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HIGH IMPACT OPPORTUNITIES FOR ENERGY EFFICIENCY IN INDIA

INDIA ENERGY EFFICIENCY SERIES

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FOREWORD

Energy is the prime mover of economic growth and is vital to the maintenance of a modern economy. Sustainable developments require the long-term availability of energy from sources that are affordable, accessible and environmentally friendly. India needs to accelerate the growth of its energy sector to meet the growing demands of a vibrant economy. India is a net importer of energy, with more than 25% of its primary energy needs being met by imports, but it is undertaking measures to reduce its dependence on imports and enhance its energy security. Energy efficiency is an important part of this endeavour.

Energy security is another important issue, and the government is undertaking several measures in this regard. Energy supply is being augmented at an accelerated pace to bridge the gap between supply and demand, and the government has renewed its focus on energy efficiency in order to moderate the growth of energy demand without compromising on service levels.

There is significant untapped potential for energy efficiency in the country. The ***Energy Conservation Act of 2001*** provides a regulatory and policy framework to catalyse the market-based implementation of energy efficiency. EESL was setup to create and sustain markets for energy efficiency in the country. It works closely with BEE and is leading the-market related activities of NMEEE, one of the eight national missions set up under the Prime Minister's National Action Plan on climate change.

Improvements in energy efficiency will be critical in achieving the ambition of limiting temperature rises below 1.5°C, as agreed at the Paris Conference of the Parties in 2015. Energy efficiency is a mitigation option with a lot of co-benefits. It is also considered to be an option with negative costs and therefore to be in the interests of the parties in promoting energy efficiency, although, due to market imperfections and institutional barriers, its full potential has not yet been realized.

In terms of the future growth of energy and CO_2 emissions, India stands out when compared to other countries due to its large size, large population and relatively fast economic growth. Keeping in mind that growth is essential for reducing poverty, unemployment and achieving other developmental goals, India has focussed on decoupling energy use from economic growth, which can in turn decouple CO_2 emissions from economic growth. As part of its NDC, India has therefore identified the strategies it will pursue to improve energy efficiency.

The High Impact Opportunities studies that the UNEP DTU Partnership has carried out in China and India represent an effort to work with national stakeholders, research institutions and practitioners to identify good practices and identify the priorities for enhancing energy efficiency in the future.

This report on ***High Impact Opportunities for Energy Efficiency in India*** describes four High Impact Opportunities (HIOs) for making improvements in energy efficiency in India in the residential, industrial and agricultural sectors. These HIOs have been taken from the long list of HIOs identified in the report on ***Enhancing Energy Efficiency in India: Assessment of Sectoral Potentials.*** HIOs have been identified based on the potential for improvements in energy efficiency that were estimated using a model-based form of assessment. Besides this model-based assessment, HIO identification has involved stakeholder consultation and expert opinions on the potential for scaling up a technology option based on its technological maturity level and its contribution to Sustainable Energy for All (SEforALL's) objectives regarding energy access, improving energy efficiency and encouraging renewable forms of energy. The four HIOs covered in this report concern LED lighting, super-efficient air conditioners, efficient agriculture pump sets and the Perform, Achieve and Trade Scheme. These HIOs are expected to play an important role in the short (until 2020) and medium terms (2020-2030).

I would like to congratulate the team of authors from the Indian Institute of Management, Ahmedabad, and EESL on their efforts, and I am sure that the report will be of interest to policy-makers, practitioners and researchers alike.

Mr. Saurabh Kumar
Managing Director
Energy Efficiency Services Limited

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Amit Garg | Bhushan Kankal | Pankaj Mohan | Saket Shukla | Saritha S. Vishwanathan

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AC	Air Conditioner
AGDSM	Agriculture Demand Side Management
BEE	Bureau of Energy Efficiency
TWH	TeraWatt Hours
BLY	Bachat Lamp Yojna
BPL	below the poverty line
C2E2	Copenhagen Centre on Energy Efficiency
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CEA	Central Electricity Authority
CFL	Compact Fluorescent Lamp
CO_2	Carbon Dioxide
DC	Designated Consumers
DELP	Domestic Efficient Lighting Program
DISCOM	Distribution Companies
DR	Demand Response
ECA	Energy Conservation Act
EE	Energy Efficient
EER	Energy Efficiency Ratings
EESL	Energy Efficiency Services Limited
EMI	Equated Monthly Installments
ESCO	Energy Service Company
EV	Electric Vehicles
FTL	Fluorescent Tube Lights
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HI	High Income
HIO	High Impact Opportunity
HP	Horsepower
HPSV	High Pressure Sodium Vapour
ICL	Incandescent Light
IIMA	Indian Institute of Management Ahmedabad
IMI	International Management Institute
INDC	India's Intended Nationally Determined Contribution
INR	Indian Rupee
ISEER	Indian Seasonal Energy Efficiency Rating
KCAL	Kilo Calorie
KW	Kilo Watt
KWH	Kilo Watt Hour
LED	Light-emitting diode
LMI	Lower Middle Income
LPG	Liquified Petroleum Gas
LTS/SEC	Liters per second
M	Meter
MANIT	Maulana Azad National Institute of Technology
GWH	GigaWatt Hours
MM	Millimeter
MMI	Medium Middle Income
MN	Million
MNRE	Ministry of New and Renewable Energy
MPCE	Monthly Per Capita Expenditure
MTOE	Million tonnes of oil equivalent
NAPCC	National Action Plan on Climate Change
NDC	Nationally Determined Contributions
NMEEE	National Mission on Enhanced Energy Efficiency
NMSH	National Mission on Sustainable Habita
OTC	Over the Counter
PAT	Perform, Achieve and Trade
PFC	Power Finance Corporation
PJ	Peta Joule
POA	Program of Activities
PSM	Payment Security Mechanism
PSU	Public-sector Undertaking
PVE	Petroleum Violation Escrow
R&D	Research & Development
RLF	Revolving Loan Funds
ROI	Return on Investment
SEforALL	Sustainable Energy for All
SEC	Specific Energy Consumption
SEO	State Energy Office
SLNP	Street Lighting National Program
T&C	Transmission & Commercial
T&D	Transmission and Distribution
TWH	Tera Watt Hour
UJALA	Unnat Jyoti by the Affordable LEDs for All
ULB	Urban Local Bodies
ULI	Upper Lower Income
UMI	Upper Middle Income
UMPP	Ultra Mega Power Plants
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollar
W.R.T	With respect to

CHAPTER 1

INTRO

INTRODUCTION

1. BACKGROUND

The Copenhagen Centre on Energy Efficiency (C2E2) is a part of the UNEP-DTU Partnership, a collaboration between the Denmark government, the UN Environmental Agency and the Technical University of Denmark (DTU). The C2E2 serves as the Energy Efficiency Hub for the Sustainable Energy for All (SEforALL) initiative.

The Sustainable Energy for All (SEforALL) initiative is a multi-stakeholder partnership between governments, the private sector and civil society. The SEforALL initiative was launched by the United Nations Secretary General in 2011 to achieve three interrelated goals by 2030:

1. Ensure universal access to modern energy services;
2. Double the share of renewable energy in the global energy mix;
3. Double the global rate of improvements in energy efficiency.

In order to facilitate the realization of the SEforALL goal on energy efficiency, C2E2 provides capacity-building, analytical and knowledge support to countries in relation to their actions to improve energy efficiency.

This report is a part of the project ***"A Study on High Impact Opportunities for Energy Efficiency Improvement in China and India"***, initiated to identify high-impact opportunities (HIOs) for energy efficiency enhancement across sectors and to facilitate the measures, including technological measures and policies, needed to achieve these objectives. This study is part of C2E2's efforts to build capacity and provide a platform for analytical work on HIOs in China and India. In India, it is being implemented with the help of the Indian Institute of Management, Ahmedabad (IIMA), and Energy Efficiency Services Limited (EESL), New Delhi, in partnership with the International Management Institute (IMI) at Kolkata and the Maulana Azad National Institute of Technology (MANIT) in Bhopal. Delineating existing policies and measures that support these HIOs and highlighting success stories in each country also form part of the overall study.

This project output consists of three reports: (1) ***Report on Good Practice and Success Stories on Energy Efficiency in India***, (2) ***Report on Enhancing Energy Efficiency in India: Assessment of Sectoral Potentials*** and (3) ***Report on High Impact Opportunities for Energy Efficiency in India.*** The first report contains a detailed overview of energy efficiency policies and measures in India, as well as eleven good practice and success stories about energy efficiency in India. The second report includes an assessment of the potential for improvements in energy efficiency in the key sectors of industry, building, transportation and power generation. The third report (this one) focuses on high-impact opportunities (HIOs), four of which are presented in this report.

Experts from the Copenhagen Centre provided guidance to the study through the overall design of the project, providing templates for each report, and reviewing and commenting on the draft reports.

2. SELECTION OF HIGH-IMPACT OPPORTUNITIES FOR ENERGY EFFICIENCY

Bottom-up modelling has been conducted to select a set of cost-effective, energy-efficient technologies. Based on the model outputs, high-impact opportunities were selected for increasing energy efficiency while maintaining India's energy security and its alignment with agreements regarding global mitigations of GHG emissions. As the HIO is a dynamic concept, present and future HIOs for each of the sectors were narrowed down based on their possible penetration rates and costs during the reporting period.

The analysis, as presented in the second report on ***Enhancing Energy Efficiency in India: Assessment of Sectoral Potentials***, examined HIOs for the short term (till 2020), medium term (2020 to 2030) and long-term (2030 to 2050). HIOs identified for the short term (Table 1) include light-emitting diode (LED) lighting, energy-efficient (EE) pump-sets for agriculture, a 'perform, achieve and trade' (PAT) scheme for eight energy-intensive sectors, and metro rail. For the medium term, our analyses indicated that the perform, achieve and trade (PAT) scheme would remain a major HIO along with energy-efficient pump sets. Emerging HIOs for this period include energy-efficient fans, solar power, smart grids, super-critical pulverized coal technology and measures to reduce T&D losses. PAT will continue to remain an HIO even after the medium term, assuming the government's 'Make in India' program continues. In the longer term, energy-intensive industries will gradually move towards a narrower specific energy-consumption band, while the residential sector will shift towards cleaner fuels like electricity and solar. Smart grids will play a crucial role in monitoring, thereby conserving energy in urban areas. Metro will remain an important HIO in the transport sector, increasing the share of public transport as one of the most convenient modes of travel.

TABLE 1. HIOs projected for the future

SECTOR	HIO – SHORT TERM, 2015-2020	HIO – MEDIUM TERM, 2020-2030	HIO – LONG TERM, 2030-2050
Agriculture	Energy-efficient (EE) Pumps	EE Pumps	EE and Solar Pumps
Residential	LED, advanced space-cooling systems, cleaner cooking (LPG, biofuels)	Energy-efficient fans, advanced space-cooling systems (ACs), cleaner cooking (LPG, biofuels)	Advanced space-cooling systems (AC with cool roof), solar concentrators for cooking, city/housing complexes-based heating and cooling systems
Transport	Metro	Metro, electric vehicles (EV)	Metro, electric vehicles (EV)
Industry	PAT	PAT (enhanced sectoral and plant coverage)	PAT (enhanced specific energy-consumption targets)
Power	Transmission and commercial (T&C) loss reduction, super-critical coal-based power plants	Super-critical and ultra-mega power plants (UMPP), T&C loss reduction, solar and wind, smart grids	Super-critical and UMPP, storage technologies, solar/wind and other new and renewable sources, smart grids

Source: Vishwanathan et.al., 2017

Out of these, four HIOs were selected and are described in detail in this report. Those selected either have immediate large benefits for enhancing energy efficiency in India, are already being implemented (LED, PAT) or have high potential in future years (energy-efficient ACs, energy-efficient pump-sets, and PAT). Here PAT is indicated as an HIO right up to 2030. However, its baseline, sectoral coverage and specific energy-consumption targets deepen over time.

In the agricultural sector, the potential HIO covered in detail here is the **energy-efficient pump set,** chosen because of the increasing consumption of electricity in agriculture in recent decades. Though there will be a shift to new, renewable and cleaner sources of energy and to improved grid distribution, energy-efficient pump sets will be required to reduce energy demand for the same service. Hence, the technology will remain an HIO in the short and long terms. In the residential sector, **LED** has been selected as the HIO for the short term. By the end of May 2017, 238 million incandescent lamps had already been replaced with LEDs in India, and target is to triple this in the next couple of years. It is projected that, during the 2020s, LED will become the baseline in lighting, and therefore the gains from incremental changes would be only marginal. In the residential sector, **energy-efficient ACs** (referred to as advanced space-cooling systems in the table) were observed to be replacing LED as an HIO in the medium and long terms under existing policy and market interventions, in addition to the availability of better technology and improved economic conditions. In the industrial sector, **PAT** is and remains the HIO in the short, medium and long term.

It is estimated that the selected HIOs will be cost-effective in the short, medium and long terms. The present report provides a situational analysis of the sectors, the goals that will be achieved by each of the selected HIOs and an implementation plan to encourage and enable these HIOs through policy initiatives, regulatory measures and economic instruments. Table 2 summarizes the goals set, the barriers and the policies aimed to enable and increase the penetration of the selected HIOs.

TABLE 2: Enabling selected HIOs

HIOS	SECTOR	GOAL	BARRIERS/RISKS	ENABLING POLICIES	ENABLING POLICY INSTRUMENTS
LED	Residential and Commercial	**Physical:** 560 Mn **Energy saving:** 72 TWh	Upfront procurement costs, fast-pace technology	UJALA, SLNP	Benefit share model between EESL and DISCOMS
Energy efficient ACs	Residential and Commercial	**Physical:** 24 Mn **Energy saving:** 689 PJ	Aggregate demand	NMEEE, NMSH	Benefit share model between EESL and DISCOMS, State – Revolving Loan funds, rebates/incentives, demand response-complimentary program
Energy efficient pumps	Agriculture	**Physical:** 21 Mn **Energy saving:** 58 GWh	Adoption of new technology, high risk on return of capital	NMEEE	Benefit share model between EESL and DISCOMS
PAT	Industry	**Physical:** 11 industries **Energy saving:** 18 Mtoe (2017-2020)	**Technical:** normalization, integration of energy-saving certificates (ESCerts), require benchmarks for new industries **Financial:** Transaction costs of ESCerts, volatility in energy and EScert prices. **Economic:** Goods and Service Tax	NMEEE	

CHAPTER 2

LED LIGHTING PROGRAM IN INDIA

1. INTRODUCTION

Light-emitting diodes (LEDs) are revolutionizing the lighting market. With their high-energy efficiency, versatility and cost competitiveness, LEDs have spread quickly in the Indian household and commercial markets during the last two years.[1] Diffusion of LEDs has been accompanied by a drastic fall in the cost to consumers and constant improvements in quality. LEDs have been proved to be safe and more efficient than the products they are replacing. LED lighting technology has been evolving at a rapid rate, and hence keeping pace with this technology is of the utmost importance. Although LEDs are the most efficient lighting solution presently available, further innovations in technology and policy support are needed to cover the potential market.

