# UNLOCKING NATIONAL ENERGY EFFICIENCY POTENTIAL (UNNATEE)

**Strategy Plan Towards Developing an Energy Efficient Nation (2017-2031)**


**June 2019**

Bureau of Energy Efficiency,
(Ministry of Power, Govt. of India)

# Imprint

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# Preface

The Bureau of Energy Efficiency (BEE) has been engaged in several initiatives to design and implement energy efficiency programs. As part of this initiative, BEE is working on coming up with a national strategic plan for energy efficiency, which would lay a roadmap for recognizing and unlocking India's energy efficiency potential in its demand sectors. Energy saving through adoption of new technologies, increasing the scope of the wide gamut of energy related policies and programs and sensitizing the consumers towards the importance of saving energy in their day-to-day lives would go a long way in making India energy secure and resource efficient.

In India, there is still an immense potential to be realized from large scale implementation of energy efficiency interventions in the various demand sectors like industry, agriculture, transport, municipal, domestic and commercial lighting and appliances and Micro, small and medium scale enterprises (MSME).

In this context, BEE, with support from PricewaterhouseCoopers Private Limited has developed the national strategic plan for energy efficiency, presented in the form of this report "**Unlocking National Energy Efficiency Potential – UNNATEE, Strategy plan towards developing an energy efficient nation (2017-2031)**".

The strategy plan sheds light on the energy efficiency potential of the above mentioned sectors today and in the long term. One of the key barriers to energy efficiency financing in India is lack of awareness amongst banks and financial institutions. The strategy plan also estimates the investment potential of the sectors and the key financing instruments that would play a bigger role in the future.

The findings of the project would benefit policy makers, planners, domain consultants and other relevant stakeholders. The report will also facilitate knowledge sharing between the stakeholders and scale up the energy efficiency activities in the country in the long term.

I am happy to share this document with all stakeholders for kind persual and seeking valuable inputs

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Last but not the least, PwC is grateful to the in-house team of PwC for their consistent efforts in bringing this report to fruition.

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# *Abbreviations*

| | |
|---|---|
| AAI | Airports Authority of India |
| ACCA | Accelerated Capital Cost Allowance |
| ACEEE | American Council for an Energy-Efficient Economy |
| ADD | Advanced Direct Drive |
| ADI | Accelerated Depreciation-Based Incentivization |
| AgDSM | Agriculture Demand-Side Management |
| AJAY | Atal Jyoti Yojana |
| AMRUT | Atal Mission for Rejuvenation and Urban Transformation |
| APEDA | Arunachal Pradesh Energy Development Agency |
| APEPDCL | Andhra Pradesh Eastern Power Distribution Company Limited |
| APSECM | Andhra Pradesh State Energy Conservation Mission |
| ARRA | American Recovery and Reinvestment Act |
| ATM | Air Traffic Management |
| BAU | Business as Usual |
| BEE | Bureau of Energy Efficiency |
| BEIS | Business, Energy and Industrial Strategy |
| BESCOM | Bangalore Electricity Supply Company Limited |
| BIS | Bureau of Indian Standards |
| CAC | Credit Aggregation Centres |
| CAFÉ | Corporate Average Fuel Economy |
| CBTT | Cross-Border Technology Transfer and Energy-Efficiency Financing Facility |
| CCAs | Climate Change Agreements |
| CCL | Climate Change Levy |
| CCO | Coal Controller’s Organization |
| CCSAMMN | Climate Change and Sustainable Agriculture Monitoring, Modelling and Networking |
| CDM | Clean Development Mechanism |
| CEA | Central Electricity Authority |
| CERT | Carbon Emissions Reduction Target |
| CESP | Community Energy-Saving Programme |
| CFCs | Chlorofluorocarbons |
| CFD | Computational Fluid Dynamics |
| CIL | Coal India Limited |

| | |
|---|---|
| CIPEC | Canadian Industry Programme for Energy Conservation |
| CLCSS | Credit-Linked Capital Subsidy for Technology Upgradation |
| CS | Capital Subsidy |
| CSP | Concentrated Solar Power |
| DBT | Direct Benefit Transfer |
| DC | Designated Consumers |
| DCC | Data Communications Company |
| DDUGJY | Deendayal Upadhyaya Gram Jyoti Yojana |
| DEA | Designated Energy Auditors |
| DECC | Department of Energy and Climate Change |
| DEDE | Department of Alternative Energy Development and Efficiency |
| DEEP | Distribution Energy-Efficiency Project |
| DFC | Dedicated Freight Corridor |
| DGH | Directorate General of Hydrocarbons |
| DHI | Department of Heavy Industries |
| DISCOM | Distribution Company |
| DRC | Dynamic Reactive Compensation |
| DSM | Demand-Side Management |
| ECB | Energy Conservation Bonds |
| ECBC | Energy Conservation Building Codes |
| ECS | Eskom’s Energy Conservation Scheme |
| EDM | Energy Data Management |
| EE | Energy Efficiency |
| EEDO | Energy-Efficiency Deployment Office |
| EEDO | Energy-Efficiency Directive |
| EEDSM | Eskom’s Energy Efficiency and Demand-side Management |
| EEFP | Energy-Efficiency Financing Platform |
| EEM | Energy-Efficient Mortgage |
| EEN | Energy-Efficiency Networks |
| EESL | Energy-Efficiency Services Limited |
| EIA | Energy Information Agency |
| EIM | Energy Improvement Mortgage |
| EMC | Energy Management Centre |
| EnMS | Energy Management System |
| EPA | Environmental Protection Agency |
| EPC | Energy Performance Contracts |

| | |
|---|---|
| EPI | Energy Performance Index |
| ESCerts | Energy-Saving Certificates |
| ESCO | Energy Service Company |
| ESI | Energy-Savings Insurance |
| ETD | Energy Tax Directive |
| EXIM | Export Import |
| FAME | Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India |
| FEEED | Framework for Energy-Efficient Economic Development |
| FI | Financial Institutions |
| FortF | Forfaiting Funds |
| GCF | Green Climate Fund |
| GEF | Global Environment Facility |
| GHG | Green House Gases |
| GRF | Green Receivables Fund |
| SGDP | State Gross Domestic Product |
| GVA | Gross Value Added |
| GWP | Global Warming Potential |
| HCCI | Homogeneous Charge Compression Ignition |
| HFCs | Hydrofluorocarbons |
| HLPF | High-Level Political Forum |
| HPMP | HCFC Phase-Out Management Plan |
| HPMV | High-Pressure Mercury Vapour |
| HPS | High-Pressure Sodium |
| HPSV | High-Pressure Sodium Vapour |
| HRIDAY | Heritage City Development and Augmentation Yojana |
| HVAC | Heating, Ventilation and Airconditioning |
| ICAR | Indian Council of Agricultural Research |
| ICES | Integrated Community Energy Solutions |
| INDC | Intended Nationally Determined Contributions |
| IPPU | Industrial Processes and Product Use |
| IRBD | Interest Rate Buys Down Fund |
| IRP | Integrated Resource Planning |
| ISO | International Organization for Standardization |
| ITS | Information Technology Systems |
| KREDL | Karnataka Renewable Energy Development Limited |
| KSEB | Kerala State Electricity Board |

| | |
|---|---|
| KUSUM | Kisan Urja Suraksha Evam Utthaan Mahabhiyan |
| LED | Light-Emitting Diode |
| LPG | Liquefied Natural Gas |
| LSG | Local Self-government |
| LULUCF | Land Use, Land-Use Change and Forestry |
| MEDA | Maharashtra Energy Development Agency |
| MEEP | Municipal Energy-Efficiency Programme |
| MEPS | Minimum Energy Performance Standards |
| METI | Ministry of Economy, Trade and Industry |
| MFM | Multifunction Measurement and Control Unit |
| MNRE | Ministry of New and Renewable Energy |
| MoEFCC | Ministry of Environment, Forests and Climate Change |
| MoHUA | Ministry of Housing and Urban Affairs |
| MoMSME | Ministry of Micro, Small and Medium Enterprises |
| MoP | Ministry of Power |
| MoPNG | Ministry of Petroleum and Natural Gas |
| MoRTH | Ministry of Road Transport and Highways |
| MOSPI | Ministry of Statistics and Programme Implementation |
| MoU | Memorandum of Understanding |
| MoUD | Ministry of Urban Development |
| MSME | Micro, Small and Medium Enterprises |
| MTEE | Market Transformation for Energy Efficiency |
| Mtoe | Million Tonne of Oil Equivalent |
| MuDSM | Municipal Demand-Side Management |
| NABERS | National Australian Built Environment Rating System |
| NAPCC | National Action Plan on Climate Change |
| NBFC | Non-banking Financial Corporation |
| NDRC | National Development and Reform Commission |
| NEET | Non-Profit Energy-Efficiency Transition |
| NEMMP | National Electric Mobility Mission Plan |
| NEPP | National Energy productivity Plan |
| NHAI | National Highway Authority of India |
| NICRA | National Innovations on Climate Resilient Agriculture |
| Ni-MH | Nickel Metal Hydride |
| NIMZs | National Investment and Manufacturing Zones |
| NITI Aayog | National Institution for Transforming India |

| | |
|---|---|
| NIWE | National Institute of Wind Energy |
| NMCP | National Manufacturing Competitiveness Programme |
| NMEEE | National Mission on Enhanced Energy Efficiency |
| NMSA | National Mission on Sustainable Agriculture |
| NPCIL | Nuclear Power Corporation of India Limited |
| NSM | National Solar Mission |
| NZEB | Net Zero Energy Buildings |
| OBF | On-Bill Financing |
| ODS | Ozone-Depleting Substances |
| OFWM | On-Farm Water Management |
| OIL | Oil India Ltd. |
| ONGC | Oil and Natural Gas Corporation |
| PACE | Property Assessed Clean Energy |
| PAT | Perform, Achieve and Trade |
| PCCI | Premixed Charge Compression Ignition |
| PCP | Power Conservation Programme |
| PFCs | Perfluorocarbons |
| PKVY | Paramparagat Krishi Vikas Yojana |
| PMC | Pune Municipal Corporation |
| PMFBY | Pradhan Mantri Fasal Bima Yojana |
| PMKSY | Pradhan Mantri Krishi Sinchai Yojana |
| PMUY | Pradhan Mantri Ujjwala Yojana |
| PNG | Piped Natural Gas |
| PPAC | Petroleum Planning and Analysis Cell |
| PPL | Peer-to-Peer Lending |
| PRGF | Partial Risk Guarantee Fund |
| PRGFEE | Partial Risk Guarantee Fund for Energy Efficiency |
| PRI | Panchayati Raj Institutions |
| PSU | Public-Sector Undertakings |
| QMS | Quality Management Standards |
| QTT | Quality Technology Tools |
| RAD | Rain-Fed Area Development |
| REC | Rural Electrification Corporation |
| RES | Renewable Energy Sources |
| RLF | Revolving Loan Fund |
| RoI | Return on Investment |

| | |
|---|---|
| RRR | Reserve Replacement Ratio |
| SAATHI | Sustainable and Accelerated Adoption of Efficient Textile Technologies to Help Industries |
| SANEDI | National Energy Development Institute |
| SAUBHAGYA | Pradhan Mantri Sahaj Bijli Har Ghar Yojana |
| SCADA | Supervisory Control and Data Acquisition |
| SDA | State Designated Agencies |
| SDGs | Sustainable Development Goal |
| SERC | State Electricity Regulatory Commissions |
| SHM | Soil Health Management |
| SIDBI | Small Industries Development Bank of India |
| SLEE | Securitization of Loans for Energy-Efficient Appliances |
| SLNP | Street Lighting National Programme |
| SOP | Standard Offer Programme |
| SPFF | Stranded Project Financing Facility |
| SPV | Solar Photovoltaic |
| STIP | Science Technology and Innovation Plan |
| TADP | Transformation of Aspirational Districts Programme |
| TEDI | Thermal Energy-Demand Intensity |
| TEQUP | Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises |
| TEUI | Total Energy Use Intensity |
| TGS | Toronto Green Standard |
| UCA | Unnat Chulha Abhiyan |
| UJALA | Unnat Jyoti by Affordable LEDs for All |
| ULB | Urban Local Bodies |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNIDO | United Nations Industrial Development Organization |
| UREDA | Uttarakhand Renewable Energy Development Agency |
| VCFEE | Venture Capital Fund for Energy Efficiency |
| VEC | Village Energy Committee |
| VMC | Vadodara Municipal corporation |
| VNRs | Voluntary National Reviews |
| xEVs | Electric and Hybrid Vehicles |
| ZED | Zero Effect Zero Defect |

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# Executive Summary

The UNNATEE strategy plan lays a framework and implementation strategy—in the short, medium, and long terms—to establish a clear linkage between energy-demand scenarios and energy-efficiency opportunities in order to conceptualize a comprehensive roadmap to address India's environmental and climate change commitments. The national target for energy-efficiency savings and implementable roadmap to be achieved in the next 14 years has been established. Such an exhaustive exercise is the first of its kind clearly delineating the energy-savings targets for each state in their respective sectors. Developing India's blueprint of effective energy-efficiency strategy is a leap towards stimulating an energy-efficiency ecosystem and reducing the pressure on demand. The report is organized in the following seven chapters:

**Chapter 1** establishes India's current year (baseline) energy supply and demand, broken down into primary energy and electricity. It also covers identified data gaps in energy data reporting practice and recommendations on effective energy data management (EDM).

**Chapter 2** presents a comprehensive mapping of current polices, programmes, and action plans in India applicable for energy and energy-end-use sectors. The coverage of policies and programmes includes national programmes, state policies, local-level programmes (municipalities and panchayats), and other indirect policies that affect energy efficiency (Montreal Protocol, Kigali Amendment, and Smart Cities).

**Chapter 3** presents a mapping of key future technologies that would impact energy consumption in each of the demand sectors and provides a detailed analysis of five of the key future technologies

**Chapter 4** establishes energy-saving potential of various sectors in India by 2031. It also forecasts energy consumption by various sectors in India. The methodology for calculation of energy-saving potential is discussed in this chapter. The allocation of energy-saving targets to each state and sector is established in this chapter.

**Chapter 5** presents the energy-saving investment potential for various demand sectors in India by 2031. The chapter also explores current EE-financing landscape across the world and suggests best suited schemes for the Indian EE market.

**Chapter 6** assesses India's NDC target emissions in absolute terms, calculates the achieved emission-intensity reduction targets by 2030, and estimates the potential contribution of energy efficiency in emissions intensity reduction. It also provides a commentary on global progress made in achieving emission reduction commitments.

**Chapter 7** establishes a national implementation strategy for achieving the energy-saving target. It provides a review of global best practices for scaling up energy efficiency. It also covers a review of international energy-efficiency strategies such as that of U.K., Canada, Australia, Japan, and South Africa.

## *Establishing India's Current Energy Supply and Demand*

Effective strategy formulation in the energy sector relies on rigorous analysis of available, accurate, reliable, and comprehensive data. The baseline year for this assignment is assumed to be FY 2016–17, and the energy data for this year have been streamlined. The total energy supply and demand in the country as of FY 2016–17 is estimated to be 815.0 and 540.9 Mtoe, respectively.

| Particulars | Supply (Mtoe) | Demand (Mtoe) |
|---|---|---|
| Primary energy including electricity | 815.0 | 540.9 |
| Electricity | 123.2 | 91.7 |

The primary energy and electricity demand in FY 2016–17 for various sectors in the country is estimated below:

| Mtoe (2016–17) | Domestic | Commercial | Industry | Municipal | Transport | Agriculture | Others | Total |
|---|---|---|---|---|---|---|---|---|
| Primary energy, excluding electricity | 26.8 | 0.0 | 303.8 | 0.0 | 44.1 | 0.9[1] | 73.6 | **449.1** |
| Electricity | 22.3 | 8.5 | 36.7 | 2.6 | 1.5 | 16.8 | 3.3 | **91.7** |
| **Total energy** | 49.1 | 8.5 | 340.4 | 2.6 | 45.6 | 17.7 | 76.9 | **540.9** |

While establishing the energy data, multiple data sources were referred, which consisted of data gaps. Some of the data gaps included inconsistencies in reporting from various ministries, non-reporting of state-level primary energy data, delay in data reporting, and lack of standardized definitions. The unavailability of primary energy demand at the state level is a shortcoming in the energy data reporting practice. There are two proposed institutional solutions to overcome this barrier:

1. Setting up of a nodal agency responsible for data dissemination of primary energy at the state and national level whose role would be to enhance coordination among agencies,

2. Strengthening of the already existing agency (MOSPI) responsible for data reporting of primary energy at the national level.

Some other recommendations on effective energy data management (EDM) include:

- Improve technology and statistical methods for data collection and management,

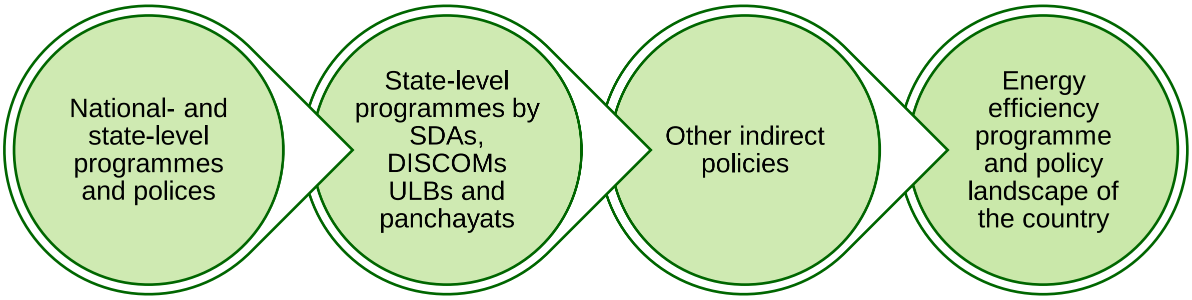
- Systematic data quality checking to ensure data consistencies,

[1] The primary energy demand of the agricultural sector in 2017 is sourced from *Energy Statistics 2018*, MOSPI. However, using the bottom-up approach of analysis, the primary energy demand of the agricultural sector in 2017 is estimated to be 12.2 Mtoe (primarily due to diesel consumption in pumps).

- Maintaining commonality in standardization,
- Improved data dissemination in user-friendly formats.

## *Mapping of Energy-Efficiency Programmes and Policy Landscape*

The current policy and programme implementation landscape of the country shapes the energy consumption of the demand sectors. Taking cognizance of the importance of mapping the programmes and policies in the country and their potential impact on the sources of energy in a demand sector, the chapter presents a complete overview of the government initiatives, direct and indirect, that have been undertaken to address the issue of energy efficiency and move towards an energy-sufficient economy. Apart from the national programmes, the implementation of some of these programmes at the state level, which are being carried out by the State Designated Agencies (SDAs), DISCOMs, and municipalities, has also been outlined.




## *Future Technological Advancements Impacting Energy Consumption*

Energy underpins every aspect of modern life, driving economic growth and prosperity, and as a result has a direct link to people's standard of living. The emerging technological innovations are creating new opportunities for progress of energy efficiency. It is creating exciting new opportunities for integrated solutions where efficiency and renewable energy work together to deliver clean energy outcomes at the lowest cost. The future technologies that would impact energy consumption in each of the demand sectors has been explored.

Some of the key future technologies/initiatives such as electric vehicles, smart meters, Blockchain, integration of renewable energy in industries and de-carbonization of industrial process have been analysed for their applications, impact on energy consumption, policy landscape, challenges in their uptake and recommendations for their promotion.

## *Estimation of Energy-Efficiency Potential*

The role of energy efficiency would be crucial in complying by India's emission-intensity reduction targets. The principal step towards estimation of energy-saving target is the forecast of energy consumption under various scenarios. The forecast of energy consumption of the country for various demand sectors has been estimated in this chapter, the methodology of which is illustrated below:

The three scenarios developed for energy-consumption forecast include these major assumptions:

| Assumptions by 2031 | Technological Improvement and Penetration | Policy/Programme/Scheme Initiatives | Change in Fuel Mix |
|---|---|---|---|
| **Scenario 1: BAU** | Current technological improvements and penetration | Current implementation of programmes | Current fuel mix |
| **Scenario 2: Moderate** | Moderate technological improvements and technology penetration as per government/other agencies target | Successful achievement of programme targets | Moderate fuel mix shift from fossil fuel to RE/electricity-based consumption |
| **Scenario 3: Ambitious** | Ambitious technological improvements and penetration over government/other agencies target | New programmes or overachievement of existing programmes | Ambitious fuel mix shift towards RE-based consumption in sector |

The energy-saving potential of the country is estimated to be 86.9 Mtoe by 2031 with the highest saving potential in the industrial sector (in the moderate savings scenario).

| **Energy Consumption (Mtoe): 2031** | | | |
|---|---|---|---|
| **Sectors** | **BAU Scenario** | **Moderate Scenario** | **Ambitious Scenario** |
| Agriculture | 64.4 | 58.7 | 54.5 |
| Commercial | 29.5 | 24.5 | 23.1 |
| Domestic | 98.6 | 86.5 | 83.5 |
| Municipal | 8.0 | 7.0 | 6.4 |
| Industrial | 443.4 | 396.0 | 371.2 |
| Transport | 232.9 | 217.2 | 209.1 |
| **Total** | **876.8** | **789.9** | **747.8** |
| **Electricity Consumption (TWh): 2031** | | | |
| **Sectors** | **BAU Scenario** | **Moderate Scenario** | **Ambitious Scenario** |
| Agriculture | 214 | 229 | 239 |
| Commercial | 343 | 286 | 269 |
| Domestic | 769 | 641 | 631 |
| Municipal | 93 | 82 | 75 |

| Energy Consumption (Mtoe): 2031 | | | |
|---|---|---|---|
| Industrial | 946 | 857 | 797 |
| Transport | 90 | 166 | 183 |
| **Total** | **2455** | **2261** | **2193** |

| Energy Savings (Mtoe): 2031 | | | | |
|---|---|---|---|---|
| **Sectors** | **Moderate Savings Scenario** | | **Ambitious Savings Scenario** | |
| | **Mtoe** | **%** | **Mtoe** | **%** |
| Agriculture | 5.7 | 9% | 9.9 | 15% |
| Commercial | 4.9 | 17% | 6.4 | 22% |
| Domestic | 12.1 | 12% | 15.1 | 15% |
| Municipal | 0.9 | 12% | 1.5 | 19% |
| Industrial | 47.5 | 11% | 72.3 | 16% |
| Transport | 15.8 | 7% | 23.8 | 10% |
| **Total** | **86.9** | **10%** | **129.0** | **15%** |
| **Electricity Savings (TWh): 2031** | | | | |
| **Sectors** | **Moderate Savings Scenario** | | **Ambitious Savings Scenario** | |
| | **TWh** | **%** | **TWh** | **%** |
| Agriculture | — | — | — | — |
| Commercial | 57 | 16% | 74 | 21% |
| Domestic | 128 | 16% | 138 | 17% |
| Municipal | 11 | 12% | 18 | 19% |
| Industrial | 89 | 9% | 149 | 15% |
| Transport | — | — | — | — |
| **Total** | **285** | **11%** | **379** | **15%** |

The moderate savings scenario is the incremental savings in energy consumption achieved in the moderate scenario over the BAU case, whereas the ambitious savings scenarios is the incremental savings in energy consumption achieved in the ambitious scenario over the moderate case.

## *Estimation of Energy-Savings Investment Potential and Analysis of Financing Instruments*

The energy-saving investment potential of the country is estimated to be Rs 1,002,329 crores by 2031 under the moderate scenario and Rs 1,320,630 crore under ambitious scenario.

| Sectors | Energy-Savings Investment by 2031 (Rs Crore) — Moderate Savings Scenario | Energy-Savings Investment by 2031 (Rs Crore) — Ambitious Savings Scenario |
|---|---|---|
| Agriculture | 51,450 | 89,004 |
| Commercial | 81,154 | 105,701 |
| Domestic | 120,233 | 145,420 |
| Municipal | 8,337 | 13,589 |
| Industrial | 515,116 | 601,210 |
| Transport | 226,039 | 365,706 |
| **Total** | **1,002,329** | **1,320,630** |

Various financing instruments such as the ones currently existing in India and across the world are explored based on their applicability and limitations. Five financing instruments are found to be highly suitable for Indian markets: energy-savings insurance, on-bill financing, cross-border technology transfer and energy efficiency financing facility, venture capital fund for energy efficiency, and energy conservation bonds.

## *Target Setting in Line with India's SDG and NDC Commitments*

As per NDC commitments, a comparison of GHG emission and emission-intensity reduction targets has been established for different countries. European Union, USA and China are among the leading countries having achieved more than 40% emission reduction target by 2015. India has achieved 18% emission reduction target by 2015.

| Country | Base Year | Target year | Target Type | Target Reduction | Base Year Metric | Metric in 2015 | Target to be Achieved | Per cent Achieved |
|---|---|---|---|---|---|---|---|---|
| European Union (28) (MtCO2e) | 1990 | 2030 | GHG | 40% | 5400 | 4000 | 3240 | 64.81% |
| USA (MtCO2e) | 2005 | 2025 | GHG | 28% | 6600 | 5830 | 4752 | 41.66% |
| Russia (MtCO2e) | 1990 | 2030 | GHG | 30% | 3900 | 2130 | 2730 | 151.28% |
| China (Exchange rates – EI) | 2005 | 2030 | Intensity | 65% | 1.44 | 0.99 | 0.504 | 48.07% |
| India (Exchange rates – EI) | 2005 | 2030 | Intensity | 35% | 0.96 | 0.9 | 0.624 | 17.86% |
| Japan (MtCO2e) | 2005 | 2030 | GHG reduction | 25.40% | 1300 | 1200 | 969.8 | 30.28% |

The target energy emissions in India for 2030 in absolute terms should be less than or equal to 6807 MtCO2e. The achievement in emission-intensity (energy and non-energy) reduction by 2030 is estimated to be 36%, under the moderate savings scenario, out of which the contribution of energy efficiency is 50%. Thus, it is deduced that India's NDC commitments would be met under the moderate scenario, which includes ongoing and future anticipated activities on energy efficiency.

| Sectors | Moderate Emission Reductions (MtCO2e): 2030 | Ambitious Emission Reductions (MtCO2e): 2030 |
|---|---|---|
| **Agriculture** | 14 | 34 |
| **Commercial** | 34 | 44 |
| **Domestic** | 101 | 134 |
| **Municipal** | 7 | 11 |
| **Industrial** | 185 | 238 |
| **Transport** | 97 | 141 |
| **Total reduction due to EE** | **438** | **623** |
| **Overall reduction** | **889** | **1053** |

## *Implementation Framework for National Strategic Plan for Energy Efficiency*

The strategy formulation for each demand sector is viewed through the prism of these five pillars. The interplay between them and the existing regulations and policies will pave the way for a robust energy-efficiency framework in the country. The strategies formulated for each sector and their conformance with each of the strategy pillars mentioned above are given below:

| Sector | Strategies |
|---|---|
| **Agriculture** | Greater coordination among stakeholders, including integration with water conservation efforts |
| | Integrate energy efficiency in agriculture studies |
| | Cheaper finance for energy-efficient equipment |
| | Research and development |
| | Mandating energy-efficient technology standards and guidelines |
| | IoT in agriculture: Moving towards smart farming practices |
| **Buildings** | Development of codes for residential buildings and simplified codes for commercial buildings with lower connected load |
| | Mandatory implementation of ECBC in states |
| | Integration of EE in government-housing schemes and cheaper financing for EE houses |
| | Synergy between BEE, IGBC and GRIHA rating system |
| | Automated building management systems in higher connected load commercial buildings |
| | Promoting EE technologies in high-rise residential buildings |
| **Industry** | Creating a National Energy-Efficiency Repository with benchmarks |

| Sector | Strategies |
|---|---|
| | Increasing the width and depth of the PAT programme including a voluntary component |
| | Creation of a unified carbon reduction programme |
| | Mandatory energy management cell with certified energy manager/energy auditor for all medium- and large-scale industries |
| | Central monitoring of all funded programmes in the MSME |
| | Promoting use of energy-efficient equipment among MSME units |
| | Promoting industry 4.0 technologies |
| **Transport** | Integrated transport planning with mandate to support movement towards EE transportation |
| | Promoting shared last-mile connectivity solutions |
| | Legislation to improve ease of doing business for new business models |
| | Increase CAFÉ standards |
| | Stakeholder engagement |
| **Cross-sectoral strategies** | Considering DSM as a resource in IRP |
| | Capacity building of DISCOMs |
| | Mandatory use of smart meters |
| | Increased consumer engagement |
| | Framework to introduce Time of Day Tariffs |
| | Increasing the scope of existing programmes with stricter enforcement and penalties |
| | Institutional framework for data collection |
| | State-wise targets |
| | Independent SDAs and building capacity of SDAs |
| | Funding for laboratories |
| | State-specific stakeholder engagement programmes |
| | Integration of harmonic products in S&L |
| | Additional cess on import of inefficient equipment |
| | Voluntary reward programme for consumers |
| | Setting up of a committee of financial institutions at the state level |

1

# ESTABLISHING INDIA'S CURRENT ENERGY SUPPLY AND DEMAND

## 1.1. Introduction

A robust baseline energy data set is essential in analysing and forecasting energy supply and demand scenarios of the country. The objective of this chapter is to streamline the data from sectoral to the national level and bring consistency in data collection and analysis. The tasks consist of establishing current energy supply and demand of the country, both in terms of electricity and primary energy, broken down at the state and sectoral levels. The energy data are also collated to form the energy balance of the country that represents the flow of various energy fuels (such as coal, gas, oil etc.) into different demand sectors (such as industry, agriculture etc.). While collecting data, it was identified that the data reporting practice across the ministries is inconsistent and the aggregation requires reference to multiple sources and documents. Such data inconsistencies and gaps are also reported along with recommendations for effective energy data management (EDM). The current (baseline) year has been assumed to FY 2016–17.

The following sections have been covered in this chapter:

- Estimating primary energy supply and demand
- Estimating electricity supply and demand
- Tool for establishing current energy supply and demand
- Preparation of energy flows (Sankey Diagram)
- Identification of data gaps and recommendations for effective energy data management (EDM)

The coverage of current energy supply and demand data across country, state and sector includes:

*Table 1: Coverage of current supply and demand data*

| | National | State | Sector |
|---|---|---|---|
| **Primary energy supply** | ✓ | NA | ✓ |
| **Primary energy demand** | ✓ | ✓ | ✓ |
| **Electricity supply** | ✓ | ✓ | ✓ |
| **Electricity demand** | ✓ | ✓ | ✓ |

*Effective strategy formulation in the energy sector relies on rigorous analysis of available, accurate, reliable and comprehensive data.*

## 1.2. Primary Energy

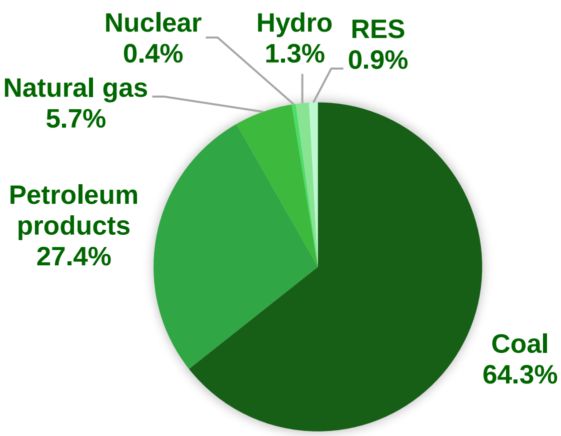
### 1.2.1. Primary energy supply

The total primary energy supply of the country for FY 2016–17 has been estimated to be 815.0[2] Mtoe based on the data collected from relevant nodal ministries of various fuel sources. Coal and oil are the major primary energy supply sources in India contributing to 64% and 27% of the primary energy supply, respectively. The share of various fuels in the primary energy supply is represented below:

*Table 2: Share of various sources in primary energy supply in FY 2016–17*

| Source | Energy (Mtoe) |
|---|---|
| Coal | 524.5 |
| Petroleum products | 223.3 |
| Natural gas | 46.5 |
| Hydro | 10.5 |
| Nuclear | 3.3 |
| RES | 7.0 |
| Wind | 4.0 |
| Solar | 1.2 |
| Biomass | 0.4 |
| Small hydro | 0.7 |
| Other RES (bagasse + waste to gen) | 0.9 |
| Electricity import/export | (0.1) |
| **Total** | **815.0** |

*Figure 1: Share of various fuels in energy supply in FY 2016–17*

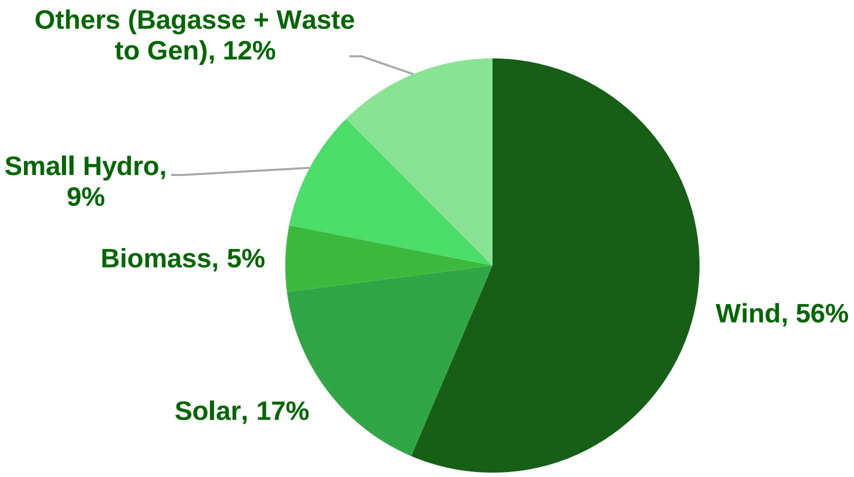



The energy mix in India is dominated by fossil fuels, as almost 97.4% of the energy supply comes from coal, oil and natural gas. This share has been increasing since 2000, as economic growth has

[2] Data Sources: Ministry of Coal (CCO), Ministry of Petroleum and Natural Gas (PPAC), Ministry of Power (CEA). Data of coal, petroleum products, nuclear, hydro and RES are provisional.

fuelled the demand in the industry and transport sectors, while at the same time households have slowly moved away from the traditional uses of solid biomass in cooking and space heating to other fuels such as liquefied petroleum gas (LPG). The large consumption of petroleum products is explained by the dominance of road freight traffic in the country. Natural gas continues to play a minor role in the energy mix, where it is mainly used for power generation and feedstock, and fuel for the production of fertilizers (it also has a small share in the residential and transport sectors).

*Figure 2: Share of various fuels in RES supply in FY 2016–17*




Wind energy, with a share of 56%, has the maximum contribution from the RES supply, followed by solar (17%) and small hydro (9%). The share for RES would increase further in the future, keeping in mind the government's target of 227 GW of generation capacity by 2022, revised from the earlier target of 175 GW.

The state-wise segregation of primary energy supply has not been covered due to insufficient data availability.

### *1.2.2. Primary energy demand*

The total energy demand by various sectors for FY 2016–17 is estimated to be 540.9[3] Mtoe. The balance of primary energy was lost in process of power generation, power transmission and distribution, auxiliary consumption (at power plants), in losses (and internal use) at refineries and natural gas processing terminals and also represented by stock difference of coal and other usages.

[3] *Energy Statistics 2018* (Ministry of Statistics and Programme implementation), *Annual Report 2017–18* (Ministry of Coal) and *TEDDY 2016–17*.

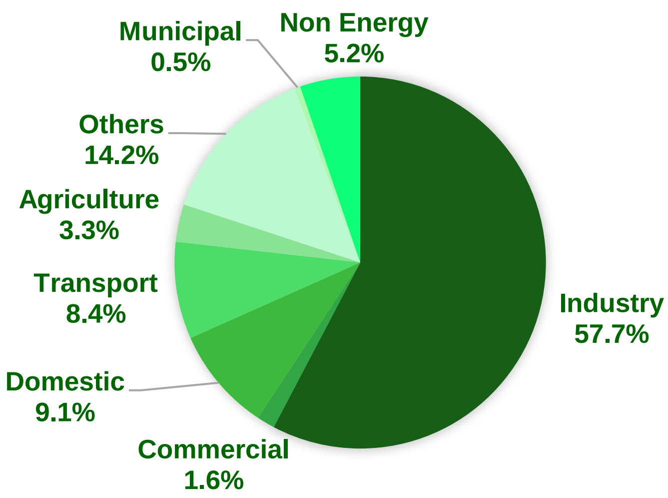
*Table 3: Share of various sectors in primary energy demand in FY 2016–17*

| Sector | Energy (Mtoe) |
|---|---|
| Industry | 303.8 |
| Transport | 44.1 |
| Domestic | 26.8 |
| Commercial | 0.0 |
| Agriculture | 0.9 |
| Others | 73.6 |
| Municipal | 0.0 |
| **Total** | **449.1** |

The industrial sector continues to be the highest consumer of primary energy, with a share of 57.7%. Industrial energy demand has almost doubled over the last 15 years, with large expansion in energy-intensive sectors such as iron and steel being one of the major drivers. The residential (domestic) sector comes in at second, with a consumption of 49.1 Mtoe. The energy demand in the domestic sector has been on the rise since the late 2000s, with increasing demand for appliance ownership, especially of fans and televisions in urban and rural areas, and an increase in refrigerators and air conditioners in urban areas.

The transport sector, with a consumption of 45.6 Mtoe, is heavily dominated by road transport, which accounts for nearly 90% of passenger and almost two-thirds of freight movement. Rail transport fuel use is still dominated by diesel, but electrification efforts continue, with the government planning to completely electrify the rail network by 2022.

*Figure 3: Share of various sectors in primary energy demand in FY 2016–17*




The state-wise segregation of primary energy-consumption data is not reported by any of the ministries. In order to segregate the national primary energy demand into states, the state gross domestic product (SGDP) is used. The rationale behind adoption of this methodology is the fact that the primary energy consumption of a state is also based on the economic activities by sectors. The methodology is illustrated below:

Niti Aayog releases a document reporting the SGDP by economic activity for all the states.[4] The economic activities include manufacturing, construction, agriculture, forestry etc. The economic activities are converted into demand sectors, i.e. industrial, municipal, commercial etc., using assumed weightages. The state GDP is then calculated for the demand sectors, and the proportion of each demand sector in a state is calculated. Similarly, once the national demand for a demand sector is established, the division into states is done based on the SGDP. The expected outcomes from the methodology for state-wise segregation of primary energy are:

- Segregation of total primary energy into states,
- Segregating the consumption by various demand sectors in a state.

The state-wise primary energy data are shown below:

[4] SGDP Data, NITI Aayog

*Table 4: State-wise primary energy consumption in sectors in FY 2016–17*

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Miscellaneous | Total Primary Energy (Coal, Gas, Oil) | Electricity | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Northern Region** | | | | | | | | | | |
| Chandigarh | 0.07 | — | 0.23 | — | 0.04 | 0.00 | 0.06 | 0.40 | 0.15 | 0.55 |
| Delhi | 1.75 | — | 7.88 | — | 1.22 | 0.00 | 1.91 | 12.76 | 2.54 | 15.30 |
| Haryana | 1.06 | — | 10.97 | — | 1.62 | 0.03 | 2.66 | 16.34 | 3.70 | 20.04 |
| Himachal Pradesh | 0.18 | — | 3.67 | — | 0.29 | 0.01 | 0.89 | 5.04 | 0.91 | 5.94 |
| Jammu and Kashmir | 0.20 | — | 1.77 | — | 0.49 | 0.01 | 0.43 | 2.89 | 0.72 | 3.62 |
| Punjab | 0.50 | — | 7.03 | — | 1.18 | 0.04 | 1.70 | 10.46 | 4.31 | 14.78 |
| Rajasthan | 1.05 | — | 14.63 | — | 2.39 | 0.06 | 3.54 | 21.67 | 5.24 | 26.91 |
| Uttar Pradesh | 2.18 | — | 19.37 | — | 4.47 | 0.11 | 4.69 | 30.82 | 7.29 | 38.11 |
| Uttarakhand | 0.19 | — | 6.97 | — | 0.28 | 0.01 | 1.69 | 9.13 | 1.16 | 10.29 |
| **Sub-total (NR)** | **7.16** | **0.00** | **72.53** | **0.00** | **11.98** | **0.26** | **17.57** | **109.50** | **26.03** | **135.53** |
| **Western Region** | | | | | | | | | | |
| Chhattisgarh | 0.38 | — | 7.78 | — | 0.51 | 0.01 | 1.89 | 10.57 | 2.03 | 12.60 |
| Gujarat | 1.03 | — | 36.43 | — | 1.57 | 0.06 | 8.83 | 47.93 | 8.80 | 56.73 |
| Madhya Pradesh | 0.57 | — | 9.09 | — | 2.23 | 0.08 | 2.20 | 14.17 | 4.74 | 18.91 |
| Maharashtra | 4.46 | — | 53.99 | — | 4.91 | 0.08 | 13.08 | 76.51 | 12.14 | 88.65 |
| Daman and Diu | — | — | — | — | — | — | — | 0.00 | 0.21 | 0.21 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Miscellaneous | Total Primary Energy (Coal, Gas, Oil) | Electricity | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Dadra and Nagar Haveli | — | — | — | — | — | — | — | 0.00 | 0.68 | 0.68 |
| Goa | 0.08 | — | 1.93 | — | 0.10 | 0.00 | 0.47 | 2.58 | 0.39 | 2.97 |
| **Sub-total (WR)** | **6.51** | **0.00** | **109.23** | **0.00** | **9.32** | **0.23** | **26.46** | **151.76** | **28.99** | **180.75** |
| **Southern Region** | | | | | | | | | | |
| Andhra Pradesh | 0.87 | — | 10.19 | — | 3.21 | 0.07 | 2.47 | 16.81 | 4.71 | 21.53 |
| Telangana | 1.39 | — | 10.63 | — | 2.11 | 0.03 | 2.58 | 16.74 | 4.33 | 21.07 |
| Karnataka | 3.47 | — | 18.89 | — | 2.99 | 0.04 | 4.58 | 29.98 | 5.99 | 35.97 |
| Kerala | 1.28 | — | 9.08 | — | 2.11 | 0.02 | 2.20 | 14.69 | 2.02 | 16.71 |
| Tamil Nadu | 2.77 | — | 25.10 | — | 3.17 | 0.05 | 6.08 | 37.16 | 8.61 | 45.77 |
| Puducherry | 0.05 | — | 0.85 | — | 0.04 | 0.00 | 0.21 | 1.15 | 0.28 | 1.43 |
| Lakhshadweep | — | — | — | — | — | — | — | 0.00 | 0.00 | 0.00 |
| **Sub-total (SR)** | **9.83** | **0.00** | **74.73** | **0.00** | **13.64** | **0.22** | **18.11** | **116.53** | **25.95** | **142.48** |
| **Eastern Region** | | | | | | | | | | |
| Bihar | 0.59 | — | 4.85 | — | 1.54 | 0.03 | 1.17 | 8.18 | 1.33 | 9.51 |
| Jharkhand | 0.27 | — | 6.80 | — | 0.79 | 0.01 | 1.65 | 9.51 | 2.03 | 11.54 |
| Odisha | 0.42 | — | 9.73 | — | 1.19 | 0.02 | 2.36 | 13.72 | 1.72 | 15.44 |
| West Bengal | 1.49 | — | 18.10 | — | 4.59 | 0.05 | 4.38 | 28.61 | 4.57 | 33.18 |
| Sikkim | 0.02 | — | 0.80 | — | 0.03 | 0.00 | 0.19 | 1.04 | 0.04 | 1.08 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Miscellaneous | Total Primary Energy (Coal, Gas, Oil) | Electricity | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Andaman and Nicobar Islands | — | — | — | — | — | — | — | 0.00 | 0.02 | 0.02 |
| **Sub-total (ER)** | **2.80** | **0.00** | **40.27** | **0.00** | **8.14** | **0.11** | **9.76** | **61.08** | **9.70** | **70.78** |
| **North Eastern Region** | | | | | | | | | | |
| Arunachal Pradesh | 0.02 | — | 0.32 | — | 0.05 | 0.00 | 0.08 | 0.47 | 0.04 | 0.51 |
| Assam | 0.29 | — | 4.82 | — | 0.72 | 0.02 | 1.17 | 7.02 | 0.64 | 7.66 |
| Manipur | 0.03 | — | 0.19 | — | 0.05 | 0.00 | 0.05 | 0.32 | 0.05 | 0.37 |
| Meghalaya | 0.03 | — | 0.62 | — | 0.09 | 0.00 | 0.15 | 0.89 | 0.14 | 1.03 |
| Mizoram | 0.02 | — | 0.25 | — | 0.04 | 0.00 | 0.06 | 0.37 | 0.03 | 0.40 |
| Nagaland | 0.03 | — | 0.16 | — | 0.05 | 0.00 | 0.04 | 0.29 | 0.05 | 0.34 |
| Tripura | 0.04 | — | 0.62 | — | 0.06 | 0.00 | 0.15 | 0.87 | 0.08 | 0.95 |
| **Sub-total (NER)** | **0.45** | **0.00** | **6.99** | **0.00** | **1.06** | **0.03** | **1.69** | **10.23** | **1.03** | **11.25** |
| **Total (all India)** | **26.8** | **0.0** | **303.8** | **0.0** | **44.1** | **0.9** | **73.6** | **449.1** | **91.7** | **540.9** |

In the northern region, the three states with the most primary energy consumption are Uttar Pradesh (38.11 Mtoe), Rajasthan (26.91 Mtoe) and Haryana (20.04 Mtoe). In the west, Maharashtra with an energy consumption of 88.65 Mtoe, Gujarat with 56.73 and Madhya Pradesh with 18.91 round off the top three. Tamil Nadu, Andhra Pradesh and Telangana, with primary energy consumption of 45.77 Mtoe, 21.53 Mtoe and 21.07 Mtoe, are the three highest consuming states in the south. In the eastern region, West Bengal, Odisha and Jharkhand, with consumptions of 33.18 Mtoe, 15.44 Mtoe and 11.54 Mtoe, make the top three. The north-eastern states have a cumulative primary energy consumption of 11.25 Mtoe, with the major share coming from Assam, Meghalaya and Tripura, who have a consumption of 7.66 Mtoe, 1.03 Mtoe and 0.95 Mtoe.

# 1.3. Electricity

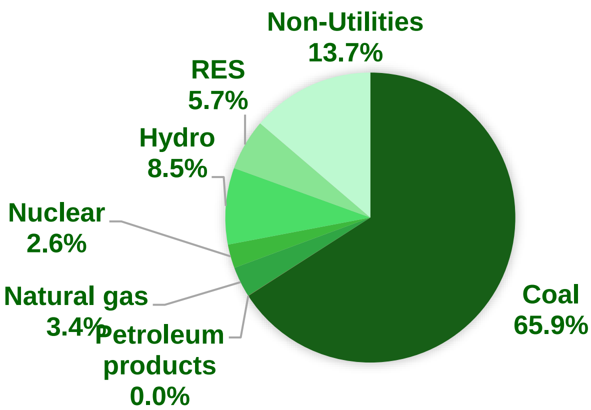
## 1.3.1. Electricity supply

The total electricity generation for FY 2016–17 was estimated to be 1433.2[5] BU or 123.2 Mtoe. The share of various fuel sources is mentioned in the table below:

*Table 5: Share of various fuels in electricity generation in FY 2016–17*

| Type of fuel | Electricity (TWh) |
|---|---|
| Coal | 944.8 |
| Petroleum products | 0.2 |
| Natural gas | 49.1 |
| Nuclear | 37.9 |
| Hydro | 122.2 |
| RES | 81.9 |
| Electricity export | 0.0 |
| Non-utilities | 197.0 |
| **Total** | **1433.2** |

*Figure 4: Share of various fuels in electricity generation in FY 2016–17*




Coal accounts for the highest share in electricity generation with 66% of the share, followed by hydro (8.5 %) and renewable energy sources (RES) with 5.7% of the share. The share for RES has been gaining over the years, with total utility scale of solar and wind installed capacity having reached 58 GW in September 2018. Solar and wind individually stood at 24 GW and 34 GW, respectively.[6] Although the Indian renewable market has performed exceptionally over the past couple of years,

[5] Includes electricity generation by non-utilities and net import/export. Data source: Ministry of Power, CEA, All India Statistics, General Review 2017

[6] Bridge To India (Oct 2018), https://bridgetoindia.com/renewable-energy-going-through-a-period-of-peaks-and-troughs/

issues such as safeguard duty imposition and ceiling on bid tariffs are challenges that still plague the sector.

The state-wise electricity generation data are demonstrated below:

*Table 6: State-wise electricity generation by fuel in FY 2016–17 (in GWh)*

| State | Hydro | Thermal | | | Nuclear | RES | Total |
|---|---|---|---|---|---|---|---|
| | | Steam | Diesel | Gas | | | |
| **Northern Region** | | | | | | | |
| Chandigarh | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| Delhi | 0 | 3774 | 0 | 3684 | 0 | 161 | 7618 |
| Haryana | 3674 | 22606 | 0 | 199 | 0 | 1672 | 28150 |
| Himachal Pradesh | 9066 | 0 | 0 | 0 | 0 | 2392 | 11458 |
| Jammu and Kashmir | 4408 | 0 | 0 | 0 | 0 | 379 | 4787 |
| Punjab | 9389 | 28403 | 0 | 199 | 0 | 1835 | 39826 |
| Rajasthan | 3530 | 48616 | 0 | 1972 | 0 | 8455 | 62573 |
| Uttar Pradesh | 961 | 51548 | 0 | 0 | 0 | 4037 | 56547 |
| Uttarakhand | 6932 | 825 | 0 | 0 | 0 | 875 | 8632 |
| Central Sector NR | 35523 | 70534 | 0 | 6828 | 12011 | 0 | 124896 |
| **Sub-total (NR)** | **73482** | **226305** | **0** | **12882** | **12011** | **19810** | **344491** |
| **Western Region** | | | | | | | |
| Chhattisgarh | 326 | 45299 | 0 | 0 | 0 | 1597 | 47222 |
| Gujarat | 1138 | 77987 | 0 | 10817 | 0 | 9961 | 99902 |
| Madhya Pradesh | 3302 | 42225 | 0 | 0 | 0 | 3622 | 49149 |
| Maharashtra | 5457 | 105653 | 0 | 4236 | 0 | 13388 | 128734 |
| Daman and Diu | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| Dadra and Nagar Haveli | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Goa | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Central Sector WR | 2953 | 83856 | 0 | 3550 | 12584 | 0 | 102943 |
| **Sub-total (WR)** | **13177** | **355019** | **0** | **18603** | **12584** | **28574** | **427957** |
| **Southern Region** | | | | | | | |
| Andhra Pradesh | 1118 | 39631 | 0 | 5767 | 0 | 3866 | 50383 |
| Telangana | 1528 | 15937 | 0 | 0 | 0 | 1299 | 18765 |
| Karnataka | 7437 | 34193 | 0 | 0 | 0 | 12522 | 54152 |

| State | Hydro | Thermal | | | Nuclear | RES | Total |
|---|---|---|---|---|---|---|---|
| Kerala | 6416 | 0 | 73 | 0 | 0 | 770 | 7260 |
| Tamil Nadu | 4511 | 36486 | 38 | 2784 | 0 | 11614 | 55432 |
| Puducherry | 0 | 0 | 0 | 237 | 0 | 0 | 237 |
| Lakshadweep | 0 | 0 | 25 | 0 | 0 | 1 | 26 |
| Central Sector SR | 0 | 67391 | 0 | 149 | 13321 | 0 | 80861 |
| **Sub-total (SR)** | **21010** | **193639** | **137** | **8937** | **13321** | **30072** | **267116** |
| **Eastern Region** | | | | | | | |
| Bihar | 0 | 0 | 0 | 0 | 0 | 205 | 205 |
| D.V.C. | 178 | 36999 | 0 | 0 | 0 | 0 | 37177 |
| Jharkhand | 52 | 9156 | 0 | 0 | 0 | 25 | 9232 |
| Odisha | 4614 | 25005 | 0 | 0 | 0 | 564 | 30183 |
| West Bengal | 1504 | 34362 | 0 | 0 | 0 | 2149 | 38014 |
| Sikkim | 501 | 0 | 0 | 0 | 0 | 52 | 553 |
| Andaman and Nicobar Islands | 0 | 0 | 139 | 0 | 0 | 23 | 162 |
| Central Sector ER | 3619 | 64252 | 0 | 0 | 0 | 0 | 67871 |
| **Sub-total (ER)** | **10467** | **169774** | **139** | **0** | **0** | **3018** | **183398** |
| **North-Eastern Region** | | | | | | | |
| Arunachal Pradesh | 0 | 0 | 0 | 0 | 0 | 23 | 23 |
| Assam | 412 | 0 | 0 | 1516 | 0 | 121 | 2049 |
| Manipur | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Meghalaya | 868 | 0 | 0 | 0 | 0 | 82 | 950 |
| Mizoram | 0 | 0 | 0 | 0 | 0 | 34 | 34 |
| Nagaland | 0 | 0 | 0 | 0 | 0 | 110 | 110 |
| Tripura | 0 | 0 | 0 | 770 | 0 | 23 | 793 |
| Central Sector NER | 2961 | 124 | 0 | 6385 | 0 | 0 | 9470 |
| **Sub-total (NER)** | **4241** | **124** | **0** | **8672** | **0** | **394** | **13431** |
| **Central sector (all India)** | **47334** | **317950** | **0** | **19974** | **37916** | **0** | **386041** |
| **Total (all India)** | **122378** | **944861** | **275** | **49094** | **37916** | **81869** | **1236392** |
| **Net import/export** | | | | | | | **196889** |
| **Total energy available in the country** | | | | | | | **1433281** |

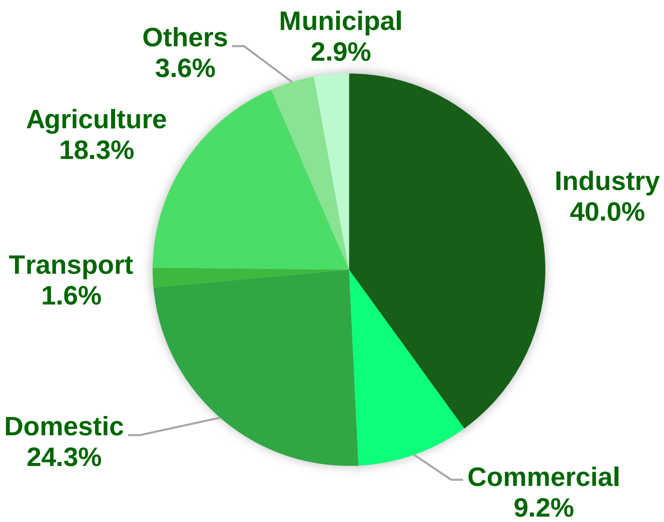
## 1.3.2. Electricity demand

The total electricity demand for FY 2016–17 is estimated to be 1066 BU[5] or 91.7 Mtoe. The industrial sector is the major consumer of electricity, and it represented about 40% of the total demand, followed by domestic (24.3%) and agriculture sectors (18.3%).

