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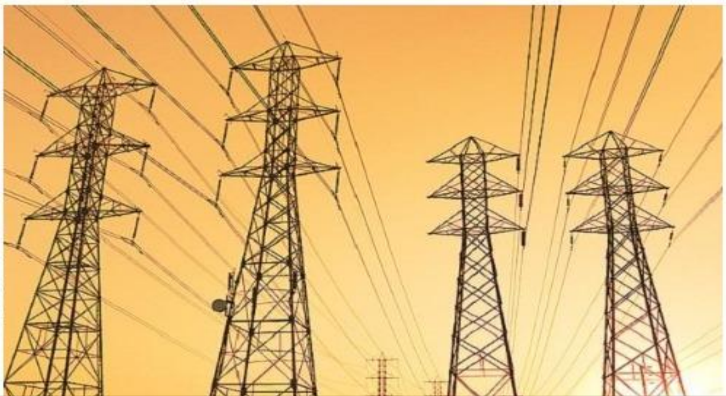
Ministry of Environment, Forest and Climate Change
Government of India

Integrated Research and Action for Development

STUDY TO DEVELOP ROADMAP FOR IMPLEMENTATION OF INDIA's NDC GOAL 3

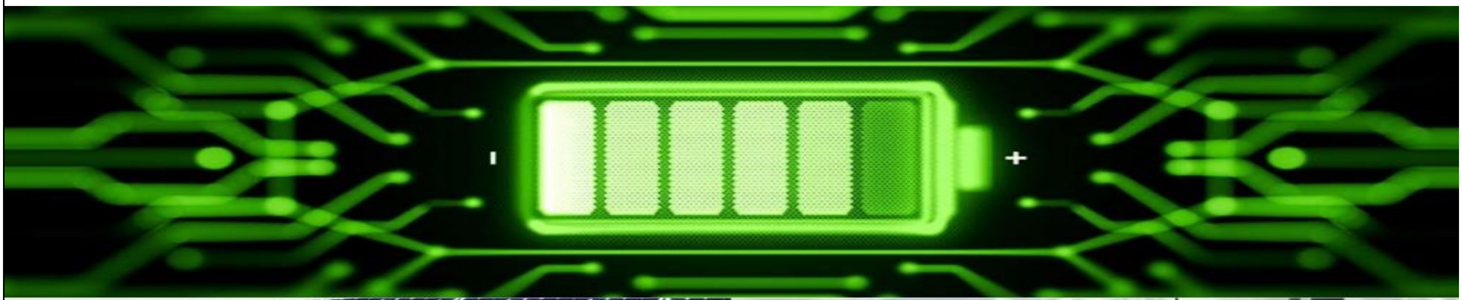


MoEFCC IRADe NDC GOAL 3 REPORT

MARCH 2020

"There is an urgent need to stop subsidizing the fossil fuel industry, dramatically reduce wasted energy, and significantly shift our power supplies from oil, coal, and natural gas to wind, solar, geothermal, and other renewable energy sources."

- Bill McKibben



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Preface

We are pleased to present the report, 'Study to develop roadmap for implementation of India's NDC Goal -3', the study was supported by the Ministry of Environment, Forest and Climate Change (MoEFCC). As per the Paris agreement on climate change, India has committed to reduce Greenhouse Gas (GHG) emissions intensity of its Gross Domestic Product (GDP) by 33–35% of 2005 levels by 2030 (INDC's). Rapid reduction in emissions from the consumption and production of energy will be essential to meet the target NDCs. The journey of transitioning to low-carbon energy systems would necessitate renewable energy sources replacing carbon-intensive sources, alongside improved efficiency in the consumption and production of energy.

The aim of the study is to assess all current policies in each sector of the economy which reduce emissions intensity and outline the sectoral factors that influence NDC Goal 3 of an emissions intensity reduction of 33 percent – 35 percent in 2030 compared to 2005 at the national level and to calculate the additional change in policies, factors and financial cost needed to achieve this.

I am grateful to MoEFCC for supporting this study and extend my gratitude to MoEFCC colleagues who supported our work. I take this opportunity to thank the IRADe team who have worked diligently, enthusiastically, and relentlessly for many months. I hope the findings of this report will be actively considered by the Government of India.

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Abbreviations

ACR	Average Cost of Revenue
AgDSM	Agricultural Demand Side Management
AFR	Alternate Fuel Resources
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ASS	Average Revenue Realization
AT&C	Aggregate Technical and Commercial
BAU	Business as Usual
BEE	Bureau of Energy Efficiency
BLY	Bachat Lamp Yojana
BOT	Build Operate Transfer
BPKM	Billion Passenger Kilometers
BS VI	Bharat Stage VI
BTKM	Billion Tonne Kilometers
BU	Billion Units
BUR	Biennial Update Report
CAFÉ	Corporate Average Fuel Efficiency
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
CFL	Compact Fluorescent Light
CLCSS	Credit Linked Capital Subsidy Scheme
CNG	Compressed Natural Gas
CPP	Captive Power Plants
DC	Designated Consumers
DISCOMs	Distribution Companies
DMICDC	Delhi Mumbai Industrial Corridor Development Corporation
DT	Distribution Transformers
EEFP	Energy Efficiency Financing Platform
EE	Energy Efficiency

EF	Electric Furnace
ERP	Enterprise Resource Planning
EESL	Energy Efficiency Services Limited
Elec_G	Switch to Grid Electricity
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FEEED	Framework for Energy Efficient Economic Development
GEDA	Gujarat Energy Development Agency
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Geographical Information System
GPS	Geographical Positioning System
GSM	Global System for Mobile communication
GVA	Gross Value Added
GW	Giga Watts
GoI	Government of India
Gb_DRI	Gas based Direct Reduce Iron
KWh	Kilo Watt Hour
IBEF	India Brand Equity Foundation
ICT	Information and Communications Technology
IEEFA	Institute for Energy Economics and Financial Analysis
IESS	India Energy Security Scenarios
INCCA	Indian Network on Climate Change Assessment
IPCC	Intergovernmental Panel on Climate Change
IPDS	Integrated Power Development Scheme
ISU	Increased Scrap Utilization
JNNSM	Jawaharlal Nehru National Solar Mission
KUSUM	Kisan Urja Suraksha evam Utthaan Mahabhiyan
LCP	Low Carbon Pathway
LDV	Light Duty Vehicles
LE	Life Extension
LULUCF	Land Use, Land Use Change and Forestry

MEEP	Municipal Energy Efficient Programme
MoEFCC	Ministry of Environment, Forest and Climate Change
MNRE	Ministry of New and Renewable Energy
MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of Road Transport and Highways
MOSPI	Ministry of Statistics and Program Implementation
MT	Million Tonnes
MTEE	Market Transformation for Energy Efficiency
MTOE	Million Tonnes of Oil Equivalent
MTPY	Million Tonnes Per Year
MTPA	Million Tonnes Per Annum
MSME	Micro, Small and Medium Enterprises
MW	Mega Watts
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication
NDC	Nationally Determined Contributions
NECA	National Energy Conservation Awards
NEMMP	National Electric Mobility Mission Plan
NHAI	National Highway Authority of India
NMEEE	National Mission on Enhanced Energy Efficiency
NSGM	National Smart Grid Mission
NUTP	National Urban Transport Policy
OREDA	Odisha Renewable Energy Development Agency
PAT	Perform, Achieve and Trade
PFC	Power Finance Corporation
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PPA	Power Purchase Agreement
PPP	Public Private Partnership
RE	Renewable Energy
REC	Renewable Energy Certificate ROSHANEE Roadmap of Sustainable and Holistic Approach to National Energy Efficiency
RPO	Renewable Purchase Obligations

R&M	Renovation and Modernization
R&D	Research and Development
SG	Smart Grids
SHP	Small Hydro Power
SLNP	Street Lighting National Programme
SME	Small and Medium Enterprise
SEC	Specific Energy Consumption
Switch_GE	Switch to Grid Electricity
SWP	Solar Water Pumps
SNA	State Nodal Agency
SJ	Soura Jalanidhi
SKY	Suryashakti Kisan Yojana
TERI	The Energy and Resources Institute
TWh	Tera Watt Hour
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UJALA	Unnat Jyoti by Affordable LEDs for All
UNNATEE	Unlocking National Energy Efficiency Potential
UDAY	Ujjwal Discom Assurance Yojana
UT	Union Territory
WHR	Waste Heat Recovery
ZED	Zero Effect and Zero Defect

1. Introduction

NDC Goal 3 sets a target of reducing the national emissions intensity by 33%-35% by 2030. The aim of this study is to assess current policies for each sector which reduce emissions intensity. And to outline the sectoral factors that influence emissions intensity and the sector-wise emissions intensity reduction that would be achieved by the current policies in 2030 based on those factors. Given the relationships of the policies with factors that influence emissions intensity reduction, the study calculates the additional changes required in the policies and factors to achieve NDC Goal 3 of emissions intensity reduction at the national level. The study also calculates the financial cost for implementing current policies and for the incremental effort to implement NDC Goal 3.

2. Methodology

National emissions intensity of GDP is the weighted average of sectoral emission intensities, with sectoral shares in GDP as the weights. The shares of sectors in the total GDP changes as the economy grows. This structural change by itself causes a reduction in emissions intensity. Low carbon policies and intervention that are currently in place would also reduce sectoral emissions over time. Thus, emissions intensity of sectors is affected by structural change in the economy and existing policies (business as usual, or BAU, scenario). Achieving the national emissions intensity reduction of 33-35 percent by 2030 would require policies and interventions in major emitting sectors. For our analysis, we concentrate on low carbon policies and interventions in Power, Transport, Cement Industry, Iron & Steel Industry and Agriculture as these sectors contribute most to India's emissions--currently as well as in future. The sectoral Intensity targets depend on the national target and the sectoral shares depend on the contribution to CO2 inventories and the GDP, as shown in equation 1 in Annexure 2.1.

Long-term sectoral growth and sectoral fuel consumption is constrained by inter-sectoral linkages, state of technology and the structural change in demand and output. To assess sectoral contributions required for achieving the national NDC Goal 3 target, we first identify current policies and levers in the major sectors for reducing emissions. This is done through sectoral demand supply models where the sectoral demands are obtained consistently in an input- output framework from IRADe's integrated assessment macroeconomic model. For supply, a spreadsheet-based analysis using various low carbon supply options is considered. The potential of each low carbon policy and intervention in a sector is measured by its contribution to the sector's emissions intensity reduction by 2030 compared to the sectoral target.

The sectoral CO_2 intensity reduction targets are worked out based on equation 1 in Annexure 2.1 assuming the same sectoral shares in GDP and CO_2 in 2005 as in 2007, Table 2.1 shows the emissions intensity reduction projected for each sector in the BAU scenario. To obtain an estimate of sectoral emissions intensity reduction that can be achieved by current policies, we use the BAU scenario from the IRADe integrated assessment model which provides the projections for sectoral share in emissions inventory and the total GDP. The national emissions intensity reduction target of 33 percent is given from NDC Goal 3. The sectoral emissions intensity reductions as calculated using the relation described above (equation 2 in Annexure 2.1) is presented in Table 2.1 below.

The analysis of each sector's demand and supply is presented in subsequent chapters with calculation of the contribution of each policy intervention to reduction in sectoral emissions intensity of GDP. Based on the analysis of the contribution of each sectoral measure to reducing the sector's emission intensity of GDP, we identify the best policies for the sector using a marginal abatement curve for the sector. In the final chapter, all the sectoral policies and levers thus identified is compared together at the national level to arrive at a roadmap of intervention to achieve NDC Goal 3 of 33-35 percent emissions intensity reduction by 2030, compared to 2005. The derivation of the mathematical relationships between sectoral emissions intensity of GDP and national emissions intensity of GDP is provided in annexure 2.1.

Table 2.1: Sectoral Emissions Intensities of GDP

	Emissions Intensity		CO_2 Share		GDP Share		Emissions Intensity Reduction
	2005	2030	2005	2030	2005	2030	2030
Total	0.432	0.272					-37%
Power	14.169	11.878	0.496	0.526	0.015	0.012	-16%
Transport	0.501	0.197	0.084	0.138	0.073	0.191	-61%
Railways	0.074	0.057	0.002	0.003	0.009	0.014	-23%
Roadways	0.644	0.477	0.081	0.120	0.054	0.069	-26%
Agriculture	0.019	0.014	0.008	0.006	0.171	0.129	-30%
Agro-processing	0.177	0.136	0.005	0.003	0.012	0.006	-23%
Textiles	0.269	0.212	0.011	0.004	0.018	0.005	-21%
Fertilizer	10.492	7.166	0.021	0.015	0.001	0.001	-32%
Cement	3.144	2.341	0.029	0.024	0.004	0.003	-26%
Steel	0.745	0.576	0.054	0.043	0.032	0.020	-23%
Manufacturing	0.530	0.416	0.104	0.081	0.085	0.053	-21%
Construction	0.281	0.251	0.058	0.051	0.089	0.055	-11%
Other Services	0.013	0.010	0.013	0.017	0.448	0.470	-21%

The sectoral outputs from the macroeconomic model are used as demand in sectoral models to assess the impacts of sectoral mitigation actions on emissions intensity of GDP and the cost of implementing the measure.

3. Power

3.1 Current Scenario

The total emission from the Indian energy sector in 2014 was 1910 MT CO_2 Eq (MoEFCC, 2018) which contributed 73 percent to the total national GHG emissions (excluding LULUCF) as shown in Table 3.1. The energy sector emitted 92 percent of the total national CO_2 emissions in 2014. This was predominated by fossil fuel combustion activities, comprising energy industries, manufacturing industries, transport and other sectors.

Electricity production alone accounted for approximately 42 percent of the total national emissions without LULUCF in 2014 (MoEFCC, 2018). Within energy, electricity is the predominant source and amounts to about 57 percent of emissions (MoEFCC, 2018). The major fuels consumed in the power plants for electricity production in India are non-coking coal, natural gas (dry), lignite, diesel, residual fuel oil and naphtha.

Table 3.1: National Greenhouse Gas Inventory in 2014

National Greenhouse Gas Inventory in 2014		
Sectors	Million Ton of CO_2 Eq.	Percent Share in Total (excl. LULCF)
Energy	1,910	73%
IPPU	202	8%
Agriculture	417	16%
LULCF	-301	-12%
Waste	78	3%
Total Emissions (Excl. LULCF)	2,607	100%
Net Emissions (Incl. LULCF)	2,306	

Source: India Second Biennial Update Report to the United Nations Framework Convention on Climate Change

Over the years, the power sector has grown manifold. Coal is the major fuel consumed in the power sector as it is one of the cheapest sources of energy. In 2016-17, coal accounted for around 95 percent[1] of the primary fuel consumed (on energy basis) in the Indian power sector (considering utilities only) followed by gas. A comparison of the Indian power sector from 2005 to 2018 with respect to types of installed capacity and power generation is provided in Figure 3.1. Traditionally, coal has always accounted for the highest share--both in generation and installed capacities.

[1] Calculated based on data from CEA General Review 2018, June 2018

Over the years, the government has been pushing for higher RE share in the Indian power generation mix; however, coal still has the highest share among all energy sources for power generation.

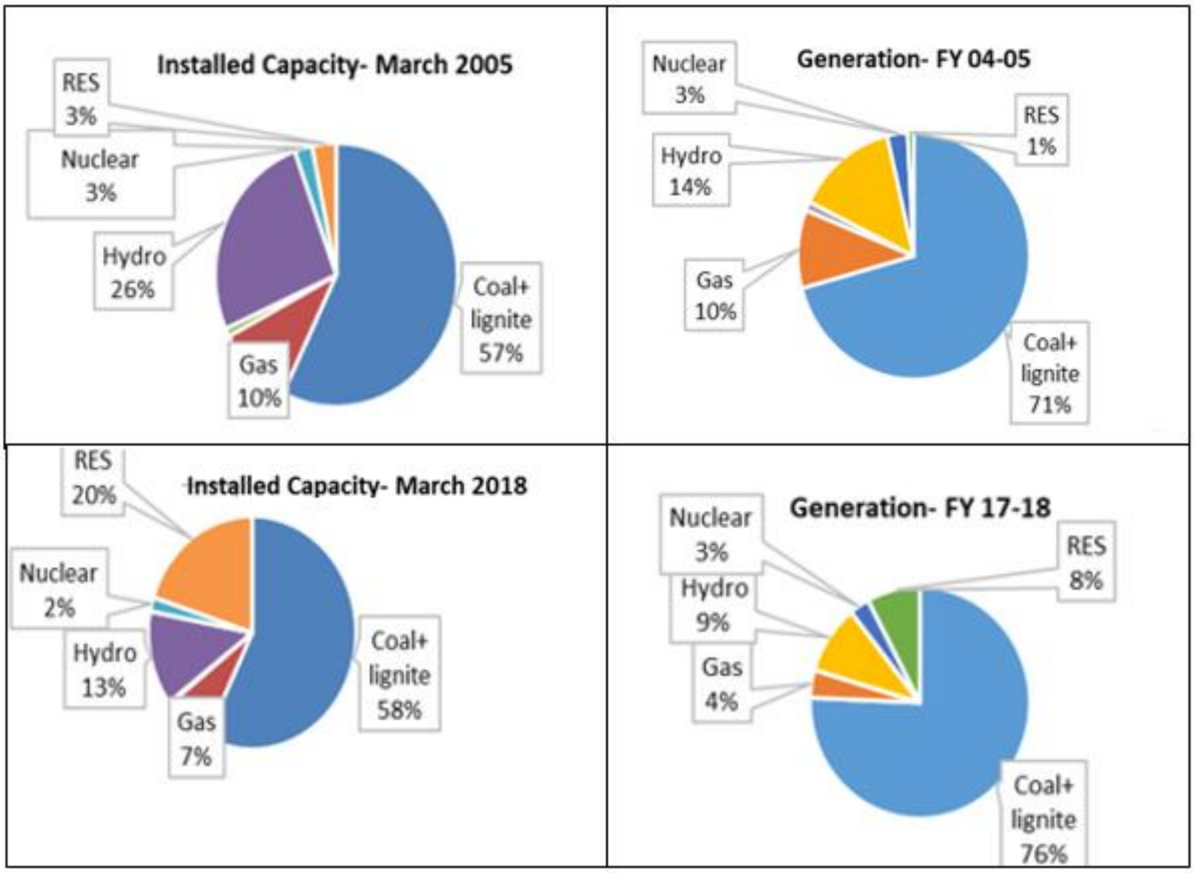

Figure 3.1: Installed Capacity and Generation (Utilities) in 2005 and 2018

3.2 Mapping Existing Program and Policies--Current Status of Implementation and Contribution in Goal 3

The power sector generation, electricity demand and consumption are impacted by various policies. A large number of policies and programs are undertaken by both the Government of India and state governments to regulate the power sector. Since the power sector is the largest emitter of CO_2 in India, the impact of these policies and targets will help in reducing the emissions from India's power sector. This will support India in achieving its NDC Goal 3. A comparative table of key targets and policies in the Indian power sector having an impact on NDC Goal 3 is provided in Table 3.2. A detailed version of the same is also provided in Annexure 3.1.

Table 3.2: Status and Contribution of Power Sector Policies and Targets in NDC Goal 3

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
175 GW Renewable Energy by 2022	MNRE	175 GW RE Capacity by 2022 - 100 GW from Solar - 60 GW from Wind - 10 GW from Bio-power - 5 GW from SHP	No information available	**As on 31 Dec 2018-** Total RE Capacity was 74081 MW (Solar- 25212, Wind- 35138, SHP- 4517, Bio-power- 9214	175 GW RE is expected to generate 326 BU of Electricity. This will result in **saving of 268 MT** CO_2 **/annum.**	Jawaharlal Nehru National Solar Mission
Unnat Jyoti by Affordable LEDs for All (UJALA)	Electricity Distribution Company of participating state and Energy Efficiency Services Limited (EESL)	**Target by March 2019:** - Overall target of replacing 770 million bulbs with LED lights in 3 years - Expected annual energy savings of 105 Billion Units - Expected reduction of peak load by 20,000 MW - Annual estimated GHG emission reductions of 79 MT of CO_2	Estimated capital investment of $ 1.23 billion	**As on 27 Feb 2019:** - Number of LED Distributed 333 million - Energy Saved per year 43 Billion Units - Cost saving of INR 17,309 Cr per year - Avoided Peak Demand of 8,663 MW **- 35 MT of CO_2 reduction per year**	Impact through reduced electricity demand and reduced peak demands thus reducing CO_2 emissions **- 35 MT of CO_2 Reduction per year**	National Mission for Enhanced Energy Efficiency (NMEEE)
PAT Scheme (under NMEEE)	Bureau of Energy Efficiency	**Perform, Achieve and Trade (PAT) Cycle -1 (2012-15):** included 478 industrial units of 8 sectors target of Energy Reduction for PAT Cycle -1 as 6.686 MTOE **PAT Cycle -2 (2016-19):** "Deepening" and "Widening" of PAT with addition of 84 more DCs; three new sectors added Railways, Petroleum Refineries, and Electricity DISCOMs; Energy reduction target of 8.86 MTOE with potential to save 30 MT of CO_2	**PAT Cycle -1 (2012-15):** Capital investment of INR 26100 Crore **PAT Cycle -2 (2016-19):** Expected investment of INR 30,000 Crore	**PAT Cycle -1 (2012-15):** Target overachieved with reduction of 8.67 MTOE **PAT Cycle -2 (2016-19):** Information not available	PAT Cycle -1 (2012-15): **Saved 31 MT CO_2 emissions per year** PAT Cycle -2 (2016-19): Expected saving of 30 MT CO_2	NMEEE
		Power Sector **PAT Cycle -1 (2012-15):** Thermal Power Plant (144 DCs) annual energy consumption of 104.56 MTOE having a target of Energy Reduction for PAT Cycle -1 as 3.211 MTOE **PAT Cycle -2 (2016-19):** Include thermal power plants (154 DCs) and Discoms; target information not available	**Power Sector** **PAT Cycle -1 (2012-15):** Capital investment of INR 32.65 billion	**Power Sector** **PAT Cycle -1 (2012-15):** Target achieved: 3.06 MTOE annual energy reduction thereby reducing emission of **13 MT of CO_2 per year** **PAT Cycle -2 (2016-19):** Data not available	**Power Sector** Increase in energy efficiency of thermal power plants, thereby reducing emissions (reduction of **13 MT of CO_2 in Phase-I**)	

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
Clean Coal Technology: Super Critical Power Plants	CEA	No more sub-critical power plants after 2017	No information available	**As on March 2017:** Super critical power plant capacities installed: 41301 MW (with gross generation of 560 BUs). This resulted in saving **20 MT CO_2 emissions,** compared to sub-critical power plants	**As on March 2017** resulted in saving **20 MT CO_2 emissions,** compared to sub-critical power plants	NMEEE)
Renovation and Modernization of existing thermal power stations	Central Electricity Authority (CEA)	**By 2017-2022:** LE / R&M of 14929 MW (LE of 7570 MW and R&M of 7359 MW). 71 thermal plants, including state and central, will be undertaken for R&M/LE	No information available	**Status as on 30 Sept 2018:** **Period 2002-07:** R&M and LE of 3445 MW **Period 2007-12:** R&M and LE of 16146 MW **Period 2012-17:** R&M and LE of 7202 MW **Period 2017-2022:** R&M and LE of 887 MW (820 MW LE and 67 MW R&M) achieved	Impact by increase in energy efficiency of existing thermal power plants, thereby reducing emissions	NMEEE
Integrated Power Development Scheme (IPDS)	Power Finance Corporation Limited (PFC)	Specific AT&C Loss reduction target for all the participating states; however, no overall target for India	Capital outlay Budget: INR 76623 Cr	**As on 30 June 2018:** Projects worth Rs.30, 005 Cr (Distribution Strengthening work: Rs 27,626 Cr in 546 circles, IT enablement: INR 985 Cr in 1931 towns, ERP INR 640 Cr and Smart Meting: INR 754 Cr) have been sanctioned	Impact through reduction in AT&C losses	NMEEE
National Smart Grid Mission (NSGM)	Ministry of Power	No information available	**Phase- I (2014-2017):** Outlay of INR 980 Cr **Phase- II (2017-2020):** Outlay of INR 990 Cr	**Status as on January 2019:** Out of 11 SG pilot projects 6 projects has been completed/go-live. 5 NSGM Smart grid projects are under various stages of implementation	Impact through reduction in AT&C losses and lowered peak demands	NMEEE

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
Ujwal DISCOM Assurance Yojana (UDAY)	Ministry of Power	1. 100% Feeder Metering by 30 June 2016 2. 100% DT Metering by 30 June 2017 3. Completion of consumer indexing & GIS Mapping by 30 Sept 2018 4. Upgradation of DT, Meters etc. by 31 Dec 2017 5. Smart meter for consumers > 500 Unit by Dec 17; >200 unit by Dec 2019 6. AT&C Losses to be reduced to 15% by FY19 7. Elimination of ACS-ARR gap by FY19	No information available	**Status as on 26 Feb 2019:** 1. Feeder Metering- 100% both Urban and Rural 2. DT Metering- 67% Urban & 62% Rural 3. Consumer indexing & GIS Mapping - No Update available 4. Upgradation of DT, Meters etc. - No Update available 5. Smart meter for consumers > 500 Unit- 4% achieved; >200- only 2% achieved 6. AT&C Losses - 19.94% (for 26 States) 7. ACS-ARR gap- INR 0.31 /Unit (for 26 States)	Impact through operational improvement (reducing AT&C loses), Reduction in cost of power generation, Development of Renewable Energy, Energy efficiency & conservation	NMEEE
Bachat Lamp Yojana (BLY)	Bureau of Energy Efficiency (BEE)	No information available	INR 5 Crore ($ 1.13 million)	**As on March 2015:** 29.1 Million CFLs distributed	Impact through reduction in electricity demand thus reducing CO_2 emissions	NMEEE
Street Light National Programme (SLNP)	EESL	Retrofitting 14 million streetlights by 2019 with energy efficient LED bulbs	No information available	**As on 27 Feb 2019:** - 8.4 Million Street Lights replaced - 5667 Mus of energy saved per year - **Saved 3.9 MT CO_2 emissions per year** - 944.5 MW of peak demand avoided	Reduction in electricity demand thus reducing CO_2 emissions - **Saved 3.9 MT CO_2 emissions per year**	NMEEE
Smart Meter National Programme	EESL	To replace 25 crore conventional meters with smart meters across India	No information available	No information available	Reduction in AT&C Losses	NMEEE

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
Municipal Energy Efficient Programme (MEEP)	EESL	**Target of reducing CO_2 emission by 3.9 MT** and annual savings of approximately INR 3,200 Cr ($ 492 million)	No information available	**Status as on 28 Feb 2019:** - 22 States participated out of 29 & with 3 UT s out of 7 - 390 Cities tied up out of 500	Reduction in Municipal demand resulting in lower emissions	NMEEE
Solar AgDSM	EESL	Replacing an estimated 2.27 crore pump sets used in the agriculture sector with energy efficient pump sets would result in annual energy savings of 46 BU, and GHG **emission reduction of 45 MT of CO_2 annually.**	No information available	No information available	Reduction In electricity demand	NMEEE
Renovation & Modernization, Uprating and Life Extension (RMU&LE) of Hydro power plants	Central Electricity Authority (CEA)	**By 2017-2022:** Capacity covered 9983 MW (including 53 Hydro Electric Power Station with 10 in Central Sector and 43 in State Sector). This will accrue benefit of 5171 MW. **By 2022-2027:** Capacity covered 2518 MW (including 22 Hydro Electric Power Stations with 1 in Central Sector and 21 in State Sector). This will accrue benefit of 2549 MW.	**By 2017-2022:** Capital outlay of INR 6676 Cr **By 2022-2027:** Capital not available	**As on 30 Sept 2018:** R& M of 213 MW completed with cost expenditure of INR 34.06 Cr is completed	Impact by increasing hydro capacity share in generation thereby replacing coal-based generation	

Source: Monthly Report on State-wise installed capacity of Grid Interactive Renewable Power, MNRE; Roadmap of Sustainable and Holistic Approach to National Energy Efficiency, Bureau of Energy Efficiency, April 2019; National Electricity Plan, CEA, January 2018; Ministry of Power; Performance Reports of State Power Utilities 2013-14 to 2015-16, Power Finance Corporation; UJALA Dashboard

Policy/Scheme wise CO_2 saving potential: Based on the available data from Table 3.2, CO_2 saving potential of key policies and schemes is populated in Table 3.3.

Table 3.3: Policy/Scheme wise CO_2 saving potential

Policy/Scheme	CO2 Saving Potential
175 GW RE by 2022	268 MT CO_2/annum
Unnat Jyoti by Affordable LEDs for All (UJALA)	35 MT CO_2/annum
PAT Cycle- I	31 MT CO_2/annum
PAT Cycle- II	30 MT CO_2/annum
Clean Coal Technology: Super Critical Power Plants	20 MT CO_2/annum

Target of 175 GW Renewable: It is evident from Table 3.2 that the government target of 175 GW renewable capacity by 2022 has the highest potential of reducing CO_2 emissions. So, the 175 GW target will be the largest contributor in achieving NDC goal 3 for the power sector. The present status of the 175 GW target is shown in Table 3.4, which indicates an overall achievement of 45 percent of the total target. However, if we see the individual resource wise target achievement, **solar lags in all the resources and has achieved only 29 percent of the target**. Therefore, for achieving the target of 175 GW RE by 2022, the government needs to push more for higher RE installations--particularly solar. Table 3.5 shows an analysis of state-wise solar capacity target achievement. For state-wise renewable target and achievement, refer Annexure 3.2.

Table 3.4: Status of 175 GW RE Target

RE Source	Target by 2022	Status as on 30 April 2019
Solar	100 GW	29 GW
Wind	60 GW	36 GW
Bio-Power	10 GW	10 GW
SHP	5 GW	4.6 GW
Total	175 GW	79 GW

Source: Monthly Report on State-wise installed capacity of Grid Interactive Renewable Power, MNRE

Table 3.5: Analysis of State-wise Solar Capacity Target as on 30 April 2019

Solar Capacity Target Achievement	Number of States & UT	Total Target Capacity (MW)	Total Installed Capacity (MW)
More than 50%	2	11,459	9,567
Between 49%- 30%	6	33,340	10,505
Between 29%-10%	7	21,054	3,206
Less than 10%	More than 19 states	33,681	5,401
Total		99,534	28,679

Source: Monthly Report on State-wise installed capacity of Grid Interactive Renewable Power, MNRE

3.2.1 Incremental Actions for meeting NDC Goal 3

a) Increasing Target of RE installation: The CEA in its recent National Electricity Plan (January 2018) envisages a more ambitious RE target for 2027 with an installed RE capacity of 275 GW. As per the same plan, this increase in capacity from 175 GW RE to 275 GW by 2027 will have an additional budgetary requirement of around INR 4, 95,082 crore for RE generation projects. The fund requirement for RE capacity 175 GW between 2017- 22 will be INR 6, 62,885 crore for generation projects. Hence, the total fund required to reach RE capacity of 275 GW by 2027 will be INR 11, 57,967 crore. **As per the National Electricity Plan, the expected electricity generation from 275 GW RE by 2027 will be 518 BU, resulting in an expected CO_2 savings of 421 MT emissions.** For further analysis, see Annexure 3.3 and Annexure 3.4.

b) Increasing Hydro and Nuclear Installed Capacities: Apart from renewables, both hydro and nuclear-based power plants can help in reducing CO_2 emissions from the power sector. As per CEA's National Electricity Plan, the expected hydro capacity addition is 6823 MW and 12000 MW during the period 2017-22 and 2022-27 respectively. Similarly, the plan provides an expected nuclear capacity addition as 3300 MW and 6800 MW during the period 2017-22 and 2022-27 respectively. The total fund requirement for the above hydro and nuclear capacity addition by 2027 will be INR 3, 39,401 crore, since these capacities will help in avoiding coal-based capacity addition. Hence, both nuclear and hydro capacity addition will account for CO_2 savings of 140 MT per annum by 2027.

c) Increasing the coverage of PAT Scheme: As per the document "Roadmap of Sustainable and Holistic Approach to National Energy Efficiency" of the BEE (April 2019), a PAT scheme will be rolled out and as of now they have envisaged a PAT cycle up to VII. Table 3.6 below shows the PAT cycles and its expected savings.