1 A more detailed description of what has been achieved in the diffusion of LEDs is available in Garg, A., Dhar, S., Kankal, B., & Mohan, P. (eds.) 2017, ***Good Practice and Success Stories on Energy Efficiency in India.*** Copenhagen: Copenhagen Centre on Energy Efficiency, UNEP DTU Partnership.

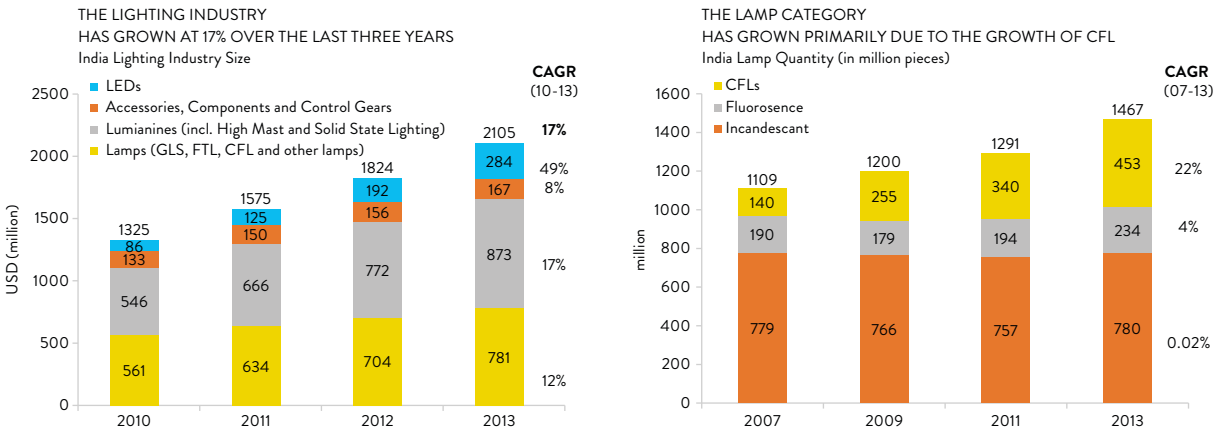
2. CONTEXT

The size of the Indian lighting industry reached INR 135 billion (USD[2] 2.1 billion) in 2013, up from INR 85 billion (USD 1.32 billion) in 2010, a compounded annual growth rate of 17 percent. The total number of bulbs in India increased from 1109 million in 2007 to 1467 million in 2013 (ELCOMA, 2016). The share of compact fluorescent lamps (CFLs) also increased from 13 percent in 2007 to 31 percent in 2013, showing an increase in its market share (Figure 1). These lamps are now being replaced by the more efficient LEDs. Within the lamp segment, the growth has been driven by CFLs, while incandescent lamps or ICLs and fluorescent tube lights (FTLs) have seen minimal growth in volumes.

During India's 11th five-year national plan (2007-2012), BEE developed the Bachat Lamp Yojana (BLY), an innovative scheme to promote energy-efficient lighting in the household sector. The scheme helped to overcome the barrier of high upfront costs by providing compact fluorescent lamps (CFL) to households at the same up-front price as incandescent lamps. The difference in cost was recovered by the BEE through carbon finance. To obtain the carbon finance, BEE developed a Program of Activities (POA) and registered it with the UNFCCC.

2 1USD=64.14 INR (as of 5 May 2017).

FIGURE 1: Growth of the Indian lighting industry



Source: ELCOMA, 2016

More recently, initiatives under the Domestic Efficient Lighting Program (DELP; now referred as Unnat Jyoti by the Affordable LEDs for All (UJALA) Program) have been introduced to promote LEDs that are even more energy-efficient than CFLs. UJALA is following an "On Bill Financing" model (see section 7). The government also plans to change all street lighting to LEDs. There is a potential market of INR 120 billion (USD 1.87 billion) for LEDs over the next three years, and another INR 395 billion (USD 6.16 billion) market for LED lights will also emerge in the commercial sector from 2017 to 2020. The government has initiated sending notifications to commercial buildings to change existing lights exclusively to LEDs, which are expected to be more receptive than the residential sector to LED lights, as their per-diem use of lighting is higher than that of residential consumers, and they can show these investments as costs in their annual accounts, thus receiving tax benefits. In the household sector the government plans to provide LED lamps to households below the poverty line (BPL) under existing DSM schemes of state governments instead of CFLs.

Energy Efficiency Services Limited (EESL), which is implementing the LED programs, plans to increase sales of domestic LEDs by providing LED bulbs at the same

up-front cost as the cost of incandescent lamps. The cost difference between ICLs and LEDs is recovered through equal monthly instalments included in the customer's electricity bill. These initiatives form a part of India's Intended Nationally Determined Contributions (INDCs) under the Paris Climate Change Agreement to mitigate carbon emissions.

3. GOALS OF THE HIO

A lot has been achieved under LED programs in India, but the remaining potential is still large. The Unnat Jyoti by Affordable LEDs for All (UJALA) Program[3] was launched in a hundred cities on 5th January 2015 for domestic consumers and street lighting. Under UJALA the target is to replace 770 million incandescent bulbs with LED bulbs for domestic consumers by 2020. Similarly, under the Street Lighting National Program (SLNP) the target is to replace 35 million conventional street lights with smart, energy-efficient LED street lights by March 2019.

Under the UJALA Program (previously DELP), more than 240 million LED bulbs had been distributed to households by 7 June 2017. It is expected that around 530 million more ICLs/CFLs will be replaced by LED lighting in the next three years across India (total target 770 million lights). This is projected to result in savings of 13 GW generating capacity creation, 65 million kWh of power generation and 50 million tons of CO_2 a year. Under the Street Light National Program (SLNP), EESL is replacing ordinary 70 W to 400 W High Pressure Sodium Vapour (HPSV) lamps with the LED Efficient Fixtures. A more detailed description of the success achieved under the two programs is available in the report on ***Good Practice and Success Stories on Energy Efficiency in India.***

3 Previously called the Domestic Efficient Lighting Program (DELP).

4. SECTORAL AND GEOGRAPHICAL SCOPE AND TIMEFRAME

The targeted segments are primarily residential and commercial buildings, as well as street lights in various Indian cities. A total of 35 states and union territories have already launched UJALA programs. Almost 240 million LEDs had been installed in these states under this program as of 7 June 2017, and almost 2.3 million street lights replaced. Twenty-three states have launched the SLNP through EESL. Figures A (1a and 1b) and A2 in the Appendix provide the detailed geographical status of these programs in India.

5. IMPLEMENTATION PLAN

The UJALA and SLNP programs are being implemented by EESL. As in the past, the LEDs bulbs will be bought in large bulk orders through open tenders by EESL, resulting in a gradual decline in prices due to economies of scale. For example, the rates of LED bulbs under UJALA were almost 70 percent lower than the retail market price of USD 5 per piece.

The high upfront capital costs have been a barrier in introducing LEDs. Creating and leveraging economies of scale for enhancing the penetration of LED lights has been the mantra in India. The LED lights program has been up-scaled to phenomenal levels (a target of 770 million in residential sector alone in five years). This has resulted in LED manufacturers reducing their prices drastically and utilities joining the program, as they benefit from the reduction in peak loads. EESL has initiated on-bill financing for domestic users and an annuity model for street lighting. Their success is evident in their results (see Figures A1 & A2 in the Appendix). To date EESL has invested USD 1.2 billion in energy-saving investments in the street lighting and domestic lighting sectors, through these investments being present in 151 cities with their street lighting investments and in 240 cities with their domestic lighting investments. The funds for upfront procurement are being arranged through a combination of equity from promoter companies and loans from bilateral and multilateral agencies and banks.

UJALA PROGRAM

The UJALA program works on a benefit-sharing basis between EESL and the electricity distribution companies (DISCOMs), in which the upfront costs of LED bulbs are borne by the DISCOMs. The consumers can either buy a fixed number of LED lamps directly from EESL at the bulk price on production of proof of their having a residential electricity connection, or they can opt for a monthly instalment scheme. The financial model used in UJALA is known as "On-Bill Financing". An instalment of USD 0.15 is deducted every month for 8-12 months from the customer's monthly electricity bills, which recovers the entire cost of the LED bulbs, including awareness, distribution and capital cost. For instance, the consumer may either buy an LED priced at INR 80 (USD 1.25) upfront through EESL-supported outlets in various cities of India, or decide to go for EMI financing, in which case INR 10 (USD 0.16) will be deducted from her monthly electricity bills for eight months. As already noted, the consumer has to show proof of their having a residential electricity connection to the LED distributing outlet. No differentiation is made for the type of consumer, whether residential or small commercial.

SLNP PROGRAM

The SLNP program follows the annuity model, which helps municipalities acquire the best available lights for street lighting with zero upfront capital costs. EESL makes the LEDs for street lighting available to municipalities. The cost difference in energy savings and maintenance cost savings is used to repay EESL. Almost half of the energy savings are guaranteed with the regular seven-year contract between the municipalities and EESL, which also includes free replacements and maintenance of lights at no additional cost to the municipality (MNRE, 2016).

6. ACTIONS FOR ADDRESSING BARRIERS

a) **Technology related:** the LED market is growing rapidly, and new technologies are continually being introduced. One innovation required relates to LED fixtures, which should become smaller and cheaper. Currently LED bulbs use Surface Mount Device (SMT) Technology. However, additional R&D and technology transfer will be needed for Chips on Board (COB) LED fixtures to be introduced so that the size of LED fixtures is reduced and lumen output is increased at a better price. Another innovation for which R&D is needed relates to lumen output. In the near future, due to R&D, the lumen ratings of LED fixtures will increase from 100 lumens per watt to 500 lumens per watt. Sourcing the material to manufacture such LED chips will be a challenge for India.

b) **Capacity:** the challenge in the domestic sector has been to improve awareness of LEDs and change people's attitudes to energy efficiency. Energy Efficiency Services Limited (EESL) has started a national program called the Domestic Efficient Lighting Program (DELP).

The government and industry need to address supply-side weaknesses in LED lighting products and LED luminaires by improving

- Luminaire design and research needs
- Limited testing capacity for LED lighting
- Reducing dependence on imports for electronic components and LED chips, as well as end product.

c) **Institutional:** the major challenge experienced by municipalities and urban local bodies (ULBs) in respect of previous LED programs was selecting ESCOs to implement energy-efficient street lighting. Municipalities and ULBs issued tenders to select the ESCOs for implementing the projects, but this did not materialize for a variety of reasons, like problems in setting the baseline, the conditions of the contracts, the availability of funds, data inadequacy and challenges associated with monitoring and verifying the data.

7. MAIN RISKS AND SUGGESTED SOLUTIONS

India has been very successful in manufacturing CFLs, something that can be replicated in the case of LEDs as well. However, additional help will be needed to match the incentives (e.g. cheap land, lower interest rates) offered by some of our neighbouring countries (like China, Sri Lanka) for the manufacture of LEDs. Furthermore, Indian manufacturing has the potential to become more cost competitive compared to China, though this would require maintaining lower labour costs and a weak INR.

Large volumes of low-quality imports in recent years have affected consumer confidence in LEDs, thus increasing the need for quality-control over market supply.

CHAPTER 3

INTRODUCING SUPER-EFFICIENT AIR CONDITIONERS IN THE INDIAN MARKET

1. INTRODUCTION

The number of air-cooling[4] appliances in India has increased by 7.7 percent in the past few years to reach to about 3.9 million units in 2016 (Euromonitor International (2017). "Air Treatment Products in India". Retrieved from Euromonitor Passport database in April 2017). Demand for space cooling and heating has the largest share of energy demand in the building sector.[5] Increases in summer temperatures and rising disposable incomes are resulting in consumers increasingly opting to buy air conditioners for their cooling needs. The market share of fans is currently over 80 percent, but the demand for air conditioners (ACs), however power intensive and comparatively expensive, is increasing. As an efficient (5-star rated air conditioner) can consume more than 1000 kWh of power in a year (Appendix, Table A1), the focus has been on introducing super-efficient ACs to cut down on the demand for energy. For the purposes of this report, super-efficient air conditioners are defined as BEE 5-star rated air conditioners that are currently available, and even more efficient ACs that will become available in the market from July 2017 (Appendix, Table A2).

4 Air-cooling appliances in this study include air conditioners, air-coolers and cooling fans.

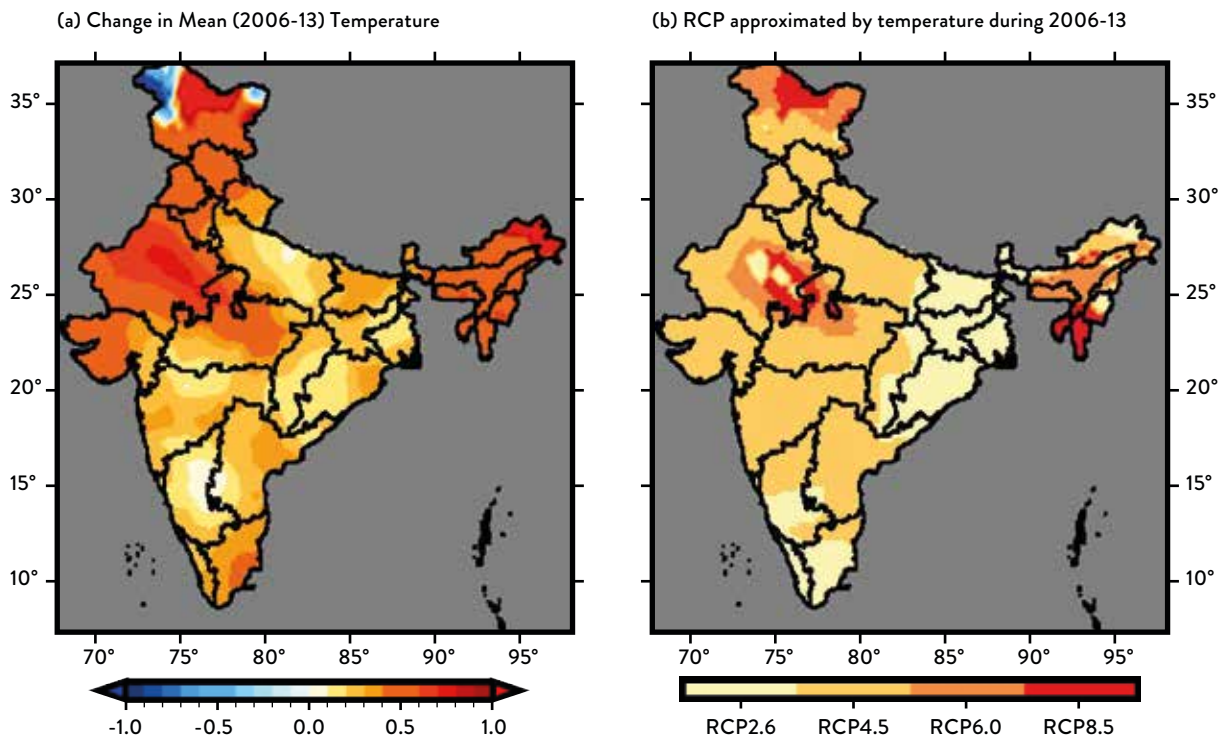
5 Around 40 percent for commercial buildings and 35 percent for the residential sector (source: IPCC AR5, Chapter 9, Buildings).