*Table 7: Share of various sectors in electricity consumption of FY 2016–17*

| Sector | Electricity (TWh) |
|---|---|
| Industry | 426.7 |
| Commercial | 98.4 |
| Domestic | 259.3 |
| Transport | 17.2 |
| Agriculture | 195.5 |
| Others | 38.7 |
| Municipal | 30.6 |
| **Total** | **1066.5** |

*Figure 5: Share of various sectors in electricity consumption of FY 2016–17*




The industrial sector continues to be the largest consumer of electricity in the country, with a consumption of 36.60 Mtoe, which accounts for close to 40% of the total demand. The domestic sector, as mentioned in the previous section, has been riding the wave of increasing demand on the account of a prospering economy, which has increased the spending power of the middle class and increased the sale of white goods such as refrigerators and air conditioners. The electricity consumption in the agriculture sector is mainly due to the usage of electric pumps, which account for close to 90% of the agriculture pumps used in the country. The share is expected to decrease in the future, with the government launching the ambitious Kisan Urja Suraksha Evam Utthaan Mahabhiyan (KUSUM) scheme, where the government aims to install 27.5 lakh solar pumps (17.5 lakh standalone and 10 lakh grid connected). The state-wise electricity consumption data are demonstrated below:

*Table 8: State-wise primary energy consumption in sectors in FY 2016–17 (in GWh)*

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Miscellaneous | Total electricity (Mtoe) |
|---|---|---|---|---|---|---|---|---|
| **Northern Region** | | | | | | | | |
| Chandigarh | 713 | 525 | 401 | 26 | 0 | 2 | 98 | 1765 |
| Delhi | 13927 | 8038 | 4682 | 1076 | 540 | 33 | 1248 | 29545 |
| Haryana | 7545 | 4179 | 15007 | 897 | 336 | 10732 | 4286 | 42983 |
| Himachal Pradesh | 2109 | 716 | 6877 | 589 | 0 | 58 | 199 | 10548 |
| Jammu and Kashmir | 3179 | 1043 | 2077 | 660 | 0 | 344 | 1120 | 8423 |
| Punjab | 12877 | 3903 | 18758 | 673 | 171 | 12999 | 792 | 50173 |
| Rajasthan | 11475 | 4646 | 19216 | 2335 | 158 | 22543 | 599 | 60972 |
| Uttar Pradesh | 30701 | 5851 | 25043 | 2648 | 1713 | 14305 | 4530 | 84792 |
| Uttarakhand | 2596 | 1279 | 8148 | 413 | 15 | 159 | 896 | 13507 |
| **Sub-total (NR)** | **85122** | **30180** | **100210** | **9318** | **2933** | **61176** | **13768** | **302708** |
| **Western Region** | | | | | | | | |
| Chhattisgarh | 5415 | 1353 | 10712 | 373 | 924 | 4544 | 315 | 23635 |
| Gujarat | 14526 | 4984 | 65809 | 2236 | 808 | 12649 | 1287 | 102299 |
| Madhya Pradesh | 11908 | 3099 | 14336 | 1695 | 1998 | 21301 | 805 | 55143 |
| Maharashtra | 30323 | 15861 | 51122 | 4496 | 2589 | 32058 | 4756 | 141206 |
| Daman and Diu | 96 | 57 | 2291 | 11 | 0 | 3 | 8 | 2466 |
| Dadra and Nagar Haveli | 107 | 33 | 6904 | 12 | 0 | 10 | 889 | 7954 |
| Goa | 1097 | 401 | 2931 | 5 | 0 | 20 | 51 | 4506 |
| **Sub-total (WR)** | **63472** | **25787** | **154105** | **8828** | **6319** | **70586** | **8112** | **337209** |
| **Southern Region** | | | | | | | | |
| Andhra Pradesh | 12480 | 2794 | 21959 | 846 | 1411 | 12385 | 2944 | 54819 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Miscellaneous | Total electricity (Mtoe) |
|---|---|---|---|---|---|---|---|---|
| Telangana | 10793 | 5533 | 17095 | 1120 | 601 | 13538 | 1632 | 50311 |
| Karnataka | 12284 | 7014 | 23659 | 3614 | 257 | 21810 | 1070 | 69708 |
| Kerala | 10934 | 4708 | 6165 | 621 | 229 | 325 | 475 | 23456 |
| Tamil Nadu | 25982 | 10799 | 45008 | 3774 | 866 | 13038 | 697 | 100164 |
| Puducherry | 712 | 213 | 2162 | 87 | 0 | 62 | 47 | 3283 |
| Lakshadweep | 37 | 12 | 0 | 1 | 0 | 0 | 0 | 50 |
| **Sub-total (SR)** | **73222** | **31072** | **116049** | **10063** | **3363** | **61157** | **6864** | **301791** |
| **Eastern Region** | | | | | | | | |
| Bihar | 5940 | 1302 | 3048 | 105 | 589 | 389 | 4092 | 15464 |
| Jharkhand | 4543 | 590 | 16758 | 262 | 1325 | 111 | 0 | 23588 |
| Odisha | 6755 | 1657 | 9048 | 234 | 1112 | 300 | 874 | 19979 |
| West Bengal | 14626 | 6200 | 23862 | 1418 | 1581 | 1721 | 3689 | 53096 |
| Sikkim | 140 | 68 | 202 | 5 | 0 | 0 | 29 | 445 |
| Andaman and Nicobar Islands | 136 | 71 | 23 | 7 | 0 | 0 | 38 | 274 |
| **Sub-total (ER)** | **32139** | **9887** | **52941** | **2031** | **4607** | **2520** | **8721** | **112847** |
| **North-Eastern Region** | | | | | | | | |
| Arunachal Pradesh | 178 | 44 | 132 | 14 | 0 | 0 | 81 | 449 |
| Assam | 3383 | 1031 | 2215 | 87 | 0 | 38 | 663 | 7418 |
| Manipur | 324 | 46 | 36 | 22 | 0 | 2 | 102 | 532 |
| Meghalaya | 459 | 105 | 917 | 40 | 0 | 0 | 133 | 1654 |
| Mizoram | 236 | 43 | 14 | 59 | 0 | 0 | 21 | 373 |
| Nagaland | 356 | 74 | 81 | 16 | 0 | 0 | 100 | 627 |
| Tripura | 478 | 86 | 64 | 125 | 0 | 38 | 117 | 908 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Miscellaneous | Total electricity (Mtoe) |
|---|---|---|---|---|---|---|---|---|
| **Sub-total (NER)** | **5415** | **1428** | **3459** | **363** | **0** | **79** | **1217** | **11961** |
| **Total (all India)** | **259371** | **98356** | **426764** | **30603** | **17221** | **195518** | **38683** | **1066516** |

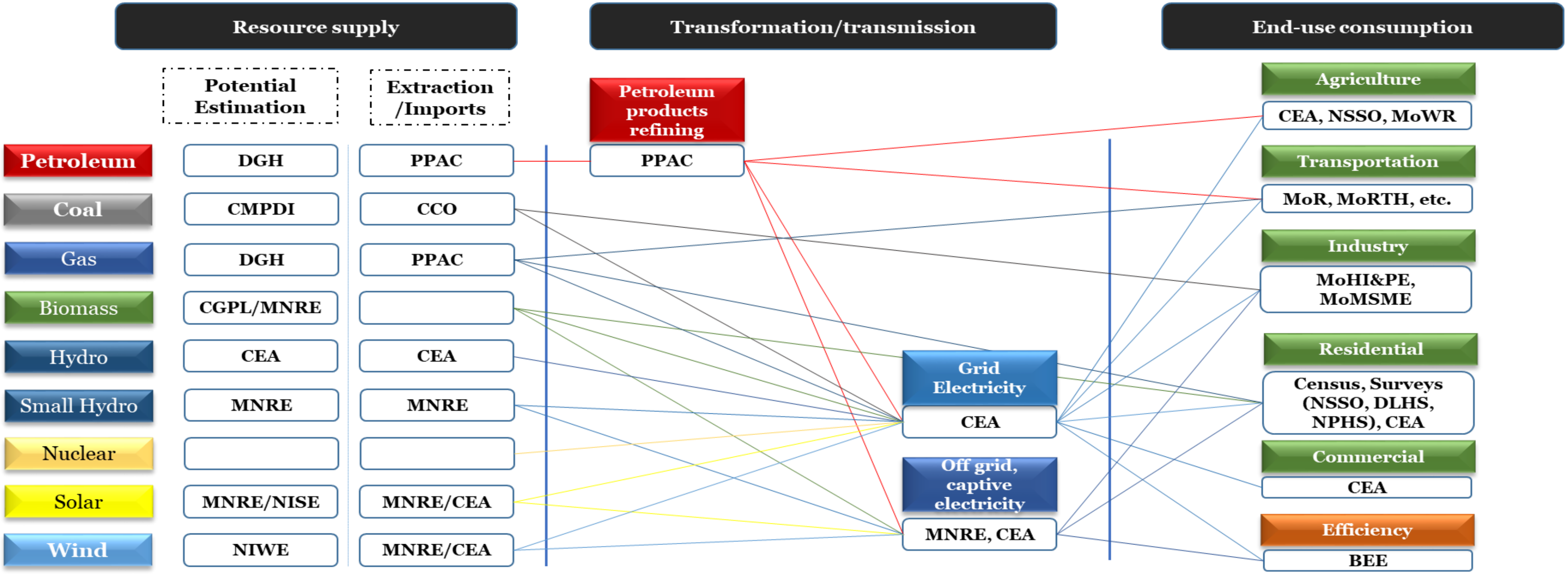
## 1.4. Data Gaps and Recommendations on Effective Energy Data Management

### 1.4.1. Organization of India's energy management data

As data collection in India is carried out by multiple agencies, coordination among these organizations can be challenging with each entity operating within its own standard operating procedure and jurisdiction. Efficiently managing energy data often hits a roadblock in the form of inconsistency in data compilation, use of different definitions and conversion factors across organizations and existence of data gaps. India's energy data management is fairly decentralized as shown in the figure below[7]:

[7] An Assessment of Energy Data Management in India (Oct 2014), Prayas (Energy Group)

*Figure 6: India's energy data management structure*




Institutions involved in the management of India's energy data fall into three groups: First, there are energy-related line ministries and their subordinate agencies or offices. These include the Ministry of Power (Central Electricity Authority and Bureau of Energy Efficiency), the Ministry of Coal (Coal Controller's Organization), the Ministry of Petroleum and Natural Gas (Petroleum Planning and Analysis Cell, the Directorate General of Hydrocarbons and Petroleum Conservation Research Association), the Ministry of New and Renewable Energy, and line ministries dealing with major energy-consuming sectors such as agriculture, industry and transport. Second, India has statistical agencies such as the Ministry of Statistics and Programme Implementation (MoSPI) and state-level directorates of economics and statistics. The third group consists of the planning institutions such as the National Institution for Transforming India (NITI) Aayog and various state-level planning departments. There is an absence of a central institute with the responsibility of collecting, analysing and disseminating the national energy data.

### 1.4.2. Identification of data gaps

While establishing the energy demand and supply for the baseline year, the analysis relied on multiple data sources available in the public domain and published by various ministries and institutions, which consisted of data gaps. A summary of the data gaps identified during data collection exercise is presented in the annexure.

### 1.4.3. Stakeholder consultation

Data gaps and inconsistencies were encountered while designing the dynamic model for the National Energy Efficiency Strategy, and in order to address the data gaps, stakeholder consultations were conducted with concerned officials of the ministries and agencies identified below:

- Coal Controller's Organization (CCO)
- Petroleum Planning and Analysis Cell (PPAC)
- Ministry of Micro, Small and Medium Enterprises (MoMSME)
- Ministry of Statistics and Programme Implementation (MOSPI)
- Ministry of Statistics and Programme Implementation (MOSPI)–Annual Survey of Industries
- Department of Heavy Industries (DHI), Ministry of Heavy Industries and Public Enterprises
- Central Electricity Authority (CEA)

## *1.4.4. Recommendations on effective energy data management*

As shown above, the energy data management in India is decentralized, mirroring the existing political and administrative structure in the country. Some of the identified data gaps include: inconsistencies in reporting from various ministries, delay in data reporting and ambiguity in the use of conversion factors by different agencies while reporting energy-consumption data. In addition to that, there is no agency in the country at present that captures the primary energy supply and demand data in the country at the state level for each demand sector. The following are some of the recommendations suggested that could fill the gaps in energy reporting in the country:

**Setting up of a nodal agency:** It is pertinent that an empowered agency should be set up that not only collects data from various sources, but also reconciles these and ensures smooth data management.

**Improved technology and statistical methods:** Automation in data collection and management should be explored as an option, which includes automated metering, online data submission and interactive data dissemination. This would improve accuracy and completeness in data collection as well as facilitate the collection of primary data for energy supply and demand at the state level, which is not reported by any agency in the country.

**Systematic data quality checking:** Quality assurance mechanisms make it possible for agencies to carry out systematic quality checks. Quality assurance needs to be conducted at multiple stages of energy data management.

**Maintaining commonality in standardization:** A common code of standardized definitions and classifications should be followed. Principles and codes of practices from the UN Statistical Commissions could be adopted in India.

**Improved data dissemination:** It is also important to disseminate data in convenient, user-friendly and easy-to-access formats. High degree of data integration, uniform data maintaining standards, end-user oriented data formats and increasing usage of modern technology would be required to achieve this.

# MAPPING OF ENERGY EFFICIENCY PROGRAMS AND POLICY LANDSCAPE

## 2.1. Introduction

The objective of this chapter is to undertake a comprehensive mapping of energy-efficiency programmes so as to align the National Strategic Plan for Energy Efficiency with various other cross-cutting instruments that impact (or are impacted by) energy-efficiency scenarios in the country. There are several programmes initiated at the national, state and sectoral levels to achieve the goal of energy efficiency and improving availability of key services in India. The macro-level impact of each of these programmes is tabulated in order to assess the impact generated by the initiative. The existing policies and programmes have been considered while projecting the future energy demand and supply across sectors and fuel types, respectively.

The impact of the implementation of various national-level policies and programmes has also been captured at the state level, especially the activities that are being carried out by the state designated agencies (SDAs), municipalities and DISCOMs. The village/panchayat-level programmes as well as other indirect policies such as Montreal Protocol and the Kigali Amendment have also been included in this chapter.

A broad overview of the major activities undertaken under the scope of this task has been provided below:

- Identifying national-level programmes and policies
- Mapping programmes and policies with implementing agencies
- Impact of programmes and policies on sources of energy identified
- Programmes and policies at the state level, for SDAs, DISCOMs, municipalities and panchayats identified
- Other indirect policies like Montreal Protocol and Kigali Amendment

Multiple domestic programmes governing various demand sectors have been reviewed, which govern the energy-efficiency sector in India, and these programmes have shaped the initiatives taken to conserve energy and reduce the energy intensity of the country. A broad summary of the initiatives taken by various ministries is presented in the next page:

## 2.1.1. Review of national programmes governing energy-efficiency sector and their impact on each fuel and sector

The first step in reviewing the policies and programmes includes outlining the impact the policy/programme has/would have in certain sectors. The analysis then shifts to the impact on the source of energy due to the implementation of the programme. The programmes and policies covered thus far are outlined in the section below. The intended change in end-user behaviour and impact on energy usage for each of the policy/programme have been outlined in the annexure.

### Agricultural and Municipal Demand-Side Management

**Launch year: 2016**

**Implementing agency**: Bureau of Energy Efficiency (BEE)

The Agriculture Demand-Side Management (AgDSM) and Municipal Demand-Side Management (MuDSM) schemes were initiated during the XI Plan and are being implemented in many states presently. The objective of the programme is to reduce the energy intensity of agriculture pumping sector (AgDSM) and municipal pumping sector (MuDSM) by carrying out efficiency upgrade of pump sets. Studies reveal that about 30%–40% energy saving is possible by adoption of energy-efficient star-labelled pump sets.

### National Mission for Enhanced Energy Efficiency

**Launch Year: 2008**

**Implementing agency**: Bureau of Energy Efficiency (BEE)

The National Mission for Enhanced Energy Efficiency (NMEEE) was formulated in 2008. A host of activities have been undertaken by the nodal implementation body, BEE, Ministry of Power, categorized as four broad initiatives under the NMEEE[8]:

- **Perform, Achieve and Trade (PAT):** A programme-mandated, market-based mechanism designed to accelerate energy savings in energy-intensive and large industries by incentivizing energy savings.
- **Market Transformation for Energy Efficiency (MTEE):** Initiative to accelerate the shift to energy-efficient appliances in designated sectors through innovative measures to make the products more affordable.
- **Energy Efficiency Financing Platform (EEFP):** A platform to promote finances for energy-efficiency projects in all sectors by capturing future energy savings.
- **Framework for Energy-Efficient Economic Development (FEEED):** A framework for developing fiscal instruments to promote energy efficiency.

EEFP and FEEED have had a **cross-sectoral impact** as the schemes focus on financing energy-efficiency activities/ESCOs (Energy Service Company). The impacts of the schemes have been:

[8] National Mission for Enhanced Energy Efficiency, Bureau of Energy Efficiency

- **Capacity building of financial institutions (FIs) and ESCOs/EE Project Developers:** The outcomes achieved under EEFP (including MoUs with FIs, development of training material, training/capacity-building activities etc.) have collectively contributed towards developing the capacity at the participating banks and FIs. There have been similar efforts through other IDA (International Development Association)-funded projects supported by BEE and SIDBI (Small Industries Development Bank of India) for training and capacity building of FIs.

- **Platform for interaction among EE-financing stakeholders (banks, NBFCs (non-banking financial corporations), ESCOs, EE project developers and consumers):** The MoUs signed with FIs result in an incremental addition in the level of commitment from the respective FIs towards efforts to promote EE financing. This includes participation of relevant officials from these FIs in various training and capacity-building initiatives.

- **Operationalization of PRGFEE and potential de-risking of EE-financing portfolio:** Partial Risk Guarantee Fund for Energy Efficiency **(**PRGFEE) is a risk-sharing mechanism to provide FIs (banks/NBFCs) with a partial coverage of risk involved in extending loans for EE projects. Under PRGFEE, the support has been provided to government buildings, private buildings (commercial or multi-storey residential buildings), municipalities, SMEs and industries.

### 24×7 Power for All

**Launch Year: 2017**

**Implementing Agency/Ministry:** Ministry of Power (MoP)

24×7 Power for All (24×7 PFA) is a joint initiative of the Government of India (GoI) and state governments with the objective to provide 24×7 power available to all households, industry, commercial businesses, public needs, any other electricity-consuming entity and adequate power to agriculture farm holdings by FY 2019.[9]

The programme aims to achieve 100% electrification of the country as well as improve the energy efficiency of the states and increase renewable energy. In states that have already achieved 100% electrification, it focuses on improving the quality of power.

### Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA)

**Launch Year: 2017**

**Implementing Agency/Ministry:** Rural Electrification Corporation (REC)

Under SAUBHAGYA scheme, free electricity connections will be provided to all households (both APL and poor families) in rural areas and poor families in urban areas. There are around 4 crore unelectrified households in the country, and they are targeted for providing electricity connections by December 2018.

### Pradhan Mantri Ujjwala Yojana (PMUY)

[9] Rural Electrification Corporation (REC), http://www.recindia.nic.in/

**Launch Year: 2016**

**Implementing Agency**: Ministry of Petroleum and Natural Gas

This scheme is for provision of clean cooking fuel to rural households. Under this scheme, 5.25 crore LPG connections have been provided to BPL (below poverty line) families with a support of Rs 1600 per connection.[10]

### National Electric Mobility Mission Plan 2020 (NEMMP)

**Launch Year: 2013**

**Implementing Agency:** Ministry of Heavy Industries and Public Enterprises

Launched by the Department of Heavy Industries in 2013 with the aim of promoting electric and hybrid vehicles, the NEMMP provided the vision and the roadmap for faster adoption of xEVs (Electric and Hybrid Vehicles). As part of the mission, the DHI has formulated the scheme for Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME). The scheme had four focus areas:[11] technology development, demand creation, pilot projects and charging infrastructure.

### Metro Rail Policy 2017

**Launch Year: 2017**

**Implementing Agency**: Ministry of Housing and Urban Affairs

The Metro Rail Policy sets out guidelines and business models available for setting up metro rail networks in cities. The policy presents an opportunity for private investments across a range of metro operations making PPP component mandatory for availing central assistance for new metro projects. This policy will help set up metro rail networks in cities across India.[12]

### National Solar Mission

**Launch Year: 2010**

**Implementing Agency**: Ministry of New and Renewable Energy (MNRE)

The National Solar Mission was launched on 11 January 2010. The solar mission recommends the implementation in three stages leading up to an installed capacity of 20,000 MW by the end of 2022.

### Smart Cities Mission

**Launch Year: 2015**

**Implementing Agency**: Ministry of Housing and Urban Affairs

The mission will cover the development of 100 Smart Cities across India in a span of 5 years. The components of the mission for the development of Smart Cities are city improvement (retrofitting),

[10] Pradhan Mantri Ujjawala Yojana (PMUY), http://www.pmujjwalayojana.com/
[11] National Electric Mobility Mission Plan (NEMMP) 2020 (Aug 2012), DHI
[12] Metro Rail Policy – 2017, MoHUA

city renewal (redevelopment) and city extension (greenfield development). Additionally, smart solutions will be applied covering larger parts of the city. SCM is carried out through a special purpose vehicle (SPV), registered under the Companies Act, 2013, instead of through a municipal corporation. It encourages private investment as well. Deadlines set in 2015 for the completion of 100 Smart Cities within 5 years by 2019–20 have been extended till 2022–23 for finishing projects in cities selected in round four. Smart water projects have been completed in six cities, while projects are under implementation or tendering in 43 cities. Similarly, smart waste water projects in 46 cities have been completed or are under implementation.[13]

### Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

**Launch Year: 2015**

**Implementing Agency**: Ministry of Housing and Urban Affairs

The Atal Mission for Rejuvenation and Urban Transformation was launched in June 2015 to provide various amenities to the poor and disadvantaged in India. The mission aims to provide basic facilities like water supply, sewage, urban transport and parks. The urban local bodies (ULBs) will be implementing the projects under this mission. The ULBs will also include some smart features in the physical infrastructure components of the city. The mission covers 500 cities, which include all cities and towns with a population of over 1 lakh with notified municipalities. The total outlay for AMRUT is Rs. 50,000 crore for 5 years from FY 2015–16 to FY 2019–20. Moreover, the potential Smart Cities will be given first preference because the Smart Cities Mission and AMRUT are complementary.[14]

### Municipal Energy Efficiency Programme (MEEP) by EESL

**Launch Year: 2016**

**Implementing Agency**: Energy Efficiency Services Limited (EESL)

To facilitate market transformation and replicate the Municipal Energy Efficiency Programme on a large scale in India, the Ministry of Urban Development (MoUD), Government of India, signed an MoU with the Energy Efficiency Services Limited (EESL), on 28 September 2016 under AMRUT. This will enable replacement of inefficient pump sets in public water works and sewerage water systems with energy-efficient pump sets at no upfront cost to the municipal bodies.

Currently, the project is in the phase of preparing DPRs for the 500 cities identified. About 200 DPRs (detailed project reports) have been prepared, and a summary of the findings has been used to make the projections in the energy demand of the sector.[15]

### Heritage City Development and Augmentation Yojana (HRIDAY)

**Launch Year: 2015**

**Implementing Agency**: Ministry of Housing and Urban Affairs

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[13] Smart Cities Mission, http://smartcities.gov.in/content/

[14] Atal Mission for Rejuvenation and Urban Transformation (June 2015), MoUD

[15] MEEP Dashboard, http://meep.eeslindia.org/dashboard/

The Ministry of Housing and Urban Affairs, Government of India, launched the HRIDAY scheme in 2015 to preserve and develop heritage cities. The scheme aims to improve the infrastructure and facilities in the cities while maintaining the heritage and essence of the city. The scheme will broadly focus on four theme areas—physical infrastructure, institutional infrastructure, economic infrastructure and social infrastructure—for reviving and revitalizing the soul of Heritage City. One of the objectives of the scheme is the implementation and enhancement of basic services with focus on sanitation services like public conveniences, toilets, water taps, street lights and the use of latest technologies to improve tourist facilities/amenities. As of March 2018, instalments amounting to Rs 261 crore have been released to city mission directorates for execution of approved projects.[16]

### Street Lighting National Programme (SLNP)

**Launch Year: 2015**

**Implementing Agency**: Energy Efficiency Services Limited (EESL)

Launched in January 2015, the EESL plans to replace 3.5 crore LED lights by March 2019 under this programme. The EESL has joined hands with the ULBs, municipal bodies and state and central governments to implement LED street lights with future-ready technology. The LEDs are 50% more energy efficient than incandescent bulbs and high-pressure sodium (HPS) lighting, along with being weather resistant. Till date, over 6 million conventional street lights have been replaced with LED lights, leading to an annual energy saving of more than 4000 million kWh, and reducing around 3 million tonnes (MT) of $CO_2$ emissions.[17]

### National Policy on Biofuels

**Launch Year: 2018**

**Implementing Agency**: Ministry of New and Renewable Energy (MNRE)

The policy aims at utilization of biofuels and envisages a greater role for it in the energy and transportation sectors of the country in coming decades. The policy will bring about accelerated development and promotion of the cultivation, production and use of biofuels to increasingly substitute petrol and diesel for transport and be used in stationary and other applications, while contributing to energy security and climate change mitigation, apart from creating new employment opportunities and leading to environmentally sustainable development.[18]

This policy will reduce crop burning and will help to effectively employ crop not suitable for consumption to produce biofuels.

### National Wind–Solar Hybrid Policy

**Launch Year: 2018**

**Implementing Agency**: Ministry of New and Renewable Energy (MNRE)

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[16] Heritage City Development and Augmentation Yojana, MoUD
[17] SLNP Dashboard, https://slnp.eeslindia.org/
[18] National Policy on Biofuels, MNRE

The main objective of the policy is to provide a framework for promotion of large grid-connected wind–solar PV hybrid system. This will lead to optimal and efficient utilization of transmission infrastructure and land, reducing the variability in renewable power generation and achieving better grid stability. The policy also aims to encourage new technologies involving combined operation of wind and solar PV plants.[19]

### Deendayal Upadhyaya Gram Jyoti Yojana

**Launch Year: 2015**

**Implementing Agency/Ministry:** Rural Electrification Corporation (REC)

The Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY) has been launched for the rural areas with the following components: (i) separation of agriculture and non-agriculture feeders in the rural areas; (ii) strengthening and augmentation of sub-transmission and distribution (ST&D) infrastructure in rural areas; (iii) rural electrification. Under this scheme, a number of projects on renewable energy sources have been sanctioned.[20]

### On-Farm Water Management (OFWM)

**Launch Year: 2006**

**Implementing Agency**: Ministry of Agriculture and Farmers' Welfare, Department of Agriculture Co-operation and Farmer's Welfare

The Government of India has been implementing centrally sponsored scheme on micro-irrigation (MI) with the objective to enhance water-use efficiency in the agriculture sector by promoting appropriate technological interventions like drip and sprinkler irrigation technologies and encourage the farmers to use water saving and conservation technologies.[21]

The scheme has performed well in terms of reduction in input cost, and significant cost saving has been observed for irrigation in all the surveyed states. Irrigation cost is reduced by 20%–50% with an average of 32.3%. The average electricity consumption has been reduced by about 31% after using the micro-irrigation system.

### Green Highways Policy, 2015

**Launch Year: 2015**

**Implementing Agency**: Ministry of Road Transport and Highways

The policy envisages creation of eco-friendly highways with participation of the community, farmers, NGOs, private sector, institutions, government agencies and forest department. It also highlights the promotion of green fuels such as bio-CNG, bioethanol and biodiesel and green modes of transport such as e-rickshaws and electric buses.

[19] Draft National Wind–Solar Hybrid Policy, MNRE
[20] Deendayal Upadhyaya Gram Jyoti Yojana, http://www.ddugjy.gov.in/portal/SBD_for_Standalone.jsp
[21] Pradhan Mantri Krishi Sinchayee Yojana, http://pmksy.gov.in/microirrigation/Aboutus.aspx

### Miles to Smiles

It has nine specific components: HI Stop HI Jal—toilets and drinking water facilities at petrol pumps along highways; HI Fastag—convert all toll booths to e-toll systems; HI FM—Highway Advisory Services; HI Nirbhaya—security for women travelling on highways and buses with IT-enabled safety measures; HI Swachh—dustbins at toll plazas for garbage collection; HI safe zebra crossing; HI Navik mobile application; HI help toll free number 1033; HI Green—for green initiatives such as tree planting, biofuel buses, biodiesel petrol pumps, electronic hybrid vehicles, e-rickshaws and green highways policy.[22]

### National Biogas and Manure Management Programme

**Launch Year: 1981**

**Implementing Agency**: Ministry of New and Renewable Energy (MNRE)

The National Biogas and Manure Management Programme is a central sector scheme, which provides for setting up of family-type biogas plants mainly for rural and semi-urban/households[23] to generate a clean gaseous fuel, particularly for cooking and meeting lighting needs, and replace the use of fuel-wood, thereby reducing deforestation.[24]

### Unnat Chulha Abhiyan (UCA)

**Launch Year: 2014**

**Implementing Agency**: Ministry of New and Renewable Energy (MNRE)

The Unnat Chulha Abhiyan (UCA) is a programme of the Ministry of New and Renewable Energy to develop and deploy improved biomass cook stoves for providing cleaner cooking energy solutions in rural, semi-urban and urban areas using biomass as fuel for cooking.

### Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises (TEQUP)

**Launch Year: 2010**

**Implementing Agency**: Ministry of Micro, Small and Medium Enterprises

The first objective of the scheme is to sensitize the manufacturing MSME sector in India to the use of energy-efficient technologies and manufacturing processes so as to reduce the cost of production and the emissions of greenhouse gases.[22]

Major activities under the scheme include[25]:

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[22] TERI Energy Handbook, 2015–16

[23] National Biogas and Manure Management Programme, https://cag.gov.in/sites/default/files/audit_report_files/Union_Civil_Performance_Renewable_Energy_Report_34_2015_chap_8.pdf

[24] https://mnre.gov.in/sites/default/files/schemes/New-National-Biogas-Organic-Manure-Program%28NNBOMP%29-upto-2020–1.pdf

[25] DC-MSME Scheme, http://www.dcmsme.gov.in/schemes/TEQUPDetail.htm

- Capacity building of MSME clusters for energy efficiency/clean development interventions and other technologies mandated as per the global standards.
- Implementations of energy-efficiency units (EET) in MSME units.
- Setting up of carbon credit aggregation (CCA) centres for introducing and popularizing clean development mechanism (CDM) in MSME clusters.
- Encouraging MSMEs to acquire product certification/licenses from national/international bodies and adopt other technologies mandated as per the global standards.

### Sagarmala

**Launch Year: 2015**

**Implementing Agency**: Ministry of Shipping

The Sagarmala programme envisions significant reduction in logistics cost of bulk commodities by locating future industrial capacity near the coast and optimizing the modal mix. The four major tenets of the programme are[26]:

1. **Port modernization and new port development:** De-bottlenecking and capacity expansion of existing ports and development of new greenfield ports.

2. **Port connectivity enhancement:** Enhancing the connectivity of the ports to the hinterland and optimizing cost and time of cargo movement.

3. **Port-linked industrialization:** Developing port-proximate industrial clusters and coastal economic zones to reduce logistics cost and time of EXIM (export import) and domestic cargo.

4. **Coastal community development:** Promoting sustainable development of coastal communities.

### Dedicated Freight Corridor (DFC) Programme

**Launch Year: 2006**

**Implementing Agency**: Dedicated Freight Corridor Corporation of India Ltd.

Dedicated freight corridor (DFC) is a strategic initiative to augment rail capacity across the major trunk routes in India. DFC can cater to the need for multi-faceted Indian economy, ranging from agriculture to manufacturing and knowledge economy businesses, all sectors depending on the movement of freight in some way.

### Green Urban Mobility Scheme 2017

**Launch Year: 2017**

**Implementing Agency**: Ministry of Housing and Urban Affairs

[26] Sagarmala, Ministry of Shipping, http://sagarmala.gov.in/about-sagarmala/vision-objectives

The scheme would focus primarily on three objectives:

1. **Sustainable urban mobility:** Infrastructure enabling bus systems, safe pedestrian pathways, cycling track, public bike sharing, integrating modes with physical and soft infrastructure, e.g. cashless payment systems and intelligent transport system (ITS) and strategies for urban freight management.

2. **Sustainable vehicles and fuels:** Shift to electric/hybrid vehicles for public transport, shift to non-fossil fuel for public transport projects.

3. Projects demonstrating reduction in GHG emissions.

### National Auto Policy 2018

**Launch Year: 2018**

**Implementing Agency**: Department of Heavy Industry

Some of the key policy guidelines included are:

- Roll out of a comprehensive long-term (10-year) roadmap that will define the emission standards applicable after BSVI with a target of harmonizing with the most stringent global standards by 2028, across all vehicle segments.
- Adopt reduction in $CO_2$ through Corporate Average Fuel Economy (CAFÉ) regulations: Roadmap will define corporate average $CO_2$ g/km targets for all passenger vehicle manufacturers from 2020 onwards.
- Introduce a composite criterion based on length and $CO_2$ emissions to classify vehicles for taxation: Vehicle length based classification will target reduction in vehicular congestion and $CO_2$ emissions based classification will align with the overall vision of reducing GHG emissions. Monitor and review the thresholds based on market evolution and target of increasing share of greener vehicles.
- Define a list of target technologies in the areas of green mobility, emission control, safety etc., with corresponding components and equipment that will be eligible for import duty reduction.
- Conduct a detailed study on requirement of public infrastructure for green vehicles to determine the quantity, density and mix of green mobility infrastructure required in the country as per target adoption plans. Also, standards for green vehicle infrastructure in terms of power supply, connectors, refuelling etc. will be proposed.

### National Mission on Sustainable Agriculture (NMSA)

**Launch Year: 2013**

**Implementing Agency:** Ministry of Agriculture and Farmers' Welfare, Department of Agriculture Co-operation and Farmers' Welfare

The mission aims at enhancing food security and protection of resources such as land, water, biodiversity and genetics. The mission focuses on new technologies and practices in cultivation and development of specific genotypes of crops that have enhanced $CO_2$ fixation potential and are less water consuming.[27]

### National Innovations on Climate Resilient Agriculture (NICRA)

**Launch Year: 2011**

**Implementing Agency**: Indian Council of Agriculture Research (ICAR)

Some of the key attributes of the programme include:

- Real-time contingency crop plan implementation both on station and on farm in a participatory mode: To sustain the productivity of pearl millet, cluster bean, sesame under normal and drought conditions. To improve the productivity of mustard, chickpea and wheat under rain-fed conditions.

- Rainwater harvesting (in situ and ex situ) and efficient use: Demonstration on efficient in-situ moisture conservation practices to conserve more moisture (ridge and furrow planting, compartmental bundling etc.). Efficient and multiple use of harvested water or enhancing water-use efficiency (lifesaving irrigation, sprinkler irrigation). Groundwater recharging through bore well and open well, defunct well.

- Efficient energy use and management: Introduction of modern tools/implements and to create awareness in the farming community about their use for different crops (establishing custom hiring centre and ensuring services in the village).

- Alternate land use for carbon sequestration and ecosystem services: To develop alternate land-use system/farming system for carbon sequestration and ecosystem services. The package included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring centre and alternate land-use and ecosystem services.

### Kisan Urja Suraksha Evam Utthaan Mahabhiyan (KUSUM)

**Launch Year: 2018**

**Implementing Agency**: Ministry of New and Renewable Energy (MNRE)

The scheme, being formulated by the Government of India, will aim towards installation of solar water pumps in remote areas for irrigation needs of farmers and supplement an extra source of income by selling surplus solar power to DISCOMs. The specific targets of the programme include[28]:

- Installation of grid-connected solar power plants each of capacity up to 2 MW in the rural areas.

- Installation of standalone off-grid solar water pumps to fulfil irrigation needs of farmers not connected to grid.

[27] National Mission for Sustainable Agriculture Being Launched in Twelfth Plan (Dec 2013), http://pib.nic.in/newsite/PrintRelease.aspx?relid=101133

[28] KUSUM Scheme – harnessing solar power for rural India (Mar 2018), http://pib.nic.in/newsite/PrintRelease.aspx?relid=177489

- Solarization of existing grid-connected agriculture pumps to make farmers independent of grid supply and also enable them to sell surplus solar power generated to DISCOM and get extra income.
- Solarization of tube wells and lift irrigation projects of the government sector.

### Perform, Achieve and Trade (PAT)

**Launch Year: 2008**

**Implementing Agency**: Bureau of Energy Efficiency (BEE)

The Perform, Achieve and Trade (PAT), a market-based energy-efficiency trading mechanism, is being implemented in three phases. PAT cycle I ran from 2012 to 2015, covering 478 facilities from eight energy-intensive sectors. These eight sectors account for roughly 38% of India's total primary energy consumption. The second phase of the PAT scheme (PAT cycle II) runs from 2016 to 2019 covering 707 units from 11 energy-intensive sectors. PAT cycle II focuses on deepening and widening PAT cycle I with the inclusion of 61 new designated consumers (DCs) from the existing eight sectors and the addition of 170 DCs from three new sectors: railways, refineries and electricity distribution companies (DISCOM).

### Zero Effect, Zero Defect (ZED)

**Launch Year: 2016**

**Implementing Agency**: Ministry of Micro, Small and Medium Enterprises

The ZED (Zero Effect, Zero Defect) scheme is an integrated and holistic certification system that will account for quality, productivity, energy efficiency, pollution mitigation and technological depth, including design and IPR in products and processes for medium and small industries.[29]

### Sustainable and Accelerated Adoption of Efficient Textile Technologies to Help Small Industries (SAATHI) Scheme

**Launch Year: 2017**

**Implementing Agency**: Energy Efficiency Services Limited (EESL) and Office of the Textile Commissioner

Under this initiative, the EESL would procure energy-efficient power looms, motors and rapier kits in bulk and provide them to small and medium power loom units at no upfront cost. The use of these efficient equipment would result in energy savings and cost savings to the unit owner and he would repay in instalments to EESL over a 4–5 year period. This is the aggregation, bulk procurement and financing model that EESL has successfully deployed in several sectors like LED bulbs, smart meters and electric vehicles. The unit owner neither has to allocate any upfront capital cost to procure these equipment, nor does it has to allocate additional expenditure for repayment as the repayments to EESL are made from the savings that accrue as a result of higher efficiency equipment and cost savings. The aggregation of demand and bulk procurement will also lead to reduction in capital cost,

[29] Zero Defect, Zero Effect, MoMSME, https://www.zed.org.in/

benefits of which will be passed to the power loom units so that their repayment amount and period would reduce.[30]

### Atal Jyoti Yojana (AJAY)

**Launch Year: 2018**

**Implementing Agency**: Energy Efficiency Services Limited (EESL)

The Ministry of New and Renewable Energy (MNRE) launched the Atal Jyoti Yojana (AJAY) to illuminate dark regions across five states through solar power. It is a sub-scheme under off-grid and decentralized solar application scheme of the Ministry of New and Renewable Energy (MNRE), Government of India. The rural, semi-urban and urban areas that face less than 50% grid connectivity in Uttar Pradesh, Assam, Bihar, Jharkhand and Odisha will be illuminated with solar LED street lights. These solar lights will be installed on major roads, markets and public conveniences in remote areas to sustainably enhance the citizens' quality of life.

### Energy Conservation Building Codes (ECBC)

**Launch Year: 2007**

**Implementing Agency:** Bureau of Energy Efficiency

The ECBC sets minimum performance standards for building envelope, which includes roof and windows, lighting systems, air-conditioning system, electrical distribution system and water heating and pumping system. The new ECBC code launched in 2017 had the following new features[31]:

- International benchmark code specific to Indian conditions, climate and construction and will pave the way for future net zero energy buildings.
- Wider scope in comfort systems and controls, integration of low energy comfort systems, natural ventilation, set points and controls.
- Day lighting and shading requirement with relaxed U-values.

Stringent lighting requirements with focus on better controls and compliance for new construction, core and shell, tenant lease type, etc.

### National Manufacturing Competitiveness Programme (NMCP)

**Launch Year: 2005**

**Implementing Agency:** Ministry of Micro, Small and Medium Enterprises

The objective of NMCP is to develop global competitiveness among Indian MSMEs. This programme targets at enhancing the entire value chain of the MSME sector through the following components: promoting information technology and communication tools in MSME sector, design clinic schemes

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[30] Ministries of Power and Textiles join hands under new initiative SAATHI (Sustainable and Accelerated Adoption of efficient Textile technologies to Help small Industries) (Oct 2017), http://pib.nic.in/newsite/PrintRelease.aspx?relid=171894

[31] http://www.aeee.in/wp-content/uploads/2017/05/ECBC-presentation-by-BEE.pdf

for MSMEs, marketing assistance and technology upgradation scheme for MSMEs, bar code under market development assistance scheme, etc.[32]

### Transformation of Aspirational Districts Programme (TADP)

**Launch Year: 2018**

**Implementing Agency:** NITI Aayog

The programme aims at transforming 115 districts that were selected from 28 states. At the core of the programme lies three crucial aspects that aim to foster these districts into the mainstream of development and growth. These are: convergence (of central and state schemes), collaboration (of central, state-level "prabhari" officers and district collectors), and competition among districts. Driven primarily by the states and instituted for the states, this initiative focuses on the strengths of each district and identifies the attainable outcomes for immediate improvement, while measuring progress and ranking the selected districts.[33]

## *2.1.2. State-level policies*

### Andhra Pradesh

**Electric Mobility Policy, 2018–23**: The Industries and Commerce (P&I) Department of the Andhra Pradesh Government issued the Electric Mobility Policy 2018–23 for the state. The Andhra Pradesh EV Policy gives incentives to consumers, auto makers, battery manufacturers and charging infrastructure firms. It includes policies for both private as well as government players to purchase or lease electric vehicles such as waiver of road tax and subsidies. The state intends to be a frontrunner in building a sustainable transport system by investing in electric mobility.[34]

**Andhra Pradesh Solar Policy, 2015**: The Andhra Pradesh Solar Policy, 2015 was issued by the Government of Andhra Pradesh on 12 February 2015. The policy follows the previous solar policy of the state, Andhra Pradesh Solar Policy, 2012, which was valid till 2017. During the course of the policy, Andhra Pradesh was bifurcated into Telangana and Andhra Pradesh. The policy had also not achieved the target of 2000 MW by 30 June 2014. Hence, the state government decided to issue a new solar policy. The policy targets a minimum total solar power capacity addition of 5000 MW in the 5 years after it was issued (till 2020). The policy has various incentives for the development of solar parks and solar rooftop projects. Solar power projects that are commissioned during the operative period of the policy shall be eligible for incentives for a period of 10 years from commissioning.[35]

**Andhra Pradesh Wind Power Policy, 2015:** The Andhra Pradesh Wind Power Policy was issued on 13 February 2015. Considering the wind power potential existing in the state of Andhra Pradesh, the policy plans to achieve 4000 MW capacity addition through wind power during the next 5 years period, i.e. 2015–20. The policy aims to attract private investment in setting up wind power projects in the state.[36]

[32] Scheme for Promotion of Information and Communication Technology (ICT) in MSME Sector
[33] Aspirational Districts – Unlocking Potentials (Jan 2018), NITI Aayog
[34] State Electric Mobility/Energy Storage Policy
[35] State Solar Power Policy
[36] State Wind Power Policy

## Delhi

**Delhi Solar Policy, 2016**: The Department of Power, Government of NCT of Delhi, issued the Delhi Solar Policy, 2016. Delhi is completely landlocked, and solar power is the primary source of renewable power for the state. The policy aims to reduce the reliance on unsustainable energy while increasing its energy security and lowering average energy prices in the long term. The policy promotes rapid growth of rooftop solar power via a combination of generation targets, regulations, mandates and incentives.[35]

**Delhi Energy Conservation Building Code (ECBC), 2018:** The Energy Efficiency and Renewable Energy Management Centre, Government of NCT of Delhi, released the draft Delhi Energy Building Code for comments in February 2018. It provides guidelines for the minimum requirements for the energy-efficient design and construction of buildings in Delhi. The guidelines recommend installation of renewable energy generation on commercial buildings across the city.[37]

**Delhi Electricity Regulatory Commission (Demand Side Management) Regulations, 2014:** The regulations are applicable to distribution licensees in Delhi. The regulations intend to reduce the cost of electricity to the distribution licensee as well as its customers by economical and efficient use of resources. The DSM regulations provide the framework for designing, development implementation of DSM-related activities in the state.[38]

## Gujarat

**Gujarat Solar Power Policy, 2015:** The Gujarat Solar Power Policy, 2015 was issued by the Government of Gujarat on 13 August 2015. The policy aims to scale up solar power in the state in a sustainable manner. It aims to promote clean and green power to reduce the state's carbon emission and reduce its dependence on fossil fuels. It also aims to encourage development of local manufacturing facilities in line with "Make in India" policy.[35]

**Gujarat Waste to Energy Policy, 2016:** The Energy and Petrochemicals Department of the Government of Gujarat issued the Gujarat Waste to Energy Policy, 2016 on 28 March 2016. The policy intends to facilitate and promote utilization of municipal solid waste as a renewable resource for generation of electricity at a low cost and in a sustainable way and thus also contribute to Swachh Bharat Abhiyan.[39]

**Gujarat Wind Power Policy, 2016:** The Gujarat Wind Power Policy, 2016 was issued on 2 August 2016 by the Energy and Petrochemicals Department, Government of Gujarat. The state of Gujarat has a long coastline and good wind speeds, which can be harnessed in the form of wind energy. The policy intends to increase the private investment in wind power projects in the state.[36]

## Haryana

**Haryana Solar Power Policy, 2014:** The Haryana Solar Power Policy, 2014 was issued on 4 September 2014 by the Government of Haryana. The objective of the policy is to promote the use of solar power in the state. The policy aims to use solar power for creating steam for cooking and industrial applications. It lists specific type of solar projects that will be encouraged in the state.[35]

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[37] Delhi Energy Conservation Building Code 2018

[38] DERC DSM Regulations 2014

[39] State Waste to Energy Policy, MNRE

## Jharkhand

**Jharkhand State Solar Power Policy, 2015:** The Jharkhand State Solar Power Policy, 2015 was issued by the Department of Energy, Government of Jharkhand, on 10 August 2015. The policy intends to encourage participation of the private sector to set up solar power plant projects in the state as well as scale up the solar power generation of the state to 2650 MW by 2020. The policy also aims to encourage local manufacturing facilities and increase employment in the state.[35]

## Himachal Pradesh

**Himachal Pradesh Solar Power Policy, 2014:** The Department of Non-Conventional Energy Sources, Himachal Pradesh issued the Himachal Pradesh Solar Power Policy, 2014 on 4 March 2014. The policy aims to harness the potential of solar power for various uses in the state. The state receives ample sunlight for commercial as well as domestic applications of solar energy. The policy lists the different types of solar power plants and power projects that will be encouraged by the state. The nodal agency for the policy is Himurja.[35]

## Jammu and Kashmir

**Solar Power Policy for Jammu and Kashmir:** The Department of Science and Technology, Government of Jammu and Kashmir, issued the Solar Power Policy for Jammu and Kashmir on 18 March 2013. The policy intends to encourage the generation of green and clean power in the state via the use of solar energy and to contribute to meeting the targets of the Jawaharlal Nehru National Solar Mission. The solar power projects under the policy have to be of minimum 1 MW.[35]

## Karnataka

**Karnataka Electric Vehicle and Energy Storage Policy, 2017:** The Government of Karnataka issued the policy on 25 September 2017 to promote electric mobility in the state and attract investments in the sector. The policy envisages Karnataka to be the preferred destination for electric mobility. The policy aims to attract investments of Rs 31,000 crore in the state. All initiatives and incentives for promotion of electric mobility are outlined in the policy document.[34]

**The Karnataka Solar Policy 2014–21:** The Government of Karnataka issued the Karnataka Solar Policy 2014–21 on 22 May 2014. The Government of Karnataka had issued an earlier solar policy in 2012. Karnataka is a state rich in sunlight and has about 240–300 clear sunny days with a solar radiation of 5.4 to 6.2 kWh/m$^2$/day. It was the first southern state to notify its first solar policy in 2011. The policy aims to achieve 2000 MW solar power in the state by 2021 via different types of projects such as grid-connected projects and rooftop projects.[35]

## Kerala

**Kerala Solar Energy Policy, 2013:** The Government of Kerala issued the Kerala Solar Energy Policy, 2013 on 25 November 2013. The policy intends to increase the share of solar power in the energy mix of the state and to ensure optimal usage of the available solar potential in the state. The state plans to achieve a capacity of 2500 MW by 2030. The Agency for Non-conventional Energy and Rural Technology will be administrating the policy in the state.[35]

## Madhya Pradesh

**Policy for Implementation of Solar Power Based Projects in Madhya Pradesh, 2012:** The policy was issued by the Government of Madhya Pradesh in 2012. The policy states that the state is heavily dependent on conventional energy sources and, thus, has taken the measure to increase renewable energy in the state. The state receives plenty of sunlight for 300 days in a year. The policy intends to encourage private investment in solar power projects in the state. The policy defines the incentives and benefits provided to the participants from the private sector in solar power in the state.[35]

**Wind Power Project Policy, 2012:** Considering the huge potential of untapped wind energy in the state, the government issued the Wind Power Project Policy, 2012. The policy defines all projects that will be allotted under the policy will be on a build, own and operate basis. Rules and regulations for allotment of projects and incentives for setting up of wind power projects are listed in the policy.[36]

**Policy for Implementation of Small Hydel-Power-Based Electricity Projects in Madhya Pradesh, 2011:** The policy was issued by the New and Renewable Energy Department, Government of Madhya Pradesh, on 3 November 2011. The policy is applicable to all small hydel power projects up to 25 MW. The policy intends to promote pollution-free small hydel power-generating projects by private-sector participants and to define the incentives available to the private sector.

## Maharashtra

**Maharashtra's Electric Vehicle Policy, 2018:** Based on the recent developments in technology and the potential benefits of electric vehicles, the Government of Maharashtra issued the Maharashtra's Electric Vehicle Policy, 2018. The policy envisages 5 lakh electric vehicles in the state, an investment of Rs. 25,000 crore in EV, EV and component manufacturing, battery manufacturing, assembly enterprises and charging infrastructure equipment manufacturing. The policy lists all incentives applicable to electric vehicles in the state.[34]

## Odisha

**Odisha Solar Policy, 2013:** The Science and Technology Department, Government of Odisha, issued the Odisha Solar Policy in 2013. The principal objective of the policy is to promote the use of solar energy in the state to support development and address the problem of energy security. The policy details the scope and potential of the state to harness solar power. The policy lists incentives for setting up solar projects, including waiver of electricity duty on solar power plants.[35]

## Rajasthan

**Rajasthan Solar Energy Policy, 2011:** The Energy Department, Government of Rajasthan, issued the Rajasthan Solar Energy Policy, 2011 on 19 April 2011. Rajasthan receives maximum solar radiation intensity in India with very low average rainfall. The policy intends to increase the development of solar projects in the state.[35]

## Tamil Nadu

**Tamil Nadu Solar Energy Policy, 2012:** The Tamil Nadu Solar Energy Policy, 2012 was issued by the Energy Department, Government of Tamil Nadu, in 2012. The policy intends to achieve energy security and reduce carbon emissions by increasing the solar power generation in the state. It introduces many initiatives such as promotion of rooftop solar, net metering, solar water heating systems and solar parks.[35]

### Telangana

**Telangana Solar Power Policy, 2015:** The Telangana Solar Power Policy, 2015 was issued by the Government of Telangana and is valid for 5 years. The state receives plenty of sunlight that can be harnessed. The policy aims to promote a sustainable fuel mix by increasing the use of solar power. Private and public investment is encouraged in solar power generation in the state via the policy, including encouraging the development of solar parks.[35]

### Uttarakhand

**Solar Energy Policy of Uttarakhand, 2013:** The Government of Uttarakhand issued the Solar Energy Policy of Uttarakhand, 2013 on 27 June 2013. The policy endeavours to create an enabling environment to attract public and private investment in the generation of solar energy projects. The policy describes the different solar projects that are encouraged in the state. The Uttarakhand Renewable Energy Development Agency (UREDA) is the nodal agency for the implementation of the policy.[35]

## *2.1.3. Energy-efficiency programmes by municipalities*

Municipal energy efficiency saves scarce commodities and stretches tight budgets, giving citizens improved access to electricity, water, heat and air conditioning. Energy efficiency in municipal water supply systems can save water and energy while reducing costs and improve service at the same time. Some of the programmes undertaken by progressive municipalities are mentioned below:

### Vadodara Municipal Corporation (VMC)

Some of the energy-efficiency measures taken by the VMC are as follows[40]:

- Replacement of 45,000 36 W FTL with 15 W LEDs in 2013–14. This move had an energy-saving potential of 66% with annual electricity bill saving of Rs 2.94 crore.
- Design-based lighting, which includes dimming of lights during off-peak hours. The programme was started in 2002 for all the main roads in Vadodara. The programme resulted in 58% energy efficiency by improving 300% service delivery, as compared to conventional installations. A total energy saving of 80.34 lakh kWh was achieved in 2013–14.
- The VMC was also the first city in the country to install and implement SCADA (supervisory control and data acquisition) in street light service. This programme was implemented in 2008 with installation of microprocessor-based intelligent street light controller with GSM technology for remotely monitoring and controlling street lights.
- Annual programmable time switches in street lights were installed in 2012–13, which resulted in energy savings of 7.32 lakh kWh during 2013–14.
- A programme for conversion of HPMV (high-pressure mercury vapour lamps) into HPSV (high-pressure sodium vapour lamps) was carried out, which resulted in energy savings of 16.24 lakh kWh during 2013–14.

A summary of the savings from different energy-efficiency measures are mentioned below:

[40] http://knowledgeplatform.in/wp-content/uploads/2016/03/20.-General-Category-Sub-sectors-of-EC-Award-Page-142–157.pdf

*Table 9: Energy-efficiency measures taken by the Vadodara Municipal Corporation*

| Steps Taken | Description | Investment | Total Quantity | Annual Savings |
|---|---|---|---|---|
| **Replacement** | 36 W tube light fixtures into 15 W LED fixtures | Rs 15 crore | 45000 | 56.67 lakh kWh |
| **Inventory** | Design-based lighting on main roads with GSM and microprocessor-based energy saver unit | Rs 2.64 crore | 220 units | 80.34 lakh kWh |
| **Procurement** | Annual programmable time switches for automation | Rs 76.3 lakh | 700 | 6.15 lakh kWh |
| **Conversion** | 125 W HPMV into 70 W HPSV (saving of 58 W) | No cost | 692 | 1.61 lakh kWh |
| **Conversion** | 250 W HPMV into 150 W HPSV (saving of 113 W) | No cost | 3225 | 14.63 lakh |
| **Inventory** | Low watt loss ballast for sodium fitting (saving of 5 W) | No cost | 30424 | 6.39 lakh kWh |

A snapshot of energy savings achieved by the VMC during 2009–14 by implementation of various energy-efficiency measures are given below[40]:

*Table 10: Energy savings achieved by the Vadodara Municipal Corporation during 2009–14*

| Year | Actual kWh Consumption | kWh without Energy Efficiency (Lakh Unit) | kWh Saving by Implementing Energy-Saving Measures (Lakh Unit) | Amount Savings (in lakh Rs) | Reduction in $CO_2$ emission in metric tonne |
|---|---|---|---|---|---|
| **2009–10** | 234.83 | 304.81 | 69.68 | 278.53 | 5.95 |
| **2010–11** | 238.28 | 333.39 | 95.11 | 380.44 | 8.08 |
| **2011–12** | 230.41 | 337.31 | 106.90 | 478.92 | 9.09 |
| **2012–13** | 236.00 | 350.78 | 114.78 | 550.95 | 9.7 |
| **2013–14** | 236.70 | 415.70 | 165.78 | 862.06 | 14.09 |
| **Total savings of 5 years** | | | **552.55** | **2550.89** | **46.97** |

## Greater Vishakhapatnam Municipal Corporation

**Street-lighting project:** The project aimed at overall reduction in the energy consumption and electricity load on street lighting along with improving the quality of lighting from that of conventional lighting. A summary of street-lighting fixtures inventory details is provided below[41]:

*Table 11: Greater Vishakhapatnam Municipal Corporation LED replacement measures*

| Sl. No. | Existing Conventional Lights | | | | Replaced LED Lights | | | |
|---|---|---|---|---|---|---|---|---|
| | Category | 1st phase | 2nd | Total | Category | 1st phase | 2nd | Total |

[41] http://knowledgeplatform.in/wp-content/uploads/2016/01/Greater-Visakhapatnam-Municipal-Corp_1st-Prize.pdf

| Sl. | Existing Conventional Lights | | | | Replaced LED Lights | | | |
|---|---|---|---|---|---|---|---|---|
| | | Qty (Nos) | Phase Qty (Nos) | | | Qty (Nos) | phase Qty (Nos) | |
| **1** | 40 W tube light | 60395 | 6236 | 66631 | 20 W LED | 59687 | 25 | 59712 |
| **2** | 70 W SV lamp | 4084 | 286 | 4370 | 40W LED | 4078 | 50 | 4128 |
| **3** | 150 W SV lamp | 18392 | 2464 | 20856 | 70 W LED | 18426 | 884 | 19310 |
| **4** | 250 W SV lamp | 8778 | 1797 | 10575 | 120 W LED | 9486 | 365 | 9851 |
| **5** | 400 W SV lamp | 126 | — | 126 | 210 W LED | 98 | 6 | 104 |
| **Total** | | **91775** | **10783** | **102558** | | **91775** | **1330** | **93105** |

A comparison of the energy-consumption charges, before and after installation of LED lights in 2014 and 2015, is shown below[41]:

*Table 12: Greater Vishakhapatnam monetary savings from LED installations*

| Sl. No. | Before LED Installation | | | After LED Installation | | |
|---|---|---|---|---|---|---|
| | Month | Units in lakhs | Amount in lakhs | Month | Units in lakhs | Amount in lakhs |
| **1** | Jan-14 | 23.80 | 194.63 | Jan-15 | 12.70 | 93.07 |
| **2** | Feb-14 | 23.89 | 186.14 | Feb-15 | 12.72 | 94.93 |
| **3** | Mar-14 | 17.08 | 174.09 | Mar-15 | 11.85 | 90.19 |
| **4** | Apr-14 | 19.60 | 161.96 | Apr-15 | 12.34 | 102.21 |
| **5** | May-14 | 18.01 | 140.30 | May-15 | 10.92 | 81.68 |
| **6** | Jun-14 | 17.22 | 145.07 | Jun-15 | 10.79 | 96.21 |
| **7** | Jul-14 | 16.80 | 144.21 | Jul-15 | 10.09 | 90.89 |
| **8** | Aug-14 | 17.57 | 145.82 | Aug-15 | 11.33 | 103.65 |
| **9** | Sep-14 | 18.81 | 166.02 | Sep-15 | 11.78 | 111.45 |
| **Total** | | **172.78** | **1458.24** | | **104.52** | **864.28** |

### Directorate of Local Bodies, Department of Local Self-government, Rajasthan

The Department of Local Self-government (LSG) is the controlling department of all municipalities for all administrative purposes. The function of monitoring and coordination for all the 190 municipal bodies of the state is also carried out by this department. The Directorate of Local Bodies works at the behest of this department and looks after the day-to-day functioning of all ULBs.

**Street-lighting project:** The state government signed an MoU with the Energy Efficiency Services Limited for replacing conventional sodium lights and tube lights with LED lights. Energy savings observed under this project are mentioned below[42]:

*Table 13: Energy savings in Department of Local Self-government, Rajasthan*

| Energy Saving Observed | |
|---|---|
| **Energy consumption before implementation of project (2014–15)** | 399.23 lakh kWh |
| **Energy consumption after implementation of project (2015–16)** | 155.25 lakh kWh |
| **Saving in consumption** | 243.98 lakh kWh |
| **Saving in %** | 61% |
| **Energy cost incurred before implementation of the project (2014–15)** | Rs 3193.84 lakh |
| **Energy cost incurred after implementation of the project (2014–15)** | Rs 1242 lakh |
| **Financial saving in Rs** | Rs 1951.84 lakh |
| **Financial saving in %** | 61% |

By 2015–16, installation of LEDs had been completed for 11 ULBs, which include Jaipur, Ajmer, Pushkar, Dholpur, Bhiwadi, Ratangarh, Ratan Nagar, Pali, Churu, Mount Abu and Udaipur.

### Pune Municipal Corporation (PMC), Water Supply Energy Efficiency Project

The objective of the undertaking was to demonstrate that harnessing efficiencies at the juncture between municipal water and energy could immensely help ULBs to address their urban water and energy challenge at the same time. As a result of the implementation of this programme, PMC experienced annual energy savings of 37.8 lakh kWh and annual cost savings of over Rs 1.48 crore. The savings achieved were significantly higher than those that were projected in the initial energy audit report.[43] Additional benefits from the programme are summarized below:

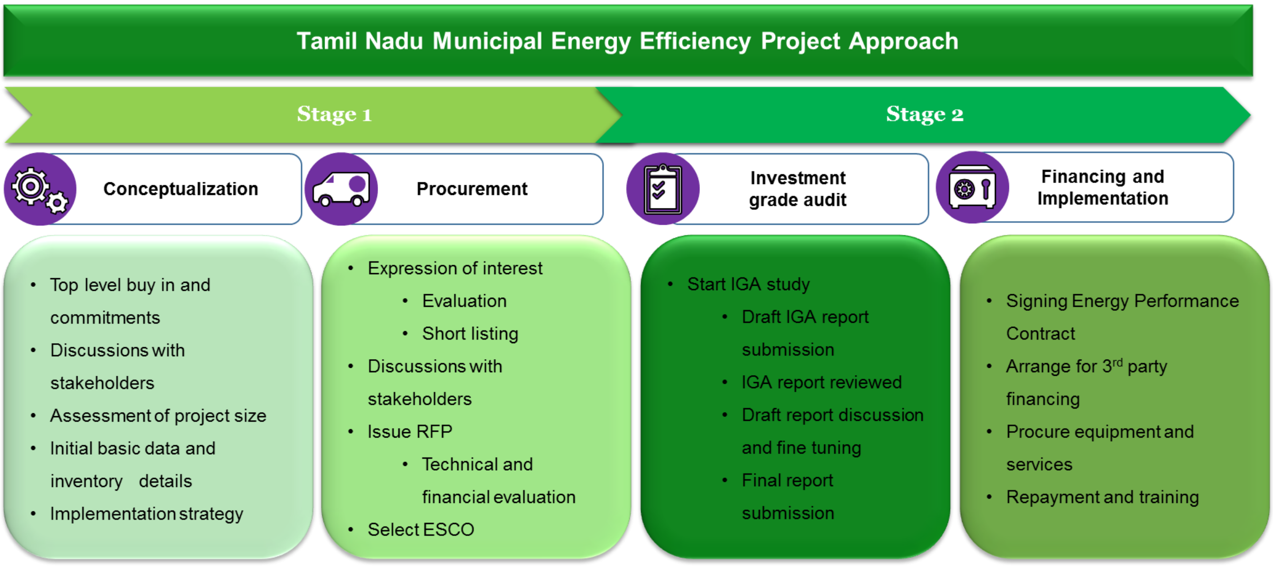
- Ten per cent additional delivery of water to the community without adding to the capacity,
- Saving additional money by qualifying for a rebate programme offered by the Maharashtra State Electricity Board. Under the programme, a rebate was offered to the facilities maintaining a good power factor and reducing usage during peak hours. Example: Parvati Water Works increased its rebate by almost 8% since FY 2003–04, from Rs 48.57 lakh to Rs 86.27 lakh.
- PMC's programme led the way in Maharashtra as various other ULBs like Thane, Nagpur and the Municipal Corporation of Greater Mumbai undertook similar efforts.