Table 3.6: PAT Cycles and Expected Savings

PAT Cycle	Number of Designated Consumers	Reduction Target (MTOE)	CO_2 Saving (MT per annum)
PAT- I (2012-15)	478	8.67 (Actual saving)	31
PAT- II (2015-18)	621	8.869	30
PAT- III (2016-19)	116	1.10	3
PAT- IV (2017- 20)	109	0.6998	2
PAT- V (2018- 21)	110	0.5130	Not Available
Total Savings from PAT Cycles		**19.85**	

Source: Roadmap of Sustainable and Holistic Approach to National Energy Efficiency, Bureau of Energy Efficiency, April 2019.

At present, 13 sectors are covered under the PAT scheme and more sectors are likely to be added in the scheme in upcoming cycles, as per those listed in the schedule of the EC Act 2001. Sectors like transport, port trust, sugar and chemicals may be added in the near future. This will further help in increasing the saving from PAT schemes. Apart from these sectors, the large number of Small and Medium Enterprises (SMEs) like foundries, brass, textiles, refractories, brick, ceramics, glass, utensils, rice mills, steel rolling, engineering, dyes and chemicals, brick, and processed foods that operate predominantly in the small scale bracket are said to have a large potential for energy savings.

d) Energy Efficiency Measures: Energy Efficiency is a key element that can contribute toward reducing energy requirements and the associated environmental implications. Energy efficiency has the maximum potential of saving CO_2 emissions. As per the BEE's document "ROSHANEE- Roadmap of Sustainable and Holistic Approach to National Energy Efficiency" and World Energy Outlook 2010, the NMEEE is one of the key missions of NAPCC as energy efficiency has the maximum abatement potential of around 51 percent followed by renewables (32 percent), biofuels (1 percent), nuclear (8 percent), and carbon capture and storage (8 percent).

As per the ROSHANEE Report of BEE, India has the potential of thermal savings of 42.7 MTOE and electrical energy savings of 558 BU (around 48 MTOE) by 2030-31. The contribution toward thermal savings are mainly from two programs, i.e., Perform, Achieve and Trade (PAT) scheme and vehicle fuel efficiency program (heavy duty vehicles) as shown in Table 3.7.

Table 3.7: Program-wise Projected Thermal Savings

Programs/ Activities	Thermal Savings (MTOE)	
	2017-18	2030-31
Industries (Thermal savings in PAT)	13.02	42.07
Heavy duty vehicles	0.16	0.64
Total	13.19	42.71

Source: ROSHANEE- Roadmap of Sustainable and Holistic Approach to National Energy Efficiency, BEE, April 2019

The total electrical savings from various schemes and policies will be around 558 BU as shown in Table 3.8. It is to be noted from the table that the maximum saving is projected from the Standards and Labelling program for appliances, followed by the LED Ujala scheme. The CO_2 mitigation from the thermal and electrical energy savings potential of activities under the mission is projected to be 557 MT by 2030-31. As per the BEE's Unlocking National Energy Efficiency Potential (UNNATEE) document (February 2019), the expected investment requirements for energy efficiency measures by 2030-31 will be INR 840,852 crore.

Table 3.8: Program-wise Projected Electrical Savings from Energy Efficiency Measures

Programs/ Activities	Electrical Savings in BU	
	2017-18	2030-31
Standards and Labeling program for appliances	54.53	242.73
LED Ujala	28.05	132.12
DISCOMs (PAT Scheme)	0.00	76.69
Energy Efficiency in Buildings	1.56	15.55
LED Street Lighting National Program (SLNP)	0.71	12.67
National Energy Conservation Awards (NECA)	1.45	2.73
Industries (PAT Scheme- Electrical savings)	0.29	0.78
Total Savings at Consumer End	86.59	483.27
T&D Losses (Factor)	1.25	1.15
Total Savings at Generation End	108.05	557.85

Source: ROSHANEE- Roadmap of Sustainable and Holistic Approach to National Energy Efficiency, BEE, April 2019

3.2.2 Financial Resource Requirements

The financial resource requirements for non-fossil and energy efficiency schemes are provided in Table 3.9 based on various government organization estimates. Figure 3.2 provides the marginal abatement cost of non-fossil and energy efficiency policies. With these estimated financial numbers and the expected CO_2 savings, energy efficiency measures are more cost-effective in reducing emissions.

Table 3.9: Financial Resource Requirements for Non-Fossil and Energy Efficiency

Scheme/Policy	Financial Requirement (INR Crore)	Expected CO_2 saving (MT per annum)
18 GW Hydro Capacity Addition by 2027	2,04,361	67
10 GW of Nuclear Capacity Addition by 2027	1,35,040	72
275 GW RE by 2027 from 2017- 2027	11,57,967	421
Energy Efficiency Measures from 2017-31	8,40,852	557

Source: IRADe Analysis

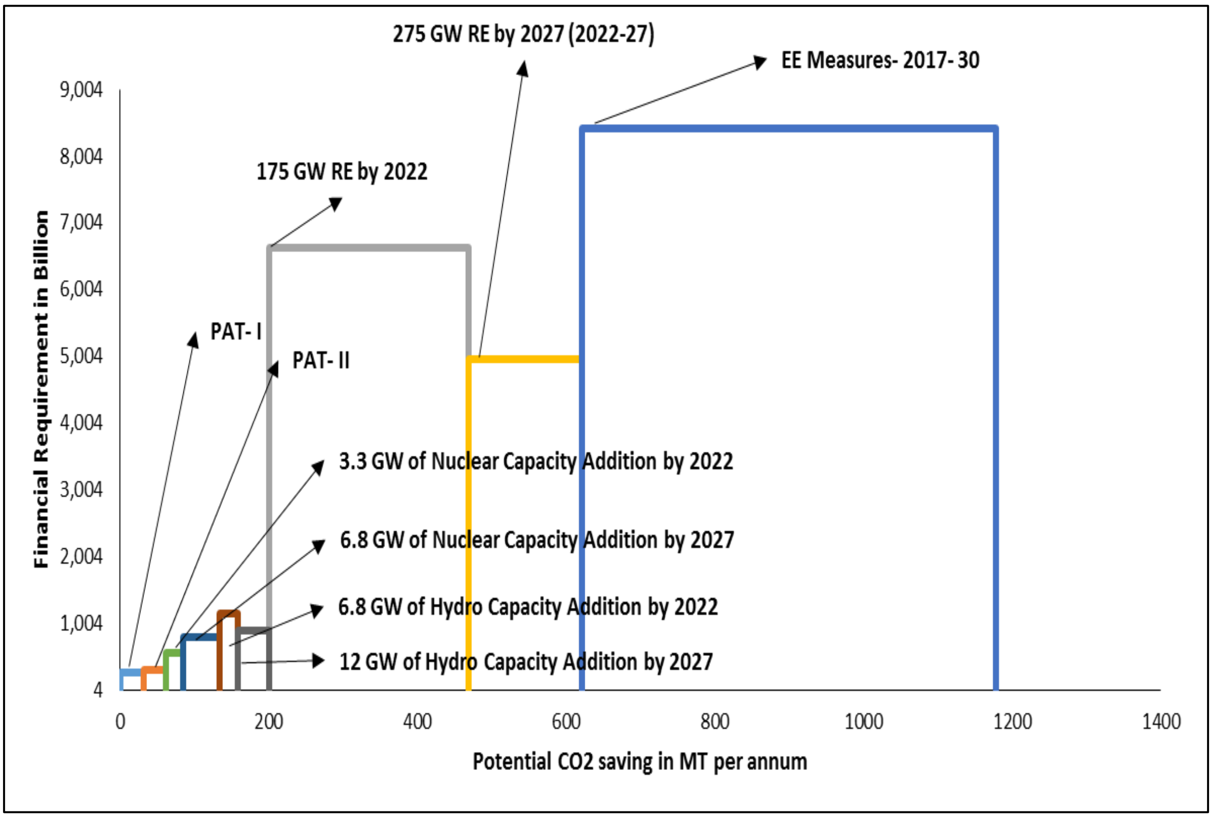

Figure 3.2: Marginal Abatement Cost for Non-Fossil and Energy Efficiency
Source: IRADe Analysis

3.2.3 Emission Intensity Reduction Potential from Non-Fossil and Energy Efficiency Policies

For estimation of emission intensity reduction from non-fossil and energy efficiency policies, we have assumed the GDP growth of 7 percent on 2004-05 levels to calculate the GDP in 2030 at 2004-05 prices. Table 3.10 shows the emission intensity reduction potential of each policy.

Table 3.10: Emission Intensity Reduction Potential from RE and Energy Efficiency Policies

Policy/Scheme	Duration	CO_2 Savings (MT per annum)	Additional Emission Intensity reduction (CO_2 saved/GDP 2030 at 2004-05 prices) in INR/Kg
175 GW RE by 2022	2017-22	268	0.0017
275 GW RE by 2027 (2022-27)	2022- 27	153	0.0009
PAT- I	2012-15	31	0.0002
PAT- II	2015-18	30	0.0002
18 GW Hydro Capacity Addition by 2027	2017-27	67	0.0004
10 GW of Nuclear Capacity Addition by 2027	2017-27	73	0.0005
EE Measures- 2017- 30	2017-30	557	0.0035

Source: IRADe Analysis

3.3 Factors Influencing Goal 3

- **Achieving Renewable Capacity Addition:** Installation of RE capacities will deeply influence the achievement of India's NDC goal 3 as it has the highest potential among all the other policies and initiatives of the Government of India. RE addition of 175 GW by 2022 alone can help India in reducing its power sector emission intensity by almost 24 percent by 2030--compared to 2005 emissions (CO_2/Kwh)--and if the target of 275 GW RE by 2027 is achieved, than India can achieve emission reduction of 27 percent. **Therefore, capacity addition in the renewable segment is essential for meeting INDC Goal 3.**

- **Energy Efficiency at Generation and Demand side:** Energy efficiency in the form of power plant operations and distribution companies' loss reduction activities will help in reducing the energy input per unit output. For instance, the UJALA scheme, launched in January 2015, aims to save 105 BU of electricity by replacing 770 million bulbs by March 2019. However, until now, around 40 percent of the target has been achieved, which has resulted in an electricity demand reduction of around 3 percent[2]. Further, as per the ROSHANEE document of BEE, energy efficiency measures have the potential to save 558 BU of electrical energy by 2030, which is a significant number considering the current demand of electricity which is around 1337 BU.

3.4 Challenges and Opportunities for Goal 3

Challenges:

- **Implementation of Policies at State Level:** In Indian polity, many decisions lie solely with the state, some jointly with the Centre while some are exclusively the Centre's. Therefore, several policy objectives of the central government require state specific actions. Experience has shown that not all states are able to attain the goals set by the central government due to various reasons, such as a state's capacity and financial resources.

- **Increasing RE Penetration at State Level:** The RE sector is facing multiple challenges such as non-availability of land, transmission constraints, PPA signing, non-payment of charges by Discoms etc. While analyzing the 175 GW RE target at the all-India level, the target achievement for solar was 29 percent, wind 60 percent, Bio Power 99 percent and SHP 92 percent as on 30 April 2019[3]. Therefore, both solar and wind capacity installations at the state level need to be pushed. As on 30 April 2019, only two states, Rajasthan and Karnataka, have achieved 100 percent and 60 percent of their solar targets respectively. The rest of the states have achieved less than 50 percent of the targets. For details, refer Annexure 4.3.

- **Power Procurement Strategies:** Many Discoms have long term PPA's with thermal power plants that involve payment of both fixed charges and energy charges. Therefore, if Discoms buy renewable power, they must back down their share from thermal power plants while still paying for fixed charges. This causes an increased financial burden for Discoms in acquiring renewable power aggressively[4].

- **Grid Integration:** With increase in RE capacities, flexible generation resources such as hydro, gas or coal plants capable of ramping operation will be required, especially at the state level for integrating intermittent RE capacities. Apart from within the state, this will also require planning and operation of interstate transmission interconnections among states.

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[2] Considering electricity demand of 1337 BU for 2018-19 from CEA's Load Generation Balance Report 2018-19
[3] MNRE Monthly Report on State-wise installed capacity of Grid Interactive Renewable Power
[4] https://mercomindia.com/solar-wind-procurement-mess-india/

- **Financing:** Financing of RE projects is not much of challenge as the projects are backed by legally binding power purchase agreements. However, financing continues to be the grey area in energy efficiency due to the high risk, longer investment period, low awareness and lack of capacity in the financial institutions to understand energy efficiency financing concepts.
- **Capacity Building and Awareness of End Users:** Implementation of policies like UJALA and demand side management etc. will require a behavioral change among the masses. However, standard labeling has motivated consumers to buy energy efficient appliances on their own (Parikh and Parikh, 2016).

Opportunities:

- **Creating Market for RE through Strict Implementation of RPOs:** Effective implementation of Renewable Purchase obligations (RPOs) on the obligated entities such as power distribution companies, captive power plants (CPPs) and other large electricity consumers will help in creating higher demand for renewables. This will help in achieving the 175 GW RE target faster. For instance, as on May 2019, 19 lakh[5] renewable energy certificates (RECs) are unsold. Although the volumes of unsold RECs are decreasing, it could be further reduced with strict compliance of RPOs.

- **Storage based Renewable:** Since a renewable such as solar is not available in the evening peak hours, adding storage capacities will increase its availability and flexibility for DISCOMs. Although the high cost of storage is a hindrance in adopting storage-based renewables, still, soon, they might become viable with decreasing costs of solar photovoltaic (PV) and storage batteries (Parikh, Parikh and Ghosh, 2018) globally.

- **Incentive Compatible Policy Design:** There is a need to design policies that are incentive compatible in the sense that the concerns and issues of different stakeholders are accounted for. Both the Centre and state governments must take measures that provide incentives to stakeholders to behave in the way the state desires for achieving the required objectives.

- **Establishing India as a global leader:** With its huge potential of RE and energy efficiency, India can develop its domestic market to drive the change in global markets. For instance, many countries are closely observing the success of India's PAT-I program for developing similar programs of their own.

[5] https://recregistryindia.nic.in/

3.5 Recommendations

- **Policy:** The effective implementation of energy efficiency measures will require amendment of the Energy Conservation Act 2001 in such a way that it brings more sectors and areas of energy efficiency under the Act. For higher penetration of RE, amendment of the Electricity Act 2003 is required for the country's changing electricity markets and systems, with increasing renewable capacities and the emergence of a smart grid network.

- **Technology:** Accelerated development of renewables requires adequate indigenous manufacturing facility for renewables-related equipment. A policy framework should be developed to encourage setting up of renewables-related equipment manufacturing facilities in the country. This would be consistent with the Government of India's "Make in India" policy. Similarly, for energy efficiency, the government needs to promote public/private partnerships, incubators and accelerators and basic R&D on energy efficient technologies. India should also leverage ICT tools for bringing in energy efficiency.

- **Capacity Building:** Institutional strengthening is particularly required at the state level for both RE implementation and energy efficiency. For energy efficiency, strengthening of state level designated agencies is critical in implanting national targets at the state level. Cooperation with international bodies should also be explored.

- **Financial Requirements:** A total of INR 23943 billion is expected to be required for implementing the non-fossil energy use and energy efficiency program.

- **Monitoring and Evaluation:** Implementation of national policies and targets at the state level needs to be monitored, and periodic course corrections should be undertaken. For instance, many of the states are lagging in achieving their respective targets for solar capacity addition by 2022.

Other Recommendations:

- **PAT Scheme:** Coverage of PAT scheme needs to be increased. At present, it covers only 13 sectors. Sectors such as transport, ports, sugar, chemicals and SME's can be added to contribute more in energy efficiency and CO_2 emission reduction.

- **Increasing RE Share:** For increasing RE share, compliance of RPO mechanism can be used as an effective tool to promote the REC market and renewables. Further, states that are lacking in meeting their RE targets need to be pushed to meet RE installation targets.

- **Payment Security Mechanism for RE generators:** The payment security mechanism needs to be strengthened for power producers in India as many DISCOMs fail to make payments on time. Further, this gives a negative signal to future investors and it increases price discovered through bidding for upcoming capacities due to the increased risk on investment.

- **Grid Integration:** For higher RE penetration, grid integration of renewables will be a major challenge, particularly for solar and wind. This needs more planning and coordination among state and central authorities such as state and central transmission utilities.

- **Hydro Power Plants:** Construction of hydro power plants as per schedule needs to be examined closely as the hydro sector is underperforming due to challenges such as environment clearance, resettlements issues, land acquisition issues and cost overruns.

- **UJALA Scheme:** The potential of schemes like UJALA reduces over the years as the energy efficiency in the focused sector increases. Therefore, the scope and coverage of the UJALA Scheme can be further increased to other energy intensive appliances such as air conditioners, ceiling fans and water heaters.

- **Shift to Low Carbon Technologies:** Shifting to clean coal technologies such as ultra-supercritical and advanced ultra-supercritical is also an option for India as coal-based power generation is expected to provide a significant share in the overall generation and capacity mix for quite some time.

4. Transport

4.1 Current Scenario

The transport sector is an important infrastructure sector for a developing country like India as it provides people with mobility for earning a livelihood and helps economic growth. The transport sector services are facilitated through the intensive road and rail network spread across the whole country. Compared to rail, road transport is a more dominant mode of transport in India, both in terms of its share in passenger and freight; and in terms of contribution to the national economy (road transport contributes around 5 percent of GDP (MoPNG, 2014)). Road transport carries about 90 percent of the total passenger traffic and 67 percent freight traffic (MoRTH, 2018b). The stock of road length in India was reported at 56.03 lakh km as on 31 March 2016, out of which 62 percent were surfaced roads. The per passenger kilometer or per tonne kilometer fuel consumption from road vehicles is higher and more expensive than railways. Comparatively, the resources that are consumed in transportation in India are much larger compared to developed--or even some other developing--countries and this is due to inadequate or insufficient physical infrastructure facilities, the lack of smooth interconnectivity, and excessive idling time at traffic signals. This makes for higher costs of doing business, reduces energy security and highlights an area where, with the right interventions, considerable efficiency gains can be achieved.

India had seen an exponential growth in vehicle ownership in the last decade. The number of registered vehicles in India as on 31 March 2016 was 230 million (road transport statistics, 2016). During the period 2010-16, the annual growth rate of registered vehicles outpaced the rate of increase in road length by a huge margin (MOSPI, 2016). And the growth was primarily in private and commercial vehicles, which increased congestion and pollution in urban areas (metropolitan cities). India is the fourth largest vehicle manufacturer and is expected to show strong growth in vehicle production till 2020 across all segments. Such a huge stock of vehicles would require a huge quantity of fuel. India imports around 70 percent of its crude oil. To reduce the fuel requirements of its large stock of vehicles, the fuel specification and emission standards adopted are predominantly from the European models. During 2005-15, the energy consumption in the transport sector increased at a CAGR of 8.3 percent and, in 2017-18, it became the second-largest energy consuming sector in India, accounting for around 24 percent of the country’s total energy consumption (TERI, 2018). The total GHG emissions from this consumption of fuel increased by 22 percent from the 2007 levels (MoEFCC, 2015) and contributed around 10 percent to the total national emissions. The overall energy consumption in the transport sector is driven by both passenger and freight movement. There is a significant increase in passenger and freight traffic during the period 2007 to 2015. Figure 4.1 shows the passenger and freight movement in the road transport sector.

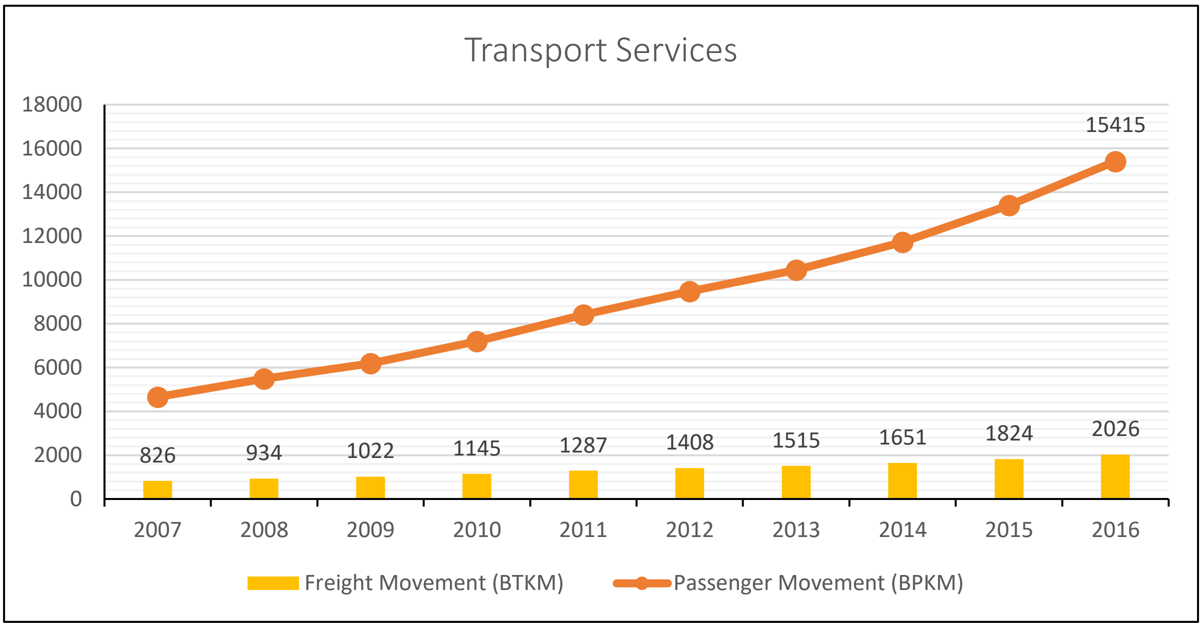


Figure 4.1: Transport Services

During this period, the passenger kilometers grew at a CAGR of 14.2 percent and freight kilometers grew at a CAGR of 10.5 percent (MoRTH, 2018a). Complementary to this, the energy consumption (petrol and diesel) in the transport sector also increased. Figure 4.2 shows the fuel consumption in the road transport sector. During 2007-15, petrol consumption in the transport sector increased at a rate of 9.4 percent and diesel at 6.2 percent.

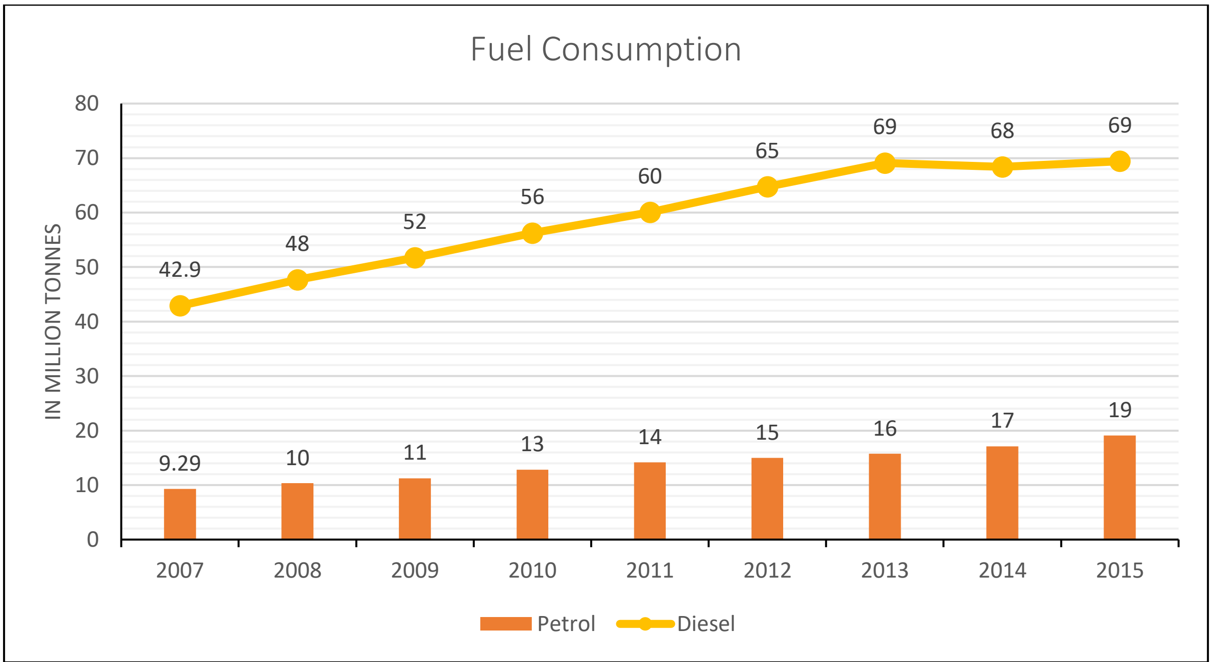


Figure 4.2: Fuel Consumption

4.2 Mapping Existing Program and Policies: Current Status of Implementation and Contribution to Goal 3

To improve the efficiency of the Indian transport sector, the Government of India has formulated or implemented various policies for road and rail network under the national mission for sustainable development. Most of the policies indicate qualitative improvement and some of them define quantifiable targets. For this study, we have listed all the policies that are useful to achieve the NDC Goal 3 and developed scenarios according to them. Broadly, the scenarios are grouped under improving the public transport system, energy efficiency of vehicles and introducing green and alternate fuel vehicles. A list of Government of India policies in the road transport sector and railways is provided in the section below and a comparative table of key policy targets for the Indian transport sector (having implication on NDC Goal 3) is provided in Table 4.1 below.

4.2.1 Road Network

4.2.1.1 Shift to Public Transport, Infrastructure Development, Sustainable & Shared Mobility

- **Strengthening of Public Transport System:** The ministry will provide financial assistance to states for strengthening the public transport system by GPS, GSM, electronic ticket etc.
- **Development of Bus Terminal and Multi-Modal Transit System:** The project focuses on development of large bus terminals in states/ UTs under PPP on BOT basis.
- Security of women in public transport system: Installation of vehicle location device and one or more panic buttons.
- **AMRUT:** The mission focuses on pedestrian, non-motorized and public transport facilities, parking spaces etc.
- **Smart City Mission:** The mission focuses on smart solutions for efficient urban mobility and public transport.
- **Taxi Policy:** The focus of the policy is to have safe, secure and affordable taxi service.
- **Sugamya Bharat Abhiyan (Accessible India Campaign):** To make 10 percent of govt.-owned public transport fully accessible to persons with disabilities.
- **Model Automated Centers for Checking Fitness of Vehicles:** Inspection and certification centers for testing fitness of commercial vehicles through an automated system.
- **National Transport Policy:** To conduct road transport with faster integration of the economy, the National Transport Policy is initiated.

- **Inter-state Connectivity Scheme:** To develop state roads and roads of economic importance and inter-state connectivity as per the provisions of the Central Road Fund Act, 2000 amended by the Finance Act.

4.2.1.2 Electrification

- **National Electric Mobility Mission Plan 2020:** To promote of hybrid and electric mobility in India through a combination of policies, ensuring a vehicle population of about 6-7 million electric/hybrid vehicles in India by 2020.

- **The FAME India Scheme:** It focuses on four areas--technology development, demand creation, pilot projects and charging infrastructure for hybrid and EVs.

4.2.1.3 Green Transport and Standards

- **National Mission on Sustainable Habitat:** Promotes sustainable mobility options such as walking and cycling and supports the development of transport infrastructure for green mobility.

- **Green Urban Transport Scheme:** The scheme focuses on taking strict actions on polluting public transport system and replacing conventional vehicles with eco-friendly vehicles.

- **Service Level Benchmarks for Urban Transport:** The benchmarks provide the standards to assess the sustainability and quality of public transport.

- **Indian Emission Standards:** Vehicular emissions standards as per the Bharat Stages.

4.2.1.4 Vehicle Fuel Efficiency Programme

- **India Auto Fuel Policy:** The policy recommends a roadmap for auto fuel quality till 2025 for emission reduction of vehicles, growth of vehicles and supply and availability of fuels. It also recommends a suitable mix of auto fuels, including gas and its specifications.

- **National Auto Policy:** The plan envisions that by 2026, India will be among the top three countries in the world in engineering, manufacturing and export of vehicles and auto components.

4.2.2 Rail Network

4.2.2.1 Infrastructure Upgradation

- Increase throughput on existing network: Increase throughput by 10 percent by an integrated approach across two or three critical corridors.
- Build terminal infrastructure: Expand capacity and scope of terminal services by partnering with existing government agencies (e.g., DMICDC, state governments, NHAI) to build multi-commodity, multi-modal freight logistics parks.
- Deliver high-speed network: Develop semi high-speed corridors by raising maximum permissible speed to 150-200 kmph for mail/express trains by 2019.
- High speed passenger trains.

4.2.2.2 Sustainability

- **Alternate Sources of Energy:** Commission 1000 MW of solar energy over five years and commission 130 MW of wind energy.

- **Sustainable Development:** Install LEDs to reduce electricity consumption and cover all railway stations with LED lights.