2. CONTEXT

The Indian room air-conditioner (AC) market has grown at around 20 percent per year over the last decade. This is expected to increase further due to rising incomes and the rise in average temperatures, especially during summers throughout India's cities. This will naturally increase the demand for electricity. Phadke et al. (2014) projected an increase in the electricity demand for ACs to 239 TWh per year by 2030, requiring the addition of 300 new coal-fired power plants rated at 500 MW each. Thus, energy-efficient ACs comes out as one of the most cost-effective solution to ease the load of the AC peak power demand. The high growth potential of the air-conditioning appliance market in India would therefore be better served by promoting energy-efficient air conditioners.

The number of air conditioners per thousand Indian households increased in urban areas from 109 in 2001 to 235 in 2011, at a rate of 8 percent compound annual growth rate (CAGR) over this decade (NSSO, 2000; 2011). This growth has been highest in the top two income classes according to the NSSO's surveys. Global climate models predict a warmer future climate. The mean annual temperature increase predicted under different scenarios varies from 1 to 1.5°C for the period 2016-2045. Additionally, the temperature increase in climate differs across regions. As observed in Figure 2a, the ambient air temperature increased in the northern, north-western, western and north-eastern regions compared to other regions of India from 2006 to 2013.

FIGURE 2: (a) Change in mean (2006-13) annual temperature as compared to historical (1951-2005) period and (b) Representative Concentration Pathway (RCP)



Source: Garg et al., 2015.

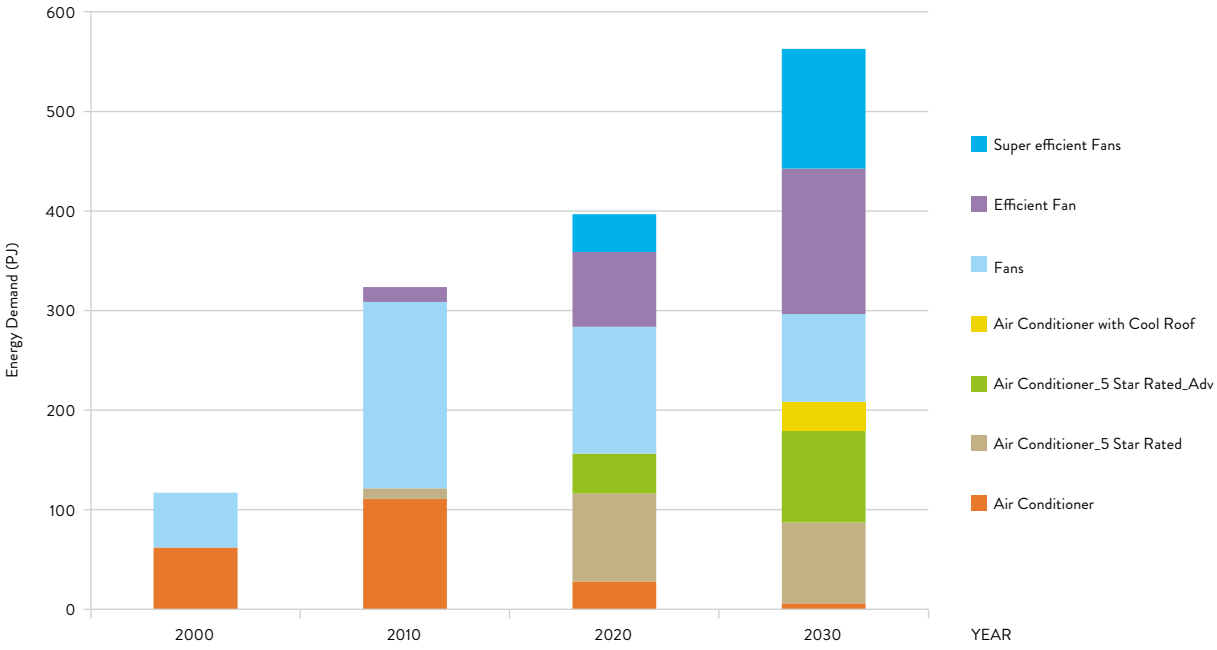
This warming of the climate, along with increases in household incomes with economic growth, will lead to greater use of air conditioners. In 2016, the penetration rates for split air conditioners and window air conditioners in India were 89 percent and 11 percent respectively. In 2015, a top official from Bluestar Ltd., one of the major AC and commercial refrigeration firms, projected the market size of ACs to grow to ten million by 2020 at a penetration rate of 11 percent.[6] According to "India Air Conditioners Market by Product Type, By End Use Sector, By Tonnage Capacity, By Top City Competition Forecast & Opportunities, 2011–2021"[7], the market for air conditioners in India is anticipated to cross USD 6 billion by the end of 2021. The light commercial air-conditioner segment dominated the AC market in 2015, and the segment is anticipated to maintain its dominance over the next five years as well, owing to the various advantages of ACs, such as energy efficiency, lower running costs, easy availability and integration of the latest technologies. Another analysis forecasts the segment's growth in sales (volume) at 6.64 million units in 2020 over 2016, with a CAGR of 11 percent, and to INR 200 billion in sales (value), with a CAGR of 9 percent (Euromonitor International, 2017). India's southern states generate the highest revenue from air conditioners in the country, followed by the northern states. Among the leading firms are Voltas, LG, Daikin, Samsung, Blue Star and Hitachi.

The energy demand share for cooling services (mainly ACs and fans) will increase as shown in Figure 3. However, the share of energy consumption for ACs among all cooling appliances will decline from 52 percent in 2000 to 37 percent in 2030 with increasing energy efficiency and additional EE building technologies such as cool roofs.

6 Business Standard (2015). Source: http://www.business-standard.com/article/companies/room-ac-market-to-touch-10-mn-units-by-2020-115021901210_1.html

7 Source: https://www.techsciresearch.com/report/india-air-conditioners-market-by-product-type-light-commercial-air-conditioners-chillers-vrfs-ductable-splits-others-by-end-use-sector-by-tonnage-capacity-below-2tr-2-10tr-etc-by-top-city-competition-forecast-opportunities/808.html#

FIGURE 3: Energy demand for cooling services



Source: Dhar et.al, 2017.

3. GOALS OF THE HIO

EESL plans to launch this program by July 2017 by awarding manufacturing contracts for the super-efficient 100,000 ACs to manufacturers of two premium brands. To operationalize the program, EESL will have forward agreements with some bulk consumers, such as banks for loans and EMIs. Their future plan is to increase economies of scale expediently by introducing up to ten million AC units into the market in order to reduce the overall selling and market price.

The demand for ACs is expected to reach seven to ten million in 2020 (Reporter, 2015 and Dutta, 2017). Table 3 shows technology transitions for ACs and corresponding improvements in specific energy consumption (SEC) and the energy savings between 2015 and 2030 due to energy efficient ACs in the short, and medium and long terms. In the short term, conventional ACs are being replaced by more efficient 5-star rated ACs. In the medium term, 5-star ACs (appendix, Table A1) will be replaced by advanced ACs (Indian Seasonal Energy Efficiency Rating or ISEER more than 3.09) depending on the type of volume. In the long term, it would be replaced by advanced ACs along with energy efficient building measures such as cool roof.

TABLE 3: Super-efficient ACs HIO: technology transitions, improvements in SEC and energy savings in the short, medium and long terms

PERIOD	HIOS	IMPROVEMENTS IN SEC (PERCENT)	ENERGY SAVINGS (PJ)	INSTALLED CAPACITY (GW)
Short (2015-20)	AC (5-star) w.r.t AC	15 percent	62	2
Medium (2020-30)	AC (5-star) w.r.t AC	AC: 15 percent	AC: 179	9.7
	AC (Advanced) w.r.t AC 5-star	AC Adv.: 29 percent	AC Adv.:128	

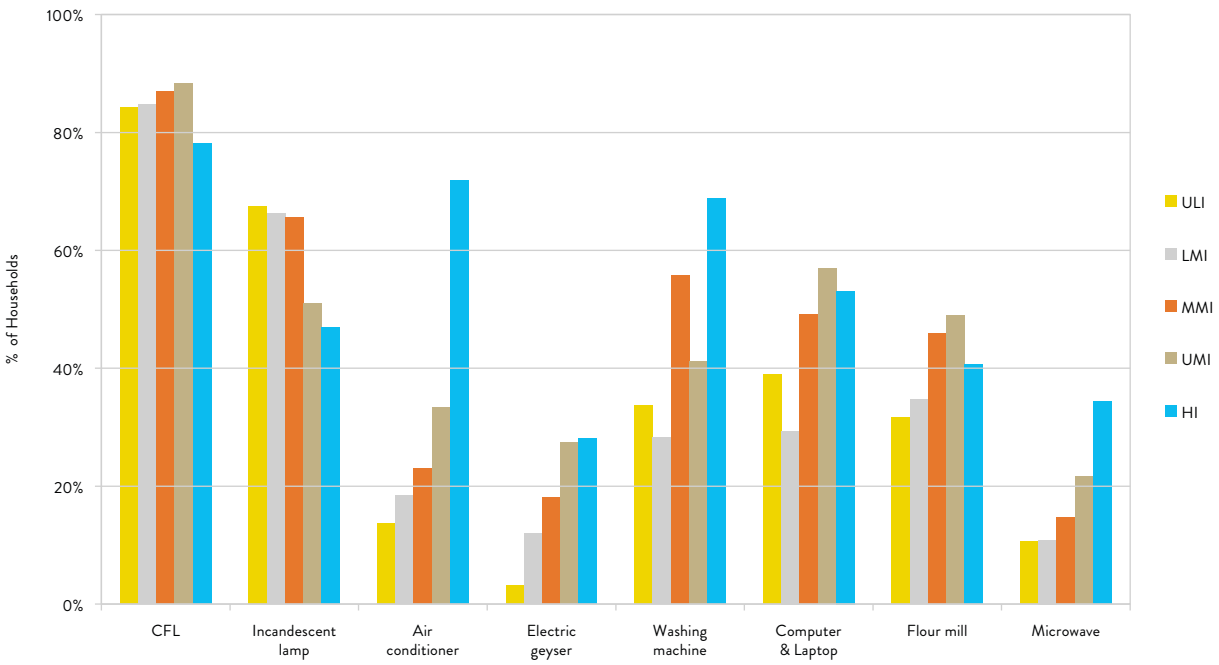
Source: Garg et al. (2014).

4. SECTORAL AND GEOGRAPHICAL SCOPE AND TIMEFRAME

The targeted segments are primarily residential and commercial buildings in various Indian cities. EESL is narrowing down on the geographical areas and market segments it will target. It is planning to launch in the major cities, where the demand for star-rated ACs has been high.

As mentioned before, average temperature rises will differ across various regions of the country. The current distribution of ACs has been observed to differ across states based on the income, type of city and their geographical location. For example, a survey conducted in Gujarat concluded that space-cooling occupied the highest share of connected load in high-income households. ACs were observed to be among the top four appliances in all income category households except the lowest income group (Figure 4). Average load per household per day in the large cities was found to be 0.9 kW as compared to 0.5 kW in both medium and small cities during summer, with figures of 0.5 kW and 0.3 kW respectively during the winter (Garg et al., 2014).

FIGURE 4: Income category wise appliance ownership



Note: ULI (Upper Lower Income) range up to INR 1773 (USD 27.64) Average MPCE (monthly per capita expenditure), LMI (Lower Middle Income) range up to INR 2159 (USD 33.66), MMI (Medium Middle Income) range INR up to 2615 (USD 40.77), UMI (Upper Middle Income) range INR up to 3820 (USD 59.56), HI (High Income) range INR up to 7100 USD 109.14).

Source: Garg et al. (2014).

The distribution will also differ based on load curves across the residential and commercial sectors, as presented for Gujarat and Delhi in Figure 5-8. It has been observed for the residential sector that ACs are generally used in summer, mostly during the early morning, in the afternoon and at night, while in commercial and industrial areas ACs are used during office hours in summer. The shape of the load curve differs seasonally in both states and is observed to be comparatively lower in the winter. The increase in overall electricity demand and changes in temperature have led to the introduction of additional features such as inverters (to regulate temperature), and it may lead to new features such as the addition of heat pumps (to be used during winter).