### Bundled Municipal Energy Efficiency Programme, Tamil Nadu

The programme was set up as an experimental project that bundled municipalities for implementation of energy efficiency in water pumping and street lighting by energy service companies (ESCOs) through Energy Performance Contracts (EPCs). The conceptualization, planning and implementation of the project was carried out in two stages as shown below[43]:

[42] http://knowledgeplatform.in/wp-content/uploads/2017/02/16.-General-Category-sub-sec.pdf
[43] Mainstreaming Energy Efficiency in Urban Water and Wastewater management in the wake of climate change (2017), MoUD

*Figure 7: Tamil Nadu energy-efficiency project structure*




## 2.1.4. Energy-efficiency programmes by panchayats

A list of demonstration projects and village campaigns carried out across the country is given below:

*Table 14: List of energy-efficiency demonstration projects and village campaigns*

| State | Year | Details of Village Campaign | Number of Appliances Covered through the Project | Projected Energy Savings (kWh) |
|---|---|---|---|---|
| **Andaman and Nicobar** | FY 2012–13 | LED village campaign at Caddlegunj village at Farrargunj Tehsil, S/Andaman in 142 households | 5W LED bulbs (120 nos), 6W LED bulbs (240 nos), 8W LED bulbs (120 nos) | 24440 |
| | | Installation of LED street lighting in Caddlegunj village | 116W LED street lights (25 nos) | 6460 |
| | FY 2015–16 | LED village campaign at Tapong village in Kamorta Island | 8W LED bulbs (150 nos), 12W LED bulbs (225 nos) | 25733 |
| | | Installation of LED street lighting at Tapong village | 25W LED street lights (25 nos) | 5475 |
| | | Installation of LED street lighting at Kinyuka village under Sansad Adarsh Gram Yojana (SAGY) | 25W LED street lights (50 nos) | — |
| **Andhra Pradesh** | FY 2015–16 | LED street-lighting project in gram panchayats has been implemented in six villages in on 50–50 | LED street lights (540) | — |

| State | Year | Details of Village Campaign | Number of Appliances Covered through the Project | Projected Energy Savings (kWh) |
|---|---|---|---|---|
| | | funding basis limited to Rs 1 lakh contribution from each side | | |
| | FY 2016–17 | LED street-lighting project in gram panchayats has been implemented in four villages in FY 2016–17 on 50–50 basis covering the entire village street lights | — | — |
| **Arunachal Pradesh** | FY 2012–13 | LED village campaign in eight villages | Installation of 1600 16W LED bulbs | 416000 |
| **Assam** | FY 2014–15 | LED village campaign in two villages. Freely distributed 7W LED bulbs and installed 18W LED street lights | — | 147387 |
| **Gujarat** | FY 2016–17 | 5000 LED street lights in selected village of Gujarat (18W) installed in 40 villages | 5000 LED street lights | 675000 |
| **Karnataka** | FY 2016–17 | LED street lights project at 45 villages in BESCOM Jurisdiction under Phase – I (Government of Karnataka fund) | 3750 | 480004 |
| | | LED street lights project in 30 villages in BESCOM jurisdiction under Phase II (Government of Karnataka fund) | 3014 | 591298 |
| **Kerala** | During XII plan period | LED village campaign at Alappuzha, Nilambur and Vithura | 4600 | 15400 |

A brief mention about some of the progressive panchayat schemes are mentioned below:

### Bhintbudrak, Tapi district, Gujarat

Bhintbudrak is one of the richest in terms of dairy products in the state of Gujarat, with each family owning up to six buffaloes. With the high availability of dung in this village, Surat Milk Union Limited (SUMUL) dairy started a community biogas plant, with a network of pipeline grid through the village, supplying cooking biogas to the village. The slurry output from the plant was vermin-composted to produce organic fertilizer, and sold. Villagers received cooking gas for two hours in the morning and two hours in the evening.[44] In addition to that, the sale of the organic fertilizer made the whole process more feasible. A brief overview of the project is presented below:

*Table 15: Bhintbudrak project overview*

| Parameter | Description |
|---|---|
| **Ownership** | Village cooperative society |
| **Number of beneficiaries** | 121 |
| **Feedstock** | Cattle dung |
| **Capacity** | 4000–4500 kg per day |
| **Size of digester** | 2 × 85 $m^2$ |
| **Digester type** | Floating type |
| **Auxiliary systems** | Mechanized mixing of dung and water, pressure regulating tank, network of pipes for distribution, water supply from nearby tank, emergency diesel generator, vermin compost sheds |
| **Input rate** | 3.5 tonnes per day |
| **Water** | 1:1 |
| **Slurry** | Vermicompost made out of a fraction of total output slurry of 2.5 tonnes per day |
| **Gas supply** | Underground pipes from the plant to the beneficiaries |
| **Gas availability** | 2 hours each in the morning and the evening |

The reduction in GHGs happens due to the conversion of methane ($CH_4$) into cooking fuel, which further helps in prevention of deforestation for firewood. This has resulted in an annual carbon credits worth of USD 3900, at around USD 10 per tonne of CO2.[45]

### Pilicode Gram Panchayat, Kerala

The Pilicode Gram Panchayat in Kerala, along with the Energy Management Centre (EMC), Kerala's SDA, and Kerala State Electricity Board (KSEB) conducted a DSM programme spanning 1 year, resulting in a bimonthly reduction of 120,328 units power consumption in the panchayat.[46] An awareness programme was carried out by approximately 650 volunteers, trained in energy conservation, wherein they visited each household to create awareness about power consumption of different types of lighting appliances and usage during peak hours, i.e. 6 pm to 10 m. The panchayat set a goal to be "filament bulb free" and worked with EMC and KSEB to distribute subsidized LED bulbs to all households, shops and establishments. Street lights and lighting in all government buildings were replaced with LED fixtures. Government buildings also replaced inefficient ceiling fans with five-star rated fans.

### Energy Efficiency in Gram Panchayats, Odisha

The project which was carried out from September 2009 to December 2011 covered five villages: Khuard, Uparkundi, Purunapani under Jaleswar block and Badakhudi and Chakrada under Basta

[44] Raising the Sustainability Quotient (Jan–Mar 2014), Bombay Chamber of Commerce and
[45] Biogas for Rural Communities (May 2011), CTARA – IIT Bombay
[46] State Energy Efficiency Preparedness Index (2018), AEEE

block of Balasore district. Some of the activities that were carried out as a part of the programme are as follows[47]:

- Raising awareness about energy-saving practices through focus group trainings by targeting gram panchayats and SME entrepreneurs, school meetings and village meetings.
- Identifying energy champions in each village and formation of VEC (Village Energy Committee), which develops the sustainable village energy plan.
- Installation of energy meters in different households to know the electricity consumption in households, before and after interventions.
- Developing a plan for cost-sharing mechanism with the local community to foster local ownerships through the VECs.
- Exploring possible linkages and co-financing from various agencies to address the issues of introducing smokeless chulha, solar street lights, etc.

#### Rashtriya Gram Swaraj Yojana

The scheme is to be implemented from 2018 to 2022 and would help Panchayati Raj Institutions (PRIs) to develop governance capabilities to achieve Sustainable Development Goals (SDGs) through inclusive governance and focusing on the optimum utilization of available resources. Under the Gram Swaraj Abhiyan campaign that was implemented between 14 April and 5 May 2018, the EESL reached out to 16,000 villages, which had a significantly large number of low-income households, through the flagging off of the UJALA van that made LED bulbs available to these households at Rs 50.[48]

### *2.1.5. Other policies/programmes*

#### Montreal Protocol and Kigali Amendment

In the mid-1980s, scientists discovered thinning of the ozone layer that forms naturally in the stratosphere, over Antarctica. The reason for this ozone depletion was pinned on the increasing presence of a group of chemicals in the atmosphere called chlorofluorocarbons (CFCs), which were commonly found in white goods such as refrigerators, room air conditioners, fire extinguishers and aerosol cans. Serious health and environment consequences were also linked to ozone depletion as a result of which in 1987, world leaders signed the Montreal Protocol, an agreement for the complete phase out of ozone-depleting substances (ODS). The Montreal Protocol has been ratified by 197 countries and is one of the most successful international environmental treaties in history.[49]

The Montreal Protocol identified both first-generation and second-generation ozone-depleting substances.[50] The treaty was designed to restore the ozone layer by ending production of ODSs and by encouraging alternative substitutes through a systemic phase out.

[47] http://www.sgpindia.org/documents/Energy_Efficiency.pdf
[48] https://www.eeslindia.org/DMS/gsy.pdf
[49] United Nations Environment - Ozone Parliament, http://ozone.unep.org/montreal-protocol-substances-deplete-ozone-layer/32506
[50] The Montreal Protocol and its implications for climate change (Oct 2009), Environmental and Energy Study Institute

*Table 16: First-generation ODS*

| Chemical Group | Production Phase-Out Dates | Deadline Met |
|---|---|---|
| **Halons** | 1 January 1994 | Yes |
| **CFCs** | 1 January 1996 | Yes |
| **Carbon tetrachloride** | 1 January 1996 | Yes |
| **Hydrobromofluorocarbons (HBFCs)** | 1 January 1996 | Yes |
| **Methyl chloroform** | 1 January 1996 | Yes |
| **Chlorobromomethane** | 18 August 2003 | Yes |
| **Methyl bromide** | 1 January 2005 | Yes |

The Kigali meeting amended the 1987 Montreal Protocol by aiming to phase out hydrofluorocarbons (HFCs) by the late 2040s. The agreement has three different roadmaps for different countries[51]:

1. Developed economies such as the USA and EU would start to limit their use of HFCs within a few years and make a reduction of at least 10% from 2019 onwards. Overall, these economies would have to reduce HFCs to about 15% of 2010–12 baseline levels by 2036.
2. China, Brazil and other developing economies would have to freeze HFC levels by 2024, cutting it to 20% of 2020–22 baseline levels by 2045.
3. India, along with countries like Iran, Pakistan, Saudi Arabia, etc. belongs to the third group of countries that would have to freeze HFC levels by 2028 and reduce them to about 15% of 2024–26 baseline levels by 2047.

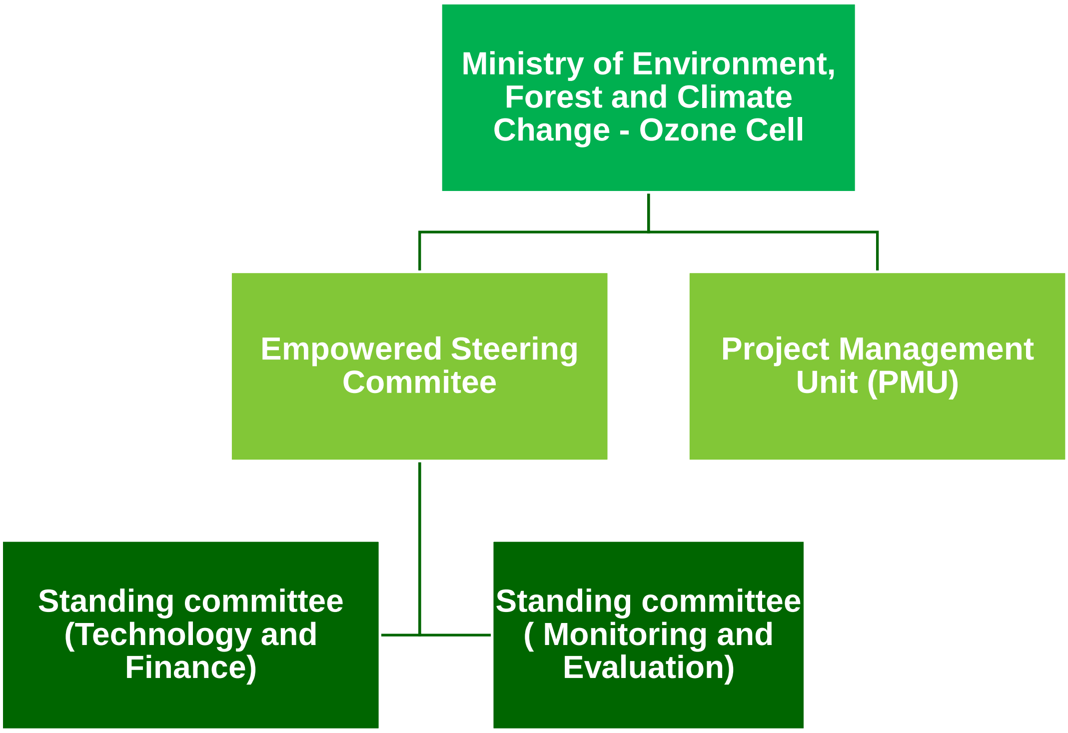
## Steps taken by India after ratifying the Montreal Protocol

### Institutional framework

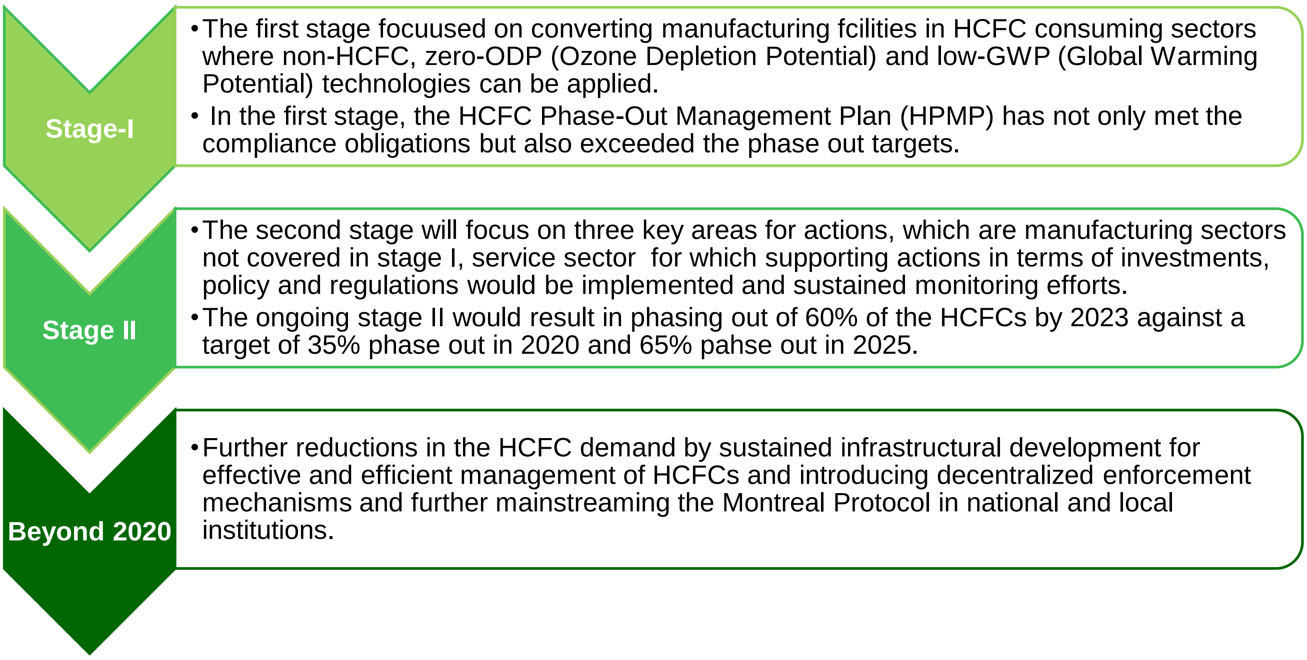
The Government of India designated the Ministry of Environment, Forests and Climate Change (MoEFCC) as the nodal ministry for the Montreal Protocol. Within MoEFCC, the Ozone Cell functions as a special directorate, dedicated to managing and coordinating the implementation of the Montreal Protocol in India. The various functions of the Ozone Cell include notifying various regulations pertaining to the Montreal Protocol, handling issues related to international cooperation, maintaining and managing data on the production, imports, exports and consumption of ODS, working together with scientific, technical and other public institutions for technical matters, etc. The institutional arrangement for implementation of the Montreal Protocol in India is depicted below[52]:

[51] https://www.insightsonindia.com/wp-content/uploads/2016/10/Kigali-Agreement.pdf
[52] India HCFC Phase-Out Management Plan (HPMP Phase 1) for compliance with the 2013 and 2015 control targets for consumption of Annex C, Group I substances, Ozone Cell, MoEFCC

*Figure 8: Institutional arrangement for implementing Montreal Protocol in India*




**Strategic roadmap for HCFC Phase-Out Management Plan (HPMP)**




### *2.1.6. Conclusion*

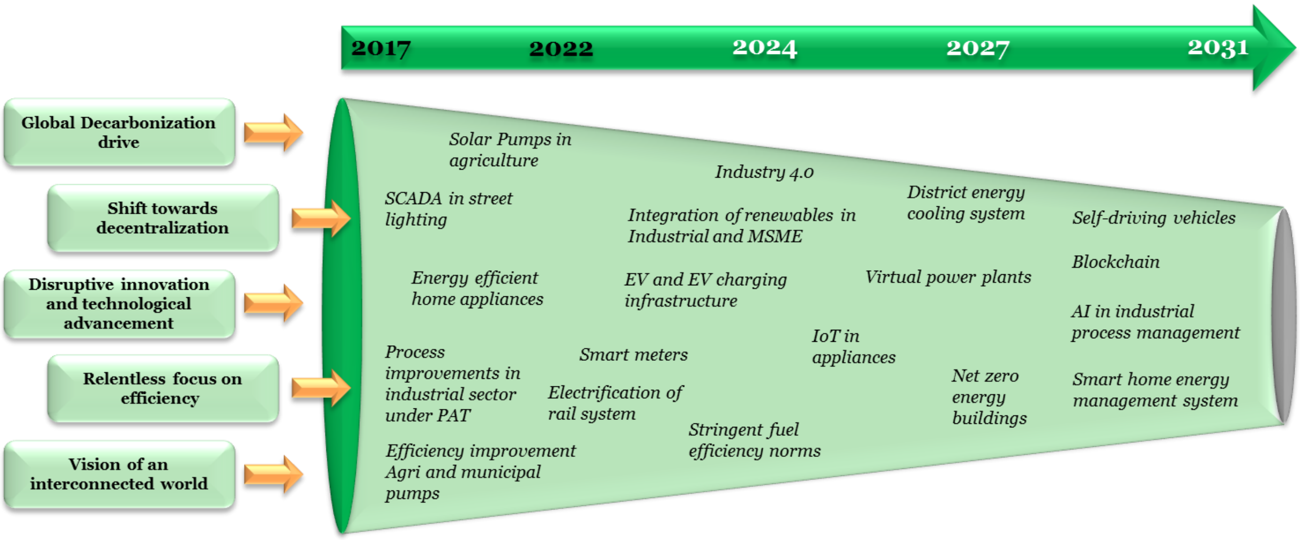
A detailed mapping of various programmes and policies at the national, state, municipal and panchayat levels has been analysed based on their impacts on sectors and sources of energy. The impacts that have been stated above are used as inputs while developing sectoral models and estimating the energy demand and saving potential, the latter of which is presented in the next chapter.

# 3

# FUTURE TECHNOLOGICAL ADVANCEMENTS IMPACTING ENERGY EFFICIENCY

## 3.1. Introduction

Energy underpins every aspect of modern life, driving economic growth and prosperity, and as a result has a direct link to people's standard of living. The emerging technological innovations are creating new opportunities for progress of energy efficiency. It is creating exciting new opportunities for integrated solutions where efficiency and renewable energy work together to deliver clean energy outcomes at the lowest cost. In this chapter, we have explored key future technologies that would impact each of the demand sectors. Some of the key trends that would drive significant transformation includes global de-carbonization drive, a shift towards decentralization, disruptive innovation and technological advancement, relentless focus on efficiency and vision of an interconnected world.




The following sections have been covered in this chapter:

- Brief description of sector-wise future technologies
- Detailed analysis of key future technologies

## 3.2. Sector-Wise Future Technologies/Innovative Interventions

This section covers a brief description of sector-wise future technologies that might impact energy consumption.

### 3.2.1. Agriculture sector

#### Efficient Star-Rated Pumps

With an estimated 21 million agricultural pump sets connected to the power grid in India, irrigation becomes a substantial cost in agriculture. Locally made pump sets used for irrigation are both inefficient and unreliable, causing massive water waste and higher energy consumption. While the efficiency of a local pump is usually in the range of 25%–35%, the efficiency of a star-rated energy-efficient pump set (EEPS) is in the range of 45%–50%. Studies reveal that there is an energy-saving potential of 25%–40% from replacement of inefficient pumps with efficient pumps.

#### Solar Pumps

The introduction of solar pumps would change the fuel mix in the water pump subsector, which has been predominantly served by diesel and electricity. With the adoption of solar pumps, farmers would no longer have to be dependent on grid supply for their irrigation requirements and also have an option to generate a supplementary source of revenue by selling excess electricity generated back to the DISCOM. The government has lately launched the Kisan Urja Suraksha evam Utthaan Mahaabhiyan (KUSUM) scheme to promote solar farming among farmers.

#### Precision Farming

The use of information- and technology-based farm management system to identify, analyse and manage variability within fields for optimum profitability, sustainability and protection of the land resource comes under the general purview of precision farming. Precision farming involves looking at the increased efficiencies that can be realized by understanding and dealing with the natural variability found within a field.

#### Industry 4.0 in Agriculture

Beyond the introduction of new tools and practices, the real promise of Agriculture 4.0 in terms of productivity increase resides in the ability to remotely collect, use and exchange data. A first range of application is the use of IoT to collect and publish information on the production processes and the farm.

#### Artificial Intelligence

The emergence of new-age technologies like Artificial Intelligence (AI), Cloud Machine Learning, Satellite Imagery and advanced analytics will create an ecosystem for smart farming. Fusion of all these technologies is enabling farmers to achieve higher average yield and better price control.

#### Smart Control Panels

Smart control panels would provide easy control for the farmers by allowing remote monitoring and would contribute in reducing hours of pump usage, resulting in energy savings. EESL has advanced the AgDSM programme and has started distributing smart control panels along with EEPS.

### *3.2.2. Transport sector*

The prospective technological advancements in the transport sector are provided for road, air and rail transport.

## *Road transport*

### Alternative fuel vehicles

Penetration of alternative fuel vehicles such as electric vehicles, fuel cell vehicles and biodiesel vehicles would impact the energy mix and emission profile of the country.

### Vehicle-to-vehicle and vehicle-to-infrastructure communication

Smart and efficient transfer of information between vehicle and infrastructural set-up using in-vehicle telematics.

### Alternative combustion

Use of Homogenous Charge Compression Ignition (HCCI), Premixed Charge Compression Ignition (PCCI) and other alternative combustion techniques along with computational fluid dynamics (CFD) and chemical kinetic modelling.

### Fuel efficiency

Increasing fuel injection pressure up to 3000 bars to improve thermal efficiency and reduce emissions. Improvement of thermodynamic cycles for engines with thermal efficiency greater than 70%.

### Improvement in battery technology and infrastructure

High-capacity lithium ion/Ni-MH (nickel metal hydride)/lithium-air batteries. Building public chargers and quick change battery stations.

### Self-driving and situationally aware vehicles

Self-driving vehicles with autonomous driving capabilities with limited or no human interventions.

## *Air transport*

### Airframe system and materials

Computational fluid dynamics for design analysis and flow diagnostics combined with additive manufacturing (3D) printing.

### Alternative fuel

Development of next-generation energy solutions based on low-cost alternative fuels. Alternate energy would include biomass to fuel or bio jet, synthetic paraffin kerosene, biodiesel, etc.

### Nanotechnology

Advanced nano-modified composites, engineered materials and carbon nanotubes, adaptive materials for better aerodynamics and drag reduction.

#### Automation

Deployment of ATM (air traffic management) automation systems with decision support functionality and SWIM (system wide information management) for efficient management of flight operations.

#### Engine

Design and development of engine components, materials and subsystems like advanced direct drive (ADD), geared turbofan, counter-rotating fan and other new engine core concepts.

### *Rail transport*

#### Energy-efficient traction with regeneration

Every type of electric traction rolling stock must have regenerative capability and feedback to the grid with development of suitable energy recovery devices.

#### Development of hydrogen fuel cell based locomotives

Development of hybrid electric cum fuel cell locomotives. The initial focus can be on low power shunting engine of a rail car.

#### Tapping piezo-electric power (floors) for energy needs

Development of suitable technology to derive piezoelectric power from the floors of station area made of piezoelectric crystals.

#### Captive development of alternative fuels for traction

Alternative fuels like biodiesel, CNG/LNG are cheaper than diesel and have potential to replace diesel as a preferred choice for traction fuel.

#### High-speed technologies

Capability to model panto-catenary interaction at high speeds, especially with multiple locomotives attached to the train with high-speed bogie and suspension arrangement.

## *3.2.3. Domestic and commercial sector*

#### District cooling system

District cooling distributes thermal energy in the form of chilled water from a central source to residential, commercial, institutional and industrial consumers for use in space cooling and dehumidification. Thus, the cooling effect comes from a distribution medium rather than being generated on site at each facility. A district cooling system consists of a central chiller plant, the distribution/piping network and the consumer systems.

#### Induction Cook Stoves

Induction cook stoves have steadily gained a foothold in urban Indian households, much in the similar fashion that gas stoves were replacing oil-filled stoves about a couple of decades ago. Gas stoves were bought by Indian households for being efficient, economical and non-polluting, and today the characteristics of the induction cooker are the same and at the same time it scores several times better on almost all counts than LPG.

Access to reliable electricity supply in rural areas remains a major barrier to the penetration of electricity-based cooking. Although just over 1% of rural households used an electric or induction stove in 2015, only 0.01% of households used it as primary cooking energy.[53]

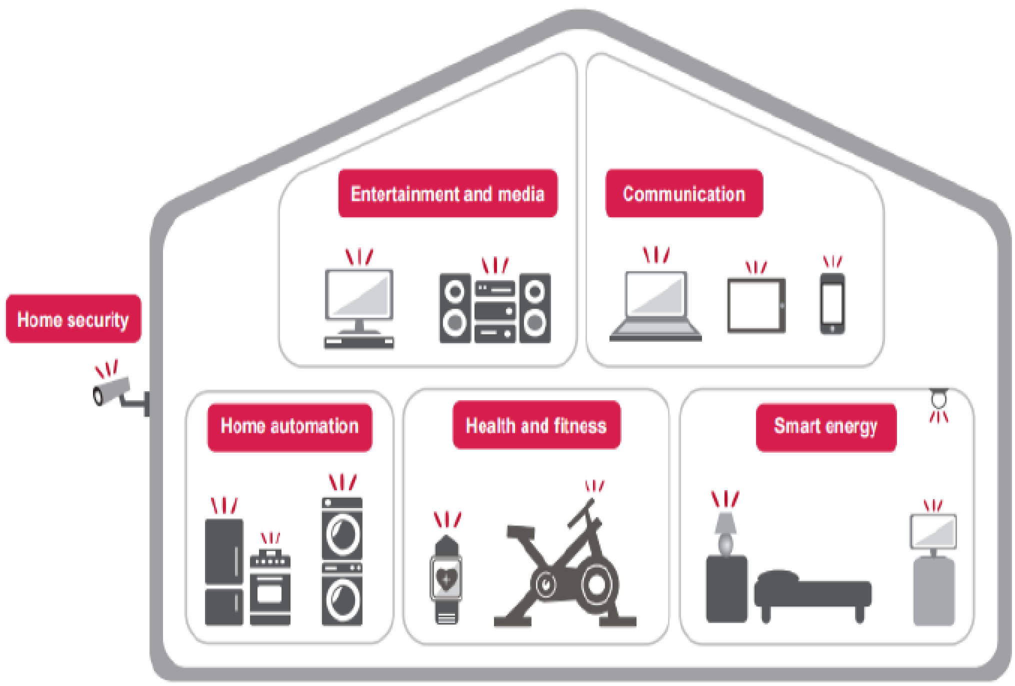
## Net Zero Energy Buildings

Net or nearly zero energy buildings (NZEBs) are highly efficient buildings with extremely low energy demand, which is met by renewable energy sources. Such buildings produce as much energy as they consume, accounted for annually. In order to achieve their net zero energy goals, NZEBs must first sharply reduce energy demand using energy-efficient technologies, and then utilize renewable energy sources (RES) to meet the residual demand. In such buildings, efficiency gains enable the balance of energy needs to be supplied with renewable energy technologies. This is the most logical approach to reach NZEB goal.[54]

## Smart home automation systems

A smart home is one that incorporates advanced sensing and automation systems to provide the inhabitants with monitoring and control regardless of whether they are inside or outside the home. For example, a smart home may have controls for lighting, temperature, multi-media, security, window and door operations, as well as many other functions.[55]

*Figure 9: An illustration of a smart home*




[53] Access to clean cooking energy and electricity – Survey of States (Sep 2015), CEEW
[54] Net Zero Energy Buildings, http://www.nzeb.in/definitions-policies/definitions/
[55] M2M/IoT enablement in Smart Homes (Mar 2017), TEC

### 3.2.4. Municipal

#### Supervisory control and data acquisition (SCADA)

This system can be applied to city water supply and sewage systems. In 2014, the Bangalore Water Supply and Sewerage Board (BWSSB) signed a contract with Yokogawa India Ltd to set up a SCADA system for monitoring the city's water supply network and wastewater systems. SCADA system maximizes the pump performance and can be utilized for the management of public waterworks in India.

#### Adaptive Lighting

Adding smart controls to street lighting can increase the energy efficiency yielding an additional saving of 15%–30% of energy. Adaptive lighting is the alteration of the output or duration of lighting in response to demand, real-world lighting conditions, or other parameters. There are various methods where adaptive lighting can be applied such as constant lumen output (CLO), lumens on the road (LOR), etc.

#### Central Control Monitoring System (CCMS)

A central control monitoring system (CCMS) is a system to remotely monitor the operation and utilization of street lights and to monitor the energy consumption. Groups of street lights are equipped with communication modules and energy-monitoring modules, which update the system. It monitors the voltage, current, power factor and cumulative kWh and kVAh.

### 3.2.5. Industrial

#### Chlor-alkali sector

The chlor-alkali sector has witnessed a shift in technological aspects, i.e. from the upgrade of mercury cell technology to the latest generation of membrane cell zero gap technologies. With the development of the ODC technology, it is expected to reduce the specific energy requirement of the process to as low as 1550 kWh/MT caustic soda.[56] Comparing this technology to that of the early mercury cell technology, the specific energy requirement is reduced to more than half of its predecessor technologies. Some of the significant energy-efficient technologies and best practices that can be adopted in the chlor-alkali sector are as follows:

- Upgrading to sixth-generation (zero-type) cell in electrolyser.
- Installation of back pressure turbine to eliminate throttling from HP to LP steam and recover power.
- Recovery of waste heat for process heating and/or power generation.
- Feeding of 48% caustic soda lye at 90°C directly to caustic concentration unit from caustic evaporation unit.
- Installation of VAM to recover waste heat from 48% CSL.

[56] Outcome evaluation study for PAT Cycle-1, BEE-GIZ

- Installation of screw chiller.
- Optimization of electrolyser for current consumption by monitoring cell voltages and replacing membranes in time.

### Fertilizer sector

The fertilizer industry in India, with the total production of about 38.6 million tonnes of fertilizer products, is second largest producer of fertilizers in the world. In PAT cycle I, 29 designated consumers located in various states had been identified and assigned mandatory energy reduction targets.

The 29 designated consumers that were considered under PAT cycle I were only ammonia/urea producers. A significant change in the sector has been the adoption of natural gas as feedstock of fuel oil and naphtha. This increased the efficiency of the plants by a good margin. Some of the plants were re-vamped to make use of natural gas as feedstock. This switch from fuel oil to natural gas has brought about a significant reduction in SEC. Some of the significant energy-efficient technologies and best practices that can be adopted in the fertilizer sector are as follows:

- Replacement of urea stripper with bi-metallic stripper, replacement of trays in urea reactor with high-efficiency trays, suction cooling of $CO_2$ compressor, installation of MP pre-decomposer for recovering heat from vapours of decomposer, installation of pre-concentrator before vacuum concentration section and HP urea hydrolyser.
- Vapour absorption refrigeration (VAR) to utilize low level heat to generate chilled water and using the same to reduce section temperature of air/process gas at suction of respective compressor, use of radial-axial flow converters, additional heat recovery from furnace flue gases and additional purification of synthesis gas.

### Cement sector

The Indian cement industry is one of the most energy-intensive industries, which has a robust growth trajectory over the past decade. India is the second largest cement producer as well as consumer in the world led by the enormous growth in the infrastructure and construction sector for the last two decades. Under the first PAT cycle, 85 DCs were notified and assigned mandatory energy reduction targets.

Some of the significant energy-efficient technologies and best practices that can be adopted by the cement sector are as follows:

- Installation of waste heat recovery systems.
- Installation of vertical grinding mills, VAM, high recuperation efficiency hydraulic cooler.
- Installation of high-efficiency screw compressor.
- Increasing the usage of AFR in the kiln, the number of stages of pre-heater.
- Installation of high-efficiency third generation air separator.

## Aluminium sector

The best specific energy-consumption figures for different process paths are mentioned below. The SEC values shown below are taken by considering the best practices implemented in that process per tonne of product in order to compare with various processes.[56]

*Table 17: Global versus Indian best practices in the aluminium sector*

| Production | Global Best | Global Average | India Average | India Best Numbers | Unit |
|---|---|---|---|---|---|
| **Alumina refinery** | 0.20 | 0.267 | 0.33 | 0.23 | TOE/tonne of alumina |
| **Aluminium smelting** | 113599 | 14145 | 14361 | 14558 | kWh/tonne of molten aluminium |

Some of the significant energy-efficient technologies and best practices that can be adopted by the aluminium sector are as follows:

- Implementation of slotted anode in pots.
- Reduction in stub to carbon voltage drop.
- Eco-contact to reduce voltage drop at conductor joints.
- Use of self-developed fuel "CRYSTAL" additive for dozing inside the furnace.
- Intelligent soot blowing system, installation of VFD and highly efficient screw compressor.

## Iron and Steel sector

The iron and steel sector in India is on an upswing because of the strong global and domestic demand. In 2015–16, India produced 90 MT of crude steel and attained the position of third largest steel producer in the world, after China and Japan. The best specific energy consumption in the world achieved in the world by a plant is 5.38 GCal/tcs. The best specific energy consumption of Indian plant is 5.67 GCal/tcs in FY 2016–17. Some of the significant energy-efficient technologies and best practices that can be adopted by the iron and steel sector are as follows:

- Use of 100% pellets as iron burden reduces coal consumption, improves better metallization of pellets, reduces fines generation and iron ore loss and improves work environment.
- High top pressure blast furnace also provides an ideal opportunity for recovering energy from the large volumes of pressurized top gas. TRT can be used to generate electricity from this high top pressure.
- Waste heat recovery from DRI process reduces massively the need for external fuel like coal for generating the same amount of electricity.
- Direct rolling of hot continuous cast billet to produce TMT bars and, therefore, completely avoid uses of furnace oil in reheating furnace.

- Insulation of hot surface in after burning chamber and dust settling chamber in 500 TPD kiln. Surface to be covered with rockwool and GI sheet cladding to reduce hot surface temperature from 150°C to 60°C.

### Paper and pulp

The Indian paper and pulp sector accounts for about 3% of the world's production of paper. The paper and pulp sector has been categorized on the basis of raw materials usage: wood-based units, agro-based units, recycled-fibre-based units and 100% market-based pulp. Presently the shares in the production of paper from wood-based raw materials, agro and recycled/waste paper are 31%, 22% and 47%, respectively. Some of the significant energy-efficient technologies and best practices that can be adopted by the paper and pulp sector are as follows:

- **Chemical pulp mill:** Lime kiln oxygen enrichment, carbon dioxide washing aid, digester blow heat recovery system, use of pulping aids to improve yields.

- **Paper machine:** Use of dryer bars and stationary siphons in rimming dryers, use a dryer management system, wet dry end broke surge tanks, variable speed thick stock basis weight control, paper machine hood heat recovery.

- **Utility plant:** Black liquor in recovery boiler, modified soot blower operation, distributed boiler control system, recovery heat from boiler blow down and upgraded boiler burner.

### Textile sector

India's textile industry has been predominantly cotton-based since its inception with about 65% of fabric consumption in the country being accounted for by cotton. Some of the significant energy-efficient technologies and best practices that can be adopted by the textile sector are as follows:

- Use of variable speed drives in humidification plants and optimization of blade angle and their types matches with efficient operation, approach for direct drive instead of belt drive.
- Installation of photo cells for speed frames.
- Use of electromagnetic ballasts instead of conventional electromagnetic chokes.
- Reuse of condensate and recovery of heat from hot water.

### Thermal power plant

The thermal power sector is one of the most energy-intensive industries and was one of the eight sectors that contributed to about 46% of the total savings target under PAT cycle I. For the overall thermal power sector, the number of cold/warm start-up has increased by almost one-third and the number of hot start-ups has reduced by 23%. The variation in the number of cold/warm/hot start-ups can be attributed to various factors:

- Decreasing PLF of the power sector/load scheduling.
- Resource unavailability (fuel, water, etc.).
- Environmental compliances.
- Surplus electricity resulting in lower peak demands, hence, decreased hot start-ups.

Also, over the past years, there has been a decrease in the consumption of liquid and gaseous fuels, while the consumption of imported coal has doubled. Some of the significant energy-efficient technologies and best practices that can be adopted by the thermal power plant sector are as follows:

- Dynamic coal balancing.
- Intelligent soot blowing system.
- Installation of vapour absorption machines (VAM).

## 3.2.6. MSME

### Cross-sector technologies

The technology drivers that are most probable to find cross-sector applications are listed below:

*Table 18: Technology drivers in MSME*

| Sr. No. | Technology | Energy-Saving Potential | Cross-sector Applicability |
|---|---|---|---|
| **1** | Installation of VFD on motors | High | High |
| **2** | Improvement of insulation in thermal systems | High | High |
| **3** | Energy-efficient pumping | High | High |
| **4** | Installation of energy-efficient boilers | High | High |
| **5** | Energy-efficient compressed air systems | High | High |
| **6** | Energy-efficient cooling towers | Medium | High |
| **7** | Waste heat recovery in furnaces, ovens, etc. | High | High |

In addition to above technologies, there are several futuristic technology drivers involving industrial IoT and Industry 4.0, which also have cross-sector applications. They are:

- Rapid prototyping.
- Artificial intelligence/machine learning.
- Robotics.
- Digital traceability.

### Sector-specific technologies

Sector-specific technologies are unique to respective sector and industrial processes. A list of key technologies for the key energy-intensive sectors in presented below.

### Foundry

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| **1** | Lid mechanism for induction furnace | Energy-efficient induction melting furnace with energy meter |

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 2 | Replacing cooling tower fan blades from aluminium to fibre reinforced plastic (FRP) | Replacing inefficient conventional cupola by induction furnace |
| 3 | Conversion to divided blast cupola | Induction ladle refining furnace |

### Forging

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 1 | Fuel switching from furnace oil to natural gas for forging furnaces | Replacement of existing FO-fired furnace with energy-efficient induction billet heater |
| 2 | Application of veneering module at LPG-fired normalizing furnace | Installation of microprocessor-based pneumatic clutch-operated, screw friction presses |

### Engineering and auto-components

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 1 | PLC-based control system for furnace temperature control | CNC milling/turning/machining centres |
| 2 | Waste heat recovery in ovens and furnaces | Servo-controlled die-casting machines |

### Chemicals and pharma

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 1 | Optimization of excess air in natural-gas-fired boiler | Replacement non-IBR boiler with energy-efficient IBR boiler |
| 2 | Optimization of air circulation pattern of tray dryer to maximum utilization of the heat in the dryer | Replacement of conventional horizontal agitator system with energy-efficient agitator systems |
| 3 | Interlocking of blower with combustion cycle to avoid idle operation and residual heat loss | Flash dryers or rotary vacuum dryers (product drying) |

### Ceramics

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 1 | Improvement in insulation in kiln, spray dryer resulting in saving in fuel consumption | Preheating of input slurry of spray dryer through solar energy resulting in saving in spray dryer fuel consumption |
| 2 | Installation of recuperator in tunnel kiln thereby preheating combustion air from flue gas | Installation of natural gas turbine for electricity generation and use of exhaust flue gas of turbine in spray dryer |

**Plastics**

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 1 | Radiant barrel heater for moulding machines | Installation of all-electric (all-servo) based moulding machines |
| 2 | Accumulator controllers for hydraulic power packs | Microprocessor-controlled tape stretching lines |

**Steel re-rolling**

| Sr. No. | Energy-Efficient Retrofitting | Energy-Efficient Equipment/Replacement |
|---|---|---|
| 1 | Installation of hydraulic pusher for reheating furnace | Shell-in-shell type recuperator for reheating furnace |
| 2 | Modified coal-firing system with atomizing air | Installation of anti-friction roller bearing and universal spindles and couplings |

## *3.3. Analysis of Key Future Technologies*

This section covers a detailed analysis of key future technologies. In this section, each of the future technologies is analysed for their applications, impact on energy consumption, policy landscape, challenges in their uptake and recommendations for their promotion.

### 3.3.1. Electric vehicles

#### Overview

The automobile industry worldwide is gradually witnessing a transformation towards alternative fuel solutions such as electric vehicles (EVs). EVs represent one of the most promising pathways to increase energy security, reduce carbon emissions, and improve air quality. Accordingly, major investments, incentives and policies are being introduced globally to propagate the development, manufacturing and adoption of EVs. Some of key rationales for this transformation are as follows:

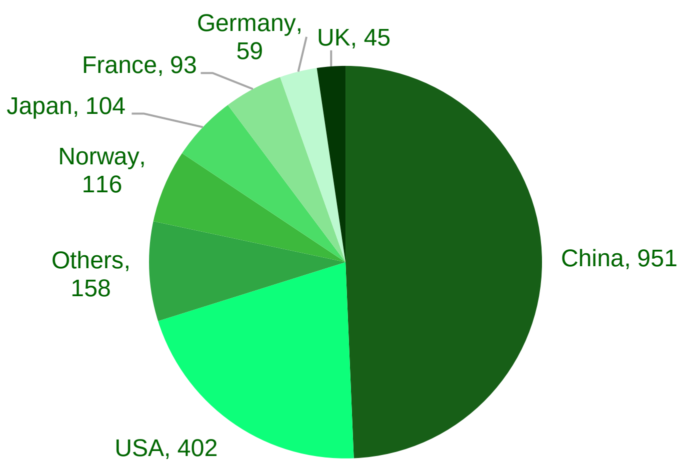
- Many Indian cities are among the world's most polluted, and vehicular pollution is a prime reason.
- India is obligated to bring down its share of global emissions and meets NDC targets by 2030.
- India imports 82% of its oil requirements and there is scarce availability of fossil fuels in India.
- India is estimated to spend USD 85 billion in FY 2018 on oil imports, and the automobile sector forms a bulk of this demand.

As per SIAM reports, the electric vehicle penetration would reach 30%–40% sales by 2030.[57] This would mean an electric load requirement of approximately 60 TWh by 2030.

#### Global Progress

India's EV industry is at a very nascent stage when compared with the other international markets. The early adopters of BEVs across the world include China, USA, Japan, Canada and the six leading European countries, which constitute 95% of the BEV population. There are approximately 1 million BEVs in China as of 2017.

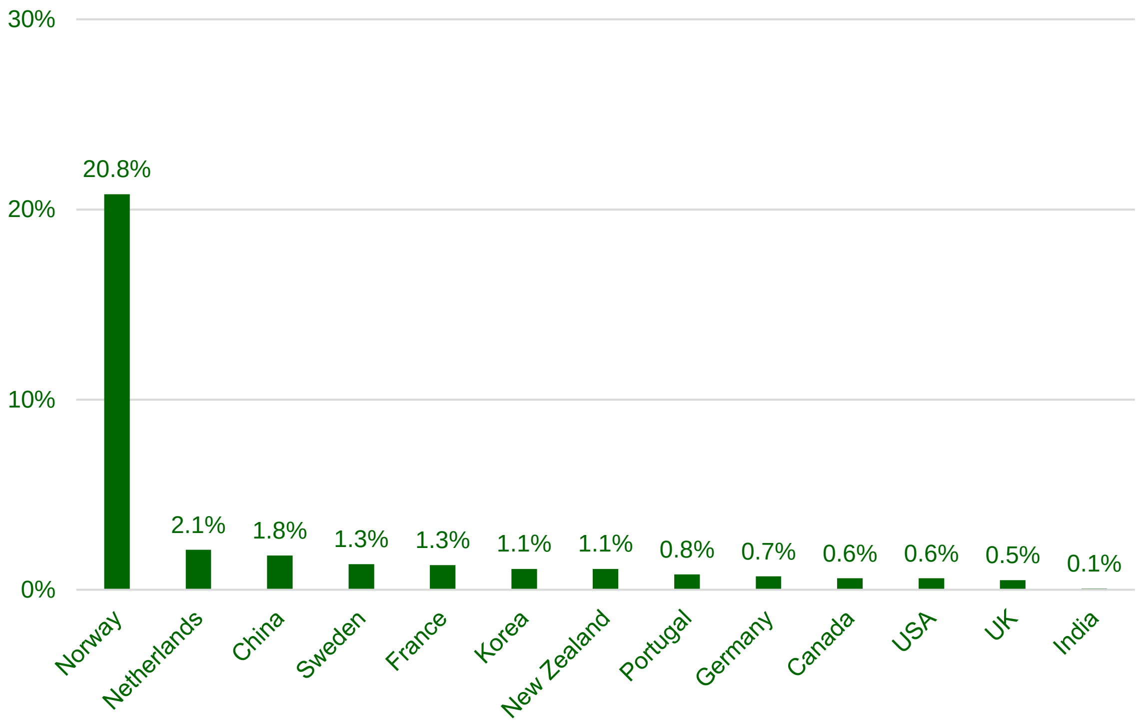
*Figure 10: BEV car stock by country (000s)*




The market penetration of BEVs is highest in Norway, wherein 21% of the total cars are BEVs. The market share of BEV cars in India as of 2017 is 0.1%.

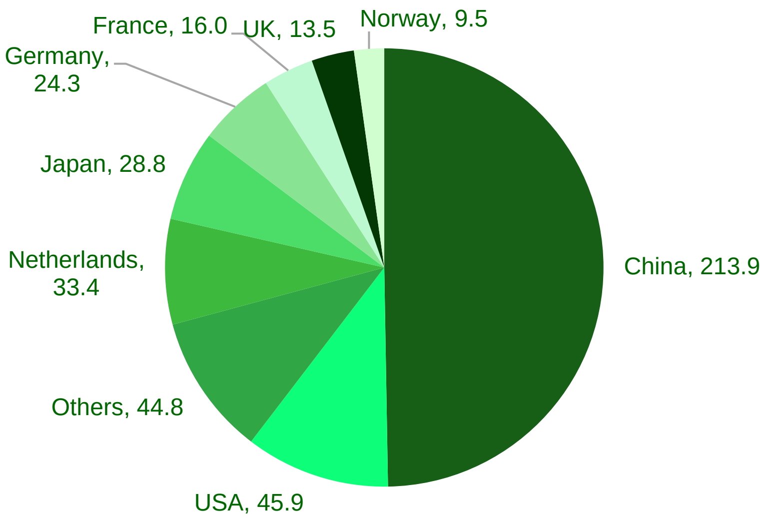
[57] https://auto.economictimes.indiatimes.com/news/industry/electric-vehicle-can-see-30–40-penetration-by-2030-siam/60468095

*Figure 11: Market share of BEV cars (%)*




China is a world leader in setting up of publicly accessible chargers with 213,900 chargers as of 2017. The number of publicly accessible chargers (slow and fast) in India is estimated to be 222 as of 2017.[58]

*Figure 12: Publicly accessible chargers by country—slow and fast (000s)*




[58] Global EV Outlook 2018 – IEA, https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/globalevoutlook2018.pdf

## Policy Initiatives

The key policy advancements over the years on the EV technology have been tabulated:

*Table 19: Key policy advancements in EV technology*

| Year | Initiative | Description |
|---|---|---|
| **2010** | MNRE initiative to promote EVs | India took an important step to promote electric vehicles (EVs) in 2010: The Ministry of New and Renewable Energy (MNRE) proposed a 20% capital subsidy for EVs that resulted in a big uptake, mostly in the e-bikes segment. |
| **2011** | National Mission of Electric Mobility (NMEM) by the Government of India | • To promote electric mobility through development and adoption of EVs<br>• Approval to set up National Council for Electric Mobility (NCEM) and National Board for Electric Mobility (NBEM)<br>• To form National Automotive Board (NAB) to provide technical advisory support |
| **2013** | National Electric Mobility Mission Plan 2020 (NEMMP 2020) by the Ministry of Heavy Industry | • Launch of NEMMP to achieve the following by 2020:<br>• ~7 million sales of EVs<br>• ~USD 2 billion savings in fuel<br>• ~1.3%–1.5% reduction in $CO_2$ emissions<br>• Generate ~60,000–65,000 additional jobs |
| **2015** | Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME) by the Ministry of Heavy Industries | • Launch of FAME India pilot phase<br>• Envisaged budget of Rs 7.95 billion (USD 122 million) across 2 years<br>• Allocation of incentives by technology/benefit<br>• Eligible vehicle categories: 2W, 3W, 4W, LCV, HCV and retrofit<br>• Restricted to major metros, capitals, Smart Cities, cities in north-eastern states |
| **2018** | 40% electric mobility sale by 2030 | Recent target suggested by SIAM, which seems practical and achievable |
| | Clarification released by MoP on charging of an EV | MoP has issued a clarification declaring that EV charging would not be considered resale/trading of electricity and hence, activity of setting up EV charging stations does not require any licence |
| | Technical and safety standards for charging stations | CEA has developed the draft technical and safety standards for charging stations and has uploaded on their website for public comments and opinions |
| **2018** | Guidelines for charging infrastructure for electric vehicles by MoP | • The guideline sets the minimum requirements for public charging infrastructure.<br>• The guideline also deals with the location of public charging stations with regard to density/distance between two charging points.<br>• The CEA has been identified as the agency to create and maintain a national-level database for all public charging |

| Year | Initiative | Description |
|---|---|---|
| | | stations through DISCOMs.<br>• The other issues that are highlighted in the guideline are: tariff for supply of electricity to EV public charging stations, service charges at PCS/BCS, priority for rollout of EV public charging infrastructure and implementation mechanism for rollout |
| **2019** | Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME) by the Ministry of Heavy Industry II | • An over 11-fold jump in the budgetary allocation for Phase II vis-à-vis Phase I (Rs 100 billion in Phase II spread over 3 fiscal years)<br>• Simplified demand incentives under Phase II as compared to FAME I, doing away with the baseline comparison (under Level 1 and Level 2) for each vehicle segment.<br>• Lead-acid batteries and vehicle retrofit becoming ineligible for incentives<br>• Priority given to public and commercial vehicle segments in offering demand incentives<br>• Linking demand incentives with vehicle battery size (kWh) and capping with the ex-factory price of a vehicle<br>• Removing geographic restriction. Earlier only metro cities, Smart Cities, state capitals and the ones with more than 1 million population were eligible for the incentives. |

Some of the recent public initiatives about EV technology includes:

- **FAME II Scheme:** DHI has issued a notification and extended the FAME I scheme with the introduced of the FAME II scheme in 2019.
- **National Agency for Charging Infra standards:** BEE has been appointed as the nodal agency for charging infrastructure standards by the Ministry of Power.
- **State-level policies that might come in 2018:** Gujarat, Telangana and Andhra Pradesh, states with an automobile manufacturing base, are working on EV policy in line with the Karnataka EV policy and might release it shortly.
- **Energy-Efficiency Services Limited (EESL) procurement:** EESL is aggregating demand for EV and EVSE and has released tenders for their bulk procurement. Phase 1 of the project is in its last stage and EESL is on its way to execute Phase 2.

*Table 20: EESL EV and EVSE deployment targets*

| EESL deployment targets | |
|---|---|
| **EV deployment** | EVSE Deployment |
| • **Phase I: 500 cars**<br>• **Phase II: 9500 cars** | • Phase I: 100 AC (slow chargers) and 25 DC (fast chargers)<br>• Phase II: 1800 AC (slow chargers) and 200 DC (fast chargers) |

- **No permits required for EVs to ply on roads:** EVs and alternative fuel run vehicles have been exempted from permit requirements.

### Barriers and Challenges in EV adoption

Despite the initiatives and policy reforms, the growth in the EV technology has been sluggish. The key barriers and challenges include:

- **High upfront capital cost:** The single major factor for slow penetration of EVs is their high price, which is around two times more than a comparable conventional vehicle. Most of the personal vehicle buyers consider upfront purchase price, fuel efficiency, maintenance and service cost, comfort features as the key buying criteria.

- **Charging time:** The charging time required to charge an EV is significantly high, i.e. 35–40 minutes for fast charging and 8 hours for slow charging compared to an ICE vehicle, i.e. 5 minutes.

- **Range per charge:** The other important concern of EVs is their range per charge. To offer a higher range, higher battery capacity in the vehicle is needed, which leads to increase in the EV price roughly proportionately and increases the price gap. This would, in turn, need more frequent charging, especially for commercial fleets where the vehicle would run for up to 200~250 km per day.

- **Lack of charging infrastructure:** A widespread and easily accessible charging network will be most crucial for mass adoption of electric vehicles to cater to the range anxiety of consumers.. Unlike conventional vehicles, which cannot be refuelled without dedicated fuelling infrastructure at designated locations, one of the positive aspects with electric vehicles is that these can be charged at many places like homes, workplaces, malls, parking spots etc. However, proper and suitable charging infrastructure will need to be in place at such locations. The number of charging points in the country as of 2017 is only 222. With the growth in the number of EVs and viable business models, businesses will be willing to set up and operate charging infrastructure.

- **Need for consensus on charging standards:** There is need to have consensus on the charging standards that would be adopted by India. Some of the various options available for adoption of charging standards in the country include CHAdeMO (Japan), Combined Charging Standard (CCS) (Europe and USA), GB/T (China) and Supercharger (Tesla Motors, USA). In India, Bharat Standards are being followed, which is highly influenced by GB/T fast-charging standards.

- **Lack of manufacturing base:** A world-class manufacturing base with a competitive strength in terms of scale, quality, cost and technology for electric vehicles and their critical components will be a must to achieve the stated goal of hundred per cent electric regime. However, very few auto OEMs in the country have set up an EV manufacturing base.

The biggest bottleneck to derive the cost down of EVs will be the battery pack or commonly called battery. Today, a pack forms on an average 40%–50% of the cost of a typical mass segment electric vehicle. The Indian companies do not manufacture battery packs, and these are imported. The other major cost components of the electric powertrain are electric drivetrain, viz. motor and motor controller, and power electronics, viz. inverter, on-board charger, DC/DC converter etc. These components form on an average 30%–35% of the cost of a typical mass segment electric vehicle. It will be imperative to have these components locally produced to reduce the cost of EVs and to create a sustainable manufacturing supply chain. The major constituents by value of the electric drivetrain and power electronics are:

| Motor, motor controller and inverter | Power distribution unit | On-board charger | DC/DC converter | Vehicle control unit |
|---|---|---|---|---|

The charging infrastructure manufacturing capacities of the companies are also not significant. One of the components of charging infrastructure that is not manufactured in India is connectors.

- **Lack of public awareness:** There is need to have consensus on the charging standards that would be adopted by India. Some of the various options available for adoption of charging standards in the country include CHAdeMO (Japan), Combined Charging Standard (CCS) (Europe and USA), GB/T (China) and Supercharger (Tesla Motors, USA). In India, Bharat Standards are being followed, which is highly influenced by GB/T fast-charging standards.

## *3.3.2. Smart meters*

### Overview

A smart meter is capable of communicating the real-time energy consumption of an electrical system in very short intervals of time to the connected utility. In electronic meters/electromechanical meters, the cumulative number of electricity units is recorded at the end of a month (or more), whereas a smart meter is connected to the utility, which is capable of transmitting the electricity usage on a real-time basis. Smart meters thus facilitate real-time pricing, automated recording of the electricity consumption and a complete eradication of errors due to manual readings and reduce labour cost and enable instant fault detection.

Smart meters are the heart of advanced metering infrastructure (AMI). AMI typically refers to the full measurement and collection system that includes meters at the customer site, communication networks between the customer and electric utility, data reception and management systems that makes the useful information available to these parties.

### Applications of a smart meter/AMI

The Central Electricity Authority (CEA) has recently (June 2016) specified the functional requirements of AMI in India along with detailed technical specifications for single- and three-phase whole current smart meters. As per these requirements, the AMI system should comprise the following core components and shall support the following minimum functionalities:

*Table 21: Functionalities of AMI*

| Core components of AMI | Minimum functionalities of AMI |
|---|---|
| • Smart meters<br>• Communication infrastructure<br>• Head end system (HES)<br>• Meter data management system (MDMS)<br>• Web application to view updated real-time data<br>• Mobile application to enable customer participation | • Remote meter data reading at configurable intervals (push/pull)<br>• Time of day (TOD)/TOU metering<br>• Pre-paid functionality<br>• Net meter billing<br>• Alarm/event detection, notification and reporting<br>• Remote load limiter and connection/disconnection at defined/on-demand conditions<br>• Integration with other existing systems like IVRS, billing and collection software, GIS mapping, consumer indexing, new connection and disconnections, analytics software, outage management system etc.<br>• Security features to prevent unauthorized access to the AMI |

It goes without saying that the AMI functional requirements stipulated by CEA support energy accounting, auditing, theft detection, outage detection, prepayment and several other important functions that will help address commercial losses, revenue assurance, reliability of supply, all of which are indispensable problems for Indian electric utilities in the foreseeable future. More importantly, AMI provides the platform for enhanced consumer engagement wherein the customers can take a more proactive role in managing their energy use and communicate their feedback to utility services. This will pave the way for enhanced DSM and also transform the dynamics of power supply industry as whole.

