Energy Conservation and Efficiency

11 Point Action Plan

Group of Secretaries

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1. Introduction

The primary energy demand in India has grown from about 450 million tons of oil equivalent (toe) in 2000 to about 770 million toe in 2012. This is expected to increase to somewhere between 1250 (estimated by International Energy Agency) and 1500 (estimated in the Integrated Energy Policy Report) million toe by 2030. This increase is driven by a number of factors, the most important of which are increasing incomes and economic growth which lead to greater demand for energy services such as lighting, cooking, space cooling, mobility, industrial production, office automation etc. The Government of India is carrying out a range of interventions to enhance energy supply, and to ensure that electricity is available to all households on a 24x7 basis by 2019.

Government of India has undertaken a two pronged approach to cater to the energy demand of its citizens while ensuring minimum growth in CO2 emissions, so that the global emissions do not lead to an irreversible damage to the earth system. In the generation side, the Government is promoting greater use of renewable in the energy mix mainly through solar and wind and at the same time shifting towards supercritical technologies for coal based power plants. Simultaneously, the impact on the consumer on account of energy prices has to be kept in mind while enhancing energy supply.

Consequently, a primary focus of the Government of India has been promotion of adoption of energy-reducing behavior and technologies, driven by savings for industrial, commercial and residential consumers. The Bureau of Energy Efficiency (BEE), established under the Energy Conservation Act 2001, has been mandated to enable and regulate the conservation and efficient use of energy in India. In 2009, the Government established Energy Efficiency Services Limited (EESL) as a joint venture of four Public Sector Undertakings to work closely with BEE to create new markets for energy-efficient technologies.

The efforts of BEE and EESL have resulted in energy savings of 18.5 billions units in 2014-15 which is equivalent to 9738 MW of avoided peak capacity. These efforts can be accelerated if risks and challenges associated with investments in energy efficiency are overcome.

Risks and Challenges
1. Appliances **a.** Information on savings, and its credibility **b.** Public acceptance for energy efficiency devices with a payback period of less than 3-5 years **2. Industry** **a.** Higher benefits in capacity expansion as compared to efficiency **b.** Higher risk perception of new energy efficiency technologies **3. Commercial and Residential Buildings** **a.** No incentive for developers

b. Lack of implementation capacity in municipalities

4. Transport

a. Large infrastructure investment for large-scale modal shifts

b. Uncertain demand growth in new modal investments

c. Lack of incentives for fuel efficiency in road freight transport

5. Electricity Distribution

a. Procurement practices dis-incentivize higher efficiency, higher cost products

b. Each transaction is small in terms of savings and investments; aggregation is important for lowering transactions costs

c. Lack of incentives for electric distribution companies to promote energy efficiency

In order to accelerate the investment by innovative intervention that could overcomes the risks and challenges in the sector, the Prime Minister constituted a Group of Secretaries to recommend a transformational action plan for energy efficiency and conservation. The Group had detailed deliberation and consulted with a wide spectrum of stakeholders, experts and presented their recommendation to the Prime Minister on 12.01.2016. The constitution of the Group and the presentation made is at Annex-I and Annex-II respectively.

The approach followed by the Group, and the recommended 11-point transformational plan, are described in the next chapter; the resources required for the implementation of this transformational plan are outlined in the 3rd chapter; and the action plans for each of the recommended 11 action points are detailed in the 4th chapter. The 5th chapter, Conclusions, provides an estimate of the impact of this transformational action plan on the energy intensity of the Indian economy, and suggests a framework for the oversight of the plan.

2. Approach and Methodology

Based on the consultations, the Group evolved a set of parameters to identify the interventions that could help overcome the barriers and usher in transformational changes in the sector. These parameters are based on the following:

a) Lowering energy intensity (energy use per unit of Gross Domestic Product);

b) Reducing energy consumption and replicating in large areas;

c) Responding to climate change/adaptation;

d) Reducing greenhouse gas emissions/mitigation;

e) Enabling affordably priced energy services;

f) Researching and developing new energy technologies.

The Group evaluated 51 different energy saving options identified (Annex-III) based on these parameters to come out with a 11-point action plan implementation of which could lead to transformational changes due to

a) Technological maturity;

b) Implementation model success;

c) Lack of additional burden on the exchequer;

d) Transformation potential; and

e) Do-ability

It was noted that almost 90% of consumption of energy is an industries, agriculture, residential, commercial and transport sectors. The action plan, therefore, focuses on energy efficiency improvement in these sectors.

Based on all these criteria and risk in view, following 11-point action point is recommended as under:

1. **Super-efficient Household Appliances deployment and Knowledge Transformation Initiative (SHAKTI):** Increase coverage of super-efficient household appliances to 50% of sales from current 10%
2. **Solar based Efficient Water-pumps for Agriculture (SEWA):** Provide 30 lakh solar based energy efficient water pumps by 2019 through a commercially viable (LED type) business model
3. **Energy Efficient (EE) Buildings & Building Material:** Incentivize new energy efficient buildings to cover at least 30% constructions and existing Government buildings to reduce energy use by 25%
4. **Energy Intensive Industries:** Expansion of Perform, Achieve and Trade Program to achieve coverage of 70% of industrial energy consumption from present 30%
5. **Transport – Roads:** Mandate Fuel Efficiency Norms for Heavy Duty Vehicles (HDVs) in range 12-40 MT in 2 stages and incentivize replacement of old HDVs in all ranges

6. **Transport – Roads:** Fuel Efficient Driver Training Program
7. **Transport – Railways:** Arrest declining share of railway in freight and increase to 40% by 2019 from the current 36%
8. **Transport – Promoting Coastal Shipping:** Increase share of coastal shipping freight to 10%
9. **Commercialization of New Technologies:** Universal lighting access by Micro solar dome (Surya Jyoti) lighting technology developed by DST
10. **Research & Development of Critical Technologies:** Advanced Ultra Super-Critical (AUSC) thermal technology and Ligno-cellulosic bioethanol for blending
11. **Energy Conservation – a People's Movement:** Energy innovation prize, district level awareness and virtual energy efficiency centres.

These 11-point action plan is developed from 51 energy saving options by clubbing few of the options and also based on rating system on the above mentioned parameters. These 11-point action are major activities, but we may also consider following other options which are also important for enhanced energy conservation and efficiency and are having rating of 4 on the scale of 5:

S. No	Technology	Acceptability
1	Coal Washery	★★★★
2	Energy Efficient Induction stove challenge program	★★★★
3	Tariff policy to provide for differential tariff incentivizing energy efficiency	★★★★
4	Automation of tolls	★★★★
5	Heavy haul technology for railways	★★★★
6	Reforms in electricity distribution	★★★★
7	Enhancing bus availability for public transport	★★★★
8	Encourage bio fuels for sustainable energy	★★★★
9	Energy Efficiency in Steel Sector	★★★★
10	Strengthening of institutional framework for implementation	★★★★
11	"Save Energy" in all Govt advertisement	★★★★

Apart from these various other options like smart grid were discussed, which is not an energy efficiency measure but helps in energy management. As this is already being implemented by Ministry of Power, hence this was not further deliberated.

It may be noted that the mandate of this group is on energy conservation and efficiency; consequently only options that result in lowering energy demand or in adoption of more energy-efficient technologies have been considered. Sources which enhance

energy supply (nuclear, animal power, ocean energy etc.) have not been considered in this report.

3. Financial Resources and Fiscal Incentives

The following resources are recommended for implementation of this 11-point action plan.

3.1 Equity infusion in EESL: A sum of Rs. 500 crore is recommended as additional equity to EESL. EESL would create the initial market (10 - 20%) for these four superefficient appliances, and will work towards reducing prices and payback periods through aggregation of demand and competitive bidding process. This will enable private sector players to gain confidence to enter these markets. It is proposed to provide equity support to EESL for:-

- **SHAKTI**
  - 10 Lakh Super-Efficient Fans
  - 5 Crore LED Tube lights
  - 5 Lakh Inverter Air Conditioners
- **SEWA**
  - 5 Lakh Solar based Efficient Water-pumps for Agriculture

This would require investment of Rs. 19,600 crore over the next 3 years including equity support of Rs. 1500 crore over this period and remaining funds will be arranged by EESL through other sources. Equity support of Rs. 500 crore is requested during the current financial year.

3.2 Budget for Outreach activities to BEE: A sum of Rs. 60 crore is recommended for BEE to enable information about these procurements would be provided to end users (and other stakeholders). This would include;-

(a) District level awareness programmes through Regional Information Centres in each State/UT and national level partnership with apex chambers.
(b) Virtual Energy Efficient Centre for information on energy efficiency product and services, pledge for energy efficiency actions and Prime Minister's awards for successful pledges.

An Expenditure Finance Committee (EFC) note for this activity would be prepared for necessary approval and a sum of Rs. 60 crores is expected to be required for the 2016-17 financial year.

3.3 Budget for R&D in New Technologies to MNRE and DST: A sum of Rs. 100 crore is suggested for commercialization of these technologies.

S.No.	Agency	Budget Allocation	Remarks
1	EESL	Rs. 500 Cr	Equity
2	BEE	Rs. 60 Cr	Grant
3	MNRE & DST	Rs. 100 Cr	Grant
	Total	Rs. 660 Cr	

3.4 Fiscal Incentives in form of lower custom/excise duties for super-efficient equipments is proposed.

4. 11-Point Transformational Action Plan

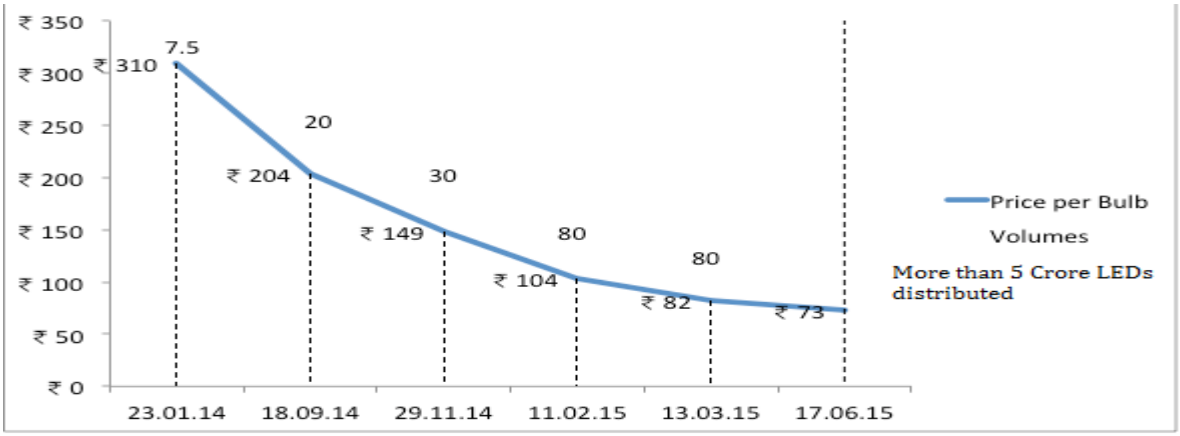
4.1 Super-efficient Household Appliances deployment and Knowledge Transformation Initiative (SHAKTI)

a. Background

The Domestic Efficient Lighting Programme (DELP) being implemented by EESL has enabled that the most efficient source of lighting is made available to households at affordable prices. The LED bulbs, with a warranty of 3 years, are being given to households on EMIs of Rs. 10 each (for 9-10 months recovered by DISCOMs from electricity bills) or at an upfront cost of Rs. 100. There is a high level of quality control that is included in this programme which includes a 3 tier checks on the LED bulbs that are being distributed. In addition, EESL undertakes independent third party monitoring of energy savings and quality of LED bulbs periodically as per the guidance received after the discusion of the programme in the Union Cabinet in June, 2015. The first such independent Monitoring & Verification has been conducted by selecting a third party report for street lighting and domestic lighting by EESL. The study conducted by PricewaterhouseCoopers indicates that failure rates of LED bulbs are less than 1%.. The Executive summary of the report is attached at Annexure IV. Similar measures will be included in this programme as well to ensure that the quality of the super-efficient equipments will not be compromised.

LED Business Model

- Aggregation of demand and bulk procurement
- Payments from consumers through electricity bills
- EMIs calibrated so that installment is less than monthly energy savings
- More than 5 Crore LEDs distributed
- Bulk price reduced by 77%



EESL approach is stimulating market transformation and the coverage of LEDs at the end of this financial year will be about 20% of the total market, which is a significant increase from less than 1% a year ago. This approach has successfully overcome the barrier of high first cost but has also enhanced the awareness of consumers towards energy efficient equipments. Similar approach will be followed for equipments included under **SHAKTI** like refrigerators, ACs, fans, tube lights etc. as the penetration of efficient equipments in the overall product mix is very low. BEE has 4 equipments in mandatory labeling programme, including ACs and Refrigerators. In addition, there are 21 equipments under voluntary programme including fans. The status of sale of 5 STAR equipments is as unders abysmally low primarily due to high cost super-efficient equipments would be costlier that the 5 star rated ones and therefor, there is a stimulates needed to enable market transformation much in the same manner as is happening in the LEDs.

S.No	Equipment	Total sales (2014-15)	5 STAR sales	Remarks
1	AC	35 lakh	16.9%	High cost of 5 STAR AC
2	Fan	2.1 crore	2%	High cost of 5 STAR

b. Implementation Methodology

The following is the suggested implementation methodology for SHAKTI:

i. **Setting Super-Efficient Standards (SES):** The SES to be finalised based on energy performance in a manner that they are at least 50% better than the most energy efficient equipment currently in the market

ii. **Issuance of Regulations under Energy Conservation Act:** Ministry of Power, in consultation with BEE, to issue regulations for standards and labels for Super-Efficient Equipment (SEE) based on the SES.

iii. **Aggregation and Procurement:** EESL, in consultation with DISCOMs and Regulatory Commissions, would aggregate demand and undertake procurement and direct distribution and pass on the price reduction to consumers.

iv. **Manufacturing capacity/ availability:** Engagement with the industry to prepare them to manufacture SEE is necessary.

v. **Safe disposal of inefficient equipment:** It is necessary to ensure that the old equipment are disposed off in environmentally safe manner so that they do not go back in the system. For this, disposal guidelines need to be issued and made part of the programme.

vi. **Business model for SHAKTI:** As is the case with DELP, SHAKTI will also work on the principle of Pay As You Save (PAYS) and the EMIs will be calibrated in a manner that the monthly payout of consumers is less than the electricity bill saving. Approval of State Electricity Regulatory Commissions (SERCs) will be obtained for each DISCOM.

c. Timeline

Activity	2016-17				2017-18				2018-19			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Setting Super-Efficient Standards												
Issuance of Regulations under EC Act												
Manufacturing capacity/ availability												
Aggregation and Procurement												
Safe disposal of old inefficient appliance												

d. Infrastructure and Budgetary Resources

The business model enables third party investments and availability of low cost long tenure funds, from bilateral/ multilateral, banks, FIs may be made available for these investments. The table below indicates, the requirement of funds is very large:

Market segment	Year	Scale of deployment (no.)	Tentative investment (INR crores)	Annual Energy Savings (million kWh)	GHG Emission Reductions (million tCO2)
BEE 5 star Ceiling Fans for Households	2016-17	10,00,000	110	126	0.10
	2017-18	1,00,00,000	1110	1260	1.03
	2018-19	2,00,00,000	2220	2520	2.07
LED self ballasted tubular lamps for households	2016-17	5,00,00,000	2500	1320	1.08
	2017-18	10,00,00,000	5000	2640	2.16
	2018-19	15,00,00,000	7500	3960	3.25
BEE 5 star air conditioners for households	2016-17	5,00,000	1750	736	0.60
	2017-18	10,00,000	3500	1472	1.21
	2018-19	20,00,000	7000	2944	2.41
Total (Cumulative)			**30,690**	**16,978**	**13.91**

The implementation will require funds of Rs. 37,000 crore over next 3 years with EESL taking the lead for at least 20% of the investments as in the case with LED proogramme. This will require additional equity infusion in EESL and it is suggested that the Government provide equity support of Rs. 500 crore in the budget for 2016-17. The remaining equity will be arranged from Promoter Companies of EESL, market, etc.

e. Impact Assessment

Third party impact assessment needs to be conducted for SHAKTI. There are guidelines for monitoring and verification that are available for most of these programmes that usually emanate from the Clean Development Mechanism (CDM). BEE will standardise these protocols and appoint validation agencies to undertake this task.