Table 4.1: Policies and Schemes

Policy/Scheme	Target	Timeline	Lever to INDC G3
National Auto Fuel Vision and Policy 2025	Fuel Efficiency: 21 kmph and to be annualized with 3%	By 2022	Reducing fuel consumption and Improving fuel efficiency
	Fuel standards: BS VI	By 2020	Improving fuel quality and reducing emissions
National Electric Mobility Mission Plan	6-7 Million EV on road	By 2020	Reducing fuel consumption
	100% EV nation	By 2030	Reducing fuel consumption
AMRUT	-	-	Shift to public and non-motorized transport
Smart Cities Mission	-	-	Shift to public and non-motorized transport
	-	-	Reduce average commute time
National Urban Transport Policy	-	-	Promotion of public transport and modern technologies for adoption
Taxi Policy	-	-	Promote shared mobility options
National Mission on Sustainable habitat	-	-	Shift to public and non-motorized transport
	-	-	Improve fuel efficiency in vehicles
	-	-	Shift to alternate fuels

Policy/Scheme	Target	Timeline	Lever to INDC G3
National Auto Policy	Defining new emission standards for BS VI	By 2028	Stringent norms for emissions
	Green vehicles: 25% of all vehicles procured by central and state government	By 2023	Promotion of green vehicles
	Green vehicles: 75% of all vehicles procured by central and state government	By 2030	
	Green vehicles: 50% of all vehicles procured by municipal corporations in metros	By 2023	
	Green vehicles: 100% of all vehicles procured by municipal corporations in metros	By 2030	
National Policy on Biofuels	Ethanol blending: 20% in petrol and 5% in diesel	By 2030	Reducing consumption of fossil fuels

4.3 Methodology

In this study, IRADe's macroeconomic model is used to project the mode wise transport demand and estimate the emissions intensity reduction in the transport sector that will be achieved by 2030 based on current policies. This is compared to the overall NDC of emission intensity reduction target of 33-35 percent by 2030. The projected demands are used as inputs into a spreadsheet based-accounting model for the transport sector which has been used to calculate the likely energy and emission implications of various mitigation strategies in the sector. The model assesses annual emissions of CO_2 from India's vehicle fleet. It considers all on-road vehicles, which is calculated by using survival rates on mode wise and technology wise annual sales of vehicles. The model also assesses the annual cost of infrastructure and vehicle stock. The annual sales are calculated from newly registered vehicles. Transport services, fuel consumption and emissions are determined using national average assumptions on on-road vehicles. For railways, passenger and freight services are used for calculation of fuel consumption and emissions.

4.3.1 Assumptions

In the model, the annual vehicle kilometers, occupancy/load factors, fuel efficiency, age and survival rates have been considered from the India Energy Security Scenario (IESS 2047) version 2.1. The Indian transport system is divided into road and rail transport sectors.

Road Transport: The model uses all modes of vehicles that ply on Indian roads. The road transport is divided into passenger and freight movement. Vehicles like two-wheelers, three-wheelers, cars, jeeps and buses are considered in the passenger sector. Light commercial vehicles (LCVs), medium commercial vehicles (MCVs) and heavy commercial vehicles (HCVs) are considered in the freight transport sector. Further, passenger traffic is divided into public and private transport movements. Segregation within the transport system is considered for proper implementation of individual policies and programs undertaken by the Government of India.

Rail Transport: The model considers both passenger and freight kilometers in the railways services. The services are improved by increasing the efficiency and share in electrification of railways in passenger and freight sections.

Further, the detailed model assumptions are provided in Annexure 4.1.

Scenarios: For the analysis, we have considered the following scenarios:

- **Baseline**: Under this scenario, no policy interventions and technological improvements are undertaken after 2012. The transport sector continues to run on the fuel standards that were released India-wide since 2012. The same fuel mix of on-road vehicles (ratio of petrol and diesel vehicles) continues till 2030. The passenger segment continues to use private vehicles and the share of public vehicles decreased as per the past trend. Also, no introduction of alternate fuel vehicles is considered in this scenario.

- **Electrification**: As per NEMMP and FAME, electric variants for each mode in the passenger segment are introduced. As there are no definite plans for freight and heavy-duty electric vehicles yet, no electrification is done in that segment. Table 4.3 shows the share of electric variants in the sales of each mode of passenger vehicle till 2030. For railways, the current 30 percent electrification scenario is considered.

  Table 4.2: Share of Electric Vehicle in Total Vehicle Sales

Year	Two- Wheelers	Three- Wheelers	Cars & Jeeps	Taxis	Buses
2030	30%	50%	3%	3%	10%

- **Modal Shift**: To increase the use of public transport, we have constructed this scenario for the movement of passenger and freight towards publicly utilized modes of transport, i.e., railways, buses, taxis and auto-rickshaws. This helps in supporting many government policies like AMRUT and NUTP (explained in Table 4.1). Public vehicles offer shared transportation at a cheaper rate and cause less pollution compared to private vehicles on a per passenger basis.

To quantify the efficiency of each policy, this scenario is divided into two parts:

- Modal shift from road to rail: Shift of passenger and freight traffic from road transport to rail transport.
- Modal shift from private to public: Shift of passenger traffic from private to public within the road transport sector.

In both scenarios, only 10 percent increase is considered till 2030 and the scenarios were run separately. This will help us to analyze the actual effect and contribution of each strategy toward NDC Goal 3.

- **Fuel Efficiency Standards Improvements**: Each mode uses a specific type of auto fuel. Two-wheelers run only on gasoline, while private cars mostly use gasoline, with some also using diesel. Three-wheelers and cars operating as commercial vehicles run on gasoline, diesel and CNG. Many private cars have switched to CNG as it has better efficiency than gasoline and diesel. Public/commercial transport such as buses, trucks and other light, medium and heavy-duty vehicles run mainly on diesel. Although CNG and LPG have been in use in India as alternative auto fuels for more than a decade, their share is low. T Table 4.3 shows the fuel technology considered for each segment of vehicles.

Table 4.3: Technology variant considered for different modes

Modes	Technology				
Two-wheelers	Petrol		Electric		
Three-wheelers	Petrol	Diesel	CNG	LPG	Electric
Cars & Jeeps	Petrol	Diesel	CNG	LPG	Electric
Taxis	Diesel	CNG		LPG	Electric
Buses	Diesel			CNG	Electric
Goods Vehicles	Diesel				CNG

The fuel efficiency of each mode is considered as per IESS 2047 V2.0. Table 4.4 shows the national average mileage of each mode of vehicle considered in the model.

Table 4.4: Fuel Efficiency (Mileage) considered for different modes

Fuel	Modes	2000	2005	2010
Gasoline (Kms/Ltr)	Cars & Jeeps	11	12	12
	Two-Wheelers	47	47	48
	Three-Wheelers	35	35	35

Fuel	Modes	2000	2005	2010
Diesel (Kms/Ltr)	Cars & Jeeps	9	10	10
	Three-Wheelers	28	28	28
	Taxis	10	10	10
	Buses	5	5	5
	Goods Vehicles	7	6	6
CNG (Kms/Ltr)	Cars & Jeeps	11	11	12
	Three-Wheelers	35	35	35
	Taxis	12	12	12
	Buses	4	4	4
LPG (Kms/Ltr)	Cars & Jeeps	11	12	12
	Three-Wheelers	30	30	30
	Taxis	12	12	12

In line with the auto fuel policy starting from 2005, the efficiency is improved till 2012 and kept constant till 2030 in the baseline scenario. But in this efficiency improvement scenario, one percent improvement is provided for till 2030.

- **Integrated**: This scenario is an aggregation of all the above-mentioned strategies. To analyze the combined effect of all the policies in the transport sector till 2030, we have considered this scenario. This scenario will also help to identify the maximum limit of reduction that India can achieve in the transport sector, if all policies follow their own time and take effect simultaneously.

4.4 Results and Discussion

The BAU scenario using the macroeconomic model, as explained in Chapter 1, estimates the emission intensity reduction achieved by 2030 for the transport sector--based on current policies--is 61 percent (Table 4.5 below). As shown in Chapter 1, in the BAU scenario itself, a 37 percent national emission intensity reduction is achieved, which is way more than the NDC target. We use the spreadsheet-based transport model as explained in the previous section and the road transport demand from BAU as inputs to assess the emission reduction potential for various policies in the road transport sector. The output of this transport model is energy consumption and CO_2 emissions. The results of the five policy scenarios run for the transport sector are discussed below.

Table 4.5: Reduction Achieved in the Transport sector

Sector	Reduction Achieved by 2030 (percent)
• Transport	61%
○ Railways	23%
○ Roadways	26%

4.4.1 Baseline Transport Services Demand

Passenger services (BPKM) and freight services (BTKM) in the road transport sector increases at a CAGR growth of 5.94 percent and 5.15 percent from 2010 to 2030. While in the railways, passenger and freight demand grew at CAGR of 6.55 and 5.48 percent from 2010 to 2030. Road transport maintains a dominating share over the railways in both passenger and freight segments. Figure 4.3 below shows the passenger and freight transport services from the road and railways sectors.

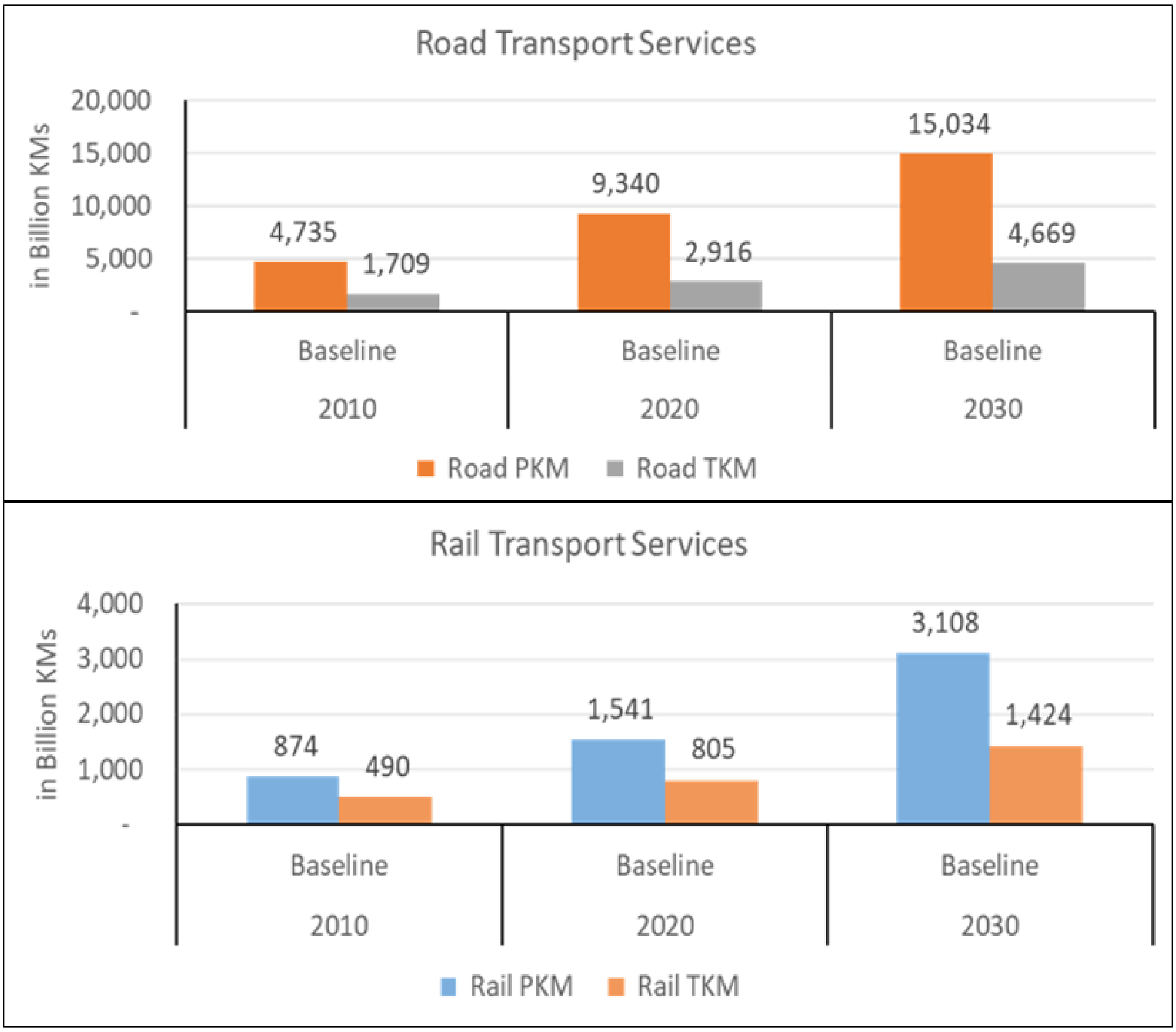


Figure 4.3: Decadal Transport Services

Figure 4.4 and 4.5 shows the mode wise contribution to passenger and freight services in the road transport sector. As can be seen in passenger services, the major share is held by bus services. The share of bus services decreases from 77 percent in 2010 to 70 percent in 2030. Whereas the share of private cars increases from 8 percent in 2010 to 12 percent in 2030 and the share of two-wheelers increases from 11 percent in 2010 to 14 percent in 2030. In freight transport, medium and heavy commercial vehicles have the major share of around 90 percent in 2010. The share of medium commercial vehicles decreases from 42 percent in 2010 to 39 percent in 2030 and the share of heavy commercial vehicles decreases from 47 percent in 2010 to 44 percent in 2030.

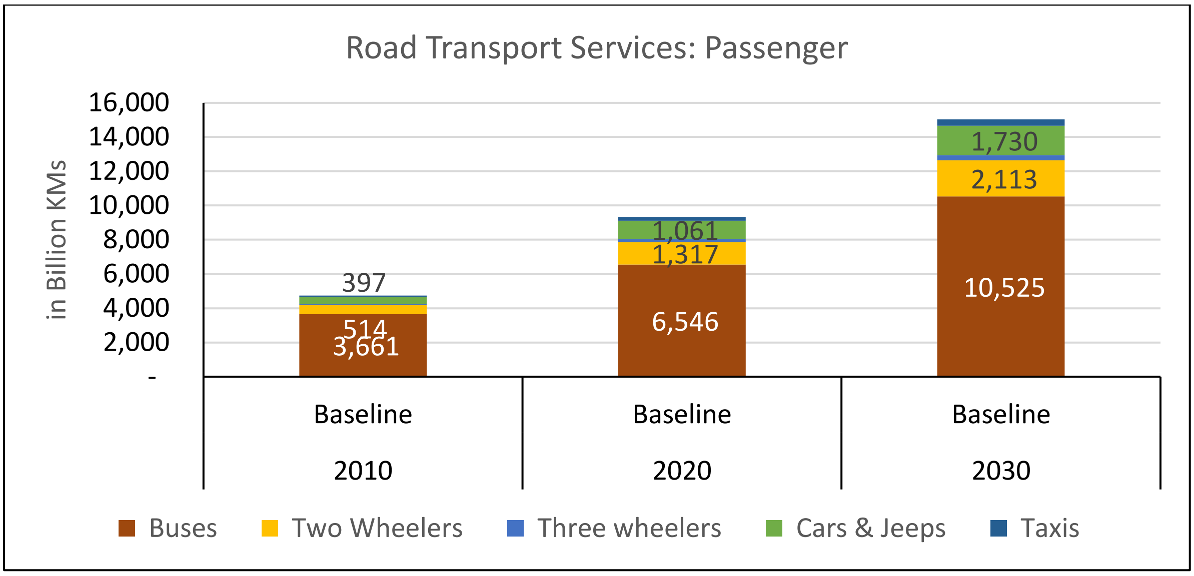


Figure 4.4: Decadal Passenger Road Transport Services

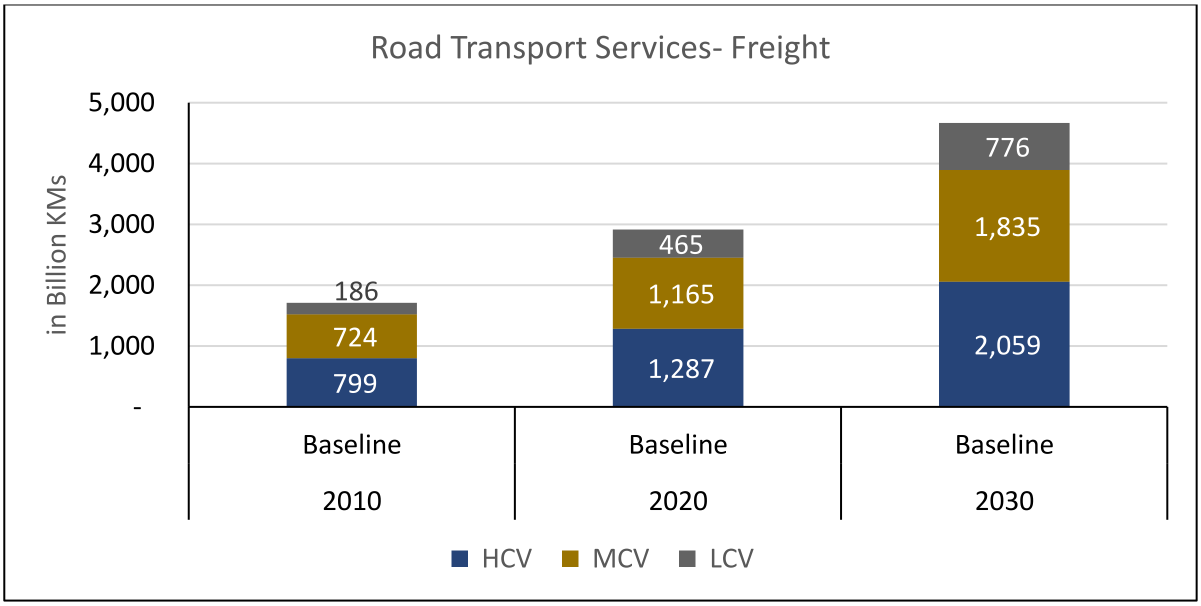


Figure 4.5: Decadal Road Freight Transport Services

4.4.2 Vehicle in Use (On-road Vehicles)

On-road vehicles are estimated using the assumed survival rates (International Council on Clean Transportation Model--India) on vehicle sales until 2030. Since most of the new vehicle policy scenarios are implemented after 2020, there is not much difference in the vehicle mix in 2020. Figure 4.6, therefore, shows on-road vehicles in 2020 only for the baseline scenario which is 154 million. However, in 2030, the modal shift from private to public shows the least number of vehicles on road, i.e., 169 million. This signifies that most passengers start using public vehicles like buses and auto rickshaws rather than buying private vehicles. Electrification of vehicles only changes the technology mix of vehicles, but the overall number of vehicles remains similar, compared to the baseline scenario.

Similarly, in the case of fuel efficiency, the same number but more efficient vehicles ply on road compared to the baseline scenario. In the integrated scenario, where all policy scenarios are implemented simultaneously according to their timeline, the on-road vehicles are reduced by 40 percent in 2030 compared to the baseline scenario.

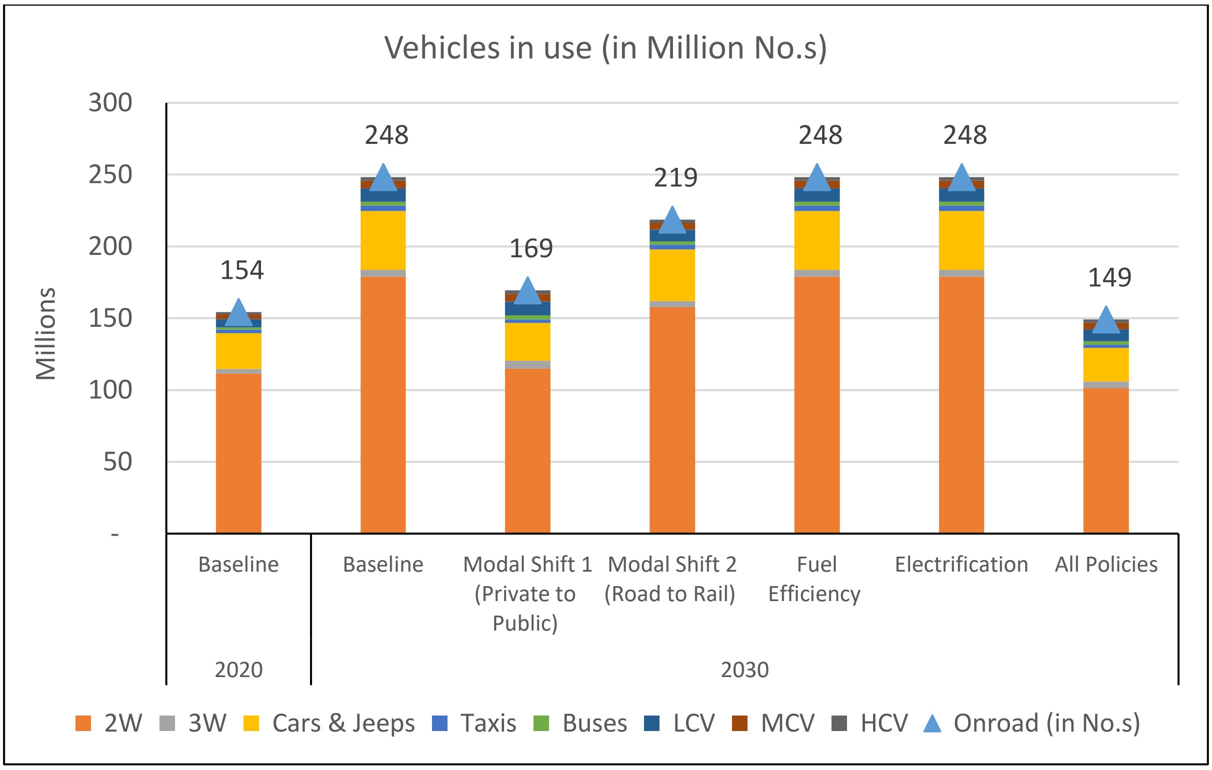


Figure 4.6: Total Vehicles in Use

4.4.3 Energy Consumption

The energy consumption share of the road transport sector in the total energy consumption by road and rail is projected at 94 percent in 2020 and it increased at a fast rate of 7.6 percent between 2010 to 2020, and by 6 percent between 2010 and 2030. Only 1 percent of energy consumed in the road transport sector is from CNG sources and the rest is from petroleum products. Based on the comparison of energy consumption under various scenarios with the baseline scenario, it is observed that until 2020 and 2030, the fuel efficiency has the highest reduction. In 2020, after fuel efficiency, electrification has the second highest reduction while the modal shift in road to rail and in private to public shows almost equal reduction. In 2030, after fuel efficiency, the modal shift in road to rail shows the second highest reduction, followed by the modal shift from private to public. Taking the integrated scenario into consideration, the energy consumption reduces 9 percent in 2020 and 27 percent in 2030 compared to the baseline scenario. Figure 4.7 shows the energy consumption in the road and rail sector in 2020 and 2030 for the considered scenarios.

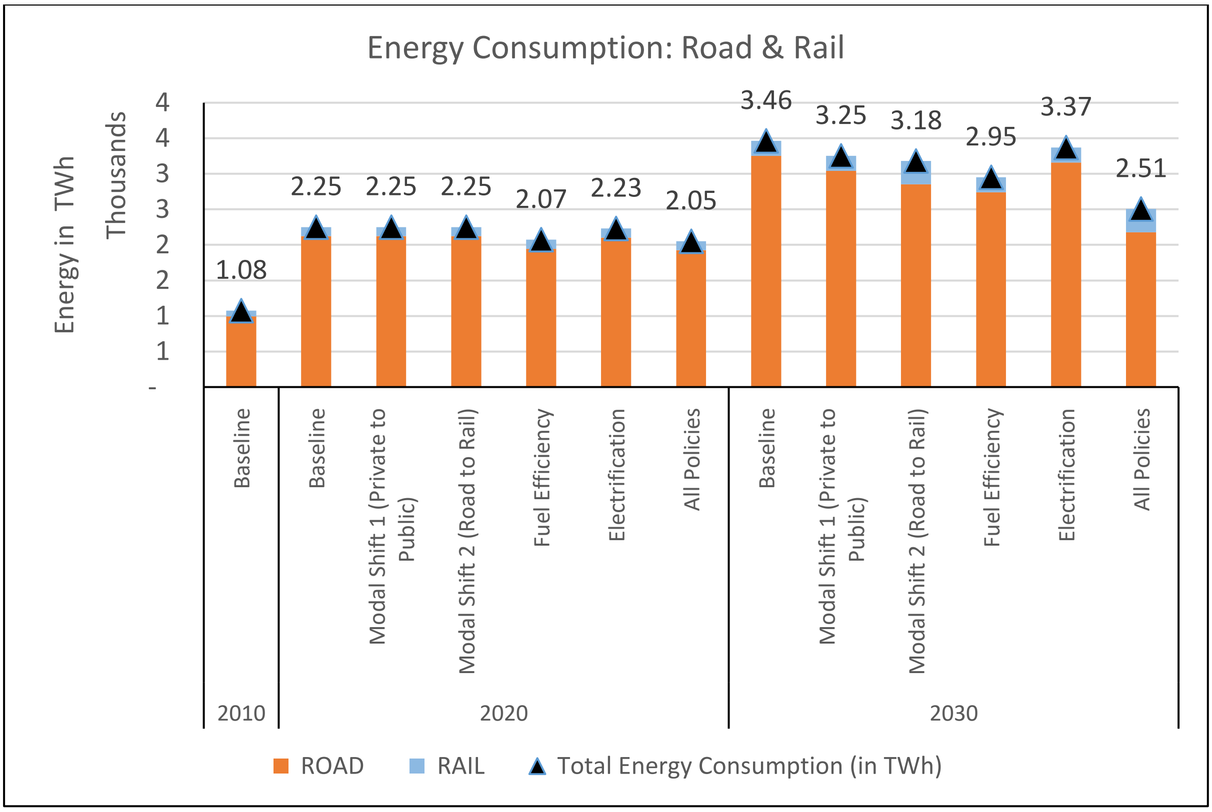


Figure 4.7: Total Energy Consumption in Transport Sector (Except Air)

4.4.4 Emissions

The emissions from the transport sector increased by CAGR of 12.8 percent in 2020 and 8.5 percent in 2030 from 2010. Figure 4.8 depicts that fuel efficiency shows the highest reduction among the individual scenarios. The mix of vehicles remained the same for the baseline and fuel efficiency scenarios, but the reduction in CO_2 emission is significant considering the latter scenario. Considering 1 percent improvement in vehicle fuel efficiency each year will result in significant reduction in the consumption of petroleum products and as a result least emissions. Other scenarios like modal shift and electrification imply vehicles with higher fuel specification, but a smaller number of vehicles on road. The integrated scenario combines the efficiency scenario with electrification and public vehicle utilization scenarios to get the maximum reduction in transport sector emissions, i.e., 33 percent, compared to the baseline in 2030.

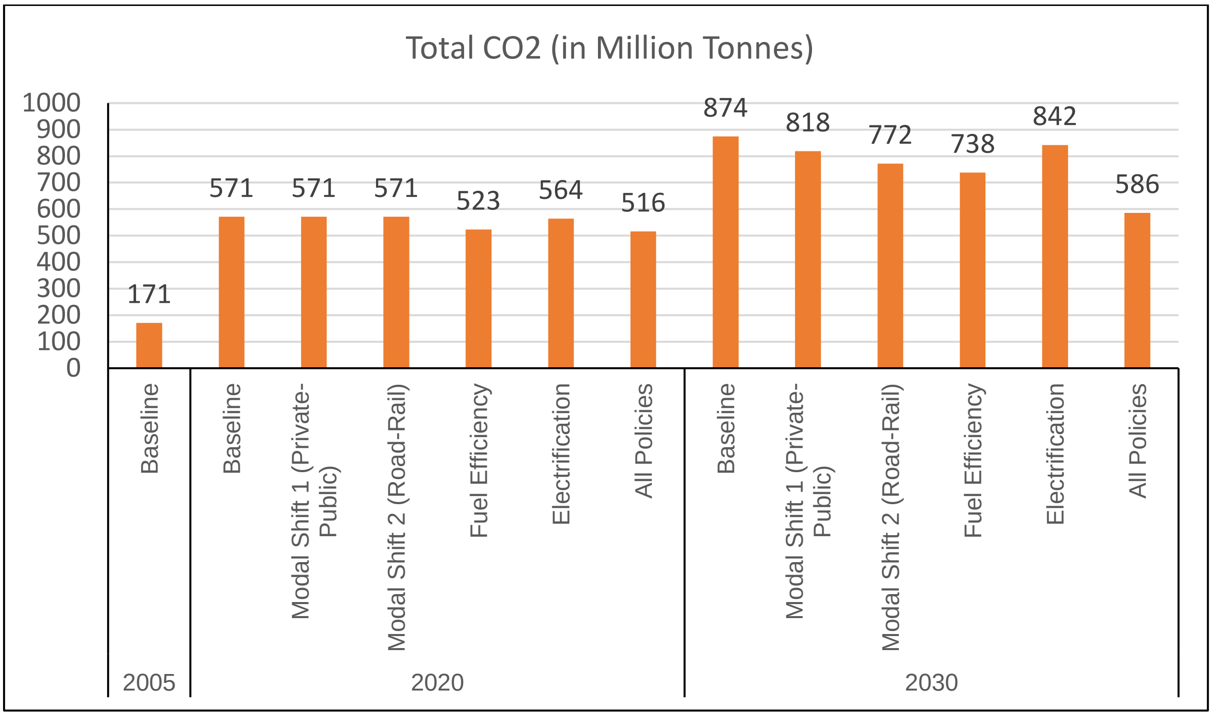


Figure 4.8: Total CO_2 Emission in Million Tonnes

It can be observed from Figure 4.9 that the emission intensities increase up to 2020 and thereafter decreases. This is because the transport sector is expected to grow in terms of its share in GDP and emissions. Also, the low carbon scenarios seem to effectively kick in *after* 2020 and, therefore, the impact of these strategies is only seen in the last decade. The combined integrated scenario evidently shows the highest reduction. Among individual strategies, fuel efficiency shows the highest reduction followed by the modal shift scenarios which are followed by the electrification scenario (whose indirect emission implication depends on the power mix of the day).

Other than CO_2, which is the main pollutant, the transport sector is also responsible for the emission of CH_4 and N_2O. The share of these two gases is only 2 percent of the total emission which remains same across all scenarios. Figure 4.10 shows the total GHG emission from the transport sector.