### Policy Initiatives for Smart Meters/AMI roll out in India

Smart meters are the heart of AMI and smart grid systems. In August 2015, the Bureau of Indian Standards (BIS), at the direction of the Ministry of Power (MoP), Government of India, published the new Smart Meter Standard, IS 16444: AC Static Direct Connected Watthour Smart Meter—Class 1 and 2 Specification covering single-phase energy meters; three-phase energy meters; single-phase energy meters with net metering facility and three-phase energy meters with net metering facility. Another standard, IS 15959: Data Exchange for Electricity Meter Reading, Tariff and Load Control — Companion Specification, was been revised and published as IS 15959: Part 2-Smart Meter in March 2016.

> According to Mr. Piyush Goel, Former Minister of State (Independent Charge) for Power, Coal and New and Renewable Energy, "India is close to implementing smart meters and at prices that will not pinch the pockets of consumers."

The MoP recently announced the government's vision to rollout smart meters on fast track for customers with a monthly consumption of 500 kWh and above in Phase 1 by December 2017 and for customers with monthly consumption of 200 kWh and above in Phase 2 by December 2019.[59] This is one of the salient goals envisaged for operational efficiency improvement of DISCOMs under the UDAY scheme, which is the largest ongoing power-sector reforms in the country. This goal is also reiterated in the recent National Tariff Policy Amendments announced by the MoP.

[59] Considering 20% metered consumers in India consume more than 500 units per month and MOP directive – Strategy for rollout of AMI in the states/UTs (Sep 2016), MoP

In addition to this, the Government of India has established the National Smart Grid Mission (NSGM), under the administrative control of the MoP, to achieve the smart grid developmental goals by adopting a coordinated and collaborative approach. The NSGM is primarily tasked with the development and implementation of smart grid pilot projects across the country. There are about 15 pilots initiated across the country, all of which aim to implement AMI with different functionalities as per the needs and priorities of the state. Also, the Forum of Regulators (FoR) published the Model Smart Grid Regulations in 2015 to initiate and regulate smart grid investments by India's electric utilities.

**Barriers and Challenges in Smart Meters/AMI adoption**

In the present scenario, the following are the challenges for smart meters/AMI rollout in India.

### Functionalities and Standards

- What functionalities and design should be adopted?
- Are the current standards comprehensive and relevant to Indian context?

### Economics

- Who will pay for the smart meter and rest of AMI? Utilities or third party?
- Poor financial health of DISCOMs
- Justification of business case? Quantification of benefits?
- Perceived impact on consumer bills

### Regulations

- Lack of smart grid regulations—targets for AMI roll out (despite the existence of Model Smart Grid Regulations, the state electricity regulatory commissions are yet to adopt this and notify comprehensive smart grid regulations)
- Data privacy—who all will have access to the meter data? What are norms for access?
- What are the cost recovery options? Should the DISCOM treat AMI traditionally as CAPEX (capital expenditure) or recover through on-bill charges from the beneficiaries only?
- Are there any options for "opt-out"? Will it be mandatory for consumers?

### Capacity and resources

- Manpower limitations for deployment, usage and management in the DISCOMs
- DISCOMs averse to complete outsourcing of AMI solutions

### Communications

- Limitations in last-mile connectivity (smart meter to DCU/HES)
- Is the license-free RF spectrum adequate considering massive roll out targets?
- Selection of last-mile communication technology?
- Interoperability standards to integrate AMI systems
- Communications is the Achilles Heel for successful utility-scale roll out of AMI in India.

### 3.3.3. Integration of Renewable energy in Industrial processes

#### Overview

A large scope exists for integrating solar energy in industries for process heat as well as for cooling requirements. After steam has been utilized in the process, through provisions for heat recovery, hot water can also be supplied for cleaning and other lower heat requirements.

Solar concentrators could produce high-temperature steam and heat through exchangers, which can be used in a variety of heat and applications and can provide an economically and environmentally friendly alternative to conventional fossil fuel technologies. General processes for various industries have been analysed. Comprehensive industry document series have been referred to for an in depth study of the general processes in various industries in this chapter.

#### Solar thermal applications in Industries

The heat produced from solar energy can be used for various industrial applications like process heating, drying, distillation/desalination, water heating, space heating, refrigeration and so on.

#### Textiles

Textile finishing requires hot water ranges (40°C to 110°C) at different stages of the process. The hot water of this range can easily be generated through the use of solar energy. Various solar technologies were identified, which can be used in different stages of the process to meet the hot water requirements. The recommended technologies are mentioned in the table below:

*Table 22: Solar mapping in textile finishing*

| Process | Type of Energy Required | Temperature Required (°C) | Recommended Solar Technology |
|---|---|---|---|
| **De-sizing** | Thermal | 60–90 | ETC |
| **Scouring** | Thermal | 90–110 | ETC/Concentrators |
| **Bleaching** | Electrical | — | Solar PV |
| | Thermal | 90–93 | ETC |
| **Mercerizing** | Electrical | — | Solar PV |
| | Thermal | 60–70 | FPC |
| **Dyeing** | Thermal | 70–90 | FPC |
| **Finishing** | Thermal | 40–100 | ETC |

#### Pulp and paper industry

This industry employs a lot of thermal processes that require high volumes of hot water and storage systems. Also there are other thermal processes that require significant process heat well below 250°C temperature. The preservation techniques that adopt various cooling applications also contribute to the significant portion of the heat energy consumed in this industry. Apart from these, there is also huge demand for drying applications, which are critical for processing the final products. A variety of solar drying systems can be very effective in reducing significant conventional energy consumption normally required for drying applications. The table below shows the mapping of solar energy technologies with the potential processes of this industry.

*Table 23: Mapping of solar technologies in paper and pulp industries*

| Process | Type of Energy Required | Application Media | Temperature Required (°C) | Recommended Solar Technology |
|---|---|---|---|---|
| **Debarking and chipping** | Thermal | Hot water | 40–60 | FPC |
| **Digesting and washing** | Thermal | Hot water | >90 | ETC, solar concentrators |
| | Electrical | | | Solar PV |
| **Pulping** | Thermal | Process heating | >120 | Solar concentrators |
| | Thermal | Boiler feed water | 70 | FPC |
| **Bleaching** | Thermal | Process heating: boiler feed water heating | 70 | FPC |
| | Thermal | Process heating: Steam | >120 | Solar concentrators |
| **Paper drying** | Thermal | Hot air supply | >120 | Solar air heating systems |

### Automobiles industry

The process sequence given above shows that only a few operations like machine shop and paint shops use significant thermal energy. The temperature requirement in machine shops is well beyond 300°C and in paint shops are <150°C. Therefore, solar thermal energy applications are more appropriate for use in paint shops for pre-treatment, drying and air-conditioning purposes. Solar photovoltaic technology may be applicable in the areas of press shop, body shop and assembly shops that operate on automated machines powered by electricity. An automobile manufacturing facility consumes approximately 4 litres of water per car mostly in the paint shop. The paint shop requires water of differing quality and temperatures. Hot water at 30–45°C is generally required for rinsing the body during pre-treatment. The table below shows the application for relevant processes in a paint shop.

*Table 24: Solar technology mapping in automobiles sector*

| Process | Energy/Fuel being used | Application Media | Temperature Requirement (°C) | Recommended Solar Technology |
|---|---|---|---|---|
| **Press shop—electric and pneumatic machines** | Electricity, compressed air | — | — | Solar PV system |
| **Body shop—electric and pneumatic machines** | Electricity, compressed air | — | — | Solar PV system |
| **Paint shop—pre-treatment** | Electricity and boiler fuels | Hot water | 40 | FPC |
| **Paint shop—air conditioning** | Electricity and boiler fuels | Hot/cold air supply | 5–50 | ETC-based chillers |
| **Paint shop—evaporation and drying** | Boiler fuels | Hot air supply | 80–100 | Solar air heating systems |

| Process | Energy/Fuel being used | Application Media | Temperature Requirement (°C) | Recommended Solar Technology |
|---|---|---|---|---|
| **Assembly shop—automated robots and machines** | Electricity, compressed air | — | — | Solar PV system |

## 3.3.4. Blockchain

### Overview

Blockchain can be defined as an open, transparent and decentralized database,[60] which forms a chain structure in which all transaction data are packed into blocks, and the blocks are connected in chronological order. There are multiple use cases that have been envisaged for the technology as it penetrates various sectors in the future like energy and utilities (smart utility metering system and decentralized energy data platform), financial services (anti-money laundering and P2P transactions), government and public services (land ownership records, tamper-proof voting records and digital identity of citizens), healthcare (storage of healthcare records and population health and clinic studies), etc.

Blockchain applications for energy offer the greatest breakthrough potential where there are rapid changes and emerging issues and there is alignment of energy sector trends with the core capabilities of Blockchain. The five core capabilities of Blockchain in the energy sector are as follows[61]:

*Table 25: Core capabilities of Blockchain in energy sector*

| Emerging Energy Sector Issues | Core Blockchain Capabilities | Promising Energy Sector Applications |
|---|---|---|
| Falling technology costs; decentralization; changing US energy supply system; evolving **grid control capabilities** | Decentralized systems can be self-administered; architecture sets permissions, regulated by rules-based system | Distributed energy resources |
| Vehicle electrification; falling battery costs; decentralization; **de-carbonization** | Enables "Smart" contracts for streamlining and automating contract terms (i.e. deposits, payments, proof of performance actions); removes need for trusted third parties; regulators and governments can observe or record details | Electric vehicle deployment |
| Decentralization; digitalization; changing US supply system; | Businesses partners can access records; removes need for trusted third parties; regulators and governments can observe or record details | Energy trading |

[60] Blockchain: Blueprint for a New Economy (2015) 1st ed.; O'Reilly: Farnham
[61] Promising Blockchain Applications for Energy: Separating the Signal from the Noise (Jul 2018), Energy Futures Initiative

| Emerging Energy Sector Issues | Core Blockchain Capabilities | Promising Energy Sector Applications |
|---|---|---|
| emerging global natural gas **markets** | | |
| De-carbonization; digitalization; changing US supply system; **evolving carbon markets** | Removes need for trusted third parties; regulators and governments can observe or record details; high process transparency and enforceability, opening access to emerging markets | Carbon tracking and registries |
| Global population growth; shifting global markets; **de-carbonization; electrification** | Supports digital payments; high process transparency and enforceability; opening access to emerging markets | Energy transactions for emerging markets |

## Global Progress

### Brooklyn Microgrid Project (TransActive Grid)

Since April 2016, an initial pilot project run in Brooklyn has been exploring how to integrate buildings equipped with distributed energy resource systems (in this case, solar energy) in a decentralized peer-to-peer power grid. The rooftop photovoltaic systems installed on five of the buildings participating in the neighbourhood project generate solar energy. All energy not used by the buildings themselves is sold to five neighbouring households. All buildings are interconnected through the conventional power grid, with transactions being managed and stored using a central Blockchain. This set-up demonstrates what a future distributed power-grid managed autonomously by a local community might look like.

### LO3 Energy: Exergy

The Exergy Project developed by the US-based company LO3 Energy is a research project aimed at heating homes using the heat generated in data centres. Heat generated from computing and the use of other electrical devices is to be captured and stored with the help of a technical module, in order to be reused in other applications. The concept builds on a storage system for thermal energy operating in conjunction with an interface directly delivering the heat to existing heating systems in homes. The system is supported by a Blockchain system, which allows participants to purchase (stored) heat via a cryptographically secured system.[62]

### RWE and Slock.it: Block Charge

The Ethereum-based start-up company Slock.it from Germany and RWE have launched two projects in which they are working to simplify the charging of electric vehicles. The first project explores how a Blockchain-based system integrating smart contract functionality can be used to charge electric vehicles. Blockchain technology can provide a common, simple and secure payment system in this

[62] http://lo3energy.com/projects/

context. The project's vision is for electric vehicles to interact automatically with charging stations to manage the billing process for the electricity received during a charging session. Ultimately, the project partners envisage that every car will have a chip with a cryptocurrency installed, which will permit the vehicle to autonomously manage the payment process for electricity. Slock.it and RWE are currently working on a prototype, which will undergo testing at a later stage.

## Applications

### Blockchain in distributed energy resources (DER)

Blockchain can help create a framework for improving visibility and control of DERs to meet increasingly complex grid operation needs as variable renewables and other DER are added to the electricity system. Blockchain, leveraged by DER entities, grid operators and utilities can create a trusted, secure system for managing the record, status and transaction of the distributed resources.[63] Distributed Energy Resource Management Systems (DERMS) can be available to analyse load behaviours and create pathways for optimizing the benefits of these aggregated resources.[64]

### Blockchain-based infrastructure for EV charging

The availability of EV chargers remains a key barrier to market penetration. In 2016, the number of electric vehicles on the road outnumbered publicly available chargers by more than six to one,[65] as most drivers rely on their own private charging systems. Estimates suggest that $2.7 trillion will need to be invested in charging stations to enable EVs to reach their forecast potential of over half a billion vehicles by 2040.[66] Blockchain's core technology—efficient and secure management of large volumes of transactions in distributed networks—coupled with the lack of a robust EV charging infrastructure and no accepted standard for billing, scheduling and payments software makes Blockchain a viable solution for EVs to "leapfrog" the build-out of a massive new wires network for managing transactions. Innogy, a subsidiary of Germany's largest utility, RWE, has already launched over 1200 charging stations supported by Blockchain.[67]

### Power trading based on Blockchain

Where individual Blockchain applications are combined, a decentralized energy transaction and supply system can become possible for the future. Energy that is generated in distributed generation facilities would be transported to end users via smaller networks. Smart meters would measure the amount of energy produced and consumed, while energy-trading activities and cryptocurrency payments would be controlled by smart contracts and executed through Blockchain.

Traders buy and sell energy on the exchanges, and banks act as payment service providers, handling the transactions made by the parties involved. Blockchain-based energy processes would no longer require energy companies, traders or banks (for payments). Instead, a decentralized energy transaction and supply system would emerge, under which Blockchain-based smart contract applications empower consumers to manage their own electricity supply contracts and consumption data.

## *Barriers and challenges in Blockchain adoption*

[63] Distributed Energy Resources – Connection, Modelling and Reliability Considerations (Feb 2017), NERC

[64] Blockchains for decentralized optimization of energy resources in microgrid networks, Eric Munsing

[65] Global EV Outlook 2017, IEA

[66] https://www.bloomberg.com/news/articles/2017–10–11/tesla-ev-network-shows-a-2–7-trillion-gap-morgan stanleysays? cmpid=socialflow twitter-business&utm_content=business&utm_campaign=socialfloworganic& utm_source=twitter&utm_medium=social

[67] Share&Charge, https://shareandcharge.com/en/

**Regulatory uncertainity**

- The energy sector is heavily regulated with detailed requirements flowing from a mix of consumer, competition, safety and other concerns, affecting all parts of the value chain. If Blockchain is to reach its full potential, greater coordination between regulators may play an important role.

**Technological uncertainity**

- A key issue is that Blockchain remains at a relatively early stage of development with most projects still at the pilot stage. Proof of concepts is only just being carried out and is still limited in scope. Rival technologies are also emerging, which their proponents claim could have leapfrog potential, overcoming potential limitations of Blockchain.

**Cyber security**

- Blockchain has not been immune to security concerns, most notably with the DAO (Distributed Autonomous Organization) hack. Based on Ethereum, the DAO had the ambition of creating a humanless venture capital firm that would allow the investors to make all the decisions through smart contracts. Launched in April 2016, it raised a reported USD 150 million but a few months later, in June 2016, it was hacked and approximately USD 60 million was diverted into the hacker's account.

**Integration with legacy systems**

- One of the key challenges for companies considering blockchain is to assess its value over existing alternatives and to also assess how it can integrate with existing systems. It is important that when making choices about blockchain technology that companies consider how it will integrate with the current architecture, and make the appropriate product selections and designs in accordance with this.

### *3.3.5. Decarbonizing industrial processes*

#### Overview

The industrial sector accounts for a lion's share of global GHG emissions. From 1990 to 2014, the overall increase in direct GHG emissions from this sector was a whopping 70%, which comes to 2.2% per year on average. This was faster than the increase in global GHG emissions, which was comparatively 30%, or 1.1% per year on average. Direct GHG emissions from industrial processes, along with indirect GHG emissions resulting from the generation of electricity used by industry, accounted for 28% of global GHG emissions in 2014.[68]

In 2014, $CO_2$ emissions were the maximum contributor to GHG emissions from industrial processes. The other 10% comprised methane (e.g. from black carbon production), fluorinated gases (used in refrigeration) and nitrous oxide (e.g. from the production of glyoxylic acid and nitric acid).

#### *Scope of technological interventions in the sector along with applications*

Innovation strategies in the industrial sector is predominantly shaped by the structure of the sector. With little room for product differentiation in the bulk basic materials segment, industries rely mostly on process innovation. These process innovations tend to follow predefined technological trajectories through incremental innovation aimed at enhancing productivity. Through learning by doing, the engineers operating the factories generate incremental process innovations that trigger partial

[68]https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability%20and%20resource%20productivity/our%20insights/how%20industry%20can%20move%20toward%20a%20low%20carbon%20future/decarbonization-of-industrial-sectors-the-next-frontier.a

reinvestments. A broad overview of the various low-carbon innovation technologies in various subsectors are mentioned below[69]:

*Table 26: Broad overview of low-carbon innovation technologies in various subsectors*

| Sector | Technology | Incremental or Radical Innovation and Technical Description | | Benefits | Bottlenecks |
|---|---|---|---|---|---|
| **All sectors** | Carbon capture and storage (CCS) | Incremental | Typical end of the pipe technology, can be incremental, but typically needs significant additional space and technology, which can make it radical; needs infrastructure to transport captured $CO_2$ | Less $CO_2$ emissions | Additional energy demand, costs, infrastructure, acceptance by local public |
| | Material efficiency and recycling | Incremental | Reduce the (primary) material intensity of supplying material services through improved product design, product reuse, high-quality recycling and different business models | Resource efficiency and less $CO_2$ emissions | Low resource versus high labour costs, traditional supply chain organization |
| **Iron and steel** | Recirculating blast furnace and CCS | Radical | Currently under R&D, needs high integration into existing plants, which might need major changes in plant/site set-up | Less $CO_2$ emissions | Higher energy demand, costs, infrastructure, acceptance |
| | Smelt reduction and CCS | Radical | Makes obsolete coke ovens, blast furnace (BF) and basic oxygen furnace (BOF) of conventional steel factories | Less $CO_2$ emissions | Costs, infrastructure, acceptance |
| | Direct reduced iron (DRI) with $H_2$ | Radical | Makes obsolete coke ovens, BF and BOF of conventional steel factories, but is combined with electric arc furnace; needs $H_2$ supply infrastructure | Less $CO_2$ emissions with potentially excess electricity converted to $H_2$ | Costs, infrastructure and technology |
| | Electro | Radical (at | Makes obsolete coke ovens, BF and BOF of | Less $CO_2$ | Only available in lab; low coal/$CO_2$ |

[69] How to decarbonize energy intensive processing industries (2016), Proceeding ECEEE Industrial Efficiency

| Sector | Technology | Incremental or Radical Innovation and Technical Description | | Benefits | Bottlenecks |
|---|---|---|---|---|---|
| | winning | very early stage of developme nt) | conventional steel factories, needs large electricity supply; technology only on lab scale available | emissions with lower capex | prices and high electricity prices |
| **Aluminium** | Advanced (inert) anodes | Incremental | Technology development necessary | Less $CO_2$ emissions with lower energy demand | Availability of technology, research needed |
| **Chemicals** | Advanced steam crackers and CCS | Incremental | Advanced furnace materials, gas turbine integration, use of membrane technology for separation, catalytic cracking | Less $CO_2$ emissions | Costs, infrastructure, acceptance |
| | Electro plastics (with RES-methane) | Incremental | Needs conversion to bio- or electricity-based feed stocks (and respective supply infrastructures) | Less $CO_2$ emissions (depending on RES share) | Costs, availability of renewable electricity and hydrogen |
| | Electro plastics (with Fischer–Tropsch) | Radical | Needs integration into existing plants to use excess heat | Less $CO_2$ emissions (depending on RES share of electricity) | Costs, availability of renewable electricity and hydrogen |
| | Bio-based polymers | Radical | New process technologies, new feedstock (with limited experience at most companies), may need new platform chemicals | Less $CO_2$ emissions with partially new properties | Relative high costs of biomass, economies of scale |
| **Cement** | Geo polymers | Radical | Requires a new way of making cements with different input materials | Less $CO_2$ emissions | Requires new resource streams; unproven long-term performance; stringent norm compliance |
| | Self-healing concrete | Radical (requires change in | Requires new production techniques to manage bacteria that regenerate concrete to enhance | Less $CO_2$, longer durability, lower | Requires new resource streams; unproven long- |

| Sector | Technology | Incremental or Radical Innovation and Technical Description | | Benefits | Bottlenecks |
|---|---|---|---|---|---|
| | | production techniques and systems) | durability | cost long term | term performance; stringent norm compliance |
| | CCS | Incremental | End of the pipe technology; needs infrastructure to transport captured $CO_2$ | Less $CO_2$ emissions | Cost |
| **Paper and pulp** | CCS | Incremental | End of the pipe technology; needs infrastructure to transport captured $CO_2$ | Less $CO_2$ emissions | Cost |
| **Refinery and petrochemicals** | Biorefinery development | Radical (at very early stage of development) | Biorefineries could potentially replace refineries. Biorefineries can merge with paper and pulp industry | Less $CO_2$ emissions | Feedstock availability and cost (competition for biomass) |
| | Electro fuels/plastics | Radical (at very early stage of development) | Fuels and chemicals can be replaced with electricity and $CO_2$-based solutions. Might also merge with biorefinery | Less $CO_2$ emissions | Electricity cost |
| | CCS | Incremental | End of the pipe technology; needs infrastructure to transport captured $CO_2$ | Less $CO_2$ emissions | Cost |

***Barriers and Challenges in decarbonizing industries***

**Iron and Steel**

- At present, iron ore sinter tends to be favoured in hot metal production as it is cheaper than pelletised iron ore and attracts higher levels of free allocation even though it is more polluting than pelletised iron ore.
- Uncertainty over energy prices, price visibility over a long period and the degree of protection from indirect carbon cost are considered to be important factors in low carbon investment
- There is limited access to infrastructure for additional energy, hydrogen and CCS required to decarbonize the sector. Industry is not in a position to develop the necessary infrastructure.

**Cement**

- The lack of a carbon price signal in cement sales prices due to the modest net $CO_2$ cost in cement production provides no incentive to consume cement with a lower carbon footprint.
- There is a lack of readily deployable $CO_2$ mitigation technologies. Carbon capture technology is currently being piloted only at a handful of cement plants.

**Glass**

- There is a lack of alternative materials to glass: Most flat glass products cannot be substituted, and polycarbonate glass, for example, is prohibitively expensive.

## 3.4. Conclusion

A brief mapping of sector-wise future technologies and a detailed analysis of various key future technologies are presented in this chapter. As a result of these prospective technologies, the energy demand would witness transformation. Going forward, there should be introduction of enabling mechanisms in the market that could steer these technological changes. Recommendations that could accelerate the adoption of some of the key technologies are also presented.

4

# ESTIMATION OF ENERGY SAVING POTENTIAL

## 4.1. Introduction

The primary energy demand and supply as well as the electricity demand and supply for the country as a whole and individual states have been defined in Chapter 1. However, the various policies and programmes discussed in the previous chapter have an impact on the energy demand, which have been incorporated while developing the dynamic model (to be discussed in the next chapter), and energy-efficiency potential for each of the demand sectors has been estimated based on three scenarios, which are mentioned below:

*Table 27: Scenarios for energy-demand calculation*

| Assumptions by 2031 | Technological improvement and penetration | Policy/programme/ scheme initiatives | Change in fuel mix |
|---|---|---|---|
| **Scenario 1: BAU** | Current technological improvements and penetration | Current implementation of programmes | Current fuel mix |
| **Scenario 2: Moderate** | Moderate technological improvements and technology penetration as per government/other agencies target | Successful achievement of programme targets | Moderate fuel mix shift from fossil fuel to RE/electricity-based consumption |
| **Scenario 3: Ambitious** | Ambitious technological improvements and penetration over government/other agencies target | New programmes or overachievement of existing programmes | Ambitious fuel mix shift towards RE-based consumption in sector |

The moderate savings scenario is the incremental savings in energy consumption achieved in the moderate scenario over the BAU case, whereas the ambitious savings scenarios is the incremental savings in energy consumption achieved in the ambitious scenario over the moderate case.

*Table 28: Energy consumption by 2031*

| Energy Consumption (Mtoe): 2031 | | | |
|---|---|---|---|
| **Sectors** | **BAU Scenario** | **Moderate Scenario** | **Ambitious Scenario** |
| Agriculture | 64.4 | 58.7 | 54.5 |
| Commercial | 29.5 | 24.5 | 23.1 |
| Domestic | 98.6 | 86.5 | 83.5 |
| Municipal | 8.0 | 7.0 | 6.4 |
| Industrial | 443.4 | 396.0 | 371.2 |
| Transport | 232.9 | 217.2 | 209.1 |
| **Total** | **876.8** | **789.9** | **747.8** |

*Table 29: Electricity consumption by 2031*

| Energy Consumption (Mtoe): 2031 | | | |
|---|---|---|---|
| **Sectors** | **BAU Scenario** | **Moderate Scenario** | **Ambitious Scenario** |
| Agriculture | 214 | 229 | 239 |
| Commercial | 343 | 286 | 269 |
| Domestic | 769 | 641 | 631 |
| Municipal | 93 | 82 | 75 |
| Industrial | 946 | 857 | 797 |
| Transport | 90 | 166 | 183 |
| **Total** | **2455** | **2261** | **2193** |

*Table 30: Energy-savings potential by 2031 (in Mtoe)*

| Energy Savings (Mtoe): 2031 | | | | |
|---|---|---|---|---|
| **Sectors** | **Moderate Savings Scenario** | | **Ambitious Savings Scenario** | |
| | **Mtoe** | **%** | **Mtoe** | **%** |
| Agriculture | 5.7 | 9% | 9.9 | 15% |
| Commercial | 4.9 | 17% | 6.4 | 22% |
| Domestic | 12.1 | 12% | 15.1 | 15% |
| Municipal | 0.9 | 12% | 1.5 | 19% |
| Industrial | 47.5 | 11% | 72.3 | 16% |
| Transport | 15.8 | 7% | 23.8 | 10% |
| **Total** | **86.9** | **10%** | **129.0** | **15%** |

*Table 31: Electricity savings by 2031 (in TWh)*

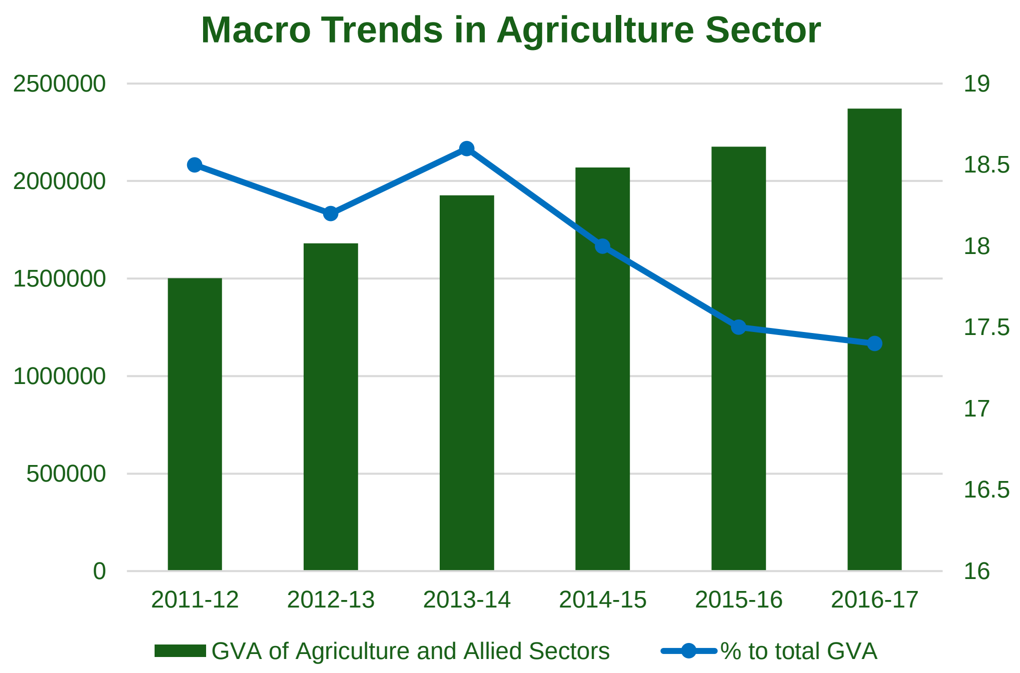
| Electricity Savings (TWh): 2031 | | | | |
|---|---|---|---|---|
| **Sectors** | **Moderate Savings Scenario** | | **Ambitious Savings Scenario** | |
| | **TWh** | **%** | **TWh** | **%** |
| Agriculture* | — | — | — | — |
| Commercial | 57 | 16% | 74 | 21% |
| Domestic | 128 | 16% | 138 | 17% |
| Municipal | 11 | 12% | 18 | 19% |
| Industrial | 89 | 9% | 149 | 15% |
| Transport* | — | — | — | — |
| **Total** | **285** | **11%** | **379** | **15%** |

**Note: Under moderate as well as ambitious scenarios, the transport and the agriculture sectors would shift from primary sources of energy and move towards electricity, resulting in an increased electricity usage in these sectors. This would result in zero electricity savings and only primary energy savings in these sectors.*

## 4.2. Agriculture

Agriculture has always played an important role in India's economy and continues to do so, with 54.6% of the population being engaged in agriculture and allied activities and its contribution of 17.4% to the country's Gross Value Added (GVA) in 2016–17 (current prices).[70]

Given the importance of agriculture sector, the Government of India took several steps for its sustainable development. Steps have been taken to improve soil fertility on a sustainable basis through the soil health card scheme, to provide improved access to irrigation and enhanced water efficiency through Pradhan Mantri Krishi Sinchai Yojana (PMKSY), to support organic farming through Paramparagat Krishi Vikas Yojana (PKVY) and to support for creation of a unified national agriculture market to boost the income of farmers. Further, to mitigate risk in the agriculture sector, a new scheme "Pradhan Mantri Fasal Bima Yojana" (PMFBY) was launched for implementation from 2016.




[70] Annual Report 2016–17, Ministry of Agriculture

## Policy and Programme advancements in the sector

**Agriculture Demand-Side Management (AgDSM)**

The objective of the programme is the replacement of inefficient agricultural pumps with BEE star-rated pumps across India.

**National Mission on Sustainable Agriculture (NMSA)**

NMSA caters to the key dimensions of "water use efficiency", "nutrient management" and "livelihood diversification" through adoption of sustainable development measures and gradually shifting to environmental friendly technologies.


**National Innovations on Climate-Resilient Agriculture (NICRA)**

The programme, spearheaded by ICAR, works towards the enhancement of resilience of Indian agriculture to climatic variability and climate change through research on adaptation and mitigation.

**Kisan Urja Suraksha Evam Utthaan Mahabhiyan (KUSUM)**

The programme focusses on the penetration of solar pumps for making farmers independent of grid supply and also enable them to sell surplus solar power generated to DISCOMs to generate extra income.

**National Mission on Agricultural Mechanization (NMAM)**

The programme focusses on enhancing farm productivity at village by introducing appropriate farm mechanization and establishment of farm machinery banks for custom hiring.

## Results under moderate and ambitious savings scenarios

| Sector | Moderate Savings 2031 | | Ambitious Savings 2031 | |
|---|---|---|---|---|
| | Mtoe | % | Mtoe | % |
| **Agriculture** | **5.7** | **9%** | **9.9** | **15%** |

| Sector | Moderate Savings 2031 | | Ambitious Savings 2031 | |
|---|---|---|---|---|
| | TWh | % | TWh | % |
| **Agriculture*** | **—** | **—** | **—** | **—** |

**Note: The agricultural sector would see a significant shift from diesel pumps usage to grid-connected pumps under the moderate and ambitious scenarios, resulting in an increased electricity usage and hence zero savings.*

| Sector | GHG Emission Savings—Moderate Scenario (MtCO2e) | GHG Emission Savings—Ambitious scenario (MtCO2e) |
|---|---|---|
| **Agriculture** | 14 | 34 |

## 4.3. Transport

The transport sector of any country works as the backbone of the nation's economy. A good transport infrastructure is crucial for the socio-economic development of the country. India's transport network is vast and diverse comprising 5,603,293 km and 115,000 km of track over a route of 65,000 km with 7500 railway stations, geographically connecting the country along its length and breadth.

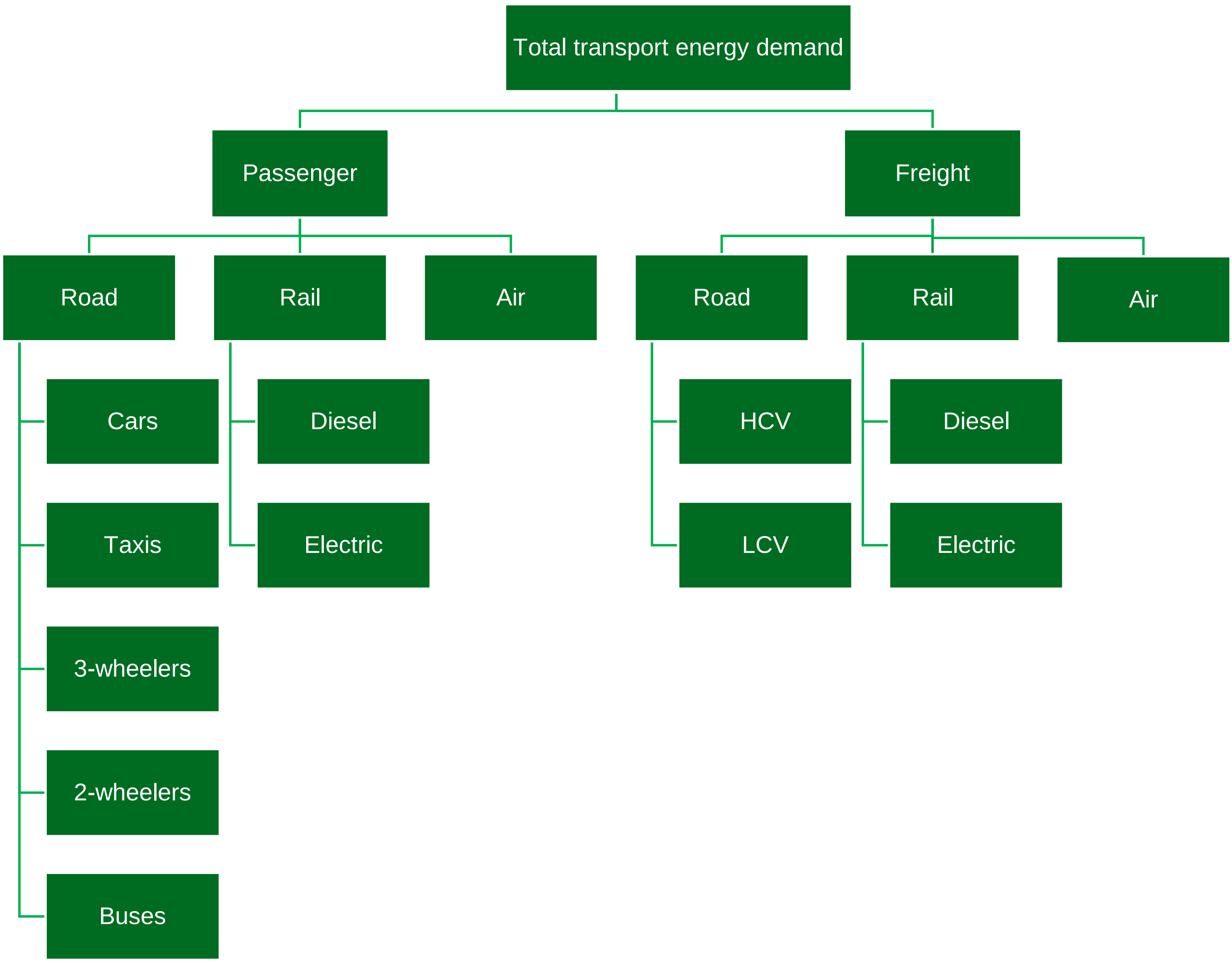
India also has an established aviation industry with the government-owned Airports Authority of India (AAI) operating 126 airports and civil enclaves out of a total of 449 airports and airstrips located throughout India. Around 80 airports/aerodromes receive regular commercial flights. The cities of

Delhi, Hyderabad, Kochi, Bengaluru and Mumbai are served by privately (or joint-venture) operated airports. Airports in India handled 295 million passengers in 2017. India is the fifth largest civil aviation market in the world behind the USA, China, Japan and the UK.

The stock of road length in India was reported at 56.03 lakh km as on 31 March 2016, out of which 62% were surfaced road. Various road development programmes of recent past have yielded significant expansion of quality road network in India. Expansion of the National Highways has been remarkable as it increased from 70,934 km in 2010–11 to 101,011 km in 2015–16, recording an annual growth rate of 7.3%.[71]

For the purpose of calculating the energy demand of the transport sector, the sector has been divided into two basic components: passenger and freight sectors. These sectors have been further subdivided as shown in the figure below:

*Figure 13: Total energy-demand distribution in transport sector*




[71] Road Transport Yearbook 2015–16, MoRTH

## *Policy and programme advancements in the sector*

**Green Urban Mobility Scheme, 2017**

The three tenets of the programme include sustainable green urban mobility, sustainable vehicle and fuels and focus on projects demonstrating reduction in GHG emissions.

**National Electric Mobility Mission Plan 2020**

Formulated in 2013, the NEMMP 2020 programme aims to promote hybrid and electric vehicles through implementation of the FAME scheme under NEMMP.

**Metro Rail Polcy 2017**

Mass rapid transport systems tend to reduce per capita vehicle ownership and usage. The metro rail policy lays down regulatory norms to be follwed by cities to build metro.

**Dedicated Freight Corridors (DFC)**

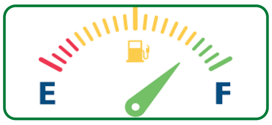
The DFC is a strategic initiative to augment rail capacity across the major trunk routes in India. The initiative also has major implications for achieving emission reductions.


**National Policy on Biofuels, 2018**

The policy looks to ensure that a minimum level of biofuels becomes readily available in the market to meet the demand at any given time.


**Sagarmala**

The four major components of the programme include port modernization, port connectivity enhancement, port-linked industrialization and coastal community development.




**Fuel efficiency standards**

The rolling out of the proposed BS VI standards are far fetching in scope and incorporate substantial changes to BS III and BS IV emission standards.

## *Results under moderate and ambitious savings scenarios*

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | Mtoe | % | Mtoe | % |
| **Transport** | **15.8** | **7%** | **23.8** | **10%** |

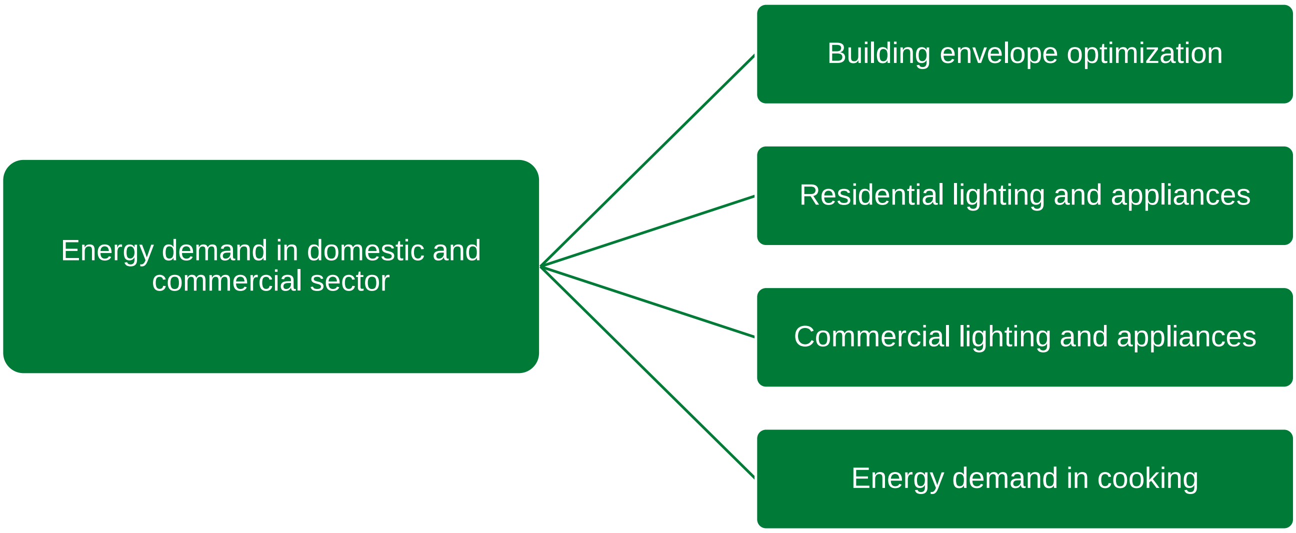
| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | TWh | % | Mtoe | % |
| **Transport** | — | — | — | — |

**Note: A gradual shift towards e-mobility and shared mobility solutions would increase the electricity consumption in the sector considerably, leading to savings from only primary energy sources.*

| Sector | GHG Emission Savings: Moderate Scenario (MtCO2e) | GHG Emission Savings: Ambitious Scenario (MtCO2e) |
|---|---|---|
| **Transport** | 97 | 141 |

## 4.4. Domestic and Commercial

The energy demand in domestic and commercial sectors has been broken down into three subcategories on the basis of energy usage: building envelop optimization, residential lighting and appliances and commercial lighting and appliances.




**Building envelope optimization:** The building envelope is the skin of a building, which is supported by the skeleton of the building structure. It acts as a thermal barrier between the enclosed conditioned space and outside environment through which the thermal energy is transferred. By minimizing the heat transfer through the building envelope, the need of energy used for space heating and cooling can be reduced considerably. Hence by judicially designing the building envelope parameters, i.e. orientation, shape, walls, fenestrations, shading device and roof, the HVAC load can be reduced in commercial buildings.

**Commercial lighting and appliances:** Energy-consuming equipment in the commercial sector includes lighting, heating, ventilation and air conditioning (HVAC) and other office-related equipment. HVAC is responsible for the greatest share in electricity consumption, and its demand is primarily from air conditioning. Lighting loads represent the second highest consumption category. The "Others" category comprises internal loads such as servers, service-specific machines and equipment, etc.

**Energy demand in cooking:** According to the World Energy Outlook report,[72] 819 million people in India use traditional biomass cook stoves for their cooking needs. Access to clean cooking energy has the transformative potential to curb the health risks posed by traditional cook stoves while also reducing the time spent by women on unpaid domestic work. For over three decades, successive central and state governments in India have made efforts to increase the penetration of clean cooking energy solutions like liquefied petroleum gas (LPG), improved biomass cook stoves (ICS), biogas plants and piped natural gas (PNG), among others.

**Residential lighting and appliances:** With the increase in electrical appliance ownership in rural and urban households due to increasing income level and reliable access, the rate of increase for appliance uptake and subsequent increase in demand depends on reliable and affordable access to power.

[72] World Energy Outlook 2016, IEA

## *Policy and programme advancements in the sector*

**Energy Conservation and Building Code (ECBC)**

The code, intoduced by the Bureau of Energy Efficiency (BEE), sets minimum performance standards for building envelope-like roofs and windows, lighting system, air-conditioning system, electrical distribution system and water-heating and pumping system.

**Pradhan Mantri Awas Yojana**

The policy would provide central assistance to implementing agencies through states and UTs for providing houses to all eleigible families by 2022.

**Standard and Labelling Programme**

The programme, spearheaded by the Bureau of Energy Efficiency (BEE), aims to provide information to the consumer about the energy-saving and cost-saving potential of marketed appliances.

**Unnat Chulha Abhiyan**

The programme works towards developing and deploying improved biomass cook stoves for providing cleaner cooking energy solutions in rural, semi-urban and urban areas using biomass as fuel for cooking.

**24×7 Power for All**

A joint initiative of central and state government, the aim is to provide electricity access to all by 2022.

**Unnat Jyoti by Affordable LEDs for All (UJALA)**

The programme aims at reducing energy consumption in lighting, which helps DISCOMs to manage peak demand, which is done by increasing the demand of LED lights by aggregating requirements across the country.

**Pradhan Mantri Ujjwala Yojana**

The scheme aims to provide clean cooking fuel to rural households at a subsidy of Rs 1600 per connection. The total connections made under PMUY up to date is 5.25 crores.

### *Results under moderate savings scenario*

#### Domestic

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | Mtoe | % | Mtoe | % |
| **Domestic** | **12.1** | **12%** | **15.1** | **15%** |

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | TWh | % | TWh | % |
| **Domestic** | **128** | **16%** | **138** | **17%** |

| Sector | GHG Emission Savings: Moderate Scenario (MtCO2e) | GHG Emission Savings: Ambitious Scenario (MtCO2e) |
|---|---|---|
| **Domestic** | 101 | 134 |

#### Commercial

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | Mtoe | % | Mtoe | % |
| **Commercial** | **4.9** | **17%** | **6.4** | **22%** |

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | TWh | % | TWh | % |
| **Commercial** | **57** | **16%** | **74** | **21%** |

| Sector | GHG Emission Savings: Moderate Scenario (MtCO2e) | GHG Emission Savings: Ambitious Scenario (MtCO2e) |
|---|---|---|
| **Commercial** | 34 | 44 |

## *4.5. Municipal*

India has one of the largest municipal systems in the world. The municipal bodies have many functions delegated to them by state governments under the municipal legislation, which are related to public health, welfare, regulatory functions, public safety, public infrastructure works and development activities.

Municipalities incur significant costs to procure energy for providing local public services like street lighting and water supply. Through cost-effective actions, energy and monetary savings of at least 25% can be achieved in water systems alone. Municipal energy efficiency saves scarce commodities and stretches tight budgets, giving citizens improved access to electricity, water, heat and air conditioning.

Among the functions carried out by municipalities, a majority of its energy demand comes from providing the services of public waterworks and public lighting. The two sectors have tremendous potential for energy conservation and many programmes in the country have been launched to improve their energy efficiency.

Municipal Energy Demand

Public Waterworks

Public Lighting

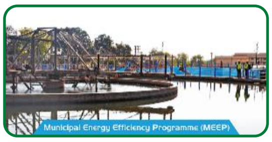
**Public waterworks:** A substantial section of India's population has no direct access to reliable, clean and affordable water services. Energy cost accounts for 40% to 60% of cost linked only with water supply in urban areas. The inefficiencies in this sector are due to aging infrastructure and overdesigning of systems. There is also inefficient equipment being utilized, which results in higher use of energy to deliver water to end users. Energy-efficiency interventions can significantly reduce this cost depending on the type and age of pump sets being used for bulk water supply.

**Public lighting:** Most urban local bodies (ULBs) have either inadequate or poor street lighting and have a high maintenance cost of 10%–15% of the budget of the ULB. Public lighting consumed about 7500 MU of electricity in 2012–13, energy-efficient street lighting has the potential to deliver substantial energy savings to ULBs. Retrofitting the entire conventional street lights with LEDs could have a potential to save about 50% of total energy consumed. Furthermore, the operational optimization can lead to additional 15%–20% energy savings. The savings will help municipalities expand street lighting to many additional areas.

## *Policy and programme advancements in the sector*

**Smart Cities Mission**
The Smart Cities Mission (SCM) is an initiative by the Government of India launched in June 2015 to drive economic growth and improve the quality of life of people by enabling local development and harnessing technology.

**Atal Mission for Rejuvenation and Urban Transformation (AMRUT)**
The Atal Mission for Rejuvenation and Urban Transformation was launched in June 2015 to provide various amenities to the poor and disadvantaged in India. The mission aims to provide basic facilities like water supply, sewage, urban transport and parks.




**Municipal Energy Efficiency Programme (MEEP)**
The programme aims to replace inefficient pump sets in public waterworks and sewerage water systems with energy-efficient pump sets at no upfront cost to the municipal bodies.

**Street Lighting National Programme (SLNP)**
Launched in January 2015, the EESL plans to replace 1.34 crore LED lights by March 2019 under this programme. The LEDs are 50% more energy efficient than incandescent bulbs.

### *Results under moderate savings scenario*

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | Mtoe | % | Mtoe | % |
| **Municipal** | **4.9** | **17%** | **6.4** | **22%** |

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | TWh | % | TWh | % |
| **Municipal** | **11** | **12%** | **18** | **19%** |

| Sector | GHG Emission Savings: Moderate Scenario (MtCO2e) | GHG Emission Savings: Ambitious Scenario (MtCO2e) |
|---|---|---|
| **Municipal** | 34 | 44 |

## *4.6. Industrial*

The energy consumption of the industrial sector in India for FY 2016–17 was 312.2 Mtoe, an increase of 5.6% over 2015–16 energy consumption. Despite the increase in energy consumption by the industrial sector, the percentage consumption of energy by the sector has not increased dramatically and has stayed about 57% of the total primary energy consumed. Within the industry sector, aluminium, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, petrochemical, refinery and textiles are the largest energy consumers, accounting for around 51% of the total energy use in the industry subsector.

Over the years, the energy intensity of the industry sector has been reducing as several of the units across sectors have moved to more efficient processes and adopted state-of-the art technologies. There is an autonomous improvement in the energy efficiency (EE) of industry, which has been occurring over the past many decades. This improvement is driven by several factors, including the high cost of input energy in industrial processes, a high share of the manufacturing cost, increased competitiveness among industry and the introduction of newer and efficient technologies.

### *Policy and programme advancements in the sector*

NATIONAL MANUFACTURING

**National Manufacturing Policy**

The objective includes enhancing the share of manufacturing in GDP to 25% and creating 100 million jobs over a decade or so. The policy is based on the principle of industrial growth in partnership with the states.

PAT SCHEME

**Perform, Achieve and Trade (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.

**National Design Policy**

The policy advocates the setting up of specialized design centres that provide common facilities and enabling tools like rapid product development, high performance visualization, etc.

## 4.7. MSME

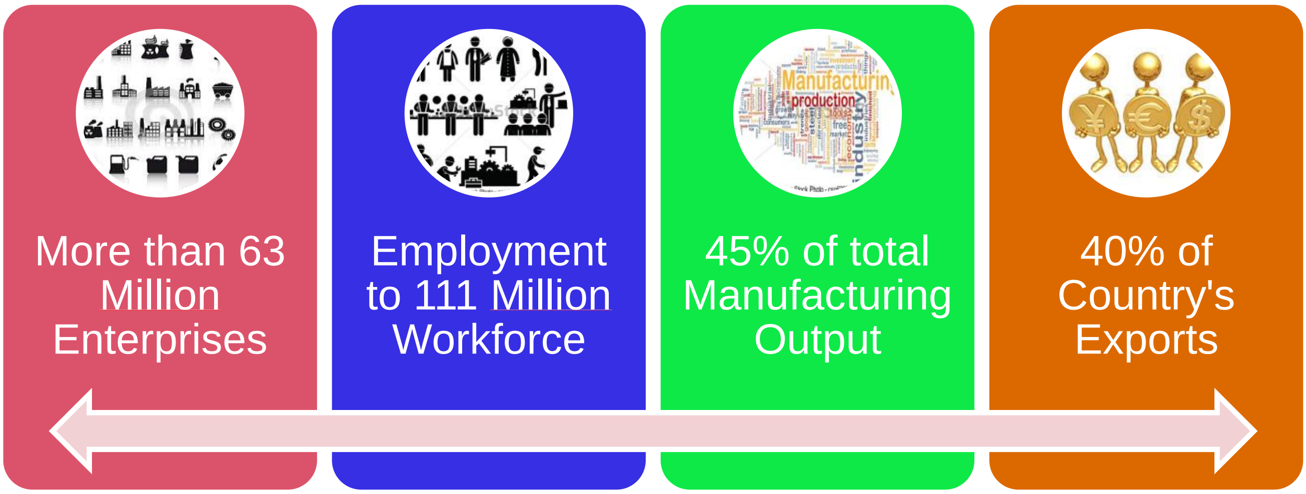
Micro, small and medium enterprises (MSMEs) in India are defined by the Micro, Small and Medium Enterprises Development Act, 2006, on the basis of investment in core plant and machinery (for the manufacturing sector) and equipment (for the service sector) as shown below.

(Upper limit on investment in core plant and machinery, and equipment; Rs million)

| Category | Manufacturing Sector | Service Sector |
|---|---|---|
| **Micro** | 2.5 | 1.0 |
| **Small** | 50 | 20 |
| **Medium** | 100 | 50 |

MSMEs contribute to over 28% share of national GDP[73] by producing over 6000 different products. MSMEs in India play an integral role in the overall economy in terms of their significant contribution, as shown below.[73]

*Figure 14: Contribution of MSMEs to India's economy*




MSMEs are the second largest provider of employment after the agriculture sector in India. As can be seen from above, MSMEs contribute significantly in manufacturing output, employment generation and contribution to the national gross domestic product (GDP) in the Indian economy.

*MSMEs can very well be termed as the backbone of Indian industrial economy.*

MSMEs in India are generally located in concentrated geographic "clusters", which produce similar products. The geographical location and the product type combination are often used to identify the cluster; for example, Rajkot foundry cluster, Ludhiana knitwear cluster, etc. These clusters are dispersed across the national territory and serve the needs of the local market, often acting as ancillaries to bigger industries or OEMs. The last all-India census of MSMEs (fourth) was carried out in 2006–07, and it established the share of unregistered MSMEs at only 6% of the total number of enterprises.

[73] Annual Report 2017–18, Ministry of Micro, Small and Medium Enterprises (MSMEs)

Of the 63 million enterprises, about a third, i.e. 19.7 million (31%), are categorized as manufacturing segment, while the remaining are service and trade enterprises. As per various estimates, the number of industrial clusters in India stands around 400, and there are additional 2000 artisan-based clusters that are engaged in traditional crafts.

### Energy consumption in MSMEs

Energy consumption in manufacturing processes forms a significant share of MSMEs' overall production cost, with sometimes the share of energy cost being as high as 50% of total manufacturing cost. The *Report of the Working Group on Power for Twelfth Plan* (2012–17) provides an estimate of the energy consumption of the entire MSME sector. According to this report, the MSME manufacturing sector consumed about one-quarter of the total energy consumed by the industrial sector. However, a more detailed breakdown of energy-consumption data by sector is not provided.[74]

The BEE's National Programme for SMEs and SAMEEEKSHA (a collaborative platform supported by BEE, Ministry of MSME, SDC, Shakti Foundation and TERI) are the most recent and comprehensive exercises for establishing actual energy consumption by the most energy-intensive MSME clusters.

As per BEE's estimates, there are about 180 energy-intensive MSME clusters in the country, which consume approximately 40% of the overall energy consumption by industrial MSMEs in 400 clusters, estimated at 68 Mtoe in 2017.

[74] Factors Influencing the uptake of energy efficiency initiatives by Indian MSMEs (Aug 2018), CEEW and SSEF

## *Policy and programme advancements in the sector*


**National Manufacturing Competitiveness Programme (NMCP)**

NMCP is the umbrella programme for MSMEs, which aims at increasing competitiveness of the MSME sector by addressing issues of access to technology, high share of energy cost due to technological obsolescence, product design, IPR issues, market penetration, quality certification, etc.


**Credit-Linked Capital Subsidy for Technology Upgradation (CLCSS)**

CLCSS provides 15% subsidy for additional investment up to Rs 1 crore for technology upgradation by MSMEs. Technology upgradation would ordinarily mean induction of state-of-the-art or near state-of-the- art technology.

**Technology and Quality Upgradation Support to MSMEs (TEQUP)**

The scheme advocates the use of energy-efficient technologies (EETs) in manufacturing units to reduce the cost of production and adopt clean development mechanism.

**GEF UNIDO BEE Programme**

The GEF UNIDO BEE programme aims to increase the uptake of energy efficient and renewable energy technologies in 12 MSME clusters in India under five sectors: brass, ceramics, dairy, foundry and hand tools.

**GEF World Bank BEE SIDBI Project**

The project, initially started for five energy-intensive MSME clusters in the first phase, has now increased the programme footprint to 15 clusters in the third phase.