4.2 Solar Based Efficient Water - Pumps for Agriculture (SEWA)

a. Background

Agriculture sector consumers about 20% of electricity and has over 3 crore water pumps, of which about 2.1 crore are grid connected. The average rating of pumps is 5 HP (2.25 kw). Replacement of all 2.1 crore grid connected pumps with solar agricultural pumps in 3-5 years could result in:

i. Reduction of energy consumption by 170 billion units.

ii. Installation of solar capacity of 47,000 MW.

iii. GHG emission reduction of 130 mt CO_2 every year.

iv. Saving of subsidy of state government, taking the actual cost of supplying electricity as Rs. 4 per unit, of Rs. 68,000 crores.

b. Implementation Methodology

Solar agricultural pumps have a very high capital cost and therefore the demand is low. It is suggested that 30 lakh pumps of capacity upto 5HP be replaced in the first 3 years. These 30 lakh pumps will be primarily from those areas where green revolution is not implemented, where low heads are required for water pumping and water table is high. As advised by Prime Minister, Task Force will be setup under Ministry of New & Renewable Energy for coordination and inter-ministerial functioning. Further, the coverage of the pumps will include grid connected pumps and off-grid pumps and states will also be encouraged to implement this scheme. The following is the suggested implementation methodology for SEWA is as under:

i. **Setting Super-Efficient Standards (SES):** Solar pumps will be able to pump water for 10-12 hours as against the normal pumping hours of 6-7 for grid connected pumps. Therefore, larger capacity pumps could be replaced with lower ones and standards for the same needs to be set by BEE after field testing, energy audits, etc.

ii. **Issuance of Regulations under Energy Conservation Act:** Government of India, through Ministry of Power and Agriculture may issue policy guidance / Regulation to states that inter-alia include standard specifications and labels for solar agricultural pumps.

iii. **Aggregation and Procurement:** Solar Energy corporation of India (SECI) and EESL, in consultation with State Governments, DISCOMs and Regulatory Commissions, could structure SEWA on the same lines as that of DELP and aggregate demand. States will also be encouraged to implement this programme Transparent procurement and direct distribution would help in price reductions which will be passed on as lower annuity to states.

iv. **Manufacturing capacity/ availability:** There is substantial manufacturing capacity in India for pumps. In order to prepare the industry for solar pumps, it

is necessary to engage with them at the start of the Programme and give the industry lead time to upgrade.

v. **Safe disposal of inefficient equipment:** It is necessary to ensure that the old inefficient pumps are disposed off in environmentally safe manner so that they do not go back in the system. EESL already has such guidelines for its interventions for grid connected pumps which can be standardized.

vi. **Business model for SEWA:** The replacement of grid connected pumps with solar ones will eliminate state government agricultural subsidy. The state government will need to encourage investment in the sector by having long term implementation agreements with third parties (like EESL/ SECI) where the investments are repaid over 11-12 year period.

c. Timeline

Activity	2016-17				2017-18				2018-19			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Setting Super-Efficient Standards												
Issuance of Regulations under EC Act												
Manufacturing capacity/ availability												
Aggregation and Procurement												
Safe disposal of old inefficient appliance												

d. Infrastructure and Budgetary Resources

The business model is such that it suits investments by third party, as is the case with EESL. It is therefore suggested that low cost long tenure funds, from bilateral/ multilateral, banks, FIs may be made available for these investments. As the table indicates, these actions will also result in GHG emissions reductions, which can be monetized and be used to leverage carbon finance. It is also suggested that VAT/ Excise may be reduced for these kind of solar agriculture pumps. Large-scale demand creation would not only result in reduction of prices, but also help in setting up domestic manufacturing. However, as the table below indicates, the requirement of funds is very large:

Market segment	Year	Scale of deployment (no.)	Tentative investment (INR crores)	Annual Energy Savings (million kWh)	GHG Emission Reductions (million tCO2)
Solar water Pumps for Agriculture	2016-17	5,00,000	15,000	2200	1.80
	2017-18	10,00,000	30,000	4400	3.61
	2018-19	15,00,000	45,000	6600	5.41
Total (Cumulative)			**90,000**	**13200**	**10.82**

SEWA implementation will require large amount of funding as the cost of solar agriculture pump is about Rs. 90,000 per HP as a 3 HP pump will cost around Rs. 2.7 lakhs. The total funds required are assessed at Rs. 5.7 lakh crore. Given that farmers do not pay for electricity, it is unlikely that they will invest in such pumps. The investments therefore needs to be mobilised to provide solar pump free to the farmers. Taking the assessed investment and savings in subsidy (of Rs. 68,000 crores), the sample payback on investment is a little over 8 years. Thus, if the state government sign an agreement with a third party investor (like EESL) for 11-12 years by monetizing the subsidy savings. 30 lakh pumps are targeted in 3 years with a total investment of Rs. 80,000 crore. In the first year, the target is 5 lakh pumps followed by 10 lakh and 15 lakh in the next 2 years. The investment required is estimated to be Rs. 13,000 crore with equity of Rs. 3,900 crore. As indicated in the earlier section, EESL and SECI will arrange equity from budget of the Government, other sources including public.

e. Impact Assessment

Third party impact assessment needs to be conducted for SEWA. There are guidelines for monitoring and verification that are available for most of these programmes that usually emanate from the Clean Development Mechanism (CDM). BEE to standardise these protocols and appoint validation agencies which can undertake this task.

4.3 Energy Efficient (EE) Buildings & Building Material

a. Background

The Building sector accounts for a third of the country's electricity consumption. Rapid increase in population and the GDP growth will lead to enormous demand for buildings and therefore energy in the coming years.

Present stock of certified/ registered energy efficient buildings is **less than 1%** of the total existing stock. While such rapid expansion presents an opportunity to make a significant contribution to both energy savings and tackling climate change, so far, the potential for building energy efficiency remains largely unexploited.

The Energy Conservation Building Code (ECBC) was developed by the Bureau of Energy Efficiency for new commercial buildings in 2007. It establishes minimum requirements for energy-efficient design and construction for buildings with a connected load of 100 kW/120 kVA or more and provides guidelines for building design, including the envelope, lighting, heating, air-conditioning, and electrical systems.

b. Implementation Methodology

The following is the suggested implementation methodology:

i. **Provision of Incentives – higher FAR/ground coverage with conditionality:** One of the most effective strategies to encourage construction of Energy Efficient buildings is to incentivize the market through structural or financial incentives. Rewarding developers or builders who practice energy efficient building techniques spurs innovation and demand for such technologies. Formulation of incentive scheme to be done by BEE. Circulation can be done through Ministry of Urban Development (MoUD) by issuance of notification to State local authorities to incentivize 1% to 5% extra ground coverage and Floor Area Ratio (FAR) for projects that are ECBC compliant.

ii. **National Electricity Tariff Policy to provide for graded levy of connection charges/tariff for compliance with Code:** Providing graded levy of connection charges and relaxed tariff for ECBC buildings is one other way of encouraging construction of energy efficient buildings. BEE could meet with FOR to discuss the modality to provide graded levy of connection charges/tariff. Draft memorandum to be formulated by BEE.

iii. **Extend the coverage of ECBC to Multi-Storey Residential Buildings:** BEE to conduct study to access the potential areas/ projects, develop potential market based model and identification of key partners (regulators, investors and solution providers). Ministry of Power to amend EC Act to include residential buildings. Regulations will also be formulated, notified and circulated to the States by BEE.

iv. **Promotion of new technologies**: Technologies for Combined Heat and Power, like Trigeneration that uses gas to generated electricity, traps the waste heat to generate cooling and hot water can have operating efficiencies of over 80%.

These technologies are most suited for buildings that have the use of all three applications 24X7 and include hospitals, hotels, airports, etc.

c. Timeline

Activity	Sub-Activities	2016-17				2017-18			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Provision of Incentives - higher FAR/ground coverage with conditionality	Formulation of the incentive scheme								
	Circulation by notification to States								
National Electricity Tariff Policy to provide for graded levy of connection charges/tariff for compliance with Code:	Meeting with FOR								
	Formulation of Draft Memorandum								
Extend coverage of ECBC to Residential buildings	Conduct of study to assess ▸ Potential areas/ projects suitable for system ▸ Potential market based models & key partners								
	Amendment of EC Act								
	Regulation Formulation								
	Notification of Regulation								
	Adoption of regulation by States								

4.4 Energy Intensive Industries

a. Background:

There is less motivation in the industry for promoting energy efficiency as it is seen higher benefits in capacity expansion as compared to efficiency improvements and there is higher risk perception of new energy efficiency technologies and thereby making such project less attractive for implementation because of its low priority for financial lending agencies.

Perform Achieve and Trade Scheme (PAT), a regulatory instrument to reduce specific energy consumption in energy intensive industries, with an associated market based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.

In the first cycle of PAT (2012-13 to 2014-15), 478 industrial units in 8 sectors (Aluminium, Cement, Chlor-Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power, Textile) have been mandated to reduce their specific energy consumption (SEC). Overall, the SEC reduction targets aimed to secure 4.05% reduction in the total energy consumption of these industries totalling an energy saving of 6.686 million tonne of oil equivalent.

b. Implementation Methodology:

To bring transformative change in the industrial energy efficiency, expansion of PAT program to achieve coverage of 70% of industrial energy consumption from present 30% under the PAT Cycle I is envisaged.

Inclusion of more sectors from identified energy intensive sectors in the Schedule of the Energy Conservation Act 2001 for large scale expansion. To achieve about 70% of coverage at least five more sectors other than eight sectors that have been part of PAT Cycle I. This expansion would include following sectors viz. Railways, Electricity Distribution Companies, Refineries, Petrochemical and 24 hours day usage Commercial Buildings.

c. Timelines:

Notification of energy saving targets of first three sectors i.e. Railways, Distribution Companies and Refineries to be completed by **March 2016**. For the remaining two sectors i.e. Petrochemical and 24 hours day usage Commercial Buildings, baseline data collection and formulation of targets by **December 2016** and Notification of targets by **March 2017.**

d. Infrastructure and budgetary support:

The activities including identification of Designated Consumers in identified sector, their notification, and development of reporting formats, collection of baseline data and formulation of targets would be carried out by Bureau of Energy Efficiency (BEE), Ministry of Power. Given that the coverage in terms of DCs is going to be almost double, technical and other manpower requirements would need atleast to be doubled thereby requiring a corpus of equivalent amount that was provided under XI plan i.e. Rs. 30 crores (factoring rise in salary due to 7th Pay Commission). Further, for inclusion of new sectors, development of reporting formats, preparation and publication of program

documents, capacity building etc. an estimated additional fund of about Rs. 115 crores based on the past expenses incurred for in PAT cycle I and quantum of work involved in PAT cycle II may be required totaling to an estimated amount of Rs. 150 Crores.

e. Impact:

Third party verification process instituted under PAT Cycle I will continue to carry out monitoring and verification of the performance of the DCs. The impact expected from the expansion of PAT is as under by the year 2018-19.

Energy Savings	Avoided Generation	Cost Savings
16.8 Billion Units 18 million toe	8800 MW	Rs 19,700 Crore/year

4.5 Transport – Roads

a. Background

The fuel efficiency norms in transport sector are being recognized globally as one of the priority action items by different governments, reason being the programs have the potential to accelerate reduction in average fuel consumption of vehicles sold in the market thereby reducing primary fuel consumption in the country, reducing the import burden and saving environment. Concern for energy security is the main driver for considering a transport sector fuel efficiency program in India. India's estimated requirement of High Speed Diesel (HSD) is likely to increase from 69.40 MMT in 2014-15 to 86.76 MMT in 2017-18*. The major consumption of diesel is accounted for by Heavy Duty Vehicles (trucks and buses).

Diesel is the highest consumed petroleum product in India. The transport sector is the major consumer of diesel and accounts for more than 70% of total diesel sales in India. Heavy duty vehicles (Trucks & Buses) have maximum HSD consumption share in transport sector. The transport sector in India is steadily expanding and will be one of the most attractive regions for manufacturers across the world. This eventually means the related fuel consumption (in transport sector) and emissions will also rise in the country.

The HDVs will be one of the highest categories in the area of fuel emissions because the kilometers travelled by HDVs are much higher in comparison with other categories. In order to reduce the fuel emissions and energy security concerns, it has been observed that the transport sector in India, with such a large fleet of Heavy Duty Vehicles, has significant potential to bring energy /fuel savings.

Initiatives to introduce more efficient vehicles in the country through setting a fuel efficiency norm (especially in heavy commercial segment where the emissions are much higher), will complement India's target set under INDC. Therefore, introducing a fuel efficiency norm for HDVs in India will be highly beneficial for the country and is the need of the hour.

Simulatenously, a movement to phase out old, fuel inefficient trucks in use for carrying road freight is necessary. Since phasing out old trucks imposes costs in terms of new investments, policy effort must be to incentivise scrapping of old trucks at the time of purchase of new trucks.

b. Implementation Methodology

Different countries across the world are using different methodologies for assessing fuel economy for HDVs. For example, India is considering 'On-road testing or Constant Speed Fuel Consumption (CSFC)' procedure at 40 kmph and 60 kmph for testing as per CMVR (SO 1365 Dt. 13-12-2004). Other countries like US, China & Japan use computer

* Source: Petroleum Planning and Analysis Cell

simulation with data inputs from tests like Chassis Dynamometer and Engine Dynamometer.

Constant Speed Fuel Consumption (CSFC) has been a proven method of testing in India for the last 30 years or more. A standardized approach is used in CSFC method for obtaining the fuel economy. There is sufficient testing infrastructure available in the country to test HDVs as per CSFC methodology. This methodology is readily implementable and will have immediate impact.

There is limited infrastructure presently available in the country to develop simulation methods as adopted globally, which will require huge infrastructural investments and larger time scale for implementation (5-10 years).

Furthermore, all the vehicle manufacturers are aware of the operational processes involved in CSFC testing and for it to be revamped and fine-tuned to current needs. Thus, it would be prudent to move forward with current available test procedure using CSFC in the short term approach.