FIGURE 5: Load analysis curve for Gujarat – residential area

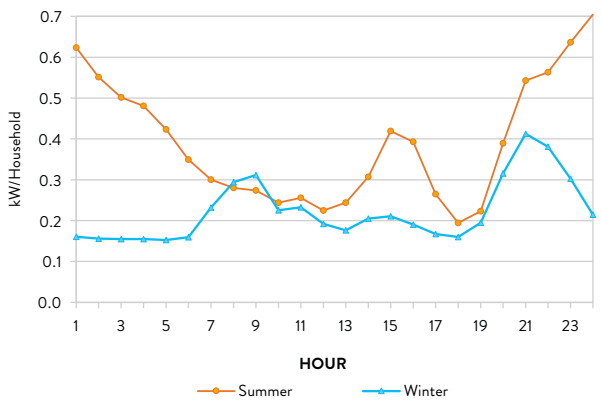
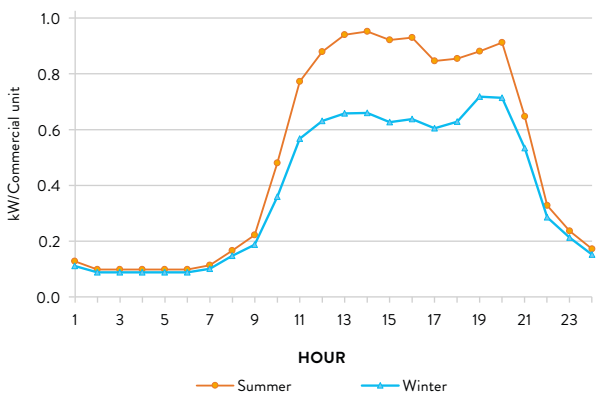
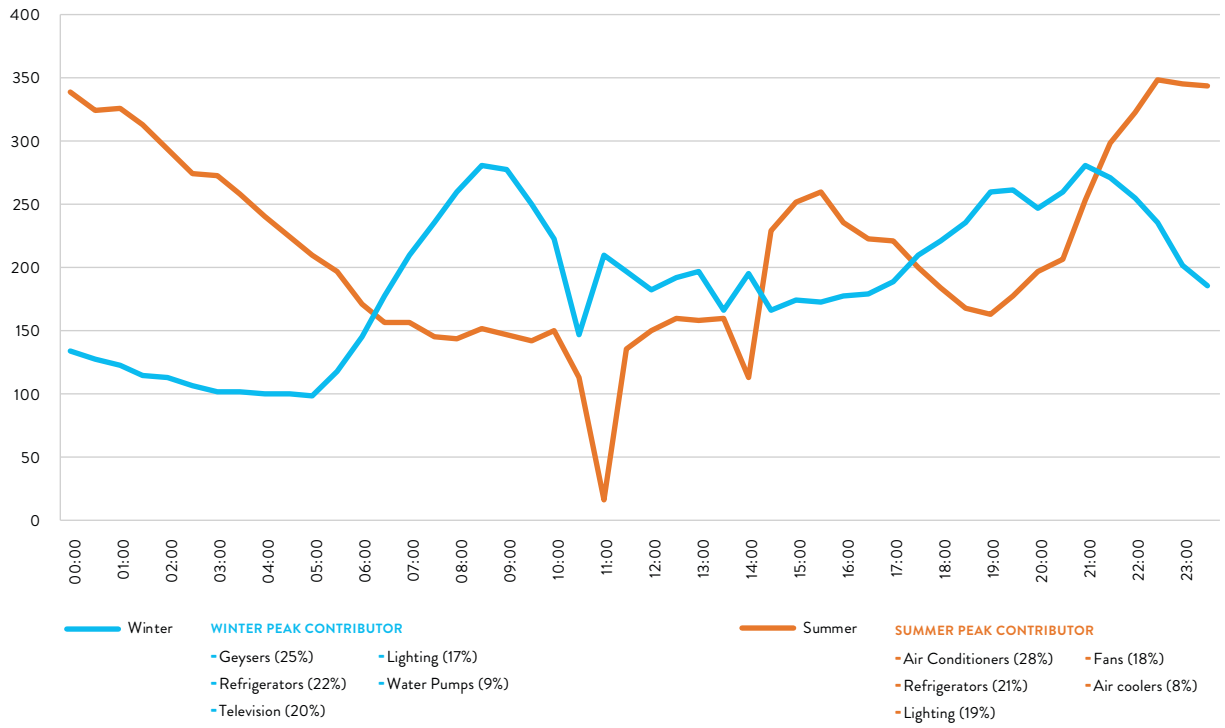


FIGURE 6: Load analysis curve for Gujarat – commercial area



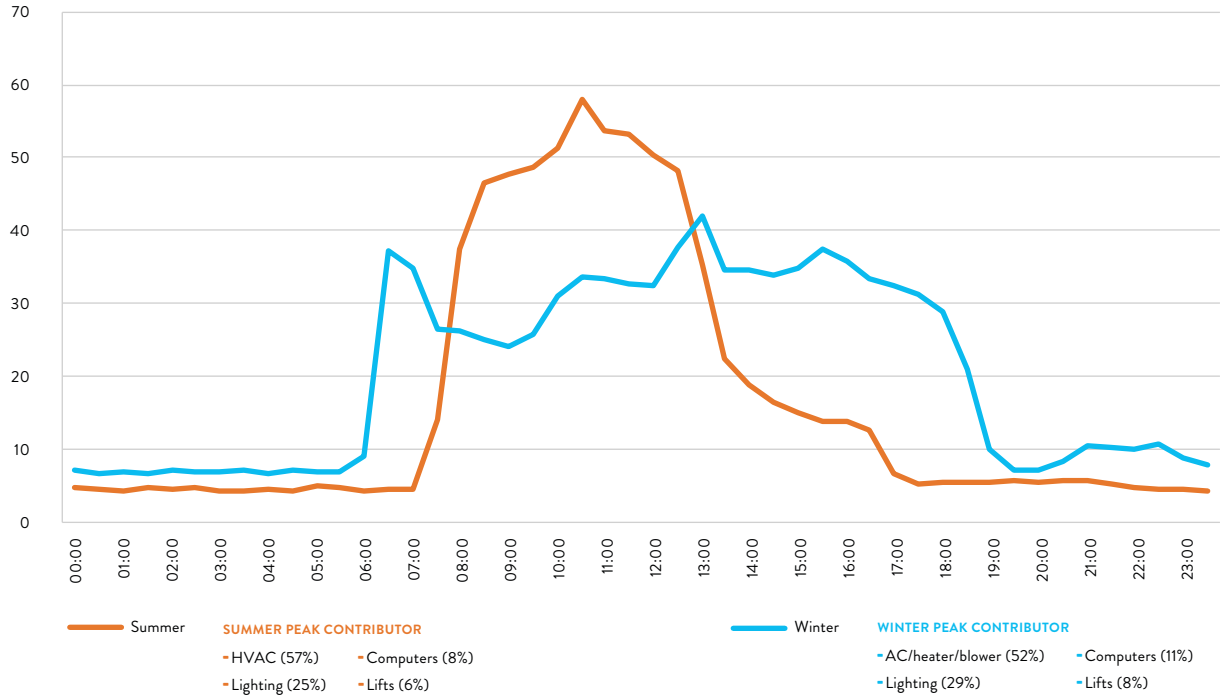
Source: Garg et al. (2014).

FIGURE 7: **Load analysis curve for Delhi – residential area**



Source: BSES (2016).

FIGURE 8: **Load analysis curve for Delhi – commercial area**



Source: BSES (2016).

5. IMPLEMENTATION PLAN

The platform launch for the product is still undergoing planning. As there is a lot of push for energy efficiency in India due to energy shortages and climate change[8], he efficiencies of energy-efficient ACs are expected to improve in the coming years. One driver for this will be prices of electricity, which are expected to increase, since current prices do not include the price of the externalities caused by electricity production.

In January 2017, the central government had planned to launch a new scheme with EESL to bring down the prices of current 5-star ACs by INR 10,000 (USD 155.9) by 2018. EESL is in talks with banks and mobile money to replicate the success of the LED scheme[9]. The plan offers to help the consumer replace old, inefficient ACs with efficient ACs by paying the three-year equated monthly instalments (EMIs) from the estimated 30-40 percent savings in power bills over those three years. EESL is offering to sell super-efficient ACs either through direct purchase or through an annuity model based upon the preference of the prospective buyer or institution, as described below:

1. Supply contract (CAPEX): customers pay the full amount on delivery and installation.
2. Service contract (annuity model): investment borne by EESL is paid back in terms of a fixed annuity (payable through EMI) over a period of three years. This annuity covers EESL's capital expenditure, PMC and financing costs, along with a fixed return to EESL.

EESL plans to raise money in the market for the program by borrowing USD 233 million from the domestic market, USD 100 million through "masala bonds" and USD 900 million from multilateral agencies over the next couple of years. ACs will be procured through auctions and be distributed to consumers through EMI schemes. This will decrease the cost per unit of ACs over the next few years, similar to LEDs.

The 5-star ACs manufactured and sold through existing distribution channels are of 3.5 Energy Efficiency Rating (EER). Energy Efficiency Services Limited (EESL) is executing a strategy to leap-frog and accelerate the introduction of super-efficient air conditioners (ACs rated ISEER >5.2) in the Indian market.

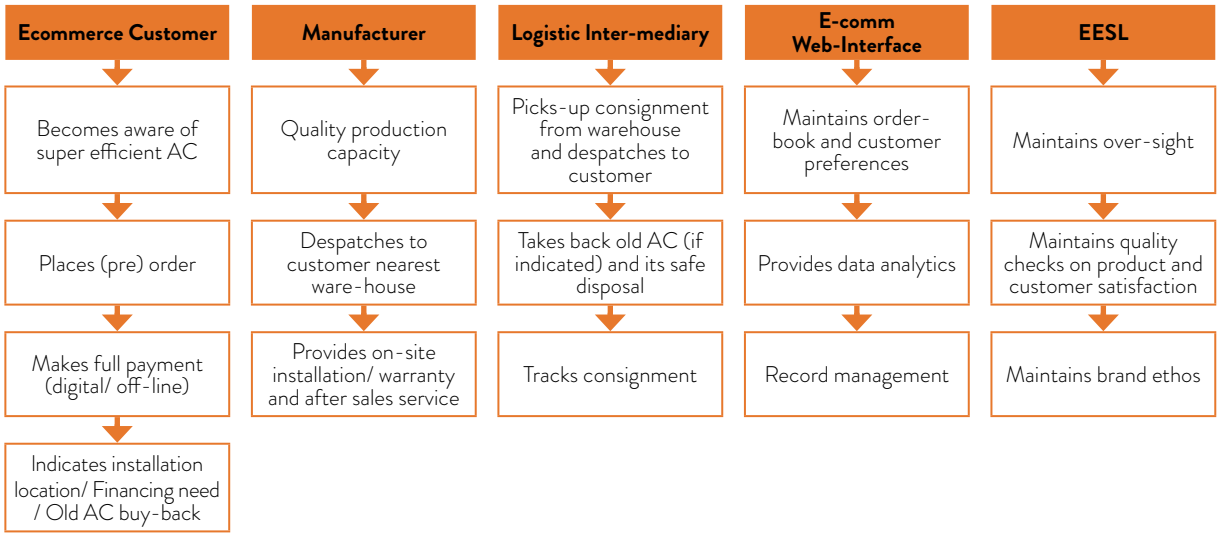
Under EESL's accelerated approach, ACs superior to the most efficient technology (ISEER 5.0) (Appendix, Table A2) available today in the Indian market will be introduced, implying a reduction in energy bills of nearly 35 percent even if a current day 5-star labelled AC of around EER 3.5 is replaced. These ACs are nearly 40 percent more efficient than the 5-star rated ACs currently available in the Indian market, and they come with a three-year all-comprehensive warranty and a class installation kit, the component of which are designed to improve operating efficiency and the life-cycle period further. Installation will be carried out by trained technicians of the manufacturers. EESL will also provide three annual maintenance visits free of charge to ensure the continuous operation of high levels of energy efficiency. This implies that the consumer will receive an AC with a high design life and low ownership costs compared to the market.

EESL plans to launch the program for super energy-efficient air conditioners in India using an e-commerce distribution channel as a rolling-out strategy, as shown in Figure 9. The fundamental strategy is based on achieving economies of scale by promoting advances in technology. The 5-star ACs manufactured and sold through existing distribution channels are of have a 3.5 EER. Even in the case of the best inverter-based 1.5-tons ACs, the maximum is around 5 ISEER in India and around 8 ISEER globally. These advanced ACs, which are planned to be sold in future, are expected to be rated at ISEER 5.2 or more.

8 The INDC of India has a clear focus on energy efficiency.

9 The Economic Times, 2017 (http://economictimes.indiatimes.com/industry/cons-products/electronics/eesl-to-replicate-success-of-led-scheme-for-air-conditioners/articleshow/56481500.cms)

FIGURE 9: Strategy to implement efficient AC program in India



6. ACTIONS REQUIRED FOR ADDRESSING BARRIERS

India's imperative to reduce consumer energy bills and meet its climate mitigation commitments need to leap-frog and accelerate the introduction of super-efficient air conditioners now in order to meet the challenge of increasing electricity demand from ACs sustainably and of reducing GHG emissions.

Replacing 5-star ACs with super-efficient ACs will not be as easy as in the case of LED bulbs. This is because super-efficient ACs are costlier than 5-star ACs presently, and fewer households (about 10 percent) in urban areas use ACs. Cost reductions would hold the trump card in this case, as also with LEDs, although this would require a much larger canvas. EESL plans deep economies of scale through which the costs of super-efficient ACs could come down to those of present 5-star rated ACs or even below. However, the financing barriers are expected to remain. Along with EMI schemes, state energy office (SEO) revolving loan funds (RLF), rebates, incentives and complementary programs can be used to remove financing barriers, as explained below.

STATE ENERGY OFFICE (SEO) REVOLVING LOAN FUNDS (RLF)

RLFs typically hold borrowers to standard financial requirements of loan security. The funds have a maximum allowable payback period for projects, allowing borrowers to repay their principal and interest. The money is returned to the fund to make additional loans, thus enabling the RLF to continue operating without exhausting its pool of capital. State RLFs in the US date back to the 1970s and 1980s, seeding petroleum violation escrow (PVE) and oil overcharge allocations for Nebraska and Texas. Lately, it has been used to finance energy efficiency and clean energy programs in the US building and industrial sectors (NASEO, 2013).

REBATES AND INCENTIVES

A rebate is an amount paid by way of reduction, return or refund on what has already been paid or contributed. The most notable ones are in Japan and Korea, although these programs were much broader (for example, they included other appliances and gave consumers "credits" which could be used in the purchase of any other merchandise).

COMPLEMENTARY PROGRAMS

A procurement requirement for demand response (DR) ready or "smart" ACs could be used in conjunction with utility DR programs to reduce peak load and also integrate variable renewable energy. Various countries have adopted or are considering the adoption of "smart" or demand response readiness requirements for various appliances, including ACs. Several utilities like Con Edison of New York or Pacific Gas and Electric in California offer demand response programs in addition to equipment energy efficiency. Con Edison's room AC DR program was one of the most successful in the US in recent years.

7. MAIN RISKS AND SUGGESTED SOLUTIONS

Air conditioners are much higher value items than compared to LED bulbs, and consumer decisions will be affected by a variety of factors, including initial expenditure, perceived quality of the product and ease of maintenance. Hence, the main risk includes challenges in aggregating demand. Therefore to ensure a minimum demand for super-efficient air conditioners, a few large institutional customers would need to be included, such as the ATM outlets of large banks, individual offices in government buildings and public-sector undertakings (PSUs) and large housing complexes. It has also been suggested that, once economies of scale set in and price of the product drops, there would be an automatic pull in the market. The initial push therefore has to be provided by EESL, product suppliers and financial institutions under an enabling policy environment set by the government.