## *Results under moderate savings scenario (industrial and MSME)*

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | Mtoe | % | Mtoe | % |
| **Industrial and MSME** | **47.5** | **11%** | **72.3** | **16%** |

| Sector | Moderate Savings: 2031 | | Ambitious Savings: 2031 | |
|---|---|---|---|---|
| | TWh | % | TWh | % |
| **Industrial and MSME** | **89** | **9%** | **149** | **15%** |

| Sector | GHG Emission Savings: Moderate Scenario (MtCO2e) | GHG Emission Savings: Ambitious Scenario (MtCO2e) |
|---|---|---|
| **Industrial and MSME** | 185 | 238 |

## 4.8. State-Wise Energy-Saving Target by 2031

The state-wise energy-saving target has been calculated by segregating the total energy-saving potential in each of the sectors into the respective states, based on the methodology used for finding out the primary energy demand in each state in Chapter 1. The economic activities in each state include manufacturing, construction, agriculture, forestry etc. The economic activities are converted into demand sectors, i.e. industrial, municipal, commercial etc. using assumed weightages. The state GDP (for 2016–17) is then calculated for the demand sectors, and the proportion of each demand sector in a state is calculated. Similarly, once the national energy-saving potential for a demand sector is established, the division into states is done based on the SGDP. The energy- and electricity-saving target thus calculated (in Mtoe and TWh) under the moderate scenario is presented below:

*Table 32: State energy-saving target (in Mtoe) by 2031 under moderate savings scenario*

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Chandigarh | 0.031 | 0.026 | 0.037 | 0.001 | 0.014 | 0.000 | 0.110 |
| Delhi | 0.726 | 0.400 | 1.156 | 0.032 | 0.438 | 0.001 | 2.754 |
| Haryana | 0.422 | 0.208 | 1.710 | 0.026 | 0.571 | 0.309 | 3.247 |
| Himachal Pradesh | 0.089 | 0.036 | 0.595 | 0.017 | 0.101 | 0.004 | 0.841 |
| Jammu and Kashmir | 0.116 | 0.052 | 0.272 | 0.019 | 0.170 | 0.012 | 0.641 |
| Punjab | 0.397 | 0.194 | 1.207 | 0.020 | 0.414 | 0.373 | 2.605 |
| Rajasthan | 0.501 | 0.231 | 2.272 | 0.069 | 0.831 | 0.646 | 4.550 |
| Uttar Pradesh | 1.188 | 0.292 | 3.003 | 0.078 | 1.600 | 0.431 | 6.591 |
| Uttarakhand | 0.101 | 0.064 | 1.070 | 0.012 | 0.096 | 0.006 | 1.350 |
| Chhattisgarh | 0.209 | 0.067 | 1.214 | 0.011 | 0.203 | 0.131 | 1.836 |
| Gujarat | 0.563 | 0.248 | 5.873 | 0.066 | 0.569 | 0.371 | 7.689 |
| Madhya Pradesh | 0.392 | 0.154 | 1.440 | 0.050 | 0.831 | 0.617 | 3.485 |
| Maharashtra | 1.742 | 0.790 | 8.146 | 0.132 | 1.777 | 0.914 | 13.502 |
| Daman and Diu | 0.002 | 0.003 | 0.027 | 0.000 | 0.000 | 0.000 | 0.033 |
| Dadra and Nagar Haveli | 0.002 | 0.002 | 0.083 | 0.000 | 0.000 | 0.000 | 0.087 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Goa | 0.042 | 0.020 | 0.305 | 0.000 | 0.035 | 0.001 | 0.403 |
| Andhra Pradesh | 0.479 | 0.139 | 1.685 | 0.025 | 1.156 | 0.367 | 3.850 |
| Telangana | 0.573 | 0.276 | 1.688 | 0.033 | 0.749 | 0.386 | 3.705 |
| Karnataka | 1.117 | 0.349 | 2.919 | 0.106 | 1.045 | 0.619 | 6.156 |
| Kerala | 0.548 | 0.235 | 1.341 | 0.018 | 0.738 | 0.016 | 2.896 |
| Tamil Nadu | 1.233 | 0.538 | 4.042 | 0.111 | 1.122 | 0.377 | 7.423 |
| Puducherry | 0.028 | 0.011 | 0.144 | 0.003 | 0.014 | 0.002 | 0.201 |
| Lakshadweep | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Bihar | 0.272 | 0.065 | 0.713 | 0.003 | 0.551 | 0.020 | 1.623 |
| Jharkhand | 0.164 | 0.029 | 1.149 | 0.008 | 0.312 | 0.007 | 1.669 |
| Odisha | 0.247 | 0.083 | 1.466 | 0.007 | 0.445 | 0.016 | 2.264 |
| West Bengal | 0.679 | 0.309 | 2.811 | 0.042 | 1.638 | 0.063 | 5.541 |
| Sikkim | 0.007 | 0.003 | 0.114 | 0.000 | 0.011 | 0.000 | 0.136 |
| Andaman and Nicobar Islands | 0.003 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 |
| Arunachal Pradesh | 0.010 | 0.002 | 0.046 | 0.000 | 0.016 | 0.001 | 0.075 |
| Assam | 0.143 | 0.051 | 0.700 | 0.003 | 0.250 | 0.007 | 1.153 |
| Manipur | 0.014 | 0.002 | 0.027 | 0.001 | 0.019 | 0.001 | 0.064 |
| Meghalaya | 0.016 | 0.005 | 0.098 | 0.001 | 0.030 | 0.000 | 0.151 |
| Mizoram | 0.010 | 0.002 | 0.035 | 0.002 | 0.014 | 0.000 | 0.062 |
| Nagaland | 0.014 | 0.004 | 0.024 | 0.000 | 0.018 | 0.001 | 0.061 |
| Tripura | 0.019 | 0.004 | 0.087 | 0.004 | 0.021 | 0.002 | 0.137 |
| **Total (all India)** | **12.1** | **4.9** | **47.5** | **0.9** | **15.8** | **5.7** | **86.9** |

*Table 33: State electricity-saving target (in TWh) by 2031 under moderate savings scenario*

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Chandigarh | 0.33 | 0.30 | 0.07 | 0.01 | — | — | 0.71 |
| Delhi | 7.68 | 4.66 | 2.17 | 0.39 | — | — | 14.89 |
| Haryana | 4.47 | 2.42 | 3.20 | 0.32 | — | — | 10.42 |
| Himachal Pradesh | 0.94 | 0.42 | 1.11 | 0.21 | — | — | 2.69 |
| Jammu and Kashmir | 1.22 | 0.61 | 0.51 | 0.23 | — | — | 2.57 |
| Punjab | 4.20 | 2.26 | 2.26 | 0.24 | — | — | 8.97 |
| Rajasthan | 5.31 | 2.69 | 4.26 | 0.84 | — | — | 13.09 |
| Uttar Pradesh | 12.56 | 3.39 | 5.63 | 0.95 | — | — | 22.54 |
| Uttarakhand | 1.07 | 0.74 | 2.01 | 0.15 | — | — | 3.96 |
| Chhattisgarh | 2.21 | 0.78 | 2.27 | 0.13 | — | — | 5.40 |
| Gujarat | 5.95 | 2.89 | 11.00 | 0.81 | — | — | 20.65 |
| Madhya Pradesh | 4.15 | 1.80 | 2.70 | 0.61 | — | — | 9.26 |
| Maharashtra | 18.43 | 9.19 | 15.26 | 1.61 | — | — | 44.50 |
| Daman and Diu | 0.03 | 0.04 | 0.05 | 0.01 | — | — | 0.12 |
| Dadra and Nagar Haveli | 0.03 | 0.02 | 0.16 | 0.01 | — | — | 0.21 |
| Goa | 0.45 | 0.23 | 0.57 | 0.00 | — | — | 1.25 |
| Andhra Pradesh | 5.06 | 1.62 | 3.16 | 0.30 | — | — | 10.14 |
| Telangana | 6.06 | 3.21 | 3.16 | 0.40 | — | — | 12.83 |
| Karnataka | 11.82 | 4.06 | 5.47 | 1.30 | — | — | 22.65 |
| Kerala | 5.79 | 2.73 | 2.51 | 0.22 | — | — | 11.25 |
| Tamil Nadu | 13.05 | 6.26 | 7.57 | 1.36 | — | — | 28.24 |
| Puducherry | 0.30 | 0.12 | 0.27 | 0.03 | — | — | 0.72 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Lakshadweep | 0.01 | 0.01 | 0.00 | 0.00 | — | — | 0.02 |
| Bihar | 2.88 | 0.76 | 1.34 | 0.04 | — | — | 5.01 |
| Jharkhand | 1.73 | 0.34 | 2.15 | 0.10 | — | — | 4.32 |
| Odisha | 2.62 | 0.96 | 2.75 | 0.08 | — | — | 6.41 |
| West Bengal | 7.18 | 3.59 | 5.27 | 0.51 | — | — | 16.55 |
| Sikkim | 0.08 | 0.04 | 0.21 | 0.00 | — | — | 0.33 |
| Andaman and Nicobar Islands | 0.03 | 0.04 | 0.00 | 0.00 | — | — | 0.08 |
| Arunachal Pradesh | 0.10 | 0.03 | 0.09 | 0.01 | — | — | 0.22 |
| Assam | 1.51 | 0.60 | 1.31 | 0.03 | — | — | 3.45 |
| Manipur | 0.14 | 0.03 | 0.05 | 0.01 | — | — | 0.23 |
| Meghalaya | 0.17 | 0.06 | 0.18 | 0.01 | — | — | 0.43 |
| Mizoram | 0.10 | 0.03 | 0.07 | 0.02 | — | — | 0.22 |
| Nagaland | 0.15 | 0.04 | 0.04 | 0.01 | — | — | 0.25 |
| Tripura | 0.20 | 0.05 | 0.16 | 0.04 | — | — | 0.46 |
| **Total (all India)** | **128.00** | **57.00** | **89.00** | **11.00** | — | — | **285.00** |

The state-wise energy- and electricity-saving target under the ambitious scenario is presented below:

*Table 34: State energy-saving target (in Mtoe) by 2031 under ambitious savings scenario*

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Chandigarh | 0.039 | 0.034 | 0.057 | 0.001 | 0.021 | 0.000 | 0.153 |
| Delhi | 0.906 | 0.523 | 1.760 | 0.053 | 0.660 | 0.002 | 3.904 |
| Haryana | 0.527 | 0.272 | 2.603 | 0.044 | 0.861 | 0.536 | 4.843 |
| Himachal Pradesh | 0.111 | 0.047 | 0.905 | 0.029 | 0.151 | 0.006 | 1.249 |
| Jammu and Kashmir | 0.144 | 0.068 | 0.414 | 0.032 | 0.256 | 0.021 | 0.936 |
| Punjab | 0.496 | 0.254 | 1.837 | 0.033 | 0.624 | 0.648 | 3.891 |
| Rajasthan | 0.626 | 0.302 | 3.458 | 0.114 | 1.252 | 1.122 | 6.874 |
| Uttar Pradesh | 1.482 | 0.381 | 4.571 | 0.130 | 2.410 | 0.748 | 9.722 |
| Uttarakhand | 0.126 | 0.083 | 1.629 | 0.020 | 0.145 | 0.011 | 2.015 |
| Chhattisgarh | 0.261 | 0.088 | 1.848 | 0.018 | 0.306 | 0.227 | 2.749 |
| Gujarat | 0.702 | 0.324 | 8.939 | 0.110 | 0.857 | 0.644 | 11.576 |
| Madhya Pradesh | 0.490 | 0.202 | 2.192 | 0.083 | 1.252 | 1.071 | 5.290 |
| Maharashtra | 2.174 | 1.032 | 12.399 | 0.220 | 2.677 | 1.587 | 20.090 |
| Daman and Diu | 0.003 | 0.004 | 0.042 | 0.001 | 0.000 | 0.000 | 0.049 |
| Dadra and Nagar Haveli | 0.003 | 0.002 | 0.126 | 0.001 | 0.000 | 0.000 | 0.132 |
| Goa | 0.053 | 0.026 | 0.464 | 0.000 | 0.052 | 0.002 | 0.597 |
| Andhra Pradesh | 0.597 | 0.182 | 2.565 | 0.041 | 1.741 | 0.637 | 5.763 |
| Telangana | 0.715 | 0.360 | 2.569 | 0.055 | 1.129 | 0.671 | 5.499 |
| Karnataka | 1.394 | 0.456 | 4.444 | 0.177 | 1.574 | 1.075 | 9.120 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Kerala | 0.683 | 0.306 | 2.041 | 0.030 | 1.112 | 0.028 | 4.201 |
| Tamil Nadu | 1.539 | 0.703 | 6.152 | 0.185 | 1.691 | 0.654 | 10.924 |
| Puducherry | 0.035 | 0.014 | 0.219 | 0.004 | 0.022 | 0.003 | 0.297 |
| Lakshadweep | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 |
| Bihar | 0.340 | 0.085 | 1.085 | 0.005 | 0.829 | 0.034 | 2.378 |
| Jharkhand | 0.204 | 0.038 | 1.750 | 0.013 | 0.469 | 0.012 | 2.486 |
| Odisha | 0.309 | 0.108 | 2.232 | 0.011 | 0.670 | 0.028 | 3.358 |
| West Bengal | 0.847 | 0.403 | 4.279 | 0.070 | 2.467 | 0.110 | 8.175 |
| Sikkim | 0.009 | 0.004 | 0.174 | 0.000 | 0.017 | 0.000 | 0.204 |
| Andaman and Nicobar Islands | 0.004 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 |
| Arunachal Pradesh | 0.012 | 0.003 | 0.070 | 0.001 | 0.025 | 0.001 | 0.111 |
| Assam | 0.178 | 0.067 | 1.065 | 0.004 | 0.377 | 0.011 | 1.703 |
| Manipur | 0.017 | 0.003 | 0.042 | 0.001 | 0.029 | 0.001 | 0.092 |
| Meghalaya | 0.020 | 0.007 | 0.149 | 0.002 | 0.046 | 0.001 | 0.224 |
| Mizoram | 0.012 | 0.003 | 0.053 | 0.003 | 0.021 | 0.001 | 0.092 |
| Nagaland | 0.018 | 0.005 | 0.036 | 0.001 | 0.027 | 0.001 | 0.089 |
| Tripura | 0.024 | 0.006 | 0.133 | 0.006 | 0.031 | 0.004 | 0.204 |
| **Total (all India)** | **15.1** | **6.4** | **72.3** | **1.5** | **23.8** | **9.9** | **129** |

*Table 35: State electricity-saving target (in TWh) by 2031 under ambitious savings scenario*

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Chandigarh | 0.36 | 0.39 | 0.12 | 0.01 | — | — | 0.88 |
| Delhi | 8.28 | 6.05 | 3.63 | 0.64 | — | — | 18.59 |
| Haryana | 4.82 | 3.15 | 5.36 | 0.53 | — | — | 13.85 |
| Himachal Pradesh | 1.01 | 0.54 | 1.87 | 0.35 | — | — | 3.77 |
| Jammu and Kashmir | 1.32 | 0.79 | 0.85 | 0.38 | — | — | 3.34 |
| Punjab | 4.53 | 2.94 | 3.79 | 0.40 | — | — | 11.65 |
| Rajasthan | 5.72 | 3.49 | 7.13 | 1.37 | — | — | 17.71 |
| Uttar Pradesh | 13.54 | 4.41 | 9.42 | 1.56 | — | — | 28.93 |
| Uttarakhand | 1.15 | 0.96 | 3.36 | 0.24 | — | — | 5.71 |
| Chhattisgarh | 2.39 | 1.02 | 3.81 | 0.22 | — | — | 7.43 |
| Gujarat | 6.42 | 3.75 | 18.42 | 1.32 | — | — | 29.90 |
| Madhya Pradesh | 4.48 | 2.34 | 4.52 | 1.00 | — | — | 12.33 |
| Maharashtra | 19.87 | 11.93 | 25.55 | 2.64 | — | — | 59.99 |
| Daman and Diu | 0.03 | 0.05 | 0.09 | 0.01 | — | — | 0.17 |
| Dadra and Nagar Haveli | 0.03 | 0.02 | 0.26 | 0.01 | — | — | 0.32 |
| Goa | 0.48 | 0.30 | 0.96 | 0.00 | — | — | 1.74 |
| Andhra Pradesh | 5.46 | 2.10 | 5.29 | 0.49 | — | — | 13.34 |
| Telangana | 6.53 | 4.16 | 5.29 | 0.66 | — | — | 16.65 |
| Karnataka | 12.74 | 5.27 | 9.16 | 2.12 | — | — | 29.29 |
| Kerala | 6.24 | 3.54 | 4.21 | 0.36 | — | — | 14.35 |
| Tamil Nadu | 14.07 | 8.13 | 12.68 | 2.22 | — | — | 37.09 |
| Puducherry | 0.32 | 0.16 | 0.45 | 0.05 | — | — | 0.98 |

| State/UTs | Domestic | Commercial | Industrial | Municipal | Transport | Agriculture | Total |
|---|---|---|---|---|---|---|---|
| Lakshadweep | 0.01 | 0.01 | 0.00 | 0.00 | — | — | 0.02 |
| Bihar | 3.11 | 0.98 | 2.24 | 0.06 | — | — | 6.39 |
| Jharkhand | 1.86 | 0.44 | 3.61 | 0.16 | — | — | 6.07 |
| Odisha | 2.82 | 1.25 | 4.60 | 0.13 | — | — | 8.80 |
| West Bengal | 7.74 | 4.66 | 8.82 | 0.84 | — | — | 22.06 |
| Sikkim | 0.08 | 0.05 | 0.36 | 0.00 | — | — | 0.49 |
| Andaman and Nicobar Islands | 0.04 | 0.06 | 0.00 | 0.00 | — | — | 0.09 |
| Arunachal Pradesh | 0.11 | 0.03 | 0.14 | 0.01 | — | — | 0.30 |
| Assam | 1.63 | 0.77 | 2.19 | 0.05 | — | — | 4.64 |
| Manipur | 0.16 | 0.03 | 0.09 | 0.01 | — | — | 0.29 |
| Meghalaya | 0.18 | 0.08 | 0.31 | 0.02 | — | — | 0.59 |
| Mizoram | 0.11 | 0.03 | 0.11 | 0.04 | — | — | 0.29 |
| Nagaland | 0.16 | 0.06 | 0.07 | 0.01 | — | — | 0.31 |
| Tripura | 0.22 | 0.07 | 0.27 | 0.07 | — | — | 0.63 |
| **Total (all India)** | **138.00** | **74.00** | **149.00** | **18.00** | — | — | **379.00** |

5

# ESTIMATION OF ENERGY SAVING INVESTMENT POTENTIAL AND ANALYSIS OF FINANCING INSTRUMENTS

## 5.1. Introduction

After calculating the energy-efficiency potential in the previous chapter, it is important to determine the investments that would have to be made to achieve the said potential. This chapter outlines the sectoral investment potential for each of the demand sectors as well as the state-wise sectoral investments that would be required to achieve the energy savings found out in the previous chapter.

The chapter also covers the assessment of various financing schemes that are employed around the world to fund energy-efficiency programmes. These financing schemes are assessed based on cross-sector applicability, ease of implementation, financial market maturity, minimum risk to investors and high potential impact, post which financial schemes that are applicable to demand sectors in the country are identified.

The following sections have been covered in this chapter:

| Calculation of sectoral investement potential, at the national and state levels | Mapping of financing schemes employed around the world | Selection of financing schemes for individual demand sectors |
|---|---|---|

## 5.2. Calculation of Sectoral Investment Potential

The following are the steps involved while calculating the investment potential for each sector:

**Step-1**
- Calculation of price per Mtoe for various sources of energy. The calculations in this step are common for every sector.

**Step-2**
- Calculation of weighted average cost of source of energy for each sector based on the share of energy source in the sector.

**Step-3**
- Determination of payback period for each demand sector along with the escalation of fuel prices for the sector.

**Step-4**
- Calculation of incremental savings for each sector and determination of the investment potential using results from steps 2 and 3.

The energy-saving investment potential of the country is estimated to be Rs 1,002,329 crore by 2031, under the moderate savings scenario, with the industrial sector constituting highest energy-saving investment potential.

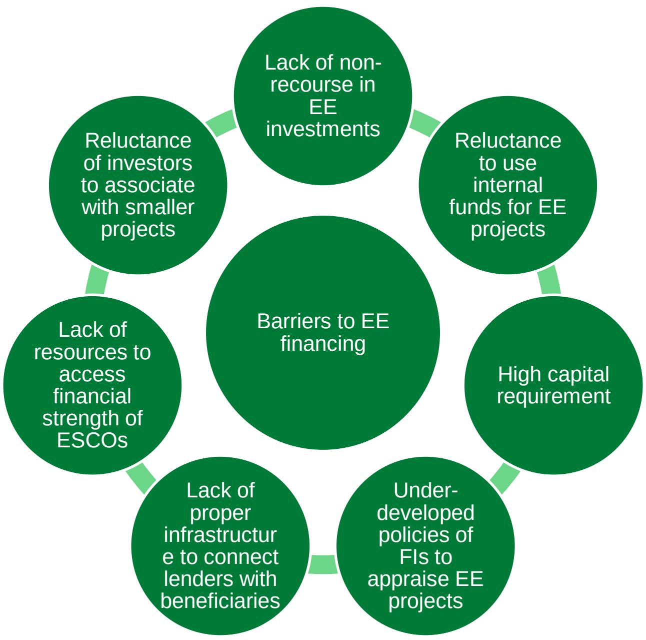
*Table 36: Energy-saving investment potential (Rs crore)*

| Sectors | Energy-Savings Investment by 2031 (Rs Crore): Moderate Savings Scenario | Energy-Savings Investment by 2031 (Rr Crore): Ambitious Savings Scenario |
|---|---|---|
| Agriculture | 51450 | 89004 |
| Commercial | 81154 | 105701 |
| Domestic | 120233 | 145420 |
| Municipal | 8337 | 13589 |
| Industrial | 515116 | 601210 |
| Transport | 226039 | 365706 |
| **Total** | **1002329** | **1320630** |

## 5.3. Exploring Financing Instruments and Options to Achieve EE Potential

The transition towards an energy-efficient economy requires huge capital investments in energy-efficient technologies, which at present is moving at a slow pace in India, due to risks perceived by investors of energy-efficient projects. Barriers in the implementation of energy-efficiency projects can be broadly categorized into financial and non-financial barriers. Financial barriers are mainly centred on issues related to the unavailability of low-cost financing, whereas non-financial barriers relate to the gaps in the technical know-how, required to implement energy-efficiency projects. Some of the common financial barriers are presented below:

*Figure 15: Barriers in EE financing*



### *5.3.1. Instruments for energy-efficiency financing*

The instruments discussed here are either operational or have been conceptualized in one form or the other, around the globe. The initial analysis and discussions of the instruments would provide various important insights regarding the objective at hand, i.e. to find more ways to finance energy-efficiency measures in the Indian context. The analysis of existing instruments in detail would clarify the barriers and challenges expected to be faced in the Indian context. By employing permutations and combinations in the different attributes or building blocks of any instrument, a lot many new instruments can be framed, but not all of these would be suitable for the Indian context.

The various attributes that define instruments for EE financing are as follows:

| | | | |
|---|---|---|---|
| Entities involved | Type of funding | Form of capital | Expected direct benefit of EE instrument |
| Application of capital | Primary repayment mechanism | Secondary repayment mechanism | Risk mitigation mechanism |

- **Entities involved:** This attribute describes the primary stakeholders involved in the various stages of the instrument implementation. These entities can be subcategorized into three:
  - **Financier:** The financier in any instrument would be the entity that directly provides the fund required for the successful implementation of the instrument. The instrument might be self-financed or require no external source of financing, or the instrument might also require government support.
  - **Programme manager/service provider:** A programme manager would be an entity that performs all the operations required for the successful implementation of the programme. The involvement of a programme manager would be imperative in case the implementation phase requires a complex operation procedure.
  - **Beneficiary:** The beneficiary would be an entity that receives the direct benefits of the EE-financing instrument. This would be an entity, the benefit of whom the instrument focusses on. The beneficiary can be the end user or the customer, and also the ESCOs or the service provider in certain cases.
- **Type of funding:** This attribute would consider whether the capital required for the instrument is provided in the form of debt, or equity or a mixture of both. In limited instances, the capital or some portion of the capital can also be in the form of grant or subsidy.
- **Form of capital:** This attribute would represent the financial stake in the instrument held by the financier for the capital provided by them. This can be in the form of common shares, preference shares, long-term loans, mezzanine debt, etc.
- **Instrument objective/expected direct benefits in EE investment:** This attribute would entail the direct or the first benefit due to the investment made by the service provider. This may be defined as the first objective the instrument seeks to achieve by the application of funds.

- **Application of capital in implementation phase:** This attribute would define the way in which the capital is expected to be applied by the programme manager. The implementation phase of the project would start after this investment.
- **Primary repayment mechanism (between end user and service provider):** After investment made for the EE improvement measure, the beneficiary is expected to repay the financier for the benefits enjoyed by them. Primary payment mechanism defines the financial agreement for repayment between the beneficiary and the service provider (or programme manager). This attribute has been further subdivided into two components:
    - **Whether transferable:** This refers to the clause whence the repayment liability of the end user or the beneficiary is transferable to another entity, without any change in the payment terms.
    - **Modes of repayment:** This defines the mode of repayment by the end user to the service provider for the EE investment.
- **Secondary repayment mechanism (between service provider and financer):** This is defined as payment terms for the cash flow from service provider to the financier. This attribute would define the return on investment for the financier.
- **Risk mitigation:** This attribute describes if any risk-mitigation strategy is present in the working model of the instrument.

Presented below is a snapshot of popular EE-financing instruments that have been used/are in use in various contexts in India:

*Table 37: EE-financing instruments in India*

| Instrument | Attribute |
|---|---|
| **Energy-saving certificates (ESCerts)** | Designated consumers who implement energy-saving projects and manage to save more energy than targeted would obtain ESCerts. These can then be traded and sold to scheme participants who have an obligation to meet energy-savings targets each year by surrendering ESCs or by paying a penalty. |
| **On-bill financing (OBF)** | It refers to a financial instrument that is serviced by or in partnership with a utility company for EE improvements and repaid by the customer on its monthly utility bill. |
| **Capital subsidy (CS)** | Capital subsidy is a grant provided by the local/state government to EE investment project, where a subsidy of a particular amount/ percentage is given to cover capital costs in incorporating EE improvement mechanisms. |
| **Revolving loan fund (RLF)** | Revolving loan funds (RLFs) are used to promote EE lending. Here the loans are made to borrowers consistent with standard prudent lending practices. As loans are repaid by the borrowers, the money is returned to the RLF to make additional loans. |
| **Accelerated depreciation-based incentivization (ADI)** | Accelerated depreciation-based instruments are aimed at incentivizing industries to implement EE schemes by allowing project developers to take the benefit of higher depreciation in the initial years. |
| **Loan loss recovery/partial risk guarantee fund (PRGF)** | The fund provides partial risk coverage to lenders, meaning that the reserve will cover a pre-specified percentage of loan losses. |
| **Venture Capital Fund for Energy Efficiency (VCFEE)** | VCFEE provides risk capital support to EE investments in new technologies, goods and services. The fund provides last-mile equity support to specific EE projects, limited to a maximum of certain percentage of total equity required, through special purpose vehicles. |

In addition to the above, there are a few more EE-financing instruments that find prominence in more mature EE markets. A brief snapshot of such EE-financing instruments that are available in other EE markets and may be customized to suit the Indian context is presented in the table below:

*Table 38: EE-financing instruments in other markets and their attributes*

| Instrument | Attribute |
|---|---|
| **Tax based (Tax)** | These instruments provide some form of tax incentive to users as a compensation for energy-efficiency investment. These can be in the form of tax rebates, tax holidays or tax credits. This instrument is also used to incentivize manufacturers for engaging in the production of energy-efficient equipment. |
| **Energy-savings insurance (ESI)** | ESI provides insurance cover to investors that the EE project would generate the projected financial savings. Basically an insurance contract is signed between either the building owner or a third-party service provider and the insurer. If actual savings would come out to be lower than the projected figure, ESI insurer would bear the difference. |
| **Revenue decoupling models for DSM (RD)** | Utilities receive differential rates per unit, depending on total electricity demand. The objective is non-reduction in revenues of utilities due to EE measures. Decoupling motivates utilities to push customers to incorporate EE measures. |
| **Energy conservation bonds (ECB)** | These are debt instruments issued by a state or local government (or another eligible entity), which are either sold in the public market, placed with investors by an investment banking firm or purchased directly by a bank. |

| Instrument | Attribute |
|---|---|
| **Interest rate buys down fund (IRBDF)** | Interest rate is typically bought down by a dedicated federal/state non-revolving fund. The lower interest rate offered by the private banker motivates borrower for energy-efficiency projects. |
| **Property assessed clean energy (PACE)** | PACE is a financing mechanism that enables low-cost, long-term funding for energy efficiency, repaid as an additional payment on a property's regular local property tax. |
| **Cross-border technology transfer and energy-efficiency financing facility (CBTT)** | It is a growth equity fund, aiming to invest in 10–20 companies, in both developed and developing countries, which have proven technological solutions for climate resilience and have demonstrated market demand and revenue. The fund, together with an accompanying technical assistance facility, will help companies to expand into new sectors and geographies, while the risks would be diversified by investing the larger part of the fund into proven commercial investment instruments. |
| **Green receivables fund (GRF)** | In this instrument, an FI initially funds a portfolio of investment project, thus mitigating development risk during early stages, when private finance is not readily available. The institution then clubs the receivables from these projects and distributes them into several trances, which are then sold in the capital market to public/private investors based on their risk profile. |
| **Securitization of loans for energy-efficient appliances (SLEE)** | This instrument focuses on providing low-cost financing through securitization of energy-efficiency loans. It would provide an opportunity to low-income groups of consumers to invest in energy-efficient appliances, since they would be financed at lower interest rate achieved by loan securitization. Securitization lowers costs by creating liquidity and freeing up capital to make more loans. |
| **Peer-to-peer lending (PPL)** | The instrument provides an online marketplace based platform where SMEs with good track record could connect with individual investors looking for investment opportunities in instruments with good returns. |
| **Stranded project financing facility (SPFF)** | Provides refinancing opportunities to stranded projects, at below market rates through a revolving debt facility combined with an early-stage venture investment model. |
| **Forfaiting funds (FortF)** | In this instrument, transfer of future receivables from one party (cessionary—an ESCO) to another (buyer—an FI) takes place. The original creditor (the ESCO) cedes his claims and the new creditor (the FI) gains the right to claim future receivables from the debtor (the client). The ESCO sells future receivables to an FI in return for a discounted one-time payment. |
| **Factoring fund (FactF)** | Factoring is an arrangement that converts receivables into ready cash, and there is no need for the ESCO to wait for the payment of receivables at a future date. Further, there is no involvement of ESCO, post-sale of receivables. |
| **Operation lease/vendor financing (OL)** | Operating leases are not capitalized on a company's balance sheet, and lease payments are treated as an expense for accounting purposes. The period of contract is less than the life of the equipment and the lessor (investor) pays all maintenance and servicing costs. |
| **Capital/financial lease (FL)** | Under a capital lease, a lessee is required to show the leased equipment as an asset and the present value of lease payments as debt on its balance sheet. |
| **Energy improvement mortgage (EIM)** | An EIM is used to purchase existing homes that will have an energy-efficiency improvement made. EIMs allow borrowers to include the cost of energy-efficiency improvement in the mortgage without increasing the down payment. The money saved in utility bills will be used by borrowers to finance energy improvements. |
| **Energy-efficient mortgage (EEM)** | EEM is a reduced rate mortgage that credits the energy efficiency of the building in the mortgage itself. The energy savings from a new energy-efficient home is used to increase the home buying power of consumers and capitalizes the energy |

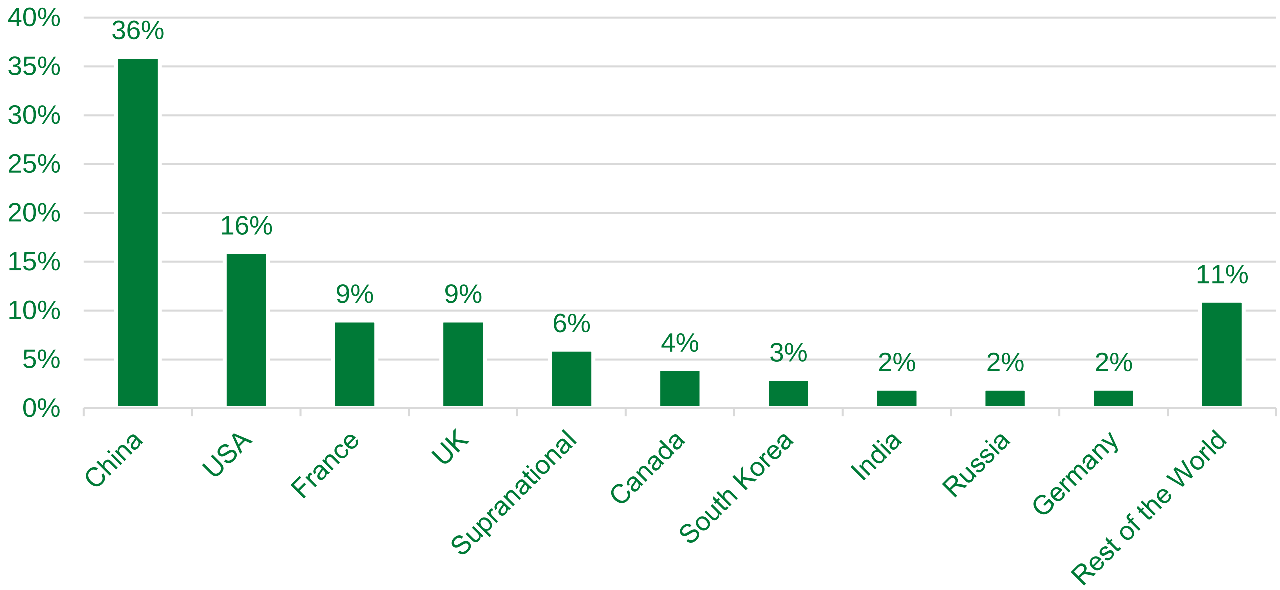
| Instrument | Attribute |
|---|---|
| | savings in the appraisal. |
| **Carbon finance (CF)** | Carbon funds typically do not lend or grant resources to projects, but rather contract to purchase emission reductions similar to a commercial transaction, paying for them annually or periodically once they have been verified by a third-party auditor. Carbon finance increases the financial viability of projects, by adding an additional revenue stream, which reduces the risks of commercial lending or grant finance. Thus, carbon finance provides a means of leveraging new private and public investment into projects that reduce greenhouse gas emissions. |
| **Subordinate debt (SD)** | Also known as mezzanine financing, it is generally made available directly from insurance companies, subordinated debt funds or finance companies. Alternatively, it is raised with public offerings of high-yield bonds to institutional investor. |

## 5.3.2. Popular EE-financing instruments used around the world

### Green bonds

These are fixed-income debt securities that are used to raise funds from investors willing to invest in initiatives that are geared towards environmental benefits. Though there are currently no universally accepted guidelines that govern the green bond market, the International Capital Market Association (ICMA) has established the Green Bond Principles (GBP) that promote transparency in the green bond market. The total outstanding green bond issuance by country, as of 2016, is shown below[75]:

*Figure 16: Green bond issuance, 2016*

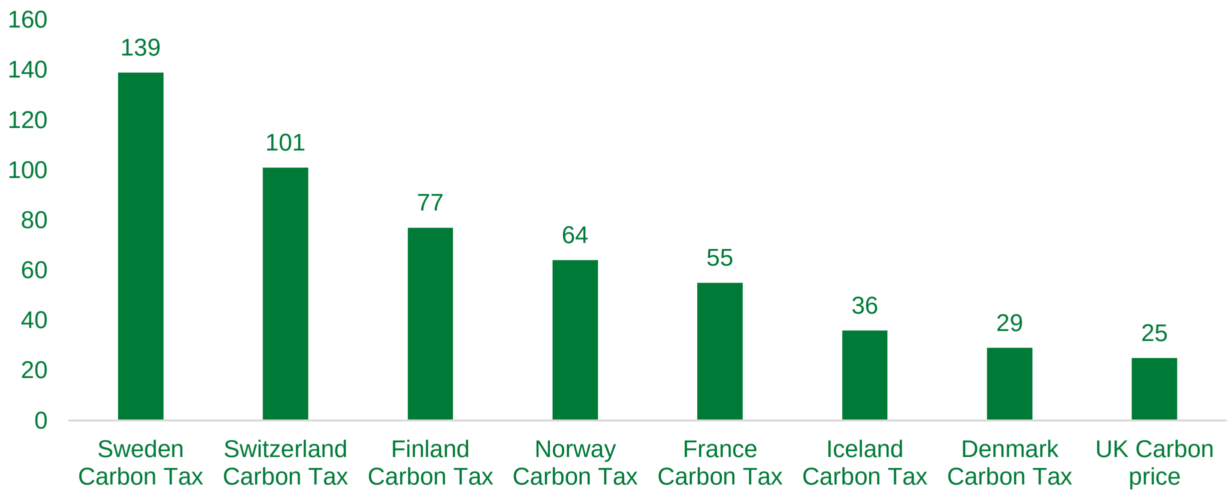



### Carbon pricing

[75] The rise of green bonds (Oct 2017), ECLAC Washington Office

Carbon price, explained in the simplest terms, is the cost that is levied on carbon pollution to encourage polluters to reduce the amount of greenhouse gases that is emitted into the atmosphere. Carbon pricing acts as a two-pronged approach to tackle the problem of pollution. It not only encourages adoption of low-carbon alternatives but also raises money to be used further for clean-up of the environment. Progressive prices in implemented carbon-pricing initiatives from around the world are shown below[76]:

*Figure 17: Carbon pricing across countries (USD/t$CO_2$)*




### Carbon Finance

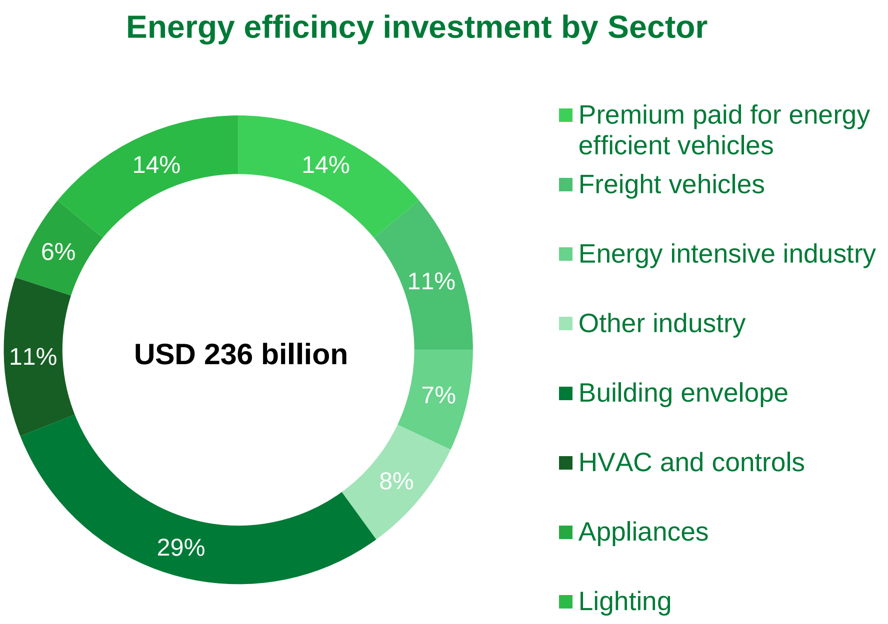
Carbon finance is the fund provided to a project to acquire appropriately certified greenhouse gas (GHG) emission reductions ("carbon" for short). The purchaser can then use these reductions to meet, for example, obligations to reduce carbon emissions that may have been incurred under EU or national legislation. Commitments of finance for the purchase of carbon have grown rapidly since the first carbon purchases began in 1996. Carbon funds are financial entities that facilitate the operation of carbon finance.[77]

The European Union Emissions Trading Scheme (ETS), launched on 1 January 2005, is a system for trading carbon credits or "allowances" between the installations bound by the enabling legislation. It has become the cornerstone of EU efforts to reduce emissions cost effectively. The carbon credits that the EIB's carbon funds are concerned with are eligible for meeting EU ETS obligations.

## *5.3.3. Global energy-efficiency investment scenario*

As Europe remains the biggest source of investment for energy efficiency in the world, at the same time, investments in the USA as well as in the People's Republic of China have fallen. Overall, the global investment in the sector has grown by 3% to USD 236 billion in 2017.[78] A sector-wise break-up of these investments for 2017 is provided below:

[76] State and trends of carbon pricing 2018, World Bank Group
[77] The EIB and Carbon Finance – FAQs, European Investment Bank
[78] Market Report Series – Energy Efficiency 2018, IEA




The global ESCO market has grown by 8% in 2017 and is currently a USD 28.6 billion industry. China continues to be the fulcrum for the global ESCO market, growing at 11% to nearly USD 17 billion in 2017.[78] The majority of ESCO projects takes place in the non-residential buildings sector, followed by industry, while transport projects remain scarce. The prominence of the non-residential buildings sector reflects the availability of low-risk efficiency opportunities that are easily implemented and scaled up, such as lighting replacements, building envelope improvements and heating, ventilation and air conditioning (HVAC) upgrades.

In the past 2 years, the role of green banks has grown immensely in providing energy-efficiency finance as well. Green banks are established by national or regional governments to provide finance and leverage private investment for projects that will benefit the environment and are commercially viable but struggle to attract finance. The investment of green banks in energy efficiency and low-emission transport projects has been increasing and reached USD 430 million in 2017, of which the majority share of the investment was in the buildings sector, having received 81% of the proceeds.[78] The majority of this finance has been loans to small and medium-sized enterprises (SMEs) for building and equipment upgrades, plus new construction of energy-efficient single-family homes.

## *5.3.4. Framework for selection of EE-financing instruments*

In the earlier sections, we have discussed the existing barriers to EE financing and have also analysed various instruments used in the global markets to promote energy efficiency. Further, an attempt has been made in this section to access the applicability of these financial instruments in the Indian context and select the top five instruments that can play a larger role in promoting energy efficiency in the country. To this extent, a framework has been developed, which will rank the instruments in the order of their suitability for Indian market.

### Purpose of the Framework

The purpose of this framework is to rank various financial instruments in the order of their suitability for Indian market and suggest top five instruments that can play a larger role in promoting energy efficiency in the country.

### Application of Framework

This framework would be applied to all EE-financing instruments discussed in the previous sections.

## Formulation of Framework

The success of any financial instrument in a particular market depends largely on a multitude of factors. In order to be considered a success, a financial instrument must have the following qualities/attributes:

- Should have cross-sector applicability.
- Should be easy to implement.
- Must align with financial market maturity.
- Should minimize the risk of investors (i.e. residual risk).
- Must have high potential impact.

Below, we have defined these attributes in greater detail:

### 1. Cross-sector applicability

The cross-sector applicability of an instrument is defined as its ability to be adaptable across multiple sectors with scope for energy-efficiency investment. This parameter requires the instrument to provide benefits to the beneficiary in multiple sectors such that the financier is also suitably compensated.

Under this attribute, the following sectors have been considered across which cross-sector applicability shall be tested:

- Industries
- Municipal
- Transport
- Domestic and commercial
- Agriculture

The marking of the instrument has been done in the following manner:

- When applicable across all the five sectors, 5 marks have been awarded.
- When applicable across any four sectors, 4 marks have been awarded.
- When applicable across any three sectors, 3 marks have been awarded.
- When applicable across any two sectors, 2 marks have been awarded.
- When applicable across any one sector, 1 mark has been awarded.
- When not applicable across any sectors, no marks have been awarded.

### 2. Ease of Implementation

Ease of implementation of an instrument is defined as the relative ease with which an instrument can be operationalized under the given market conditions. To achieve the desired outcome, this parameter has been further subcategorized into three different sub-parameters, described as follows:

**Number of stakeholders involved:** Complexity of any instrument is directly affected by the number of stakeholders involved. This is because of the management issues that are associated with handling of multiple stakeholders. This may also lead to additional costs, which would then be passed to the beneficiary and increase the financial burden of managing the instrument.

The marking of the instrument has been done in the following manner:

- Where four or more than four stakeholders are involved, 1 mark has been awarded.
- Where three stakeholders are involved, 2 marks have been awarded.
- Where only two stakeholders are involved, 3 marks have been awarded.

**Legal and regulatory barriers:** All policies and programmes that come into play have to pass the barriers put forward by the existing legal and regulatory provisions prevalent in the country. So the existing legal and regulatory provisions should not hamper the operational structure of the energy-efficiency instrument. An instrument cannot be termed successful if it cannot dodge even one of the barriers.

The marking of the instrument has been done in the following manner:

- Where the existing legal and regulatory provisions prevent the operationalization of any instrument, no marks has been awarded, else 3 marks have been awarded against this sub-parameter.

**Market readiness:** It depicts the preparedness level of a market to accept the new EE instrument. Market readiness is deemed to be high when there is an already existing market of similar instruments in areas other than energy efficiency or if different segments/components of the new instrument are operational as isolated instruments in the existing market.

The marking of the instrument has been done in the following manner:

- When market readiness is high, 3 marks have been awarded.
- Where market readiness is medium, 2 marks have been awarded.
- Where market readiness is low, 1 mark has been awarded.

### 3. Alignment with financial market maturity

Alignment with financial market maturity depicts the degree of coherence between the form of capital employed by the EE instrument and the shifting market trend of different financial instruments. In India, debt-based instruments have dominated the capital market for quite a long period of time, with most of the projects being debt funded. However, the market is slowly shifting towards equity-based instruments, with more and more investments taking place in equity-linked products. Thus, it is expected that in the long term, equity and subordinate debt instruments would dominate the capital market when compared with debt-based instruments and will provide the necessary capital requirement.

The marking of the instrument has been done in the following manner:

- If the instrument is equity funded, or based on insurance cover, 3 marks have been awarded.
- If the instrument is both equity and debt funded, 2 marks have been awarded.
- If the instrument is debt funded, 1 mark has been awarded.
- If the instrument is funded by subsidy/grant, or no financial support has been provided, no mark has been awarded.

## 4. Residual Risks

Any energy-efficiency instrument, if introduced, is expected to reduce some risk to one or other of the stakeholders involved. Residual risk is defined as the overall leftover risk of the system after the instrument has been implemented.

The various risks that can crop up during the lifecycle of the instrument have been subcategorized as follows:

- **Refinancing risk:** All long-term projects face a refinancing risk, i.e. there is a risk that the project might not get additional funding requirement in later stages of project development. In this case, the initial investors and project managers would have to face the burden of the stalled project.
- **Project implementation risk:** While the refinancing risk points to the possible financial hazard to the project, project implementation risk points to the operational risk cropping up during the implementation phase of the project. This can either lead to reduced output from the project or, in the worst case, stalling of the project.
- **Risk for financier/service provider:** It refers to the risk of the financier/service provider that the project might not return the expected return on investment.
- **Risk of default by end user:** If the end user is an individual customer, or a small organization, there is a high risk of default associated with them. EE financing generally entails financing to high-risk consumers, and thus this risk is prevalent in most of the EE project models.

The marking of the instrument has been done in the following manner, for each of the subcategories of the risks defined above:

- If the reduction in risk due to the instrument is high, 3 marks have been awarded.
- If the reduction in risk due to the instrument is moderate, 2 marks have been awarded.
- If the reduction in risk due to the instrument is low, 1 mark has been awarded.
- If the risk due to the instrument remains unchanged, no mark has been awarded.

## 5. Potential Impact

The potential impact of an EE instrument would be assessed on how effective the project is in inspiring more future projects of similar or bigger scale, and how effectively it affects the indirect stakeholders—the common public, the government, and the entities involved in other related sectors. The impact can be assessed by the level of awareness the programme brings for the various stakeholders involved, and the depth of benefits expected to be enjoyed by the stakeholders during the operational phase of the project.

The rating would be done in the following manner:

- If expected benefits are high and large-scale awareness is created by the instrument, 3 marks have been awarded.
- If the expected benefits are of medium scale and it creates moderate awareness, 2 marks have been awarded.
- If the expected benefits are low and only small-scale awareness is created, 1 mark has been awarded.

**Weightages assigned to different parameters under this framework:**

The present scenario of energy-efficiency investment in India shows a grim picture; EE investment has been low in India as compared to other major economies in the world. The major reason for this lag is the lack of investor confidence due to high perceived risk that an instrument would underperform in the market. So the need of the hour is the de-risking for two market players: end users and the financiers.

If the potential impact of an instrument is high, then the end users would be more inclined towards implementing the EE measure. This would attract the investors to invest in the field. At present, a majority of the investments being made in India for EE measures are through debt-based instruments. Debt repayment puts an extra burden of interest payment on the implementers. So if an instrument is able to de-risk the equity investment, it would also reduce interest burden on implementers so that the potential impact would further improve. So the instrument that could reduce risk for the investors would be preferred. Accordingly, the weightage of 25% each has been assigned to the two parameters: potential impact and residual risk.

The parameter "alignment with market maturity" would support the instrument implementation as early as possible in the Indian market and has been assigned a weightage of 20%.

The parameters "cross-sector applicability" and "ease of implementation" have been given lower weightages, since these two parameters could be developed in the future, once investment streamlines. So an instrument would be attractive for the market even if these two parameters have lower score for them.

The table below summarizes the assigned weightages to various parameters of the framework.

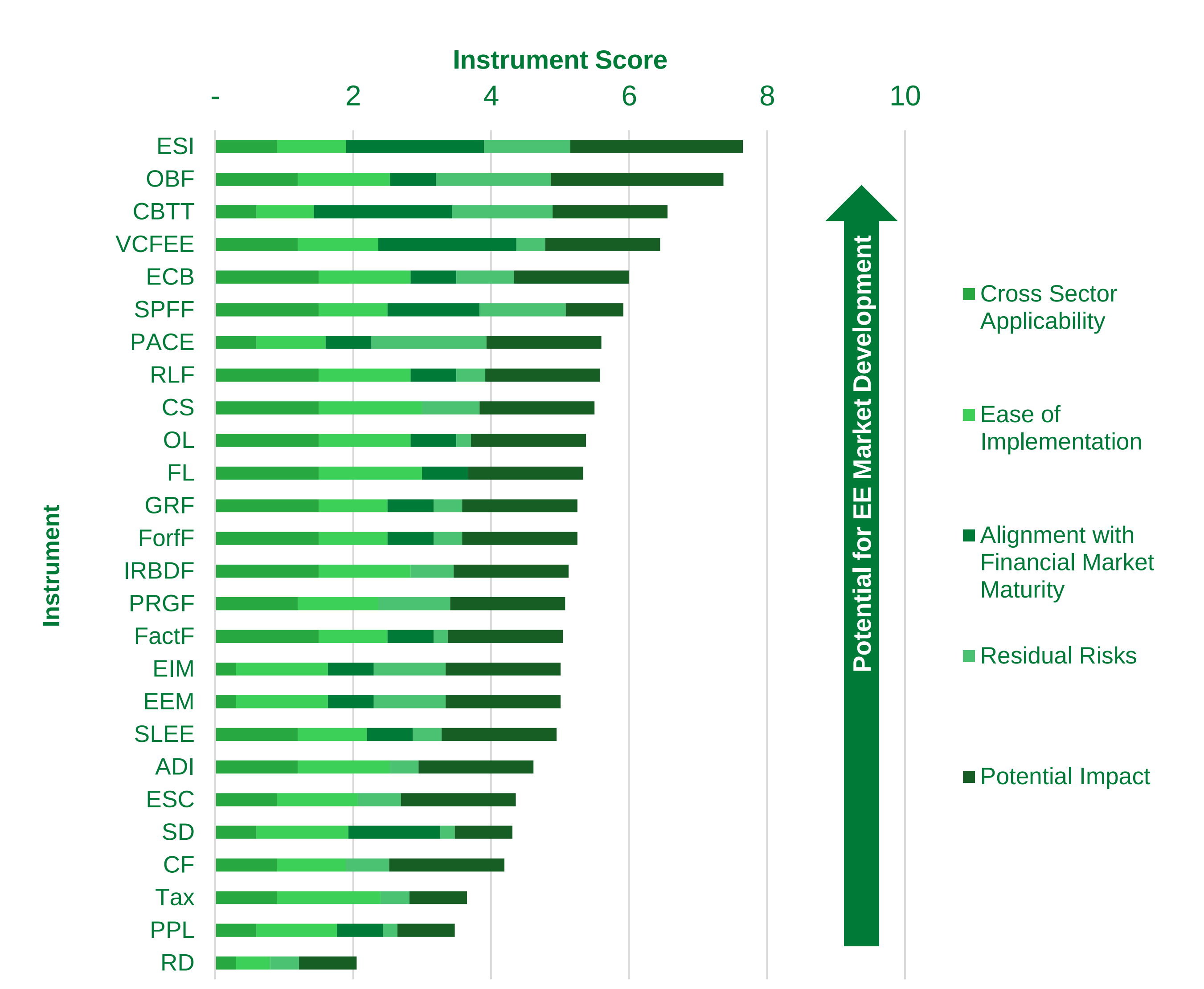
*Table 39: Assigned weightages to different parameters of the framework*

| Parameter | Weightage |
|---|---|
| **Cross-sector applicability** | 15% |
| **Ease of implementation** | 15% |
| **Alignment with financial market maturity** | 20% |
| **Residual risks** | 25% |
| **Potential impact** | 25% |

### Results of the framework

The above framework has been used to study 26 different EE instruments, which are either in conceptualization stage or are operational in different parts of the world. Based on the defined parameters and their corresponding weightages, these instruments have been assigned scores and normalized, so that they could be compared on a relative scale. The figure below shows the relative scoring of various instruments obtained on a scale of 10.

*Figure 18: Relative scoring of EE instruments*



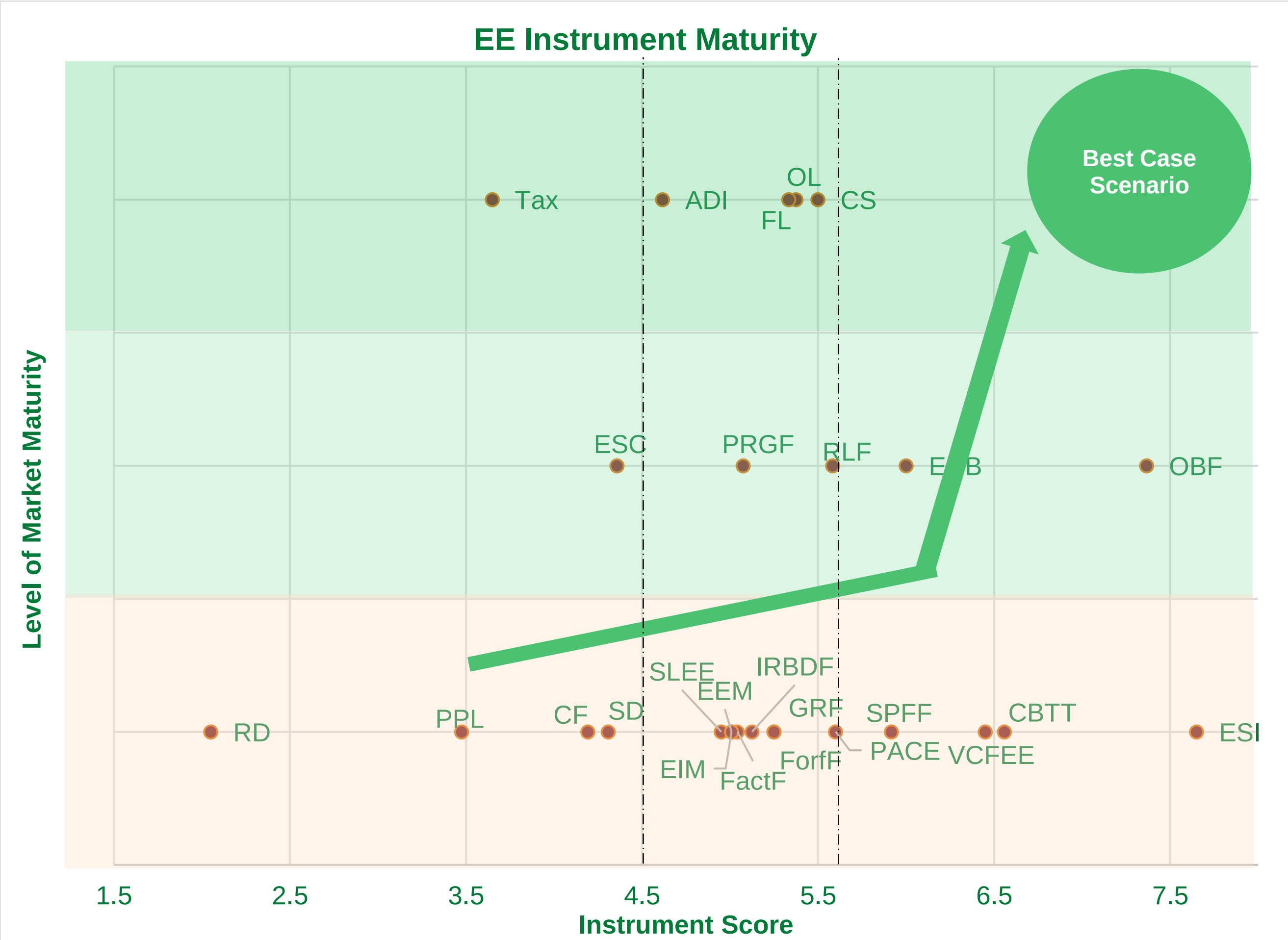

It is observed that the following five instruments have obtained the highest scores:

1. Energy-savings insurance
2. On-bill financing
3. Cross-border technology transfer and energy-efficiency financing facility
4. Venture capital fund for energy efficiency
5. Energy conservation bonds

These instruments, if implemented properly, can play a larger role in developing the EE market in India in the long term. Apart from these five instruments, there are other instruments that have obtained moderate scores (such as property assessed clean energy, revolving loan fund, stranded project financing facility etc.), but can contribute significantly to the EE market development provided that their weak spots are addressed.

The energy-efficiency instrument maturity matrix reflects the current market maturity of various instruments relative to their scoring and suitability in the Indian context. The level of market maturity of an instrument can be classified into three categories, namely, established, new and under conceptualized.

*Figure 19: Energy-efficiency investment maturity matrix*




**Established instruments:** This includes instruments that have been in place in the Indian market for long time and have reached a particular level of maturity, not only in terms of their ease of operationalization but also in terms of their awareness among beneficiaries.

**New instruments:** This includes instruments that have recently been introduced in the Indian market.

**Under conceptualized:** This includes instruments that are in the concept stage or have been implemented in countries other than India.

Thus, the figure in the previous page reinforces the need to introduce measures to aid the instruments in their transition from low score, low maturity level to high-score, high-maturity level in order to realize the best case scenario for market development for energy efficiency in India.

6

# TARGET SETTING IN LINE WITH INDIA'S NDC AND SDG COMMITMENTS

## 6.1. Introduction

The emissions forecast and profiling across sectors are essential in devising the national strategy to meet country's emission reduction commitments. The objective of this chapter is to assess if the country would succeed in meeting the emission reduction commitments based on the energy consumption.

The following sections have been covered in this chapter:

Overview of Sustainable Development Goals (SDGs)

Overview of Nationally Determined Contributions (NDCs)

Global comparison of emission reduction commitements

Progress in achieving NDC targets by India and other countries

GHG emissions foreacast by various sectors in India and NDC target assessment

*India's total greenhouse gas (GHG) emissions represent 6% of the global emissions.*

## 6.2. Overview of Sustainable Development Goals

### Introduction

The 17 Goals of the 2030 Agenda for Sustainable Development, which was adopted by 193 nations in September 2015 at the UN Summit, officially came to force on 1 January 2016. While these goals are ambitious in nature, they have charted out a path for nations to achieve development that is fair, equitable, environment friendly and above all inclusive in nature. Human and environmental rights underpin the foundation of the SDGs that demand robust and integrated actions nationally, recognizing the role of different actors in the process.

India has played an important role in shaping the Sustainable Development Goals (SDGs).[79] This means that the country's national development goals are mirrored in the SDGs. As such, India has been effectively committed to achieving the SDGs even before they were fully crystallized. As one of the 40 countries that have volunteered to take part in the Voluntary National Reviews (VNRs) at the High-Level Political Forum (HLPF) 2017, India appreciates the focus on "Eradicating poverty and promoting prosperity in a changing world".

[79] Voluntary National Review Report on the implementation of SDGs (2017), United Nations

Figure 20: SDGs having direct impact on energy demand


Among the various SDGs, the following goals would have a direct impact on the energy demand and consumption:

## Affordable and Clean Energy

The growing population coupled with the country's aspiration to reach a double-digit growth in order to drive the lion's share of people above the poverty line has been driving India's energy consumption. This is evident from the fact that the country's per capita energy consumption has grown from 5439 KWh in 2011–12 to 6209 KWh in 2016–17. Improvement in EE policies and technologies will lead to huge potential savings that can be used to power sections that are energy poor.