The Group proposes a one-time buyback policy for old, inefficient trucks and scrapping the trucks in lieu of a purchase of a new, fuel efficient truck. The buyback would be implemented by the Ministry of Road Transport & Highways along with the Ministry of Heavy Industries and the Society of Indian Automotive Manufacturers (SIAM). Rs 1.5 to 2 lakhs would be deducted from cost of purchase of energy efficient truck (~ Rs 10 lakhs), if old truck (registered prior to 31.12.2005) is handed over as scrap to dealer. The dealer would transmit the old truck to Metal Scrap Trading Corporation as scrap who would pay the rebate value. The Group proposes an increased and graded levy of Motor Vehicle Tax on vehicles beyond 10 years to incentivise the buy-back. Imposition of Motor Vehicle Tax falls within the jurisdiction of States but Central Government can define the principles for such imposition by virtue of the powers available to it under entry 35 of List III of the 7th Schedule of the Constitution. Waiver of excise duty on sale of scrap by MSTC for recycling can also be considered to allow a greater pass through of benefit accruing from sale of scrap. The annual energy savings is estimated at Rs 312 crores through replacement of 5 lakh vehicles through this process. This will also provide an impetus for indigenous truck manufacturing industry and motivate adoption of fuel efficiency standards in the freight sector which consumer diesel.

c. Timelines

The proposed tentative implementation plan for the norms is:

Tentative implementation plan	
Preparatory lead time for vehicle manufacturers – Fuel efficiency norms to be notified as per Energy Conservation Act, 2001	Notification time (Sept 2016 to March 2017)
First phase from 1st April 2018 onwards & Second Phase from 1st April 2021 onwards	

Also, during the intermediate period (between the finalization of norms and commencement of mandatory implementation from April 2018) it is proposed that stakeholders shall finalize the data sharing requirements and set the protocols for compliance verification. These standards would be implemented by MoRTH.

Adoption of fuel efficiency norms for heavy duty vehicles (above 12 T weight category) offers tremendous potential for savings in terms of fuel, money and CO2 equivalent GHG emissions.

The saving potential for the proposed norms is given below:

S. No.	Approach	Period					
		3rd Year Onwards*			5th Year Onwards*		
		Fuel Saving (MMT)	Monetary Saving (Rs. In crores)	GHG reduction (MMT CO2)	Fuel Saving (MMT)	Monetary Saving (Rs. In crores)	GHG reduction (MMT CO2)
1	Top Runner for 1st and 2nd Both Phases	1.97	11819	6.16	3.44	20663	10.76
2	20th percentile in 1st Phase & Top Runner for Second Phase	1.04	6250	3.26	2.54	15259	7.95
3	33rd Percentile in 1st Phase & Top Runner for Second Phase	0.77	4595	2.39	2.27	13600	7.08
4	Average as norm in 1st Phase & Top Runner for Second Phase	0.48	2868	1.49	1.98	11872	6.18
5	Average as norm in 1st Phase & 20th percentile for Second Phase	0.48	2868	1.49	1.26	7576	3.95
6	Average as norm in 1st Phase & 33rd percentile for Second Phase	0.48	2868	1.49	1.05	6327	3.30

*Assumptions:

1. For Vehicle sales projection 5% CAGR has been taken on Sales data od 2014-15.
2. Price of Diesel is taken as Rs. 50 per liter.
3. Conversion Factor of Diesel to GHG has been taken as 2.6 Kg / Liter.
4. Specific gravity of diesel has been taken as 0.832.

Second Phase of implementation of HDV fuel economy norms will commence from 1.4.2021. These potential savings have been estimated only considering the fresh stock that is added in the market each year.

Apart from this, old HDVs will be replaced through buy-back scheme. Under this scheme old truck will replaced under buy-back mechanism. Rebate will be provided on cost of replacement with energy efficient pumps and higher MV tax will be levied on older vehicles to make the mechanism more viable.

d. Infrastructure & Budgetary Resources

The investment will have to be made by the OEMs to improve their vehicle engines & components to meet the norms. There will not be any liability on the exchequer.

e. Impact Assessment

Third party impact assessment may be conducted for this programme. The assessment can also be done by multiplied the units of vehicles sold with the improvement in their fuel efficiency.

4.6 Transport - Fuel Efficient Driver Training Program

a. Background

India's estimated requirement of High Speed Diesel (HSD) is likely to increase from 69.4 Million Metric Tons (MMT) in 2014-15 to 86.76 MMT in 2017-18. The major consumption of diesel (approx. 43%) is accounted for by Heavy Commercial Vehicle (Trucks and Buses). Therefore, it is imperative to focus on fuel conservation in this sector.

The growing number of vehicles would require trained drivers for their own safety in specific & safety of people in general. There is also urgent need to conserve petroleum products and reduce GHG emissions. Therefore, there is a strong need to train Heavy Commercial drivers and improve their driving skills to save fuel, safety on road and protect environment.

Change of driving habits of the drivers, particularly in India, offers a good scope for petroleum conservation. Therefore, it is extremely critical that drivers of heavy commercial vehicles are trained in a professional manner through the driver training program (DTP). PCRA conducts such type of driver training programs which is a 3 days extensive programme and the activities covered during the training are:

Day-1 Test of individual driver as per his usual driving habits.

Day-2 Class room training to all the participants.

Day-3 Driving test of individual driver to check the training efficacy.

There are approximately 24 lacs heavy commercial vehicles (more than 7.5 T category) drivers in India. It is proposed that these 24 lacs drivers are trained during next three years. This will require training of 1000 instructors of driver training institutes who will further impart training to the drivers. This will happen only when fuel efficient driving training is made mandatory for HCV drivers through amendment in Central Motor Vehicles Rules-1989(CMVR). It will require inclusion of the provision of mandatory fuel efficient driver training in the syllabus under chapter -2 point 31 of CMVR-1989 for issuance of fresh/renewal of HCV driving license. The program will also help in improving the road safety and reducing maintenance cost of the vehicle.

The HCVs category (more than 7.5 T) consumes about 21 MMT of HSD per annum. After this training programme, the drivers, as established in the study by PwC, can easily save 10% of their HSD consumption which will amount to a saving of 2.1 MMT per annum from 3rd year onwards. In monetary terms, this quantity computes to a saving of Rs. 12,620 Crores and this will also result in the reduction of Green House Gas emission by 6.6 million Tons of CO2 per annum from 3rd year onwards.

b. Implementation methodology

PCRA has adequate experience in conducting DTPs. In the last 15 years, PCRA has trained 2,36,556 drivers successfully. PCRA has 70 trainers who will train 1000 instructors of abovementioned driver training institutes on fuel efficient driving. These instructors in turn will carry the baton and train the heavy commercial drivers to cover

all the drivers in this category. There will not be any additional expenditure since the prospective drivers will bear the cost of training, rate of which will be fixed by MoRTH. As PCRA has carried out this programme for large numbers of drivers, its doability is time tested.

Presently, in most of the states, the drivers are visiting driver training institutes (Govt. as well as Private) at the driving learning stage as well as at the time of renewal of the license. These schools are approved by state transport department on the basis of their infrastructure, facilities and trained manpower. If the DTP is included in the CMVR, as compulsory training program and these institutes include driver training program in their curriculum, all the drivers of the country can be covered under this initiative.

c. Timelines & Savings

Timeline	Drivers Trained (Cumulative in lacs)	Total Saving Fuel (MMT)	GHG Emission Reductions (MMT CO2)	Saving in Rs. Crore
2016-17	8	0.7	2.2	4207
2017-18	16	1.4	4.4	8413
2018-19	24	2.1	6.6	12620

Assumptions: Rate of HSD = Rs. 50/liter or Rs.6000 Cr/MMT
Specific Gravity of HSD = 0.832

d. Infrastructure & Budgetary Resources

The current infrastructure of the Driver Training Institutes (Govt. as well as private) would be used to implement this initiative. The programme is self-sustaining since, the Driver Training Institutes will recover their expenses from the fee (fixed by MoRTH) of drivers, who will come for training at these institutes.

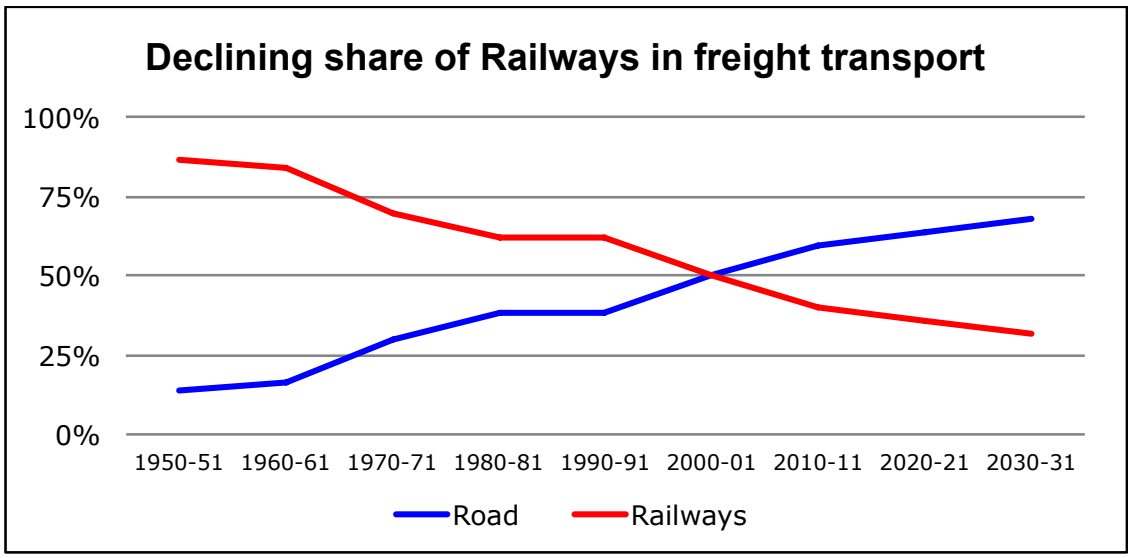
e. Impact Assessment

Since, KMPL of the driver would be recorded before and after the training, the impact would be known immediately. We may also go for a third party impact assessment to check the efficacy of the programme.

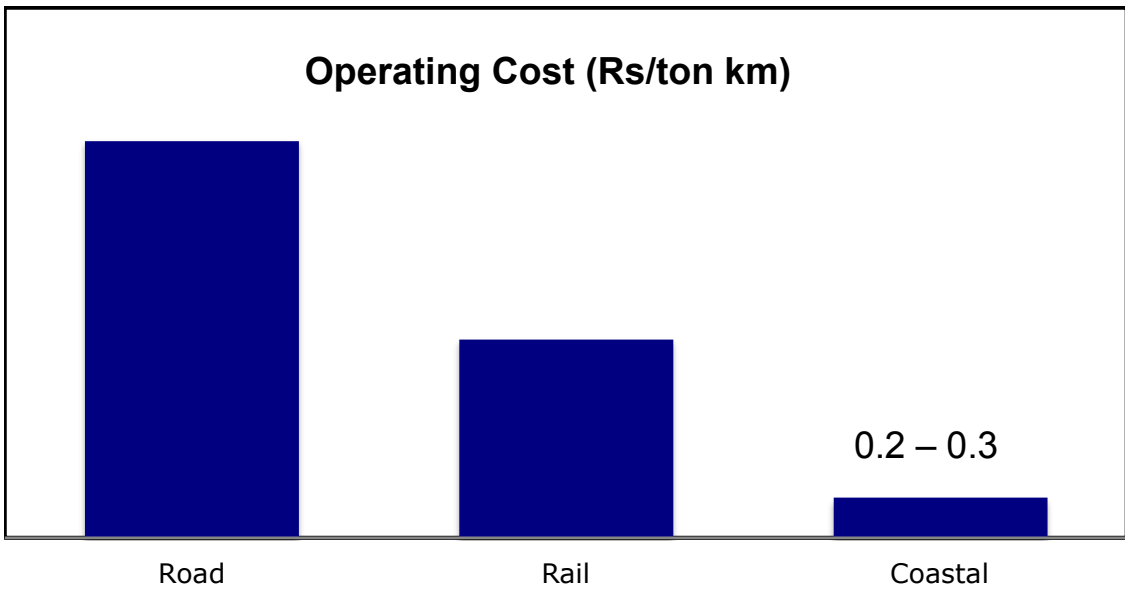
4.7 Transport - Railways

a. Background

The share of freight carried by Railways has been declining consistently over the last few years. The graphs below indicate this trend:



The operating cost of freight carried by Railways is 50% lower than that of road as indicated below:



Increase in share of Railways from present 36% to 40% would significantly enhance energy saving. Prime Minister recommended that feasibility of dedicated freight corridor for Delhi-Chennai, Chennai-Kolkata and Mumbai-Kolkata sector should be evaluated under PPP model. He also recommended that as railway is having land in

various regions, so railways should look at the options for dedicated freight corridor wherever it is possible.

b. Implementation Methodology

The following is the suggested implementation methodology:

(a) In the short and medium term, technological interventions which cut down on the time and increase density of trains

(b) Rationalization of Freight Rates to be made competitive – freight to be made lower than road beyond 500 km by September 2016

(c) Completion of Western and Eastern Dedicated Freight Corridors as schedule

(d) Completion of DPRs for Mumbai-Kolkata and Delhi-Chennai freight corridors

(e) Railways to develop models which can attract major PPP investments

c. Timeline

Activity	2016-17				2017-18				2018-19			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Rationalisation of rates												
Completion of freight corridors												
DPR for new corridors												
PPP models												

d. Infrastructure and Budgetary Resources

The budgets for all the activities is part of the budget of Railways.

e. Impact Assessment

Assessment of impact will be in form of higher share of freight and revenues.

4.8 Transport – Promoting Coastal Shipping

a. Background

Total freight traffic in 2014-15 is ~2000 billion t-km and is expected to grow by 6% annually till 2019-20. Coastal shipping has ~6% share in the overall modal freight mix in the country. This share includes both inland waterway and coastal shipping transportation. On the other hand, countries like China move one-fourth of their cargo through water. We estimate that increasing this share to 10% will result in cost savings to the tune of 54,000 crore and ~9mtoe of fuel saving.

a. Implementation Methodology

Three broad level initiatives should be undertaken to increase the share of coastal shipping in modal mix to 10% –

1. Removal of policy constraints

The Government should come up with a comprehensive plan and supporting policy structure that incentivize freight movement through coastal shipping against road/rail.

Example of these policies could be –

- Selective cabotage relaxation for encouraging coastal movement
- Rationalization taxes on bunker fuel for domestic shipping
- Management of issues like seasonality, routes to be plied by the ships etc. need to be done at a central level to ensure optimal utilisation
- Ministry of Shipping should be the nodal agency in-charge of ensuring the drafting of policies and there implementation in a defined time horizon.

2. Creation of coastal shipping infrastructure

One major reason that coastal shipping has been unable to pick up in the country is due to the lack of suitable infrastructure that enables movement through coast. Hence availability of dedicated infrastructure will go a long way in promoting coastal shipping as a mode of freight transportation. Hence infrastructure at ports and supporting infrastructure using rail/road to facilitate coastal movement should be created.

- Dedicated coastal shipping berths, bunkering, storage at relevant ports
- Creation of supporting transport infrastructure (e.g., Talcher-Paradip railway line), slurry pipelines etc
- Last mile connectivity projects with industrial areas
- Appropriate ship-repairing/ship-building facilities on key ports; currently most of the ship repairs happen outside the country
- Dedicated capacity fleet under shipping companies
- Management of dedicated coastal berths(if any) and their operations
- Ministry of shipping with cooperation from ports and railways should undertake development of this infrastructure.