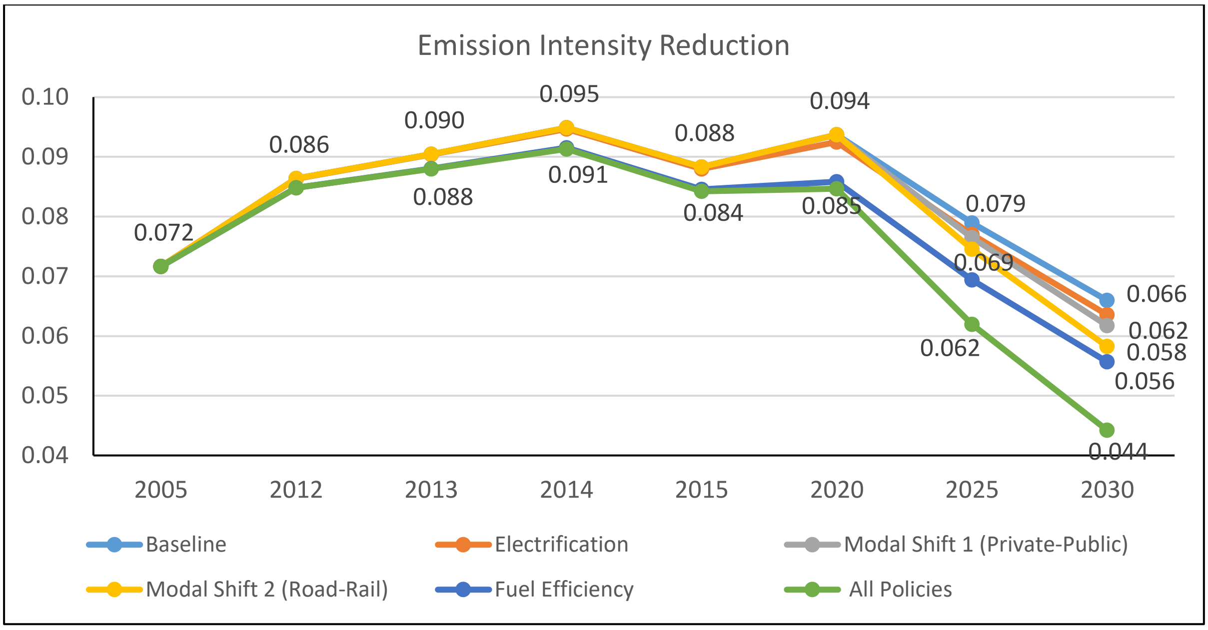


Figure 4.9: Emission Intensity Reduction for all Scenarios

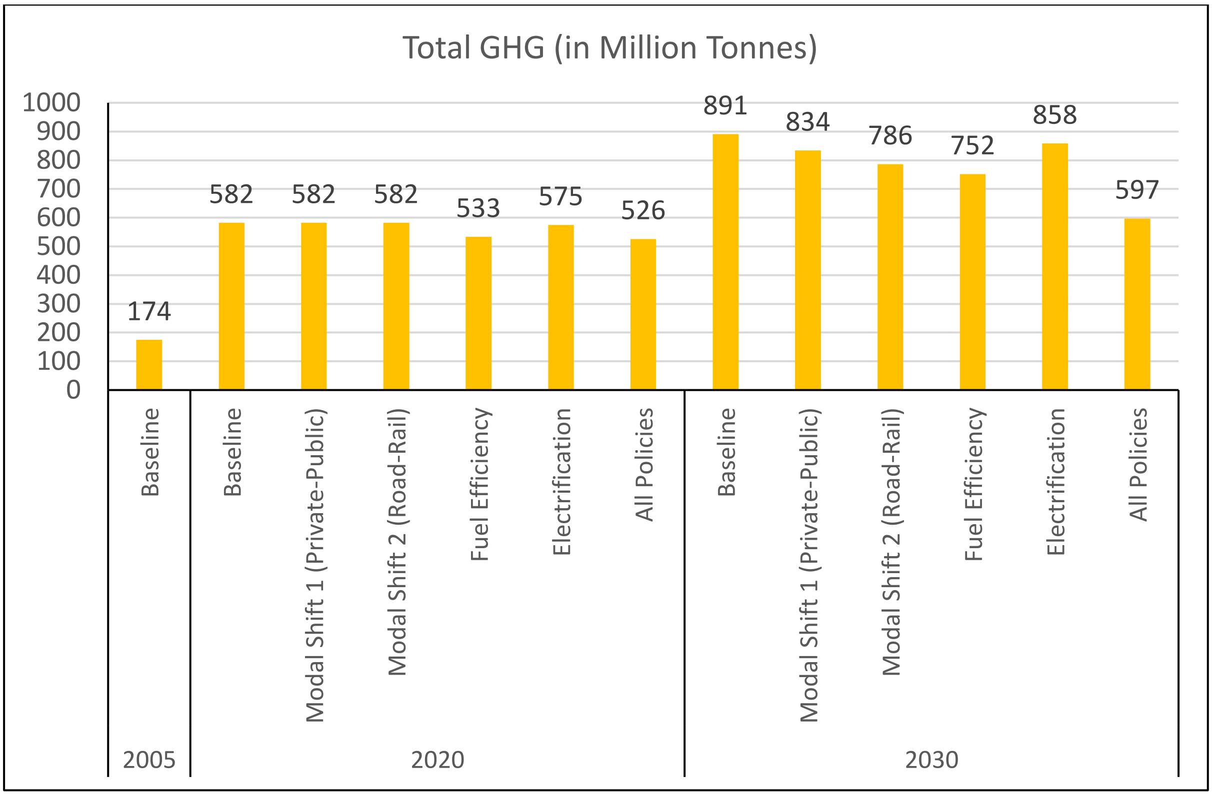


Figure 4.10: Total GHG Emission in Million Tonnes

4.4.5 Scenario Cost

The total cost of the transport sector in each scenario consists of the undiscounted sum of the cost of vehicle ownership and the cost of investment in road infrastructure. The cost coefficient is taken from the IESS 2047 calculator. Figure 4.11 shows the cost of different scenarios for the transport sector from 2005 to 2030. It is to be noted that the scenario cost for fuel efficiency is the highest as compared to the baseline scenario. As is expected, the cost for improved vehicles is to be borne by the manufacturers which, in turn, will increase the price of the vehicles. The electrification scenario will have a higher cost of vehicle, but the share of EVs would be small compared to conventional vehicles. Hence the scenario cost is higher than the baseline scenario, but less than the fuel efficiency scenario. The modal shift from private to public mode of transport helps in reducing the scenario cost to INR 7.64 trillion compared to INR 8.55 trillion in the baseline scenario. The cost implication of this policy makes it the second-best alternative for the transport sector. The modal shift from road to rail will replace the costlier road-based vehicles by the railways which is a cheaper means of transport for serving the same passenger services demand, and hence is more efficient and has the least cost.

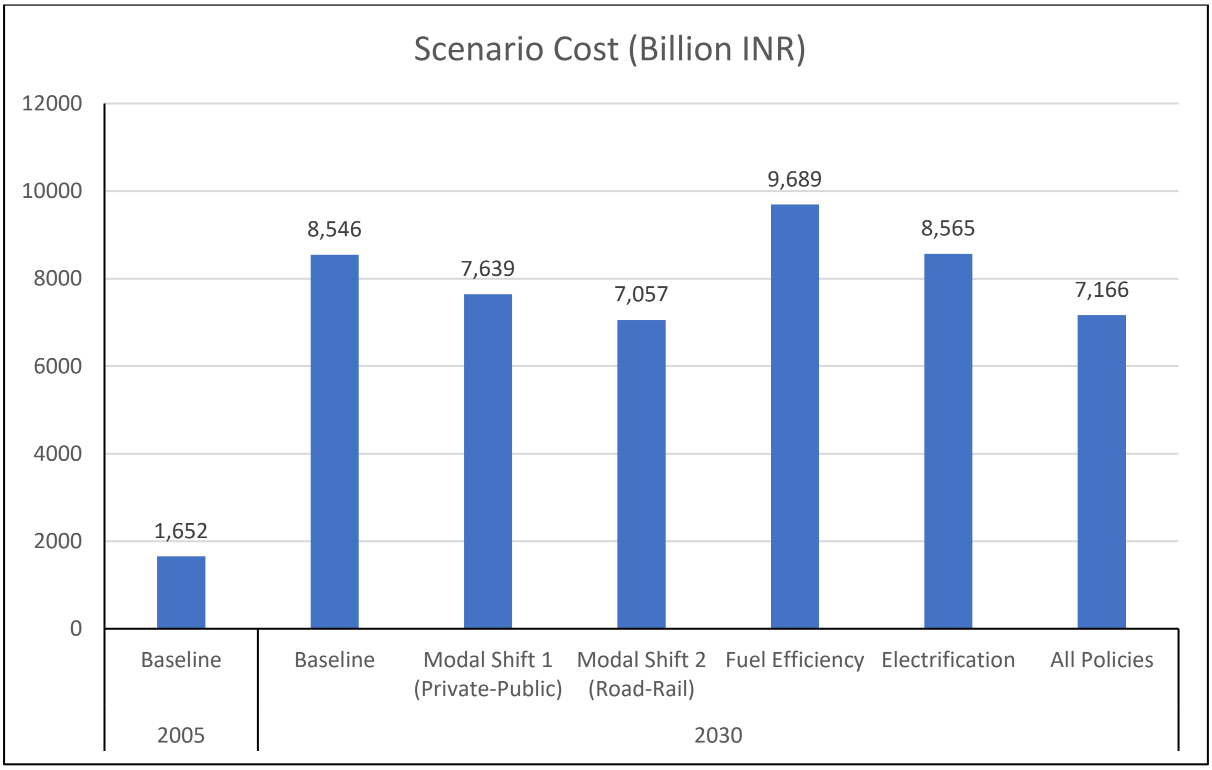


Figure 4.11: Scenario Cost by the Transport Sector from 2005 to 2030

Each scenario will have a CO_2 saving potential and a cost implication. The CO_2 saving potential for each policy scenario is calculated by comparing it with a baseline scenario where no intervention in the transport sector was considered after 2012. Figure 4.12 shows the marginal abatement cost for all the five policy options compared with the baseline at 2011-12 prices. It is to be noted that, as mentioned above, the fuel efficiency scenario incurs the highest cost in our analysis as its burden will be on the manufacturers to produce the vehicle as per prescribed CAFÉ standards which will, in turn, increase the cost of the vehicle. Electrification also increases the cost of producing the vehicle. Modal shift scenarios promote more efficient forms of transport and reduce cost to the economy. Other than the individual scenarios, the integrated scenario combines all the impacts of each scenario and becomes the better option to implement in the transport sector.

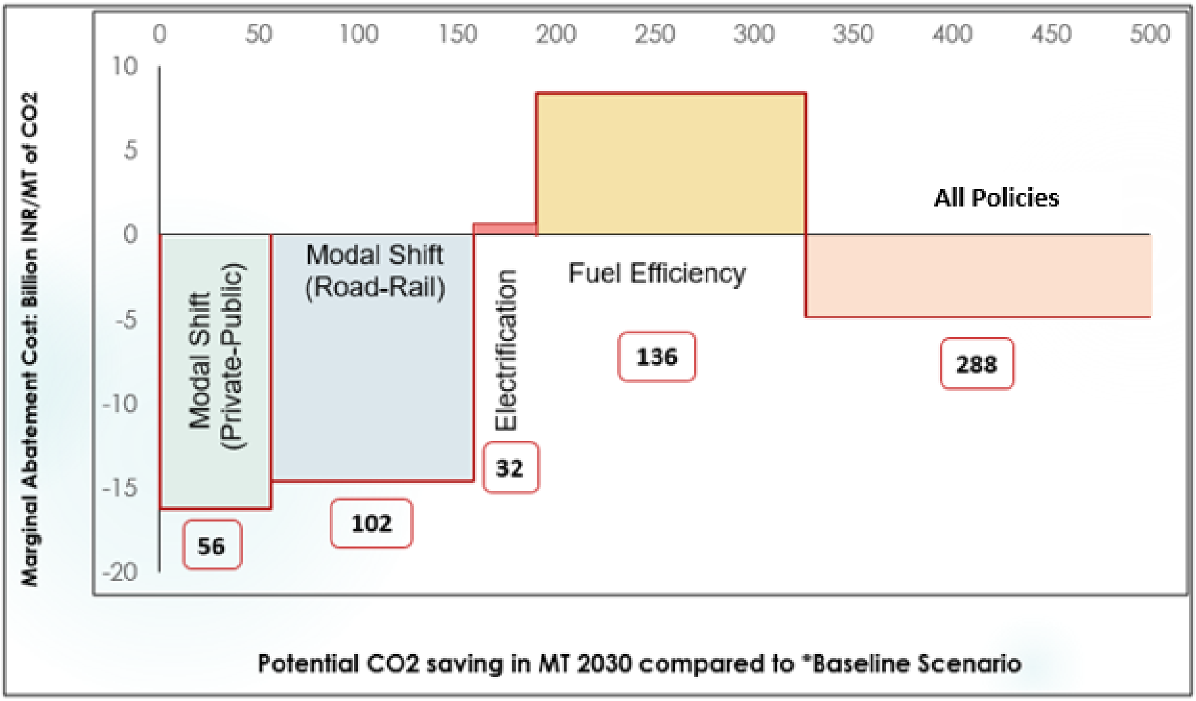


Figure 4.12: Marginal Abatement Cost for All Considered Scenarios (at 2011-12 prices)

4.5 Findings and Recommendations

- The results show that introducing EVs, improving energy efficiency, and shifting to rail from road transport and from private to public within road will reduce sectoral emission by 38 percent compared to the baseline scenario in 2030.

- **Fuel Efficiency Improvements:**

  - As per our study, the implementation of new technologies for meeting the CAFÉ standards will have the maximum impact on transport emissions. To achieve the efficiency target of 113g CO_2/KM by 2022, vehicle manufacturers are required to meet the new fleet average efficiency by introducing more efficient vehicles (Transportpolicy.net, 2018). The new standards are expected to keep approximately 50 million tons of CO_2 out of the atmosphere by 2030 (UNFCCC, 2015). But in our study, it is estimated that fuel efficiency will save approximately 136 million tons of CO_2 as compared to 2010 efficiency level (Baseline Scenario). It is very important to apply the efficiency standards to the entire range of vehicles (passenger and commercial) and to ensure that there is strict implementation and compliance of these regulations. Our study also shows that if the fuel efficiency standard is complemented with other scenarios like mass transition and electrification, it will help us achieving the greater goal of reduced fuel dependence and promote a cleaner and efficient transport system in India. It is, therefore, important to implement these scenarios together in order to realize the full benefits of stringent efficiency standards.

- **Shift to Mass Transportation Systems**
  - In India, the increasing income level in metropolitan cities has made us realize that people prefer private modes of transport over public. Both in road and rail transport systems, the share of public transport in passenger travel demand has been declining over the years. This is due to the availability of poor quality, slow and inefficient public transport system. The public transport system is unable to meet the growing passenger travel demand, which leads to increase in mobility of private vehicles on the road. Many metropolitan cities like Delhi, Bangalore and Mumbai face the issue of congestion, pollution and accidents due to the huge penetration of private vehicles on the road. To cater to these issues, local and state governments have introduced several schemes and policies to improve the efficiency of the public transport system. Introduction of metros solves only a part of the problem, but the conventional form of public transportation needs to be upgraded to attract customers and encourage them to switch from private mode to public. In this study, we assume a 10 percent shift from private to public transport from 2020 and, from our spreadsheet model, obtained a saving of 56 million tonnes of CO_2 in the next decade. Similarly, a shift of 10 percent from road to rail (including passenger and freight) could save up to 102 million tonnes of CO_2 in a decade. These assumptions signify that public and shared modes of transportation are eco-friendly as they save fuel consumption besides reducing local emissions. The main reason why people the prefer private mode over public transport in India is because of its convenience, comfort and end-to-end connectivity of the journey, which the public transport fails to provide. So improvement in the quality of services, plus punctuality, will attract more ridership.

- **Electrification**
  - In 2019, the introduction of EVs has been the most debated topic for the MoRTH. Since 2013, the government had introduced several programs and policies (NEMMP, FAME-I, FAME-II) for smooth integration of these vehicles on Indian roads. It has also pushed vehicle manufacturers to introduce their electric variants to achieve a 30 percent EV penetration target by 2030. Extrapolating from the same, India could realize EV sales penetration of 30 per cent of private cars, 70 per cent of commercial cars, 40 per cent of buses and 80 per cent of two- and three-wheelers by 2030 (NITI Aayog and Rocky

Mountain Institute, 2017). These targets set by the government are highly ambitious and have the potential of greatly reducing oil and carbon emissions. But our approach in this study on electrification is quite realistic, keeping an eye on the current progress till 2019 and the EV policies released by different states and in consultation with different ministries. We assumed sales of 30 percent of two-wheelers, 50 percent of three-wheelers, 3 percent of private and commercial cars and 10 percent of buses by 2030 in our spread-sheet model. Achieving these levels of market share by 2030 could generate cumulative savings of 32 million tonnes of CO_2 over the total deployed vehicle's lifetime. To promote EV adoption, the government has considered a bouquet of potential policies, such as congestion pricing, zero emission vehicle (ZEV) credits, low emission/exclusion zones, parking policies, variable tax structure, vehicle rating programs etc. The GoI also intends to improve India’s energy security scenario by incentivizing vehicle manufacturers for electrification and catalyzing the market for faster adoption of EVs to ensure durable economic growth and global competitiveness for India's automotive industry. This will help India in moving towards cleaner mobility in future.

5. Industries

5.1 Current Scenario

The industry sector in India is a major consumer of energy in the economy. In 2016-17, the share of the industry sector was nearly 30 percent in GVA at current prices (MoSPI, 2019) of which the share of the manufacturing sector was 17 percent. The industry sector accounted for 21.7 percent of total emissions (412.55 million tons of CO_2 equivalent) in the 2005 (Planning Commission, 2014), with a CO_2 emission intensity of 73 thousand tonnes CO_2/billion rupees of production (Reddy and Ray, 2010). Whereas in 2014, the industry sector contributed around 21 percent (546.03 million tons of CO_2eq) of India's total emissions (MoEFCC, 2018).

Among all industries, cement and iron & steel are the largest contributors to GHG emissions and are also critical inputs for the growth of infrastructure in the country. Housing, infrastructure and irrigation sectors are major drivers for growth of demand in the cement sector (Planning Commission, 2011). Forecasts suggest an estimated growth of 13 percent in the production of cement in 2019 over the previous year (India Brand Equity Foundation, 2019). Cement production capacity stood at 502 million tonnes per year (MTPY) in 2018 (India Brand Equity Foundation, 2018). India's steel sector also witnessed immense growth in both production and consumption due to the National Steel Policy 2017. The capacity of steel production has increased from 97 million tons in 2012-13 to 138 million tons in 2017-18 (Press Information Bureau, 2018). The 'Make in India' policy, through various initiatives such as capacity expansion, quality control, and skill development, intends to increase the capacity of steel production in the country to 300 Million Tonnes Per Annum (MTPA) by 2025.

In 2007, cement manufacturing and iron & steel industries accounted for 6.8 percent emissions (129.92 million tons of CO_2 eq) and 6.2 percent emissions (117.32 million tons of CO_2 eq) of total emissions respectively. Cumulatively, the two of them have a collective share of around 70 percent in total industrial emissions (GHG Platform India, 2017). In order to reduce the Industry emission contributions, adoption of low carbon technologies and energy efficiency in these two sectors can be major interventions.

5.2 Mapping Existing Program and Policies- Current Status of Implementation and Contribution in Goal 3

The GoI has initiated various schemes and policies to achieve energy efficiency and emission reduction targets for the industry sector. The NMEEE is one of the eight national missions under the NAPCC operating in India toward energy efficiency of various sectors. As a part of NMEEE, the GoI launched the following four initiatives to enhance energy efficiency in energy intensive industries: Perform, Achieve and Trade (PAT), Energy Efficiency Financing Platform (EEFP), Market Transformation for Energy Efficiency (MTEE) and Framework for Energy Efficient Economic Development (FEEED).

Table 5.1: Current Programs and Policies in the Industry Sector in India

S No.	Policy/Scheme	Industry	Nodal Agency	Lever to NDC goal 3
1	Perform, Achieve and Trade	Cement; Aluminium; paper and Pulp; Iron and Steel and Textiles	Ministry of Power	Reduction in energy consumption
2	National Manufacturing Policy (Make in India)		Ministry of Commerce and Industries	Promoting energy efficient manufacturing zones
3	Solid Waste Management Rules 2016	Cement	MoEFCC	Reduction in energy consumption (use of AFRM)
4	National Steel Policy 2017	Iron and steel	Ministry of Steel	Energy efficient and environmentally sustainable steel production
5	Credit Linked Capital Subsidy Scheme (CLCSS)	MSMEs	Ministry of MSMEs	Technology improvement for energy efficiency
6	Energy Conservation Guidelines for Industries	MSMEs	Ministry of MSMEs	Improving energy performance

PAT Scheme:

The existing government policy in the industries sector is primarily the PAT mechanism implemented by the Bureau of Energy Efficiency (BEE). The PAT scheme is a unique and innovative policy initiative by the Ministry of Power (MoP) and is currently under its third, fourth and fifth cycle with their control period designated as 2016-2019, 2017-2020 and 2018-2021 respectively. It is a market-based instrument where large energy intensive industries (known as Designated Consumers or DCs) are given targets to reduce their Specific Energy Consumption (SEC) by specified dates. The DCs that over-achieve their energy savings targets are issued Energy Saving Certificates (ESCerts) which are traded with those DCs that do not achieve their targets. PAT is a multi-cycle scheme, with each cycle running for three years, and a provision for monitoring and verification at the end of the cycle (Press Information Bureau, 2012). The PAT- I (2012-13 to 2014-15) achieved energy savings of 8.67 Mtoe, which is 30 percent more than the target of 6.686 Mtoe in eight energy-intensive sectors. The scheme was then launched on a rolling-cycle basis with PAT- II being launched in 2016, identifying new DCs in the above-listed sectors as well three new sectors aiming for energy savings of 8.87 Mtoe. PAT- III was then launched in 2017 with an energy saving target of 1.01 Mtoe followed by PAT- IV and V launched in 2018 and 2019 respectively. PAT Cycle 1 was completed in March 2015 while the 2nd cycle ended in March 2018.

PAT 1 identified 478 DCs in the industrial sector, including thermal power plants, out of which 18 percent were from the cement sector while 14 percent were from the iron & steel sector. PAT 1 helped in CO_2 emission reduction of around 31 million tonnes which was roughly 1.93 percent of India's total CO_2 emission. The cement sector interventions led to a CO_2 eq emission reduction of 4.34 million tonnes. The iron & steel sector emissions, during the same period, reduced by around 6.51 million tonnes of CO_2 equivalent. Table 5.2 shows the number of DCs identified and energy savings target for the ongoing and future PAT cycles.

Table 5.2: Number of Designated Consumers and Energy Saving Targets in Cement and Iron & Steel Industry in PAT Cycles

S. No.	Sector	PAT 3		PAT 4		PAT 5	
		Number of DCs	Energy Savings Target (Million toe)	Number of DCs	Energy Savings Target (Million toe)	Numbe r of DCs	Energy Savings Target (Million toe)
1	Cement	14	0.1	1	0.004	12	0.0870
2	Iron & Steel	29	0.46	35	0.1926	23	0.1687

Table 5.3 highlights the average SEC reduction targets given to the DCs of the cement and iron & steel industries as per the PAT targets.

Table 5.3: Average SEC Reduction Targets for DCs of Cement and Iron & Steel Sectors as per PAT Targets

Year	SEC Reduction in Cement	SEC Reduction in Iron & Steel
2015	5%	4%
2020	6%	6%

Source: BEE -PAT notifications and IRADe analysis

Table 5.4 shows the SEC reduction considered while implementing the EE interventions in the cement and iron & steel sectors.

Table 5.4: SEC Reductions for Various EE Interventions in Cement and Iron & Steel Sectors

Year	Cement			Iron & Steel			
	SEC Reduction (percent)			SEC Reduction (percent)			
	Increased WHR	Increased AFRM	Increased Grid Electricity	Increased Gas based DRI	Increased Scrap Utilization	Increased Electricity from Grid	Electric Furnace
2015	4%	2%	3%	4%	2%	3%	5%
2020	5%	4%	6%	6%	6%	6%	5%
2025	6%	8%	10%	7%	10%	10%	5%
2030	6%	13%	13%	9%	14%	13%	7%

Source: IESS

The above two tables reveal that the targets identified in the PAT cycles for the two sectors (cement and iron & steel) are comparable to those identified in this study for achieving NDC goal 3.

A large share of the industry sector is occupied by the Micro, Small and Medium scale Enterprises (MSMEs). Unlike large industries, MSMEs do not have adequate funds and exposure to upgrade their technology, thus they require government interventions for the same. In line with this, the GoI launched Credit Linked Capital Subsidy Scheme (CLCSS) which will subsidize capital investment for technology upgradation in MSMEs by 15 percent.

In October 2016, the GoI launched financial support to MSMEs in the Zero Effect and Zero Defect (ZED) Certification Scheme which promotes ZED manufacturing and ZED assessment for their certification. This was done to encourage MSMEs to upgrade their quality standards without impacting their production. In addition to this, the GoI has also taken various steps aimed at development of MSE clusters to enhance their productivity, competitiveness and support sustainability among them (Ministry of Micro, Small and Medium Enterprises, 2018).

5.3 Methodology

Low carbon pathways, or LCPs (policies, programs, technologies etc.) are being applied from 2015 and the reduction in energy demand through reduction in SEC, or change in energy mix, is being observed after their implementation.

Since the cement and iron & steel industries contribute nearly 70 percent to the emissions from the industry sector, application of low carbon pathways is considered only for these two industries which could facilitate the overall sector to achieve its proposed reduction in emission intensity.

A spreadsheet-based accounting model is developed to project the technology wise supply of output to meet an exogenously specified demand and calculate the corresponding fuel consumption, emissions and cost implications of the supply requirement. The model is used to estimate the reduction in emission intensity of GDP in each industry for which a separate Business as Usual (BAU) scenario and low carbon pathway scenario (LCP) are developed.

***BAU scenario**:* In BAU, the penetration of technologies, policies and programs are considered till 2015. It is assumed that no additional efforts will be put in the industry and existing efforts will remain constant till 2030. However, the scenario does consider an autonomous improvement in the energy efficiency of the industry over the years.

***LCP scenario**:* In LCP, the penetration of technologies, policies and programs are considered from 2015 to 2030. LCP scenarios are based on the IESS 2047 V2. The chosen pathway will reduce the emission intensity (by changing the energy mix or reducing the SEC) from the BAU scenario.

Energy demand in LCP scenarios is calculated by factoring in the percentage of SEC reduction by the specified LCP with the energy demand in the BAU scenario. From this energy demand, emission intensity is calculated as the weighted sum of emissions by different fuels over the sector's GDP.

Emission intensity is calculated in both the scenarios to estimate the reduction accounted for by the LCP. Additionally, the incremental cost which will be incurred in doing so is also calculated by applying the cost factor to the change in energy demand. For the detailed method of estimation, refer to Annexure 5.1.

5.4 Results and Discussion

Based on the methodology, various scenarios were prepared for the different industries in the sector. Since cement and iron & steel are the major contributors to the sectors emissions, the impact of various LCPs (technology interventions) have been estimated to analyze the progress of the industry toward the NDC Goal 3 (Reduction in emission intensity of GDP). IRADe's macroeconomic model is used to project the industry-wise demand and estimate the industry-wise emissions intensity targets that need to be achieved by 2030 to achieve the overall NDC of emission intensity reduction target of 33-35 percent by 2030. Table 5.5 describes the sectoral targets for each industry.

Table 5.5: Reduction targets for industries (Estimated by IRADe's Macro-model)

S No.	Industry	Reduction Target by 2030 (percent)
1	Cement	24 %
2	Iron and Steel	**22%**

5.4.1 Cement Industry

The cement industry in India is one of the most efficient in the world. It is matured and market driven with market economics playing a big part in its operation. Cement industry being one of the few heavy energy intensive industries, it was included in the PAT mechanism and substantial SEC reduction has been achieved in PAT 1. The sector achieved savings of 1.48 million TOE as compared to the target of 0.815 million TOE, resulting in overachieving the target by more than 80 percent. This helped in GHG emission reduction of approx. 4.34 million tonnes of CO_2 eq (BEE, 2019).

Tech Update

- **Waste Heat Recovery**
  In the process of clinkerization, only about 55 percent of total heat input is utilized. The available waste heat is then used for drying of waste material or coal. Even after this, additional waste heat is available from the kiln gases and cooler exhaust air. This heat can be used for electricity production. Up to 30 percent of power demand of a cement plant can be met through these waste heat recovery plants.

- **Switch to Grid Electricity**
  This intervention involves sourcing of electricity from the grid rather than the inefficient Captive Power Plants (CPPs). The inefficiency of CPPs is because of their small size and their fuel mix being dominated by fossils. Apart from that, CPPs have limited emission control technologies when compared to grid-based electricity.

- **Alternate Fuel Resources (AFR)**
  AFR refers to co-processing of domestic, agricultural or industrial “wastes” to substitute fossil fuels. The “wastes”, if not used for this process, would have been incinerated or landfilled without any energy recovery. Large temperatures and high residence time offer efficient combustion of these wastes leading to effective emission savings. Also, the ash produced in the process can be utilized as raw material for the cement production process.

In the cement industry, Waste Heat Recovery (WHR), Alternate Fuel Resources (AFR), Switch to Grid Electricity (Switch_GE) and different combinations of all these technologies are the key interventions considered. These interventions help in reduction of emission intensity by reducing the SEC of the sector or using a cleaner fuel. Figure 5.1 describes the reduction in emission intensities of GDP due to adoption of these technologies over the span of 2015 to 2030.

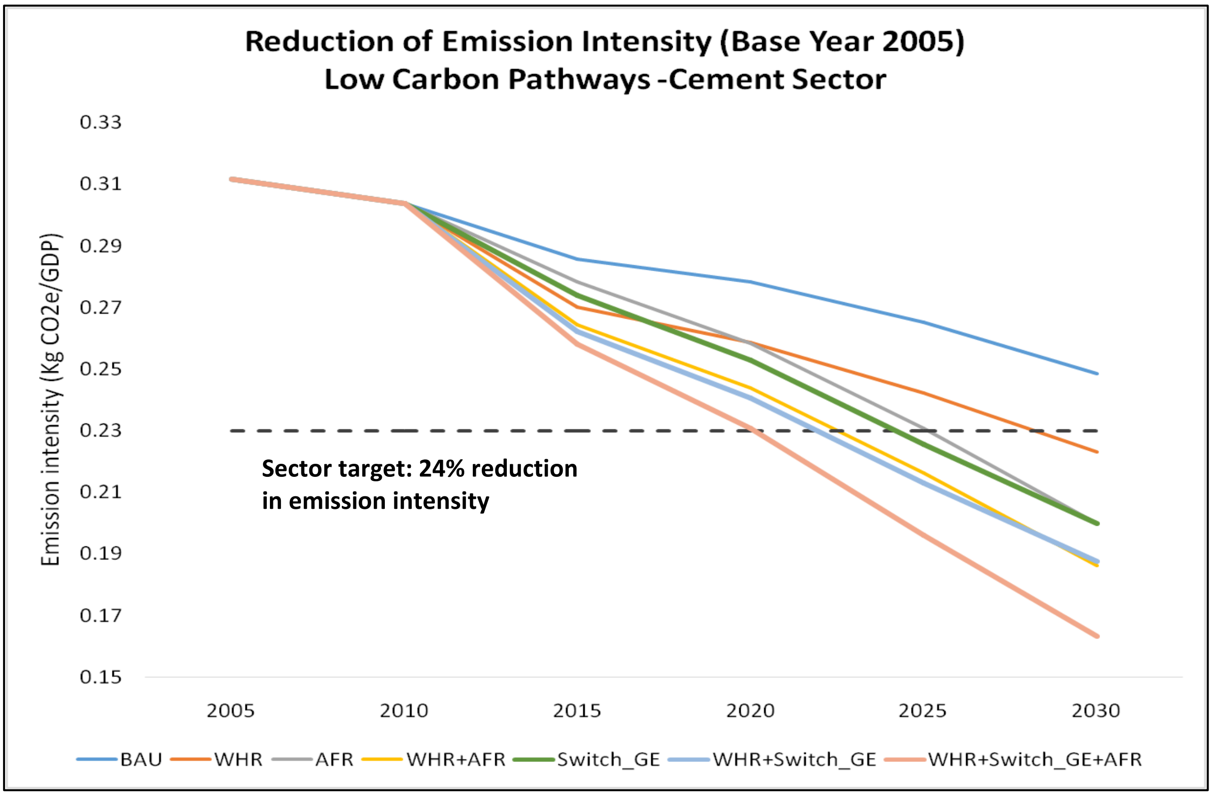


Figure 5.1: Reduction in Emission Intensities in BAU and Various LCP Scenarios In the Cement Sector

It can be observed from figure 5.1 that all LCP scenarios (WHR, AFR and Switch_GE) will have a much more than required impact on the reduction of emission intensity of GDP. In the BAU scenario, which assumes mainly generic energy efficiency, the emission intensity of the industry gradually reduces, but the emission intensity target consistent with NDC3 goal will still be missed by nearly 3.7 percent.