CHAPTER 4

EFFICIENT AGRICULTURAL PUMP SETS WITH SOLAR AND NET METERING

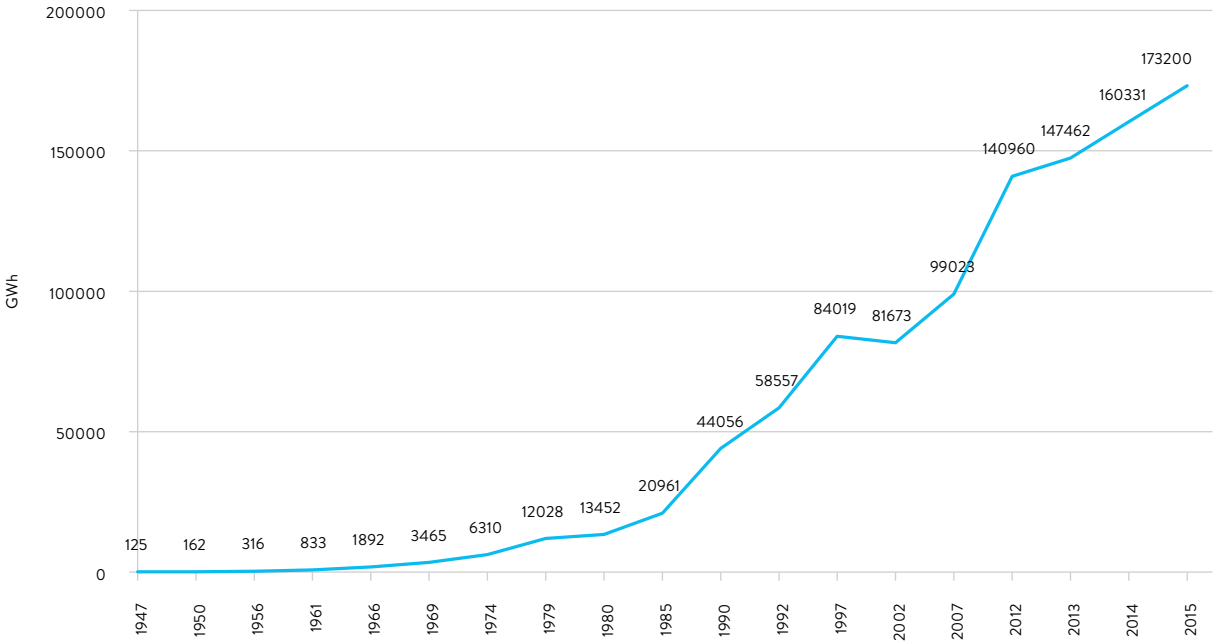
1. INTRODUCTION

There is a huge gap between supply of and demand for electricity in India, the deficit currently standing at approximately eight percent annually. The gap can be bridged either by increasing the supply by setting up more power generation units or decreasing demand by consuming less power. Energy efficiency and demand-side management are important tools for controlling the demand for electricity. Agricultural pumping consumes 18 percent of electricity in India. Hence the demand-side management of agricultural pumps has the ability to reduce the demand-supply gap significantly.

The agricultural sector is the largest contributor to the total demand for pumps, accounting for approximately 35 percent of the total market for pumps in India. Currently, the agricultural sector is characterised by the penetration of low-cost pumps. The government's various policies and subsidies to promote the use of efficient and quality pumps are likely to boost the demand for efficient agricultural pumps.

The agricultural sector is the third largest consumer of electricity after industry and the domestic sector. According to the Central Electricity Authority (CEA, 2015), in the Ministry of Power, the consumption of electricity in the agricultural sector, mainly from pumping, was estimated at 173.2 billion kWh during 2015-16 (Figure 4), which is approximately 18.45 percent of India's total electricity consumption. Energy consumption by the agricultural sector has grown at an average rate of over 7 percent in the last five years, which is higher than the growth of the electricity sector.

FIGURE 10: Plan-wise growth of electricity consumption in agriculture



Source: CEA, 2015.

Efficient pump sets also require an efficient water management system for the crops. A drip irrigation system would aid in aiding the efficiency of these pumps. Drip irrigation systems are one of the most highly preferred methods of irrigating, as they have very high irrigation and water application efficiencies. They are easy to install, inexpensive to use, and help reduce problems with disease associated with different levels of moisture on plants. They have also proved efficient due to factors such as allowing the water to soak into the soil before evaporating. Secondly, with the help of a number of pipes, tubes and emitters, the water drips directly on to the roots of the plants, where it is needed, rather than being sprayed everywhere. We suggest that efficient pump sets would reduce the power consumption of an inefficient pump by around 30 percent. Installing a drip irrigation system could reduce the demand for irrigation by almost a similar percentage. The pump wattage requirement would therefore go down by almost 50 percent for an existing irrigation pump set without any drip irrigation. Various state governments provide up to 70 percent of subsidy on drip irrigation systems. Therefore, from the farmer's point of view, the cost of installing an efficient pump set could be 30-50 percent lower than that for an equivalent inefficient new pump set. Financing models have to be developed for this.

2. CONTEXT

POOR QUANTITY AND QUALITY OF ELECTRICITY SUPPLY

Government initiatives in the agricultural sector—especially subsidised or free electricity—have simply promoted inefficient irrigation. However, the agricultural sector faces major impediments from the poor levels of quantity and quality of electricity. This makes it difficult for farmers to make full and efficient use of the pumps they purchase. In most regions, farmers do not even receive the scheduled eight-hour electricity supply.

The irregular supply of electricity does not just discourage the installation of efficient pumps, it also triggers the penetration of the unorganised sector, which is flooding the market with sub-standard pumps. The market for agricultural pumps is characterised by the dominance of the unorganised sector, which has a 48 percent market share. The voltage level of electricity in most agricultural regions is significantly lower than that required by quality pump sets. Players from the unorganised sector are tapping into this opportunity by providing pump sets that can operate at much lower voltage levels and also at prices that are 30-40 percent lower than in the organised sector. However, these pumps are highly inefficient in respect of electricity consumption, leading to national-level losses in terms of the total power consumed. This situation is placing immense cost pressures on the organised market, squeezing the margins that these manufacturers receive year after year, which has led to low levels of investment in R&D.

TYPES OF WATER PUMP MOTORS

There are two types of water pump motors prevalent in India: alternating current and direct current motors. alternating current motors require inverters to convert direct current to alternating current. Solar pumping systems use special electronically controlled variable frequency inverters, which optimises matching between the panel and the pump. direct current motors with permanent magnets are generally more efficient. direct current motors may come with or without carbon brushes. The brushes need to be replaced approximately every two years, while the brushless designs require electronic commutation. Brushless direct current motors are becoming popular in solar water pumps.

LACK OF INCENTIVES TO USE ENERGY-EFFICIENT PUMPS.

The agricultural sector in India consumes a significant part of the total power generated in the country. A significant amount of this share could be saved by farmers using energy-efficient pumps. However, the subsidies the government offers for power consumption and the lack of any direct incentives to use energy-efficient pumps restricts farmers for opting for energy-effective solutions.

SUBSIDIES

According to the estimates of the Economic Survey for 2015-16, the cumulative agricultural subsidies of the states total more than INR 653 billion (USD 9.75 billion) every year. The *Report on the Performance of State Utilities* for 2013-14, compiled by the Power Finance Corporation (PFC), puts the aggregate losses of all utilities in 2013-14 at INR 986 billion (USD 14.72 billion). Any reduction in energy consumption in the agricultural sector will provide direct benefits to DISCOMs, as well as to state governments.

The subsidy bill is already a significant proportion of a state's GDP, and therefore there is a strong incentive for a state to facilitate investment in energy-efficient agricultural pump sets and thus reduce electricity consumption. Farmers receive subsidised electricity, in some cases at zero price, and therefore do not have any incentive to invest in energy-efficient pumps, also because of the high upfront capital costs. However, as the experiences of BEE and EESL have shown, carefully designed interventions cannot only leverage savings on subsidies in order to attract third-party investments, they can also create incentives for farmers to participate in the program.

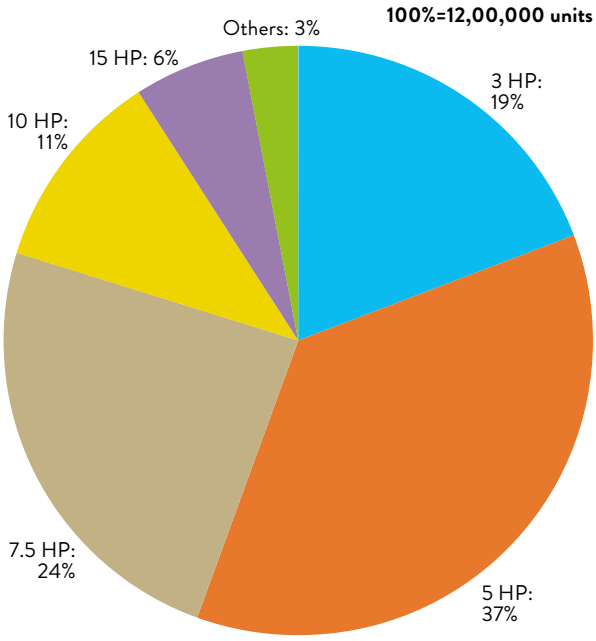
NEED FOR DESIGNING AN AGRICULTURAL DEMAND-SIDE MANAGEMENT PROGRAM

Due to the factors mentioned above, the star labelling program of the Bureau of Energy Efficiency (BEE) to promote energy-efficient pump sets has not encouraged industry as much as it has in the case of other equipment. There is therefore a need to design a program that helps to overcome these barriers and encourage large-scale replication.

PUMP CHARACTERISTICS

Presently, average pump efficiency is around 22-30 percent. These agriculture pumps would have an energy-saving potential of around 27.79 TWh (TeraWatt Hours, 10^{12} Wh) (Patel, 2016) if the whole stock of 21 million pumps in India were to be replaced. In terms of capacity, the five-horsepower (HP) pump is widely used in India. Figure 11 shows the typical share of pumps in India:

FIGURE 11: HP-based market share of pumps



Source: Shakti Foundation, 2012.

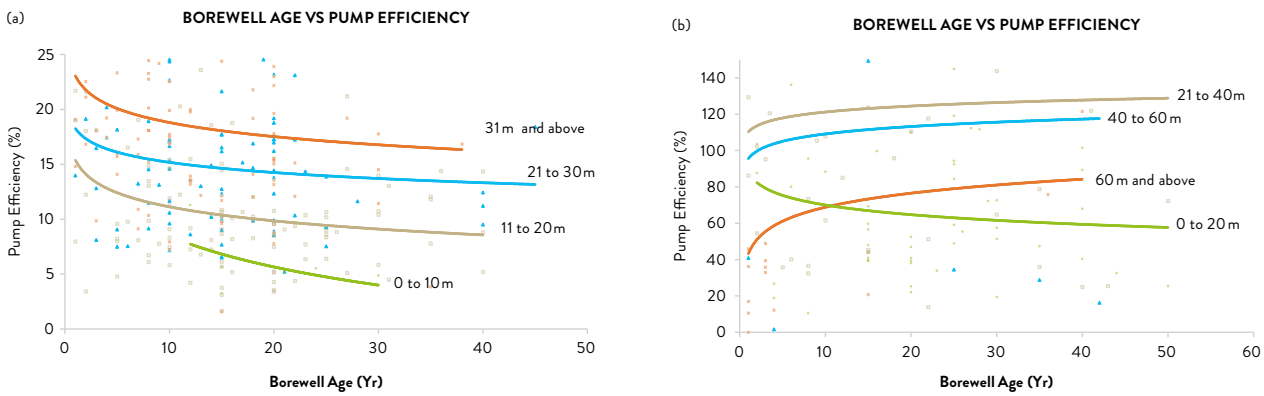
TABLE 4: Pump specification for various HP pumps in India

POWER RATING (HP)	PIPE SIZE (MM)		TOTAL HEADS (M)															
	Suc	Del	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
			DISCHARGE (LTS/SEC)															
3	80	80	19	17.5	15.5	13.2	9.0											
3	80	65		13.2	12.3	11.4	10.4	9.1	7.4									
3	65	50				8.8	8.4	7.9	7.5	6.9	6.3	5.6	4.7	3.2				
3	50	40							4.7	4.5	4.4	4.2	4	3.8	3.5	3.1	2.7	2.1
5	80	80		22.7	21.6	20.4	19.0	17.3	15.4	13.2	10.0							
5	80	65					14.9	14.2	13.5	12.6	11.6	10.3	8.8	6.4				
7.5	100	100				27.0	25.5	23.8	21.7	19.7	17.1	13.8						
7.5	80	65						18.9	18	17.2	16.2	15.2	14.0	12.4	10.1			
10	100	100				32.0	31.0	29.8	28.5	27.0	25.2	23.4	20.9	17.9	13.2			
10	80	65				21.0	20.6	20.4	20.0	19.5	19.0	18.6	18.0	17.2	16.5	15.5	14.5	13.4
15	100	100					36.0	35.5	35.0	35.0	34.0	33.0	32.0	31.0	28.0	24.0	16.0	6.0

Source: Kirloskar, 2016.

Pump efficiency vs bore depth and age: although many pumps do undergo periodic servicing, a gradual declining trend in their efficiency is still evident with increases with bore-well age and depth (Figure 12). This impacts in a major way on the fuel consumption of pumps for extraction of same amount of water from an efficient and an inefficient pump respectively.

FIGURE 12: The trend of falling pump efficiency with bore depth and increase in bore-well years: (a) diesel pumps (b) electric pumps

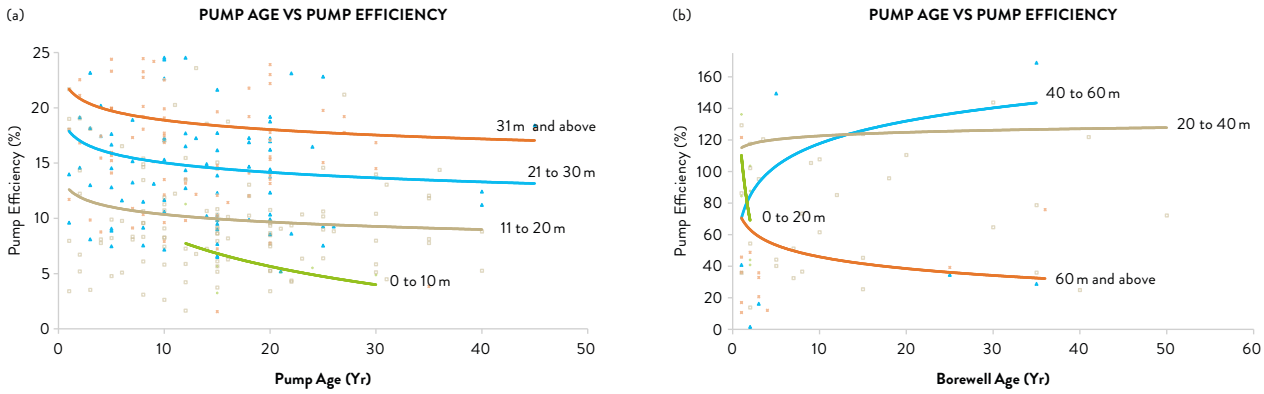


Source: Garg et al., 2012.

Efficiency vs pump age:

Similar trends can be observed for pump efficiency with pump age and depth comparison. It can be clearly seen that, as the age of the pump increases, it tends to lose its pumping capacity, which is again added on due to the need for water suction at greater depths (Figure 13). Here too the trend is more visible in diesel pumps than in electric pumps.