3. Aggregation of logistic providers

GenCos, steel plants and other consumers of commodities of steel, coal etc require the delivery of raw material at their doorstep. Logistic providers

operating in isolation cannot serve the consumers and hence there exists a need to aggregate their services in collaboration with ship owners. Similarly a single commodity load may not be able to make a lot of routes feasible and hence aggregation of commodity should also be undertaken. INSA and ship owners should then take the responsibility of selling the idea and on-boarding PSU players (Power utilities, SAIL, Dept. of Fertilisers) and private players (Steel, cement producers) to initiate coastal shipping

- Identifying or setting-up aggregation agency to handle small parcel sizes and operate logistics
- A cross commodity aggregation needs to be done in order to ensure large number of routes are plied upon
- Individual plants/ companies many not have enough volumes to charter a vessel
- Currently outsourced to different logistics providers who in turn charter these vessels on demand basis

b. Timeline

Activity	2016-17				2017-18				2018-19			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Policy level changes												
Aggregation of logistic providers												
Creation of infrastructure												

c. Infrastructure and Budgetary Resources

Creation of infrastructure requires a huge magnitude of resources and investment. According to estimates, building the railway connectivity projects, port infrastructure and heavy haul projects would require investment of INR 20,000+ Crore. Since the investment required is large, it would be prudent collect these funds through –

- Cess fund
- PPP models
- Institutional funding and loans
- Tax free bonds

d. Impact Assessment

Coastal shipping uses cheaper bunker fuel as compared to diesel used by rail and the cost of bunker fuel is ~30% lesser than diesel cost. Additionally the amount of fuel used in coastal shipping is also lower as compared to road/rail on a per t-km basis. Both the factors result in lower fuel cost per t-km – Total fuel cost per t-km in coastal shipping is Rs. 0.06 and fuel cost in surface transport is Rs. 0.6. Hence increase in penetration of coastal shipping will result in saving of 9 mtoe fuel and Rs. 54,000 Cr by 2019-20.

4.9 Commercialization of New Technologies

a. Background:

Lighting is basic need of humanity and there are about 300 million in our country who still lack access to good quality lighting service. Providing major part of this population through conventional grid electricity and other off-grid options has been a challenge given the geographical and economic aspects.

Micro Solar Dome (Surya Jyoti), a dome type day lighting device developed by DST has a transparent semi spherical dome shaped acrylic material which captures the sunlight as much as possible. The captured light is then passing through tubular shaped pipe having a thin layer of highly reflective coating on the inner wall of the passage. At the end of this passage there is a suitable retrofit to illuminate every corner of the room with good luminosity.

b. Implementation Methodology:

Providing low cost universal lighting access to about 10 million rural households and urban slum dwellings by Micro solar dome (Surya Jyoti) lighting technology. For being able to reach out to 10 million households/dwellings, the technology need to be tried at locations across the country and fro that extensive field trials to be. For providing such devices on this scale, capacities for manufacturing have to be developed. For implantation of such device, this activity can be dovetailed with the other schemes such as MPLADS and CSR.

c. Timelines:

Field trials at representative locations and conditions need to be completed by July 2016, and capacities for manufacturing have to be developed by Dec 2016 so that bulk procurements and deployment could be carried out.

d. Infrastructure and budgetary support:

Ministry of New and Renewable Energy in partnership with Ministry of Science and Technology and organizations such as TERI and EESL having pan India presence for implementing trials and deployment. Once its trails are successful, EESL can aggregate demand and procure such systems and deploy in rural households. For supporting such program a funding of initial amount of about Rs. 100 crores may be sought from NECF to create a revolving fund where the fund get replenished from the service charge returns from users.

e. Impact:

Access to reliable and cheap lighting service to about 10 million rural households and urban dwellings will have transformative change in the quality of life mainly in health and education. Mostly kerosene-using devices emit substantial fine particulates which causes lung diseases, asthma etc. as reported. Availability of good quality light will extend and enhance the productive time and hence improvement in their economic status. Impact assessment study could be carried out.

4.10 Research & Development of Critical Technologies

1. Advanced Ultra Super-Critical (AUSC) thermal technology

a. Background:

Given that the our energy supply will majorly be coal based despite projected large scale deployment of non-fossil fuel based generation, advancement in technology of the coal based power plant is essential. Existence of large fleet of low efficiency coal based power plants and poor financial health of GENCOs to be able to undertake retirement, R&M/LE etc. for efficiency improvement also stresses for introduction of highly efficient thermal power plant technology.

Introduction of Advanced Ultra Super-Critical (AUSC) thermal technology would have huge impact both in terms of energy saving and subsequent emission mitigation as the technology enables increase in generation efficiency from about 37% to about 45%. It is estimates that 1% increase leads to saving of 10,000 ton coal per year for 100MW power plant.

b. Implementation Methodology:

Support R&D and deployment of such technology for introduction of Advanced Ultra Super-Critical (AUSC) thermal technology based thermal power plants. Conduct R&D for development of super alloys primarily with enhanced creep-rupture properties.

c. Timelines:

Setting up of at least 2 R&D centers at premier material science research centers by March, 2017.

Demonstration of development of super alloys for AUSC temperatures and pressures by March 2019.

d. Organizations and Budgetary Support:

BHEL, Coal India Limited and NTPC in collaboration with countries and Institutions and companies who have such know how with support from Department of Science and Technology to engage in the R&D and demonstration activities. Establish research centers at IITs or other reputed R&D institutions. Funding for such R&D can be sourced from Funding stream from DST.

e. Impact:

It is estimates that 1% increase leads to saving of 10,000 ton coal per year for 100MW power plant.

2. Ligno-cellulosic bioethanol for blending

a. Background:

High dependency of fossil based fuel primarily for transportation and potential for blending in large quantity thereby reducing import dependency.

Ligno cellulosic ethanol can be developed from biomass waste and India being an agrarian country, there are huge potential for using biomass in general and agrarian biomass in particular for generation of bioethanol.

b. Implementation Methodology:

Introduction of Ligno-cellulosic bioethanol for blending produced through Enzyme Technology development by Department of Biotechnology and demonstration plant can be established by Oil companies.

c. Timelines:

Setting up of at least 2 R&D centers at premier material science research centers by March, 2017. Demonstration of development of Enzyme Technology by March 2019.

d. Infrastructure and Budgetary Support:

For execution of such activity has to be headed by Department of Bio-Technology where such research in production of Ligno cellulosic ethanol.

e. Impact:

Production of ethanol for blending will be help avoid consumption of fossil fuel for transportation. It is estimated that blending to the extent 10% can be done with impacting the performance.

4.11 Energy Conservation - a Peoples Movement

a. Energy Innovation prize

- For mass replicable innovative ideas and products on energy savings

b. District level awareness

- Information centres supported/managed by local industry association and information provided by BEE/State Designated Agencies
- Partnership at the national level with the apex chambers

c. Virtual Energy Efficiency Centre

- Website for all energy efficiency information including latest technology
- Tip of the day
- Information on savings, availability and suppliers of energy efficient products Encourage homes, offices and industry to pledge energy efficiency action
- Prime Minister's award for the most successful pledges
- BEE will develop slogan through like "Urja Daksh Bharat, Unnat Bharat" or "Bijli ki Bachat to Bharat Unnat" as suggested by Smt. Sushma Swaraj, through some contest and will be used by all Government Departments for promotion of energy conservation.

5. Conclusion

Based on the detailed deliberation of Group of Secretaries and their consultations with a wide spectrum of stakeholders, experts, vision and goals for energy conservation and efficiency was formulated and is hereunder:

Vision:

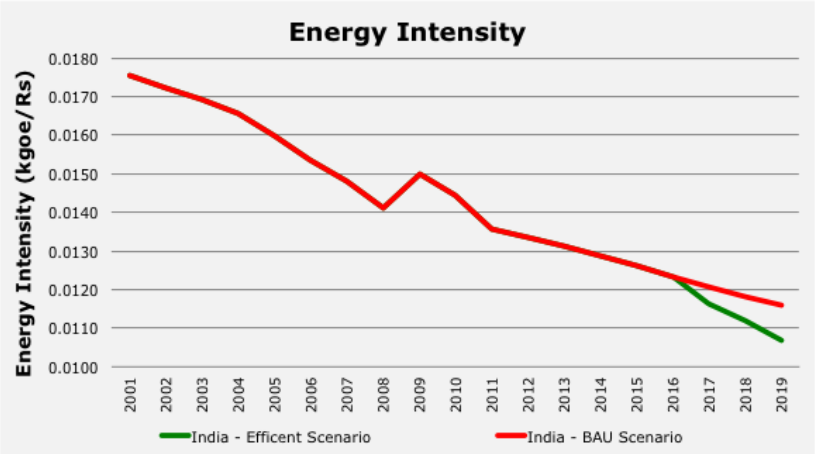
Effectively manage India's energy resources through energy conservation and efficiency

Goals:

Triple the energy savings by 2019

Reduction in energy intensity between 2016 and 2019 by 7 %

Across the world, this **energy *intensity*** is used to compare efficiency of utilization of energy use by the country, and is the ratio of total primary energy supply to the GDP of the country. As per the World Energy Statistics of International Energy Agency (IEA), in 2013 India (0.13 kgoe/'000 USD) is below the world average energy intensity 0.16 kgoe/'000 USD. Countries more than India are: China (0.22 kgoe/'000 USD), USA (0.15 kgoe/'000 USD), Australia and Korea (0.14 kgoe/'000 USD). Countries lower than India are UK (0.09 kgoe/'000 USD), Germany & Japan (0.11 kgoe/'000 USD) and France (0.12 kgoe/'000 USD).



India's energy intensity has been decreasing - between 2005 and 2010, the intensity reduced by 12%. At the same rate, the reduction in 2019 (from 2005 level) will be 26%. Based on the 11-point action plan, India will save 44 million toe of energy and avoid generation capacity for about 28,600 MW. Further this will reduce energy intensity further by 7% from business as usual scenario.

However to implement this additional sum of Rs. 1860 crore is required in 3 years for successful implementation and market transformation for energy conservation and efficiency. Detailed fund requirement is shown in the table below:

S.No.	Agency	Budget Allocation (2016-17)	Budget Allocation (2017-18)	Budget Allocation (2018-19)	Remarks
1	EESL	Rs. 500 Cr	Rs. 500 Cr	Rs. 500 Cr	Equity
2	BEE	Rs. 60 Cr	Rs 100 Cr	Rs 100 Cr	Grant
3	MNRE & DST	Rs. 100 Cr			Grant
	Total	Rs 660	Rs 600	Rs. 600 Cr	

Apart from these funding requirement, fiscal Incentives in form of lower custom/excise duties for super-efficient equipment and appliances is proposed.

Capacity Building of BEE and EESL

For rapid market transformation and implementation of energy conservation and efficiency measures, strengthening of Bureau of Energy Efficiency (BEE) and Energy Efficiency Services Limited (EESL) is required.

As of now, BEE is having only 20 officer level position including Director General. These 11-point action plans will cover 90% of India's energy consumption, so expansion of BEE capacities is the need of the hour. BEE shall be allowed to increase officers and staff strength as and when required with approval of Secretary (Power), which may be funded through BEE's internal resources like labeling fee from star rated appliances.

Annexure – I

A1. Energy Conservation and Efficiency – Group of Secretaries

S. No	Names, Ministries
1	Shri Balvender Kumar, Mines
2	Shri Ashutosh Sharma, Science and Tech.
3	Shri Sekhar Basu, Atomic Energy
4	Ms. Nandita Chatterjee, HUPA
5	Shri Upendra Tripathy, MNRE
6	Shri Anuj Kumar Bishnoi, Fertilizers
7	Shri G. Narayana Raju, Legislative Deptt.
8	Shri Prabhu Dayal Meena, Ex-Ser. Welfare
9	Shri Anoop Kr. Srivastava, Border Management
10	Shri Kapil Dev Tripathi, Petroleum
11	Shri Rajive Kumar, Shipping-Rapporteur

Annexure – II

A2. Energy Conservation and Efficiency – Group of Joint Secretaries

Group 1

S. No	Ministry/Department	Names
1	**NSCS**	**V. Umashankar - Rapporteur**
2	HUPA	Rajiv Ranjan Mishra
3	Shipping	Pravir Krishna
4	Coal	Rameshwar Prasad Gupta
5	Animal Husbandry	Arun Kumar
6	Steel	Syedain Abbasi
7	Pharmaceuticals	Sudhansh Pant
8	P & NG	Sandeep Pondrik
9	P & NG	Ashutosh Jindal
10	DoNER	Jitendra Kumar Sinha
11	Power	Arun Kumar Verma
12	MHA	Praveen
13	P & NG	Sanjay Sudhir
14	Heavy Industry	Vishvajit Sahay
15	JS (ES), MEA	Soumen Bagchi

Group 2

S. No	Ministry/Dept	Names
1	**MNRE**	**Tarun Kapoor – Rapporteur**
2	Defence	Suresh Kumar
3	Fertilizer	Dharam Pal
4	Rural Development	Atal Dulloo
5	Animal Husbandry	Sanjay R Bhoosreddy
6	Food & Public Distribution	Deepak Kumar
7	Drinking Water & Sanitation	Satya Brata Sahu
8	Health & Family Welfare	Rakesh Kumar
9	Labour & Employment	Dheeraj Kumar
10	DoPT	Archana Verma
11	Water Resources	B. Rajender
12	Disinvestment	Ravi Agarwal
13	Higher Education	Darshana Momaya Dabral
14	Commerce	Sanjay Chadha
15	MEA	Pradeep Kumar Rawat

Annexure – III

A3. Energy Saving Options

S. No	Technology	Acceptability	Remarks
1	Energy Efficiency in Industries	★★★★★	Accepted
2	Scaling-up of Super-Efficient appliance (like LEDs)	★★★★★	Accepted
3	Solar Based Water Pumps	★★★★★	Accepted
4	Implementation of fuel efficiency Norms for HDVs	★★★★★	Accepted
5	Driver Training Program	★★★★★	Accepted
6	Advanced ultra super-critical thermal technology	★★★★★	Accepted
7	Coal Washery	★★★★	Issue in do-ability
8	Multi Modal Freight	★★★★★	Accepted
9	Fuel shift for public transportation from Diesel / Petrol to CNG	★★	Not an energy efficiency option
10	Technology development for energy storage	★★★	Not matured
11	Energy Efficient Buildings	★★★★★	Accepted
12	Mandatory Star Rating for Agriculture Pump-sets	★★★	Already included in BEE Activities
13	Awareness Campaigns	★★★★★	Accepted
14	Energy Efficiency in telecom towers	★★★	In process by telecom industries
15	Energy Audit of water supply	★★	Additional burden on exchequer & do ability issue

S. No	Technology	Acceptability	Remarks
16	Waste to energy plants	★★★	Additional burden on exchequer & do ability issue
17	Strengthening of Institutional framework	★★★★★	Accepted
18	LED Lights in all Government buildings	★★★★★	Accepted
19	Targets for Ministries/PSU for roof top solar targets	★★	Additional burden on exchequer & implementation model issue
20	Mandatory metering for farmers	★	Additional burden on exchequer & implementation model issue
21	Integrated energy and water management in agriculture sector	★★★★★	Accepted
22	Use of solar thermal in industries	★	Technology is not matured
23	Widening of PAT scheme	★★★★★	Accepted
24	Smart Grids	★★★	Already under implementation
25	Promotion of electric and Hybrid vehicles	★★★	Already under implementation
26	Optimization of AC regulators, Microwaves instead of hotcases	★★★	Do-ability issue
27	Incentives for Green buildings & EE Buildings	★★★★★	Accepted
28	Solar cooking to be promoted on large scale	★★	Implementation model issue
29	Energy Efficient Induction stove challenge program	★★★★	Implementation model issue