Application of all three interventions of the cement industry simultaneously (i.e. WHR + Switch_GE + AFR) may result in emission reductions of 47 percent by 2030. This corresponds to an overachievement of 24 percent over the NDC target.

Since, as per the current trends, the autonomous energy efficiency assumed in BAU is not enough to reach the target, additional interventions or measures implied by the LCPs seem necessary. *Waste Heat Recovery (WHR),* which is currently being used in the cement industry, has demonstrated its effectiveness in reducing the emission intensity.

If WHR is promoted, the cement industry in India can overachieve the estimated target for the cement sector by nearly 4.4 percent. If Alternative Fuel Resources (AFR) is opted for, the industry can overachieve the estimated targeted by nearly 12 percent and for Switch_GE, the emissions intensity reduction overachievement above its required target level is estimated to be almost 12 percent. A combination of the above technologies scenarios will lead to even higher overachievement in the estimated target for the cement industry. Table 5.6 presents the summary of the reduction in emission intensity with respect to 2005 by 2030 by the different scenarios.

Table 5.6: Summary of Emission Intensity in 2030 and Reduction in Various Scenarios in the Cement Sector

Scenarios	Emission Intensity (Kg CO_2/GDP)	% Reductions wrt. 2005
BAU	0.25	20.23
WHR	0.22	28.39
AFR	0.20	35.87
Switch_GE	0.20	35.87
WHR+AFR	0.19	40.23
WHR+Switch_GE	0.19	39.82
WHR+Switch_GE+AFR	0.16	47.65

Adopting these technological interventions to reduce emission intensity, however, involves a significant cost of implementation. Figure 5.2 describes the cost incurred by the presented LCP to abate one ton of CO_2e in year 2030.

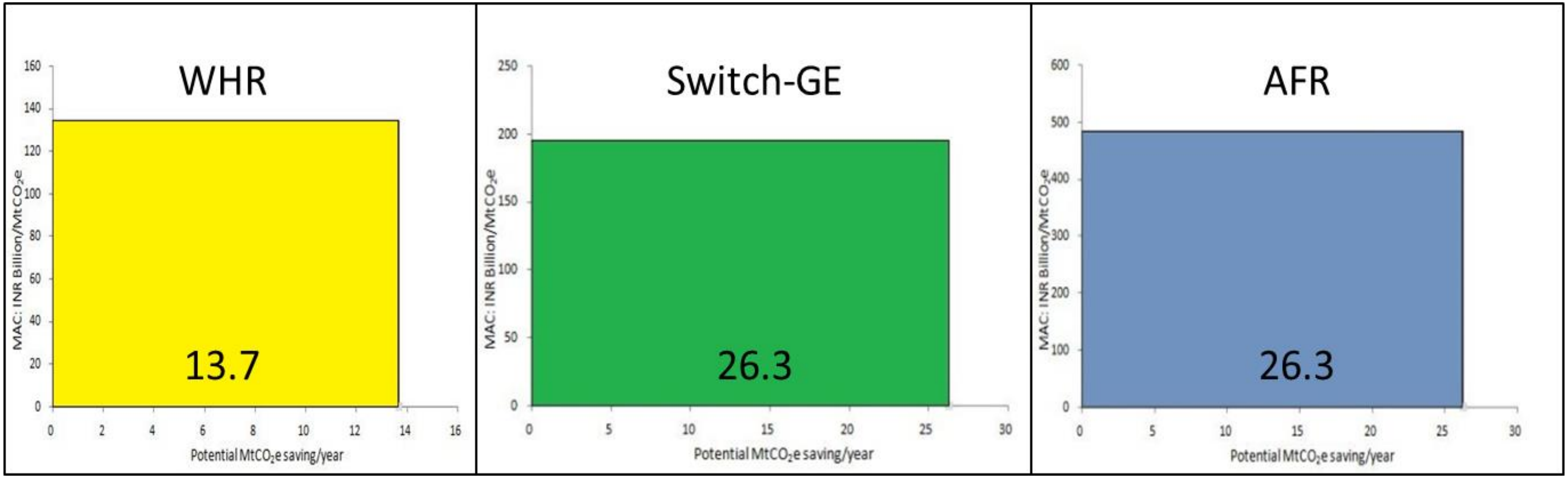


Figure 5. 2: MAC Curve Representing Individual LCP Scenarios in the cement sector in 2030

Of all the individual interventions, promotion and adoption of WHR is the cheapest, but it results in the least emission reductions. Promotion and adoption of AFR and Switch_GE also result in comparable emission reductions. But since Switch_GE has lower cost implications, it turns out to be the most cost-effective pathway.

However, a combination of all the aforementioned interventions, when applied one over the other (i.e., WHR + Switch_GE + AFR, in that order) yields different results, giving a combined emission reduction of 46 MT of CO_2e in 2030, as shown in Figure 5.3

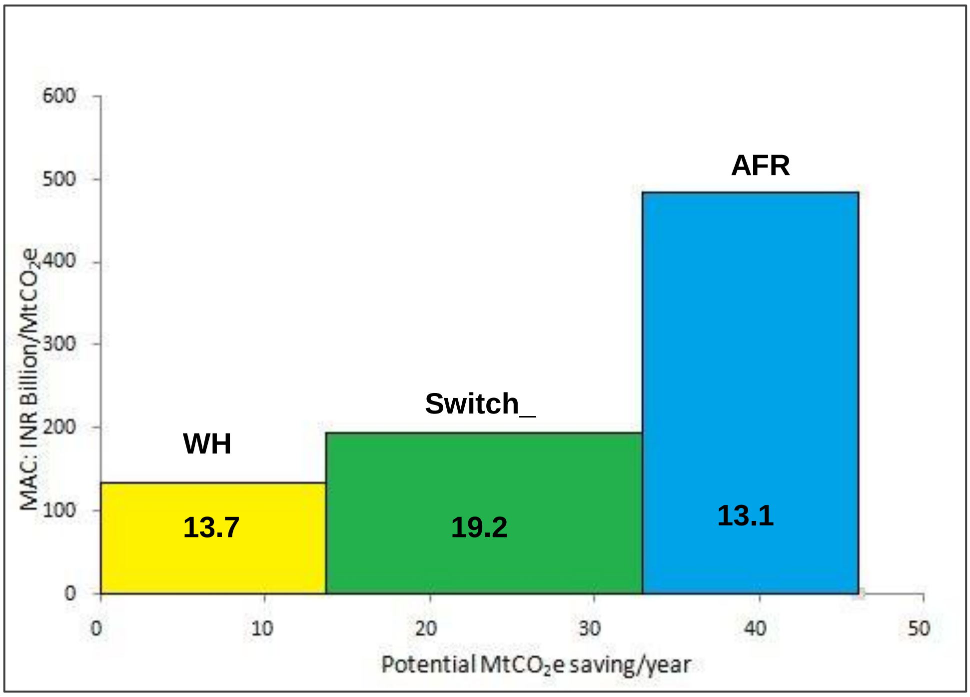


Figure 5.3: MAC curve Representing Combined LCP Scenarios in the cement sector in 2030

In a combination scenario of WHR + Switch_GE + AFR, the mitigation potential of both Switch_GE and AFR is affected, but Switch_GE still seems to be a very cost-effective pathway for emission reduction in the Indian cement industry.

Typically, a MAC curve represents individual interventions and their emission reductions. But this may cause overestimation of the reduction potential, as application of one pathway affects the reduction potential of other pathways. Thus, to prevent this overestimation, pathways have been applied one over the other, which yields a realistic representation of the total emission reduction potential of the sector. Also, for any amount of potential MtCO$_2$*e savings/ year, the area under the curve gives the total investment cost for that much potential savings.*

5.4.2 Iron and Steel Industry

The iron & steel industry in India uses resource minimization and profit maximization. The industry, being one of the heavy energy intensive industries, was included in the PAT mechanism and substantial SEC reduction has been achieved in PAT 1. The sector achieved a savings of 2.1 million TOE as compared to the target of 1.4 million TOE, resulting in overachieving the target. This helped in a GHG emission reduction of approx. 6.51 million tonnes of CO_2 eq (BEE, 2019).

Tech Update

- **Gas-based Direct Reduced Iron (DRI)**

  Direct reduced iron or sponge iron is formed by reducing the iron ore in its solid state. The process is intrinsically more efficient than a blast furnace. Major DRI units in India are coal-based, but gas-based DRI is more efficient and releases fewer emissions. Natural gas is used as a reductant in gas-based DRI plants.

- **Increased Scrap Utilization**

  In manufacturing steel, typically 60 percent of the energy is used for making iron. Thus, utilization of scrap can significantly reduce the energy consumption and, in turn, the emissions from the process. For effective utilization of scrap, its chemical composition and physical characteristics should be well known. European and Japanese steel plants currently run with 30 to 50 percent of scrap, while the numbers are quite low in India. Thus, the opportunity of savings is very high from this pathway.

- **Switch to Grid Electricity**

  This intervention involves sourcing of electricity from the grid rather than the inefficient CPPs. The inefficiency of CPPs is because of their small size and their fuel mix being dominated by fossils. Apart from that, CPPs have limited emission control technologies when compared to grid-based electricity.

Increasing Gas based Directly Reduced Iron (Gb_DRI), Increased Scrap Utilization (ISU), Switch to Grid Electricity (ElecG), Switch to Electric Furnace (EF), and various combinations of these LCPs are the key interventions being focused on in the iron and steel industry of India. Figure 5.4 describes the reduction in emission intensities of GDP by the penetration of these technologies in the iron and steel industry over the span of 2015 to 2030.

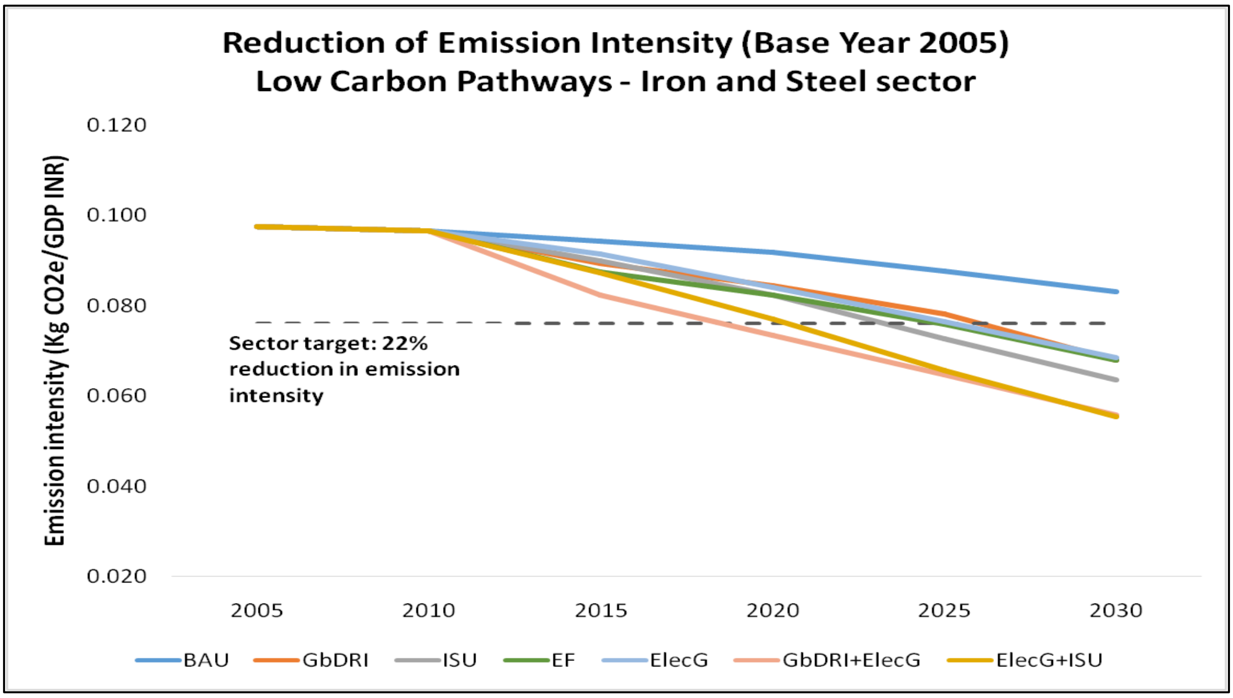


Figure 5.4: Reduction in Emission Intensities in BAU and Various LCP Scenarios in the Iron and Steel Sector

It can be observed in figure 5.4 that in the *business as usual* scenario, the industry will not be able to achieve the proposed target with a gap of approximately 7.3 percent, however, all LCP scenarios will have a significant impact on reduction of emission intensities of GDP in the iron and steel industry. In the case of the Gb_DRI scenario, the industry will overachieve the target by 8.4 percent. The ISU scenario will overachieve the target by around 13 percent, the ElecG scenario will overachieve the target by 7.8 percent and the EF by 8.4 percent. The overachievement of emissions intensity reduction will be even higher for the combination scenarios.

On promoting Switch to Grid Electricity and Increased Scrap Utilization simultaneously (i.e. ElecG + ISU), emission reductions of 43% may be achieved by 2030. This will imply to an overachievement of 21%.

Reductions in emission intensity by various scenarios in 2030 with respect to 2005 is shown in Table 5.7.

Table 5. 7: Summary of Emission Intensity in 2030 and Reduction in Various Scenarios in the Iron & Steel Sector

Scenarios	Emission Intensity (Kg CO_2/GDP)	% Reductions wrt. 2005
BAU	0.08	14.73
Gb_DRI	0.07	30.40
ISU	0.06	34.81
ElecG	0.07	29.85
EF	0.07	30.38
ElecG+ISU	0.05	43.22
ElecG+Gb_DRI	0.05	42.83

A significant investment cost is involved in the application of these technological interventions. For successful implementation of an intervention, its cost implications are to be kept in mind. Figure 5.5 describes the cost incurred by the presented LCPs to abate one ton of CO_2 eq. in 2030 in the iron and steel sector.

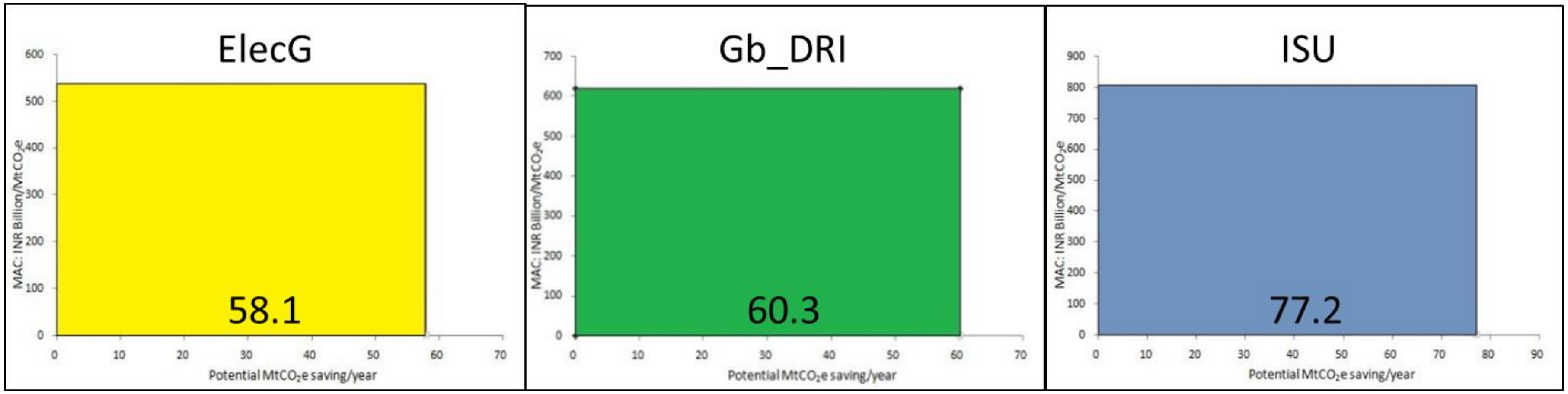


Figure 5.5: Cumulative Cost of Implementation of Various Scenarios by 2030 in the Iron and Steel Sector

While the ISU scenario gives most reduction in emissions, it is also the costliest pathway. It is around 23 percent costlier than the Gb_DRI scenario and 33 percent costlier than the ElecG scenario. ElecG seems to be most cost-effective pathway.

For cumulative emission savings, combination pathways were considered. In the first case, Gb_DRI was applied over ElecG, giving a total emission reduction of 108.1 MT of CO_2e in 2030. In the second case, ISU was applied over ElecG, giving a total emission reduction of 109.5 MT of CO_2e in 2030.

It is to be noted that a combination of all three scenarios was not modelled because of conflict between the application of Gb_DRI and ISU together. It was felt that the application of the ISU scenario may affect the penetration of Gb_DRI.
Figure 5.6 represents the two combination cases in the iron and steel industry.

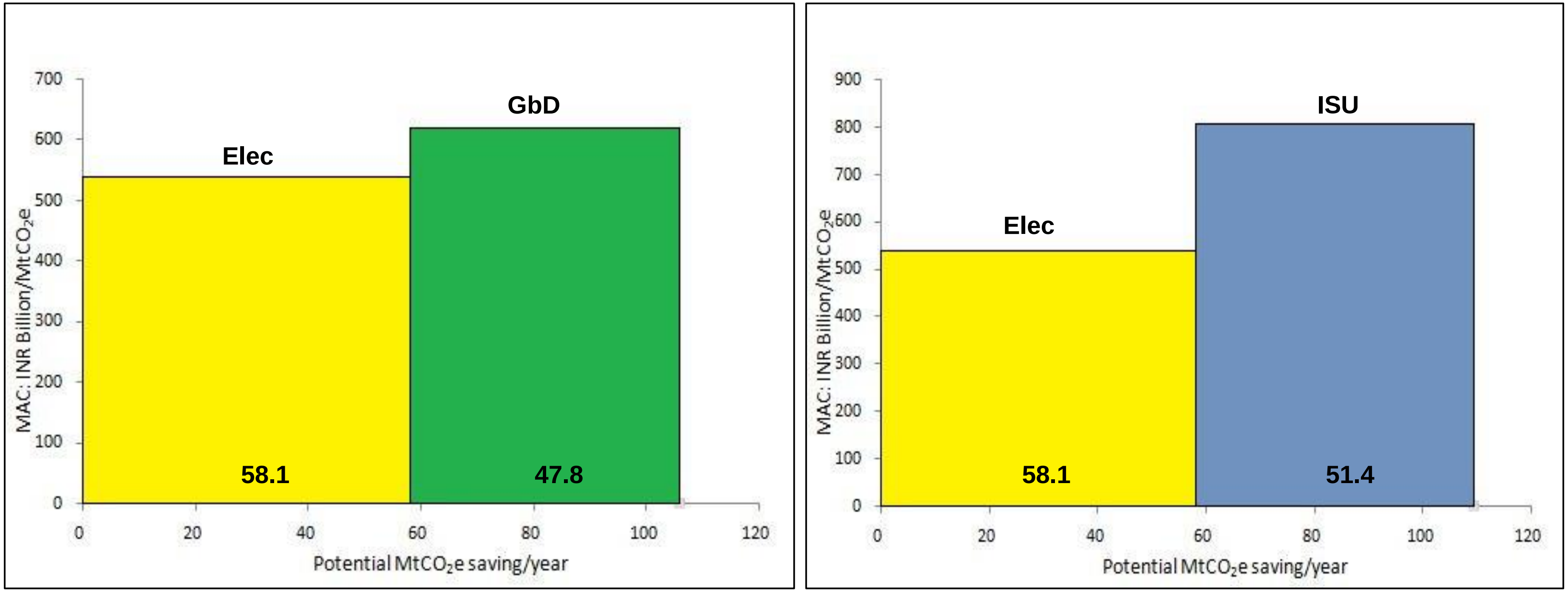


Figure 5.6: MAC Curve representing combined LCP scenarios in the Iron and Steel Sector in 2030

From the combination pathways, it can be seen that CO_2 reductions from the ElecG+ISU pathway is slightly higher than the ElecG+Gb_DRI pathway, but the cost implications from ElecG+ISU is much higher.

5.5 Summary of the Industry Sector

India is the world's second largest cement and steel producer with a production of 502 million tonnes per year (IBEF, 2018) and 106.5 MT (IBEF, 2019) in 2018 and 2019 respectively. Together, the two industries account for 70 percent of the total emissions from the industry sector. The Indian steel industry is very modern with state-of-the-art steel mills. The industry sector--especially cement and iron & steel--due to sufficient involvement of private and public sector players, are competitive and always strive for continuous modernization and up-gradation of older plants to achieve higher energy efficiency levels.

- The adoption of higher energy efficiency levels has been aided by the landmark PAT mechanism of the GoI.
- The PAT mechanism has substantially brought SEC of various industries down and provided the designated consumers an opportunity to make extra capital by trading their energy saving certificates (allocated for achieving higher than targeted savings) in the market.
- The PAT mechanism is currently in its 3rd, 4th and 5th cycles and aims to achieve even higher EE standards.

While there has been success, there are also challenges in implementing EE interventions in the cement and iron & steel industries, apart from the obvious challenge of high implementation costs. These are mentioned below.

- While WHR is one of the most cost-effective methods of improving efficiency in the cement sector, the limited number of indigenous technology suppliers and service providers hinders the adoption of the technology beyond a limit.

- Switching to grid electricity seems like an easy option for reducing the energy consumption and emissions of an industrial unit. But its viability heavily depends on the condition that reliable electricity is always ensured to the industry. For this intervention to play an important role, it is vital that the power sector is stable with minimum disturbance.

- The use of AFR appears to be an ideal intervention for the cement sector, but variability in the physical and chemical properties of the wastes to be utilized as fuel is a practical problem. Apart from that, the cost of sourcing these materials is also an important variable for the industry.

- For the promotion and adoption of gas-based DRI, the availability of natural gas at competitive prices is a major challenge. Since iron & steel is not a priority sector for gas (most of the gas is used for the fertilizer industry), ensuring regular supply of gas is crucial parameter for the adoption of this intervention.

Thus, the PAT program, reliable electricity and the availability of gas can ensure an NDC compliant industry sector.

6. Agriculture

6.1 Current Scenario

The agriculture sector plays a vital role in the Indian economy. About 49 percent of the country's population is dependent on agriculture and its allied activities and approximately 205 million people will be employed in this sector by 2019-20 (MoSPI, 2019). In India, the agriculture sector contributes 19 percent of total greenhouse gases (GHGs) emission (INCCA, 2010). Indian agriculture contributes 7 percent of the global emission from the agriculture sector (Pathak et al., 2014; Pathak, 2015). GHG emission from the agriculture sector is mainly in the form of methane and nitrous oxide (INCCA, 2010; NATCOM, 2012; IPCC, 2014). This sector emitted approximately 67 percent (13.77 million tonnes) of the total methane emission and 61 percent (0.15 million tonnes) of the total nitrous oxide emission of India in 2007 (INCCA, 2010).

The agriculture sector accounts for around 13 percent of diesel consumption at an all India level The percentage consumption is: pump sets, 3.33 percent; tractors, 7.65 percent and agricultural implements, 3.13 percent, with the maximum consumption by tractors in the agriculture sector. Agricultural implements include harvesters, threshers, etc. (PPAC Cell Report, 2013). A major consumer of fossil fuel-based energy are diesel and electric water pumps used for irrigation in India. Almost 45 million tons of CO_2 is added to the atmosphere by using diesel and electric water pumps annually, which is equivalent to 8 percent–12 percent of the total GHGs (Shah, 2009; Rathore et al. 2018). India has 4 percent of the world's water resources and 18 percent of the world's population and India's population is expected to be about 1.5 billion by 2050 resulting in double the demand for food (World Population Prospects 2019, UN). The amount of water required for the production of food will then be significantly high (Central Water Commission, GoI, 2017). With limited cultivable land, it is necessary to find ways of increasing the agricultural yield from the same cultivable area by increasing cropping intensity and also by the adoption of efficient means of irrigation which would result in an increase in the consumption of energy by the agriculture sector. The energy use in the agriculture sector from 1990 to 2015 registered a high growth rate of 10.4percent (Alam & Chandra, 2015).

This sector accounts for 16.2 percent of the total GHG emissions in India and thus has been identified as one of the priority sectors for GHG emission reduction as per India's Nationally Determined Contributions (NDCs) that aim to reduce the GHG emissions intensity of GDP by 33–35 percent of 2005 levels, by 2030 (UNDP, 2016). The overall annual emissions from the agriculture sector increased between 2005 and 2010 from 374 Mt CO_2e to 390 Mt CO_2e (Dhingra & Mehta, 2017). The pumps used for irrigation may be powered by diesel, electric or solar energy. In India, about 66 percent of the pumps were electric, 33 percent were diesel and 1 percent were solar in 2012 (ibid).

The demand for commercial energy sources like diesel and electricity would significantly increase in the agriculture sector in the coming years which would result in increased GHG emissions from this sector. Electric pump sets accounted for 18.3 percent of India's total electricity consumption in 2016–17 and the consumption grew at 6.5 percent CAGR from 2006–07 to 2016–17; diesel pump sets consumed 3.3 percent of India's total diesel consumption in 2011–12 (MOSPI, 2018).

As given in Table 6.1, nearly 30 million irrigation pumps are in use in India, out of which, about 70 percent run on grid electricity, 30 percent are powered by diesel, and only 0.4 percent are powered by solar (Agrawal and Jain, 2015; MNRE, 2017a).

Table 6.1: Irrigation Pumps in India

Type	In Millions of Units
Electricity Grid Connected	19
Diesel Powered	7
Solar Powered	0.013
Total	**26.013**

Source: Agrawal and Jain, 2015; MNRE, 2017a

Electric pump sets are preferred over diesel pump sets for irrigation purposes as electric motors are far more efficient and economical than diesel pump sets. Also, the average efficiency of existing irrigation pump sets is low, ranging under 20 percent to 35 percent and the overall efficiency of energy-efficient pump sets is 45 percent to 55 percent (BEE, 2015; Saini, 2011). In India, most states provide power for free or at heavily subsidized prices for agriculture which has led to relentless ground water extraction. The government can promote efficient use of electricity and water by the farmers by heavily incentivizing the same. Another factor that has severely impacted the availability of surface water are the erratic monsoons due to climate change (Mehta, Chandel, & Senthilkumar, 2014). The government has implemented numerous schemes and programs at the national as well as state levels to promote efficiency of existing pump sets and also to promote the replacement of existing inefficient pump sets with efficient ones across the country. The use of efficient pump sets can increase the agricultural produce by up to 30 percent and reduce the input cost by about 20 percent (World Bank Group, 2017).

The operation of electric and diesel pump set depends upon the timely supply of electricity and availability of diesel. The government has heavily subsidized the agricultural grid connection, but the problem of erratic electricity supply still persists in rural areas. However, in the case of solar water pump sets, there is no operational cost involved as solar energy is available in abundance and is free of cost, but its capital cost is comparatively much higher than electric and diesel pump sets.

In Fig 6.1, the key stakeholders and their roles & interactions in the solar water pumps (SWPs) value chain have been mapped and shown. SWPs can help farmers to create an alternate source of revenue by selling the additional power back to the grid. The initial capital cost of SWPs is high but if looked at the life-time cost analysis, it is observed that they offer lower operating costs and zero CO_2 emissions, thereby offering a reduced carbon footprint, reliable day time power and a secondary source of income. Solarization of existing grid-connected agricultural pumps should be significantly promoted to make farmers independent of grid supply and enable them to sell the surplus power generated to DISCOMs thereby getting additional income.

Scaling up the use of SWPs in irrigation will provide multiple benefits to the farmers, DISCOMs and to the country at large in many ways. These include: 1) providing distributed generation/end-of-grid generation; 2) reducing the need for providing highly subsidized electricity for the agricultural sector; 3) helping to alleviate financial distress on the DISCOMs; 4) creation of a positive alignment of solar generation with water irrigation time of use; 5) replacing the use of subsidized, imported diesel with the associated foreign exchange and reduced current account drain; 6) significantly enhancing India's 100GW-solar-by-2022 mission; 7) lessening the environmental impact; 8) expanding and diversifying farmer incomes and 9) providing a sustained domestic and, perhaps, even an export opportunity for system manufacturing under the government's "Make in India" campaign (IEEFA, 2018).