## Industry, Innovation and Infrastructure

### Building Infrastructure

All forms of transportation—roads, railways, civil aviation and waterways—are being expanded rapidly. A total of 8231 km of National Highways was constructed during 2016–17. Thus far, 70% of targeted rural habitations without road connectivity have been connected with all-weather roads. Further, development of 37 national waterways is planned over the next 3 years. This will have a positive impact on the reduction of overall logistics-related costs and environmental impact. A total length of 8000 km of pavements and cycle tracks will also be laid in 106 cities over the course of the next 5 years to promote non-motorized transport and reduce the carbon footprint. To strengthen the railways sector, 3500 km of lines will be laid in 2017–18. The government has set an investment target of Rs 25 trillion (USD 390 billion) for infrastructure development over a period of 3 years (2016–19).

By March 2018, renewable energy accounted for 70 GW out of the 345 GW of installed power-generation capacity of India, making up 20.32% of the total power-generation capacity pie. Solar accounted for 22 GW of the total installed capacity and recorded the largest increase with capacity installations rising 89% year over year (YoY). Wind currently accounts for 34 GW of total installed capacity and around 10% of the overall power generation.

## Moulding the Manufacturing Sector

The National Manufacturing Policy focuses on sustainable job creation in this sector in partnership with sub-national governments. The policy has raised the targeted output from 16% of GDP in 2011 to 25% by 2022 along with creation of 100 million jobs.

National Investment and Manufacturing Zones (NIMZs) have been introduced as crucial instruments to boost and spur manufacturing activity across the nation. Eight NIMZs have been approved along the Delhi–Mumbai Industrial Corridor and three are being set up in the states of Andhra Pradesh, Telangana and Odisha. These zones are envisaged as integrated industrial townships with state-of-the-art infrastructure, energy-efficient technology as well as skill-development facilities for providing an enabling ecosystem for manufacturing industries.

The Perform, Achieve and Trade (PAT), a market-based energy-efficiency trading mechanism, is being implemented in three phases. PAT cycle I ran during 2012–15, covering 478 facilities from eight energy-intensive sectors. These eight sectors account for roughly 38% of India's total primary energy consumption. The second phase of the PAT scheme (PAT cycle II) ran during 2016–19 covering 707 units from 11 energy-intensive sectors. PAT cycle II focuses on deepening and widening PAT cycle I with the inclusion of 61 new designated consumers from the existing eight sectors and the addition of 170 DCs from three new sectors: railways, refineries and electricity distribution companies (DISCOM). In continuation to the rolling cycles of PAT, the third cycle was notified on 31 March 2017. The baseline year was taken as 2015–16, and the target year will be 2018–19. The total number of DCs notified was 116 from six sectors: thermal power plants, iron and steel, cement, aluminium, pulp and paper and textile. No new sectors were added in this cycle. The total target was given as 1.06 Mtoe, which corresponds to a reduction of around 3 Mtoe of $CO_2$.[80] The fourth cycle of PAT was notified on 28 March 2018. The baseline year is taken as 2016–17 and the target year as 2020–21. A total of 106 DCs are likely to get a total reduction target of 0.6344 Mtoe. These DCs are from eight sectors consisting of six existing sectors and two new sectors. The new sectors are petrochemicals and buildings. Under the building sector, hotels have been selected as the potential designated consumer subsector for this cycle. Other subsectors in the building sector may come up in future. Under petrochemical, naphtha crackers and gas crackers have been considered under this cycle of PAT. The total expected $CO_2$ emission reduction from PAT IV is around 2 million tonnes.

The ZED (Zero Effect, Zero Defect) scheme is an integrated and holistic certification system that will account for quality, productivity, energy efficiency, pollution mitigation and technological depth, including design and IPR in products and processes for medium and small industries.

## Boosting Innovation and leveraging ICT (Information and Communication Technology)

Under the aegis of the Digital India Policy of the Government of India, Direct Benefit Transfer (DBT) has transformed service delivery in a majority of government programmes with a cumulative disbursement of Rs 1.6 trillion (USD 25 billion) to 329 million beneficiaries. The Bharat Broadband Network Ltd. aims to provide high-speed broadband connectivity to 247,864 villages or clusters thereof in the country. There are currently 432 million Internet users in India. Another important initiative is Digi Locker through which access is provided to 1.7 billion digitized documents (driving license, school certificates etc.).

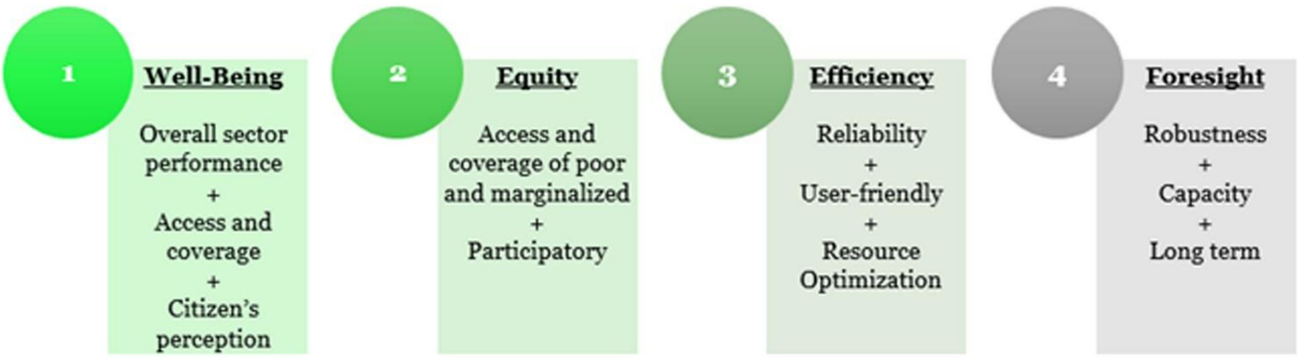
[80] Draft ROSHANEE document 2018, BEE

India is also emerging as a major research and development (R&D) hub in information technology and electronics. India accounted for 40% (USD 13.4 billion) of the global engineering research and development in 2016.[79] The Science Technology and Innovation Plan (STIP) 2013 makes a point of departure from the earlier S&T policies when it stated "science, technology and innovation for the people" as the new paradigm of the Indian STI enterprise. The roadmap along with the STIP 2013 presents the broad contours of the new inclusive innovation paradigm and the trajectory therein.

### Sustainable Cities and Communities

The Government of India's Smart Cities Mission focuses on redefining urban development initiatives that make cities more liveable, inclusive and centres of economic growth. The guiding principles for the Smart Cities programme are as follows:

*Figure 21: Smart Cities programme guiding principles*




In 2011, the Government of India has also recognized the concept of Net Zero Emission Buildings (NZEB) and formally taken initiatives to develop a roadmap to achieve the proposed NZEB vision by 2030.[81] By 2015, all the identified projects were completed and made operational for demonstration.

### Climate Action

Under the SDG framework, actions under the climate action goal are largely based on the outcomes of the climate change negotiations in the United Nations Framework Convention on Climate Change (UNFCCC). India's efforts in integrating climate change measures in national policies have been focused on achieving pre-2020 commitment and its Nationally Determined Contribution (NDC) as also reflected by the national indicators. India agreed in Copenhagen (2009) to reduce its energy intensity by 20%–25% until 2020 over the 2005 level and in Paris (2015) to reduce its emission intensity by 33%–35% by 2030 over the 2005 levels. The National Action Plan on Climate Change (NAPCC, 2008) and State Action Plan/s on Climate Change (mainly looking at adaptation) are constrained by financial support, appropriate institutional structure, meaningful monitoring and clear roadmap, struggle to find a way forward.[82]

## 6.3. Overview of Nationally Determined Contributions

The Intended Nationally Determined Contributions (INDCs) identifiy the actions a national government intends to take under the future UNFCCC climate deal agreed in Paris in December

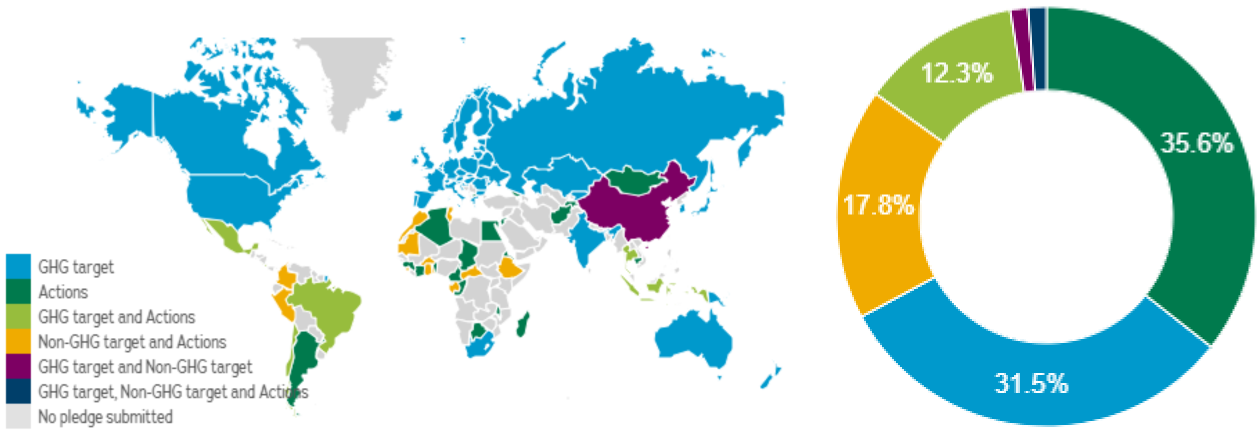
[81] Strategy Roadmap for Net Zero Energy Buildings in India (Aug 2011), USAID, BEE
[82]: http://www.ifmrlead.org /wp-content/uploads/2015/10/NAPCC/REPORT_NAPCC%20Progress%20and%20Eval%20Report.pdf

2015.[83] INDCs are, therefore, the basis of global emissions reduction commitments that will be included in the future climate agreement. INDCs refer both to developed and developing countries' plans.

In their INDCs, UNFCCC Parties are requested to outline the steps they are taking/will take to reduce emissions at the national level. Starting with Switzerland, till date 165 INDCs have been submitted. This reflects the commitments of countries who are responsible for around 96.4% of global emissions. The nature of commitments and the type of target for each country are varied.

## Distribution of countries based on nature of commitment

*Figure 22: Countries based on nature of commitment*



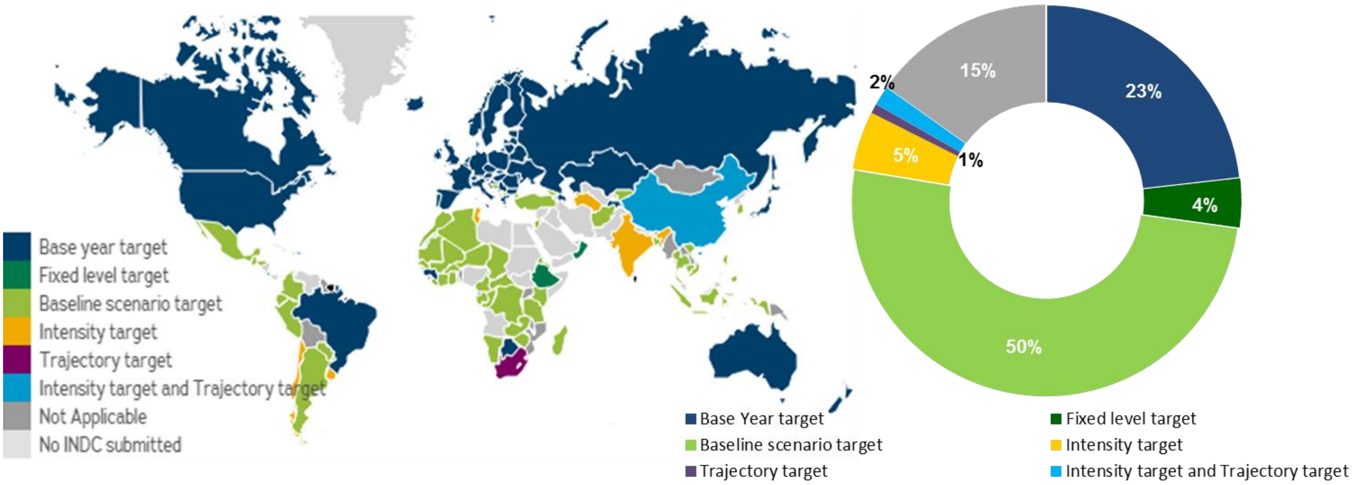

Most of the developed countries (Annex I) countries have committed a GHG target, whereas India has submitted a target that is based on emission-intensity reduction, non-fossil fuel based capacity addition and afforestation.

## Distribution of countries based on GHG target type

Countries have even differed based on the type of GHG target committed. Most of the countries have committed to a baseline scenario target (reduction as compared to BAU scenario). Many developed countries have also committed to a base year target. China is one of the few countries that have submitted both intensity and trajectory targets.

[83] http://climateobserver.org/open-and-shut/indc/

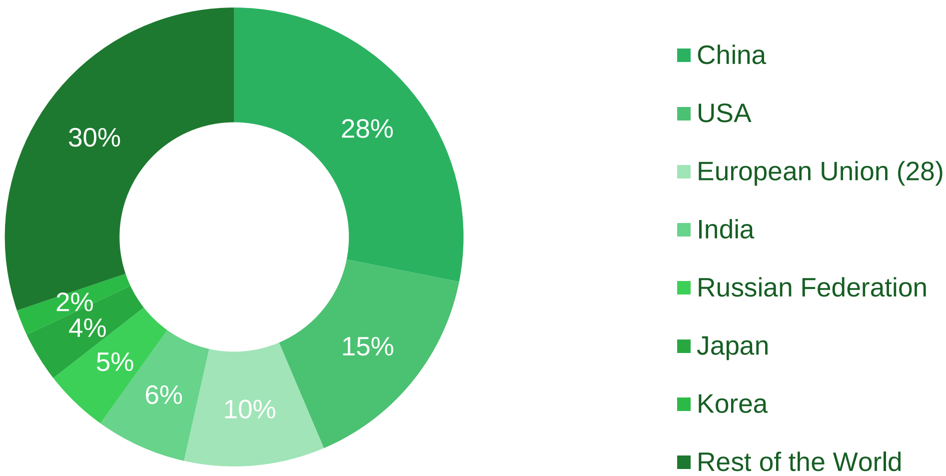
*Figure 23: Countries based on GHG target type*




## 6.4. Global Comparison of Emission Reduction Commitments

In 2015, the total $CO_2$ emissions from fuel combustion reached 32,294 $MtCO_2$. The top seven polluters China, USA, European Union (28 countries), India, the Russian Federation, Japan and Korea contributed to about 70% of this emission. Cumulatively, China and USA contribute to more than one-third of the Global GHG emissions.

*Figure 24: Contribution of leading polluters in global emissions*




Though India’s emissions per capita are below the global average of 4.4, measuring in at 1.58, when compared based on emission intensity (as shown below), China had the maximum emission intensity followed by India and Russia in 2015. The emission intensity of these countries is substantially above the world average of 0.43 $KgCO_2$/USD using 2010 prices.[84]

[84] https://www.iea.org/publications/freepublications/publication/CO2EmissionsfromFuelCombustionHighlights2017.pdf

*Figure 25: Emission intensity using exchange rates (kgCO₂/USD using 2010 prices) in 2015*

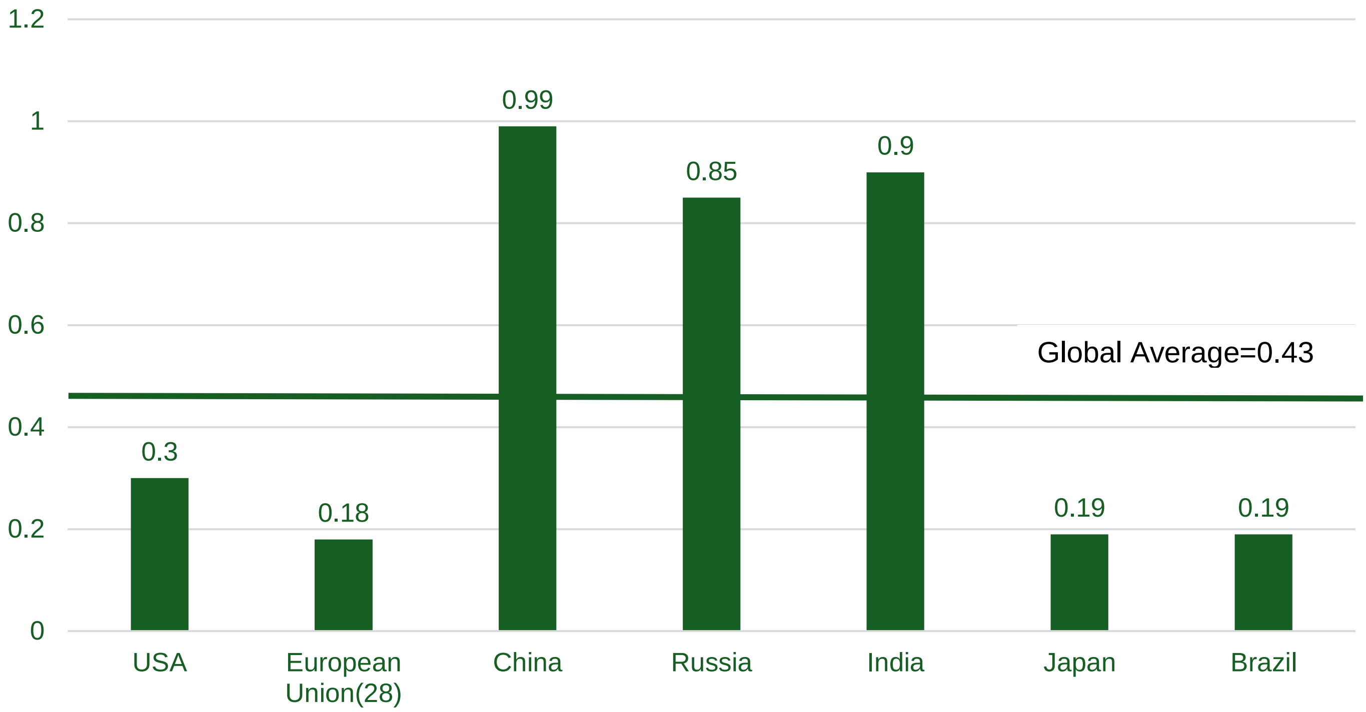



*Table 40: Comparison of NDCs*[85]

| Country | NDC Summary | Sectors Covered | Greenhouse Gases Covered |
|---|---|---|---|
| **European Union (28)** | The EU and its Member States are committed to a binding target of at least 40% domestic reduction in GHG emissions by 2030 compared to 1990, to be fulfilled jointly, as set out in the conclusions by the European Council of October 2014. | Energy, industrial processes and product use, agriculture, waste, land use, land-use change and forestry | All greenhouse gases not controlled by the Montreal Protocol: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride, nitrogen trifluoride |
| **USA** | The USA intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%–28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%. | The US target covers all IPCC sectors. | GHGs included in the 2014 inventory of USA—greenhouse gas emissions and sinks: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride, nitrogen trifluoride |

[85] http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx

| Country | NDC Summary | Sectors Covered | Greenhouse Gases Covered |
|---|---|---|---|
| **Russia** | Limiting anthropogenic greenhouse gases in Russia to 70%–75% of 1990 levels by 2030 might be a long-term indicator, subject to the maximum possible account of absorbing capacity of forests. | Economy-wide, in particular, as determined by decisions of the UNFCCC Conference of the Parties on reporting: energy; industrial processes and products use; agriculture; land use, land-use change and forestry; waste. | Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride, nitrogen trifluoride |
| **China** | China has nationally determined its actions by 2030 as follows:<br>• To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;<br>• To lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level;<br>• To increase the share of non-fossil fuels in primary energy consumption to around 20%; and<br>• To increase the forest stock volume by around 4.5 billion cubic metres on the 2005 level. | Not specified for GHG targets, but various sectors mentioned for policies and actions such as energy, buildings, transportation, industrial processes, agriculture, forestry and land use | Carbon dioxide |
| **Brazil** | Brazil intends to commit to reduce greenhouse gas emissions by 37% below the 2005 levels in 2025. | Brazil's target covers all sectors. | Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride |
| **India** | India communicates its Intended Nationally Determined Contribution for the period 2021 to 2030:<br>• To reduce the emissions intensity of its GDP by 33% to 35% by 2030 from the 2005 level.<br>• To achieve about 40% cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF).<br>• To create an additional carbon sink of 2.5 to 3 billion tonnes of $CO_2$ equivalent through additional forest | Not specified; various sectors mentioned for mitigation and adaptation strategies such as energy, industry, transportation, agriculture, forestry, waste. | Not specified |

| Country | NDC Summary | Sectors Covered | Greenhouse Gases Covered |
|---|---|---|---|
| | and tree cover by 2030. | | |
| **Japan** | Japan's NDC towards post-2020 GHG emission reductions is at the level of a reduction of 26.0% by FY 2030 compared to FY 2013 (25.4% reduction compared to FY 2005) (approximately 1.042 billion t-CO2 eq. as 2030 emissions) | All sectors and categories encompassing the following:<br>• Energy<br>○ Fuel combustion (energy industries, manufacturing industries and construction, transport, commercial/ institutional, residential, agriculture/forestry/fishing, and other)<br>○ Fugitive emissions from fuels, $CO_2$ transport and storage<br>• Industrial processes and product use<br>• Agriculture<br>• Land use, land-use change and forestry (LULUCF)<br>• Waste | Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride ($SF_6$), nitrogen trifluoride ($NF_3$) |

## 6.5. Progress in Achieving NDC Commitments by India and Other Countries

As discussed in the previous sections, the NDCs are based on different parameters, which make it difficult to compare the commitments. In the subsequent section, an attempt has been made to compare the GHG emission targets at an absolute level based on certain assumptions[84]:

*Table 41: Progress in NDC achievements*

| Country | Base Year | Target year | Target Type | Target Reduction | Base Year Metric | Metric in 2015 | Target to be Achieved | Per cent Achieved |
|---|---|---|---|---|---|---|---|---|
| **European Union (28) (MtCO2e)** | 1990 | 2030 | GHG | 40% | 5400 | 4000 | 3240 | 64.81% |
| **USA (MtCO2e)** | 2005 | 2025 | GHG | 28% | 6600 | 5830 | 4752 | 41.66% |
| **Russia (MtCO2e)** | 1990 | 2030 | GHG | 30% | 3900 | 2130 | 2730 | 151.28% |
| **China (EI in GDP and PPP)** | 2005 | 2030 | Intensity | 65% | 1.44 (exchange rate) | 0.99 (exchange rate) | 0.504 | 48.07% |
| | | | | | 0.72 (PPP) | 0.49 (PPP) | 0.252 | 49.14% |
| **Brazil (MtCO2e)** | 2005 | 2025 | GHG | 43% | 750 | 1357.18 | 427.5 | −188.2% |

| Country | Base Year | Target year | Target Type | Target Reduction | Base Year Metric | Metric in 2015 | Target to be Achieved | Per cent Achieved |
|---|---|---|---|---|---|---|---|---|
| **India (EI in GDP and PPP)** | 2005 | 2030 | Intensity | 35% | 0.96 (exchange rate) | 0.90 (exchange rate) | 0.624 | 17.86% |
| | | | | | 0.30 (PPP) | 0.28 (PPP) | 0.195 | 19.05% |
| **Japan (MtCO2e)** | 2005 | 2030 | GHG reduction | 25.4% | 1300 | 1200 | 969.8 | 30.28% |

**Notes and Assumptions:**

- LULUCF (land use, land-use change and forestry) data have been taken into account to calculate MtCO2e.

## Commentary on global progress in achieving emission reduction targets

**European Union (28):** The EU target reduction of 40% falls 19% short of the desired levels as of 2015. The EU's 2050 goal of decreasing its emission by 80%–95% below the 1990 levels is also not in line with the Paris Agreement's long-term warning goal.

The EU recognizes that it is not on track to meet its 2030 levels, and thus the new long-term greenhouse gas emission strategy, which the commission seeks to prepare by the first quarter of 2019, will offer an opportunity to achieve the NDCs.

**USA:** Despite the US administrations intent to withdraw from the Paris Agreement, wind and solar have reached record shares in the electricity mix in 2017 and fossil fuel electricity has experienced its steepest decline since the 2008 financial crisis.

With the recent increase in tariffs for imported solar cells and modules and the EPA (Environmental Protection Agency) deciding to limit emission reductions to actions at the individual plant level rather than requiring states to meets emission standards, the US NDC target looks far-fetched.

**Russian Federation:** While it looks more than likely that Russia would achieve its NDC target, it can be argued that the target was not ambitious in the first place as it would not require GHG emissions to decrease from the current levels.

The Russian Federation remains the only big emitter to not have ratified the Paris Agreement. With the current approach, Russia risks losing out on global competitiveness in the long term when the market is moving towards low-carbon technologies.

**China:** China ratified the Paris Agreement in 2016 and has put stringent policies in place to achieve its NDC targets. China's 13th five-year plan stipulates a maximum 58% share of coal in its national energy consumption by 2020.

$CO_2$ emissions rose in 2017 after a declining trend from 2014 to 2016, which says that it is still too early to suggest if they have reached their peak.[86] Despite this, Chinese officials have claimed that the country has met its 2020 carbon intensity in 2017, 3 years ahead of schedule.

**Brazil:** Emissions are expected to rise until 2030. To achieve its target and rapidly decrease its emission levels once they peak, Brazil will need to turn around the current trend of weakening climate policy by improving policy implementation in the forestry sector and accelerate mitigation actions in the LULUCF sector.

Recent developments in energy infrastructure and reversal of deforestation policies are evidence of Brazil's worsening climate change policies, which will pull them further away from their NDC targets.

**India:** With the emission intensity achieved by India in 2015, India is expected to achieve its climate action targets submitted under the Paris Agreement. Under current implemented policy projections by the Asian Development Bank (ADB), GHG emissions are expected to reach levels of around 5285 MtCO2e in 2030, which is more than double of the 2010 levels.

*Table 42: ADB GHG emission projections*

| GHG emission projections by ADB[87] | | | | |
|---|---|---|---|---|
| **Member Country** | NDC covered emission (MtCO2e/year) | | | |
| | 2010 | 2030 | | Per cent change |
| | | High | Low | |
| **India** | 2043 | 5285 | 3802 | 158.68 |

The "high" scenario is the high-emission case, which is taken as the higher emission end of the range (7567 MtCO2e) of the NDC pledge, whereas the "low" scenario is the low-emission case, which is taken as the lower end of the range (4644 MtCO2e) of the NDC pledge. The growth in emissions is in line with the emission intensity pledges of 2020 and 2030 as well.

**Japan:** Coal power is projected to increase to 34% by 2020 from 32% in 2015, if Japan fails to reintroduce nuclear power and push for renewables. Nevertheless, Japan looks set to reach its 2020 pledge but may fall short of fulfilling its NDC.

Japan's new Basic Energy Plan and a long-term energy strategy focusses on whether new nuclear reactors could be constructed by 2050 and reduction in costs from renewable electricity.

## *6.6. GHG Emission Profiling of India*

In order to assess India's progress towards ambitious commitment of 33%–35% reduction in emission intensity by 2030, it is essential to account for emissions inclusive of all constituents (not just emissions from energy sources). Emissions intensity is the level of GHG emissions per unit of economic activity, usually measured at the national level as emissions intensity of GDP. The metric is a composite of two other indicators—energy intensity and fuel mix (which reflects the fossil intensity of energy consumed). Further, it also accounts for non-energy GHG emissions. Hence, progress

[86]https://www.reuters.com/article/us-china-climatechange-carbon/china-meets-2020-carbon-target-ahead-of-schedule-xinhua-idUSKBN1H312U

[87] https://www.adb.org/sites/default/files/publication/189882/sdwp-044.pdf

against the NDC pledge to reduce emissions intensity of GDP needs to account for economic activity, fossil intensity of energy supply and energy efficiency in end-use sectors. Keeping this in mind, the economy-wide emissions can be divided into two categories: energy and non-energy. Energy emissions contribute a large portion of the overall emissions. Non-energy emissions such as agriculture, waste, IPPU and LULUCF sectors account for a minor portion of the overall emissions.[88]

As India's NDC target has been specified in terms of emissions intensity reduction in the range of 33%–35% from the 2005 levels, it is important to deduce an absolute emissions target by 2030 to accurately identify how the emissions from the demand sectors of the economy contribute towards the overall emissions by 2030. To achieve this, an estimated GDP growth rate of 8% has been assumed till 2030 to calculate the nominal GDP of the country by 2030. Assuming that India achieves the 33% target emission-intensity reduction, the absolute emissions by 2030 are estimated to be 6807 MtCO2e, out of which the contribution from energy sources is 5302 MtCO2e and 1505 MtCO2e from non-energy sources. This means that the overall emissions in the economy would have to be limited to 6807 MtCO2e to successfully meet our NDC commitment.

The UNNATEE report, while emphasizing on the energy savings in each of the demand sectors, brings out the emission reduction that is possible through the adoption of efficient energy-saving practices, adoption of novel technologies and better enforcement of existing policy and programmes. The emission savings projections under the moderate and ambitious scenarios for each sector are mentioned in the table below:

*Table 43: Emission reduction projections*

| Sectors | Moderate Emission Reductions (MtCO2e): 2030 | Ambitious Emission Reductions (MtCO2e): 2030 |
|---|---|---|
| **Agriculture** | 14 | 34 |
| **Commercial** | 34 | 44 |
| **Domestic** | 101 | 134 |
| **Municipal** | 7 | 11 |
| **Industrial** | 185 | 238 |
| **Transport** | 97 | 141 |
| **Total reduction due to EE** | **438** | **623** |
| **Overall reduction** | **889** | **1053** |

Under the moderate and ambitious savings scenario, the total emissions from energy sources in the country would amount to 4413 MtCO2e and 4249 MtCO2e, respectively.

[88] GHG Platform India

# IMPLEMENTATION FRAMEWORK FOR NATIONAL ENERGY EFFICIENCY STRATEGY

## 7.1. Introduction

To achieve the energy-efficiency potential targets as well as for India to stay within its NDC targets mentioned in the preceding chapters, it is necessary to structure a robust implementation strategy that paves the way for energy security and sufficiency in the country. To that effect, the chapter presents a compendium of global best practices identified on the basis of their reported success in scaling up EE at national, state and local levels. The best practices cover energy-efficiency laws, regulations, financing mechanisms, institutions, innovative business models, implementation/delivery mechanisms and several other programmatic interventions that are recognized for their ability to overcome critical barriers and create favourable market conditions for EE. The chapter also contains a detailed review of the international strategic plans for five countries: Australia, Canada, South Africa, United Kingdom and Japan. The policies and programmes in these countries have been studied according to the various demand sectors, with a comparison with the present state of policy and programme interventions in India for the respective sectors. In the end, implementation strategies for each of the demand sectors as well as those strategies that cut across sectors and have an overall impact for influencing the energy-efficiency landscape in the country are presented.

A broad overview of the tasks covered in this chapter are as follows:

| | | |
|---|---|---|
| Identification of global best practices based on their success on scalng up EE | International strategic plan review for five countries: Australia, Canada, South Africa, United Kingdom and Japan | Implementation strategies for each demand sector as well as those that cut across sectors |

## 7.2. Best Practices for Scaling up Energy Efficiency

Each best practice includes an overview of the concept, initiative, significance and benefits, examples of their effective implementation, achievements, lessons learned and the critical success factors. The selected practices are not intended to be a comprehensive overview of all the successful policies and initiatives, but rather a selection of those that are the most applicable to emerging economies involved in expanding their energy-efficiency markets. This compendium will serve as a library of successful programme and policy models that may be easily replicated or suitably adapted for implementation in the emerging markets.

### 7.2.1. Promotion of Energy Management System Standards through Government Policies and Programmatic Efforts

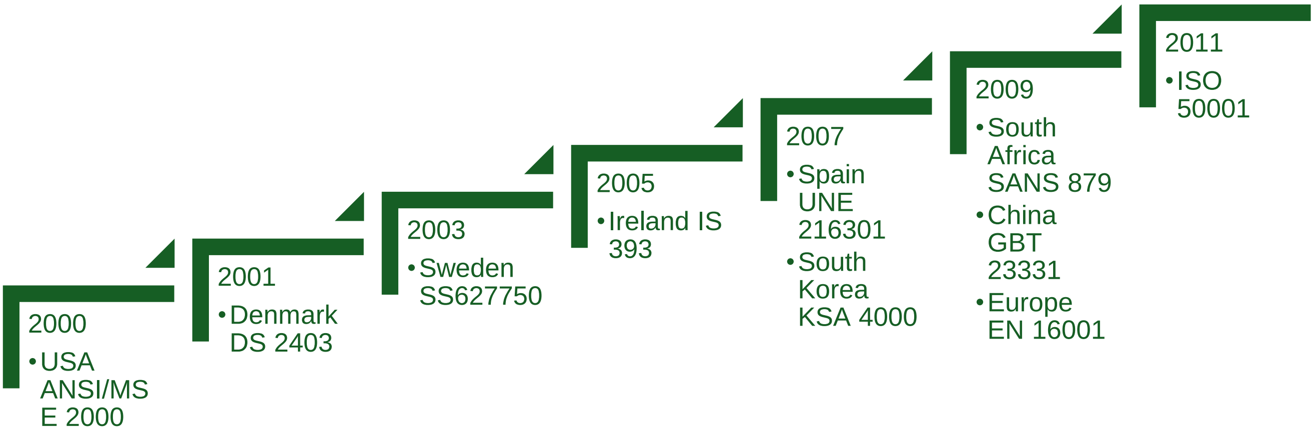
#### Overview

Experience has shown that organizations can save around 10%–30% of their annual energy consumption and reduce energy costs through better energy management, often just by making operational changes.[89] An energy management system (EnMS) allows organizations to systematically manage energy performance with established procedures and practices. An EnMS aims to integrate energy performance into daily management practices and business systems, leading to a lasting change in organizational culture. Implementation of EnMS requires organizations

[89] https://www.researchgate.net/publication/238066344_Setting_the_Standard_for_Industrial_Energy_Efficiency

to assess baseline energy use, actively monitor, control and manage energy use and costs, reduce emissions and continue to improve energy use/product output over time.[90] A number of standards for EnMS exist or are applied in the EU countries, Korea, South Africa, USA and China. Promotion of standardized EnMS has been an important strategy for governments in these countries to address critical barriers for scaling up energy efficiency.

*Figure 26: Progression of international standards*




ISO 50001:2011 is the latest international standard for energy management system, developed by the International Organization for Standardization (ISO). It is a classical management system standard for manufacturing and services and can be adopted by different organizations of all sizes in both public and private sectors.

### *Experience of government policies and programmes to drive EnMS uptake*

Experience in the EU countries, USA, Korea and India has indicated that government policies, in the form of specifically designed programmatic interventions, stimulate the market uptake of standardized EnMS (ISO 50001). Such programmes typically include financial incentives, regulations concerning energy use, rewards and recognition programmes, access to guidance information and technical tools. Government programmes focusing on technical assistance help companies overcome barriers related to lack of information and technical expertise for implementation of EnMS. Financial incentives and reward programmes aim to create value for organizations by improving profitability and giving recognition.

[90] https://www1.eere.energy.gov/manufacturing/pdfs/webcast_2009–0122_energy_mngmnt_stnds.pdf

### *Examples of government programmes promoting uptake of EnMS standards*[91]

| Country | Financial/fiscal Incentive | Regulations (Binding Targets for Energy Performance) | Technical Assistance | Rewards and Recognition |
|---|---|---|---|---|
| **Germany** | Exemptions on energy tax and renewable levies on electricity | Energy intensity target for industries (1.3%) | Energy-efficiency networks (EEN) for sharing experiences in energy management, subsidized energy audits | N/A |
| **Sweden, Denmark and Ireland** | Fiscal incentives (reimbursement of energy/carbon tax) under voluntary agreements (except in Ireland) | N/A | Technical support through agreement support managers | N/A |
| **USA** | N/A | N/A | Certification process<br>e-guide for ISO 50001<br>Quick Plant Energy profile<br>Strategic Energy Management Checklist<br>Energy Performance Indicator Tool<br>System Assessment Standards | Silver, Gold and Platinum recognitions under Superior Energy Performance programme |
| **Korea** | N/A | N/A | Training courses<br>Technical information<br>Pilot EnMS certification programmes | N/A |
| **India** | White certificates trading under PAT scheme | Binding targets on energy-intensive industries (2012–15) under PAT scheme | Energy audits and benchmarking of specific energy consumption | National Energy Conservation Awards |

### *Learnings from international experience*

Fiscal incentives have been very effective in accelerating the uptake of ISO 50001 EnMS. Access to incentives helps reduce costs, improve profitability and get the attention of top management. Without these incentives, the uptake depends on government-driven technical assistance programmes combined with market recognition and rewards. Technical assistance and capacity-building measures such as guidance documents, establishment of clear certification rules/process, energy audits and training play a key role in implementation of EnMS by the industry. Consultations and continuous dialogue with industry, industry associations and other relevant stakeholders have helped

[91] https://pubarchive.lbl.gov/islandora/object/ir%3A125483/datastream/PDF/download/citation.pdf

governments to implement initiatives and programmes that address the specific barriers in the national context.[92]

## 7.2.2. EE obligations, resource standards and integrated resource planning (IRP)

### Overview

A survey by the World Energy Council, in 2012–13, has indicated that more than 70 countries in the world have adopted some form of quantified energy-efficiency improvement targets. Targets do not necessarily mean obligations, but they have certainly emphasized the commitment of governments towards energy efficiency and also helped in streamlining the policy and planning for effective scale up.

An energy-efficiency obligation (EEO) is a regulatory mechanism that requires obligated parties to meet quantitative energy-efficiency improvement targets in a predefined time frame. Typically, EEO is placed on energy utilities, which are in the business of distribution and retail sales of energy commodities, and even on end users of energy. EEO for utilities requires them to reduce the demand for energy by promotion of demand-side measures. EEO for end users requires them to improve energy performance indicators by implementing end-use energy-efficiency measures. A survey by IEA in 2012 has found dozens of jurisdictions around the world with some form of the EEO.

Typically EEOs implemented across the globe share the following features:

- A quantitative binding target for energy-efficiency improvement.
- Target enforced by laws and regulations with the threat of financial penalties.
- Clear definition of obligated parties that must meet the target.
- A systematic process for compliance verification.

*Snapshot of EEO features in select countries across the globe*

| Country | Target | Obligated Parties | Enforcement Mechanism | Compliance Mechanism | Performance Incentives |
|---|---|---|---|---|---|
| **Canada – Ontario** | 1330 MW reduction in peak demand by 2014<br>6000 GWh of energy savings by 2014 | Electricity distribution licensees | Combination of legislation and regulation | Self-achievement of savings verified by third party and approved by regulator | CAD 0.3 to 1.8 per unit allowed for goal achievement ranging from 80% to 140% |
| **China** | 0.3% of electricity sales and maximum load in the previous year | Government-owned grid companies | Regulation issued by central government agency | Self-achievement of savings verified by third party | None |
| **USA, California** | 6965 GWh, 1537 MW, and | Investor-owned and publicly | Combination of legislation and | Self-achievement of | Capped at USD 450 million for |

[92] https://www.oecd.org/sti/ind/DSTI-SU-SC(2014)14-FINAL-ENG.pdf

| Country | Target | Obligated Parties | Enforcement Mechanism | Compliance Mechanism | Performance Incentives |
|---|---|---|---|---|---|
| | 150 million tonne in 2010–12 for investor-owned utilities; 700,000 MWh for publicly owned utilities | owned electricity and natural gas utilities | regulation, financial penalty for non-compliance | savings rigorously verified by third-party contractors | investor-owned utilities |
| **India - Perform Achieve and Trade (PAT) Scheme** | 6.6 Mtoe cumulative by 2015 | Large energy-intensive industries, including electricity-generating utilities | Combination of legislation and regulation, financial penalty for noncompliance | Self-achievement of savings or purchase of energy-efficiency certificates | Trading of energy efficiency-certificates among obligated parties |

## Examples of IRP in USA

| Utility | IRP year | Target |
|---|---|---|
| **Arizona Public Service** | 2012 IRP | Increase in the energy-efficiency portfolio share (in the overall energy mix) from 4.7% in 2012 to 15.4% by 2027 |
| **PacifiCorp** | 2011 IRP | Increase in the DSM portfolio share from 0.9% in 2011 to 11.2% by 2027 |

The targets for EEO schemes have varied widely in terms of how they are set. The prominent practice has been to denominate the target in terms of final energy consumption by specifying the form of final energy. Targets for utilities are usually set in the form of energy served by them and stipulate the quantum of savings in the final energy consumption or percentage of total final energy consumption. Targets for end users are usually stipulated in terms of the quantum of final energy consumption in one common energy unit or units of electricity or weights of specific fuels. Such targets for end users could be affected by changes in the production output of end users. In order to overcome this challenge, India has set the targets in the form of specific energy consumption of individual obligated entities.

Many EEO schemes are accompanied with performance incentives in order to drive compliance. There are prominently two different incentive mechanisms adopted in the EEO schemes. One mechanism awards financial incentives for all obligated entities for every unit of energy saved beyond the target with capped limits of maximum incentive. The second mechanism allows partial compliance of targets through purchase of “certificates” in addition to self-achievement. The “certificates” are tradable instruments issued by appropriate authority or third parties for a specific quantum of energy savings achieved by the obligated entity, over and above the target savings. These certificates are allowed to be traded among obligated parties for partial compliance.

## Learnings

The emphasis on energy efficiency as a “resource alternative” has allowed it to compete directly with energy supply options in resource procurement and wholesale markets.

Enforcement is the key to the success of any form of energy-efficiency obligations. The international experience indicates that a strong legal framework enacted through legislative actions is the pillar of effective enforcement of such obligations. In addition, high levels of penalty for noncompliance, incentives for performance beyond targets, a systematic procedure for obligated parties to report claimed energy savings to an appropriate authority and a process for checking and verifying these savings by independent/qualified/certified third parties are the basic tenets of good compliance regimes.

Targets under EEO schemes should reflect the achievable (market) potential for energy savings rather than the technical (theoretical) and economic (cost-effective) potential. Targets for end users should be based on the baseline assessment of energy performance indicators conducted for each and every obligated entity/user. It is not feasible to define a single target/norm/standard unless there is significant homogeneity among end user group. Therefore, the energy-efficiency improvement targets should be “user specific”.

An appropriate funding mechanism is another critical success factor for the EEO schemes, especially when the obligated parties are energy utilities, who are not the direct beneficiaries of accrued energy savings. Cost recovery through tariffs will enable a sustainable funding mechanisms for utilities in meeting their individual energy-saving targets.

A successful IRP should include consideration in detail of the following elements: a load forecast, reserves and reliability, demand-side management, supply options, fuel prices, environmental costs and constraints, evaluation of existing resources, integrated analysis, time frame, uncertainty, valuation and selecting plans, action plan and documentation.

### *7.2.3. Standard Offer programme (SOP) design for EE resource acquisition by utilities*

The Standard Offer is a mechanism under which utilities purchase energy savings and/or demand reductions at a predetermined rate per kWh or per kW (termed as Standard Offer rates). Any energy user (utility customer) or energy service company (ESCO) that can deliver energy and/or demand savings is paid fixed amounts per kWh or kW by the utility upon realization/verification of energy savings. The fundamental idea of the Standard Offer approach is that it treats EE projects and investments in a manner analogous to generation of electricity and considers the energy savings and demand reductions as resources (virtual power supply) that the utility will pay for. This essentially means that the Standard Offer rates are considered as feed-in tariffs for energy-efficiency resources, thus creating favourable market conditions to compete directly with other resources (viz. thermal, hydro, nuclear and renewable sources) available with utilities while planning for long/short term energy demand. Standard Offer approach indirectly emphasizes energy efficiency as an alternative resource and further streamlines the evaluation process of energy-efficiency project proposals and disbursement of incentives/payments. The greater transparency, shorter processing times and reduced transaction risk of the Standard Offer approach would facilitate mobilization of commercial financing, essential to achieve substantial scaling up of EE/DSM investments.

The Standard Offer Programme (SOP) designs have been widely adopted in the USA, South Africa, India and many other countries. SOPs in California have resulted in over 385 GWh of electricity savings and 50 MW of demand reduction in 2010–11.[93] In South Africa, SOPs have generated cumulative savings of 726 GWh and 104 MW of demand reduction.[94] Eskom, which is the national integrated electric utility of South Africa, published a list of pre-approved EE/DSM technologies or measures that are eligible for payments under the SOP.

### *Published standard offer technology category rates in Rm/MW and c/kWh*

| Target technologies and end-use applications | Rm/MW | c/kWh |
|---|---|---|
| **Energy-efficient lighting systems** | 5.25 | 42 |
| **LED lighting technologies** | 6.86 | 55 |
| **Building management systems** | 5.25 | 42 |
| **Hot water systems** | 5.25 | 42 |
| **Process optimization** | 5.25 | 42 |
| **Industrial and commercial solar water systems** | 8.736 | 70 |

### Learnings

Publishing the list of eligible technologies for various end-use applications and established Standard Offer rates has broadened the scope of uptake for SOP in South Africa. Also allowing ratepayers (customers), energy service companies, equipment and appliance manufacturers, dealers/suppliers, customer cooperatives and nongovernment organizations as eligible applicants has further widened the scope for uptake of SOPs.

In India, deemed savings approach, simplified M&V and adopting conventional feed-in-tariff establishment methods in the valuation of standard offer rates have been the critical success factors for rising uptake of SOPs by utilities.

## *7.2.4. On-bill financing for utility-driven EE programmes*

On-bill financing is a mechanism whereby a utility company includes the repayment for energy-efficiency improvements on the customer's monthly bill. In many ways, on-bill financing is uniquely positioned to reduce first cost barriers in several energy-efficiency markets. On-bill financing leverages the customer's existing relationship with the utility to avail convenient access for funding energy-efficiency retrofits.

A recent market update[95] on "Financing Energy Improvements on Utility Bills" has indicated that on-bill programmes are operating or preparing to launch in at least 25 states in the USA, as well as in Canada and the UK. The programmes reviewed under this market update have delivered over USD 1.8 billion of on-bill financing to consumers for energy improvements.

In India, electricity distribution licensees in Delhi NCR and Rajasthan have recently launched the DELP on-bill financing model that aims to overcome the first cost barriers for adoption of self-ballasted LED retrofit lamps by the residential consumers. The scheme envisages to achieve 504 million units of annual reduction in electricity consumption. The Energy Efficiency Services Limited (EESL) has been providing the technical and financial support for these projects.

[93] CPUC 2010–2011 Energy Efficiency Annual Progress Evaluation Report
[94] 'Standard Offer Programmes – Review of International Experience', Shakti Sustainable Energy Foundation, 2014
[95] State and Local Energy Efficiency Action Network's (SEE Action) Financing Solutions Working Group, 2014

## Learnings

Some of the main challenges faced by utilities worldwide for widespread adoption of on-bill financing for energy-efficiency improvements are:

- Low participation rates,
- Upfront costs to utilities for modifying their billing systems,
- Non-payment or defaulters,
- Finding capital to finance on-bill programmes.

International experience suggests there cannot be “one size fits all” solution, and utilities worldwide have adopted varying programme design options to overcome some of the key barriers for widespread adoption of on-bill financing.

Given that on-bill programmes are mostly voluntary in nature, the participation rate depends on the eligibility criteria/conditions, eligible measures, terms of agreement (between utility and customer for structuring the on-bill financing transaction) and cost of financing.

Typically on-bill financing programmes have been targeted at small business enterprises and residential consumers to provide and expand access to energy-efficiency funds. The utility bill payment history is utilized to assess the creditworthiness of participants.

Measures with low payback periods and zero-interest loans have greater participation rates. Several on-bill programmes in the USA and India are “bill neutral” to the consumer, meaning that the consumer’s net utility bill (after accounting for both financing charges and for reduced energy costs) is lower than it had been in the past.

The terms of on-bill financing agreement (between utility and customer) typically involve two key design questions:

- Whether non-payment can lead to the disconnection of energy service?
- Whether the on-bill financing loan payments are paid off when the building occupants change, or is attached to the meter and is paid by the subsequent occupants?

The threat of utility service termination may secure the consumer’s payments towards the on-bill financing loan. However, regulated utilities must review and amend the existing regulations for service termination to include non-payment of on-bill financing loan payments.

Tying the on-bill financing obligations to a utility meter rather than occupant/owner can facilitate automatic transfer of obligations to subsequent occupants. However, this design can also increase the risk of split incentives among existing and subsequent occupants/owners.

Legislative and regulatory actions mandating utilities to provide on-bill financing options to select class of consumers have been prominent in many states in the USA (Illinois, South Carolina, New York, California etc.) to drive widespread adoption of on-bill financing mechanism.

Ratepayer funds and revolving funds established by budgetary allocations/grants are the major sources of capital for on-bill financing programmes in the USA. These sources can be leveraged to provide zero-interest loans to participants, but limited availability may impose challenges for expansion. Third-party capital available from multilateral/bilateral/commercial banks and energy service companies (ESCO) is best suited for scaling up on-bill financing programmes. Credit security and treatment of partial utility bill payments are key design options for on-bill programmes seeking third-party capital.

Utilities that rely on private capital to fund their on-bill financing programmes also need to consider the potential impact of using just the utility bill payment history and service termination as the criteria to approve participant applications in the programme. Programmes that have successfully leveraged private capital, in the USA, have provided robust credit security mechanisms (e.g. a loan loss reserve or partial risk guarantee, which reduces the risk of poor repayment performance to private capital providers).

One of most important programme design considerations that has evolved from the experience of on-bill financing programmes worldwide is to address who gets paid first in the event that a consumer only makes partial payment of the utility bill. Specifically, in the event of a partial utility bill payment, does the on-bill financing charge get repaid before other utility charges are paid, or is the payment distributed “pro rata” (proportionally) across all charges, or is the on-bill financing charge subordinated (i.e. is collected after all other utility charges are paid in full)? The payment priority of the on-bill financial charge relative to other charges is particularly important for those programmes that seek to access third-party capital. Private investors will seek senior or pro rata treatment for repayment of the on-bill financing charge and may look unfavourably upon subordination of the financing charge relative to other charges.

### *7.2.5. Establishment of a nodal institution with statutory powers for promotion and regulation of EE*

Worldwide experience has shown different institutional models for governing EE. Some the most commonly observed models[96] are as follows:

| Institutional Model | Examples |
|---|---|
| **Government agency with broad energy-related responsibilities** | US Department of Energy, Office of Energy Efficiency and Renewable Energy,<br>Danish Energy Authority,<br>Japan—Energy Efficiency Division (METI) |
| **Government agency focused on clean energy—energy efficiency, renewable energy, sustainable energy, global climate change** | Mexico CONAE,<br>Australian Greenhouse Office<br>Czech Republic—Czech Energy Agency,<br>France—ADEME,<br>Netherlands—NOVEM,<br>Sweden—Swedish Energy Agency |

[96] An Analytical Compendium of Institutional Frameworks for Energy Efficiency Implementation, ESMAP, 2008

| Institutional Model | Examples |
|---|---|
| **Government agency focused on energy efficiency only** | Thailand—Department of Alternative Energy Development and Efficiency (DEDE),<br>Brazil's National Electrical Energy Conservation Programme (PROCEL),<br>New Zealand—Energy Efficiency Conservation Authority (EECA),<br>India's BEE,<br>Pakistan's ENERCON,<br>Bangladesh's SREDA |
| **Independent statutory authority with a government-appointed board to promote energy efficiency or clean energy** | The Sustainable Energy Authority of Ireland (SEAI),<br>UK Energy Saving Trust,<br>Sri Lanka Sustainable Energy Authority (SLSEA) |
| **An independent corporation owned by the government** | The Korea Energy Management Corporation (KEMCO),<br>South Africa—National Energy Efficiency Agency |
| **A public–private partnership (PPP), by government and nongovernment entities** | Polish National Conservation Agency,<br>Germany—DENA |
| **A nongovernment organization (NGO)** | Austrian Energy Agency,<br>Croatia Energy Institute |

A statutory basis through constitutional enactment confers a definite institutional advantage for nodal energy-efficiency agencies, especially if the legal basis includes provisions for regulation, funding or other resources.[97]

### Learnings

Worldwide experience indicates that there is no single institutional model. Experience has shown that the institutional mechanisms must be designed and adapted to fit local needs and situations. The choice and design of energy-efficiency nodal agency should reflect historical development, country context, and alignment with sector and energy-efficiency objectives, policy implementation requirement, existing institutions and many other factors. Statutory bodies with strong leadership, financial independence, sufficient resources, good external cooperation and private-sector involvement are the critical factors and core competencies that contribute to successful energy-efficiency nodal agencies.

## *7.2.6. Establishment of a public-sector corporation to lead investment-related actions of EE*

Worldwide experience indicates that the public-sector resources are crucial to scale up EE investments and lead the market-related actions in capturing the EE potential in the overall economy.

[97] *Energy Efficiency Governance Handbook*, IEA 2010

The nodal agencies generally do not have the mandate (unless they are independent corporations) to undertake large-scale EE investments, and they also have many competing demands for their internal funds/resources. Implementing policy-driven regulations, awareness, capacity building and other programmatic interventions always takes priority over large-scale investments.

Establishment of a public-sector corporation with adequate seed capital for the sole purpose of leading the market-related investments has proven to be very successful in scaling up EE. Such institutions can leverage the public-sector equity to raise sufficient debt funds in order to overcome the critical financial barriers for large-scale EE investment opportunities. They provide resources for design, procurement, and commissioning and project management of EE projects and also offer services and solutions under their own business models.

Dubai's "Etihad Energy Services" and India's "Energy Efficiency Services Limited (EESL)" are some of the relevant examples of public-sector corporations established to lead investment-related actions of energy efficiency.

#### Learnings

Experience indicates that public-sector corporations can effectively aggregate demand and substantially reduce the high initial costs, thereby creating commercially viable investment opportunities and facilitating higher uptake of solutions by end users.. They need a working relationship with commercial financing institutions, well-established resources and a clear business strategy to drive large-scale investments using innovative business and implementation models such as energy performance contracting. Apart from leading the investment-related efforts, such corporations can also engage the private-sector energy service companies (ESCOs) and energy-efficient technology/equipment manufacturers to invest and support in the development of energy-efficiency services infrastructure in the country.

### *7.2.7. Adapting ESCO financing and energy performance contract structures to fit local market conditions*

Energy service companies (ESCOs) help end users and energy utilities identify, package, finance, implement and monitor energy-savings projects. Typically, this is done through energy performance contracting (EPC), where the ESCO is paid over time from the energy savings. ESCO financing provides a way to facilitate access to commercial financing by leveraging reduction in energy bills over the life of the project. ESCOs can also serve as market aggregators, by allowing financiers to support a portfolio of energy-efficiency projects.

In the developed countries, such as the USA, Germany, France, Japan, Canada, Finland and Denmark, ESCOs have performed EPC projects by taking on the performance risk of energy-efficiency improvements, guarantee cost savings to the end user, and use the energy bill savings resulting from the projects to pay off the initial investment at no upfront cost to the end user or utility.

#### Learnings

Familiarity with EPC models adopted in the developed countries can be important in understanding the range of options, but those models need to be adapted incrementally to work in developing countries. Where local EPC experience exists, it may be prudent to build on successful transactions and institutionalize those aspects that have worked well. It may also be worth considering efforts to bundle projects to reduce transaction costs and make such projects more attractive to target markets and vendors. ESCO promotion and development is a long-term undertaking and must have significant government support in order to succeed.[98] Often it may be advisable to begin with simpler models first and develop more complex transactions as the market develops. Considerations for target markets, long-term financing requirements and potential sources, substantial market organization and development, massive dissemination of early successes, proactive resolution of common legal, financial, accounting/tax and other issues associated with EPCs, etc. are all necessary. While the traditional EPC models have been more common in the developed world, simpler models may be more appropriate in developing countries, at least until the market has a chance to evolve to more sophisticated contractual arrangements over time.

### 7.2.8. Minimum energy performance standards (MEPS) and labels for appliances and equipment

Standards and labels work in tandem to improve efficiency of end-use appliances. Together, standards and labelling (S&L) programmes are market transformation mechanisms that aim to promote energy efficiency in appliances and equipment markets.

Review of global programmes suggests that many developed and developing countries started adopting MEPS and labels early (15–40 years) and have progressed and covered a number of product categories in their programmes. In addition, mandatory labelling measures seem to have increased substantially as compared to voluntary measures in many product categories.[99] A survey by World Energy Council in 2012–13 indicates that 90% of the 71 countries surveyed have introduced mandatory labels. In EU, Japan, Korea, Thailand, China, USA and many others countries, a strong legal and regulatory framework has provided the statutory basis for specifying standards, institutionalization and effective implementation of S&L programmes. Apart from this, clear allocation of sufficient and stable funds has helped the USA, China, EU and Korea to establish adequate resources (testing laboratories) and support effective programme development and monitoring.

Australia places a great deal of importance on accurate performance information. The government requires technical information about energy performance of products before bringing them into the country or into the market. Under a check-testing programme, appliances from retail outlets are tested in accredited independent laboratories to verify that the information provided on the label is accurate.[100]

In the Republic of Korea, fines apply to products that enter the consumer market without meeting minimum energy performance standards, and product labels inform consumers about the energy consumption of devices even during sleep, passive and “off”-mode status.

In Japan’s Top Runner programme, mandatory standards (as applicable to various products and appliances) are established for given target years, based on the performance of the most efficient product available in the market.

#### Learnings

[98] Public Procurement of Energy Services
[99] IEA, 2013
[100] World Resources Institute 2013

Effective monitoring and compliance mechanism is important to increase market uptake of labelled appliances. These countries have separate fund earmarked for monitoring the uptake of labelled appliances in the market. Stringent penalties have ensured a strong compliance regime in many countries.

### 7.2.9. Leveraging economies of scale through demand aggregation and bundled procurement to moderate high upfront costs of EE technologies

One of the major barriers for accelerating the penetration of energy-efficient technologies in any country is the high upfront cost. Demand aggregation is often considered an important strategy to significantly enhance volumes, improve economies of scale and reduce the upfront cost in the process. Bundling demand allows for bulk procurement in public-sector institutions and markets, which hold significant potential for improved EE and represents a large and important market in all countries. The common ownership and homogeneous nature of many of the facilities, particularly those with common functions (schools, hospitals), offer unique opportunities for bundling many projects together, allowing procurement at a large-scale and attracting new suppliers into the energy-efficiency business.

In India, a central core committee formed in 2009 recommended several demand aggregation strategies to enhance market volumes and reduce the high upfront cost of LEDs for general lighting illumination purposes.[101] The EESL, in 2014–15, successfully bundled LED lighting demand at utility scale in its flagship scheme, DSM-based efficient lighting programme (DELP), which replaced incandescent bulbs with self-ballasted LED lamps in households. In a span of 1 year, EESL bundled more than 70 lakh LED lamps under one procurement cycle to reduce the upfront cost from Rs 320 per lamp to Rs 83 per lamp, thereby achieving a whopping 75% reduction due to demand aggregation.