S. No	Technology	Acceptability	Remarks
30	Tariff policy to include for differential tariff	★★★★	Implementation model issue
31	Property Tax disincentive for inefficient new property construction	★★★	Implementation model issue
32	Automation of tolls	★★★★	Implementation model issue
33	Improved roads for energy efficiency	★★	Additional burden on exchequer
34	Golden arrow corridor for freight in railways	★★★★★	Accepted
35	Heavy haul technology for railways	★★★★	Additional burden on exchequer
36	Reforms in electricity distribution	★★★★	Additional burden on exchequer
37	Promotion of rail freight	★★★★★	Accepted
38	Enhancing bus availability for public transport	★★★★	Not an energy efficiency option
39	Establish Special purpose vehicle for PNG in large cities	★★★	Not an energy efficiency option
40	Incentivize building code compliance	★★★★★	Accepted
41	Improving standards for ACs and Geysers	★★★	Already in place
42	Encourage bio fuels for sustainable energy	★★★★	Issue in implementation
43	Energy Efficiency in Steel Sector	★★★★	Included in PAT scheme of BEE
44	Strengthening of institutional framework for implementation	★★★★	Additional burden on exchequer

S. No	Technology	Acceptability	Remarks
45	Mandatory procurement of EE appliances by Government	★★★★★	Accepted
46	"Save Energy" in all Govt advertisement	★★★★	Accepted
47	Energy usage benchmark in agriculture	★★★	Do-ability issue
48	Utilization of Nuclear and Ocean Energy	★★★	Technology is not mature
49	Unnat Chulha Developement	★★★	Technology is not mature
50	LPG stove standard to be made mandatory	★★★	Already in process by BEE
51	Innovative technology in building sector	★★★	Do-ability issue

Annexure – IV

Monitoring and Verification Report

Street Lighting and DELP projects

Strictly Private and Confidential

September 2015

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List of Abbreviations and Acronyms

BEE	Bureau of Energy Efficiency
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
DELP	Domestic Efficient Lighting Program
EESL	Energy Efficiency Services Limited
GHG	Green House Gases
INR	Indian Rupees
kWh	Kilowatt hour
LED	Light Emitting Diodes
M&V	Monitoring and Verification
MW	Mega watt
tCO_2	Tonnes of carbon dioxide
THD	Total Harmonics Distortion
ULB	Urban Local Bodies

1. Executive Summary

Lighting sector accounts for about 20% of the total electricity consumption in India. It has been estimated that the use of LEDs in domestic and public lighting could result in 50-90% reduction in energy consumption. However, there are several barriers that limit the use of efficient LED lighting in the country, including:

- High upfront cost of LED
- Inadequate information about the life of LED
- Cycle of low consumer demand leading to lower supply capacities leading to higher costs
- Inadequate financial resources, lack of capacity and information about the benefits of LEDs at ULB/ Municipality level

The Hon'ble Prime Minister of India launched the "100 cities LED based Domestic Efficient Lighting Program (DELP) and National Street Lighting Program on 5th January, 2015 to address these barriers. Under the National Street Lighting Program, 35 million conventional street lights are to be replaced with energy efficient LED street lights. The national DELP program also envisions replacement of 770 million incandescent bulbs with energy efficient LED bulbs.

Till date, EESL has successfully implemented the street lighting program and the DELP in 18 and 5 cities respectively. EESL engaged PwC to carry out monitoring and verification of these projects. The objective of this study is to estimate the energy savings, reduction of load and reduction of GHG emissions resulting from these projects. Further these results were extrapolated for the national targets mentioned above. The results of the M&V study will set the direction for efficient lighting projects and learnings from it will help better implementation of the future projects. This would also be a key input for developing energy policies related to lighting sector in India.

1.1. Street Lighting

A survey was conducted for 5 street lighting projects in Varanasi, Jhalawar, Mount Abu, Visakhapatnam and Agartala. Based on the survey conducted, the project team assessed the operational status of the installed LED street lights. The key observations of the survey have been tabulated below:

Sr. No.	District / City	Total LED street lights installed (A)	Number of defective LED street lights (B)	Percentage of defective LED street lights (A*100/B)
1.	Varanasi	947	21	2.22%
2.	Jhalawar	2449	21	0.86%
3.	Mount Abu	1807	38	2.10%
4.	Visakhapatnam	91775	884	0.96%

5.	Agartala	34200	425	1.24%
	Total	**131178**	**1389**	**1.06%**

It was observed during the survey that most of the installed LED street lights were in working condition and only 1 percent of the installed street lights were observed to be non-working at the time of survey.

The key parameters like annual energy savings (in kWh), peak load reduction (in MW) and avoided annual GHG emission (in tCO_2) have been computed based on the findings of the survey. The computed results are provided below:

Name of Cities	Number of LEDs (in thousands)	Annual energy savings (million kWh)	Avoided GHG emission (thousand tCO2)	Peak load reduction (MW)
Varanasi	0.947	1.56	1.278	0.39
Jhalawar	2.449	0.37	0.303	0.09
Mount Abu	1.807	0.65	0.530	0.16
Vizag	91.775	23.54	19.302	5.05
Agartala	34.200	3.90	3.200	0.97
Total (for 5 cities)	**131.178**	**30.02**	**24.613**	**6.66**
Total (at national level for 3.5 crore street lights)	**35000**	**8008.59**	**6567.04**	**1777**

It can be seen from the table that the installation of 131,178 LED street lights in the 5 cities has led to an annual energy savings of 30.02 million kWh, an avoided annual GHG emissions of 24,613 tCO_2 and peak load reduction of 6.66 MW.

Similarly, the installation of 35 million LED street lights will lead to an annual energy savings of 8008.59 million kWh, an avoided annual GHG emissions of 6.57 million tCO_2 and peak load reduction of 1,777 MW at the national level.

In order to check the lighting level on the streets, lux measurements were also carried out during the study at certain places on a sample basis. It was observed that the lux levels have increased considerably post the installation of LED street lights.

1.2. DELP

Monitoring and verification activity was carried out for DELP projects implemented in Puducherry and four districts of Andhra Pradesh. Survey was carried out for 120 households in each of the five project areas. The key results from the survey are:

Sr No.	District / City	Total LED bulbs distributed [A = B+C]	Number of LEDs found operational [B]	Number of LEDs currently not operational [C = i+ii]	Number of defective LEDs [i]	Number of LEDs kept for future purpose and others [ii]
1	Puducherry	338	331	7	4	3
2	Anantapur	240	237	3	2	1
3	Guntur	240	237	3	2	1
5	Srikakulam	240	237	3	3	0
6	W. Godavari	240	238	2	1	1
Total		1298	1280	18	12	6
Percentage		100.00%	98.61%	1.39%	0.92%	0.46%

For the purpose of the analysis, it is assumed that the broken and damaged bulbs will be replaced with new LED bulbs by the consumers and therefore included in the number of operational LEDs. It was observed that bulbs were broken during cleaning (0.84%) and suffered from water damage (1%)

Based on these survey results, the total savings, reduction of peak load and emission reduction for every project was calculated.

Region	Units saved for the overall project (million kWh)	Peak load reduction (MW)	Emission reduction (thousand tCO2)
Puducherry	80.95	15.81	65.6
Anantapur	150.06	29.36	121.5
Guntur	249.33	48.70	202.0
Srikakulam	142.04	27.87	115.1
W. Godavari	214.10	41.82	173.4
Total (for five cities)	836.48	163.56	677.6
National Level (for 77 crores LED bulb distribution)	102901	20122	84379.5

These results were further extrapolated to the entire national program (replacement of 77 crore domestic lights). At a national level 102.9 billion kWh would be saved annually resulting in reduction of 20,100 MW peak load and 84.37 million tCO_2 reduction.

2. Background of the study

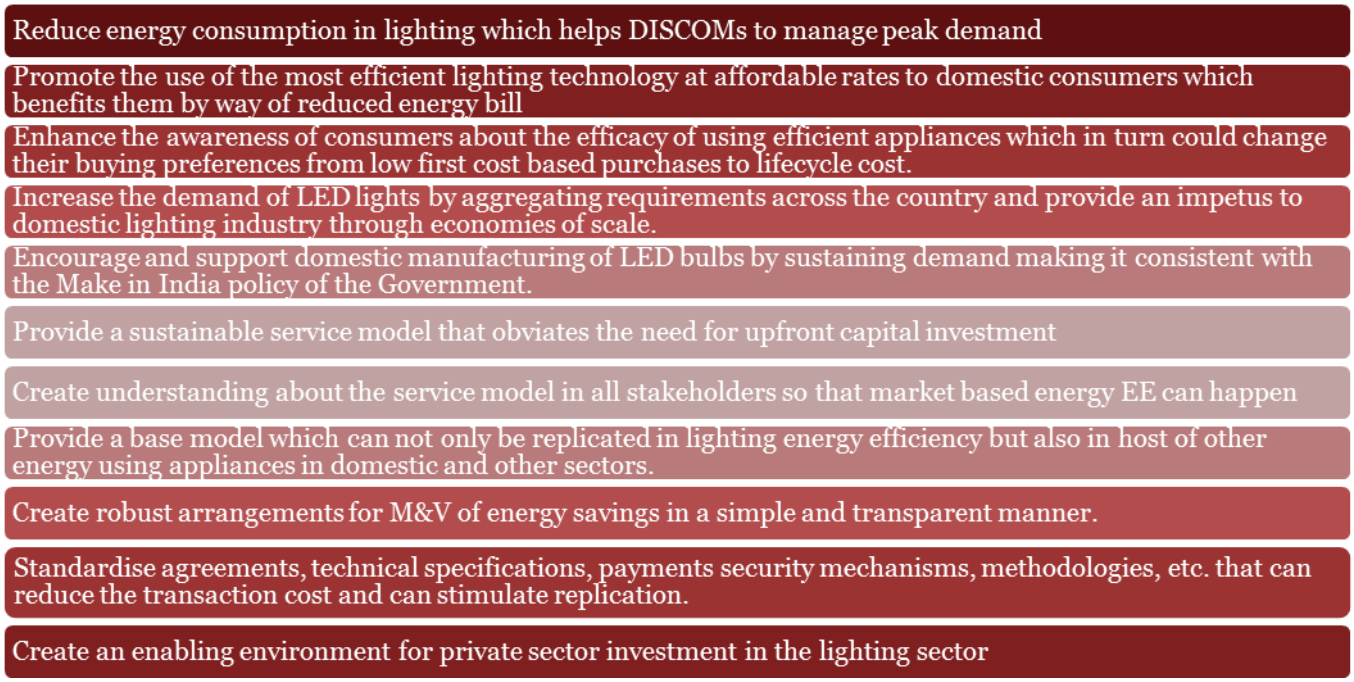
Lighting sector accounts for about 20% of the total electricity consumption in India. Most of the lighting needs in domestic and public lighting sector are met by conventional lights, including highly inefficient incandescent bulbs in domestic sector and conventional street lights in public lighting sector. LED provides better light output than conventional light.

Use of LEDs in domestic and public lighting could result in 50-90% reduction in energy consumption. However, there are several barriers that limit the use of efficient LED lighting in the country. Some of the key barriers are:

Figure 1: Barriers limiting use of LED lighting

To address these barriers the "100 Cities LED based Domestic Efficient Lighting Program (DELP) and Street Lighting National Program" was launched by the Prime Minister of India on 5th January, 2015. Energy Efficiency Services Limited (EESL) has been designated as the implementing agency for the program. The key objectives of the national program are:

Figure 2: Objectives of 100 Cities LED based Domestic Efficient Lighting Program (DELP) and Street Lighting National Program



2.1. Objective of the study and methodology adopted

The overall objective of this study is to conduct surveys and measurements to quantify energy savings of five DELP and street lighting projects individually, extrapolate the savings to overall program and also to evaluate the GHG emission reductions.

The key output of this study is computation of the total energy saving of the DELP and the EE street lighting national level. The results of this study would be used in developing energy policies in India.

Figure 3: Methodology adopted for the assignment

Project Planning:
- Finalization of work schedule , questionnaire and methodology with EESL
- Discussion with EESL and local authorities to finalize the sampling distribution (sampling plan)
- Support required from relevant authorities
- Collection of data from relevant authorities

Survey and Measurement:
- Questionnaire based survey for DELP scheme based on the approved questionnaire
- Measurement has to be taken at switch point level for few hours
- & snapshot reading shall be taken for individual pole/light for street lights

Analysis:
- Quantitative and Qualitative analysis of Surveys
- Based on survey and measurement calculation of actual savings, avoided capacity addition and GHG emission reduction for each project
- Extrapolation of these parameters to the entire programme

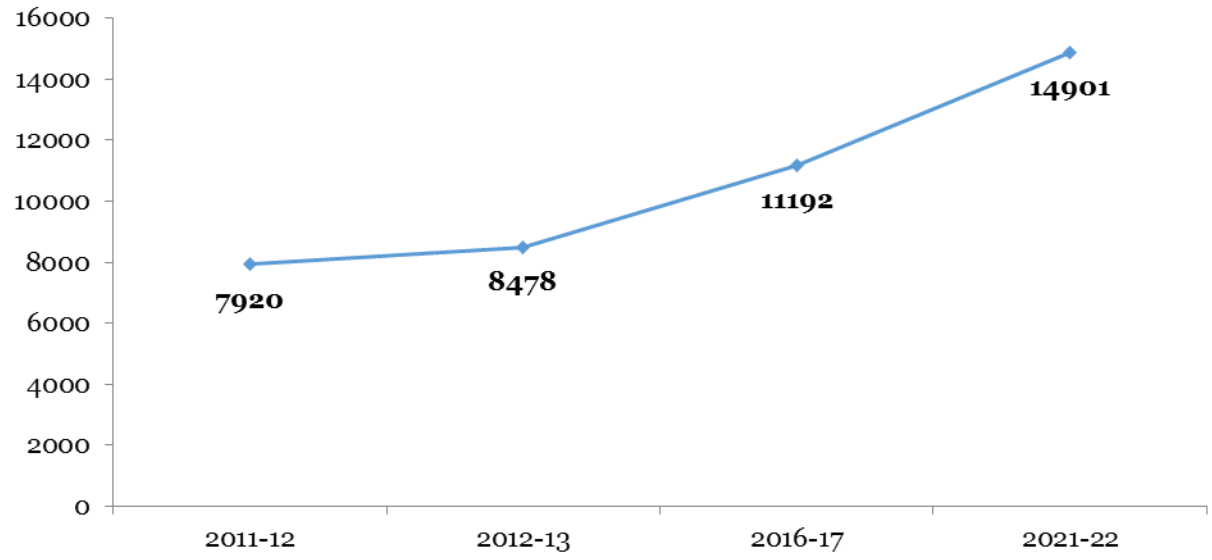
3. Street Lighting Projects

3.1. Overview of Street Lighting in India

In India, providing public lighting is one important function that urban local bodies (ULB) fulfill. Street lighting provides an important function; keeping pedestrians, drivers, and other roadway users safe, while promoting use of public spaces. Studies have shown that proper street lighting can substantially reduce fatalities and crashes with pedestrians and lighted intersections and highways have fewer crashes than their unlit counterparts. However, public lighting is costly for local governments. Street lights have high hours-of-use (they are on for over 4,000 hours per year) and thus are large consumers of energy. Different studies indicate that municipal street lighting can represent from 5% to over 60% of a ULB's electric bill, depending on the municipality's size, the services it offers, and the efficiency of its public lighting.