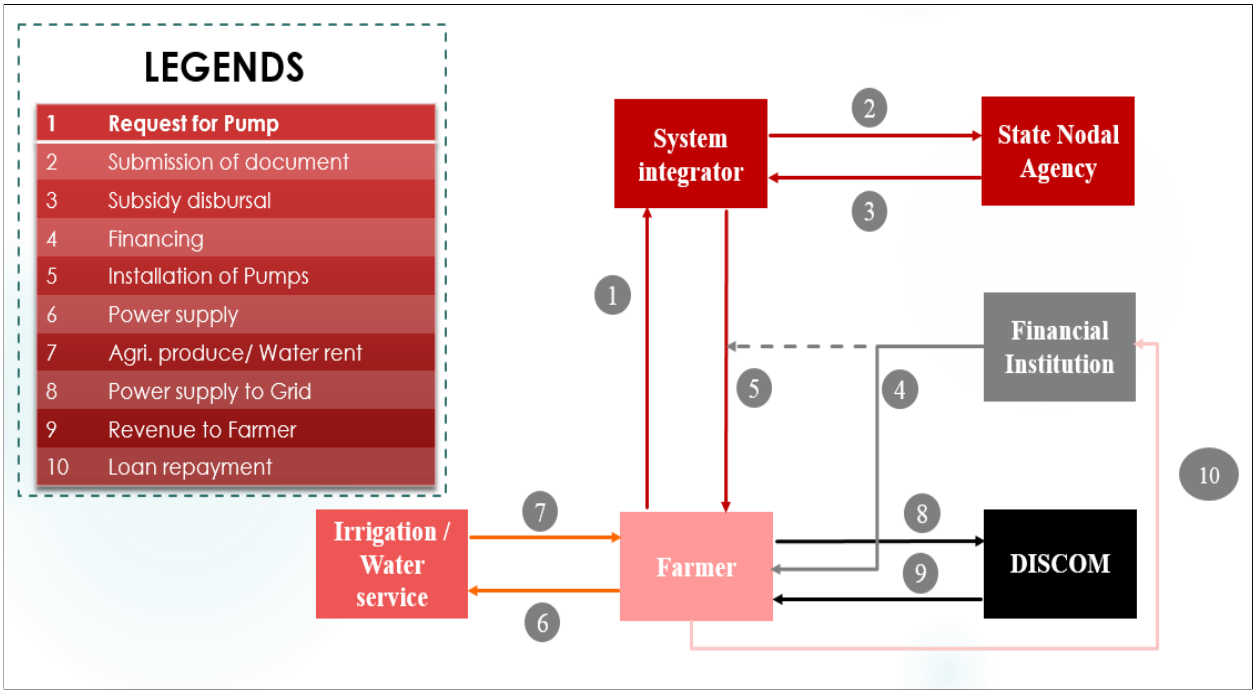


Figure 6.1: Key Stakeholders in SWP Irrigation and Their Interactions
Source: Grant Thornton, 2017

The use of proper farm equipment can increase the agricultural produce by up to 30 percent. Tractors account for a major percentage of farm mechanization in the agriculture sector in India, and their penetration has increased from one per 150 hectares to one per 30 hectares. Their penetration is lower with small and marginal segment farmers who own less than 5 hectares of land and this segment constitutes over 80 percent of the land holdings in India. So there is immense potential for increasing their penetration further (World Bank Group, 2017). There are various direct and indirect benefits of farm mechanization like decrease in workload on women as a consequence of improved efficiency of labor, and encouraging the youth to opt for farming as a career option.

Diesel tractors are a source of significant GHG emission and they have majorly contributed to the deteriorating air quality due to particulate emissions from the tail pipe during the preparation of farmland for planting and post-harvest activities. Agriculture tractors are widely used in rural areas and they use limited emission control technology. The emissions from the diesel engines are expected to be significant and have the potential to negatively impact the local air quality and health in India.

In the next section, existing policies, programs and low carbon growth strategies implemented by the government have been mapped for achieving sector-wide reduction in CO_2 emissions, followed by recommendations on the way forward for the agriculture sector for achieving India's NDC Goal 3 target.

6.2 Mapping Existing Program and Policies: Current Status of Implementation and Contribution in Goal 3

As discussed above, diesel and electric pump sets have been extensively used for irrigation purposes in India and they have accounted for substantial GHG emissions from the agriculture sector. Of late, diesel prices have been going through the roof and the grid supply in rural areas is highly unreliable due to frequent outages and high distribution costs. As a result, the government has tried to help the farmers by providing power subsidies in the agriculture sector, which has led to relentless groundwater extraction and wastage of electricity as there are no incentives to save either (CEEW, 2018). Subsidized electricity rates for farmers and un-metered electricity contribute hugely to the high losses in the power sector. So, focus needs to be laid on shifting to cleaner fuels that will not only help in reducing GHG emissions but will also increase the crop yield, helping, in turn, to achieve the NDC Goal 3 target set by India (Barnwal and Tiwari, 2008). Replacing inefficient irrigation pump sets with at least 4-star rated pump sets and promoting the adoption of precision water application devices like drips, sprinklers, pivots and rain-guns will result in significant emission reduction. Such measures will also improve the living standards of farmers by providing them reliable, predictable and affordable energy for irrigation, while scaling up of SWP installations will help address health, education, and gender issues in rural areas (IEEFA, 2018).

As discussed above, SWPs have significant potential. But a key barrier to their mass scale growth and adoption is their high upfront cost as compared to the conventional pumping options and the reluctance to accept new technologies; The GoI has been making tremendous efforts for encouraging farmers to install stand-alone solar-powered off-grid pumps to not only meet their irrigation demands but also to have an extra source of income by selling the surplus power generated to DISCOMs (Shah, 2009).

The thrust areas of the policies and programs at the national and state levels that impact irrigation in the agriculture sector in India are given in Fig 6.2.

- ***Replace inefficient irrigation pump sets with at least 4-star rated pump sets***
- ***Promote solar water pumps for micro-irrigation***
- ***Promote improvement in on-farm water use efficiency***
- ***Promote precision water application devices like drips, sprinklers, pivots and rain-guns in the farm***
- ***Promote extending irrigation coverage***
- ***Promote adoption of SWPs by selling surplus power to DISCOMs***
- ***Mandate use of energy-efficient irrigation pump sets***
- ***Subsidies on the adoption of solar pump sets***

Figure 6:2: Thrust Areas of National and State Level Policies and Programs

The status and contribution of various national and state level policies and programs in the agriculture sector along with their impact on NDC Goal 3 have been mapped in Table 6.2.

Table 6.2: Status and Contribution of Agriculture Sector Policies and Targets in NDC Goal 3

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
Jawaharlal Nehru National Solar Mission (JNNSM)	MNRE, State Nodal Agencies (SNAs), National Bank for Agriculture and Rural Development (NABARD)	**Target** • 100,000 SWPs per year • Total 1,000,000 solar pumps by 2020-21, through SNAs and NABARD	No information available	• 13,000 pumps installed in 2014-15 • 32,165 installed in 2015-16 • 53,044 installed in 2016-17 • 32,649 installed in 2017-18, however more than 96,000 pumps sanctioned • MNRE in 2017 closed the NABARD credit linked subsidy scheme	• Impact through reduced electricity and diesel demand and reduced peak demands thus reducing CO_2 emissions	175 GW RE Capacity by 2022 • 100 GW from Solar • Promotes replacement of existing diesel pumps with SWPs
National Energy Efficient Agricultural Pumps Programme (NMEEE)	EESL	**Target** • Replace an estimated 2.27 Cr pump sets used in the agriculture sector with BEE star rated smart pumps (more than 2,00,000 BEE star rated smart pumps to be distributed to farmers free of cost)	No information available	No information available	• Replace existing inefficient IP sets with at least 4-star rated pump sets Reduce or stop manufacturing of inefficient pump sets	• Result in annual energy savings of 46 BU, and GHG emission reduction of 45 MT of CO_2 annually.
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	Dept. of Water Resources and Dept. of Agriculture & Cooperation	**Target** • Expand cultivable area under irrigation • Enhance recharge of aquifers and introduce sustainable water conservation practice • Convergence of investment in irrigation at the field level • Expand cultivable area under irrigation- 'Har Khet ko Pani' • 'More Crop per Drop' focuses on improving on-farm water use efficiency to reduce wastage of water • Enhance the adoption of being precise in irrigation and other water saving technologies (more crop per drop)	INR 50,000 Cr for 5 years (2015-16 to 2019-20)	No information available	Replace existing inefficient IP sets with at least 4 star rated pump sets Reduce or stop manufacturing of inefficient pump sets	• Impact through reduced electricity and diesel demand thereby reducing CO_2 emissions

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM)	Central and State Govt. along with NABARD	**Target** • Component A - installation of 17.50 lakh standalone SWP • Component B - Solarization of 10 lakh grid-connected agriculture pumps • Component C - individual farmers will be supported to solarize pumps of capacity up to 7.5 HP • Farmers are to contribute 10% of the capital cost upfront; 30% to be covered by bank loan, 60% to be borne equally by a subsidy provided by the union and respective state governments	INR 1,40,000 Cr for over 10 years	No information available	• Impact through reduced electricity and diesel demand and reduced peak demands thus reducing CO_2 emissions	• Promotes replacement of diesel pumps and grid-connected electric tube wells with SWPs • Promotes a buy-back arrangement for surplus solar energy at a remunerative price • Eventually aims at ensuring every agricultural pump set to be solar powered
Soura Jalanidhi (SJ) scheme	State Government and OREDA	**Target** • In first phase, the facility will be available for those farmers where electricity is not available for operating pump sets • Govt. will give INR 54,000 per pump to farmers + farmers share INR 5,400 (self-finance or bank loan) for surface pump and INR 22,257 for submersible pump • Farmers having valid farmer-ID, belonging to small and marginal categories having minimum 0.5-acre cultivable land holding and a dug well will be covered under the program	INR 27.18 Crore	No information available	• Impact through reduced electricity and diesel demand and reduced peak demands thus reducing CO_2 emissions	

Scheme/Policies/ Initiatives	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3	Contribution to National Mission
Assam Solar Energy Policy, 2017	State Agriculture Department shall be the Nodal Agency for promotion and implementation of SWP systems in the State.	**Target** • Assam has set a target to promote 1200 SWPs for micro-irrigation and drinking water supply by 2019-20 • State of Assam shall provide a maximum subsidy up to 30% of the capital cost of the SWP system	No information available	No information available	• Impact through reduced electricity and diesel demand and reduced peak demands thus reducing CO_2 emissions	• State Government of Assam aims to fulfil its commitments under SDGs by promoting clean' accessible, affordable, and equitable solar energy
Suryashakti Kisan Yojana (SKY)	Gujarat Energy Development Agency (GEDA)	**Target** • This scheme envisages setting up of separate feeders for agricultural solar energy consumption • State and Central governments will give 60 % subsidy on the cost of project. The farmer is required to take 5% cost, while 35% will be provided to him as an affordable loan with interest rates of 4.5-6% • Scheme duration is 25 years, which is split between 7-year period and 18-year period • For the first 7 years, farmers will get per unit rate of INR 7 (INR 3.5 by GUVNL + INR 3.5 by state govt.). For the subsequent 18 years they will get the rate of INR 3.5 for each unit sold • Setting up of 137 agricultural feeders • 12,400 farmers from 33 districts will be covered under the pilot project	INR 870 Crore	No information available	• In Gujarat 26% of the total power is consumed by the agriculture sector • Doubling farmer's income and provide 12-hours power supply to farmers during the daytime	• Impact through reduced electricity and diesel demand and reduced peak demands, thus reducing CO_2 emissions

6.3 Methodology

The demand for diesel pumps has gone up in the past decade. A spreadsheet model has been developed by adopting IESS 2047 version 2.1 for forecasting the fuel consumption by diesel, electric and solar pump sets for irrigation in the agriculture sector and also estimating the reduction in their emission intensity by varying the share of types of pump sets and fuel split (fraction).

6.3.1 Assumptions

The energy demand model for the irrigation sector has been developed using various parameters. They include reduction in demand due to improvement in pump efficiency (percentage), pump ratings, annual hours of usage and emission factors of CO_2, CH_4 and N_2O for solid, liquid and gaseous hydrocarbons. These have been considered on the basis the IESS 2047 version 2.1.

An analysis has been carried out for new pump sets that have been installed after 2015. The number of pumps already installed by 2015 are stated below and they have been exempted from future projections:

- Diesel pumps = 1,90,00,000
- Electric pumps = 70,00,000
- Solar pumps = 13,000

Further, the detailed assumptions are provided in Annexure 6.1.

Scenarios: The analysis has been carried out by considering BAU and LCP scenarios as illustrated in Table 6.3:

Table 6.3: Scenarios Considered for the Analysis

New Pumps - Split by Fuel (%)			
Scenarios	Diesel	Electricity	Solar
Business as Usual (BAU)	70%	25%	5%
Low Carbon Pathway (LCP) 1	30%	30%	40%
Low Carbon Pathway (LCP) 2	15%	35%	50%
Low Carbon Pathway (LCP) 3	5%	35%	60%

For the analysis, we have considered the following scenarios:

- **BAU Scenario:** Under this scenario, no policy intervention or technological improvements were considered after 2015. On the basis of past fuel consumption pattern by agricultural water pump sets, the fuel spilt (fraction) has been considered in this scenario assuming it remains constant till 2030. The increase in demand for diesel and the increase in growth rate for pumping, have been considered on the basis of IESS 2047 version 2.1.

- **LCP scenario:** In the LCP scenario, the demand for pumping, the share of diesel, electric and solar pump sets, pump rating, hours of pump usage, the impact of various national level policies and programs (mapped) that promote penetration of solar and electric pumps were considered from 2015 to 2030, on the basis of the various scenarios considered in IESS 2047 version 2.1. The reduction in emission intensity has been achieved by adopting change in fuel split (fraction). The estimation of emission intensity and the reduction in emission for all the four scenarios have been carried out by adopting the methodology provided in Annexure 6.2.

The cumulative capital and operational cost of 5HP diesel, solar and electric water pump sets have been computed by using IESS 2047 version 2.1 and the methodology provided in Annexure 6.2. These costs are utilized to determine the additional incremental cost that will be incurred to achieve the emission reduction target for the agriculture sector proposed by IRADe's model. The results obtained are discussed in the next section.

6.4 Results and Discussion

Based on the above methodology, four policy scenarios were run for the agriculture sector. IRADe's Macro-model estimated the agriculture GDP and sector-wise target that needs to be achieved by 2030 to achieve the overall NDC goal: an emission intensity reduction target of 33-35 percent by 2030. Table 6.4 describes the sectoral targets for the agriculture sector.

Table 6.4: Emission Intensity Reduction Targets for the Agriculture Sector (estimated by IRADe's Macro-model)

Sector	Reduction target by 2030 (%)
Agriculture	28%

Most of the GHG emissions from this sector come from diesel pumps. The impact of various fuel split (percentage) on new pumps has been estimated to analyze the progress of this sector towards the NDC Goal 3. The results obtained from the analysis carried out for the agriculture sector are discussed below. The growth in GDP projected by IRADe's macroeconomic model for the agriculture sector is shown in Figure 6.3.

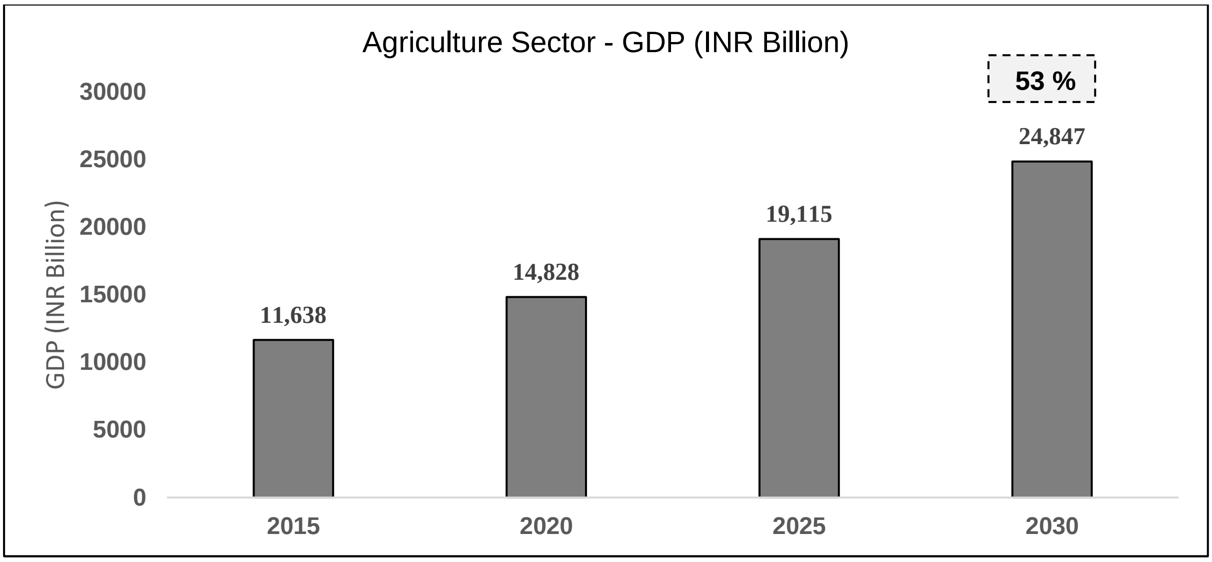


Figure 6.3: Agriculture Sector - GDP (INR Billion)

As can be seen in Figure 6.4 below, the demand for diesel in the agriculture sector has been increasing and will show the same increasing trend in the future as well if the same trend for diesel consumption continues.

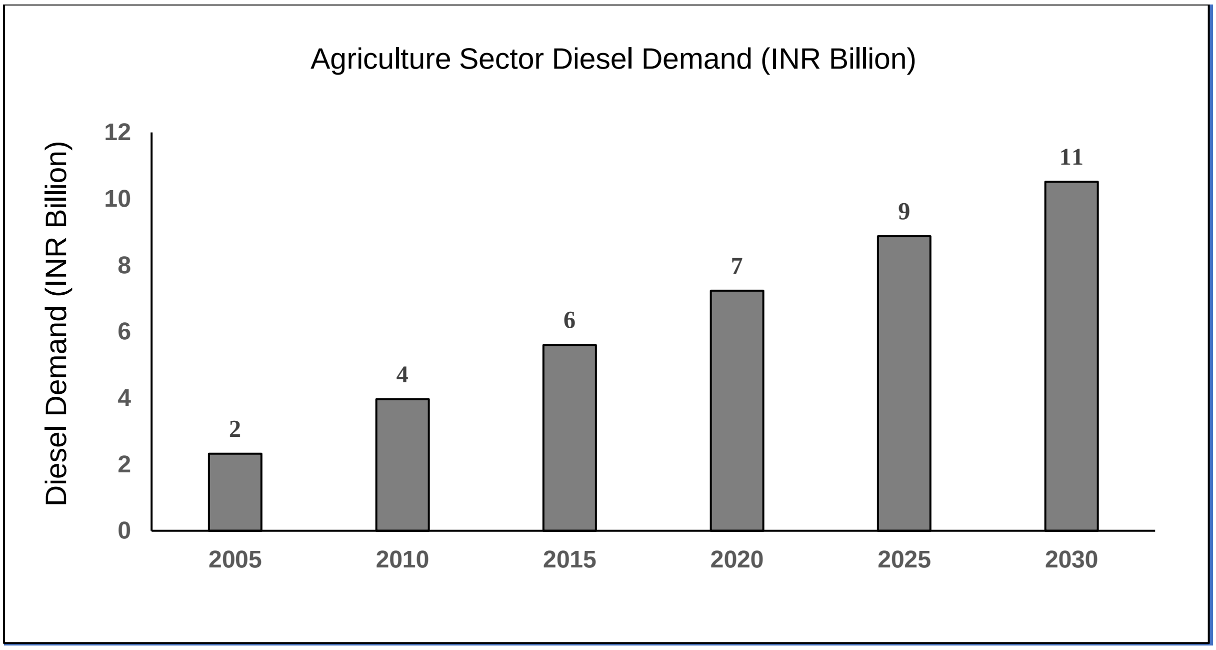


Figure 6.4: Agriculture Sector Diesel Demand (INR Billion) at 2007-08 prices

If the population continues to grow at an alarming rate in India, the demand for food will keep on increasing. As a result, the total demand of diesel for pumping will continue to increase till 2030 as shown in Figure 6.5:

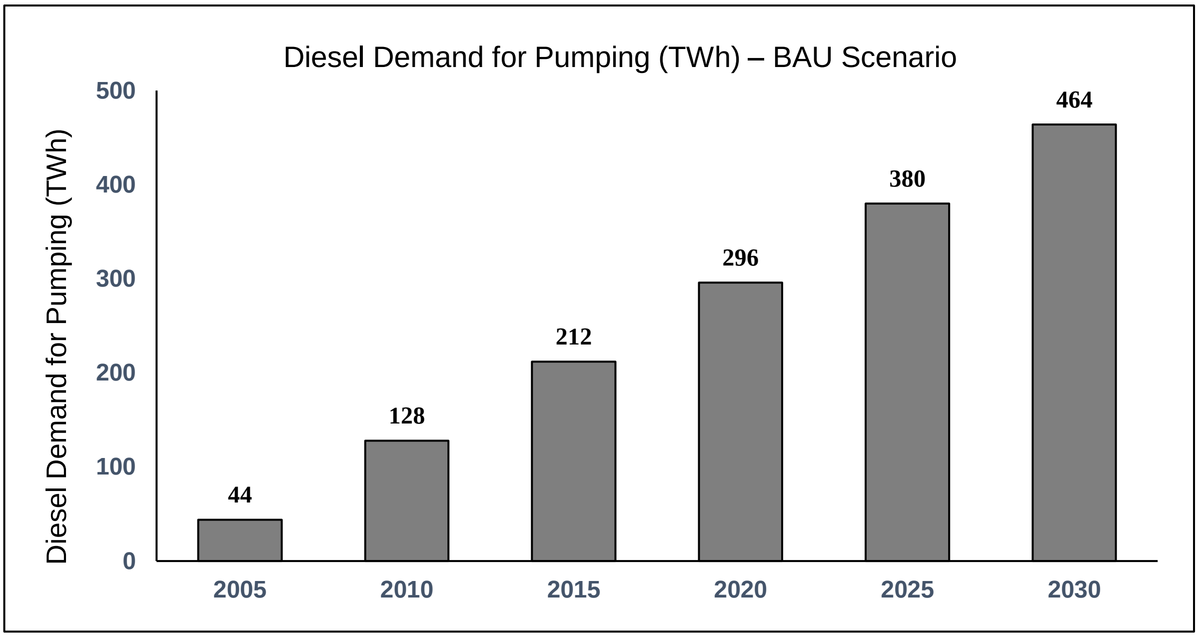


Figure 6.5: Diesel Demand for Pumping (TWh) – BAU Scenario

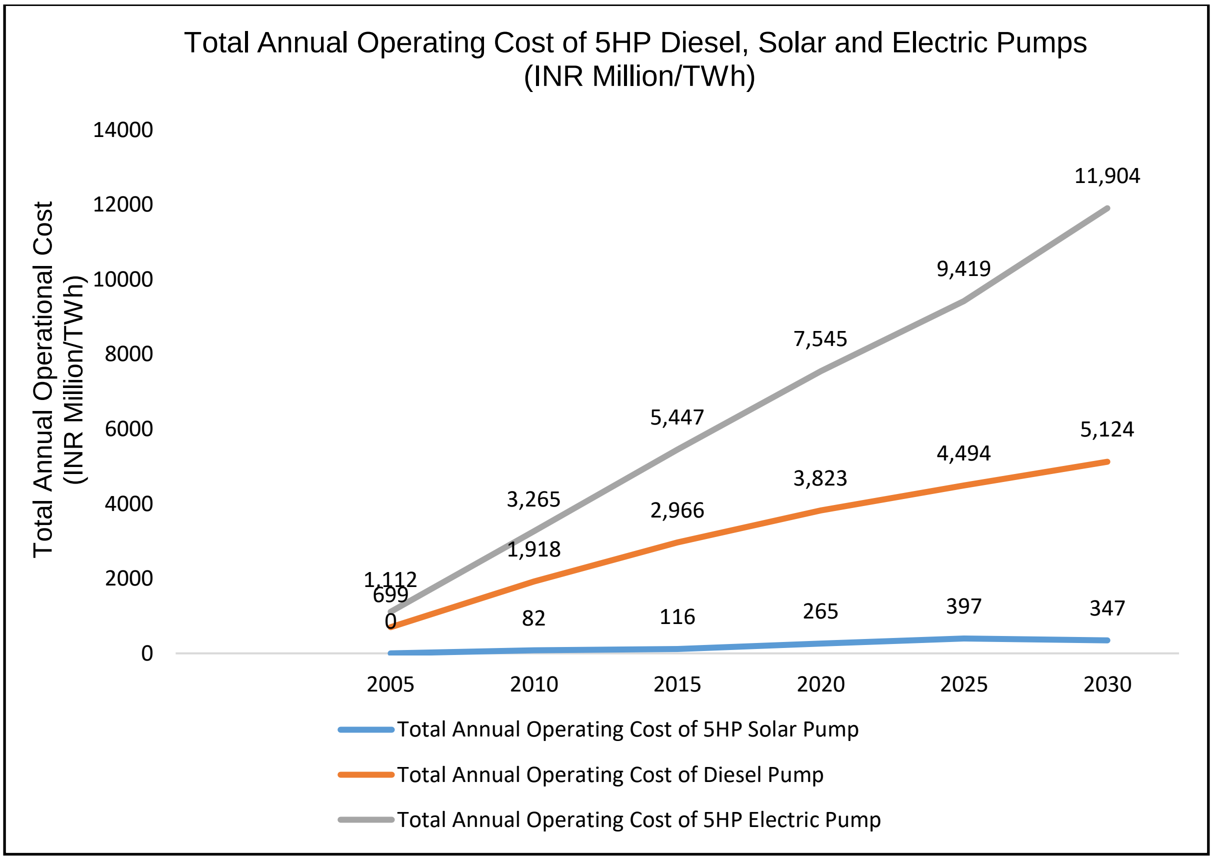


Figure 6.6: Total Annual Operating Cost of 5HP Diesel, Solar and Electric Pumps (INR Million/TWh)

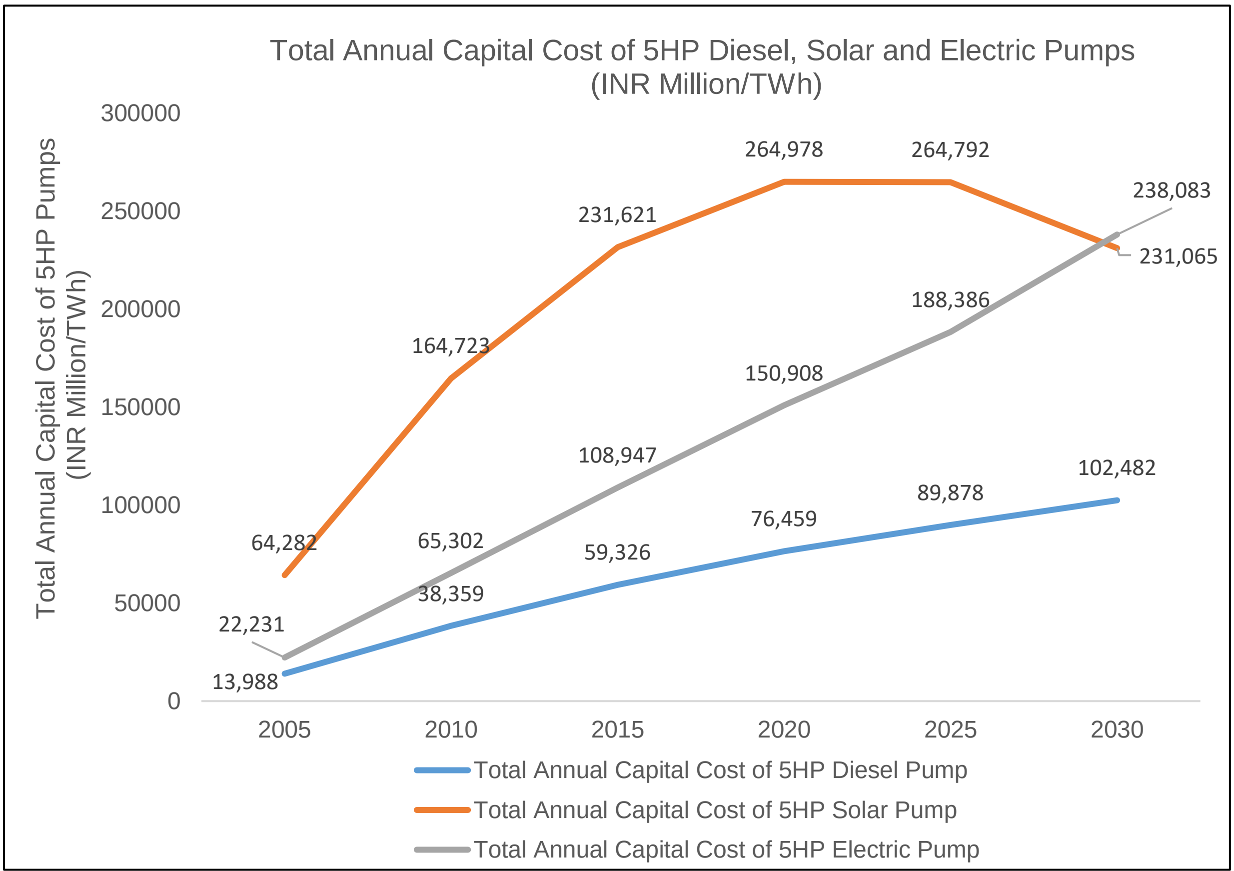


Figure 6.7: Total Annual Capital Cost of 5HP Diesel, Solar and Electric Pumps (INR Million/TWh)

The capital cost for the installation of water pumps is a one-time cost that is incurred initially. It comprises cost of the equipment and accessories, along with the cost of installation and cost of transport. The capital cost of SWP is high in comparison to fuel-powered pumping systems due to the high cost of solar modules, electrical wiring and associated installation services. In comparison, the capital cost of diesel and electric pumps is generally less as shown in Fig 6.6. The cost of the PV module has significantly reduced in the last ten years, making them very competitive in price, but they still contribute hugely to the high capital cost of SWPs.

Another reason for the high capital cost of electric pumps could be the location of the grid. At times, the connection to the grid may require the installation of poles and wires from the nearest grid supply point to the pumping location.

In case of SWP, the fuel and maintenance costs are very low. However, in the case of a diesel and electric pump, they continuously incur operational expenses which are impacted by the increasing fuel costs. They also incur additional labor and higher maintenance costs as shown in Fig 6.7. The percentage share of diesel pumps is set to increase at a rapid rate as compared to the total number of solar and electric pumps, as shown in Fig 6.8 below.

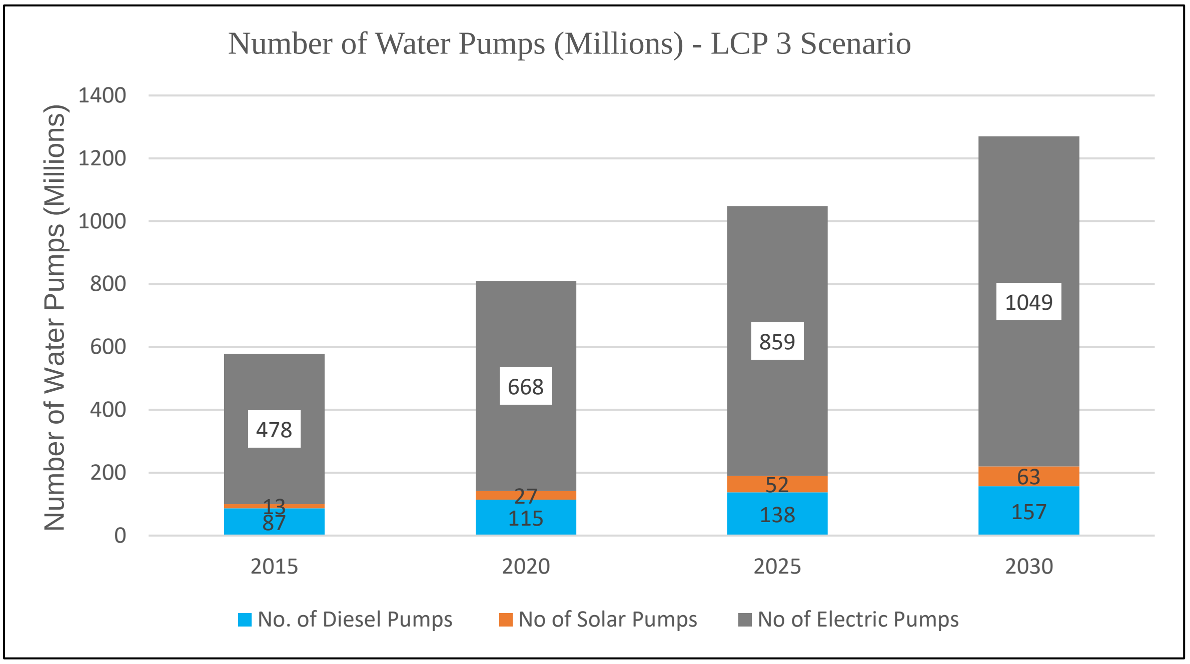


Figure 6.8: Number of Diesel, Solar & Electric Water Pumps (Millions) – LCP 3 Scenario

As shown in Fig 6.9 below, the best scenario out of the three LCPs that can help in achieving the target of NDC Goal 3 is LCP 3. This scenario promotes rapid electrification of existing water pumps and the adoption of SWPs for irrigation.

