (Dhupia, 2021).

The demand for LED lighting may have been transformed, but on the supply front, opportunities have been missed.

The LED lighting technology value chain comprises three segments: (1) upstream, including the production of semiconductor wafers and LED chips; (2) middle-stream, including the design and production of LED-printed circuits boards, LED drivers and their packaging with LED chips; and (3) downstream, including the assembly of components along with external packaging (e.g. heat sinks and lenses) for final application. The upstream and middle-stream segments are technologically intensive, and the quality of LED lights depends on the technological solutions employed within these segments – most of which are patent protected. Also, the production of semiconductor wafers and LED chips requires large capital investments. Historically, India had no manufacturing capacity or technological capability to produce semiconductor wafers.

One of the enablers for India's quick transition to LEDs was technological advances and overcapacity within the upstream segment of the LED value chain in China. Around 2008/2009, China, through various energy-efficiency measures, created huge domestic demand for LEDs. To meet this, state subsidies were provided for firms to establish manufacturing units for LED lighting components within the upstream and middle-stream segments, leading to substantial investments by private companies, both domestic and international. This facilitated technology transfer and knowledge-sharing between international and domestic manufacturers, and enhanced domestic Chinese R&D capacities. As a result, manufacturers in China were able to produce medium-quality LED lighting products at a lower cost than their international competitors, with domestic production satisfying around 75% of domestic demand in 2013 (from zero in 2002) (Butollo & Brink, 2018). This helped India to make bulk procurements at historically low prices, although the quality of the bulbs was relatively low (the warranty on the life of those distributed under the UJALA scheme reduced from eight years initially, to just three in later procurement rounds).

UJALA's secondary objective was to increase the domestic manufacturing of LEDs. In 2015 the GOI announced a Preferential Market Allocation (PMA) policy, insisting that LEDs procured for the UJALA and SLNP schemes had some component of Indian value-added. This resulted in a shift from importing bulbs to importing LED components, which were then assembled domestically. In 2017, duties on the import of final LED products were increased relative to that on components. This led to the establishment of a domestic industry in downstream LED manufacturing (i.e., assembly of the final product), growing from negligible levels in 2010 to 176 manufacturing units and more than 300 registered establishments, with a present market value of more than $1 billion (Chunekar, et al., 2017) (ELCOMA, 2019), increasingly driven by new markets such as backlighting units, automobiles and signalling. As a result, the import of LED components has rapidly increased in recent years, and imports of final products have reduced. However, in recent years the GOI has sought to meet India's growing LED demand with superior quality bulbs and, in April 2021, the Department for the Promotion of Industry and Internal Trade announced a production-linked incentive (PLI) scheme for the production of LED components in India.

The UJALA scheme created a huge and sustainable market for LEDs in India, in effect adding to global demand. However, from the supply side, India remains highly dependent on imports from China. Developing a high-value LED supply chain, i.e. manufacturing semiconductor wafers and LED chips, requires considerable investments, local R&D infrastructure, and technical capability, which India lacked until recently. Additionally, market penetration of LEDs in India was low, where global production capacity was increasing (especially in China), resulting in decline in the cost of LEDs. Therefore, policymakers considered deployment of LEDs and creating a sustainable market demand as the main objective of the UJALA programme, rather than development of manufacturing capability. As such, the policy environment did not focus on domestic R&D or promoting infrastructure investments related to manufacturing of upstream LED components, and with limited access to technology due to restrictive intellectual property rules, consequently prevented a domestic upstream LED manufacturing industry and supply chain to flourish.

Reflections: A mixed legacy

Despite the challenges that a developing country could have faced in terms of inertia among the relatively poor households to switch over to lighting systems with much higher upfront costs, policy decisions were successful in rapidly improving end-use efficiencies at the national level as access to electricity increased. This played an important role in containing the spur in growth of electricity demand as the number of households with electricity connections increased.

But the widespread deployment of LEDs can also be attributed to the development of institutional capacity. The learning acquired from earlier schemes and constant exchange of knowledge among stakeholders helped identify and address the barriers to LED adoption. For instance, BEE, drawing its experience from the BLY scheme and Standard and Labelling programme, was able to create the right network of stakeholders to quickly develop the minimal technical standards for LEDs. Likewise, EESL engaged with the state regulator and distribution utilities to create the required distribution value chain, developed initially during the BYL scheme and subsequently efficiently utilised for LEDs (Malhotra et al., 2021). EESL marketing campaigns advocating the energy and cost-saving benefits of LEDs and their availability at a lower price created awareness not only for the targeted consumers of UJALA, but also the larger public. It added to the demand, thereby driving the local LED market. Subsequently, mandating the need for domestic value-addition enabled local manufacturing and supply capacity for LED final product. The proportion of domestic value reached 20% by 2017, and with the PLI scheme announced recently, this share is expected to go beyond 40%.

Decisionmakers invariably evaluate the relative costs and benefits of various options to determine least-cost paths, but they can also steer the economy effectively towards alternative pathways by incorporating learnings (from both successes and failures) and putting in place appropriate enabling policies and measures. This also opens up the space to examine whether more holistic approaches to transformative structural changes with wider socio-economic implications can be enabled by adopting a different approach to decision-making as India transitions towards electric mobility and greater use of new renewables and hydrogen.

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