FIGURE 13: The trend of falling pump efficiency with bore depth and increase in pump age years: (a) diesel pumps (b) electric pumps

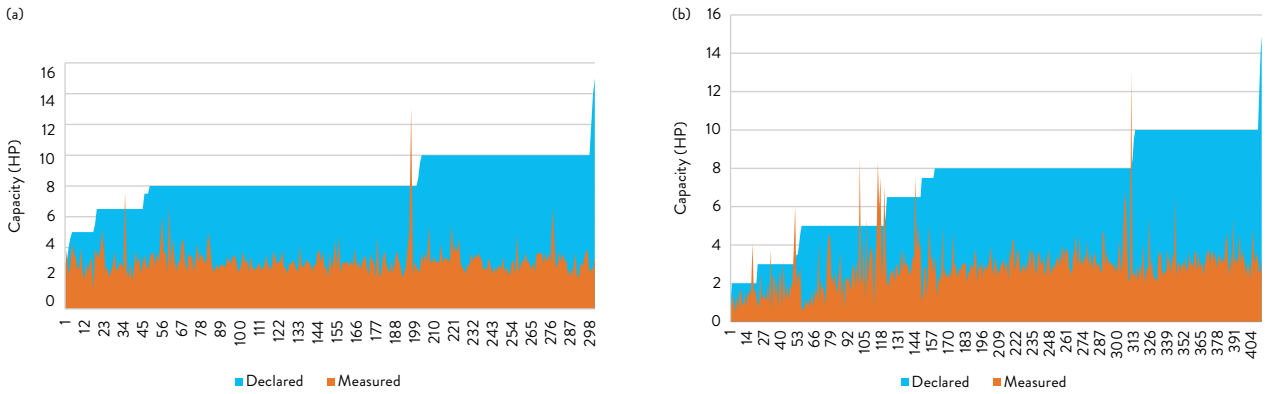


Source: Garg et al., 2012.

Rated (declared) pump capacity vs. actual measured capacity:

Pump capacity (generally indicated by the horsepower generated) is the indicator of the ability of the pump to draw water. The higher the capacity the greater should be its ability to draw water, including also from greater depths. It is generally rated on the pump motor. However, calculation of HP from the amount of water drawn or the fuel consumed shows that actual HP in field conditions is lower than the rated capacity (Figure 14).

FIGURE 14: The declared (rated) vs. measured capacity (HP) of the pumps surveyed: (a) diesel (b) electric



Source: Garg et al., 2012.

SOLAR PUMPING TECHNOLOGY

Solar pumps are available in multiple configurations starting from 1 HP to 5 HP and higher and are suitable for water extraction from shallow water tables (less than 5 m) to higher water tables. India has an installed base of around 12,000 to 13,000 solar agricultural pumps, concentrated in a few states: over 70 percent are estimated to be concentrated in Punjab, Rajasthan, Haryana and Bihar (KPMG, 2014). These pumps have been installed largely by state renewable-development agencies with capital subsidy assistance from the Ministry of New and Renewable Energy (MNRE). MNRE provides a 30 percent capital subsidy, which, coupled with state subsidy assistance, has historically ranged between 50-60 percent, thus offering subsidised pumps to farmers at 15 percent-20 percent of their total cost.

3. GOALS OF THE HIO

EESL's AgDSM program is targeting replacement of the 21 million agricultural pump sets in India with energy-efficient pump sets.

The key goals of the HIO will be:

- Installation of energy-efficient pump sets, which are expected to reduce the level of cross subsidies on commercial and industrial consumers, thereby helping rationalize tariffs.
- Distribution of smart control panels to enable remote operations that will help farmers switch pumps on and off using mobile phones, thus allowing farmers to save time and money and conserve water.
- Reduction in commercial losses for utilities and hence reduction of subsidy burden.

4. SECTORAL AND GEOGRAPHICAL SCOPE AND TIMEFRAME

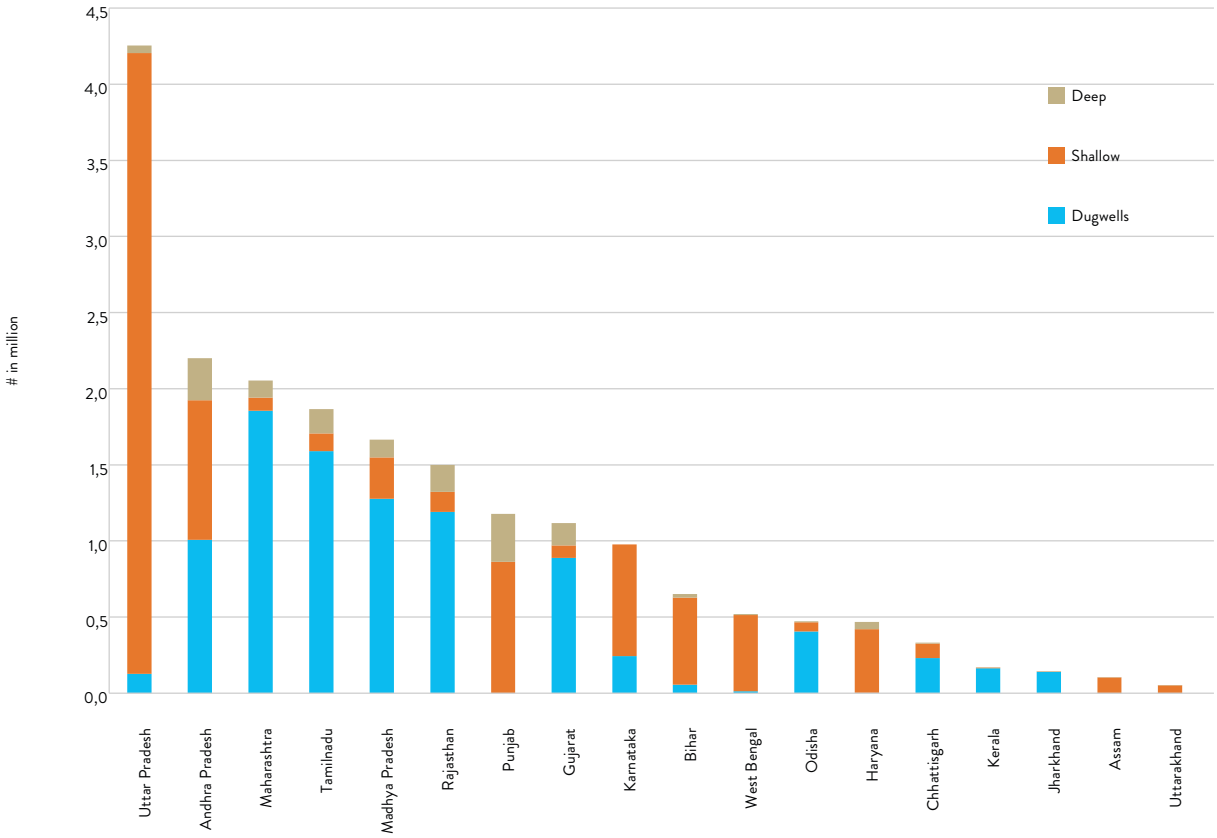
The 21 million agricultural pumps in India account for almost 22 percent of the country's electricity consumption (Figure 15 shows the distribution of pump sets across India's states). All these pump sets potentially fall within the scope of HIO. However, to target the EESL program in coordination with DISCOMs better, project areas will be identified with the following preferences:

a) A high proportion of old pumps

b) Agriculture feeders having been segregated, and

c) Installation of a high-voltage distribution system (HVDS)

FIGURE 15: State-wise number of pump sets in India



Source: MIC, 2006.

EESL EXPERIENCE OF PILOT AGDSM PROJECTS

The experiences of BEE and EESL have shown that carefully designed interventions could not only leverage subsidy savings to attract third-party investments, they could also create incentives for farmers to participate in the program. Table 5 shows the features of some of the pilot AgDSM projects, demonstrating that investments in the energy efficiency of agricultural pump sets can be recovered in a short time, while at the same time reducing energy consumption and subsidy burdens.

TABLE 5: The features of some of the pilot AgDSM Projects

SR. NO.	PARTICULARS	BEE: SOLAPUR AGDSM	EESL: HUBLI AGDSM	EESL: MYSORE AGDSM	EESL: AP AGDSM (IN PROGRESS)
1.	No. of pumps replaced	2209	590	1337	2496
2.	Annual energy savings achieved (GWh)	6.1	2.9	5.7	21
3.	Energy savings (percent)	25	37	37	30
4.	Investment [INR (USD)]-million	80 (1.19)	24 (0.36)	50 (0.75)	220 (3.3)
5.	Contract period (years)	5	6	6	5

The pilot projects exhibit the following aspects:

a) Efficiency improvements between 25-37 percent are possible by replacing inefficient pump sets with BEE 5-star labelled ones for capacities of up to 20 HP rating and ISI marked ones for capacities above 20 HP rating.

b) Properly designed DSM projects, both technically and commercially, can attract investments for the ESCO model

c) Availability of efficient agricultural pumps conforming to BEE 5-star is not a constraint.

d) Real energy savings, duly monitored and verified (in the cases of Solapur, Hubli and Mysore) over a period of time.

e) The projects can include free repair and maintenance support for the entire duration of the project, which was found to be a major incentive for farmers who usually pay between INR 3,000 and 4,000 (USD 44.77-59.70) per annum for pump maintenance.

5. IMPLEMENTATION PLAN

The approach followed for implementation is based on lessons learned from implementation of the pilot projects (Table 6):

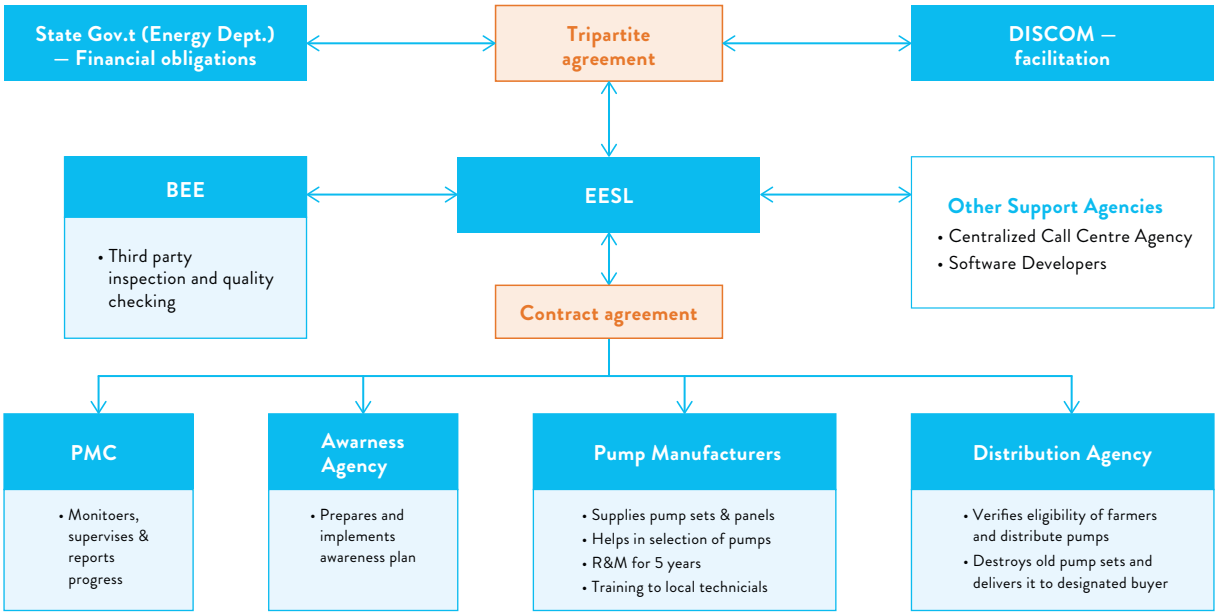
TABLE 6: Status of AgDSM pilot projects

SR. NO.	PROJECT	NO. OF PUMPS	IMPLEMENTATION PERIOD (MONTHS)	MONTHLY INSTALLATION
1.	Solapur	2200	36	62
2.	Hubli	590	10	59
3.	Mysore	1337	9	148
4.	Andhra Pradesh	2496	Ongoing	

5.1 PROJECT CONTRACTUAL STRUCTURE

Based on the above, the emerging contractual structure of the project is given in Figure 16:

FIGURE 16: The contractual structure of the project



5.2 PROGRAM ELEMENTS AND COMPONENTS

The following functions will become the program's elements and components:

1. PROGRAM DESIGN

EESL will develop a blueprint of the program in terms of the number of pumps, their existing capacities and the proposed size and capacity of energy-efficient pumps based on data collected from Discom, the pump manufacturers, their dealer networks, their association and field-level sample surveys, all of which would be discussed and finalized with the State. EESL will enter into a tripartite agreement with state governments (Energy Department) and DISCOMs to implement the program. The state government will mandate EESL to implement the project and make annuity payments, while DISCOM will provide the necessary support for the execution of the project by providing the space to set up a distribution centre at their sub-stations, offices etc. The energy savings would be based on a "deemed savings model", i.e. reductions in energy consumption will be calculated from the difference in ratings of the new and old pumps and the number of hours of electricity supplied, using a deemed savings approach. The responsibility, cost and risk of the installation of new pump sets will lie with the farmer. BEE 5-star, standard rated pump-sets, along with smart panels, will be offered as a bundle for replacement in the project area based on the sanctioned load. If the consumer needs a higher rated pump, this may be replaced upon revision of the sanctioned load.

2. AWARENESS CREATION

EESL will actively engage with state governments to obtain their full co-operation in supporting implementation of the program. The state will separately plan and carry out an awareness program on the proposed AgDSM project in consultation with EESL and its public relation agency and at its own cost. In addition, EESL will roll out a separate program on awareness creation at the state and district level by involving local community leaders and various other means.

3. PROCUREMENT OF PUMP SETS WITH SMART CONTROL PANELS

Upon execution of the tripartite agreement with state governments and DISCOM, EESL will start procuring pumps and smart control panels, distribution facilities, project management services and awareness agencies for the project areas. The procurement of pumps and control panels may be undertaken in such a manner that the demand from several states is aggregated so that large volumes can drive down costs. The actual cost of equipment revealed through a competitive e-bidding process would be used to determine the project's finances. Distribution, project management and awareness agencies will be selected for each project area. Farmers will be provided with Energy Efficient BEE 5-star labelled pump sets (with bundled smart panels) with HP falling within the sanctioned load if 20 HP and below rating and ISI-marked pump sets if above 20 HP rating through multiple distribution desks in the project area.

4. DISTRIBUTION OF PUMP SETS

Distribution of pumps will be done at the ***taluka (sub-district)*** or village level with the involvement of local expertise and distribution agencies in a manner that enhances coverage of the entire project area.

5. MONITORING, SUPERVISION AND CONTROL OF THE ENTIRE PROGRAM

As the program is implemented, the pump will be equipped with a GSM system, which is further connected to a cloud-based system to obtain data like running hours, electricity consumed, electricity saved, etc. on a daily basis.