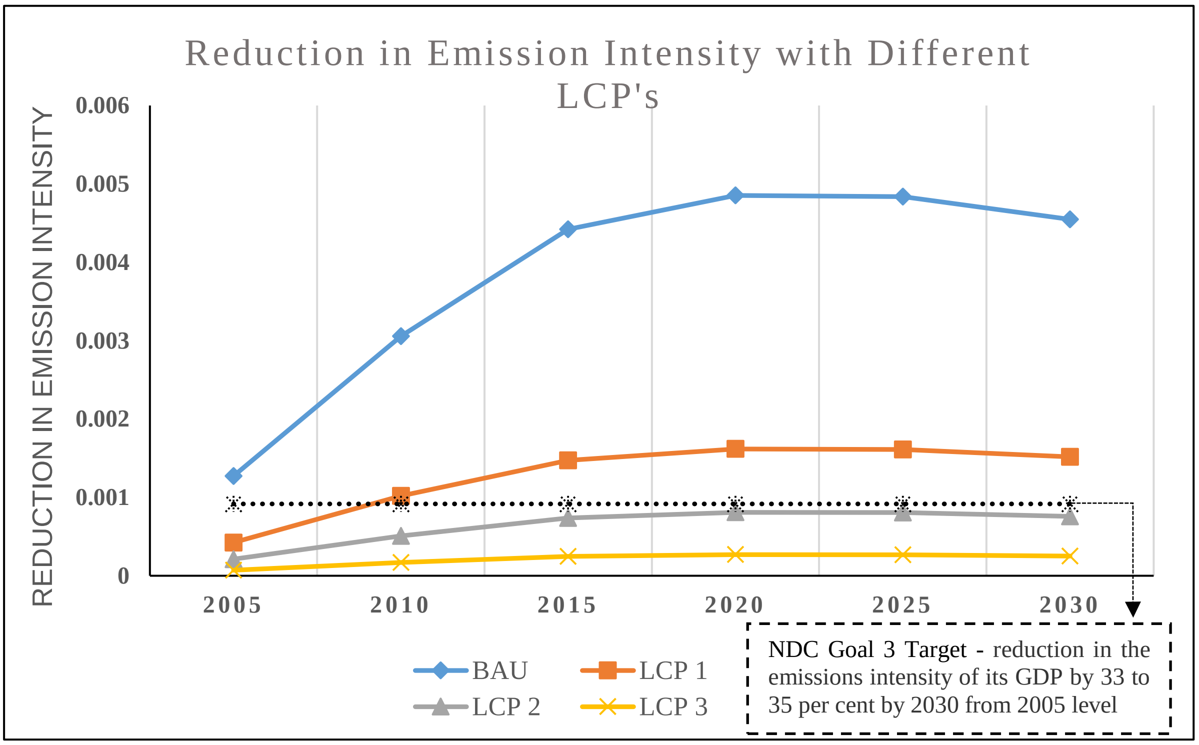


Figure 6.9: Reduction in Emission Intensity in the Agriculture Sector with Different LCP's for Achieving NDC Goal 3 Target (Base Year 2005)

The several benefits of adoption of SWPs to the end beneficiaries, i.e. the farmers, DISCOMs and the government are stated below:

- **Benefits to the farmer**
  - Farmers receive reliable daytime power
  - Farmers have secondary source of income by selling surplus power to the DISCOMs
  - Farmers are incentivized to use less power for agriculture
- **Benefits to the DISCOMs**
  - DISCOMs save upfront capital expenditure by providing only one main connection to the farmer cooperative
  - DISCOMs can claim RPO on the solar power generated
- **Benefits to the Government**
  - Fulfilment of RPO

6.5 Recommendations

Indian agriculture is dependent on the monsoon as a source of water for various agricultural activities. Therefore, a shortage or failure of monsoon in any particular year results in below average crop yield, adding to farmer's distress--particularly in drought prone areas like parts of Maharashtra, Karnataka, Andhra Pradesh, Odisha, Gujarat, Madhya Pradesh, and Rajasthan where there is a visible impact.

Though we have assessed reduction in emissions from irrigation pumps alone, other policies help reduce water use and the need for pumping, thereby reducing energy further. The adoption of various energy efficient irrigation techniques that aid in efficient and minimum usage of water in agriculture have been suggested below. These techniques help to maintain an optimal crop productivity rate while reducing GHG emissions from the agriculture sector.

- **Micro-irrigation** – This technique comprises drip and sprinkler systems and involves frequent application of small quantities of water directly above and below the soil surface--usually as discrete drops, continuous drips or tiny streams through emitters placed along a water delivery line through low pressure delivery. It has become the method of choice for increasing rice production with reduced water demand and increased water productivity.

  The states of Maharashtra, Rajasthan, Gujarat, Haryana, Bihar, Karnataka and Andhra Pradesh are drought prone areas and are also amongst the leading states having high potential of micro-irrigation in India. Therefore, with proper planning and implementation micro-irrigation can provide major relief to drought prone areas of the country. It can help in saving water, increase yield, help to irrigate marginal lands and ultimately help in saving energy.

- **Rainwater Harvesting –** This technique involves the collection and storage of rainwater at the surface or in sub-surface aquifers before it is lost as surface runoff. The water from these resources can be harvested whenever needed. This technique does not allow the rainwater to drain away and cause floods. This technique also helps to improve the ground water quality, decrease salinity and improves the ground water table, thus saving energy to lift water. The cost of recharging subsurface aquifers is lower than surface reservoirs. The subsurface aquifer also serves as a storage and distribution system. No land is wasted for storage purposes and no population displacement is involved. Thus, storing water underground is environment friendly.

- **Recharging of Aquifers Artificially –** It can be done by adding rainwater to underground water reservoirs which enables communities to continue farming for more than half of the year. The non-saline rainwater when mixed with the underground saline water brings down the salinity of the groundwater, making it fit for agricultural use. The system also enables one to lift and use the stored water during dry spells. The massive underground reservoir can hold as much as 40 million liters of rainwater. It harvests water for about ten days in a year and can supply water for as long as seven months. These wells can hold up to two crore liters of rainwater.

- **Mulching –** It involves the spreading of organic material like straw, sawdust, grass clippings, peat moss, leaves, or paper on the ground to protect the soil and the roots of plants from the effects of soil crusting, erosion, or freezing. It helps to improve nutrient and water retention in the soil, encourages favorable soil microbial activity and worms, and suppresses weed growth.

- **Develop a One-Window Online Application Platform for Electric/SWPs--** This can cater to the needs of suppliers and vendors, as well as target end-beneficiaries. Suppliers would access the eligibility criteria for pumps as well as the necessary technical assistance and support to get empaneled and participate in the tender. Farmers would be able to access details about pump types on offer, their suitability criteria, enlisted vendors, their service networks, etc. Other than the current set of questions, the application form should also include self-reporting of essential characteristics such as distance of the farm from the grid, and the number and types of existing pump sets in use.

- **Focus on Policy Convergence at the State Level** - Farmers should get access to information on multiple allied policies during the time of application, and they should be able to apply for any of them through one window.

- **Availability of Variety of Pump Sizes for Selection** - Based on the farmers' need, there should be a variety of pump sizes to choose from. Low levels of awareness and access to the scheme for farmers owe partly due to inadequate demand generation efforts on the part of state nodal agencies.

- **Electrification of Water Pumps** - Farmers with no water pumps should be targeted to adopt electric water pumps in order to maximize CO_2 emission reduction from the agriculture sector. Also, promote shifting to electric pumps from diesel pumps; the conversion from diesel-driven to electric pumps will improve pumping efficiency and reduce costs.

- **Solar Water Pumps (SWPs)** - Promote switching to SWPs in rural areas with no power grid connectivity or where it is cumbersome to carry gasoline or diesel to feed a pump. The existing MNRE policies need to adapt to the current beneficiary needs. Improvements to the current policy may include targeting/prioritizing end beneficiaries and locations that would benefit most from the policy. Currently, the majority of SWPs are owned by electric pump farmers (44 percent). The focus needs to be shifted to diesel farmers who have high operational expenses.

  Promote solar energy as a remunerative cash crop by involving DISCOMs. Farmers can earn additional income from energy sales. A detriment is the high upfront capital cost of SWP's which makes them expensive for farmers. Promote SIPs as an integrated energy-water livelihoods solution and persuade farmers, state governments and DISCOMs to promote the adoption of solar water pumps aggressively. Set up standalone solar micro-grids and promote capital subsidy schemes. The intended beneficiaries from the adoption of SWP'S are state DISCOMs, state electricity departments, state electricity regulatory commissions, state transport authorities/ planning division, farmers, and consumer. In rural areas of India, where there is no power grid or it is cumbersome to carry gasoline or diesel to feed a pump, switching to solar pumps is the best choice for powering pumps. Focus should be laid on states with less than 7-8 hours of electricity availability on a day-to-day basis. Land sizes for SWP farmers vary from 2-7 hectares and require different pump sizes, instead of the current one-size-fits-all policy. Also, explore group or community ownership models for farmers with adjacent lands to share water.

- **Promote Integration of SWPs with Drip Irrigation Systems –** It will result in improved agricultural returns per additional drop of water.

- **Upgrade Farmer Capabilities and Change Behaviors** - for improved utilization of new farm technologies.

- **Tracking Pump Installations and their Operations –** At the state level, remote tracking of electric and SWP installation and operations should be done by using GPS-enabled chips. Also, a designated helpline number and task force for farmer complaints should be established.

- **Build Awareness** - Build confidence amongst farmers by showcasing working installations of electric/SWPs.

- **Customer Assurance on Performance and Services -** The pump should deliver as promised. The farmer can plan to manage irrigation with an alternate source during winter or foggy seasons when solar output would get affected. They should be aware about performance inconsistencies.

- **Quick Resolution for Technical Issues with SWPs** - Local technicians generally cannot service SWPs. The solution provider needs to ensure that any technical issue with the SWP gets addressed quickly as water is critical for the crops.

  Primary technical know-how should be imparted to the farmers for carrying out basic repair and maintenance work. Proper maintenance of these pumps can help to keep the water yield consistent and extend the lifecycle of the product. Regular cleaning of panels, checking wires, cleaning pipes and replacing inverters (every 8-10 years) can help ensure the high investment in SWPs pays back the farmer over its entire guaranteed lifetime of 25 years. The farmer should be able to identify times of the day when solar irradiation is maximum and move the panels to track the sun's movement (in case the PV panels are of the manual tracking type) , and to install appropriate add-on technologies such as water tanks and irrigation systems that can improve the use of water drawn by the pumps.

7. Roadmap for implementation of India's NDC Goal 3

7.1 Current Programs and Policies

The study aims to assess all current programs and policies for each sector of India's economy and outline various sectoral factors that influence the achievement of INDC Goal 3 i.e. 33 – 35 percent reduction in emissions intensity in 2030 as compared to 2005 at the national level and also to build a roadmap stating the changes/ additional policies, factors and financial costs that are required to achieve the set target.

7.1.1 Sectoral Study

So far we have discussed the various feasible technological interventions in the power, transport, industry, and agriculture sectors as they together contribute to around 67 percent of India's GHG emissions from energy use in 2014 (including LULUCF). The sectoral chapters outline the current policies or programs announced by the GoI and/ various state governments, as well as sector-specific technological interventions and policies that could be applicable in the future for achieving India's NDC Goal 3 target.

The status of current programs and levers that can impact the INDC Goal 3 target has been assessed and it was found that the programs and policies already implemented fall short of achieving sectoral emissions intensity reduction targets which are required to achieve the overall NDC goal 3 target at the national level. Now the next question is that are the current programs and levers sufficient for achieving the NDC Goal 3 target, or, would they enable us to over-achieve target?

7.1.2 Emissions Reduction for Achieving NDC Goal 3

In this chapter, we integrate sectoral actions with the national target of meeting INDC Goal 3. Out of all the sectoral policies and programs identified in the previous chapters, we have listed out 39 of them that are likely to have maximum impact on the NDC Goal 3 in decreasing order of magnitude of emission intensity reduction and are given in Table 7.1. These policies and programs are currently being implemented by the GoI alone. We have given their current status and emissions reduction potential in 2015 and 2030, compared to 2005.

Mostly, the reduction potential for many of these programs and policies were available from GoI documents. However, for some programs, like those related to the industry, agriculture, transport, and energy efficiency (PAT 3, 4, and 5), the CO_2 mitigation potential has been calculated based on a spreadsheet analysis.

However, in some cases, no explicit targets are mentioned, and so no numeric computation of emissions reduction potential was possible. The methodology applied to estimate the contribution of policies, schemes, and interventions to emissions intensity reduction is provided in Annexure 7.1. The value of emissions intensity reduction is calculated based on equation (Eq.) 6 in Annexure 7.1. and is provided in the last column in the table.

It is evident from the table that the power sector programs can majorly contribute towards achieving maximum emissions reduction, followed by policies under the National Mission for Energy Efficiency (NMEE) and finally followed by policies under the sustainable habitat mission which includes smart cities and transport policies.

Table 7.1: Climate Policies, Current Status and Emissions Reduction Potential in 2030

S. No	Scheme	Sector	Nodal Agency	Implementat-ion Agency	Status of CO_2eq Savings (MT/annum) (∆EMt)		Emission Intensity Reduction in % compared to 2005 levels (∆CIt)
					Present Status	2030	
1	175 GW Renewable Energy by 2022	Power	Ministry of New and Renewable Energy	MNRE, State Governments, DISCOMs	113	268	3.19%
2	275 GW Renewable by 2027	Power		MNRE, State Governments, DISCOMs	Yet to be impleme nted	153	1.82%
3	6.8 GW of Nuclear Capacity Addition by 2027	Power	Ministry of Power	Department of Atomic Energy		49	0.58%
4	12 GW of Hydro Capacity Addition by 2027	Power		Central Electricity Authority		43	0.51%
5	3.3 GW of Nuclear Capacity Addition by 2022	Power		Department of Atomic Energy		24	0.29%
6	6.8 GW of Hydro Capacity Addition by 2022	Power		Central Electricity Authority		24	0.29%
7	Clean Coal Technology: Super Critical Power Plants	Power		Central Electricity Authority	20	Not Availab le	

S. No	Scheme	Sector	Nodal Agency	Implementation Agency	Status of CO2eq Savings (MT/annum) (∆EMt)		Emission Intensity Reduction in % compared to 2005 levels (∆CIt)
					Present Status	2030	
8	Renovation and Modernization of Existing Thermal Power Stations	Power		Central Electricity Authority	Not Available	Not Available	
9	Integrated Power Development Scheme (IPDS)	Power		Power Finance Corporation	Not Available	Not Available	
10	National Smart Grid Mission (NSGM)	Power		Power Grid Corporation of India	Not Available	Not Available	
11	Ujwal DISCOM Assurance Yojana (UDAY)	Power		Rural Electrification Corporation Limited	Not Available	Not Available	
12	Bachat Lamp Yojana (BLY)	Power		Bureau of Energy Efficiency	Completed	Not Available	
13	Smart Meter National Program	Power		Energy Efficiency Services Limited	Not Available	Not Available	
14	Renovation & Modernization, Uprating and Life Extension (RMU&LE) of Hydro Power Plants	Power		Central Electricity Authority	Not Available	Not Available	
15	Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM)	Power/ Agriculture	Ministry of New and Renewable Energy	State Nodal Agency, DISCOMs	Yet to be implemented	Not Available	
16	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	Agriculture			Not Available	Not Available	

S. No	Scheme	Sector	Nodal Agency	Implementation Agency	Status of CO2eq Savings (MT/annum) (ΔEMt)		Emission Intensity Reduction in % compared to 2005 levels (ΔCIt)
					Present Status	2030	
17	India Cooling Action Plan	Household/ Industries			Not Available	Not Available	
18	National Mission for Energy Efficiency					557	6.63%
19	Standards and Labelling program for appliances	Power/ Households	Ministry of Power	Bureau of Energy Efficiency	38	172	2.05%
20	Unnat Jyoti by Affordable LEDs for All (UJALA)	Power/ Households	Ministry of Power	Energy Efficiency Services Limited	35	93	1.11%
21	Solar AgDSM	Power/ Agriculture		Energy Efficiency Services Limited	Not Available	45	0.54%
22	PAT Cycle -1	Power/ Industries		Bureau of Energy Efficiency	31	31	0.37%
23	PAT Cycle -2	Power/ Industries		Bureau of Energy Efficiency	30	30	0.36%
24	Energy efficiency in Buildings	Power/ Households		Bureau of Energy Efficiency	1	11	0.13%
25	Street Light National Program (SLNP)	Power		Energy Efficiency Services Limited	4	6.5	0.08%
26	Municipal Energy Efficient Program (MEEP)	Power		Energy Efficiency Services Limited	Not Available	3.9	0.05%
27	PAT Cycle -3	Power/ Industries		Bureau of Energy Efficiency	Not Available	3	0.04%
28	PAT Cycle -4	Power/ Industries		Bureau of Energy Efficiency	Not Available	2	0.02%

S. No	Scheme	Sector	Nodal Agency	Implementation Agency	Status of CO2eq Savings (MT/annum) (ΔEMt)		Emission Intensity Reduction in % compared to 2005 levels (ΔCIt)
					Present Status	2030	
29	PAT Cycle -5	Power/ Industries		Bureau of Energy Efficiency	Not Available	1.5	0.02%
30	National Energy Efficient Agricultural Pumps Program (NMEEE)	Power/ Agriculture			37	Not Available	
31	National Mission on Sustainable Habitat					133	1.58%
32	Atal Mission on Rejuvenation and Urban Transformation (AMRUT)	Transport/ Buildings	Ministry of Housing and Urban Affairs				
33	Swachh Bharat Mission	Waste Management	Department of Drinking Water and Sanitation and Ministry of Housing and Urban Affairs	Ministry of Housing and Urban Affairs			
34	Smart Cities Mission	Power/ Transport/ Buildings	Ministry of Housing and Urban Affairs				
35	Urban Transport Program						

S. No	Scheme	Sector	Nodal Agency	Implementation Agency	Status of CO2eq Savings (MT/annum) (ΔEMt)		Emission Intensity Reduction in % compared to 2005 levels (ΔCIt)
					Present Status	2030	
36	Auto Fuel Policy (Standards & Fuel Specification)	Transport			16	136	1.62%
37	Shift to Rail Transportation (Passenger and Freight)	Transport			0	102	1.22%
38	Shift to Public Transportation in Road	Transport			0	56	0.67%
39	Electric Vehicles	Transport/ Power			1	32	0.38%
Total						1251	14.90%
	Reduction in Emissions Intensity from 2005 Achieved Up To 2015						21.00%
	Emissions Intensity Reduction from 2015-2030 due to Costless Energy Efficiency of 5% through autonomous energy efficiency increase (AEEI)						7.24%
	Emissions Intensity Reduction in 2030 due to Current Government Schemes and Programs (after 2015)						15%
	Total Reduction in Emissions Intensity Reduction by 2030						43%

7.1.3 Emissions Reduction Achieved So Far

As per the MOEFCC's Second Biennial Update Report (BUR), between 2005 to 2015, India achieved a reduction in the emissions intensity of GDP by 21 percent. Some amount of emissions intensity reduction has been happening due to an autonomous energy efficiency increase (AEEI) reduction of 0.5 percent per year.

7.1.4 Emissions Reduction for Baseline Scenario in 2030

The emissions intensity of GDP in 2030 in the baseline case (without any interventions) should be emissions intensity reduction achieved up to 2015 plus emissions intensity reduction due to AEEI, which accrue automatically without cost to the economy from 2015 to 2030. Thus, in the baseline case, emissions intensity reduction of 21 percent + 1-(1-0.005)15 = 28 percent will be achieved.

The aggregate reduction that can be obtained by the successful implementation of all the schemes is 1251 MT of CO_2 eq provided in the entry for column '2030' in the row for 'Total'. Dividing the ratio of aggregate emissions reduction to GDP by the emissions intensity of 2005 (substituting 1251 for ΔEM_{2030} in Eq. 6 in Annexure 7.1) gives an additional emissions intensity reduction of 0.1490.

Thus, if all the policies and programs of the GoI are implemented, the economy is likely to see an emissions intensity reduction of 0.1490, or 15 percent additional reduction in 2030, over and above BAU. In total, if all the policies and programs of the GoI are implemented, the economy is likely to see an emissions intensity reduction of 0.2824 + 0.1490= 0.4314, or, a 43 percent (substituting Eq. 5 and Eq. 6 in Eq. 4 of annexure 7.1) reduction.

The emissions intensity reduction achieved in 2030 will be more than our objective of achieving a 33 -35 percent emissions intensity reduction by 2030 compared to 2005 (if all the policies and programs of the GoI are implemented). However, each mitigation intervention has its own cost implication and is constrained by its mitigation potential. Given the cost implication of various measures, it is important to prioritize interventions that help us reach the target of NDC Goal 3 at the least cost.

7.2 Technological Roadmap for Achieving India's NDC (INDC) Goal 3

In this section, we have developed a roadmap of technological interventions that will help us in achieving the INDC Goal 3 target with the least cost to the economy.

7.2.1 Scenarios

To assess the impact of various technological interventions on INDC Goal 3, we have developed three scenarios:

(i) Business As Usual (BAU) Scenario

The current policies, programs, and interventions that are being implemented have been given in Table 7.1 and they have been assumed to be a part of the BAU scenario.

(ii) Baseline Scenario

The policies, programs, and interventions that have already been implemented and have resulted in emission intensity reduction achieved up to 2015 are given in Table 7.2; they have been assumed to be a part of the baseline scenario.

(iii) Low Carbon Interventions

All other future policies, programs, and interventions that have been identified are considered under low carbon interventions.

7.2.2 MACC for Achieving India's NDC Goal 3

A marginal abatement cost curve (MACC) has been plotted and is shown in Figure 7.1, it showcases the contribution of each technological intervention towards the achievement of emission intensity reduction in 2030 as compared to 2005, the total costs in billion INR have been plotted on the Y-axis, and the reduction in emission intensity as compared to 2005 in Kg/INR has been plotted on the X-axis.

All the policies, programs, and interventions identified for each sector under the three scenarios mentioned above have been arranged in increasing order of their cost and are plotted under the combined marginal abatement cost curve (MACC) for the whole economy. It helps us identify the additional measures required for achieving the INDC Goal 3 target. Some measures with higher costs have been placed prior to the MACC as they need to be implemented first. For example, 175 GW of RE has a higher cost than the additional 100 GW leading to 275 GW of RE capacity.

The study of the marginal abatement cost curve (MACC) that has been generated and is showcased in Figure 7.1 shows the following:

- The first dotted line in the MACC shows a reduction in emission intensity up to 2015.
- The distance in the X-axis between the first and second dotted lines shows the emissions intensity reduction by 2030 due to costless autonomous energy efficiency of 0.5 percent per year from 2015-2030.
- The distance between the second and third dotted line gives the contribution of various programs, policies, and interventions (listed in Table 7.2) towards emissions intensity reduction.
- The total distance on the X-axis up to the third dotted line shows that a total of 32 percent reduction of emission intensity would be achieved under the BAU scenario in 2030.
- The rectangular bars in between the third and fourth dotted lines showcase the additional policies and interventions that are needed to achieve the 33 percent emissions intensity reduction in 2030 compared to 2005.

- The rectangular bars in between the third and fifth dotted lines showcase the additional policies and interventions that are needed to achieve 35 percent emissions intensity reduction in 2030 compared to 2005.

Table 7.2: Current Policies Already Under Implementation

Sector	Power	Industries	Transport	Agriculture
Policies	175 GW RE by 2022 Super Critical Power Plants PAT Cycle -1 (2012-15) Street Light National Programme (SLNP) UJALA Solar AgDSM	PAT Cycle - 1 (2012-15) PAT Cycle - 2 (2015-19)	Vehicle Fuel Efficiency India 2000 Bharat Stage 2 and 3	73% Diesel, 27% Electric Pumps
Emissions (GHGs) inventories in MOEFCC Second BUR 2014	1083438	201723	250173	2383
Share in Total with LULUCF	47%	9%	11%	0.1%

7.2.3 Achieving India's NDC Goal 3 at the Least Cost

The cost implication of various interventions needs to be taken into account while prioritizing, i.e. those measures that can help us achieve the NDC Goal 3 target at the least cost need to be given priority. Some of them are given below:

- Energy efficiency (EE) programs have a huge reduction potential, however, they have high costs involved. This is because the cost of information for the sub-schemes of EE programs was not available. The cost information is from "ROSHANEE- Roadmap of Sustainable and Holistic Approach to National Energy Efficiency" BEE (2019). However, some of these schemes can be very cost-effective.
- India is likely to achieve a 28 percent emission intensity reduction in 2030 compared to 2005 due to costless Energy Efficiency alone.

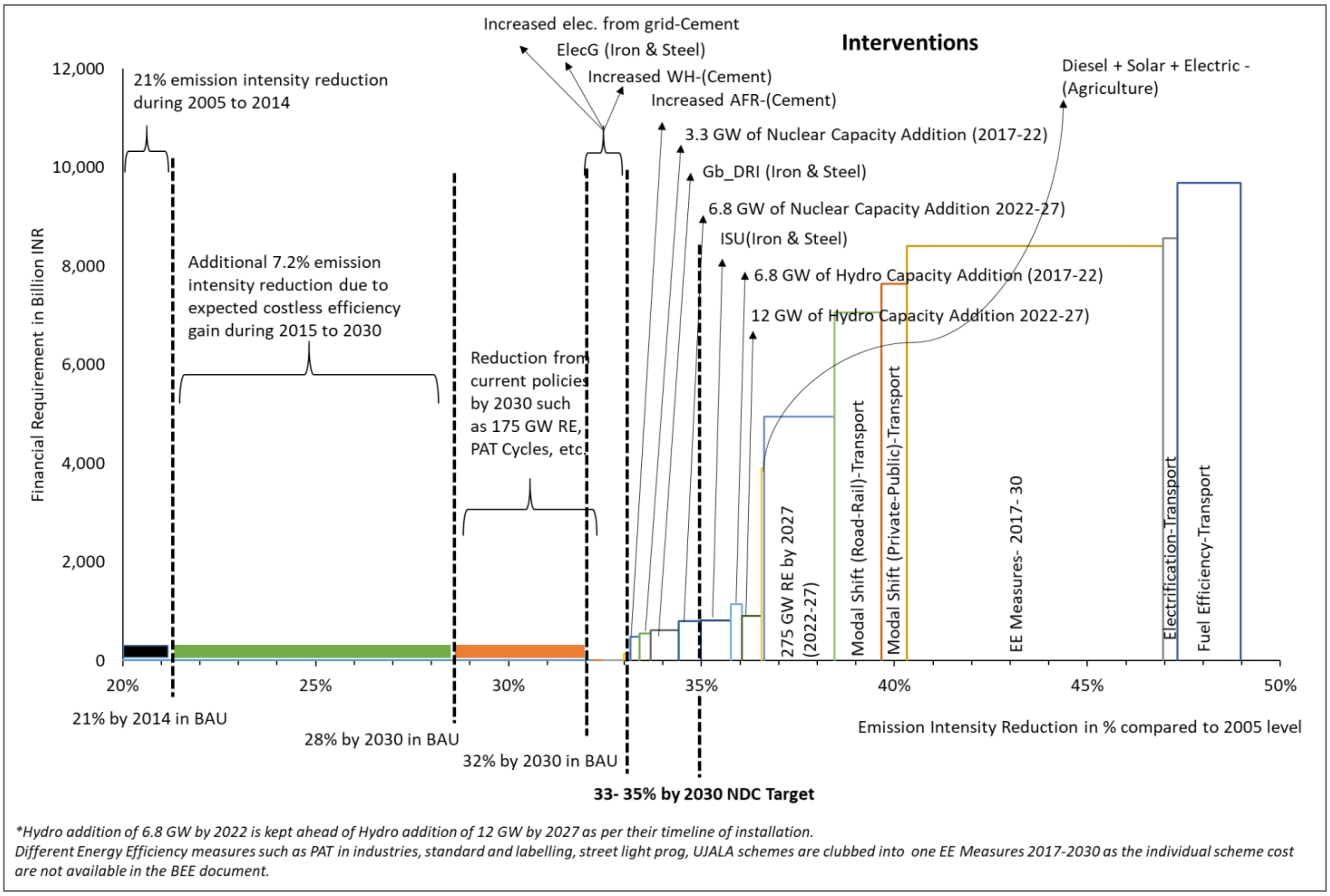


Figure 7.1: MACC for Achieving India's NDC Goal 3

7.2.4 Incremental Actions

The various government programs and policies that are already being implemented would reduce emissions intensity additionally to 32 percent in 2030. As a result, only a very narrow gap needs to be covered up. Some additional measures and/ technological interventions are given below:

- Increased electricity from the grid for cement and iron and steel
- Increased waste heat recovery and
- Increased alternate fuel resources in the cement industry

To further achieve 35 percent emissions intensity reduction, the following incremental actions may be implemented:

- Nuclear capacity additions
- Gas-based Direct Reduced Iron and
- Increased scrap utilization (ISU) technologies in iron and steel

Table 7.3: Incremental Action and Policies and Nodal Agencies to Implement Them

S. No	Incremental Action	Implementing Measure	Sector	Nodal Agency	Implementation Agency
1	Waste Heat Recovery - Cement	- Increased PAT targets	Industry	MoP	BEE
2	Switch to Grid Electricity - Cement	- Reliable power supply- Tax rebate on electricity usage from the grid		MoP/ Ministry of Finance	DISCOMs, State Governments, MoP
3	Alternate Fuel Resources - Cement	- Better SWM practices to ensure reliable and cost-effective supply of wastes to industries - Increased PAT targets		MoP, MoEFCC	MoP, MoEFCC, BEE, Municipalities/ Urban Local Bodies
4	Gas-based Direct Reduced Iron - Iron and Steel	- Availability of gas to industries			MoP&NG, BEE
5	Increased Scrap Utilization - Iron and Steel	- Increased PAT targets- Better organization of the scrap industry and converting it into a formal sector			Ministry of Steel, MoP, BEE
6	Switch to Grid Electricity - Iron and Steel	- Reliable power supply- Tax rebate on electricity usage from the grid			Ministry of Finance, DISCOMs, State Governments, MoP
7	275 GW Renewable by 2027	- Increasing RE target	Power	Ministry of New and Renewable Energy	MNRE, State Governments, DISCOMs
8	6.8 GW of Nuclear Capacity Addition by 2027	- Increasing Nuclear Target - Ensuring availability of Nuclear fuel for planned plants		Ministry of Power	Department of Atomic Energy
9	12 GW of Hydro Capacity Addition by 2027			Ministry of Power	Central Electricity Authority
10	3.3 GW of Nuclear Capacity Addition by 2022	- Increasing Nuclear Target - Ensuring availability of Nuclear fuel for planned plants		Ministry of Power	Department of Atomic Energy
11	6.8 GW of Hydro Capacity Addition by 2022			Ministry of Power	Central Electricity Authority
12	Increasing the coverage of PAT Scheme	- Sectors like Transport, Port Trust, Sugar, Chemicals and Small, and Medium Industries, may be added under PAT coverage		Ministry of Power	Bureau of Energy Efficiency

Table 7.3 above provides a list of incremental actions as illustrated in Figure 7.1. It also lists the measures required to achieve those incremental actions and the nodal and implementing agencies for taking the required measures.