As per the 18th Electric Power Survey of Central Electricity Authority (CEA), the estimated energy consumption in Indian public lighting sector with 2009-10 as the base year was about 8,478 million kWh in 2012-13. This is expected to grow at a CAGR of 7% during the XII and XIII plan periods. The chart below indicates this trend:

Figure 4: Demand of public lighting in India (in million units)



Source: 18th Electric Power Survey, CEA

Unfortunately, there is no comprehensive data available for street or public lighting specifying luminaire types currently installed. Some public lighting retrofit reports give detailed information on luminaire types replaced, but do not provide detail on current public lighting installations. Different type of luminaire being used in public lighting in India are Incandescent, Tungsten halogen, Compact Fluorescent, High intensity discharge, Linear fluorescent, etc. Most of these luminaire types are inefficient type of street lighting luminaires in comparison to the

latest technology i.e. LED type luminaires which are highly energy efficient. Thus, there is significant potential not only for energy-efficiency retrofits, but also for improved operational procedures in new or relocated street lighting installations.

3.2. Energy Efficiency Potential in Street Lighting in India

The potential impact for energy savings in street lighting in India is substantial and has been considered as one of seven key levers that India can use to reduce carbon emissions. Public lighting could have a large, swift impact, as each ULB has a substantial lighting footprint. In addition to the environmental benefits, any initiative for energy consumption reduction in public lighting will also lead to the better financial health of the ULBs.

With public lighting consuming about 8,500 million kWh of electricity in 2012-13, energy efficient street lighting is poised to deliver substantial energy savings to Urban Local Bodies. Bureau of Energy Efficiency (BEE), the apex body for conservation of energy in India, is already running a program called Municipal Demand Side Management (MuDSM) and has already carried out studies in 269 ULBs across 15 states to develop energy efficiency opportunities in Municipal sector. Results of the studies indicated that retrofitting the entire conventional streetlights with LEDs could result in potential annual savings of 4,300 million kWh, which is about 50% of total energy consumed (2012-13). Furthermore, the operational optimization could lead to an additional 15-20% energy savings.

Despite this potential, the progress in transition to energy efficient street lighting in the Municipalities and ULBs has been slow. While several states have taken steps to implement energy efficiency in the street light sector through ESCO mode, the actual implementation on the ground has been largely unsuccessful. This may be due to many factors including: inadequate baseline data, lack of performance contracts standardization, and lack of access to finance by Municipalities or poor financial position of ESCOs.

Use of efficient lighting infrastructure could help reduce the energy usage between 25-60%. For instance, retrofitting the entire conventional streetlights with LEDs could result in a potential annual savings of 4300 million kWh, which is about 50% of the total energy consumed. In addition, the operational optimization such as use of twilight switching controls, dimming and voltage optimization, could lead to an additional energy savings of 15-20%. The total opportunity of energy savings at the national level could increase from 4300 million kWh to about 5000 million kWh annually. Assuming a power cost of Rs. 5 per kWh, this translates to an annual cost savings of Rs. 2,500 crores.

3.3. EESL service model

EESL, justifying its origin, started working in this sector in last 2-3 years as a government ESCO company and worked towards developing faith of the municipalities in new and innovative

technologies and implemented a few successful projects in ESCO mode. EESL has evolved a service model where it replaces the conventional street lights with LEDs at its own costs (without any need for municipalities to invest) and the consequent reduction in energy and maintenance cost of the municipality is used to repay EESL over a period of time. The contracts that EESL enters into with municipalities are typically of 7 years duration where it not only guarantees a minimum energy saving (of-typically 50%) but also provides free replacements and maintenance of lights at no additional cost to the municipality during the contract period. The service model enables the municipalities to go in for state of the art street lights with no upfront capital cost and repayments to EESL are within the present level of expenditure. Thus, there is no additional revenue expenditure required to be incurred by the municipality for change over to energy efficient LED street lights.

3.4. Background of the Street Lighting M&V project

The Hon'ble Prime Minister of India launched the "100 cities LED based Domestic Efficient Lighting Program (DELP) and National Street Lighting Program on 5th January, 2015. Under the National Street Lighting Program, the conventional street lights are being replaced with smart and energy efficient LED street lights. EESL has been given the task of replacing conventional street lights in the selected 100 cities with the LED street lights.

At present, EESL has already successfully implemented 18 projects for street lighting. To assess the impact of the implemented projects, EESL has carried out this M&V study through PwC. The objective of this study is to evaluate the impact in terms of energy savings and reduction of GHG emissions as a result of these projects. Further, the results have been extrapolated for the entire National Street Lighting Program. The results of the M&V study will set the direction for the future street lighting projects and learnings from it will help better implementation of the future projects. This would also be a key input for developing energy policies related to street lighting in India.

3.5. Street Lighting projects targets

The targets for the street lighting projects are:

Table 1: Targets for the street lighting projects

No. of street lights to be replaced	35 million
Expected annual energy savings	9000 million kWh
Expected reduction of installed street light load	1500 MW
Estimated capital investment (excluding O&M)	Rs. 35,000 crore
Annual estimated greenhouse gas emission reductions	6.2 million tonnes of CO_2

3.6. Current Status of the Projects

To accomplish the targets of replacing 35 million conventional street lights with LED street lights across India, EESL has successfully implemented projects in 18 cities and work is under progress in 82 cities. The current status of LED street lighting projects is tabulated below:

Table 2: Status of street lighting projects

Parameters	Details
No of ULBs enrolled	302
No of ULBs where work has been completed	18
No of ULBs where work is under progress	82

The M&V project has been carried out for LED street lights projects implemented in 5 cities namely Agartala, Mount Abu, Jhalawar, Visakhapatnam and Varanasi. The total numbers of LED fixtures installed in these 5 cities are reflected as:

Table 3: Number of LED fixtures installed in 5 cities under the M&V project

S. No.	City	No of LED fixtures installed (nos.)
1.	Agartala	34,200
2.	Mount Abu	1,807
3.	Jhalawar	2,449
4.	Visakhapatnam	91,775
5.	Varanasi	947

3.7. Survey Methodology

3.7.1. Sample Plan Distribution

The savings from street lighting projects is computed based on the sample measurements of each lighting fixture types in the towns. The sample sizes decided for the individual

measurements based on 80% confidence level and 10% margin of error have been computed by using the following formula:

$$Sample\ size\ n = \frac{41\ X\ N}{41 + N}$$

For the switch points recording of 4 hours, one sample switch point for each lighting fixture type has been considered for carrying the measurements in all the cities.

Based on the above sampling formula and approved approach for recording measurements in the switch points, the sampling size for various types of LED fixtures types in different cities is provided below.

Table 4: Sample size for street lighting projects

1. Varanasi, Uttar Pradesh

		Fixture type & Numbers			
S. No.	Parameters	120W	160W (Flood Lights)	160W (Street Lights)	200W
1	Number of fixtures installed	101	136	102	608
2	Sample size to be covered for each fixture type	30	32	30	39
3	Sample number of switch points to be covered	1	1	1	1

2. Jhalawar, Rajasthan

		Fixture type & Numbers					
S. No.	Parameters	12W	18W	40W	72W	120W	190W
1	Number of fixtures installed	372	1624	157	140	120	36
2	Sample size to be covered for each fixture type	38	41	33	32	31	20
3	Sample number of switch points to be covered	1	1	1	1	1	1

3. Mount Abu, Rajasthan

		Fixture type & Numbers			
S. No.	Parameters	15W	35W	70W	120W

1	Number of fixtures installed	551	119	966	171
2	Sample size to be covered for each fixture type	39	31	40	34
3	Sample number of switch points to be covered	1	1	1	1

4. Visakhapatnam, Andhra Pradesh

		Fixture types & Numbers						
S. No.	Parameters	20W	40W	70W	120W	150W	160W	210W
1	Number of fixtures installed	60395	4084	18392	4578	3000	1200	126
2	Sample size to be covered for each fixture type	42	41	41	41	41	40	32
3	Sample number of switch points to be covered	1	1	1	1	1	1	1

5. Agartala, Tripura

		Fixture types & Numbers					
S. No.	Parameters	10W	12W	36W	40W	120W	150W
1	Number of fixtures installed	16930	11286	984	656	3844	500
2	Sample size to be covered for each fixture type	41	41	40	39	41	39
3	Sample number of switch points to be covered	1	1	1	1	1	1

3.8. Survey Questionnaire

The questionnaire prepared for survey captured the various parameters including:

- Number of LED street lights installed and in working condition and non-working condition
- Measurement of electrical parameters like voltage, current, power, power factor, harmonics etc. for the sample of LED fixtures
- Recording of measurements of electrical parameters for 4 hours on the feeder i.e. switch point for the sample of lighting fixtures

The results of the questionnaire have been used to extrapolate the number of LED street lights in working condition. Based on the survey findings, the actual energy savings accrued due to the installation of LED street lights have also been quantified in terms of estimated energy savings

in million units/annum, avoided peak load reduction in MW and reduction in GHG emissions in tonnes of CO_2.

The survey questionnaire prepared is attached as Annexure in this report.

3.9. Schedule of Surveys

The survey was carried out with the help of EESL's site officials in all the five cities. The dates of the survey are given below:

Table 5: Schedule of the M&V survey

Sr. No.	Area	Date of M&V survey
1	Varanasi	9-13 September 2015
2	Jhalawar	16-17 September 2015
3	Mount Abu	18-21 September 2015
4	Visakhapatnam	22-25 September 2015
5	Agartala	1-4 October 2015

3.10. Observations of the survey

Based on the surveys conducted, the project team analyzed the data to evaluate the operational status of the LED street lights installed. The observations of the survey have been tabulated below:

Table 6: Observations of the M&V survey

Sr No.	District / City	Total LED street lights installed (A)	Number of defective LED street lights (B)	Percentage of defective LED street lights (A*100/B)
1.	Varanasi	947	21	2.22%
2.	Jhalawar	2449	21	0.86%
3.	Mount Abu	1807	38	2.10%
4.	Visakhapatnam	91775	884	0.96%
5.	Agartala	34200	425	1.24%

Total	131178	1389	1.06%

It was observed during the survey that most of the LED street lights installed were in working condition and only 1 percent of the installed street lights were observed to be non-working. Based on discussion with the officials of Municipal Corporation and local suppliers in these cities, it was found that line faults were the major reasons for non-working of LEDs. And in most cases, the drivers were replaced/repaired with the new ones.

3.11. Computation of key parameters

The key parameters like annual energy savings (in kWh), peak load reduction (in MW) and avoided annual GHG emission (in tCO_2) have been computed based on the findings of the survey. The computed results are provided below:

3.11.1. Energy Savings

Energy saved has been computed based on the number of LED Street lights installed. The formula used for computation is

$$Energy\ Savings = Baseline\ Consumption - Consumption\ post\ Project\ Implementation$$

The results of the survey were further extrapolated to the cities as provided below:

Table 7: Key results of the M&V survey

1. Varanasi, Uttar Pradesh

Rating of street lighting lamp before LED installation (W)	Rating of installed LED lamp (W)	Average measured power of installed LED lamp (W)	Annual energy consumption before LED installation (kWh)	Annual energy consumption after LED installation (kWh)	Annual energy savings (kWh)
250 W	120W	113	111517	45673	65843
250 W	160W Street Lights	159	112621	65198	47423
400 W	160W Flood Lights	161	360386	87641	272745
2x400 W, 400 W	200W, 160 W	186	1624910	452910	1172000
	Total Savings		**2209433**	**651422**	**155801**

					1
	Total percentage savings (%)				**71%**

2. Jhalawar, Rajasthan

Rating of street lighting lamp before LED installation (W)	Rating of installed LED lamp (W)	Average measured power of installed LED lamp (W)	Annual energy consumption before LED installation (kWh)	Annual energy consumption after LED installation (kWh)	Annual energy savings (kWh)
20 W	12W	12	29872	18581	11290
40 W	18W	19	299937	125661	174276
70 W	40W	43	47277	27194	20082
150 W	72W	70	95557	39132	56425
250 W	120W	128	132495	61539	70956
400 W	190W	195	65043	28136	36907
	Total Savings		**670180**	**300242**	**369938**
	Total percentage savings (%)				**55%**

3. Mount Abu, Rajasthan

Rating of street lighting lamp before LED installation (W)	Rating of installed LED lamp (W)	Average measured power of installed LED lamp (W)	Annual energy consumption before LED installation (kWh)	Annual energy consumption after LED installation (kWh)	Annual energy savings (kWh)
36 W	15W	16	79642	34293	45348
70 W	35W	39	35834	18526	17308
150 W	70W	76	659343	295789	363554
400 W	120W	129	308954	88885	220069
	Total Savings		1083773	437493	646280
	Total				**60%**

	percentage savings (%)				

4. Visakhapatnam, Andhra Pradesh

Rating of street lighting lamp before LED installation (W)	Rating of installed LED lamp (W)	Average measured power of installed LED lamp (W)	Annual energy consumption before LED installation (kWh)	Annual energy consumption after LED installation (kWh)	Annual energy savings (kWh)
40 W	20W	22.08	13755565	5353873	8401692
70 W	40W	40.71	1431034	667484	763550
150 W	70W	67.66	13291898	4996571	8295327
250 W	120W	115.31	5514201	2119387	3394814
250 W	150W	146.10	3613500	1759796	1853704
250 W	160W	154.16	1445400	742722	702678
400 W	210W	212.43	234549	107466	127083
	Total Savings		**39286147**	**15747299**	**23538848**
	Total percentage savings (%)				**60%**

5. Agartala, Tripura

Rating of street lighting lamp before LED installation (W)	Rating of installed LED lamp (W)	Average measured power of installed LED lamp (W)	Annual energy consumption before LED installation (kWh)	Annual energy consumption after LED installation (kWh)	Annual energy savings (kWh)
18 W	10 W	9.03	1223531	613712	609819
18 W	12 W	11.65	815639	527883	287756
85 W	36 W	35.52	335815	140339	195476
85 W	40 W	40.06	223876	105516	118360
250 W	120 W	116.93	4244257	1804622	2439635
250 W	150 W	149.67	552063	300466	251596

	Total Savings		**7395180**	**3492538**	**3902642**
	Total percentage savings (%)				**53%**

3.11.2. Peak load reduction

The peak load reduction refers to the MW savings accrued with the implementation of LED street lighting projects. This reduces the burden on the already constrained generation capacity of the nation.

The peak load reduction can be calculated by the formula:

$$\text{Load reduction in kW} = \frac{\text{Number of LEDs installed (wattage of conventional lights} - \text{wattage of LEDs)} \times \text{Peak Coincidence Factor}}{1000}$$

For the computation of peak load reduction from implementation of LED street lighting projects, the peak coincidence factor has been taken as 1 based on various load research studies.