During implementation the implementing agency must submit a form filled in by the farmers with the date of the installation and commissioning of the pump so that the proper warranty period for the pumps can be controlled.

6. CUSTOMER CARE SUPPORT FOR DISTRIBUTION, REPAIR AND MAINTENANCE

Free, on-site, 5 year repair and maintenance packages will be provided to the farmer, for which the latter otherwise spends INR 12,000 - 20,000 (USD 187.09-311.82) in a five-year period.

7. FINANCIAL MODEL

EESL will make capital investments in developing the program, awareness campaigns, procurement, distribution, and repair and maintenance of the energy-efficient pumps. Payment security mechanisms in the form of escrow accounts, revolving letters of credits or comfort letters from the state government will be provided, as applicable.

5.3 ROLES AND RESPONSIBILITIES OF STAKE-HOLDERS

Based on the functionalities required by the project, the following are the stakeholders that have been identified, including their roles and responsibilities for the time-bound implementation of the project:

A. STATE GOVERNMENT AGENCIES

Facilitating the program by providing ground-level support for implementation, engagement with farmers, repayment of investments over time and dispute resolution are the most important and critical factors for the success of the program.

B. AWARENESS AGENCY

The awareness agency will design and roll out print and electronic media campaigns soon after execution of the tripartite agreement and at regular intervals thereafter during the program under the supervision of EESL or its appointed agency for project management.

C. PUMP-SET SUPPLIERS

A smart panel with the ability to switch the pump on and off, monitor, set auto-timers, control and monitor operational parameters, reset, with alarms in case of tampering, etc. will play a crucial role in implementing the program successfully and ensuring that the distributed pump sets are being used for the intended purpose.

This smart panel will be made a component of the pump sets for supply, along with a five-year warranty and coverage for repairs.

Further, the pump-set supplier will be required to enter into contractual arrangements with their local dealers, at least at district level, to extend the support and facilitation in distributing the pump-sets and providing repair, maintenance and warranty coverage during the project period. A definitive timeline of 72 hours from the time of reporting will be prescribed for repairs and replacements (as the case may be) under warranty.

D. DISTRIBUTION AGENCY

The distribution agency will be the main agency distributing pump sets to farmers. The agency will open periodic kiosks, OTCs, mobile vans, etc. for purposes of distribution. The following are the modalities envisaged for the distribution of pump-sets:

a) The awareness agency and distribution agency will provide the dates on which kiosks may be operated in a certain ***taluka (sub-district)***. The details of the scheme will be circulated beforehand at the block and panchayat offices and in pamphlets.

b) The farmer will visit the kiosks on the day and provide the document confirming his sanctioned loads. On verification of the sanctioned load using the database available from DISCOM, the farmer will be given information about the pump set. He will then hand over his old pumps for immediate destruction by drilling holes in the impeller, his identity card (***aadhar***) and bank details (for transfer of scrap value) and sign the digital copy of the agreement. A photo of the farmer will be clicked with the old (destroyed) and new pumps as a record.

c) If the farmer is motivated to enter the program, the dealer will issue an on-line ***challan***, which may be presented to the distribution agency for the handing over of pumps, and the procedure outlined above may then be followed.

d) The old pumps will be destroyed so as to render them unusable and they will then be scrapped.

E. PROJECT MANAGEMENT AGENCY (PMA)

The project management agency will be the coordination and project management agency to coordinate, monitor, supervise and control the project on behalf of EESL. The following is the broad role of the PMA:

I. Coordinate and communicate among the stakeholders
II. Prepare a comprehensive schedule for program roll-out, supplies and distribution
III. Prepare the program operations manual for reference
IV. Monitor and supervise the functions of the awareness agency, distribution agency and suppliers
V. Create and maintain a management information system and reports
VI. Support distribution verification and the invoicing of suppliers and other agencies
VII. Support EESL in conducting material inspections at the factory. May facilitate third-party inspections and testing of supply material
VIII. Prepare and submit quarterly progress reports

F. CUSTOMER CARE SUPPORT

A customer care support system is essential for recording and maintaining the repair and maintenance support during the warranty period, which extends the program term by five years. Customer care is envisaged as using a toll-free number on which calls can be made and complaints recorded. These complaints will be forwarded to the suppliers concerned for free repairs and/or replacement while still under warranty. The timeframe for attending and closing complaints will be pre-defined in the contracts with suppliers for supplies and services. Once the compliant has been closed, this will be recorded. Also, app-based complaint reporting may be developed.

G. LOCAL DEALERS, MECHANICS

Local dealers and mechanics will play a vital role in motivating farmer's decisions concerning purchase and size. They regularly provide services to farmers as well. Accordingly, utilization of these local skills and infrastructure is indispensable to make the program a success. As part of the tendering process for selection of the suppliers, it may be made a requirement either to submit tie-ups to support documents upfront with their tenders, or the successful bidder may be required to submit documents as evidence of the tie-up with local agencies before the letter of authorization (LoA) is issued.

6. ACTIONS REQUIRED TO ADDRESS BARRIERS

The experiences gained at the four locations for the replacement of agricultural pump sets indicates the following as the key reasons for the slow pace of implementation:

I. Locating the farmers and the field was a tedious and time-consuming exercise
II. It has taken more time to convince farmers of the benefits of the scheme
III. The local skills and capacity needed for installation and dismantling is scarce
IV. Access to the site was difficult during the rainy season
V. Availability of power during the day to measure pump parameters

7. MAIN RISKS AND SUGGESTED SOLUTIONS TO ADDRESS THE RISKS TO THE SUCCESS OF ACTIONS SUGGESTED FOR THE HIO

a) There is always a perceived risk in farmers adopting a new technology. Farmers do not readily adopt new technologies and do not want to reduce the wattages of their pumps. They think that reducing the wattage of the pump will reduce the supply of water to their crops.

b) Financial risks on return of capital: The higher risk will be on the return on investments, as farmers will not pay for the new pumps. In that case, a suitable payment security mechanism (PSM), consisting of a letter of credit and/or an escrow account backed by the state government, may provide sufficient comfort over returns on investments to lenders and investors alike.

CHAPTER

5

PERFORM, ACHIEVE AND TRADE (PAT) SCHEME

1. INTRODUCTION

Perform, Achieve and Trade (PAT) is an instrument to reduce specific energy consumption in energy-intensive industries, with a market-based regulatory mechanism. PAT is an innovative, market-based trading scheme that was announced by the Government of India in 2008 under its National Mission on Enhanced Energy Efficiency (NMEEE) and National Action Plan on Climate Change (NAPCC). It aims to improve energy efficiency in industries by trading in energy efficiency certificates in energy-intensive sectors.

2. CONTEXT

Designated consumers (DCs), as notified under the Energy Conservation Act, 2001, account for 25 percent of India's gross domestic product (GDP) and about 45 percent of the commercial energy use in India. Since 2000, industrial GDP has been growing at the rate of 8.6 percent annually, whereas energy use in industry has been growing at a comparatively lower growth rate of 5.8 percent. The lower rate of growth of industrial energy use can be attributed to many reasons. It has been observed that, in recent years, industry has been choosing state-of-the-art technologies, which are more energy-efficient. Also, the industry has made many in-house efforts to become more energy-efficient. The Perform Achieve and Trade (PAT) mechanism has been designed to accelerate and incentivize energy efficiency further.

3. GOALS OF THE HIO

Participation in the scheme is mandatory for DCs under the Energy Conservation Act (ECA). It is being administered by the BEE, which sets targets for specific energy consumption within larger, energy-intensive facilities. The main elements of the PAT scheme are presented in Box 1.

BOX 1. Main elements of the PAT framework

1. Methodology for setting specific energy consumption for each DC in the baseline year.
2. Methodology for setting the target to reduce the SEC by the target year from the baseline year.
3. The process to verify the SEC of each DC in the baseline year and in the target year by an accredited verification agency.
4. The process to issue energy savings certificates (ESCerts) to those DCs that achieve SECs lower than the specified value.
5. Trading of ESCerts.
6. Compliance and reconciliation of ESCerts.
7. Cross-sectoral use of ESCerts and their possible synergies with renewable energy certificates.

Source: 12th Five Year Plan

4. SECTORAL AND GEOGRAPHICAL SCOPE AND TIMEFRAME

The scheme has been implemented in two phases (PAT Cycle I and PAT Cycle II), with 478 designated consumers (DCs) across India in Cycle I and 707 DCs in Cycle II (Table 1).

5. IMPLEMENTATION PLAN

The PAT scheme is being implemented in three phases. The first phase (PAT Cycle I) ran from 2012-2015, covering 478 facilities from eight energy-intensive sectors. These eight sectors account for roughly 38 percent of India's total primary energy consumption. It targeted energy consumption reductions of 6.686 million tonnes of oil equivalent (Mtoe), but actually achieved a reduction of 8.86 Mtoe in 427 of the 478 covered facilities.

The targets were set by carrying out the baseline audits in PAT Cycle I. The baseline audits were carried out by BEE-empanelled agencies having certified energy auditors and energy managers. The audits were carried out to assess the potential of energy efficiency and the level of consumption at the time. This audit was called baseline audit, and the targets for the designated consumers (DCs) in PAT Cycle I were based on it.

The second phase of the PAT Scheme (PAT Cycle II) runs from 2016-2019, covering 707 units from eleven energy-intensive sectors. PAT Cycle II focuses on deepening and widening PAT Cycle I, i.e. the inclusion of 61 new DCs from the existing eight sectors and the addition of 170 DCs from three new sectors, namely railways, refineries, and electricity distribution companies (DISCOM). This will expand the coverage from 38 percent to 70 percent of total primary energy consumption. There are around 188 units from four sectors (cement, pulp & paper, iron & steel and textiles), and around 130 units from the remaining four sectors (aluminium, fertilizers, chlor-alkali and thermal power plants). The new sectors, railways, refineries and DISCOM, include around 170 units to date. More DCs are under identification, which would bring the total to approximately 707.

TABLE 7: Targeted savings for PAT Cycle I and PAT Cycle II

S. NO.	SECTORS	UNIT OF SEC	PAT CYCLE I#		PAT CYCLE II##	
			NUMBER OF DCS	TARGETED SAVINGS (MTOE)	NUMBER OF DCS	TARGETED SAVINGS (MTOE)
1.	Power (thermal)	Kcal/kWh	144	3.21	154	3.13
2.	Iron and steel	toe/tonne of product	67	1.47	71	2.28
3.	Cement	toe/tonne of product	85	0.82	111	1.12
4.	Aluminium	toe/tonne of product	10	0.46	12	0.47
5.	Fertilizer	toe/tonne of product	29	0.48	37	0.45
6.	Paper and pulp	toe/tonne of product	31	0.12	29	0.15
7.	Textile	toe/tonne of product	90	0.07	99	0.09
8.	Chlor-alkali	toe/tonne of product	22	0.05	24	0.10
9.	Petroleum refinery	Million British thermal units per thousand barrels per energy factor	-	-	20	1.11
10.	Railways	Litres/1000 GTKm	-	-	100	na
11.	DISCOMs	percent of transmission and distribution losses	-	-	50	0.94
	Total		**478**	**6.686**	**707**	**18.00**

Sources: #BEE (2016a); ##BEE (2016b).

For the majority of the sectors (for the new DCs), the last financial year of the three-year reported data will be considered the baseline year for PAT Cycle II. For the new sectors, proper workshops will first be presented to the empanelled agencies to fill up data in the pro-forma and target fixation methodology. This will be carried out by BEE for the three new sectors included in PAT Cycle II, i.e. railways, refineries and DISCOMs.

PAT Cycle I has already achieved a savings of 8.67 Mtoe from 427 DCs as against the target of 6.686 Mtoe (Table 8).

TABLE 8: The achievement of PAT Cycle I

S. No.	SECTORS	No. OF IDENTIFIED DCS	SAVINGS (MILLION TOE)
1	Aluminium	10	0.73
2	Cement	75	1.44
3	Chlor-alkali	22	0.13
4	Fertilizer	29	0.83
5	Iron and steel	60	2.1
6	Pulp and paper	26	0.26
7	Textiles	82	0.12
8	Thermal power plant	123	3.06
	Total	**427**	**8.67**

Source: BEE, 2016a

The PAT Cycle II targets for individual DCs were notified by the Ministry of Power on 31 March 2016 (BEE, 2016a). The notification clearly mentions that any entity that has consumed 30 ktoe in a year would be a designated consumer. Detailed methodologies for measurement and verifications are also provided through a Performance Assessment Document (BEE, 2016b). The gazetting of PAT Cycle II mentions that designated consumers will comply with the energy consumption norms and standards specified against their names by the target year of 2018-2019, a period of three years from 1 April 2016 until 31 March 2019.

6. ACTIONS REQUIRED TO ADDRESS BARRIERS

Deepening of the PAT in existing sectors presents technical barriers such as normalization and integration in issuing the ESCerts, fixing current baselines through monitoring and verification, and meeting the target set for INDC. Broadening coverage to include refinery, railways and electricity DISCOMs will require the setting of benchmarks and capacity-building for various stages of the scheme. Greater involvement by BEE/SDA to facilitate data collection and rigorous statistical modelling are required to set future targets in the medium and long terms.

7. MAIN RISKS AND SUGGESTED SOLUTIONS TO ADDRESS THE RISKS TO THE SUCCESS OF ACTIONS SUGGESTED FOR THE HIO

The implementation of Phase 1 of the PAT scheme has created a strong foundation, and it will be helpful to extend the experience to the new sectors and address the technical barriers. The financial risks include transaction costs to generate energy-saving certificates, volatility in energy prices due to the shift towards cleaner and renewable forms of energy, externalities due to market failure in the trading of energy-saving certificates in the future and the influence of new economic instruments such as goods and service taxes.

Transaction costs are ubiquitous, including in this case administrative and negotiating costs. Information through transparency is one way to reduce these costs. Policy instruments need to be designed to address the barriers arising from institutional characteristics. The financial risks involved are of two types, one related to energy prices, the other the prices of the energy-saving certificates generated during the implementation of the PAT scheme. The lack of accurate information on market fundamentals will reduce efficiency and increase price volatility. Hence, better information, analysis of global and local markets and improved transparency could reduce the incidence and magnitude of the occurrence. Apart from transparency, financial instruments are needed such as futures contracts, price swaps, options and forward contracts for the short and medium terms. In the long term, contracts with an ESCO or the firm or designated consumers can act as physical hedges.

In the absence of price clarity for ESCerts, it will be very difficult to justify any EE capex investments to top management. The oversupply of ESCerts is likely to affect the ROI for the investment in energy-efficient projects by the DCs. Re-trading of ESCerts should not be allowed, as this could lead to black marketeering. RECs and ESCerts should not be fungible unless demanded by a few stakeholders, as the aim of both certificates is clearly different – RECs for energy security and ESCerts for energy efficiency. Depth (number of companies) and width (number of sectors) under the PAT scheme both need to be increased to ensure a competitive market for price discovery and the trading of ESCerts. Trading frequencies should be at least three to five times a year to ensure enough buyers and sellers during each trading cycle.