#### Learnings

Bundled procurement must be carefully orchestrated with robust technical standards, quality-control mechanisms and testing infrastructure to have sustained benefits. In many cases, the manufacturers may hesitate to participate in bundled procurement tenders because of the inherent wholesaler, dealer conflicts.

### 7.2.10. Mandatory building energy codes

Buildings are significant consumers of energy, but their performance can be improved by the enactment and enforcement of building energy codes. These codes set thresholds for building energy consumption through design and construction standards that apply to energy systems, equipment and the building envelope.

The Chinese codes provide two options for compliance: a prescriptive path, which provides detailed specifications for individual building components, and a performance path, which requires that the proposed new building not consume more energy (in its design) than a reference building. The code

[101] The economic case to stimulate LED lighting in India, 2010, Ministry of Power, Govt. of India

includes provisions with design standards for all major climate zones and the main construction processes, including design, construction, acceptance, operation and retrofit.

Many countries (Australia, Canada, France, Germany, Italy, Japan, South Korea, the USA, the UK, etc.) couple building energy codes with incentives and robust policy packages, such as green loan programmes, financial schemes and incentives and public incentives including tax credits, and some countries have offered incentives such as relaxed building height and size restrictions, such as in Japan. France's scheme for new residential buildings, called the Prêt à Taux Zéro+, or "Zero-Interest Loan +" provides loans to homeowners for their primary residence to encourage home buyers to purchase highly energy-efficient homes. Other enforcement mechanisms (viz. China) include building permit refusal, fines and fees for noncompliance.[102]

Many countries such as France, China, Canada, the USA etc. are also using third-party inspectors to help code enforcement.

Countries such as the USA and China have established well-developed compliance evaluation systems[103] to assess compliance with codes.

### Learnings

Enforcement and high compliance rate are critical to achieving intended energy savings with mandatory building energy codes. Stringency of codes does not matter when the compliance rate is low. Using third-party inspectors to help code enforcement agencies build capacity and roll out code implementation rapidly. Coupling building codes with incentives can effectively complement or motivate compliance. Compliance evaluation can help state and national governments track the progress of ECBC implementation.

## *7.2.11. Public procurement of energy-efficient appliances*

Public procurement holds significant potential for EE improvement and represents a large and important market in any country.

In Japan, the green purchasing (governmental purchasing programme) agenda was introduced through legislation in 2000. The law requires the central government to develop a green procurement policy and implementation plan and to set up a competent authority to publish guidelines and product criteria. Since 2001, the government has designated over 250 green procurement products in 19 product categories. Eco Mark criteria and labelled products are widely adopted in the governmental green purchasing programme. Through implementing this law since 2007, all central government ministries, 47 prefectural governments, 12 designated cities and 68% of 700 local governments and cities have been practicing green purchasing.[104]

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[102] Global Approaches: A Comparison of Building Energy Codes in 15 Countries, ACEEE, 2014

[103] Refers to a set of processes and procedures through which factual information is provided, assessed and checked to determine whether buildings effectively meet respective energy code requirements. It is also important to note that compliance evaluation is different from regular compliance checks that are used to enforce energy codes. Compliance checks are part of the code enforcement procedures; code officials or third-party inspectors check and verify if a single building complies with the requirements of the codes at the design and construction stages and then issue building permits. In contrast, compliance evaluation assesses the overall compliance rate of all buildings and may involve using statistical methods instead of checking every single building.

[104] Public procurement of energy-efficient products, ESMAP, 2012

In China, the Ministry of Finance (MOF) and National Development and Reform Commission (NDRC) introduced the government's energy-efficient procurement policy in 2004. It requires public institutions to give priority to energy-saving products, provided they offer the same functions as the standard products. The procurement policy for energy-saving products was made mandatory in 2006. By 2011, the Chinese government expanded or updated the energy-efficient product list nine times. The list has expanded from the initial eight product categories in 2004 to 28 product categories in 2011, including 22 energy-saving categories and six water-saving categories. Among them, nine categories are specified as mandatory.[105]

**Learnings**

Governments should consider using a holistic approach, from policy development and planning to tools and outreach to tracking. Some of the most critical elements of success relate to having established a clear policy, supporting tools (e.g. labels, LCC calculators, qualified product lists) to help lower transaction costs of procurement by public-sector agencies.

## *7.2.12. Revolving loan funds (RLF) to finance EE investments*

RLF is fundamentally a source of money from which low-cost loans are made to borrowers consistent with standard, prudent lending practices. As the borrowers repay loans, the money is returned to the RLF to make additional loans. In that manner, the RLF becomes an ongoing or "revolving" financial tool.

In the USA, the American Recovery and Reinvestment Act (ARRA) provided funding of USD 3.1 billion for state energy programmes (SEP). The ARRA legislation encouraged the creation of long-term funding mechanisms such as RLF, in order to extend the impact of the ARRA funds. In this regard, many states applied for ARRA funding and have set up RLFs for financing EE projects. Public-sector institutions have been the major borrowers of these RLFs. Typically, the interest and fees paid by the borrowers support RLF administration costs, and the fund's capital base remains intact. Energy-savings performance contracts and on-bill recovery programmes have been the favourites for approval among these RLFs.

**Learnings**

RLF has the potential to overcome the high-cost financing barriers that are derailing the institutional investments for EE. It supports the EE investors to build the business case for cost effectiveness, sustainability and helps to create a long-term self-sustainable financial mechanism that can extend the impact of initial budgetary allocations by governments.

## *7.2.13. DSM regulations and incentives*

In a regulated industry, such as the electricity supply and distribution, DSM regulations provide the mandate as well as an objective framework to plan, finance and acquire DSM resources.

In the USA, the DSM regulations notified by regulatory commissions, in many states, have provided the following key strategies to promote utility-driven DSM.

[105] ESMAP,2012

- Aggressive energy saving and demand reduction targets to capture the full potential for cost-effective savings.
- Utilities can recover the prudently incurred costs of EE programmes through consumer tariffs.
- Incentives to break the link between sales and recovery of authorized fixed costs.
- Processes and protocols for independent evaluation and measurement of energy savings.

In addition to the above strategies, the DSM regulations in the USA have also provided guidelines, templates and tools (listed below) for the various stages of the DSM programme planning and implementation cycle. These measures have played a key role in building the technical capacity of utilities to evaluate DSM resources and investments.

- California Standard Practice Manual for establishing cost effectiveness of DSM programmes.
- California Energy Efficiency Evaluation Protocols.
- E3 Avoided Cost Calculator for establishing cost effectiveness of DSM programmes.

### Learnings

Targets, cost recovery mechanism, incentives and capacity building are some of the key strategic areas addressed through DSM regulations in order to scale up utility-driven EE programmes and investments.

## *7.2.14. Vehicular fuel efficiency standards and labels*

In many countries, the transport sector is responsible for the fastest rate of growth in the consumption of fossil fuels relative to other sectors such as buildings and industry. In order to address this issue and reduce the energy intensity in the transport sector, countries have adopted several measures to promote fuel efficiency in vehicles. Some of the major measures are indicated in the table below.

| Measures | Countries |
|---|---|
| **Fuel economy standards and labels** | USA, Japan, Australia, China, Korea, Brazil, Chile etc. |
| **Fiscal incentives (fuel taxes and differential vehicle fees and taxes)** | EU, Japan, China etc. |
| **New technology incentives (R&D funding and subsidies)** | USA, Japan, China, EU, India etc. |

### Learnings

The fuel economy standards should be developed in an inclusive manner by holding extensive consultations with a range of stakeholders from industry, state governments and consumer and environmental groups.

## *7.2.15. Upstream and midstream incentives*

Incentives are policy tools that motivate purchase, retail stocking and production decisions towards energy-efficient products. Incentives complement mandatory standards and labelling policies by accelerating market penetration of products that are more energy efficient than required by existing standards. They can also prepare the market for expanding appliances in the mandatory regime or for stringent future mandatory requirements. Incentives can be directed at different points in the appliance's supply chain. One point may be more effective than another depending on the technology's maturity, market penetration and other local conditions. Incentives targeting end users/consumers are referred to as "downstream", targeting retailers and distributors are referred to as "midstream", and targeting manufacturers are referred to as "upstream". Examples of midstream programmes are as follows:

| Country | Programme | Timeframe | Incentive Form | Recipient | Administrator | Funding | Product |
|---|---|---|---|---|---|---|---|
| **US Texas** | Distributor Air Conditioning Market Transformation | 2001 to 2004 | Rebate | Retailers | Utility | Rate funded | Central air-conditionin g units |
| **US California** | California Business and Consumer Electronics (BCE) | 2007 till present | Rebate | Retailers | Utility | Rate funded | Televisions and computer monitors |

### *Examples of Upstream programmes*

| Country | Programme | Timeframe | Incentive Form | Recipient | Administrator | Funding | Product |
|---|---|---|---|---|---|---|---|
| **China** | Promotion products programme | 2008 to present | Upstream subsidy | Manufacturers | Government | General budget | CFLs, ACs, TV, water heaters, washing machines, refrigerator |
| **India** | Super Energy-Efficient Equipment Programme (SEEP) | In developm ent | Upstream subsidy | Manufacturers | Government | General budget | Ceiling fans |
| **Sweden** | Ground source heat pump technology procurement programme | 1993 | Upstream technology procureme nt | Manufacturers | Government | General budget | Ground source heat pumps |
| **US** | Federal Energy- | 2005–11 | Upstream tax credit | Manufacturers | Government | General budget | Residential refrigerator |

| Country | Programme | Timeframe | Incentive Form | Recipient | Administrator | Funding | Product |
|---|---|---|---|---|---|---|---|
| | Efficiency Tax Incentives for Manufacturers | | | | | | s, clothes washers, dishwashers |

## Learnings

Upstream incentives are particularly effective for reducing the upfront cost of technologies that are at an early stage of penetration. Upstream incentives are offered to manufacturers to streamline their production lines and increase production at a lower price. The main advantage of these programmes is that they can influence a large portion of the market through fewer actors and, therefore, have lower transaction costs. Moreover, by reducing the price before products reach the market, the incentive has more impact on purchase price than a downstream incentive.

The main disadvantages of upstream programmes are that financial incentives offered to manufacturers are not seen by consumers and that robust monitoring and verification are required to ensure the incentive is passed through to consumers.[106] Another drawback is that implementing these programmes successfully requires estimating how much it will cost to the manufacturer to produce more efficient products so that the programme administrator can negotiate a fair price for the incentive.

Midstream incentives encourage retailers to stock or sell a larger percentage of highly efficient products. These programmes influence customers at their point of decision and help address the lack of availability of highly efficient products. They can be particularly effective when a consumer is replacing equipment in an emergency and the purchase decision depends on the immediate availability of a product. Targeting midstream actors can also be advantageous in split incentive situations. Midstream programmes also educate and motivate retailers to promote highly efficient technologies in general and to use electricity bill savings as a selling point for the products. A midstream programme can be particularly effective when a programme budget is small and the price of equipment is high. Because the profit margin for distributors and retailers tends to be small, even a small increase in profit from an incentive can give a retailer significant motivation to sell more efficient equipment. However, focusing on the midstream point in the supply chain means more transaction costs than an upstream programme (although fewer than in a downstream programme). In addition, midstream programmes tend to focus on a selection of distributors and retailers and, therefore, may not reach all the distribution channels. As a result, these incentives only affect the portion of the market that is reached by the participating retailers and/or distributors. Furthermore, it could be argued that choosing which retailer or distributor participates in a programme is effectively "picking winners" and penalizing other retailers who are not chosen.

[106] Friedmann, Rafael. "A Fresh Look at Evaluation to Support Energy Efficiency in the 21st Century." Proceedings of the IEPEC 2011 Conference. Boston, Mass.: International Energy Programme Evaluation Conference.

## *7.3. Review of International Strategy Plans*

This section presents a review of international strategy plans and the applicability of their programmes to Indian EE market.

### United Kingdom

The measures of the country towards energy efficiency are summarized below.

*Table 44: UK EE measures and adaptability to India*

| Sector | Measure | About the Programme |
|---|---|---|
| **Cross-sectoral/public bodies** | Climate Change Levy (CCL) and Climate Change Agreements | • The CCL was introduced in 2001 and is levied on the supply of energy to business and public-sector consumers. Each of the four main groups of taxable commodities (electricity, gas, coal and liquefied petroleum gas) has its own main rate per unit of energy. The main rates of the CCL are intended to change business behaviour to reduce energy consumption and ensure the UK fulfils its EU obligations under the Energy Tax Directive (ETD). |
| | The Green Deal | • The Green Deal enables consumers to take out loans to pay for energy-efficiency improvements in their homes, with repayments made through their energy bill. Repayments are made on a "Pay As You Save" (PAYS) basis: After the improvement has been made, the consumer begins to save energy, their energy bills are less than they would have been without the improvement, and these savings are used to repay the loan. The scheme has been since discontinued. |
| **Household sector** | Smart metering | • The Government of UK has put in place license conditions requiring energy suppliers to take all reasonable steps to roll out smart meters to all domestic properties and smaller non-domestic premises in Great Britain by the end of 2020. |
| | Buildings regulations | • The building regulations set minimum energy performance standards for new buildings and when "building work" is carried out to existing properties. Since 2002, the building regulations have been responsible for energy-efficiency standards being strengthened by 6% compared to the 2010 requirements for new homes and 9% for non-domestic, in 2013. |
| | Energy Company Obligation (ECO) | • The Energy Company Obligation replaced the Carbon Emissions Reduction Target (CERT) and Community Energy Saving Programme (CESP) from January 2013 and, like its predecessors, required domestic energy suppliers over a certain size to achieve carbon and notional bill savings by promoting and installing energy-efficiency measures into domestic homes. |
| **Industrial** | Carbon Trust | • The Carbon Trust, originally set up and funded by the UK Government from 2001 to 2012 (and now a self-financing private company), promotes its Carbon Trust Standard to businesses. Obtaining the standard requires the measurement, reduction and management of emissions/energy use. |

| Sector | Measure | About the Programme |
|---|---|---|
| **Transport** | Low-emission vehicles | • The UK Government has a broad range of measures in place to support the UK's growing ultra-low emission vehicle (ULEV) market. This includes consumer grants of up to £4500 towards the cost of ultra-low emission cars, as well as up to £8000 for ultra-low emission vans, up to £7500 for ultra-low emission taxis and up to £1500 for ultra-low emission motorcycles. |
| | Rail Electrification | • The Department for Transport has set out its policy for rail infrastructure investment, including electrification and the associated funding for nominated schemes through its Rail Investment Strategy.<br>• This strategy is produced every 5 years with the most recent one published in June 2012 covering rail investments in the period 2014 to 2019. |

## Canada

The measures of the country towards energy efficiency are summarized below.

*Table 45: Canada EE measures and adaptability to India*

| Sector | Measure | About the Programme |
|---|---|---|
| **Cross-sectoral/ public bodies** | The Energy Efficiency Act, 1992 | • The act enforces minimum efficiency standards nationwide for energy-consuming products, making it illegal to sell or import products that fail to adhere to these standards. It allows for stringent implementation of such standards through seizing, inspection and testing of suspicious products. It also places heavy fines up to CAD 50,000 on individuals who fail to follow said standards.[107] |
| | ecoENERGY innovation Initiative Research and Development | • This initiative had the objective of advancing Canadian leadership in clean energy technologies by investing CAD 268 million over a 5-year period (2011–16) in various priority areas.[108] |
| | Ontario's Five-Year Climate Change Action Plan | • This action plan broadly describes a number of projects in the pipeline from 2016 to 2020, which will reduce the emissions and increase the energy efficiency in the city of Ontario, moving it towards a more sustainable future. There are in excess of 50 separate projects within this action plan. |
| | Integrated Community Energy Solutions (ICES) | • This is an ambitious project of the Canadian Government to reduce the energy demand at the community level through increasing the energy efficiency of utilities such as water supply, electricity distribution as well as reducing the energy demand of community-relevant sectors such as transport, industry and land |

[107] Justice Laws Website (Canada), Energy Efficiency Act, 1992: http://laws-lois.justice.gc.ca/eng/acts/e-6.4/
[108] Government of Canada, ecoEnergy Innovation Initiative: https://www.canada.ca/en/news/archive/2015/02/ecoenergy-innovation-initiative.html

| Sector | Measure | About the Programme |
|---|---|---|
| | | use.[109] |
| | Pan Canadian Framework on Clean Growth and Climate Change | • The Canadian Government consulted tens of thousands of Canadians from all walks of life from 2016 to 2017, and using the insights gained from thousands of suggestions, they formed a nationwide framework for the reduction of emissions and guidelines to combat climate change and achieve the targets set by the Paris Agreement in 2015.[110] |
| **Household sector** | ecoENERGY Retrofit – Homes | • Starting back in 2009, this scheme involved giving grants to households for energy-efficiency upgrades. A maximum of CAD 5000 could be issued as a grant if the following steps were taken for the household: A licensed and independent energy advisor performs a pre-retrofit residential energy assessment, homeowner completes selected upgrades within 18 months, have the home re-assessed. |
| | R-2000 Building Standards | • These standards are voluntary and are so far not mandatory in any province of Canada; however, in many provinces, the adoption of these standards is incentivized by tax rebates and other financial assistance.[111] |
| **Industrial** | Accelerated capital cost allowance | • An accelerated capital cost allowance (ACCA) is a CCA rate that is greater than the rate, which would reflect the useful life of the asset class. The government has provided ACCA tax incentives since 1994 under which companies in the industrial sector can invest in energy-efficient systems and generate electricity themselves. |
| | Pulp and Paper Green Transformation Programme | • This unique programme launched in 2009 gave the Canadian pulp and paper industry credit on the basis of a producer's productivity at the rate of $0.16 per litre of "black liquor". These companies had until 2012 to invest the earned credit into energy-efficiency programmes that would reduce their emissions and make economic sense for the companies.[112] |
| | Canadian Industry Programme for Energy Conservation (CIPEC) | • As a part of the ecoENERGY Efficiency for Industry, the CIPEC is a partnership between private industry and the federal government to promote and improve Canada's industrial energy efficiency and reduce greenhouse gas emissions from energy use in the industrial sector. The programme started in 1975, and it is a voluntary programme to promote energy efficiency in the industrial sector. The programme involves sector-specific task forces that promote and develop voluntary energy-efficiency targets and develop action plans for energy efficiency in their sector. The programme currently has the participation of 1400 companies. |

[109] QUEST Canada: http://www.questcanada.org/rh/aa539c1b53703fb55223c353998566be.pdf
[110] Pan Canadian Framework on Clean Growth and Climate Change (2016), Canada's Plan to address Climate change and grow the economy
[111] New Home Construction Incentives, Prince Edward Island Canada, https://www.princeedwardisland.ca/en/information/transportation-infrastructure-and-energy/new-home-construction-incentives
[112] Pulp and Paper Green Transformation Programme, Natural Resources Canada, https://www.nrcan.gc.ca/forests/federal-programmes/13141

## Australia

The measures of the country towards energy efficiency are summarized below.

*Table 46: Australia EE measures and adaptability to India*

| Sector | Measure | About the Programme |
|---|---|---|
| **Cross-sectoral/ public bodies** | Energy efficiency in Government Operations Act | • In 2006, the government recognized the need to increase the efficiency of its own activities in its office buildings. Every year the government spent AUD 450 million on energy alone and any efforts to decrease the consumption of energy would be a step towards environmental and energy security as well as economic growth.[113] |
| | National Australian Built Environment Rating System (NABERS) | • This is the national building rating system for maintaining environmental standards. The system analyses the energy efficiency, water usage, waste management and indoor environment quality of a building and tenancy. The system is meant to translate complicated billing mechanisms such as electricity and gas bills into a simpler to understand star rating system from one to six stars.[114] |
| | Promotion of energy productivity skills and energy audit | • Under these schemes, the government conducted a study to identify the necessary skills, knowledge and experience required to provide energy efficiency and energy productivity services. It proposes an improvement pathway for professionals reflecting the needs of the industry. It analyses the current courses offered and capacity-building opportunities for developing energy productivity skillset of existing professionals and increasing the number of energy auditors and experts in this field.[115] |
| | Emissions Reduction Fund | • This fund enables businesses, farmers and land managers to earn incentives for reducing their emissions by issuing Australian Carbon Credit Units (ACCUs) to these business-owners, which can be later sold to the government through competitive reverse auctions. The methods followed for assessing the emissions reductions vary for each industry, but a major emissions reduction through reduced energy consumption (i.e. greater energy efficiency) is a major deciding factor in the issuing of these credits. The fund has a total allocation of AUD 2.55 billion. This plan covers the energy used by small businesses, farmers, homeowners as well as credits the installation of energy-efficiency cooling and lighting technologies.[116] |

[113] Energy Efficiency in Government Operations Policy – Australia (2007), Australian Government
[114] https://www.nabers.gov.au/public/WebPages/Home.aspx
[115] Energy Productivity skills and training pathway – Australia (Oct 2017), Energy Efficiency Council
[116] Department of Environment and Energy - Australia, http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/about

| Sector | Measure | About the Programme |
|---|---|---|
| **Household sector** | The Equipment Energy Efficiency (E3) Programme | • This programme involving the Australian Government, State Governments and New Zealand is responsible for starting the energy-efficiency standards and energy labelling of appliances across these territories. It was started over 30 years ago and continues to be one of the primary means of improving domestic energy efficiency in the nation. |
| **Industrial** | Energy strategy for Australian directors and executives | • This scheme is aimed at engaging with high-level management and executives of businesses to assist them in developing energy-efficient programmes and policies within their own organizations. This is supported by the gas efficiency guide for businesses, which explains to executives and managers how to better use gas as a resource for their businesses and increase their efficiency. |
| | Boosting small business energy efficiency through accelerated depreciation | • This scheme provided up to AUD 20,000 in asset cost deductions for businesses with a turnover of under AUD 10 million for energy-efficiency upgrades to their businesses. |
| | National Energy Productivity Plan (NEPP) | • In 2015, the Government of Australia published its National Energy Productivity Plan (NEPP) to increase its energy productivity by 40% within the period 2015–30. The NEPP is a far-reaching plan having an impact on almost every economic sector of Australia and has six key pillars of activities: energy initiatives, empowering customers, helping business compete, consumer protections, competitive modern markets, innovation support. |
| | Carbon-pricing mechanism | • From FY2012–15, the carbon price was fixed by the government and trading options were limited. This was followed by the Flexible Price period with trading, of which the first 3 years (FY2015–18) will be restricted by imposing price floors and price ceilings. After 2018, there will be full trading of all types of units and no price controls.[117] |
| | Clean Energy Finance Corporation | • The CEFC partners with co-financiers, provides loans at discounted rates for energy-efficiency projects such as efficient water heating systems, high-efficiency motors and ventilation etc. These schemes are applicable to industry, domestic and agribusiness projects.[118] |

[117] Industrial Efficiency Policy Database – Australia, http://iepd.iipnetwork.org/policy/carbon-pricing-mechanism-cpm
[118] CEFC Annual Report 2017–18, Clean Energy Finance Corp

## Japan

The measures of the country towards energy efficiency are summarized below.

*Table 47: Japan EE measures and adaptability to India*

| Sector | Measure/Proposed Measure | About the Programme |
|---|---|---|
| **Cross sectoral** | Act on the Rational Use of Energy (Energy Conservation Act) | • The law is the pillar of Japanese energy conservation policy. It was enacted in 1979 in the light of the oil shock with a purpose of promoting effective and rational use of energy. It covers the following sectors: energy management in the industrial, commercial, residential and transportation sectors; energy-efficiency standards for vehicles and appliances.[119] |
| | Subsidy Scheme for Energy Efficiency | • With the objective of increasing the cost effectiveness of investments in energy efficiency, Japan provides subsidies to promote energy efficiency. The subsidies are managed via The New Energy and Industrial Technology Development Organization (NEDO), which is a government organization to promote the development and introduction of new energy technologies. |
| **Residential and commercial sectors** | Top Runner Programme | • The Top Runner Programme was introduced in a 1990 amendment of the Act on the Rational Use of Energy, which certifies manufacturers and other entities that satisfy "Top Runner" criteria. Criteria for the energy-saving performance regarding their products within the target fiscal years (within 3 to 10 years) are set based on the performance of the products with the highest (according to latest level) energy-consumption efficiency (top runner performance). The programme applies to machinery, equipment and building materials, as well as LED lamps and three-phase induction motors. The last amendment, in November 2014, added windows to the programme. |
| **Industry and mining** | Mandatory Energy Management | • This measure is implemented under the aegis of The Act on the Rational Use of Energy where the promotion of energy management is the main measure. About 14,000 factories (90% of Japanese industries) are designated as either Class 1 (high energy use) or Class 2 (lower energy use). The requirements for energy management are more stringent for Class 1 factories.<br>• The requirements for Class 1 are: appointment of an energy manager, regular reporting and preparation of a mid- and long-term energy-efficiency plan. The latter is not required for Class 2 factories. The act prescribes both the establishment of an energy management system as well as mandatory energy planning and identification of energy-efficiency measures. |

[119] http://www.lse.ac.uk/GranthamInstitute/law/law-concerning-the-rational-use-of-energy-energy-conservation-act-law-no-49-of-1979/

| Sector | Measure/Proposed Measure | About the Programme |
|---|---|---|
| | Keidanren Voluntary Action Plan | • The Keidanren Voluntary Action Plan (VAP) on the Environment was a unilateral, voluntary and non-binding commitment devised by the Nippon Keidanren (Japan Business Federation). The VAP was an important component of the Kyoto Protocol Target Achievement Plan adopted in 2008 by the Japanese Government. It included a non-binding target to reduce $CO_2$ emissions in industry and the energy sector below their 1990 levels by 2010. The programme has currently ended.<br>• VAP was comprehensive in its coverage, accounting for about 40% of total emissions in Japan in 1990 and 80% of industrial emissions. In the VAP, separate sector plans were drafted by respective industrial branch/sector organizations in consultation with government and the companies in the sector. |
| | Fiscal Incentives for Energy Efficiency | • In the industrial sector, Japan has implemented a tax system to promote investment in energy-efficiency technology. This system allows individuals and corporations to claim a tax credit or a flexible depreciation for eligible equipment. The tax credit is equivalent to 7% of relevant equipment acquisition costs to be deducted from the corporate tax amount and the special depreciation covers 30% of the equipment acquisition cost in the initial year.[120] |
| | Japanese Voluntary Emissions Trading Scheme (JVETS) | • The Japanese Voluntary Emissions Trading Scheme (JVETS) was introduced in September 2005 by the Ministry of Environment Japan (MOEJ) to support greenhouse gas (GHG) emissions reduction activities by Japanese companies that are not included under the VAP. |

[120] Energy Policies of IEA Countries (2008), Japan Review, OECD/IEA

## South Africa

The measures of the country towards energy efficiency are summarized below.

*Table 48: South Africa EE measures and adaptability to India*

| Sector | Measure/Planned Measure | About the Programme |
|---|---|---|
| **Cross sectoral/ public** | The National Energy Act, 2008 | • The National Energy Act, 2008, is the enabling legislation that empowers the Minister of Energy to ensure that diverse energy resources are available in sustainable quantities and at affordable prices in the South African economy to support economic growth and poverty alleviation, while also taking into account environmental considerations. |
| | Eskom's Energy Conservation Scheme | • Eskom's Energy Conservation Scheme (ECS) is a response to the Government's Power Conservation Programme (PCP). The PCP is being brought in to help manage the current electricity supply shortages. Through the use of high tariffs, the scheme penalizes electricity customers that do not reduce their consumption by an allocated percentage. |
| **Residential** | Eskom's Lighting Exchange Programme | • Eskom's demand-side management programme assists communities to manage their cost of electricity by installing energy-saving technologies while at the same time reducing pressure on the national grid. A total of 614,238 compact fluorescent lamps (CFLs) were installed in North West and Gauteng during 2018 so far. Since 2015, a total of 4,922,700 CFLs have been installed. The initiative has put back more than 238 MW into the grid and created much needed employment in local communities. |
| **Industry and mining** | Eskom's Energy Efficiency and Demand-Side Management (EEDSM) incentive programme | • The Energy Efficiency and Demand-Side Management funding programme is aimed at promoting the implementation of more energy-efficient technologies, processes and behaviours among all electricity consumers. The programme has been in place since 2004, and over the years, it has evolved and been extended. |
| | Energy Efficiency Tax Incentive Regulations | • The Energy Efficiency Tax Incentive Regulations involve a tax break that can be earned by companies who are able to provide evidence of energy-efficiency savings. Evidence of energy-efficiency savings must be provided to the tax authorities by handing in energy-efficiency saving certificates. These are issued by the National Energy Development Institute (SANEDI) after they have approved report holding evidence on achieved savings. |

## 7.4. Strategies for Achieving EE Potential in India

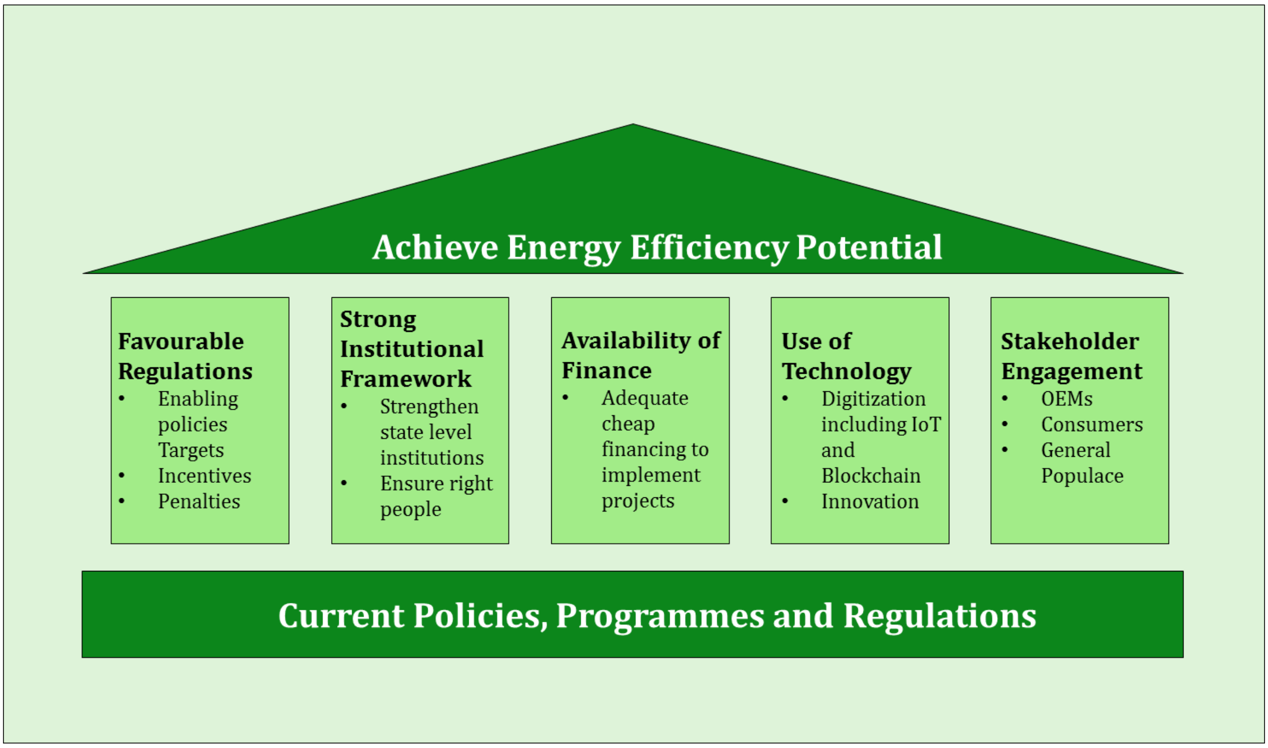
India has a huge opportunity to optimize energy use across sector. The total energy-efficiency potential in the country is 86.9 Mtoe. To achieve this potential, there is a need for a consolidated approach and strategy.

> The key objective of this strategy would be to maximize the impact of policy and programme to achieve the wider energy-efficiency potential in the country.

### 7.4.1. Elements of the strategy

Any strategy developed should address the challenges faced in implementation of energy efficiency and overcome the gaps in current policy and programmes. Further, it is important to engage all stakeholders and address the challenges across the entire value chain. India currently has multiple good policies and programmes for promotion of energy efficiency in the economy. These as well as the future programmes would be strengthened through favourable regulations, strong institutional framework, increasing availability to finance, use of technology and increased stakeholder engagement.

*Figure 27: NSPEE strategy framework*




All the elements of the strategy are interdependent and should not be looked at in isolation. For example, a regulation could mandate industry to contribute a small proportion of their profits for research and development. This would have direct impact on finance and use of technology elements.

### *7.4.1.1. Favourable regulations*

Good regulations have the capacity to act as catalyst for the growth of any sector. Regulations including policies, acts and directives provide other stakeholders a clear signal about the legislative body's intention to promote a given sector and/or technology. This direction enables stakeholders, especially suppliers and service providers, to prepare long-term strategies and allocate capital. These regulations can take many forms, including:

- **Policies:** A policy is a course of actions or directions set out to meet certain predefined objectives. The private sector could then take a cue from the policy defined by the government to plan their activities. For example, the Energy Conservation Act provided the regulatory mandate for standards and labelling of equipment and appliances; Energy Conservation Building Codes for commercial buildings; and energy-consumption norms for energy-intensive industries.

- **Targets:** The government agencies then, based on the policies defined, can establish targets for various government sectors. These targets or mandates encourage the stakeholder to meet the broader objectives set out by the government. For example, the Bureau of Energy Efficiency under EC Act set out mandates for large industry to meet certain energy intensity targets under its PAT programme.

- **Incentives:** Incentives encourage positive behaviour from various stakeholders. These incentives can take two forms:

  - Target-based incentives that encourage stakeholder to achieve more,

  - Subsidies that allow stakeholders to manage risks especially financial.

- **Penalties:** Penalties discourage stakeholders from taking decisions that are not in line with the broader objectives set out by the government. For example, the PAT programme also specifies penalties for industries that do meet the target set out by the government.

These forms of regulations also operate in combination as seen from the example of EC Act and PAT programme.

***Possible Strategies:***
*For achieving India's energy efficiency potential, there is a need to analyse the present ecosystem governing energy efficiency such as policies, laws, institutions and arrangements. On the policy front, there is no overarching energy efficiency policy. This has hampered the adoption of efficient practices across energy-consuming sectors. It is envisaged that an omnibus policy should be announced to cover all the energy-producing and -consuming sectors.*

### *7.4.1.2. Institutional framework*

Strong institutions are the cornerstone of any large intervention. The institutions should have enough well-trained and capable resources to successfully implement the intervention. Further, the institutions should have necessary mandate and authority to work with stakeholders and enforce the strategy.

In India, the institutionalization of energy conservation began in the mid-1980s, when the government formed an “energy conservation cell” within the Department of Power. The cell was vested with responsibilities to facilitate a coordinated strategy on energy conservation. In 1989, an autonomous organization called the “Energy Management Centre” was established to assist in the national energy conservation programmes.[121] In 2001, the Energy Conservation Act 2001 (EC Act) was enacted to set up the Bureau of Energy Efficiency (BEE) (from the assets of erstwhile Energy Management Centre) as a nodal agency with specific powers and functions to facilitate, regulate and promote energy efficiency in all sectors of the economy. The EC Act also provided with multiple functions and statutory powers to the central and state governments to facilitate and enforce efficient use of energy and its conservation. The state government was required to designate an agency for the implementation of functions assigned to it under the EC Act. In this regard, state designated agencies (SDA) have been notified in 29 states and seven union territories and the profile of these agencies differ from state to state [Renewable Energy Development Agency (44%), Electrical Inspectorate (25%), Distribution Companies (12%), Power Departments (16%) and others (3%)].

In addition, the 29 state electricity regulatory commissions (SERC) and around 60 electricity distribution licensees are crucial institutions to promote DSEE through utility-driven DSM. In view of the need to establish DSM cells within the utilities with adequate resources and capacity to plan and implement programmes, more than 15 SERCs have already notified DSM regulations to guide and regulate utility-driven DSM activities and investments.

The Small Industries Development Bank of India (SIDBI) and the Indian Renewable Energy Development Agency (IREDA) are the key financial institutions promoting customized DSEE financing products among micro, small and medium enterprises (MSMEs) and other key economic sectors.

The Bureau of Indian Standards, which is the body responsible to certify product quality and technical standards, has been playing a key role in establishing standards for energy-efficient appliances and equipment in various end-use applications.

***Possible Strategies:***
*It now important to strengthen the state agencies and enable them to drive the energy efficiency agenda ahead. There is need for strong enforcement mechanism at state levels which would lend further strength of the national and local level programme.*

*Another key strategy should be to remove duplicity of bureaucracy. For example, currently OEMs need to first certify that the products meet BIS standards and then apply to BEE under standard and labelling programme. A single window for approvals along with standardization of laws and regulations would help large-scale upscaling of energy efficiency initiatives.*

### 7.4.1.3. Finance

Energy-efficient solutions are generally more capital expenditure intensive than conventional solutions. Even though the lifetime cost of EE solutions is lower, high initial investment deters many from implementing EE solutions. Financial institutions also have limited understanding of these solutions and are wary of funding EE projects. India has in the past, through various capacity-building initiatives, pilot project implementation and financial instruments, including Energy Efficiency

[121] Strategy for Energy Conservation in India (1995), Rajeev Gandhi Institute for Contemporary Studies and Institution of Engineers (India)

Financing Platform (part of NMEEE), Partial Risk Sharing Facility (PRSF), attempted to increase the amount of finance available for implementation of EE projects.

Another key initiative was empanelment of ESCO and development of standard contracting documents for ESCO-based project. However, these initiatives were also marred by reluctance of financing institutions to lend on project financing model due to the lack of proper collateralization protocol of assets created under ESCO projects. For example, the borrowing agency would be the ESCO, but the asset would be created in the project proponents' property. Many large-scale projects in India have distribution utilities and municipalities as project proponents. Poor financial health and track record of these institutions are also a key barrier for financial institutions funding these projects.

***Possible Strategies:***

*To promote energy efficient solutions, it is, therefore, important that project proponents and service providers (ESCOs) have access to finance at cheaper rates. These financial solutions could take form of a revolving fund, risk guarantee or insurance facility or forming corpus for project implementation (similar to DSM fund within distribution utilities). The National Clean Environment Fund or another special cess levied could be utilized for seeding these mechanism.*

### 7.4.1.4. Use of technology

Constant improvement backed by technology improvements would be key in achieving India's energy-efficiency potential. India has instituted a structure to promote these new technologies, including formation of technology development board and committees within Bureau of Indian Standards to ensure homologation of the new technologies. Further, it is also important to ensure development and/or adoption of technologies specific to the Indian conditions. Industry-specific centres of excellence should be developed across the country. Industry associations should be encouraged to take lead in this process. India is a tropical country, and significant energy consumption in the country is for cooling. Specific interventions should be undertaken to develop cost-effective India-specific solutions.

Innovative technologies, including IoT and Blockchain, have the ability to bring an energy revolution across sectors. These technologies enable collection of data and improve connectivity, which allows for better decision-making and convenience. India has begun adopting these innovative solutions in various sectors, including agriculture (smart control panels), municipal (CCMS), commercial (building management systems) and domestic (intelligent appliances).

***Possible Strategies:***

*Large-scale implementation of the innovative technologies still looks to be years away due to challenges such as the need for skill development, capacity building and awareness, perceived concerns around investment outlay and cost benefit, inadequate know-how, lack of infrastructure and lack of adequate cybersecurity norms. Improper implementation would result in lack of trust in technology. It is important for the government to take lead in mitigating the challenges mentioned through development of infrastructure and pilot projects to showcase these technologies.*

### *7.4.1.5. Stakeholder engagement*

Involvement of all key stakeholders would result in faster adoption and smoother implementation. For example, for adoption of electric vehicles, it is important to first have policies for promotion and adoption of EVs, institutional framework to train new breed of engineers and ensure homologation, OEMs to make the transition from ICE vehicles to EVs, ecosystem players to provide services like EV charging and consumers to buy the vehicles. The entire national-level programme would fail if any one of these stakeholder is not in line with the vision.

***Possible Strategies:***
*The task is relatively easier when the programmes and solutions are targeted towards organizations. The engagement could be increased through focused group discussions and meetings. However, solutions targeted towards larger audience and general population would require larger engagement through the use of mass and social media.*

## *7.4.2. Strategies for achieving energy-efficiency potential*

Various strategies have been proposed based on the elements discussed above. A sectoral approach has been adopted and the strategies have been listed below:

## *7.4.3. Agriculture*

Although the agriculture sector has significant energy consumption, the users of energy are not incentivized to optimize their energy usage owing to the low cost of energy. The energy cost of the sector is heavily subsidized by the government. The current institutional structure is also focused on increasing productivity with minimal focus on reducing energy intensity. The following are the key strategies that could be adopted to reduce energy consumption in the sector:

| Strategy | Elements | | | | |
|---|---|---|---|---|---|
| | Favourable Regulations | Institutional Framework | Finance | Use of Technology | Stakeholder Engagement |
| **Greater coordination among stakeholders, including integration with water conservation efforts** | ✓ | ✓ | | ✓ | ✓ |
| **Integrate energy efficiency in agriculture studies** | | | | ✓ | ✓ |
| **Cheaper finance for energy-efficient equipment** | | ✓ | ✓ | | |
| **Research and development** | | | | ✓ | |
| **Mandating energy-efficient technology standards and guidelines** | ✓ | | | ✓ | ✓ |
| **IoT in agriculture: Moving towards smart farming practices** | | | | ✓ | ✓ |

### 7.4.3.1. Greater coordination among stakeholders

There are many schemes simultaneously being implemented in the agriculture sector such as Pradhan Mantri Krishi Sanchayee Yojana (PMKSY) by the Department of Agriculture, Cooperation and Farmers' welfare,[21] Kisan Urja Suraksha Evam Utthaan Mahaabhiyan[28] (KUSUM) scheme by the Ministry of New and Renewable Energy for solar pumps, AgDSM programmes by EESL.[122] The ministries along with the institutions such as National Bank for Agriculture and Rural Development (NABARD) and National Innovations on Climate Resilient Agriculture (NICRA) under the Indian Council of Agricultural Research (ICAR), apart from BEE, EESL and others also work in the sector. The programmes and organizations work in silos, and there is not much coordination between the organizations and multiple schemes are being implemented at the same time that lead to confusion among the end consumer, i.e. farmers. This is detrimental to the objectives of the schemes and programmes that are envisaged. Thus, it is recommended to have more coordination between the stakeholders.

#### Integrated efforts for Water and Energy Conservation

Several pilots conducted in the past, some with the help of donor-assisted programmes (e.g. USAID's WENEXA), have revealed that India's agriculture sector needs an integrated approach by considering both water and energy-efficiency improvements to maximize resource (water and energy) savings and tackle the menace of inefficiency in a holistic manner. Studies have revealed that waterside interventions such as drip irrigation and other measures that improve irrigation efficiency can deliver energy savings almost equivalent to the pump set replacement. More importantly, the integrated approach would also have substantial positive effects on the worsening groundwater situation in the country.

*Table 49: Energy-saving potential of EE measures in agriculture pumps*

| Measure | Energy-Saving Potential |
|---|---|
| **Pump set replacement** | 15%–25% |
| **Piping and foot valve replacement** | 5%–15% |
| **Efficient irrigation systems (drip, sprinkler, etc.)** | 15%–25% |

In this regard, the state and central government institutions along with Indian electric utilities can explore integrated DSM solutions with appropriate delivery models to maximize energy savings in the agriculture pumping loads.

### 7.4.3.2. Integrate energy efficiency in agricultural studies

There is a need to spread the knowledge of energy efficiency in the agriculture sector. An essential part of the process would be to include the study of energy efficiency in agriculture as part of undergraduate and graduate programmes in agriculture-based studies across the country. Institutions like ICAR can include specific courses for learning about energy efficiency in agriculture. This would help in disseminating information about energy efficiency and creating an awareness about the same with the workforce. ITIs can have specific courses that focus on skill development for climate smart agriculture.[80]

[122] About AgDSM - EESL, https://www.eeslindia.org/EN/Agdsm/About/

The Bureau of Energy Efficiency (BEE) has taken steps to bridge this gap by collaborating with ICAR to create awareness for energy-efficient pump sets and operational practices so as to adopt energy and resource efficient approaches. Through this collaboration, BEE and ICAR plan to improve the fuel energy and water resource use efficiency, thereby reducing the cost of cultivation so as to increase farmers' income. These steps are in line with the strategies of "Per Drop More Crop" and "Doubling Farmers' Income".

### *7.4.3.3. Cheaper finance for energy-efficient equipment*

The farmers need easier access to finance for buying energy-efficiency equipment that includes not only pumps, but tractors and other equipment on the farm as well. It is noticed that the banks provide loans under priority sector lending to farmers but the interest rates are very high.[123] There needs to be finance available to the farmers for investing in energy-efficiency equipment. This can be done via cooperatives set up for the purpose. It can also be integrated with the minimum support price.

### *7.4.3.4. Research and development*

There is a need to increase the research and development in the sector. It is also envisaged to have agricultural projects under the National Clean Energy Fund. The initiatives taken need to encourage even higher efficiency in the agricultural pumps and focus on energy efficiency of tractors as well.

### *7.4.3.5. Energy-efficient technology standards and guidelines*

There is no standardization of technology guidelines for growing and harvesting of crops. Just like the Energy Conservation Building Code, a similar code can be implemented for crops across the country. This could include the most energy-efficient equipment and procedures for each crop. One of the key initiative could be:

**Mandatory use of smart control panels and star-rated pumps for new agricultural connections**

Most projects implemented under AgDSM in India have focused on replacement of existing inefficient agricultural pump sets with BEE star-rated energy-efficient pump sets. Under the current AgDSM programmes being implemented in the country, smart control panels are also being provided along with the energy-efficient pumps. The smart control panels benefit farmers by allowing remote monitoring and control of the pump sets.[122] However, there are no guidelines for new agricultural connections across the country. It is proposed to make the installation of only BEE star-rated energy-efficient pump sets and smart control panels mandatory for new agricultural connections.

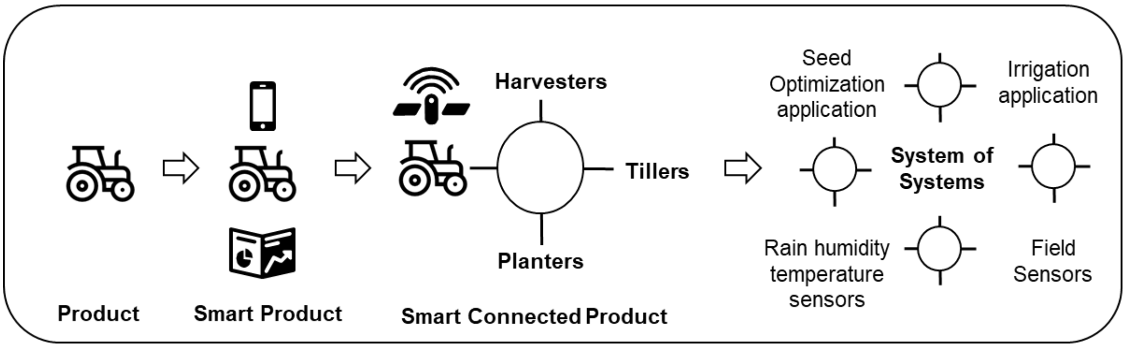
[123] India's banks crushed poor farmers with expensive tractor loans, but the Mercedes came cheap (Jun 2016), https://qz.com/india/709449/indias-banks-crushed-poor-farmers-with-expensive-tractor-loans-but-the-mercedes-came-cheap/

*Figure 28: Smart Control Panels distributed in AgDSM in Andhra Pradesh*


## *7.4.3.6. IoT in agriculture: Moving towards smart farming practices*

The advent of digitalization in agriculture is dependent on the introduction and adoption of new tools and machines into the agricultural production system. Tractors are key instruments for beginning the usage of connected and localized technologies on farmlands. This would include using localization technologies (GPS) and driver's assistance to optimize routes and shorten the harvesting and crop treatment, while reducing the fuel consumption over the period of time significantly.

*Figure 29: Advent of smart-connected farm equipment*




It is envisaged that for accelerating the use of IoT technologies in Indian agricultural farmlands, a consortium can be established that would consist of various stakeholders from government agencies, agro, telecom, automotive and agri-machinery manufacturing industries, which would focus on building an ecosystem of active research, development, testing and implementation technology, infrastructure and applications of IoT for farming. The multidisciplinary participation in the consortium would help identify the trends and disruption in the agriculture landscape in the country in the future. Identification of such trends beforehand would further prioritize the adoption of IoT can bring to the sector and recognizing potential business models and innovations in the different subsectors that can have game-changing effects in the agri-machinery industries market chain.

### 7.4.4. Buildings

Buildings are an essential element in the modern lifestyle and form a significant portion of energy consumptions in the domestic and commercial sectors. In India, rapid urbanization and improved prosperity have increased consumption from building. The following can be key strategies that could be adopted for increasing the energy efficiency of buildings.

| Strategy | Elements | | | | |
|---|---|---|---|---|---|
| | Favourable Regulations | Institutional Framework | Finance | Use of Technology | Stakeholder Engagement |
| **Development of codes for residential buildings and simplified codes for commercial buildings with lower connected load** | ✓ | ✓ | | | |
| **Mandatory implementation of ECBC in states** | ✓ | ✓ | | | ✓ |
| **Integration of EE in government-housing schemes and cheaper financing for EE houses** | ✓ | ✓ | ✓ | | ✓ |
| **Synergy between BEE, IGBC and GRIHA rating system** | ✓ | ✓ | | | ✓ |
| **Automated building management systems in higher connected load commercial buildings** | ✓ | | | ✓ | ✓ |
| **Promoting EE technologies in high-rise residential buildings** | | | | ✓ | ✓ |

#### 7.4.4.1. Development of codes for residential buildings and simplified codes for commercial buildings with lower connected load

Currently the ECBC guidelines exist for commercial buildings like malls, institutions and office complexes, which have a connected load of 100 kW or above. The guidelines for residential buildings have also been launched in 2019. Simplified codes could also be developed for smaller apartments at a later stage. Similarly for smaller commercial buildings, there can be an incorporation of a simplified energy-efficiency code for easier implementation and adoption.

#### 7.4.4.2. Mandatory implementation of ECBC in states

Even though ECBC was first launched in 2007,[124] till date less than half the states have notified the Energy Conservation Building Code (ECBC) and incorporated ECBC in municipal building bye-laws.[46] Thus, there is a requirement to make the ECBC of each state mandatory. There needs to be stricter enforcement of the rules and guidelines of the programme. A reporting framework should be

[124] ECBC Code 2017, BEE

established where the states are required to update their progress in implementation of ECBC in their state.

### 7.4.4.3. Integration of EE in government-housing schemes and cheaper financing for energy-efficient buildings

The government has launched many programmes for increasing home ownership, including the Pradhan Mantri Awas Yojana. This mission has four components: in-situ slum redevelopment with private-sector participation using land as resource, affordable housing through credit linked subsidy, affordable housing in partnership with private and public sector and beneficiary-led house construction/enhancement. Under these components, central assistance will be in the range of Rs 1 lakh (USD 1400) to Rs 2.30 lakh (USD 3200). Energy efficiency can be made a component of these programmes.

The amount of incentive for EE houses can be increased and programmes initiated to incentivize buying energy-efficient houses.

### 7.4.4.4. Synergy between BEE, IGBC and GRIHA rating system

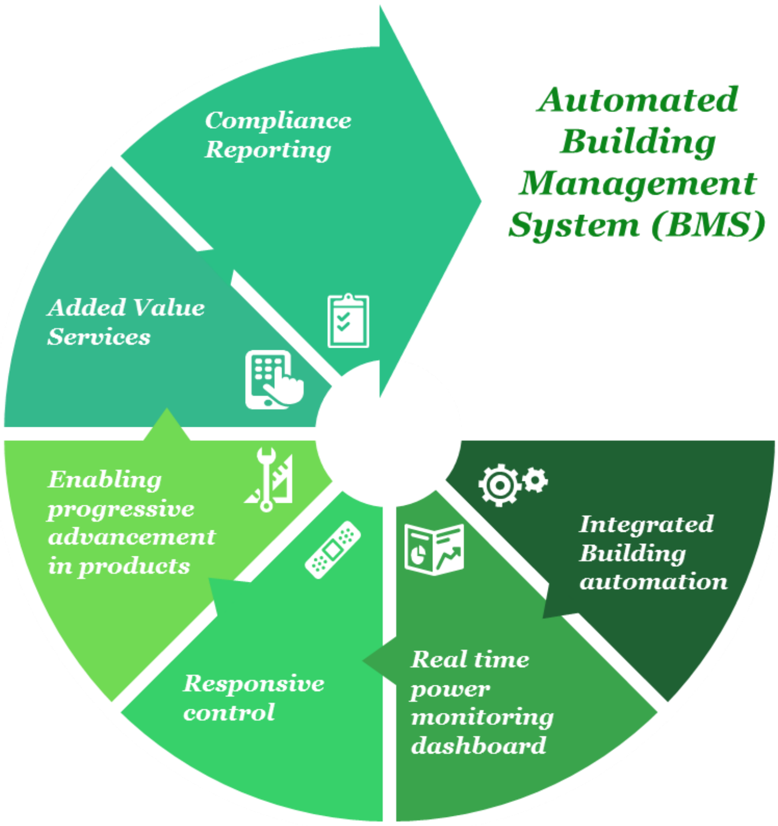
There are primarily three rating systems in India for buildings: BEE star rating system, Green Rating for Integrated Habitat Assessment (GRIHA) and Indian Green Building Council (IGBC). While the BEE star rating system takes cue from Energy Performance Index (EPI) as a parameter, the GRIHA rating system is based on 34 criteria categorized in four sections: (1) site selection and site planning, (2) conservation and efficient utilization of resources, (3) building operation and maintenance, and (4) innovation. The IGBC was formed by the Confederation of Indian Industry (CII) joining hands with US Green Building Council (USGBC) and licensing their green building standard.

The best practices from the three rating systems can be incorporated into a single comprehensive system that addresses every aspect of energy efficiency in buildings and incorporation of new technologies in building operations and energy management systems.

### 7.4.4.5. Automated building management system (BMS) in higher connected load commercial buildings

Automated building management systems (BMS) provide effective control and monitoring functions of heating, ventilation, cooling, hot water and lighting appliances, etc. improving the level of comfort for the inhabitants as well as fulfilling the purpose of saving energy.

*Figure 30: Components of an automated BMS*




At first, the importance and benefits of adopting automated BMSs can be shared with stakeholders through regional workshops conducted by SDAs in the states, before including it into the ECBC in the future. This would ensure that the adoption of the systems would be quicker, and more and more commercial spaces become BMS compliant in a short span of time.

### *7.4.4.6. Promoting energy-efficiency technologies in high-rise residential buildings*

Indian cities are witnessing an immense demographic expansion due to migration from surrounding villages, leading to urban sprawl, housing demand and rise in cost of land. This has led to more and higher rise residential buildings being constructed in Indian cities, which may or may not be adopting energy-efficient technologies that could significantly decrease the burden on electricity demand in urban India.

Some of the technologies that could be introduced in high-rise residential buildings and can be easily adopted would include energy-efficient water-pumping systems, cool roof technology, external solar shading, using elevator systems that are energy-efficient and solar water heaters.

Spreading awareness about adoption of these technologies in residential buildings could be taken up at the state level by the SDAs, starting with the largest residential complexes with the highest electricity consumption. The SDAs can further conduct a financial appraisal (pre-operative expenses, equipment costs, project implementation charges, interest during construction period, contingencies, promoters contribution, term loans, working capital for yearly operation and maintenance and repairs) and suggest ways to implement EE technologies in the buildings.

## 7.4.5. Industry

Industry is one of the largest energy-consuming sectors in India. For many industries, energy is also a substantial input cost. Therefore, the industrial consumers have an incentive to invest in energy efficiency. However, lack of knowledge, access to technology and high capital cost deter industries from investing in energy efficiency.

| Strategy | Elements | | | | |
|---|---|---|---|---|---|
| | Favourable Regulations | Institutional Framework | Finance | Use of Technology | Stakeholder Engagement |
| **Creating a national energy efficiency repository with benchmarks** | | ✓ | | | ✓ |
| **Increasing the width and depth of the PAT programme including a voluntary component** | ✓ | ✓ | | | ✓ |
| **Creation of a unified carbon reduction programme** | ✓ | ✓ | ✓ | | ✓ |
| **Mandatory energy management cell with certified energy manager/energy auditor for all medium- and large-scale industries** | | ✓ | | | ✓ |
| **Central monitoring of all funded programmes in the MSME** | | ✓ | ✓ | | ✓ |
| **Promoting use of energy-efficient equipment among MSME units** | | | | ✓ | ✓ |
| **Promoting Industry 4.0 technologies** | | | | ✓ | ✓ |

### 7.4.5.1. Creating a national energy-efficiency registry with benchmarks

There is no central database with information related to energy use of different industries. The data need to be collected on a regular basis from DISCOMs/industry itself. This will help in ascertaining the actual energy usage and the improvements that are required in the use of energy. Benchmarking can be done on the basis of the type of industry and production capacity.

### 7.4.5.2. Increasing the width and depth of the PAT programme

The baseline energy consumption of 621 DCs in PAT cycle 2 covers around 52.7% of the total industrial energy consumption (including the newly added sectors) in India.[125] Thus, there is a scope to further increase the reach of the programme. It is proposed to cover at least 80% of total industrial

[125] Impact Assessment Study on National Mission for Enhanced Energy Efficiency (NMEEE), Feb 2017, PwC

energy consumption, including targeting not only the large consumers, but smaller consumer's energy.

**Voluntary PAT programme**

The PAT programme currently covers 621 DCs, which constitute about half the industrial energy consumption in the country. Apart from widening the scope of the PAT programme, a voluntary PAT programme can be initiated for consumers not identified under the programme. The non-DC participants can be allowed to access the ESCerts Markets. They may also be given a favourable tax benefits for achieving energy efficiency in the sector. Voluntary certification can be considered positive branding for industries, and help in achieving greater energy efficiency in the sector.

### 7.4.5.3. Creation of a unified carbon reduction programme

Energy-saving certificates (ESCerts) are issued to overachievers of energy efficiency from the designated consumers (DCs) identified under the PAT programme from energy-intensive sectors of the industry and are required to be bought by underachievers of energy efficiency. Renewable energy certificates (RECs), on the other hand, are awarded to RE generators per 1 MWh of electricity injected into the grid via renewable sources. These can be purchased by distribution companies, open access consumer, captive power plants to meet their renewable purchase obligations. These two instruments can be an integral part of forming a unified carbon reduction programme for the country like "The Carbon Plan"[126] set out by the UK Government in 2011. However, the scope of these two instruments would have to be increased to achieve even further energy savings.