Table 8: Peak load reduction for 5 cities

Sr. No.	Cities	Peak load reduction (MW)
1.	Varanasi	0.39
2.	Jhalawar	0.09
3.	Mount Abu	0.16
4.	Visakhapatnam	5.05
5.	Agartala	0.97
Total (for 5 cities)		**6.66**
Total (at national level)		**1777**

Based on the results achieved, the peak load reduction for street lighting projects in these 5 cities is 6.66 MW. Similarly, the installation of 35 million LED street lights at the national level will lead to peak load reduction of 1,777 MW.

3.11.3. Emission Reduction

The reduction in GHG emission has been computed based on the Baseline Carbon Dioxide Emission Database published by Central Electricity Authority, Government of India.

$$Reduction\ in\ GHG\ emissions = Energy\ units\ saved \times Emission\ Factor$$

The most recent emission factors published by Central Electricity Authority (CEA) are:

Table 9: Assumptions for Emission Reduction

Grid	Emission factor in tCO2/MWh[1]
NEWNE	0.82
South	0.82
India	0.82

Based on the above mentioned emission factors, the emission reductions for all these projects are:

Table 10: Emission Reduction for street lighting projects

Sr. No.	Region	Units Saved (million kWh)	Emission Factor	GHG Emission Reduction (thousand tCO_2)
1.	Varanasi	1.56	0.82	1.278
2.	Jhalawar	0.37	0.82	0.303
3.	Mount Abu	0.65	0.82	0.530
4.	Visakhapatnam	23.54	0.82	19.302
5.	Agartala	3.90	0.82	3.20
Total (for 5 cities)		**30.02**	**0.82**	**24.613**
Total (at national level)		**8008.59**	**0.82**	**6567.04**

[1] Weighted average emission factor based on "User Guide (Version 10.0) of CO2 baseline database for the Indian Power Sector prepared by Central Electricity Authority, Ministry of Power, GoI.

Based on the results achieved, the reduction in GHG emissions for street lighting projects in these 5 cities is 24,613 tCO2. Similarly, the installation of 35 million LED street lights at the national level will result in the reduction of total GHG emissions of 6.57 million tCO2.

Lighting levels

The sample lighting levels measurements were carried out at certain locations in the cities. It was observed during the survey that the lux levels have considerably improved with the installation of LED street lights in comparison to the conventional street lights. During discussions with the locals in the cities, it was found that LED street lights have also illuminated those places where there was no illumination or very little illumination.

The findings of the lighting levels measurements are tabulated below:

Table 11: Lighting levels measurements

Varanasi

S. No.	Name of the location/ switch point	Average lighting levels (lux)
1	ASSI Ghat	70
2	Ganga Mahal Ghat	45
3	Bhadaini Ghat	35
4	Harishchandra Ghat	50
5	Hanumana Gardhi Ghat	15

The variation in the lux levels is attributed to the road width, distance between two poles etc. Based on the discussions, it was found that the lux levels have considerably increased with the installation of LED street lights as compared to conventional lights.

Visakhapatnam

S. No.	Name of the location/ switch point	Average lighting levels (lux)
1	PDP/SW/01	7.75
2	VM/SW/01	15.25
3	RKM/SW/01	19.06
4	AS/SW/01	19

5	FOB/SW/01	20.10

The variation in the lux levels is attributed to the road width, distance between two poles etc. It was also observed that lux levels have considerably increased with the installation of LED street lights as compared to conventional lights.

Agartala

S. No.	Name of the location/ switch point	Average lighting levels (lux)
1	Roy Medical Store	46
2	Old Secretariat	42.19
3	Gorka Basti	56.12
4	Governor house	66.13
5	Neta chowmni	7.63

The variation in the lux levels is attributed to the road width, distance between two poles etc. The lux levels have considerably increased with the installation of LED street lights as compared to conventional lights.

3.12. Switch Point Measurements

3.12.1. Varanasi

There are four types of LED lighting fixtures installed in Varanasi. The electrical parameters for one switch point of each LED lighting fixture type were recorded for about 4 hours. The consolidated details of switch points covered and the number of various lighting fixtures types connected to that switch point are provided below:

Table 12: Details of switch points in Varanasi

S. No.	Name/ location of switch point	Details of lighting fixtures	Rated load (W)	Average measured load (W)
1	BP/RDP/SW-01	8X120W	960W	984.75W
2	DS/RMG/SW-01	27X160W + 1X120W	4440W	4480W
3	BLP/AG/SW-01	24X200W + 1X120W + 50X160W	12920W	13207.87W

4	DS/CRP/SW-01	4X200W	800W	795.08W

Some of the observations regarding the switch point wise measurements in Varanasi are provided below:

- The power profile showed that the average measured load was close to the rated load. The maximum variation observed in the average measured load and rated load was 2.58 percent.
- The voltage and current profile showed that the variation in voltage is inversely proportional to the variation in current for most of the cases. This is due to the inherent characteristics of LED street lights in which it draws power close to its rated load. In case of over voltages during night times, the LED street lights draw a current lesser than the rated current.
- The voltage and current harmonics profile showed that the voltage and current harmonics are within the recommended limits as per IEEE standards.

3.12.2. Jhalawar

There are six types of LED lighting fixtures installed in Jhalawar. The electrical parameters for one switch point of each LED lighting fixture type were recorded for about 4 hours. The consolidated details of switch points covered and the number of various lighting fixtures types connected to that switch point is provided below:

Table 13: Details of switch points in Jhalawar

S. No.	Name/ location of switch point	Details of lighting fixtures	Rated load (W)	Average measured load (W)
1	Manjhi Mohalla	14X12W + 1X72W	240W	238.08W
2	Police Line	18X72W + 2X190W + 20X18W + 3X70W	2246W	2254.61W
3	Kanchan Residency	24X18W + 3X250W	1182W	1222.51W
4	Satya Chauraha/WN-21/PN-1891	6X40W + 3X90W + 1X190W	700W	620.72W
5	Master Colony Main Road	24X40W + 1X190W	1150W	1111.34W
6	Bada Bazaar (next to Jain Mandir)	33X120W	3960W	4065.24W

Some of the observations regarding the switch point wise measurements in Jhalawar are provided below:

- The power profile showed that the average measured load was close to the rated load. The maximum variation observed in the average measured load and rated load was 11.33 percent.
- The voltage and current profile showed that the variation in voltage is inversely proportional to the variation in current for most of the cases. This is due to the inherent characteristics of LED street lights in which it draws power close to its rated load. In case of over voltages during night times, the LED street lights draw a current lesser than the rated current.
- The voltage and current harmonics profile showed that the voltage and current harmonics are within the recommended limits as per IEEE standards.

3.12.3. Mount Abu

There are four types of LED lighting fixtures installed in Mount Abu. The electrical parameters for one switch point of each LED lighting fixture type were recorded for about 4 hours. The consolidated details of switch points covered and the number of various lighting fixtures types connected to that switch point is provided below:

Table 14: Details of switch points in Mount Abu

S. No.	Name/ location of switch point	Details of lighting fixtures	Rated load (W)	Average measured load (W)
1	Sophia school	12X120W + 8X70W + 17X15w + 12X70W +	5060W	4891.42W

		1X35W + 5X25W + 1X65W + 6x250W		
2	Post office crossing	6X120W + 13X70W + 11X15W + 21X70W + 6X15W + 3X25W + 5X1000W + 7X500W	11930W	11630.30W
3	Pandu Bhawan	13X15W + 4X35W + 28X70W + 4X120W + 4X500W + 1X1000W	5775W	5402.38W
4	Gora Chhapra	84X15W + 55X70W + 4X35W + 4X120W + 3X25W + 1X120W + 10x500W + 10X1000W	20925W	20219.76W

Some of the observations regarding the switch point wise measurements in Mount Abu are provided below:

- The power profile showed that the average measured load was close to the rated load. The maximum variation observed in the average measured load and rated load was 6.45 percent.
- The voltage and current profile showed that the variation in voltage is inversely proportional to the variation in current for most of the cases. This is due to the inherent characteristics of LED street lights in which it draws power close to its rated load. In case of over voltages during night times, the LED street lights draw a current lesser than the rated current.
- The voltage and current harmonics profile showed that the voltage and current harmonics are within the recommended limits as per IEEE standards.

3.12.4. Visakhapatnam

There are seven types of LED lighting fixtures installed in Visakhapatnam. The electrical parameters for one switch point of each LED lighting fixture type were recorded for about 4 hours. The consolidated details of switch points covered and the number of various lighting fixtures types connected to that switch point is provided below:

Table 15: Details of switch points in Visakhapatnam

S. No.	Name/ location of switch point	Details of lighting fixtures	Rated load (W)	Average measured load

				(W)
1	PDP/SW/01	9X20W	180W	183.49W
2	VM/SW/01	12X40W	480W	492.38W
3	RKM/SW/01	5X70W	350W	337.92W
4	AS/SW/01	42X120W	5040W	4990.15W
5	FOB/SW/01	84X150W	12600W	12655.16W
6	NH/SW/01	60X160W	9600W	10139.14W
7	PWD/SW/01	6X210W	1260W	1295.39W

Some of the observations regarding the switch point wise measurements in Visakhapatnam are provided below:

- The power profile showed that the average measured load was close to the rated load. The maximum variation observed in the average measured load and rated load was 5.62 percent.
- The voltage and current profile showed that the variation in voltage is inversely proportional to the variation in current for most of the cases. This is due to the inherent characteristics of LED street lights in which it draws power close to its rated load. In case of over voltages during night times, the LED street lights draw a current lesser than the rated current.
- The voltage and current harmonics profile showed that the voltage and current harmonics are within the recommended limits as per IEEE standards.




3.12.5. Agartala

There are six types of LED lighting fixtures installed in Agartala. The electrical parameters for one switch point of each LED lighting fixture type were recorded for about 4 hours. The consolidated details of switch points covered and the number of various lighting fixtures types connected to that switch point is provided below:

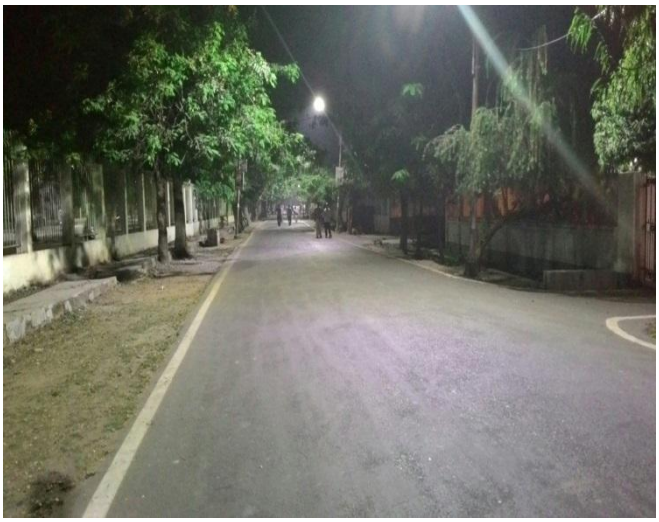
Table 16: Details of switch points in Agartala

S. No.	Name/ location of switch point	Details of lighting fixtures	Rated load (W)	Average measured load (W)
1	Ward no-26 kpb/001	31X10W	310W	311.12W
2	Ward no -02/vip/rd/001	15X12W	180W	174.37W

3	Ward no-20/jm/001	37X36W	1332W	1347.03W
4	Ward no-03/nc/001	45X40W	1800W	1788.22W
5	Ward no-31/pg/skk/001	13X120W	1560W	1570.63W
6	Ward no -03/vip/rd/001	12X150W	1800W	1834.69W

Some of the observations regarding the switch point wise measurements in Agartala are provided below:

- The power profile showed that the average measured load was close to the rated load. The maximum variation observed in the average measured load and rated load was 3.13 percent.
- The voltage and current profile showed that the variation in voltage is inversely proportional to the variation in current for most of the cases. This is due to the inherent characteristics of LED street lights in which it draws power close to its rated load. In case of over voltages during night times, the LED street lights draw a current lesser than the rated current.
- The voltage and current harmonics profile showed that the voltage and current harmonics are within the recommended limits as per IEEE standards.



4. Domestic Energy Efficient Lighting Program

4.1. Overview of Domestic Lighting Sector

As per 18th Electric Power Survey, domestic sector would accounts for about 26.5% of India's total electricity consumption (16,11,808 GWh) by end of XIII th five year plan. Major part of the energy consumption is used for lighting. A significant proportion of household lighting needs are met by use of incandescent bulbs, which are extremely energy inefficient as over 90% of electricity is wasted as heat.

According to recent statistics published by lighting manufacturers association ELCOMA, sales of ICLs were to the tune of about 77 crores in 2013-14[2]. The replacement of these ICLs will give a huge immediate market for LEDs which has potential to save more than 100 billion units which is equivalent to around 20000 MW of peak load reduction. With the cost/lumens of LEDs reaching the levels of CFLs, the overall potential of replacement by LEDs could also include CFLs.

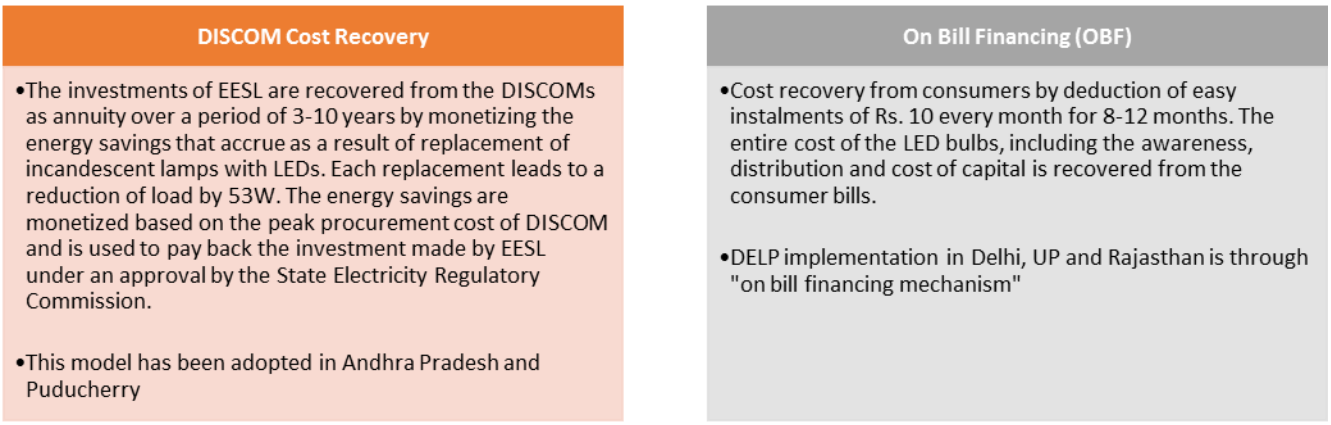
4.2. Introduction

DELP entails replacement of inefficient incandescent bulbs (ICLs) used in households with energy efficient LED lights. DELP proposes to promote using the basic architecture of Bachat Lamp Yojana (BLY). It would leverage DSM as a recovery investment, much in the same manner as CDM was used by BLY. Energy savings is achieved as LEDs consumes 50% less electricity for comparable quality of service than CFLs and 88% less in the case of ICLs

EESL has evolved a service model where it works with electricity distribution companies (DISCOMs) through a benefit sharing approach. The Domestic Efficient Lighting Program (DELP) obviates the need for DISCOMs to invest in the upfront cost of LED bulbs; EESL procures the LEDs bulbs and provides to consumers at a rate of Rs. 10 each as against their market price of Rs. 350-400. The upfront investment made by EESL is paid back in two different ways as indicated under:

[2] Source: ELCOMA

Figure 5 : Business Models for DELP



4.3. DELP targets

The targets for DELP are:

Table 17: DELP targets

No of LED lights to be replaced in 3 years	77 crore
Expected annual energy savings	105 billion KWh
Expected reduction of installed load	20,000 MW
Estimated capital investment (excluding O&M)	Rs. 8000 crore
Annual estimated greenhouse gas emission reductions	79 million tonnes of CO_2

4.4. Current Status of the Projects

The project work has already been completed in 5 towns, namely Puducherry, Guntur, Anantpur, Srikakulam, and West Godavari, and is going on successfully in 8 more districts.