Goods and Service Tax is based on credit fungibility and reductions of exemptions. Given that the renewable energy sector currently benefits from various exemptions and concessional duties, the impact on the "delivered cost of saving energy" and the trading of energy-saving certificates need to be examined under the Goods and Service Tax regime.

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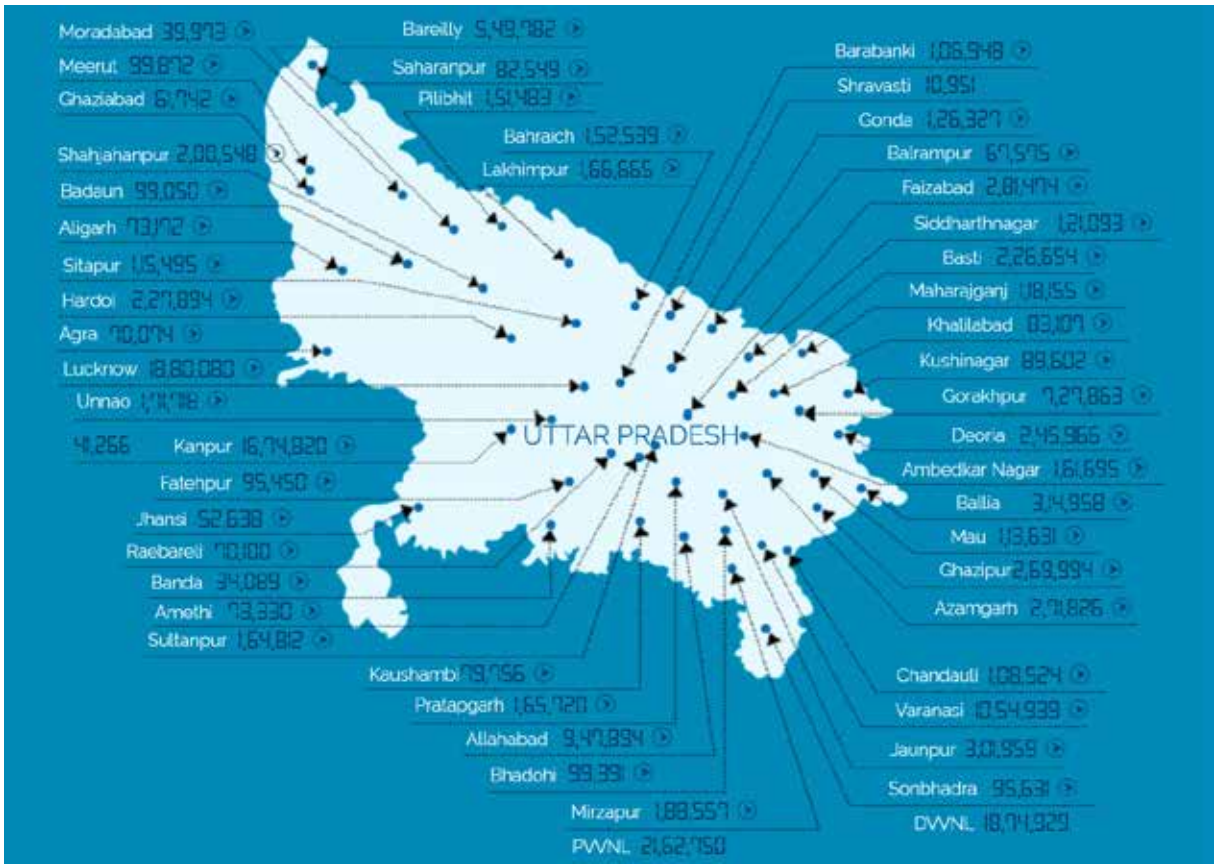
APPENDIX

FIGURE A1A:
State-wise details of the UJALA Program, with number of LED distributed and the energy savings

Source: http://www.ujala.gov.in/

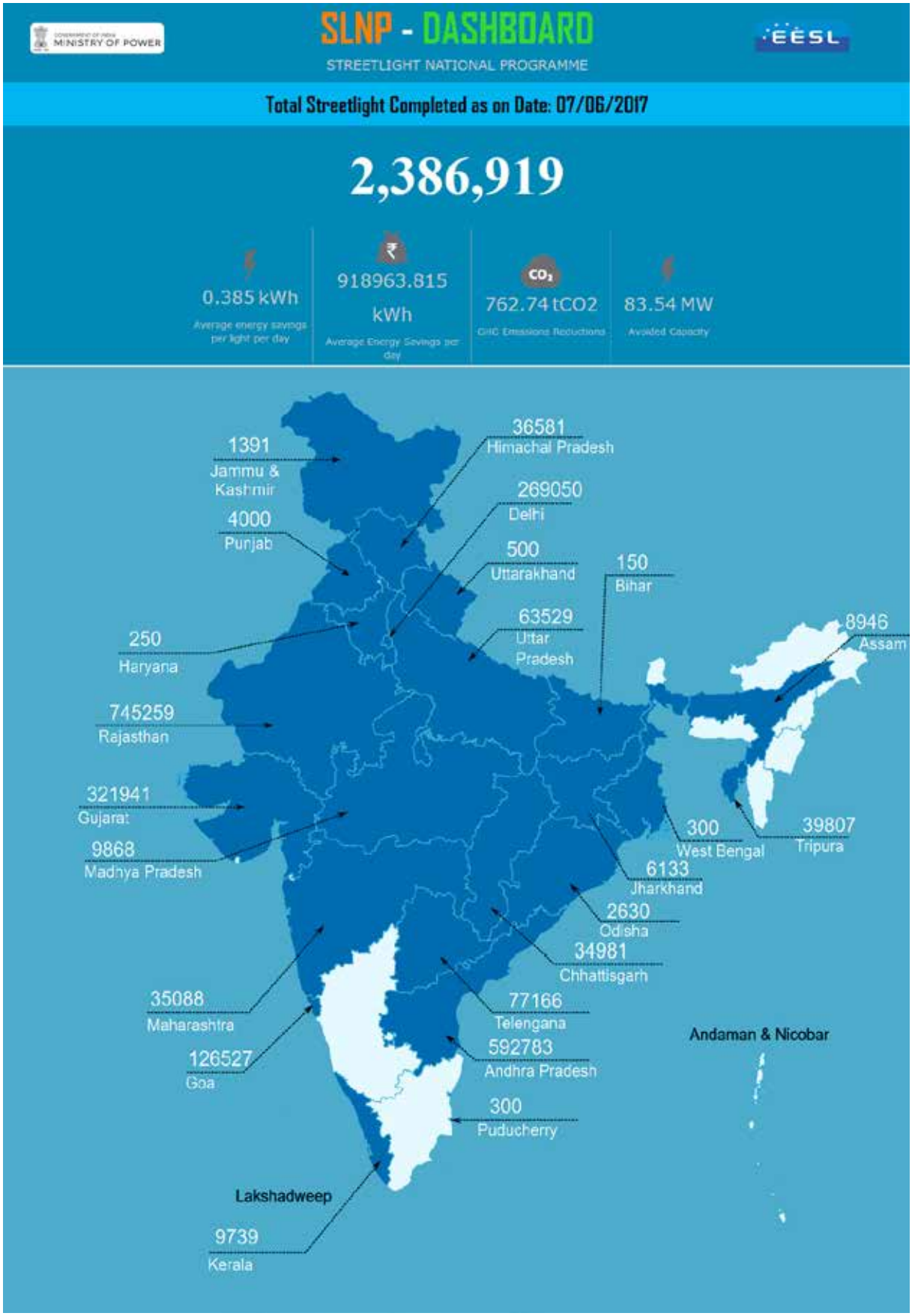
FIGURE A1B:
A representation of the coverage of cities in the state of Uttar Pradesh, India



Source: http://www.ujala.gov.in/state-dashboard/uttar-pradesh

STREET LIGHT NATIONAL PROGRAM (SLNP)

FIGURE A2:
State-wise details of the SLNP program, with number of street lights replaced and respective energy savings



Source: http://www.eeslindia.org/slnp/

In order to assess technically feasible room AC efficiency improvements, EESL conducted engineering simulations of different combinations of room AC components such as compressors, variable speed drives and heat exchangers, with varying degrees of efficiency. The ISEER range in India varies from 2.8 to 6.03 for ACs, depending on type and volume (Appendix, Tables 1 and 2).

TABLE A1: Comparative analysis of ACs with different ISEER values

ISEER (WH/WH)	COMPRESSOR EFFICIENCY (EER)	VARIABLE SPEED DRIVE (VSD)	ESTIMATED MANUFACTURING COST (INR [USD#])	ESTIMATED RETAIL PRICE (INR 2016-17 [USD#])
6.03	3.4	Direct Current Compressor and Fan with VSD	30175 [450]	72420 [1081]
5.89	3.4	Direct Current Compressor and Fan with VSD	29275 [437]	70260 [1049]
5.79	3.4	Alternating Current Compressor and Fan with VSD	27475 [410]	65940 [984]
5.61	3.4	Alternating Current Compressor and Fan with VSD	26225 [391]	62940 [939]
5.4	3.4	Alternating Current Compressor and Fan with VSD	24955 [372]	59892 [894]
5.34	3.4	Alternating Current Compressor and Fan with VSD	24335 [363]	58404 [872]
5.17	3.4	Alternating Current Compressor and Fan with VSD	23085 [345]	55404 [827]
4.99	3.4	Alternating Current Compressor and Fan with VSD	22835 [341]	54804 [818]
4.93	3.4	Alternating Current Compressor and Fan with VSD	22115 [330]	53076 [792]
4.76	3.4	Alternating Current Compressor and Fan with VSD	21595 [322]	51828 [774]
4.69	3.4	Alternating Current Compressor and Fan with VSD	21990 [328]	52776 [788]
4.61	3.4	Alternating Current Compressor and Fan with VSD	20345 [304]	48828 [729]
4.45	3.4	Alternating Current Compressor and Fan with VSD	20095 [300]	48228 [720]
3.09 (Market Average = Baseline)	3.0	-	14700 [219]	35280 [527]
2.9 (MEPS = 1 star)	2.8	-	14500 [216]	34800 [519]

Note: All room ACs presented here are 1.5 ton split units.

 # 1USD = 67 INR

Table A2:
List of 1.5 ton BEE AC models

RANK	NAME	TON	ISEER	ANNUAL UNITS (1600 HOURS)
5-Star Inverter AC				
1	DAIKIN-JTKM50	1.4	5.2	744
2	HITACHI-RSA518CAEA	1.5	5.15	793
3	GODREJ-GSC 18 GIG 5 DGOG	1.4	4.9	791
4	HITACHI-RSB518IAEA	1.5	4.85	842
5	BLUESTAR-5CNHW18PAFU	1.5	4.75	839
6	BLUESTAR-5CNHW18DAFU	1.5	4.74	850
7	TOSHIBA-RAS-18N3KCV-IN + RAS-18N3ACV-IN	1.4	4.69	818
8	BLUESTAR-5CNHW18QATX	1.5	4.68	884
9	MITSUBISHI ELECTRIC-MSY-GK18VA	1.5	4.66	847
10	SAMSUNG-AR18MV5NEWK	1.4	4.64	834
5-Star Non-Inverter AC				
1	GODREJ-GSC 18 FG 8 MOG	1.4	3.91	974
2	BLUESTAR-5HW18SBTU	1.46	3.7	1076
3	BLUESTAR-5HW18ZBRTU	1.46	3.7	1076
4	BLUESTAR-5HW18ZBWTU	1.46	3.7	1076
5	GODREJ-GSC 18 FG 6 BOG	1.42	3.7	1046
6	GODREJ-GSC 18 FG 6 ROG	1.42	3.7	1046
7	HITACHI-RAU518AVD	1.56	3.7	1150
8	HITACHI-RAU518HWDD	1.56	3.7	1150
9	HITACHI-RAU518IVD	1.56	3.7	1150
10	HITACHI-RAU518MWD	1.56	3.7	1150

Source: https://www.bijlibachao.com/top-ten-appliances/best-air-conditioner-ac-window-split-hitachi-lg-carrier-samsung-electricity-consumption-tonnage-in-india.html

Table A3:
Notification/ Regulation/ Amendment related to Room Air conditioners

TITLE	TITLE CLAUSE OF EC ACT, 2001	NOTIFICATION/ REGULATION/ AMENDMENT & DATE	REFERENCE IS/ IEC STANDARDS
Room Air Conditioner	14(b)	S.0.180(E) dated I2th January, 2009	**IS1391:1992 (Part I & H)**
(1) Unitary Type & 1:1 high wall split type	14(a)	S.0.181(E) dated 12thJanuary, 2009	
	Amendment I	S.0.24(E) dated 5thJanuary, 2010	
	Amendment II	S.O. 43(E) dated 9th January, 2012	
(2) Ceiling Mounted & Floor Standing	Amendment III	S.0.1970(E) dated 2nd July, 2013	
	Amendment IV	S.0.3543(E) dated 30thDec, 2015	
	14(d)	No.2/11(5)/03-BEE.2 dated 6thJuly, 2009	
	Amendment I	No.2/11(5)/03-BEE.2 dated 5thJanuary, 2010	
	Amendment II	No.2/11(5)/03-BEE.2 dated 8thMay, 2013	

Source: https://www.beestarlabel.com/Content/Files/gazette_floor_standing_ca.pdf

Table A4:
Prices of 1.5 tons inverter AC

BRAND	MODEL	EER RATIO (COOLING)	PRICE (INR, 2016-17)
Samsung	AR18JV5DAWKNNA	3.82	55555
Hitachi	RAU019CVEA	3.81	55900
Hitachi	RAU019IVEA	3.81	53200
Hitachi	RAU019AVEA	3.81	50600
Daikin	FTKM50PRV16	3.8	45590
LG	BS-Q186C8R6	3.67	48833
Sharp	AH-XP18PHT	3.66	43690
Sharp	AH-XP18PMT	3.66	49990
Sharp	AH-X18PET	3.66	42900
Hitachi	RAU018HVEA	3.61	52777
Samsung	AR18JV5HATQNNA	3.55	42333
Samsung	AR18JV5NBWKNNA	3.54	46444
O General	ASGA18JCC	3.51	51200
Daikin	FTKP50PRV16	3.46	42000

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The four High Impact Opportunities (HIOs) covered in this report concern light-emitting diode (LED) for residential sector, energy-efficient (EE) pump-sets for agriculture sector, 'perform, achieve and trade' (PAT) scheme for eight energy-intensive industrial sectors, and metro rail for transport sector. These HIOs are expected to have huge impacts on improving energy efficiency in India in the short (by 2020), medium (by 2030) and long term (by 2050).

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