### 7.4.5.4. Mandatory energy management cell with certified energy manager/energy auditor in all medium- and large-scale industries

Under the PAT programme, DCs presently either have in-house energy managers (EMs) and energy cells, or some of the smaller DCs have outsourced the functions of EM while retaining managerial control.[125] It is unclear whether other industrial consumers that are not covered under PAT have an energy management cell. Hence, it is proposed to have an energy management cell with certified EA/EM for all industries above Rs 10 crore capex.

### 7.4.5.5. Central monitoring of all funded programmes in MSMEs

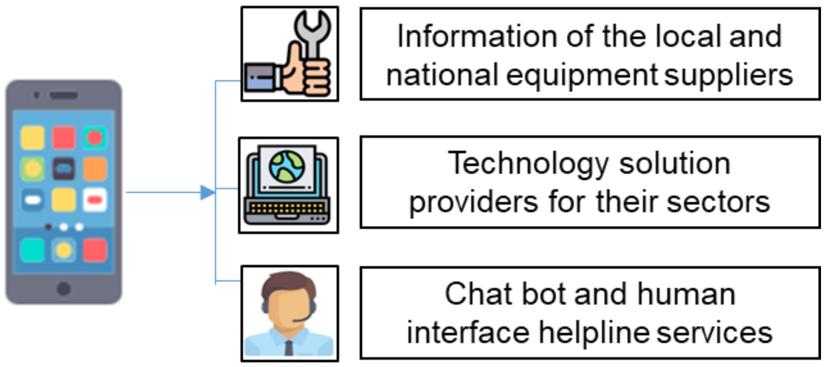
As is the case in agriculture, there are many agencies running energy-efficiency programmes in silos and are not coordinating with each other. There is a need to consolidate all the programmes and monitor them centrally.

### 7.4.5.6. Promoting use of energy-efficient equipment among MSME units

Even though the SIDBI website has a detailed list of equipment that are energy efficient, most MSME associations are unaware of this list and the vendors who supply such equipment. A mobile app, which not only provides details of the equipment but also technology and the service providers, can be set up.

[126] The Carbon Plan – Delivering our low carbon future (Dec 2011), HM Government

*Figure 31: An MSME app for manufacturers*




## 7.4.5.7. Promoting Industry 4.0 technologies

The inclusion of Industry 4.0 technologies carries with itself benefits like cost reduction, higher efficiency and energy savings in critical manufacturing processes. Under the wide gamut of technologies that come within the scope of Industry 4.0, there are eight core technology pillars that define the mega trend and would be the focus areas going into the future:

*Figure 32: Eight tenets of Industry 4.0*

| | | | |
|---|---|---|---|
| Internet of Things | Cloud Computing | Big Data Analytics | 3-D Printing |
| Augmented Reality | Robotics | Cyber Security | M2M |

Being the sixth largest manufacturing country in the world, Industry 4.0 presents a great opportunity for India to realize its long-term vision and increase the share of manufacturing in India's GDP from the current 17% to 25%. A collaborative approach on part of the government, industry and academia is the ideal way forward to drive India's manufacturing sector to adopt the eight technology tenets mentioned above.

## 7.4.6. Transport

With increased industrialization and prosperity, the transportation needs for both passenger and freight have increased and would continue to increase in the future. Besides, road transportation is also a key sector affecting local pollution levels. Greening the sector would have far-reaching effects beyond decreasing energy intensity.

| Strategy | Elements | | | | |
|---|---|---|---|---|---|
| | Favourable Regulations | Institutional Framework | Finance | Use of Technology | Stakeholder Engagement |
| **Integrated transport planning with mandate to support movement towards EE transportation** | ✓ | ✓ | | ✓ | ✓ |
| **Promoting shared last-mile connectivity solutions** | | | | ✓ | ✓ |
| **Legislation to improve ease of doing business for new business models** | ✓ | | | | |
| **Increase CAFÉ standards** | ✓ | ✓ | | ✓ | |
| **Stakeholder engagement** | | ✓ | | | ✓ |

### *7.4.6.1. Integrated transport planning and mandating support movement towards energy-efficient transportation*

India is facing rapid urbanization, and hence there is a need to plan the transport systems in the cities, state and national corridors. Many developed countries have integrated transport planning departments as a part of the transport authority. The department's main objective is to optimize transport for the citizen and to provide an uncongested path to travel. This requires a joint planning of public and private transport, which ranges from buses, metros, trains, taxis, auto rickshaws to private four wheelers and two wheelers. A planned transport network that integrates all modes of rail, water and road transport should be designed keeping in mind traffic congestion and fuel efficiency.

#### Energy-Efficient Transportation

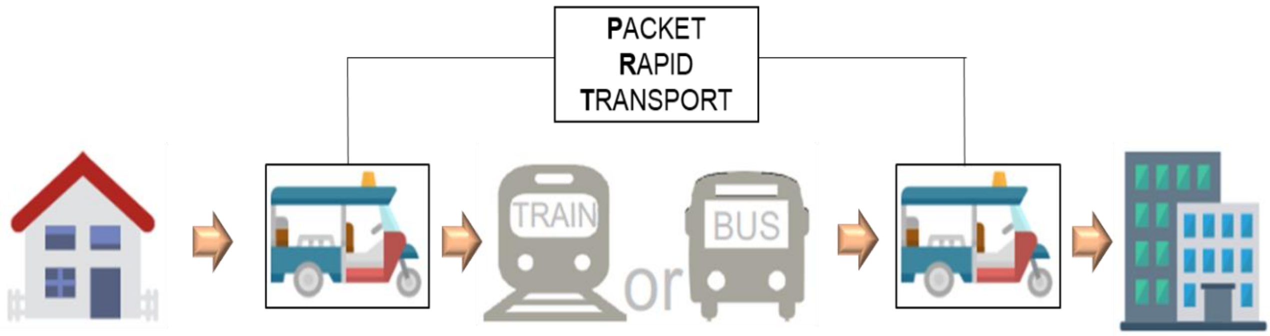
Though the country has taken initiatives to support the movement towards energy-efficient transport such as rolling out of electric vehicles to government fleets (National e-Mobility Programme by EESL), there needs to be a regulation/policy that will support the shift to electric vehicles in the country. Currently, electric vehicles provide a promising path to reduce energy consumption. They also have no tail pipe emission, which will lead to a significant reduction in the pollution in the cities. Many states have released policies on electric vehicles, but there is no such policy from the central government. Many automobile manufacturers will have to invest significantly to change their line of production and produce electric vehicles in the country. A mandate from the central government will align all the developments in the sector and lead to a smoother adoption of electric vehicles.

### *7.4.6.2. Promoting shared last-mile connectivity transport solutions*

Last-mile connectivity refers to getting people from a transportation hub like a railway station, bus depot or metro station to their final destination or vice versa. Indian cities have a huge potential for last-mile connectivity solutions. Fifty cities in India are planning metro rail systems, which increases requirement of connectivity to final destination.

A solution that can be adopted in this regard is the introduction of **packet rapid transport** models for cities where metros are being constructed and densely populated tier 1 and 2 cities. Already in place in countries like Philippines and conceptualized by the SoftBank Group, the PRT model is ideal for the Indian condition, where the last-mile connectivity is dominated by three wheelers.

*Figure 33: Packet rapid transport*




The PRT system consists of electric three wheelers that can be hailed through a mobile app during off-peak hours, and during rush hours they operate in a specific neighbourhood around metro, bus or suburban train stations.

### 7.4.6.3. Legislation to improve ease of doing business for new business models

India’s most populated cities are facing severe road traffic congestion. There is a need to adopt new business models such as shared mobility and connected ecosystem among others. However, the legislation is unclear on the legality of these business models. The Motor Vehicle Act does not have any clauses referring to these business models and may need to be updated accordingly. The business models need to be considered by the ministry as a means to reduce pollution and increase the ease of travelling from one place to another. There is a need to update the laws and regulations for allowing these opportunities to exist within the framework of the law so that they can be safe and regulated.

### 7.4.6.4. Increase CAFÉ standards

Corporate average fuel economy (CAFÉ) norms for 2022 or 2023 have been applied officially since 1 April 2017. Under the CAFÉ norms, the automakers are required to manufacture cars that are 30% or more fuel efficient from 2022 and 10% or more between 2017 and 2021. Many auto manufacturers have been able to easily adopt the CAFÉ norms. However, with the advent of electric vehicles, it is imperative to tighten these norms so as to encourage automotive manufacturers to focus on producing electric vehicles.

### 7.4.6.5. Stakeholder engagement

**Development of skills**

With the advent of new technologies such as electric cars, buses and new business models such as shared mobility, there is a need to develop the manpower to be equipped to support the proliferation of these technologies. The courses for the new technologies need to be designed and offered at government/private institutions. This would lead to a faster adoption of these technologies.

### Engagement of the general population

As transportation services are utilized for transport of people, it is important to engage with general population. Communication and engagement strategy should be adopted to encourage use of public transport and make the population aware of new technologies like electric vehicles.

## *7.4.7. Cross sectoral*

Many strategies would have resulted in energy intensity across sectors. These strategies include better management and engagement of distribution utilities in implementing energy-efficiency measures.

| Strategy | Elements | | | | |
|---|---|---|---|---|---|
| | Favourable Regulations | Institutional Framework | Finance | Use of Technology | Stakeholder Engagement |
| **Better Engagement and Management of EE Programmes in DISCOMs** | | | | | |
| **Considering DSM as a resource in IRP** | ✓ | ✓ | ✓ | | ✓ |
| **Capacity building of DISCOMs** | | ✓ | | | ✓ |
| **Mandatory use of smart meters** | | ✓ | | ✓ | |
| **Increased consumer engagement** | | ✓ | | | ✓ |
| **Framework to introduce time of day tariffs** | | | ✓ | ✓ | ✓ |
| **Other Strategies** | | | | | |
| **Increasing the scope of existing programmes with stricter enforcement and penalties** | ✓ | ✓ | ✓ | | ✓ |
| **Institutional framework for data collection** | | ✓ | | | ✓ |
| **State-wise targets** | ✓ | ✓ | ✓ | | |
| **Independent SDAs and building capacity of SDAs** | | ✓ | ✓ | | ✓ |
| **Funding for laboratories** | | | ✓ | | ✓ |
| **State-specific stakeholder engagement programmes** | | ✓ | | | ✓ |
| **Integration of harmonic products in S&L** | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Additional cess on import of inefficient equipment** | ✓ | | ✓ | | |
| **Voluntary reward programme for consumers** | ✓ | | ✓ | | ✓ |
| **Energy efficiency in** | | | | | ✓ |

| Strategy | Elements | | | | |
|---|---|---|---|---|---|
| school curriculum | | | | | |
| Enablement of new technologies | ✓ | | ✓ | ✓ | |
| Centre of excellence for industries | | ✓ | | ✓ | ✓ |
| Setting up of a committee of financial institutions at the state level | | ✓ | | | ✓ |

## *Better engagement and management of EE programmes in DISCOMs*

### Considering DSM as a resource in IRP

Given that the market-driven DSM mechanisms have gained significant momentum, India is at the cross roads for adopting the right policy approach that can effectively complement the market mechanisms in capturing the DSM potential and also delivering the promise of DSM. Demand-side resources lack the kind of impetus laid for promotion of renewable energy sources in the current legal and policy framework governing the Indian power sector. There is a need to explicitly recognize “demand-side resources” as alternative resource option in the energy resource basket of electric utilities. There are broadly two options available for the policy makers to achieve this.

- In the first option, the “demand-side resources” can be defined and emphasized as standalone independent resource apart from the conventional and renewable energy sources. This, however, requires legislative action to empower the state regulatory commissions for effective enforcement and consideration of DSM by the utilities and central/state governments.

- In the second option, the “demand-side resources” can be recognized as a qualifying resource under the definition of renewable energy sources in the existing legal and policy framework.

In addition, there is a need for consideration of demand-side resources at the planning stage to enable integrated resource planning by the electric utilities and central/state governments. The importance of IRP cannot be overstated, especially in India’s power market conditions, because it not only creates a market for demand-side resources but also saves on the enormous fixed costs otherwise paid by utilities towards the committed capacity for generation, transmission and distribution. This ensures that the enhanced penetration of demand-side resources in the overall energy resource mix of utilities effectively optimizes power resource costs and results in the reduced cost of power for consumers. This is one of the important promises of demand-side management.

### Capacity building of DISCOMs

There is a need to enhance existing skills of DISCOM employees and to support them in acquiring new skills through training or other capacity-building activity, in order to improve an existing, or establish a new DSM cell within the DISCOM. Currently, DISCOMs relate energy-efficiency programmes as revenue loss-making programmes.

Capacity building is a very important activity for implementing DSM programmes. International experience has indicated that utility-driven DSM can provide cost-effective resources, improve resource efficiency and further contribute to the reduction of utility costs. DSM resources comprise many effective load-management techniques and energy-efficiency programmes that can provide cost-effective mechanisms and market-based incentives to all the stakeholders to enhance resource efficiency and transform the power sector in the country. Key modules for a training programme would include:

| | | | | |
|---|---|---|---|---|
| Importance of DSM | Legal and Regulatory Framework | DSM Planning | Implementation of DSM Programmes | Post-implementation activities |

Well-designed DSM measures can flatten the overall load curve, reduce energy costs for both the utility and its customers, improve the service quality of the utility through enhanced system reliability, promote efficient end use of electricity by utility customers and enhance customer satisfaction. DSM programmes can also substitute fossil-fuel-based power plants and result in fewer greenhouse gas emissions.

### Mandatory use of Smart Meters

A smart meter is a type of electricity meter that communicates directly with the DISCOM. It gives the user accurate analysis of the distribution if energy use and thereafter the user can improve their use of energy and reduce overall energy demand. Smart meters are being rolled out in the country in the states of Bihar, Uttar Pradesh and Haryana by EESL.[127]

### Increased consumer engagement

DISCOMs can encourage efficient utilization of electricity by promoting the use of IoT-enabled devices such as smart speakers and mobile applications that monitor the consumption of electricity.

### Framework to introduce Time of Day Tariffs

Time of day tariffs can reduce the peak demand of electricity of DISCOMs. In Karnataka, the electricity regulatory commission has made time of day tariffs mandatory for industries with a contracted demand of more than 500 KVA.[128] The time periods defined by Karnataka Electricity Regulatory Commission are illustrated below:

*Figure 34: Time periods for ToD tariffs in Karnataka*


Similarly, the Delhi DISCOMs have sent their proposals to Delhi Electricity Regulatory Commission for time of the day metering.[129] There is a need to standardize the practice of time of day tariffs across the country. A framework needs to be developed that

[127] EESL and Bihar DISCOMs enter MoU to install 1.8 million smart meters (Aug 2018), https://mercomindia.com/eesl-bihar-discoms-mou-smart-meters/

[128] Time of day tariff system mandatory for big HT consumers (May 2012), https://www.thehindu.com/news/national/karnataka/time-of-day-tariff-system-mandatory-for-big-ht-consumers/article3371289.ece

[129] DISCOMs seek to shift peak hours (Dec 2017), https://timesofindia.indiatimes.com/city/delhi/discoms-seek-to-shift-peak-hours/articleshow/62245497.cms

IT cells of DISCOMs should be trained for new technologies such as IoT and Blockchain as they would play a huge role in reducing commercial losses.

guides a DISCOM to adopt time of day tariff for not only industrial consumers, but all types of consumers.

## *Increasing the scope of existing programmes with stricter enforcement and penalties*

India has undertaken many initiatives for reducing the energy demand in the country. Many of these initiatives have the potential to cover a wider scope. India has a good standard and labelling programme but is currently limited to a few appliances. Even though the standards for many appliances have been established, the mandatory level of compliance of the appliances needs to be raised. Market uptake of appliances with higher level of efficiency (4 and 5 stars) has been lower as the mandatory level for uptake is generally 2 to 3 stars. For example, even though 4- and 5-star air conditioners were introduced, the market was dominated by 2- to 3-star air conditioners.[130] Hence, there is a need to increase the minimum requirement of star rating for appliances. Along with the same, all appliances need to be covered under the mandatory scheme such as fans, washing machine, laptops and other equipment used in household. Further, the PAT programme currently covers 621 designated consumers (DCs), which account for about only half of the industrial energy consumption.[125] There is a need to scale up the programme to cover at least 80% of the industrial energy consumption. Similarly, AgDSM programmes are currently under way in only few states, the same can be expanded across all states. The programmes also face delays due to the slow implementation and lack of ownership of all the entities involved in the programme. Hence, to improve the implementation and effectiveness of these programmes it is proposed to:

Increase the reach of the current successful programmes such as PAT, street lighing, AgDSM, UJALA

Impose stricter enforcement guidelines to be implemented by the lead ministry in the programmes with quarterly follow-up and reporting. A framework to be established for the same.

Penalties to be applied for implementing partners for delay in implementation

## *Institutional framework for data collection*

During the course of the preparation of this report, significant data gaps were encountered in India's energy data reporting, as mentioned in the first chapter. The type of data gaps ranged from mismatch of data between various national agencies to unavailability of data at the state level for primary energy supply and demand. The following recommendations were made to improve the energy data collection and data reporting structure in the country:

- **Setting up of a nodal agency:** It is pertinent that an empowered agency should be set up that not only collects data from various sources, but also reconciles them and ensures smooth data management.

[130] Strengthening governance of India's appliance efficiency standards and labelling programme, WRI

- **Improved technology and statistical methods:** Automation in data collection and management should be explored as an option, which includes automated metering, online data submission and interactive data dissemination. This would improve accuracy and completeness in data collection as well as facilitate the collection of primary data for energy supply and demand at the state level, which is not reported by any agency in the country.

- **Systematic data quality checking:** Quality assurance mechanisms make it possible for agencies to carry out systematic quality checks. Quality assurance needs to be conducted at multiple stages of energy data management.

- **Maintaining commonality in standardization:** A common code of standardized definitions and classifications should be followed. Principles and codes of practices from the UN Statistical Commissions could be adopted in India.

- **Improved data dissemination:** It is also important to disseminate data in convenient, user-friendly and easy-to-access formats. Achieving this requires a high degree of data integration, uniform data maintaining standards, end-user-oriented data formats and increasing usage of modern technology.

## State-wise targets

To increase the ownership of the states in implementing energy-efficiency measures, it is proposed to include state-wise targets for reduction in energy use across sectors. An order can be issued by the central government to the states to report all energy-consumption and supply data along with special measures taken to implement energy-efficiency measures on a yearly basis. This can be implemented in a similar way to that of the European Union, which has directed the countries in the union to report the data. They have issued the energy-efficiency directive (EED) to all the countries that puts forward legally binding measures to step up Member States' efforts to use energy more efficiently at all stages of the energy chain. The central government can set up a similar framework with the Indian states with the following data points being collected and updated periodically:

- Sector-wise energy consumption, in comparison to the energy consumption in the previous year
- Status of all energy-efficiency programmes and the target of the same
- Future plan for energy efficiency in the next year (short term) and next 3 years (medium term)

Disbursement of funds allocated for energy efficiency should be linked to the achievement in the previous years.

## Independent SDAs and improving the capacity of SDAs

Under section 15(d) of the EC Act, 2001, state designated agencies (SDAs) have been notified by the state governments by assigning additional responsibilities to the existing state government departments. The different state departments, which are acting in the capacity of an SDA, comprise renewable energy development agencies, distribution companies/utilities, electrical inspectorate, power department and standalone energy efficiency agency. At present, there are 35 SDAs[131] in the

[131] Assessment of the impact of energy-efficiency activities taken by state designated agencies during XII five-year plan, PwC

country, out of which 16 are renewable energy development agencies, 5 are state government power departments, 7 are electrical inspectorate offices and 5 are DISTRIBUTION COMPANIES and 2 are standalone SDA.

It is noticed that since the SDAs have multiple functions, they have multiple responsibilities along with energy efficiency and energy conservation. This impacts the activities envisaged for energy efficiency. It has been observed that the standalone SDAs have been more effective in implementing energy-efficiency activities in the states.[131] Thus, it is essential to have SDAs with a standalone mandate for energy efficiency for a more focused approach to energy efficiency and for a more effective implementation of the programmes. This can be mandated by the Ministry of Power.

In most SDAs, it is noticed that all energy-efficiency schemes such as buildings, industries, standards and labelling are looked after by a single person only. The staff at the SDAs needs to be increased, and separate portfolios need to be assigned to the staff based on the qualification. To build an effective team at the SDA, it can be envisaged to conduct scheme-specific training for manpower so that they are better placed to implement the schemes in their states. It is proposed that this is taken up by BEE in a similar way that they have taken up capacity building of DISCOMs in the country. In addition to the above, the consumer awareness activities implemented by BEE and SDAs need to be synchronized and a National Energy Efficiency Awareness Strategy could be implemented to bring the awareness activities of all SDAs in line with those envisaged by BEE.

## Funding for laboratories for testing appliances under S&L

Under the standard and labelling programme, monitoring and compliance is limited by the availability of qualified test laboratories that can test the appliances. Though BEE has taken steps to empanel laboratories[130] for the programme, there is scope to increase the number of laboratories for testing the appliances. The same may be encouraged by providing easy finance for setting up the laboratories by private players. In addition, funds from labelling fees could be made available for this purpose.

## State-specific stakeholder engagement programme

It is observed that lack of communication and coordination between government departments and other stakeholders in the states results in delays in implementation of energy-efficient programmes.[46] To encourage faster implementation of programmes, it is proposed to have a state-specific stakeholder engagement programme led by the SDAs. The stakeholders in the state could include:

| | | | | |
|---|---|---|---|---|
| State Electricity Regulatory Commission | Urban Local Bodies | DISCOMs | State government departments | Energy Service Companies |

## Integration of harmonic products in S&L

Manufacturers of electrical appliances face many challenges in designing products when there are different standards available. The Bureau of Indian Standards (BIS) is the National Standard Body of India established under the BIS Act 1986 for the harmonious development of the activities of standardization, marking and quality certification of goods.

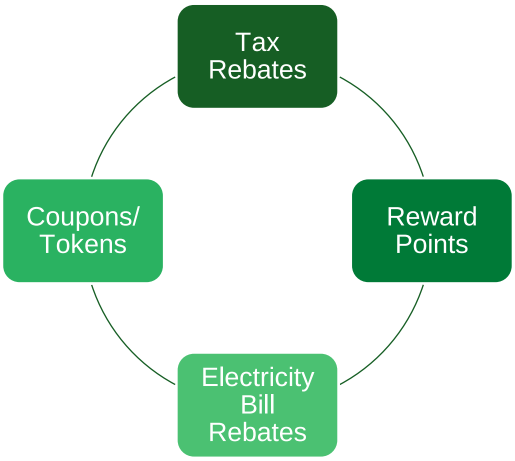
### Harmonics Standards

With increase in solid-state devices and use of capacity in many equipment, energy losses due to harmonics would rise. The new improved standards for equipment should have a special emphasis on harmonics other than energy efficiency.

## Additional cess on import of inefficient equipment

India follows an open trade policy where most products can be imported without any license. Machinery, electronics and telecom imports account for about USD 106 billion in imports, which amounts to almost 23% of India's imports.[132] It is possible that the equipment that is being imported does not utilize fuel efficiently, and there is scope for improvement in this. A cess can be imposed on substandard equipment being imported into the country by the customs department. This will reduce the import of inefficient equipment. A similar exercise was carried out by the Mauritius Government where to reduce the number of energy-inefficient appliances being imported in the country, a levy of additional 25% was applied on appliances whose efficiency was below a certain threshold. The threshold has since been raised over the years.[133]

## Voluntary reward programme for consumers




There is a lack of knowledge in consumers about energy efficiency and its benefits. An innovative way to spread information about energy-efficiency measures as well as to increase the adoption of these products is to reward the consumers who adopt these measures. In Ireland, Electric Ireland has listed measures[134] that qualify for credits in their home electricity or gas bill. Similarly, DISCOMs in India can come up with similar reward programmes. The DISCOMs can award "points" to the customer for such measures. The points can keep accumulating (like miles in airline programmes) that can be redeemed later for rewards.

In transport, there is a need to align all public services like buses, trains, metro and cabs via the same card, which will provide rebates to consumers that use the card (like the Delhi Metro card provides a rebate of 10% over cash). These will incentivize the adoption of energy-efficient methods.

## Energy efficiency in school curriculum

As mentioned earlier, there is less knowledge of energy efficiency for consumers. It is proposed that the same is incorporated in the school curriculum from Class 1 onwards. It can be started with simple dos and don'ts and can be more detailed chapters in higher classes. This will lead to widespread knowledge about energy efficiency, and the students will encourage household members to follow energy-efficiency practices.

[132] The good and the not so good imports, https://www.thehindubusinessline.com/opinion/columns/ajay-srivastav/the-good-and-the-not-so-good-imports/article24658336.ece
[133] Energy Efficiency (Labelling of Regulated Machinery) Regulations 2017, http://eemo.govmu.org/English/Documents/Energy_Labelling.pdf
[134] https://www.electricireland.ie/docs/roi-business-help---efficiency/energy-efficiency-qualifying-measures.pdf?sfvrsn=16c2bd0d_4

## *Enablement of new technologies*

New technologies such as IoT and Blockchain are proving to be essential to energy-efficient appliances. IoT is present in various new appliances such as smart meters, smart control panels on pumps, smart street lighting among others. Blockchain is still in a nascent stage but has a huge potential for application in DSM in India. The government needs to act quickly to set standards in these technologies for easier inter-operation of equipment. This will lead to a faster development of such technology and will lead to a structured approach to the introduction of these innovations. The government can run pilot programmes that can test the effectiveness of the technology. This can be undertaken by the Department of Science and Technology.

### Regulations for new technologies

Introduction of these technologies also has the potential to increase the energy consumption if inefficient communication technologies are used. India could set up policy in line with One-Watt Initiative by the International Energy Agency.

Further, to boost the sector, the government needs to establish certain guidelines. The European Union recently enforced the General Data Protection Regulation (GDPR) guidelines in May 2018. This has resulted in strict guidelines for use of data by companies. The basic rule set by the government is that the consumer needs to give consent to companies to use their data.[135] Thus regulating the industry will increase the rate of adoption of the technologies as they would be approved by the government.

## *Centre of excellence for industries*

There is scope for improving the energy efficiency in the industry by establishing sector-specific centres of excellence for industries. These centres of excellence can be funded by mandating all industries to contribute 1% of profits to their sector-specific centre of excellence. This would increase the research and development in energy-efficient equipment and processes with a specific focus on the sector, which would lead to an overall decrease in energy demand of the sector.

## *Setting up a committee of financial institutions at the state level*

The EE sector, despite having a huge potential for investment, has not been able to attract huge investments in the recent past like the renewable sector. The SDAs can play a crucial role in this regard and can act as a catalyst in facilitating finance to EE projects in the state.

The SDAs will constitute a committee of key financial institutions within the state. The SDAs would then refer EE projects to the committee members for financing. Only those projects that face financing issues would be evaluated by the committee and members of the committee may choose to finance these projects after careful evaluation, with recommendations from the SDA.

# 7.5. Actionable Instruments for Achieving Proposed Strategies

As mentioned in the section above, the energy-efficiency potential in the country can be achieved by various interventions that can be carried out across the demand sectors, as well as measures that cut across sectors. In this section, a short-, medium- and long-term timeframe has been considered

[135] Securing the IoT through effective regulation (May 2018), TrendMicro

for actionable instruments under each of the strategies mentioned above. The timeline in this context refers to the period over which the proposed strategy should come into fruition and become an integral part of the functioning of the sector, or across sectors. The table below outlines these timelines:

*Table 50: Strategy timeline for agriculture sector*

| Agriculture | | |
|---|---|---|
| **Strategy** | Actionable instruments | Timeline |
| **Integration of energy efficiency with water conservation efforts and greater coordination among various stakeholders** | Explore integrated DSM solutions with appropriate delivery models to maximize EE in the agro-pumping loads | Short term |
| | Creation of an inter-departmental task force aimed at aligning the objectives and goals of various existing programmes | Medium term |
| **Availability of EE pump sets** | Mandatory star labelling of pumps and phase out of non-star pumps | Medium term |
| **Integrate energy efficiency in agriculture studies** | Specific courses in institutions like ICAR, Specific courses in ITIs that focus on skill development in dealing with climate smart agricultural technologies | Medium term |
| **Cheaper finance for energy-efficient equipment** | Developing an energy-lending portfolio comprising several energy-specific loan products | Long term |
| | Introduction of region-specific products based on demand assessment through microfinance institutions and SHG bank linkage | Medium term |
| | Designing training programmes for staff in financial institutions | Medium term |
| **Increasing research and development in the agriculture sector** | Inclusion of agro-projects under the National Clean Energy Fund | Short term |
| | ICAR institutes and SAUs to create consortium in which private organizations can become members and access technology | Medium term |
| | A single window system for export of products and services will improve the competitiveness of sector R&D. | Medium term |
| **Mandating EE technology standards and guidelines** | Development of an energy conservation code for agro-sector | Medium term |
| | Regulation for installation of only BEE star-rated EE pump sets and smart control panels mandatory for new agricultural connections | Long term |
| | Solar pumps should mandate using only the most efficient appliances | Medium term |

| Agriculture | | |
|---|---|---|
| | Investment in efficient irrigation pumps, including solar/electric pumps for irrigation. | Medium term |
| **IoT in agriculture: Moving towards smart farming practices** | Building a forum of stakeholders interested in research, development, testing and implementation of technology, infrastructure and applications of IoT for farming | Short term |
| | Identifying trends and disruptions anticipated in Indian farming practices in the future | Medium term |
| | Running pilot projects across varying climatic conditions in the country | Medium term |
| | Funding large-scale projects post successful implementation of pilot projects | Long term |

*Table 51: Strategy timeline for the building sector*

| Buildings | | |
|---|---|---|
| **Strategy** | Actionable instruments | Timeline |
| **Mandatory implementation of residential building codes and simplified codes for commercial buildings with lower connected load** | Mandatory implementation for the recently released ECBC-R codes | Long term |
| | For smaller commercial buildings, incorporation of a simplified energy-efficiency code for easier implementation and adoption. | Medium term |
| | Energy auditors for building or ECBC | Medium term |
| **Mandatory implementation of ECBC in states** | Establish a reporting framework for where the states are required to update their progress in implementation of ECBC in their state. | Medium term |
| | Make ECBC implementation mandatory in all states by 2022 | Medium term |
| **Integration of EE in government-housing schemes and cheaper financing for EE houses** | Optimum unit planning under PMAY to enhance thermal and visual comfort by day-light integration, cross ventilation, window shading, low thermal transmittance of envelope and cool roof | Long term |
| | Site planning to optimize building orientation, WWR and heat island effect for enhanced comfort levels within the building | Long term |
| | Optimum building height to minimize common services' provision, operational energy and maintenance cost and enhanced RE integration potential | Medium term |
| | Targeting low LCOC rather than low initial building cost by building for affordable maintenance and operation as well | Medium term |
| | Introduction of incentives for purchasing EE houses | Long term |
| **Synergy between BEE, IGBC and GRIHA rating systems** | The best practices from the three rating systems can be incorporated into a single comprehensive system | Medium term and |

| Buildings | | |
|---|---|---|
| | that addresses every aspect of EE in buildings and incorporation of new technologies in building operations and EM systems | long term |
| **Automated building management system (BMS) in higher connected load commercial buildings** | Mandatory installation of automated building management systems in commercial buildings of a higher connected load to begin with. The policy can then be made mandatory for residential townships and complexes. | Medium term |
| **Promoting energy-efficiency technologies in high-rise residential buildings** | Drive awareness programmes across state capitals through SDAs | Short term |
| | Identify residential complexes in the capital cities where there is a huge scope for energy savings | Short term |
| | Collaborate with housing societies to implement small-scale EE projects | Medium term |
| | Prepare case studies of successful EE implementations in housing complexes around the country | Medium term |
| | Programme expansion to other densely populated cities in the state | Long term |

*Table 52: Strategy timeline for the industrial sector*

| Industry | | |
|---|---|---|
| **Strategy** | Actionable instruments | Timeline |
| **Creating a national energy efficiency repository with benchmarks** | Formation of a nodal agency that has representatives from the identified stakeholders | Medium term |
| | Dissemination of periodic reports and analysis, providing support to line ministries on EE activities and programmes | Long term |
| **Increasing the width and depth of the PAT programme including a voluntary component** | Increasing the scope of the PAT programme and adopting BAT to cover at least 80% of total industrial energy consumption | Medium term |
| | A voluntary PAT programme to be initiated. The non-DC participants would be allowed to access the ESCerts markets and given a favourable tax benefits for achieving EE | Medium term |
| **Creation of a unified carbon reduction programme** | Combining REC and PAT certificates—meta registry | Medium term |
| | Trading mechanisms for inter-trading between ESCerts and RECs | Medium term |
| **Mandatory energy management cell with CEMs/CEAs in all medium and large-scale industries** | List of sector experts so that other sectors can be benefited | Short term |
| | Creation of an energy management cell with certified EA/EM for all industries above Rs 10 crore capex | Medium term |

| Industry | | |
|---|---|---|
| | Running capacity-building programmes to develop the required manpower to effectively function in EM cells in the industries | Medium term |
| **Central monitoring of all funded programmes in the MSME** | Creation of a PMU within the nodal ministry to monitor the close to 30 schemes that are being run in the country | Short term |
| | The cluster associations to work closely with the PMU to help and promote new EE and RE technologies | Medium term |
| | Organizing industry and technology-specific workshops in the clusters | Medium term |
| **Promoting use of energy-efficient equipment among MSME units** | Creation of a comprehensive database of national and international vendors in the country supplying EE equipment | Short term |
| | Creating an App that helps connect MSMEs connect with equipment suppliers and technology solution providers around them | Short term |
| | Spreading awareness of the app among MSME cluster associations | Short term |
| **Promoting Industry 4.0 in manufacturing industry** | Creation of fund for R&D in industry—1% of turnover | Short term |
| | Strengthen the vocational training infrastructure and partnering with the private sector to include elements of Industry 4.0 in vocational training | Short term |
| | Establishing a network of test labs that will work closely with industry bodies, government, academia | Medium term |
| | Financial incentives like tax breaks to make it more affordable | Medium term |

*Table 53: Strategy timeline for the transport sector*

| Transport | | |
|---|---|---|
| **Strategy** | Actionable instruments | Timeline |
| **Integrated transport planning with mandate to support movement towards EE transportation** | Interdepartmental planning of transport networks in the country that integrates all modes of rail, water and road transport, focus on promoting public transport as the preferred form of transport | Medium term |
| | Develop a national policy on electric vehicles | Medium term |
| | Roll out of the proposed FAME II scheme | Medium term |
| | Introduction of ToD tariff rates for EVs | Short term |
| | Pilot projects on V2G and integration of RE and EVs in the grid | Short term |
| | Pilot projects on ancillary services of EV landscape and large-scale energy storage systems | Short term |
| **Promoting shared last-mile connectivity transport solutions** | Location survey of Indian cities apart from metros to scout for ideal locations to implement shared last-mile | Short term |

| Transport | | |
|---|---|---|
| | connectivity solutions | |
| | Implementation of pilot projects | Medium term |
| | Large-scale projects with participation of private players and solution providers | Long term |
| **Legislation to improve ease of doing business for new business models** | Developing regulations that allow for smooth functioning of shared mobility providers in the form of:<br>• Facilitating coordination and eliminating overlapping functions in planning and execution of urban mobility initiatives<br>• Integrated fare setting across modes so that various services are priced according to the affordability of the users<br>• Facilitating efficiency in regulation of shared mobility and their permit system in city | Medium term |
| **Increase CAFÉ standards** | CAFÉ standards in India to define corporate average $CO_2$ emission targets for OEMs and these are to be benchmarked against standards implemented in other countries | Medium term |
| | Provision for carbon trading in the auto sector | Long term |
| **Increasing stakeholder engagement** | Designing courses and training modules that are future ready and lead to deployment of a skilled workforce | Short term |
| | Introduction of an integrated information system by NSDC that creates a marketplace for demand aggregation of labour in the industry | Medium term |
| | Driving consumer awareness for green mobility solutions by designing an effective communication and awareness strategy for the general public | Short term |

*Table 54: Timeline for cross-sectoral strategies*

| Cross sectoral | | |
|---|---|---|
| **Better engagement and management of EE programmes in DISCOMs** | | |
| **Strategy** | Actionable instruments | Timeline |
| **Considering DSM as a resource in IRP** | Demand-side resources to be defined and emphasized as standalone independent resource apart from the conventional and RE sources | Medium term |
| | Considering demand-side resources at the planning stage to enable IRP by the electric utilities and central/state governments | Medium term |
| | Promotion of “DSM Resource Purchase Obligations” and more importantly to ensure effective enforcement of such obligations | Medium term |
| | Grid interactive demand response by smart appliances, buildings/industrial consumers, or EV chargers | Long term |
| **Capacity building of DISCOMs** | IT cells of DISCOMs to be trained for new technologies such as IoT and Blockchain to tap their role in reducing | Short term |

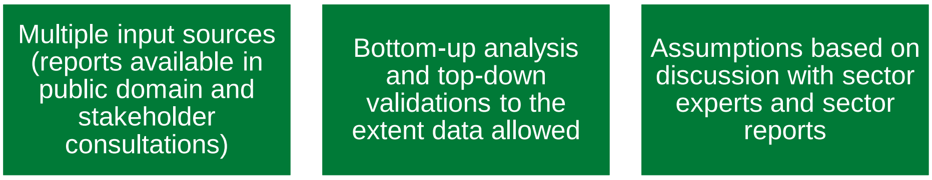
| Cross sectoral | | |
|---|---|---|
| | commercial losses | |
| | Establishing DSM cell in DISCOMs | Short term |
| **Increasing the scope of existing programmes with stricter enforcement and penalties** | Impose stricter enforcement guidelines to be implemented by the lead ministry in the programmes with quarterly follow-up | Short term |
| | DELP-type programmes to be implemented for 10 most energy-intensive appliances | Medium term |
| | Penalties to be applied for implementing partners for delay in implementation | Short term |
| | Increase the reach of the current successful programmes such as PAT, street lighting, AgDSM, UJALA | Medium term |
| | Improvement in efficiency of biomass cook stoves and gas stoves. | Medium term |
| **Institutional framework for data collection** | Setting up of a nodal agency that advocates data collection and dissemination, covering the entire energy value chain of the country | Medium term |
| **Setting state-wise targets** | Mandatory reporting of sector-wise energy consumption, status of all EE programmes and the target of the same and EE roadmap | Medium term |
| **Independent SDAs and capacity building of SDAs** | SDAs with a standalone mandate for EE for a more focused approach to EE | Medium term |
| | National Energy Efficiency Awareness Strategy to be implemented | Medium term |
| **Funding laboratories** | Increase in the number of laboratories for testing appliances | Medium term |
| **Stakeholder engagement programmes** | State-specific stakeholder engagement programme led by the SDAs. | Short term |
| **Integration of harmonic products in S&L** | Addressing the issues faced by manufacturers for conformance with BIS and S&L standards | Short term |
| | Inclusion of harmonic standards into the S&L | Short term |
| **Additional cess on import of inefficient equipment** | A cess to be imposed on substandard equipment that is being imported into the country by the customs department | Medium term |
| **Additional cess on import of inefficient equipment** | A cess to be imposed on substandard equipment that is being imported into the country by the customs department | Medium term |
| **Voluntary reward programme for consumers** | Reward programmes by DISCOMs to consumers for adopting certain pre-ordained measures | Short term |
| **Energy efficiency in school curriculum** | Knowledge about energy efficiency to be imparted at the primary school level, from Class 1 onwards | Short term |
| **Enablement of new technologies** | Mandatory standards and labelling programmes for all ceiling fans, VFRs and chillers | Short term |
| | Moving towards cleaner cooking fuel like electric cook stoves | Short term |
| | All key appliances, equipment and vehicles should be covered by mandatory standards and labelling programmes by 2020 | Medium term |
| | Setting standards for new technologies like Blockchain and | Medium term |

| Cross sectoral | | |
|---|---|---|
| | IoT | |
| | Policy on communication protocol for newer technologies | Medium term |
| **Centre of excellence for industries** | Increasing R&D in specific sectors in the industry by setting up a centre of excellence dedicated to particular sectors | Medium term |
| **Setting up a committee of financial institutions at the state level** | Constituting a committee of financial institutions at the state level, with SDAs referring EE projects to the committee that face financial issues in getting implemented | Medium term |

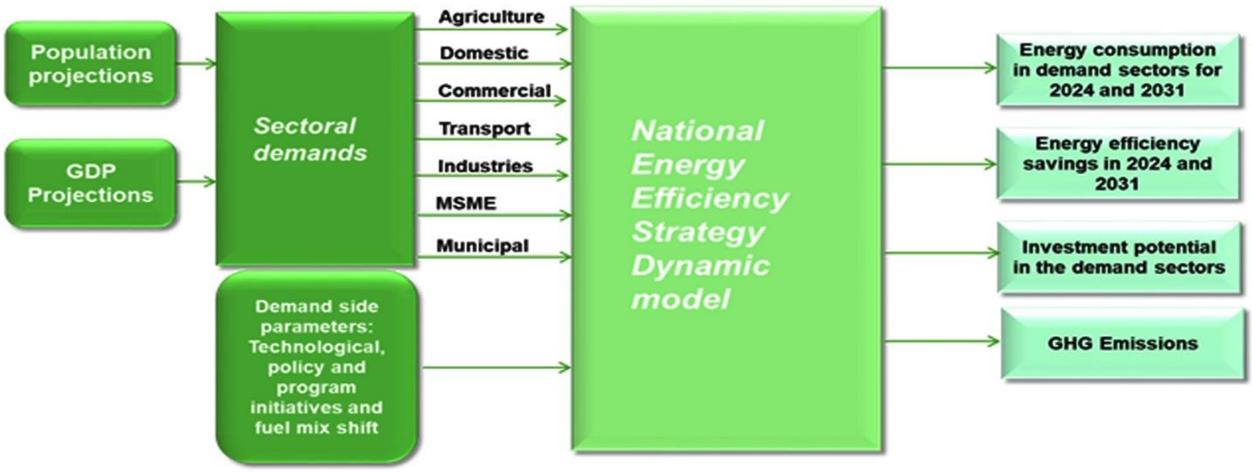
# APPENDIX

# Appendix A. Dynamic tool overview

The National Energy Efficiency Strategy document focuses on multiple sectors, and thus a flexible model was designed to adapt to the unique aspects and data availability of each of the demand sector. The underlying approach for the entire analysis hinged on three pivots:




For this study, the model database extends from the base year of 2016–17 to 2030–31 and has been updated to validate and align the energy consumption across the sectors. Discussions with sector experts were carried out in order to delineate which end-use options lend themselves to efficiency improvements and to incorporate insights regarding the levels of improvements that can be envisaged across technologies, processes and end-use equipment over 14-year period considered for this study. Extensive secondary data were collected from reports available in the public domain, from government sources as well as international and national independent organizations that regularly publish reports and journals on energy consumption and efficiency in the country. The design of the model adopted for the study is shown below:




The various intended beneficiaries of this tool would include central and state ministries and government agencies, various government and nongovernment think-tanks, expert agencies, policy makers and sector experts. The tool projects the energy consumption, energy-saving potential energy-efficiency investment potential and GHG emissions from 2016–17 till 2030–31 under various scenarios for the demand sectors as illustrated in the design model shown above. The tool also calculates the primary energy and electricity consumption for the country as well as the states for the base year, with a provision for the user to update the data every year as and when the energy data are published from various sources.

This would allow the beneficiaries to get a comprehensive view of the country's energy profile in the current scenario as well as the possible scenarios that could take place depending on the various energy pathways that have been incorporated into the model.

# Appendix B. Identification of Data Gaps

*Supply-side data gaps in energy reporting*

| Energy Source | Data Sources | Data Source | Data Gap |
|---|---|---|---|
| **Coal** | Coal Controller Organization (CCO), Ministry of Coal | **Supply:**<br>• Annual production and dispatch of raw coal and lignite<br>• Annual import and export<br>• Projected production target for CIL (Coal India Limited) till 2021<br>**Consumption:**<br>• Sector-wise offtake of total available coal state wise and within state, sector-wise offtake of raw coal and lignite | **Consumption:**<br>• State- and sector-wise offtake of imported coal<br>• Production projections unavailable for 2027 |
| **Oil and natural gas** | Petroleum Planning and Analysis Cell (PPAC), Ministry of Petroleum and Natural Gas, Directorate General of Hydrocarbons (DGH) | **Supply:**<br>• Domestic crude production (ONGC (Oil and Natural Gas Corporation), OIL (Oil India Ltd.), JV (Joint Ventures))<br>• Import of crude<br>• Import and export of petroleum products<br>• Reserve replacement ratio (RRR) data available for overall production<br>• Data available for drilling done in specific basins for shale gas/oil<br>• Only policy framework mentioned for underground coal gasification<br>**Consumption:**<br>• State-wise sales of petroleum products<br>• Sector-wise break-up of consumption (national level) is available for about 64% of the total consumption | **Supply:**<br>• Recovery factor and replacement factor for in-place oil and gas reserves<br>• Company-wise reserve replacement ratio (RRR) missing<br>• Proposed E&P data on underground coal gasification unavailable<br>• Proposed commencement of shale gas production not specified<br>**Consumption:**<br>• Sector-wise consumption of petroleum products at state level<br>• Complete sector-wise consumption at national level |
| **Bioenergy** | Ministry of New and Renewable Energy (MNRE) | — | Non-reporting of biofuel and biogas energy supply and consumption in sectors |

| Energy Source | Data Sources | Data Available | Data Gaps |
|---|---|---|---|
| **Nuclear** | Central Electricity Authority (CEA), Nuclear Power | Generation and capacity factor | Data mismatch of nuclear generation and capacity factor |

| Energy Source | Data Sources | Data Available | Data Gaps |
|---|---|---|---|
| | Corporation of India Limited (NPCIL) | | |
| **Solar** | Ministry of New and Renewable Energy (MNRE), CEA | | • Non-reporting of installed CSP (concentrated solar power) plants in the annual reports<br>• No segregation of generation of solar from solar photovoltaic and CSP<br>• Non-reporting of penetration of concentrated solar thermal (in residential and commercial sector)<br>• Data mismatch of SPV (solar photovoltaic) capacity addition YoY<br>• Data mismatch of YoY off-grid capacity addition |
| **Wind** | MNRE, CEA, National Institute of Wind Energy (NIWE) | | • Data mismatch with respect to installed wind capacity |

### *Demand-side data gaps in energy reporting*

| Sector | Data Source | Data Available | Data Gap |
|---|---|---|---|
| **MSME** | — | Cluster level energy consumption data estimated based on survey of sample units<br><br>**Source:** Cluster profile report of over 90 clusters prepared under BEE and other bilateral and multilateral agency funded project | Data regarding actual energy consumption are not available on public domain for national and state level |
| **Domestic** | CEA for electricity, MOSPI for other fuels such LPG, PNG, kerosene<br>PPAC, Ministry of Petroleum and Natural Gas | General Review, 2017, CEA provides national-level and state-level electricity consumption in domestic sector<br>Energy statistics 2018 (MOSPI), provides consumption of fuels at national level | No data available in public domain for fuel consumption such as LPG, PNG, kerosene at state level |
| **Industries** | DCs (designated consumers) under PAT (Perform, Achieve and Trade), BEE | **PAT Data:**<br>Baseline data for 109 DCs (72 industries and 37 commercial buildings) of PAT cycle 4 are available for 2016–17 | Data for 2016–17 are not available for DCs covered in PAT cycles 2 and 3<br>No energy-consumption data available in public domain regarding non-DCs (not covered in PAT) industries at |

| Sector | Data Source | Data Available | Data Gap |
|---|---|---|---|
| | | | national and state levels |
| **Municipal** | CEA for electricity | General Review, 2017, CEA provides national-level and state-level electricity | State-level data on solar street lights, solar pumps etc. |
| **Agriculture** | CEA for electricity, MOSPI for other fuels such as diesel etc. | General Review, 2017, CEA provides national-level and state-level electricity.<br>Energy statistics 2018 (MOSPI), provides consumption of fuels at national level | No data available in public domain for fuel consumption at state level |
| **Commercial** | CEA for electricity | General Review, 2017, CEA provides national-level and state-level electricity | No data available in public domain for fuel consumption such as diesel, NG and other fuels at national and state level |
| **Transport** | MOSPI | Energy Statistics 2018 (MOSPI) provides consumption of fuels and electricity at national level.<br>National- and state-level sales data of various vehicle categories | No data available in public domain for fuel and electricity consumption at state level |

# Appendix C. Mapping of Direct and Indirect Policy/Programmes

The table below lists the intended change in end use as well as the impact on energy consumption for the various policies and programmes:

| Policy/Programme | Targeted Sector | Intended Change in End Use | Change in Energy Consumption |
|---|---|---|---|
| **Agriculture and municipal demand-side management** | Municipal and gram panchayat | Replacement of pumps used for water supply and sewage will improve the energy efficiency of municipal bodies and gram panchayats. | Reduction in the consumption of electricity |
| | Agriculture | The replacement of agricultural pumps with control panels will improve the energy efficiency of the sector as well as provide farmers with good quality, star-rated pumps. | |
| **National Mission for Enhanced Energy Efficiency (NMEEE)** | Domestic | Bachat Lamp Yojana contributed as a catalyst in market transformation from a CFL market size of 180 million in 2008 to 400 million in 2012, while directly contributing about 15% towards this total growth in CFL market. The experience gained under BLY II for development of the technical specifications has been made available by BEE to support organizations like EESL (Energy Efficiency Services Limited), and REC in framing LED specifications as well as their LED distribution programmes as well as to government department/ministries like MeitY (Ministry of Electronics and Information Technology) for their programme interventions and incentive programmes, investment approvals etc. in LED-based lighting products. | Reduction in the consumption of electricity |
| | Industries | Will result in lower-energy consumption and adoption of efficient technologies of production | |

| Policy/Programme | Targeted Sector | Intended Change in End Use | Change in Energy Consumption |
|---|---|---|---|
| **24×7 Power for All** | Lighting and appliances | Power penetration to the households will result in an increase in sales of lighting and appliances. | Increase in the usage of electricity, augmented by an increasing usage of solar power to generate electricity. |
| | Large industries and MSMEs | Access to quality power will boost the industrial growth and development. It will lower the dependence on backup power of industries | |
| | Buildings | Electrification and supply of quality power to buildings will provide better work environment and will reduce dependence on backup power. | |
| | Cross sectoral | Increase in reliability of water and power supply will improve the functions of municipalities | |
| | Pumping | 24×7 power will reduce the dependence of farmers on intermittent power for irrigation. | |
| **Pradhan Mantri Sahaj Bijli Har Ghar Yojana—SAUBHAGYA** | Domestic | The scheme aims to reach all unelectrified households. The appliances that would be covered are battery banks, LED lights, fans and power plugs, smart meters etc. | Increase in consumption of electricity |
| **Pradhan Mantri Ujjwala Yojana (PMUY)** | Domestic | Use of clean fuel for cooking as well as increase in the sale of accessories for cooking like stoves, cylinders, hose and regulators. | Increased consumption of LPG |
| **National Electric Mobility Mission Plan 2020 (NEMMP)** | Transport | The government has incentivized changing to electric vehicles by providing subsidies and supporting pilot projects. | Increase in consumption of electricity for charging electric vehicles, reduction in consumption of petrol due to switch to electric vehicles, reduction in consumption of diesel due to switch to electric vehicles |
| **Metro Rail Policy 2017** | Transport | The metro rail network will improve usage of public transport. | Increase in consumption of electricity for operation of the metro rail and its stations, reduction in consumption of petrol due to switch to metro rail, reduction in consumption of diesel due to switch to metro rail |

| Policy/Programme | Targeted Sector | Intended Change in End Use | Change in Energy Consumption |
|---|---|---|---|
| **National Solar Mission** | Domestic | Remote locations that are not currently serviced by electricity can set up standalone solar power to generate electricity. | Increased reliance on solar power for electricity generation |
| | Agriculture | Fields located in remote locations can use solar pumps for irrigation. | |
| **Smart Cities Mission** | Municipal | Improved efficiency in pumping and improved water supply services | Increase in the consumption of electricity as the connected load will increase; however, it will be urbanization in a sustainable manner.<br><br>Decrease in consumption of petroleum products on account of increasing public transport share in road transport |
| | Transport | Improved utilization of public transportation would lead to less usage of petroleum products. | |
| | Domestic | Prevalent usage of smart solutions would lead to energy savings from domestic lighting and appliances. | |
| **Atal Mission for Rejuvenation and Urban Transformation (AMRUT)** | Municipal | Improved efficiency in pumping and improved water supply services | Increase in the consumption of electricity as the connected load will increase; however, it will lead to urbanization in a sustainable manner<br><br>Decrease in consumption of petroleum products on account of increasing public transport share in road transport |
| | Transport | Improved utilization of public transportation would lead to less usage of petroleum products. | |
| **Municipal Energy Efficiency Programme (MEEP) by EESL** | Municipal | Improved efficiency in pumping and improved water supply services | Reduction in the consumption of electricity as inefficient pumps are being replaced with energy-efficient pumps |
| **Street Lighting National Programme (SLNP)** | Municipal | Improved lighting infrastructure with LEDs and control systems | Decrease in the consumption of electricity as energy-intensive lights are being replaced by LEDs |
| **National Policy on Biofuels** | Transport | The policy will allow use of ethanol produced by agricultural surplus to be used in petrol. Till now only ethanol produced by sugarcane was allowed. | It will reduce the consumption of petrol and diesel as the blending ratio increase in the future. |
| **Deendayal Upadhyaya Gram Jyoti** | Domestic | Feeder separation to ensure sufficient power to farmers and regular supply to other | Increase in consumption of electricity |
| | Commercial | | |

| Policy/Programme | Targeted Sector | Intended Change in End Use | Change in Energy Consumption |
|---|---|---|---|
| **Yojana** | Agriculture | consumers | Households in remote areas will be provided with solar photovoltaic standalone system |
| **On-Farm Water Management (OFWM)** | Agriculture | The use of low-pressure pumps in drip irrigation results in usage of lower power. | Reduction in the consumption of electricity |
| **Green Highways Policy, 2015** | Transport | The government has incentivized switching to electric vehicles by providing subsidies and supporting pilot projects. | Increase in consumption of electricity for charging electric vehicles |
| **National Biogas and Manure Management Programme** | Domestic | Use of clean fuel for cooking as well as low dependence on LPG supply and electricity | Lower dependence on LPG |
| **Unnat Chulha Abhiyan (UCA)** | Domestic | Use of clean fuel for cooking, which will result in lower emission of black carbon from burning of biomass | Lower dependence on LPG |
| **Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises (TEQUP)** | MSME | Use of EETs would put MSMEs in the same league as global producers and make the sector competitive | Reduction in the consumption of electricity |
| **Sagarmala** | Transport | Share of rail in freight transport would increase, leading to efficient movement of goods within the country | Increase in the consumption of electricity as more and more diesel locomotives will be replaced by electric ones.<br><br>Reduction in consumption of diesel due to switch to rail transport |
| | Industries | Proximity to ports and well-connected railway networks would help reduce cost and dependency on heavy commercial vehicles to ferry goods from one location to another. | |
| **Dedicated Freight Corridor (DFC) programme** | Transport | Share of rail in freight transport would increase, leading to efficient and movement of goods within the country | Increase in consumption of electricity as more and more diesel locomotives will be replaced by electric ones<br><br>Reduction in consumption of diesel due to switch to rail transport |
| | Industries | Development of economic zones along the corridors | |

| Policy/Programme | Targeted Sector | Intended Change in End Use | Change in Energy Consumption |
|---|---|---|---|
| **Green Urban Mobility Scheme** | Transport | Electric and hybrid vehicles in public transport would lead to significant reduction in emissions. | Increase in consumption of electricity as more and more public buses are replaced by electric buses. |
| **National Auto Policy 2018** | Transport | Improved efficiency standards for vehicles coupled with push for alternate fuels and e-vehicles will significantly reduce energy demand and emissions in the transport sector | Increase in consumption of electricity as the policy advocates the push for use of green vehicles in public and private transport.<br><br>Reduction in consumption of diesel as consumers shift to cleaner fuels. |
| **National Mission on Sustainable Agriculture (NMSA)** | Agriculture | Improved crop types would lead to lower usage of water and hence reduced pumping demand. | Reduction in consumption of electricity as water usage would be less for improved crops<br><br>Reduction in consumption of diesel as water usage would be less for improved crops |
| **National Innovations on Climate-Resilient Agriculture (NICRA)** | Agriculture | Improved irrigation methods, rain water harvesting and introduction of modern tools | Reduction in consumption of electricity as water usage would be less due to improved water-harvesting mechanisms<br><br>Reduction in consumption of diesel as water usage would be less due to improved water-harvesting mechanisms |
| **Kisan Urja Suraksha Evam Utthaan Mahabhiyan (KUSUM)** | Agriculture | Energy savings due to installations of solar pumps | Reduction in consumption of electricity<br><br>Reduction in consumption of diesel |
| **Perform, Achieve and Trade (PAT)** | Industries | Will result in lower energy consumption and adoption of efficient technologies of production | Reduction in consumption of electricity<br><br>Reduction in consumption of diesel |
| **Zero Effect, Zero Defect (ZED)** | MSME | Will result in lower energy consumption and adoption of efficient technologies of production | Reduction in consumption of electricity<br><br>Reduction in consumption of diesel |
| **Sustainable and** | Industries | Will result in lower energy | Reduction in consumption |

| Policy/Programme | Targeted Sector | Intended Change in End Use | Change in Energy Consumption |
|---|---|---|---|
| **Accelerated Adoption of Efficient Textile Technologies to Help Small Industries (SAATHI) Scheme** | | consumption and adoption of efficient technologies of production | of electricity |
| **Atal Jyoti Yojana (AJAY)** | Municipal | Will result in lower energy consumption as solar LED street lights would be used in public areas, which would have otherwise been lit up using conventional grid-based lighting system | Reduction in consumption of electricity as solar LED lights are used. |
| **Energy Conservation Building Codes (ECBC)** | Commercial | Will result in lower energy consumption as better building designs and construction norms would require lower use of artificial lights and lower heating as well as cooling requirements. | Reduction in consumption of electricity |
| **National Manufacturing Competitiveness Programme (NMCP)** | Industries | The introduction of energy-efficient technologies as well as introduction of quality management standards (QMS) and quality technology tools (QTT) would result in lower consumption of energy in the sector | Reduction in consumption of electricity as better technology is introduced for production and management purposes |
| **Transformation of Aspirational Districts Programme (TADP)** | Domestic | With improvement in basic infrastructure being one of the thematic areas of the programme, the access to electricity for less-developed districts would result in improvement in lighting technology used | Increase in consumption of electricity as more houses and communities are grid connected with basic infrastructure |
| | Industries | Improvement in infrastructure would also provide a push to the local industries in the district, which in turn would lead to more village and local entrepreneurs popping up. | |
| | Agriculture | The programme also focuses on agriculture and water resources, with better water management practices leading to lower pumping demand | |