Table 18: Status of DELP

Parameters	Details
No of Towns enrolled	171
No of town where work completed	5 (Puducherry, Guntur, Anantpur, Srikakulam, West Godavari)
No of district / towns where work is under progress	8

The total numbers of bulbs distributed in each of the 5 districts are reflected as:

Table 19: Project Size of Completed Projects

S. No.	Project	No of BulbsDistributed (in lakhs .)
1.	Puducherry	6.09
2.	Guntur	11.22
3.	Anantapur	18.61
4.	Srikakulam	10.65
5.	West Godavari	15.91

4.5. Survey Methodology

4.5.1. Survey Questionnaire

The questionnaire prepared for the survey captures various parameters including:

- Number of LED bulbs installed and operating in the household
- Number of LED bulbs installed and non-operating in the household(reasons may be given, where relevant);
- Number of LED bulbs not installed, fused, broken, missing and/or replaced

The questionnaire prepared for the survey is attached as Annexure in this report.

4.5.2. Sample Plan Distribution

The saving from DELP projects is computed based on the survey of the sample of population availing the scheme. The survey sample sizes based on 90% confidence level and 7.5% margin of error are:

Table 20: Sample Size for DELP

S. No.	Project	No of BulbsDistributed(nos.)	Sample Size at 90%Confidence Level and 7.5%margin of error
1.	Puducherry	609251	120

2.	Guntur	1121845	120
3.	Anantapur	1860897	120
4.	Srikakulam	1065201	120
5.	West Godavari	1591230	120

Further, the sample was geographically distributed in the various division and subdivision based on the LED bulbs distributed in the area. The detailed Sampling plan is given below:

Table 21: Sample distribution for DELP

Sr. No.	Area	Number of Surveys
1	***Puducherry***	***120***
1	**Ashok Nagar**	**20**
2	Boomianpet	20
3	Gorimedu	20
4	Lawspet	20
5	Mudaliarpet	20
6	Vengata Nagar	20
2	***Anantapur***	***120***
1	**Cco Tadipatri**	**6**
2	Dharmavaram	6
3	East/Ananthapuram	6
4	Gooty	6
5	Guntakal	6
6	Hindupur Rurals	6
7	Hindupur Town	6

8	Kadiir	6
9	Kadiri E&W	6
10	Kalyanadurg Rurals	6
11	Kalyanadurg Town	6
12	Madakasira	6
13	Penukonda	6
14	Puttaparthy	6
15	Rayadurg	6
16	Tadipatri	6
17	Town 1/Ananthapuram	6
18	Town 2/Ananthapuram	6
19	Uravakonda	6
20	West/Ananthapuram	6
3	***Guntur***	***120***
1	**Bapatla**	**5**
2	Cherukupalli	5
3	Chilakaluripet	5
4	Dachepalli	5
5	Guntur-Rural1	5
6	Guntur-Rural2	5
7	Guntur-Town1	5
8	Guntur-Town2	5
9	Guntur-Town3	5
10	Guntur-Town4	5

11	Gurazala	5
12	Macherla	5
13	Mangalagiri	5
14	Narasaraopet	5
15	Narasaraopet-Rural	5
16	Nrt-Rural	5
17	Piduguralla	5
18	Ponnur	5
19	Repalle	5
20	Sattenapalli	5
21	Tenali-Rural1	5
22	Tenali-Rural2	5
23	Tenali-Town	5
24	Vinukonda	5
4	***Srikakulam***	***120***
1	**Amadalavalasa**	**12**
2	Narasannapeta	12
3	Palasa	12
4	Pathapatnam	12
5	Rajam	12
6	Seethampeta	12
7	Sompeta	12
8	Srikakulam-Rural	12
9	Srikakulam-Town	12

10	Tekkali	12
5	***West Godavari***	***120***
1	**Akiveedu**	**6**
2	Bhimadolu	6
3	Bhimavaram	8
4	Eluru	6
5	Eluru- Rural	6
6	Ganapavaram	6
7	Gopalapuram	6
8	Jangareddygudem	12
9	Jelugumilli	6
10	Kovvuru	6
11	Narsapuram	6
12	Nidadavole	6
13	Palakollu	6
14	Pedavegi	6
15	Penugonda	6
16	Tadepalligudem	6
17	Tadepalligudem- Rural	10
18	Tanuku	6

4.6. Schedule of Surveys

Based on discussions with EESL, the survey was carried out in all the five districts and towns as per the schedule given below:

Table 22: Schedule for DELP surveys

Sr. No.	Project	Date of Survey	No. of Days
1	Puducherry	11/09/2015-13/09/2015	3
2	Anantapur	14/09/2015-16/09/2015	3
3	Guntur	17/09/2015-19/09/2015	3
4	Srikakulam	20/09/2015-23/09/2015	4
5	West Godavari	20/09/2015-23/09/2015	4

4.7. Results of the survey

Based on the survey conducted the project team analyzed the data to evaluate the operational status of the LED bulbs distributed. The results of the analysis have been tabulated below:

Table 23: Results from the survey

Sr No.	Project	Total LED bulbs distributed [A = B+C]	Number of LEDs found operational [B]	Number of LEDs currently not operational [C = i+ii]	Number of defective LEDs [i]	Number of LEDs kept for future purpose and others [ii]
1	Puducherry	338	331	7	4	3
2	Anantapur	240	237	3	2	1
3	Guntur	240	237	3	2	1
5	Srikakulam	240	237	3	3	0
6	W. Godavari	240	238	2	1	1
Total		1298	1280	18	12	6
Percentage		100.00%	98.61%	1.39%	0.92%	0.46%

For the purpose of the analysis, it is assumed that the broken and damaged bulbs will be replaced with new LED bulbs by the consumers and therefore included in the number of

operational LEDs. It was observed that bulbs were broken during cleaning (0.84%) and suffered from water damage (1%)

4.8. Computation of key parameters

4.8.1. Energy Savings

Energy saved has been computed based on the number of LED bulbs found operating based on the survey. The formula used for computation is

$$Energy\ Savings = Baseline\ Consumption - Consumption\ post\ Project\ Implementation$$

The baseline consumption is calculated as the energy consumption by the system before project implementation. While calculating the baseline savings, the consumption of the lighting fixtures where LED has been kept for future use has not been considered.

$$Baseline\ Consumption = (LEDs\ distributed - LEDs\ kept\ for\ future\ purpose) \times Wattage\ of\ the\ old\ luminaire\ replaced \times Hours\ of\ operation$$

Consumption post implementation has been computed for the LEDs found operational. Additionally, for the LEDs found defective, it is assumed that the consumers have moved back to using incandescent bulbs.

$$Consumtpion\ post\ Project\ Implementation = (LEDs\ operational \times wattage\ of\ LED + LEDs\ found\ defective\ (i) \times wattage\ of\ ICL) \times hours\ of\ operation$$

The assumptions used for calculations are as follow:

Table 24: Assumption for calculations of savings for DELP

Parameter	Source
Wattage of ICL	60 W
Wattage of LED	7 W
Operating hours / days	8 hrs as per load research studies
Days of operation	320 hrs as per load research studies

The results of the survey were further extrapolated to the division / city.

Table 25: Energy Saved for 5 regions

Sr. No.	Region	Units saved annually for sample size (kWh)	Units saved per LED bulb distributed (kWh)	Units saved for the overall project (million kWh)
1	Puducherry	44910.08	132.87	80.95
2	Anantapur	32102.40	133.76	150.06
3	Guntur	32156.16	133.98	249.33
4	Srikakulam	32002.56	133.34	142.04
5	W. Godavari	32291.84	134.55	214.10
Total	**India Level (77 crore LEDs)**		133.64	102901.80

Based on the results achieved, on an average 133.64 kWh were saved for each of the bulbs distributed in DELP, therefore the total saving at national level for 77 crores bulb is approximately 102.9 billion kWh. Assuming an average domestic tariff of INR 3.5 / kWh, the total savings are INR 36015 crore annually.

EESL plans to replace the defective bulbs with technical problems with new bulbs, this would result in approximately annual savings at a national level to around 104 billion units

4.8.2. Reduction of peak installed load

Reduction of peak installed load has been calculated using the formula:

$$\text{Reduction of peak installed load} = \text{Number of LEDs operational } (\text{wattage of ICL} - \text{wattage of LEDs}) \times \text{Peak Coincidence Factor}$$

The peak coincidence factor has been conservatively assumed as 0.5. It should be noted that even though the reduction of peak installed load has been computed based on operational LEDs, the extrapolation would be done on total number of LEDs distributed.

Table 26: Reduction of peak installed load for 5 cities

Sr. No.	Cities	Peak load reduction as per sample size (kW)	Peak load reduction per LED distributed (kW)	Peak load reduction for the entire project (kW)
1	Puducherry	8.77	0.026	15810.78
2	Anantapur	6.28	0.026	29357.28

3	Guntur	6.28	0.026	48697.35
4	Srikakulam	6.28	0.026	27874.98
5	W. Godavari	6.31	0.026	41816.20
Total			0.026	20122033.90

Based on the results achieved, on an average 0.026 kW of peak reduction was achieved for each of the bulbs distributed in DELP, therefore the peak reduction at national level for 77 crores bulb is approximately 20100 MW.

4.8.3. Emission Reduction

The reduction in GHG emission would be computed based on the Baseline Carbon Dioxide Emission Database published by Central Electricity Authority, Government of India.

$$Reduction\ in\ GHG\ emissions = Energy\ units\ saved \times Emission\ Factor$$

The most recent emission factors published by CEA are:

Table 27: Assumptions for Emission Reduction

Grid	Emission factor in tCO2/MWh[3]
NEWNE	0.82
South	0.81
India	0.82

Based on the above mentioned emission factors, the emission reductions for all the projects are:

Table 28: Emission Reduction for DELP

Sr. No.	Region	Units Saved (million kWh)	Emission Factor	Emission Reduction (thousand tCO_2)
1	Puducherry	80.95	0.81	65.570
2	Anantapur	150.06	0.81	121.546
3	Guntur	249.33	0.81	201.957
4	Srikakulam	142.04	0.81	115.050

[3] Weighted average emission factor based on "User Guide (Version 10.0) of CO2 baseline database for the Indian Power Sector prepared by Central Electricity Authority, Ministry of Power, GoI.

5	W. Godavari	214.10	0.81	173.420
6	**India**	102901.80	0.82	84379.478

The DELP would result in an overall reduction of 84.37 million tCO_2 emissions.

5. Conclusion

5.1. Street Lights

Based on the monitoring & verification survey conducted, the key results of the installation of LED street lighting projects in 5 cities are tabulated below:

Name of cities	Number of LEDs installed	Annual energy savings (million kWh)	Avoided GHG emission (thousand tCO2)	Peak load reduction (MW)
Varanasi	947	1.56	1.278	0.39
Jhalawar	2449	0.37	0.303	0.09
Mount Abu	1807	0.65	0.530	0.16
Vizag	91775	23.54	19.302	5.05
Agartala	34200	3.90	3.200	0.97
Total (for 5 cities)	**131178**	**30.02**	**24.613**	**6.66**
Total (at national level)	**35000000**	**8008.59**	**6567.040**	**1777**

It can be seen from the table that the installation of 131,178 LED street lights in the 5 cities has led to an annual energy savings of 30.02 million kWh, an avoided annual GHG emissions of 24,613 tCO_2 and peak load reduction of 6.66 MW.

Similarly, the installation of 35 million LED street lights will lead to an annual energy savings of 8008.59 million kWh, an avoided annual GHG emissions of 6.57 million tCO_2 and peak load reduction of 1,777 MW at the national level.

5.2. DELP

The energy savings, reduction of peak installed load and emission reduction for the five projects surveyed under this assignment are:

Sr. No.	Region	Units saved for the overall project (million kWh)	Peak load reduction (MW)	Emission Reduction (thousand tCO_2)
1	Puducherry	80.95	15.81	65.570
2	Anantapur	150.06	29.36	121.546
3	Guntur	249.33	48.70	201.957

4	Srikakulam	142.04	27.87	115.050
5	W. Godavari	214.10	41.82	173.420

These results were further extrapolated to the entire national program (replacement of 77 crore domestic lights). At a national level 102.9 billion kWh would be saved annually resulting in reduction of 20,100 MW peak load and 84.37 million tCO_2 reductions.

6. Appendices

6.1. Questionnaire for DELP

Survey Questionnaire

Section 1: Profiling of the household and respondent

1. *Address (To be copied from database)*

   _____
   _____

2. *DISCOM Service Number (To be copied from database):* _____

3. *Name of respondent* _____

4. *Age of respondent* _____

   (Thank and terminate if age is less than 18 years. Ask for another older member in the house for the interview)

5. Gender of Respondent

Gender
Female
Male

6. *Ownership status*

Ownership
Owner
Tenant
Other

7. *Phone Number* _____

8. *Is the DISCOM Service Number registered under your name?*

Single Code
Yes
No

9. *If No,*

Relationship with the DISCOM Service Number holder

Spouse i.e. Wife/Husband

Daughter in law

Daughter/Son

Sibling i.e. Sister/Brother

Grandfather/Grandmother

Relative

Tenants i.e. rented accommodation

Any other, please specify

Section 2:

(A) Identification of the Project LEDs

1. Total number of LED distributed (as per database)
2. Total number of project LEDs found installed

	LED #1		**LED#2**		**LED#3**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
3. DELP logo						
4. Where project LED found operating						

(B) The reason of failure of the project LEDs

Reason for failure of Project LEDs	**LED #1**	**LED#2**
Defective i.e. are not in the working condition		
Broken after it was provided		
In reserve i.e. will be using sometime in the future		
Sold/given away to someone else		

(C) Whether defective project LEDs were got replaced by the household (end user)

Whether defective or broken LEDs were got replaced by you or other household member?

If LEDs were not replaced, why?

No of ICLs Collected

6.2. Questionnaire for Street Lighting

6.2.1. Switch point wise measurements for all the cities

S. No.	Switching Point/Locality/Zone	Pole type (tubular/concrete /octahedron etc.)	Type of fitting	Total number of fittings	Voltage (Volts)	Current (Amperes)	PF	Power (W)	THDv (%)	THDi (%)	Time of measurement	Remark
1												
2												
3												
4												
5												
6												

6.2.2. Individual lighting point wise measurements for all the cities

S. No.	Switching Point/Locality/Zone	Pole type (tubular/concrete/ octahedron etc.)	Type of fitting	Voltage (Volts)	Current (Amperes)	PF	Power (W)	Time of measurement	Remarks
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