The analysis to identify the incremental actions to implement NDC Goal 3 has been based on current costs and proven technologies and measures. However, these priorities can change with disruptive technologies like pumped hydro storage, improved battery storage, hydrogen-based transport, and EVs with higher km per charge compared to conventional vehicles.

7.3 Recommendations and Conclusions

The various sectoral policies and technological interventions have been studied that could help in achieving India's NDC Goal 3. We now summarize the major actions that are needed.

1) Current policies and programs like 175 GW RE by 2022, PAT 1, PAT 2, SLNP, UJALA, vehicle fuel efficiency, Bharat Stage 2 & 3 would themselves help the economy reach an emissions intensity reduction of 32 percent compared to 2005. These policies need to be implemented effectively so that their target reduction in emissions are realized on time.
2) To reach 33 percent emissions intensity reduction, additional interventions like increased electricity from the grid for cement and iron and steel, increased WHR, and AFR in the cement industry need to be implemented.
3) Nuclear capacity additions of 3.3 GW during 2017-22 and 6.8 GW during 2022-2027, Gb_DRI and ISU technologies in iron and steel can lead to a total emissions reduction of 35 percent.
4) Further policies such as ISU, the hydro capacity of 6.8 GW from 2017-22, and 12 GW from 2022-27, 275 GW RE from 2022-27, and 10 percent modal shift from road to rail and private to the public can lead to an emission reduction of 40 percent. Current policies in the power sector and some additional low carbon interventions in the power and industry sector need to be prioritized for NDC Goal 3.

Annexures

Methodology

Annexure 2.1

Determining NDC CO_2 intensity reduction target for sectors and States

For convenience of illustration, the following conventions and abbreviations are assumed. Since the major sectors of intervention are power, transport and agriculture, we disaggregate the economy into four sectors: 1) Agriculture, referenced as ‘A’; 2) Power, referenced as ‘P’; 3) Transport, referenced as ‘T’, and 4) Rest of the economy denoted as ‘R’.

The index ‘i’ denotes sectors, thus i = {A, P, T, R}, index‘s’ denotes the state and index ‘t’ denotes time.

$CO_{2,t}$ is the total CO_2 emissions of the economy at time t
$CO_{2,t}^i$ denotes the CO_2 emissions by sector i at time point t
GDP_t denotes the GDP of India’s economy at time t
$GDP_{i,t}$ denotes the GDP of sector i in India’s aggregate economy at time t
CI_t denotes the CO_2 intensity of India’s economy at time t
CI_t^i denotes the CO_2 intensity of the sector i in India’s economy at time t
$\theta_{i,t}$ denotes share of sector i in total GDP of the economy at time t
$\alpha_{i,t}$ denotes the share of CO_2 emissions from the i^{th} sector in the total economy-wide CO_2 emissions

$$\frac{CI_t^i}{CI_t} = \frac{CO_{2,t}^i}{CO_{2,t}} \times \frac{GDP_t}{GDP_{i,t}}$$

Or

$$CI_t^i = CI_t \times \frac{\alpha_{i,t}}{\theta_{i,t}} \;\ldots\ldots\ldots\ldots\ldots\ldots\;(1)$$

$$\dot{CI}_t^i = \dot{CI}_t + \dot{\alpha}_{i,t} - \dot{\theta}_{i,t} \ldots\ldots\ldots\;(2)$$

Power Sector

Annexure 3.1

Table 0. 1: Status of Power Sector Policies and Targets

Scheme/Policies/Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
Renovation & Modernization, Uprating and Life Extension (RMU&LE) of hydro power plants	RMU&LE of the existing old hydroelectric power projects is considered a cost-effective option to ensure optimization of resources, efficient operations, better availability, and to augment capacity addition in the country	Central Electricity Authority (CEA)	By 2017-2022: Capacity covered 9983 MW (including 53 Hydro Electric Power Stations with 10 in the Central Sector and 43 in the State Sector). This will accrue benefit of 5171 MW. By 2022-2027: Capacity covered 2518 MW (including 22 Hydro Electric Power Station with 1 in the Central Sector and 21 in the State Sector). This will accrue benefit of 2549 MW.	By 2017-2022: Capital outlay of INR 6676 Cr By 2022-2027: Capital not available	As on 30 Sept 2018: R&M of 213 MW completed with cost expenditure of INR 34.06 Cr	Impact by increasing hydro capacity share in generation thereby replacing coal-based generation
Renovation and Modernization (R&M) of substations and transmission lines	R&M and upgradation of existing projects is one of the cost-effective alternatives to increase the power transmission capabilities and reduce losses in the transmission system	Ministry of Power	No information available	No information available	No information available	No information available

Scheme/Policies/Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
R&M of existing thermal power stations	R&M helps in additional generation from the existing thermal power stations and better asset management due to its low cost and short gestation period	Central Electricity Authority (CEA)	By 2017-2022: LE / R&M of 14929 MW (LE of 7570 MW and R&M of 7359 MW). 71 thermal plants, including both state and central, will be undertaken for R&M/LE	No information available	Status as on 30 Sept 2018: Period 2002-07: R&M and LE of 3445 MW Period 2007-12: R&M and LE of 16146 MW Period 2012-17: R&M and LE of 7202 MW Period 2017-2022: R&M and LE of 887 MW (820 MW LE and 67 MW R&M) achieved.	Impact by increase in energy efficiency of existing thermal power plants, thereby reducing emissions
National Smart Grid Mission (NSGM)	The proposed interventions under the NSGM are: 1. Enable access and availability of quality power to all 2. Loss reduction 3. Smart Grid roll-outs including automation, micro grids and other improvements - AMI roll-out, prosumer enablement, demand response (DR)/demand side management (DSM) 4. Policies and tariffs – dynamic tariff implementation, DR programs, tariff mechanisms for solar PVs 5. Green power and energy efficiency – renewable integration 6. Electric vehicles (EVs) and energy storage – EV charging stations & energy storage systems	Ministry of Power	No information available	Phase- I (2014-2017): Outlay of INR 980 Cr Phase- II (2017-2020): Outlay of INR 990 Cr	Status as on January 2019: Out of 11 SG pilot projects, 6 projects have been completed/go-live. 5 NSGM smart grid projects are under various stages of implementation	Impact through reduction in AT&C losses and peak demands

Scheme/ Policies/ Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
Ujwal DISCOM Assurance Yojana (UDAY)	UDAY focuses on: 1. Operational improvement 2. Reduction in power generation cost 3. Development of RE 4. Energy efficiency & conservation	Ministry of Power	1- 100% Feeder Metering by 30 June 2016 2- 100% DT Metering by 30 June 2017 3- Completion of consumer indexing & GIS Mapping by 30 Sept 2018 4-Upgradation of DT, Meters etc. by 31 Dec 2017 5-Smart meter for consumers > 500 Units by Dec 17; >200 units by Dec 2019 6- AT&C Losses to be reduced to 15% by FY19 7- Elimination of ACS-ARR gap by FY19	No information available	Status as on 26 Feb 2019: 1- Feeder Metering- 100% both Urban and Rural 2- DT Metering- 67% urban & 62% rural 3-Consumer indexing & GIS Mapping - No Update available 4-Upgradation of DT, Meters etc.- No update available 5-Smart meter for consumers > 500 units- 4% achieved; >200- only 2% achieved 6- AT&C Losses - 19.94% (for 26 states) 7- ACS-ARR gap- INR 0.31 /Unit (for 26 states)	Impact through operational improvement (reducing AT&C losses), reduction in cost of power generation, development of RE, energy efficiency & conservation
Power for All	A joint initiative between the GoI, all states and Union Territories (UTs) to provide 24x7 power to all consumers except agricultural consumers. The program objectives are: - Reliable 24x7 supply to domestic, industrial and other consumers - Adequate power supply to agricultural consumers - To provide access to electricity to all unconnected households in the next five years, i.e., by FY 2018-19	Ministry of Power, GoI	No specific target by the GoI. The state governments decide the targets themselves as per the MoU	No information available	No information available	

Scheme/ Policies/ Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
National Mission for Enhanced Energy Efficiency	The NMEEE has four initiatives to enhance energy efficiency: 1. **Perform, Achieve and Trade (PAT)** is a market-based mechanism to make improvements in energy efficiency for energy-intensive large industries and to make facilities more cost-effective by certification of energy savings that can be traded 2. **Market Transformation for Energy Efficiency (MTEE)** accelerates the shift to energy-efficient appliances in designated sectors through innovative measures that make the products more affordable 3. **Energy Efficiency Financing Platform (EEFP)**, a mechanism to finance demand side management programs in all sectors by capturing future energy savings 4. **Framework for Energy Efficiency Economic Development (FEEED)**, for developing fiscal instruments to promote energy efficiency	Bureau of Energy Efficiency	Separate targets under each initiative			

Scheme/ Policies/ Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
Bachat Lamp Yojana (BLY)	It is a public-private partnership program comprising BEE, DISCOMs and private investors to accelerate market transformation in energy efficient lighting. Under this program, over 29 million incandescent bulbs have been replaced by CFLs	Bureau of Energy Efficiency (BEE)	No information available	INR 5 Cr ($ 1.13 million)	As on March 2015: 29.1 million CFLs distributed	Impact through reduction in electricity demand, thus reducing CO_2 emissions
Unnat Jyoti by Affordable LEDs for All (UJALA)	The scheme was launched on 5 January 2015 with the following objectives: 1. To reduce energy consumption in lighting, helping DISCOMs to manage peak demand 2. Promote the use of the most efficient lighting technology at affordable rates to domestic consumers that benefits them by way of reduced energy bill 3. Enhance the awareness of consumers about the efficacy of using efficient appliances that, in turn, could change their buying preferences from low first cost-based purchases to lifecycle cost	Electricity distribution company of participating state and Energy Efficiency Services Limited (EESL)	Target by March 2019: - Overall target of replacing 770 million bulbs with LED lights in 3 years - Expected annual energy savings of 105 Billion Units - Expected reduction of peak load by 20,000 MW - Annual estimated GHG emission reductions of 79 MT of CO_2	Estimated capital investment $ 1.23 billion	As on 27 Feb 2019: - Number of LED Distributed: 333 million - Energy Saved per Year: 43 Billion Units - Cost saving: INR 17,309 Cr per year - Avoided Peak Demand: 8,663 MW - 35 MT of CO_2 Reduction per year	Impact through reduced electricity demand and reduced peak demands, thus reducing CO_2 emissions - 35 MT of CO_2Reduction per year

Scheme/ Policies/ Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
Street Light National Programme (SLNP)	Launched in 2015, EESL's SLNP initiative has been instrumental in replacing over 50 lakh streetlights in over 500 cities in India, leading to 135 Cr kWh of energy savings and cost saving of INR 742 Cr every year	EESL	Retrofitting 14 million streetlights by 2019 with energy efficient LED bulbs	No information available	As on 27 Feb 2019: - 8.4 Million street-lights replaced - 5667 Mus of energy saved per year - Saved 3.9 MT CO_2 emissions per year - 944.5 MW of peak demand avoided	Reduction in electricity demand, thus reducing CO2 emissions - Saved 3.9 MT CO_2 emissions per year
Smart Meter National Programme	With its pioneering role in India's energy efficiency journey, EESL's Smart Meter National Programme (SMNP) is working to eventually replace 25 crore conventional meters with smart meters across India. This roll-out is proposed under the Build-Own-Operate-Transfer (BOOT) model, wherein EESL will undertake all the capital and operational expenditure with zero upfront investment from states and utilities. EESL will, therefore, receive a nominal Internal Rate of Return that is reflected in a mutually agreed upon, automated payback structure.	EESL	To replace 25 crore conventional meters with smart meters across India	No information available	No information available	Reduction in AT&C Losses

Scheme/ Policies/ Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
Municipal Energy Efficient Programme (MEEP)	The scheme aims at replacing inefficient pumps in public water works and sewerage systems at no upfront cost to the municipal bodies	EESL	Target of reducing CO_2 emission by 3.9 MT and annual savings of approximately INR 3,200 Cr (USD 492 million)	No information available	Status as on 28 Feb 2019: - 22 States participated out of 29 & with 3 UT s out of 7 - 390 Cities tied up out of 500	Reduction in municipal demand, resulting in lower emissions
Solar AgDSM	To provide reliable solar power supply to agricultural pump sets by setting up solar mini grids. Solar powered PV pump sets can be used to irrigate farms during daytime, thereby reducing dependence on diesel fuel	EESL	Replacing an estimated 2.27 crore pump sets used in the agriculture sector with energy efficient pump sets would result in annual energy savings of 46 BU, and GHG emission reduction of 45 MT of CO_2 annually	No information available	No information available	Reduction In electricity demand
PAT Scheme (under National Mission for Enhanced Energy Efficiency)	The "second cycle" of PAT was notified in March 2016, covering 621 DCs from 11 sectors that include eight existing sectors and three new sectors, viz., Railways, Refineries and DISCOMs	Bureau of Energy Efficiency	PAT Cycle -1 (2012-15): Thermal Power Plant (144 DCs) annual energy consumption of 104.56 MTOE having a target of energy reduction for PAT Cycle -1 as 3.211 MTOE PAT Cycle -2 (2016-19): Include thermal power plants (154 DCs); target information not available	No information available	PAT Cycle -1 (2012-15): Target achieved- 3.06 MTOE, annual energy reduction thereby reducing emission of 13 MT of CO_2 per year PAT Cycle -2 (2016-19): Data not available	Increase in energy efficiency of thermal power plants, thereby reducing emissions (reduction of 13 MT of CO_2 in Phase-I)

Scheme/ Policies/ Initiatives	Description and Key Targets	Nodal Agency	Quantifiable Target	Capital Cost	Current Status	Potential Impact on Goal 3
175 GW RE by 2022	The GoI has up-scaled the target of renewable power capacity to 175 GW which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power to be achieved by 2022	MNRE	175 GW RE Capacity by 2022 - 100 GW from solar - 60 GW from wind - 10 GW from bio-power - 5 GW from SHP	No information available	As on 31 Dec 2018- Total capacity was 74081 MW (solar- 25212, wind- 35138, SHP- 4517, bio power- 9214	175 GW RE is expected to generate 326 BU of electricity. This will result in saving of 268 MT CO_2/annum
Clean Coal Technology: Super Critical Power Plants	The GoI recently announced no more sub-critical power plants are to be planned after 2017. However, it has already been installing super critical power plants in India since 2011	CEA	No more sub-critical power plants after 2017		As on March 2017: Super critical power plant capacities installed- 41301 MW (with gross generation of 560 BUs). This resulted in a savings of 20 MT CO_2 emissions compared to sub-critical power plants (wherein sub-critical estimated CO_2 emission is 0.853 Kg CO_2/kwh. Gross and super-critical estimated CO_2 emission is 0.816 Kg CO_2/kwh Gross)	

Annexure 3.2 State-wise break-up and achievement as on 30 April 2019 of 175 GW Renewable Power target to be achieved by 2022

Table 0.1: State-wise break-up and achievement as on 30th April 2019 of 175 GW Renewable Power target to be achieved by the year 2022

	175 GW RE target to be achieved by 2022				State-wise installed capacity of Grid Interactive RE Power as on 30.04.2019				Target Achievement as on 30.04.2019			
State/UTs	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**
Karnataka	5697	6200	1500	1420	6129	4695	1255	1828	108%	76%	84%	129%
Rajasthan	5762	8600			3438	4300	24	121	60%	50%		
Andaman & Nicobar Islands	**27**				12	0	5	0	43%			
Andhra Pradesh	9834	8100		543	3089	4092	162	500	31%	51%		92%

	175 GW RE target to be achieved by 2022				State-wise installed capacity of Grid Interactive RE Power as on 30.04.2019				Target Achievement as on 30.04.2019			
State/UTs	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**
Gujarat	8020	8800	25	288	2494	6103	61	77	31%	69%	245%	27%
Tamil Nadu	8884	11900	75	649	2663	9127	123	1004	30%	77%	164%	155%
Chandigarh	153				35	0	0	0	23%			
Punjab	4772		50	244	906	0	174	326	19%		347%	134%
Lakshadweep	4				1	0	0	0	19%			
Odisha	2377				395	0	65	59	17%			

	175 GW RE target to be achieved by 2022				State-wise installed capacity of Grid Interactive RE Power as on 30.04.2019				Target Achievement as on 30.04.2019			
State/UTs	Solar	Wind	SHP	Bio Power	Solar	Wind	SHP	Bio Power	Solar	Wind	SHP	Bio Power
Arunachal Pradesh	39		500		5	0	131	0	14%		26%	
Maharashtra	11926	7600	50	2469	1634	4794	376	2529	14%	63%	751%	102%
Chhattisgarh	1783		25		231	0	76	231	13%		304%	
Uttar Pradesh	10697		25	3499	960	0	25	2116	9%		100%	60%
Kerala	1870		100		139	53	222	1	7%		222%	

	175 GW RE target to be achieved by 2022				State-wise installed capacity of Grid Interactive RE Power as on 30.04.2019				Target Achievement as on 30.04.2019			
State/UTs	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**
Daman & Diu	199				14	0	0	0	7%			
Bihar	2493		25	244	142	0	71	121	6%		283%	50%
Haryana	4142		25	209	225	0	74	206	5%		294%	98%
Tripura	105				5	0	16	0	5%			
Delhi	2762				127	0	0	52	5%			

	175 GW RE target to be achieved by 2022				State-wise installed capacity of Grid Interactive RE Power as on 30.04.2019				Target Achievement as on 30.04.2019			
State/UTs	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**
Jammu & Kashmir	1155		150		15	0	180	0	1%		120%	
Puducherry	246				3	0	0	0	1%			
D. & N. Haveli	449				5	0	0	0	1%			
Goa	358				4	0	0	0	1%			
Mizoram	72		25		1	0	36	0	1%		146%	

	175 GW RE target to be achieved by 2022				State-wise installed capacity of Grid Interactive RE Power as on 30.04.2019				Target Achievement as on 30.04.2019			
State/UTs	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**	**Solar**	**Wind**	**SHP**	**Bio Power**
Meghalaya	161		50		0	0	33	14	0%		65%	
Sikkim	36		50		0	0	52	0	0		104%	
Telangana		2000			3599	128	91	178		6%		
Other		600		120	0	4	0	0		1%		0%
All India	99534	60000	5000	10000	28679	35816	4594	9945	29%	60%	92%	99%

Source: Monthly Report on State-wise installed capacity of Grid Interactive Renewable Power, MNR

Annexure 3.3 Analysis of RE target and its impact on reducing power sector emissions

For this analysis, we have used the IRADe India Technology Model (IITec) to assess the impact of RE target of 175 GW and 275 GW RE on the Indian power sector emissions. IITec models the physical power systems of India using the energy system modelling tool called TIMES[6]. TIMES is a technology-rich, least-cost, dynamic linear programming model representing the physical aspects and functioning of the energy (power) system. It quantifies new investment needs in generation and the cost of generating electricity to meet the requirement for each time-period and sub-periods. The model has been used since 2014 for various studies of SARI/EI programs at IRADe. The model has been developed through wide stakeholder consultations with key government agencies in India such as CEA, POSOCO and NITI Aayog.

- Assumptions

In the IITec model, the technology capacity target and capacity retirement have been updated as per the latest National Electricity Plan prepared by the Central Electricity Authority, January 2018. The detailed model assumptions are provided in Annexure 3.4. The electricity demand for the IITec Model is taken from IRADe's macroeconomic model that considers fuel-wise Autonomous Energy Efficiency Improvements (AEEI) reflecting the annual reduction in energy inputs like coal, oil, natural gas and power. This captures the trend of long-term technological progress observed on the basis of cost effectiveness. For industries, the model considers an AEEI of 1.5 percent [7] based on various industry studies and the on-going PAT scheme introduced by the BEE. To reflect the use of energy-efficient appliances, the marginal demand for electricity by different household classes is assumed to fall by 2 percent, despite increased rates of appliance. These households will shift to different classes as the economy grows.

The project electricity demand (at the consumption end) from IRADe's macro-economic model is 1367 BU and 1767 BU by 2022 and 2027 respectively. This is very close to CEA's electricity consumption of 1300 BU and 1743 BU by 2022 and 2027 respectively from the 19th EPS Report (as shown in Figure 0.1). The 19th EPS report of CEA uses the partial end use methodology for demand estimation and considers various initiatives of the GoI and State governments like Power for All (PFA), Demand Side Management (DSM), energy

[6] The Integrated MARKAL-EFOM System (TIMES) model generator was developed as part of the International Energy Agency's Energy Technology Systems Analysis Program (IEA-ETSAP). TIMES is the successor of the MARKAL model generator. For more details, please see https://iea-etsap.org/index.php/etsap-tools/model-generators/times

[7] Higher AEEI rate of 1.5 percent is assumed as per the assumptions in the "Low Carbon Strategies for Inclusive Growth Report" of the Planning Commission, GoI

conservation and efficiency improvement measures, Make in India, penetration of roof-top solar, electric vehicles etc.

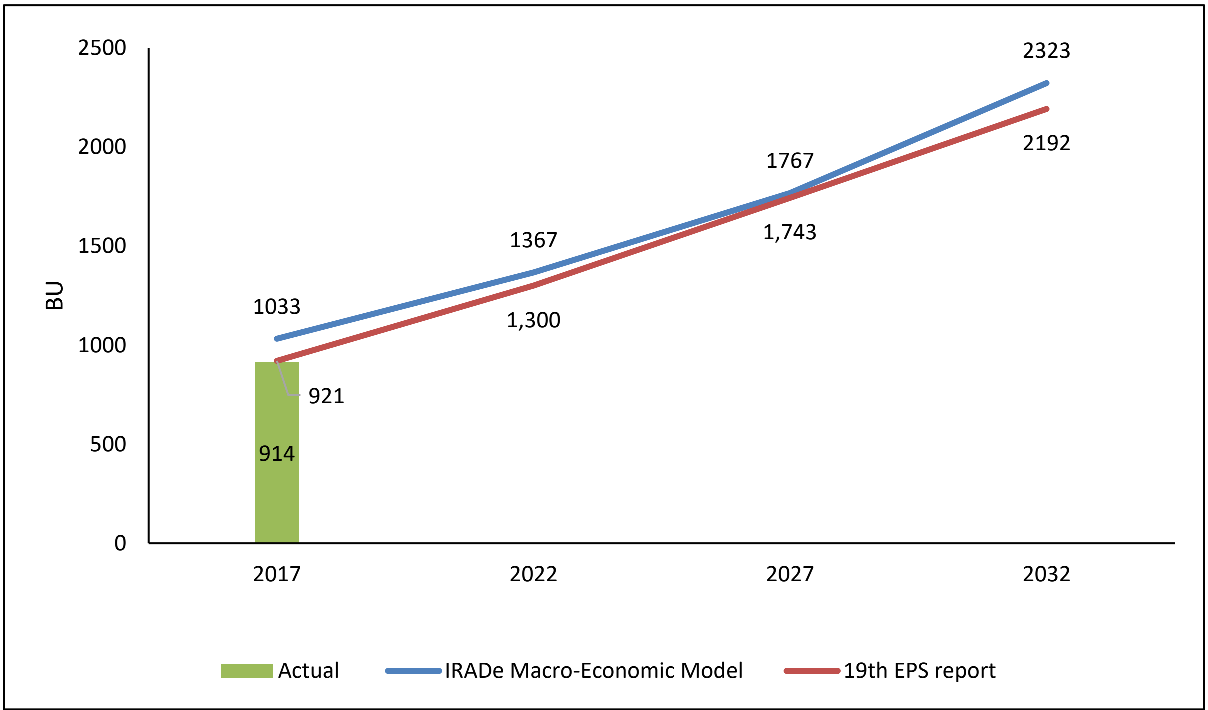


Figure 0.1: Electricity Demand Projection (Consumption End)

Scenarios: For the analysis, the following policy scenarios have been considered:

- **2022- 175 GW RE:** Under this scenario, the capacity target for renewables is fixed to 175 GW by 2022 (100 GW solar, 60 GW wind, 10 GW bio-power and 5 GW SHP).
- **2027- 275 GW RE:** Under this scenario, the capacity target for renewable is fixed to 175 GW by 2022 and 275 GW by 2027 (150 GW solar, 100 GW wind, 17 GW bio-power and 8 GW SHP).
- **2027- Solar Only:** Under this scenario, the capacity target of solar is fixed as per the 275 GW target of RE by 2027, i.e., solar installation by 2027 is fixed to 150 GW. For other RE technologies, the future installed capacities are fixed to 2017 values.
- **2027-Wind Only:** Under this scenario, the wind capacity target by 2027 is fixed as per the 275 GW target of RE, i.e., wind installation by 2027 is fixed to 100 GW. For other RE technologies, the future installed capacities are fixed to 2017 values.

Results

Based on the above methodology, four policy scenarios were run for the power sector in the IITec model. IRADe's macroeconomic-model estimated the sector-wise targets that need to be achieved by 2030 to reach the overall NDC goal of emission intensity reduction target of 33 percent-35 percent by 2030. Table 0.3 shows the emission reduction target for the power sector.

Table 0.2 Emission Intensity Reduction Targets for the Power Sector (Estimated from IRADe's Macroeconomic model)

Sector	Emission Intensity Reduction target by 2030 (%)
Power	11%

The emission intensity of electricity generation (CO_2/Kwh) under the four scenarios from the IITec model is shown in Figure 0.2. It is to be observed that the 2027-275 GW RE scenario achieves an emission reduction of 27 percent compared to 2005 levels. Similarly, the 2022-175 GW RE scenario achieves an emission reduction of 23.6 percent. Further, both the 2027-Solar Only and 2027-Wind only scenarios achieve an emission reduction of 23 percent compared to 2005 levels. Thus, the highest emission intensity reduction from electricity generation in CO_2/kWh is observed in the 2027-275 GW RE scenario.

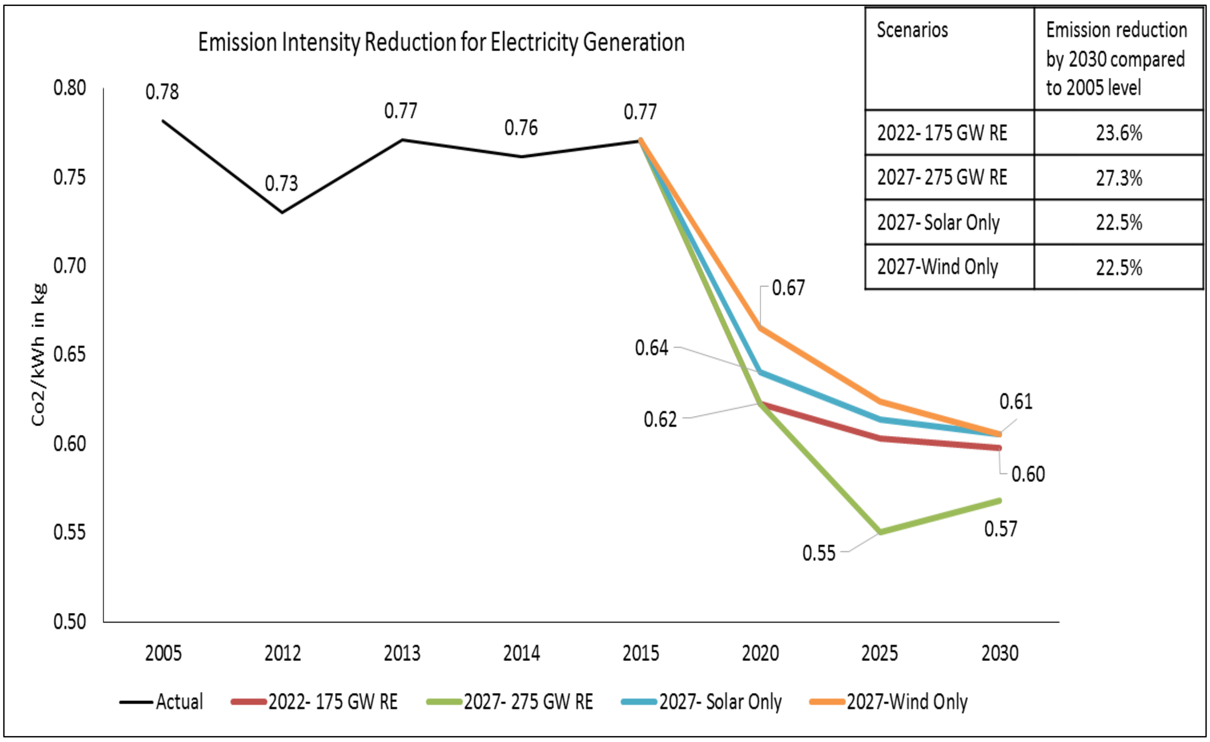


Figure 0.2: Projections for Emission Intensity of Electricity Generation

Furthermore, the emission intensity of the power sector with respect to the GDP in the 2027-275 GW RE scenario achieves the highest reduction of 31.4 percent compared to 2005 levels. The 2022-17GW RE scenario, however, achieves a reduction of 27.7 percent and both the 2027-Solar Only and 2027-Wind Only scenarios achieve a reduction of 26.6 percent as shown in Table 0.4. It is to be noted that all the four policy options achieve a higher emission intensity reduction than the sectoral target of 11 percent (refer chapter 2).

Table 0.3: Emission Intensity Reduction from the Power Sector With Respect to GDP

Scenarios	CO_2/ GDP in Kg/INR (@2007-08 prices)		2030 Emission Intensity Reduction Compared to 2005 levels (CO_2/GDP)
	2005	2030	
2022- 175 GW RE	0.011	0.0081	27.7%
2027- 275 GW RE		0.0077	31.4%
2027- Solar Only		0.0083	26.6%
2027-Wind Only		0.0083	26.6%

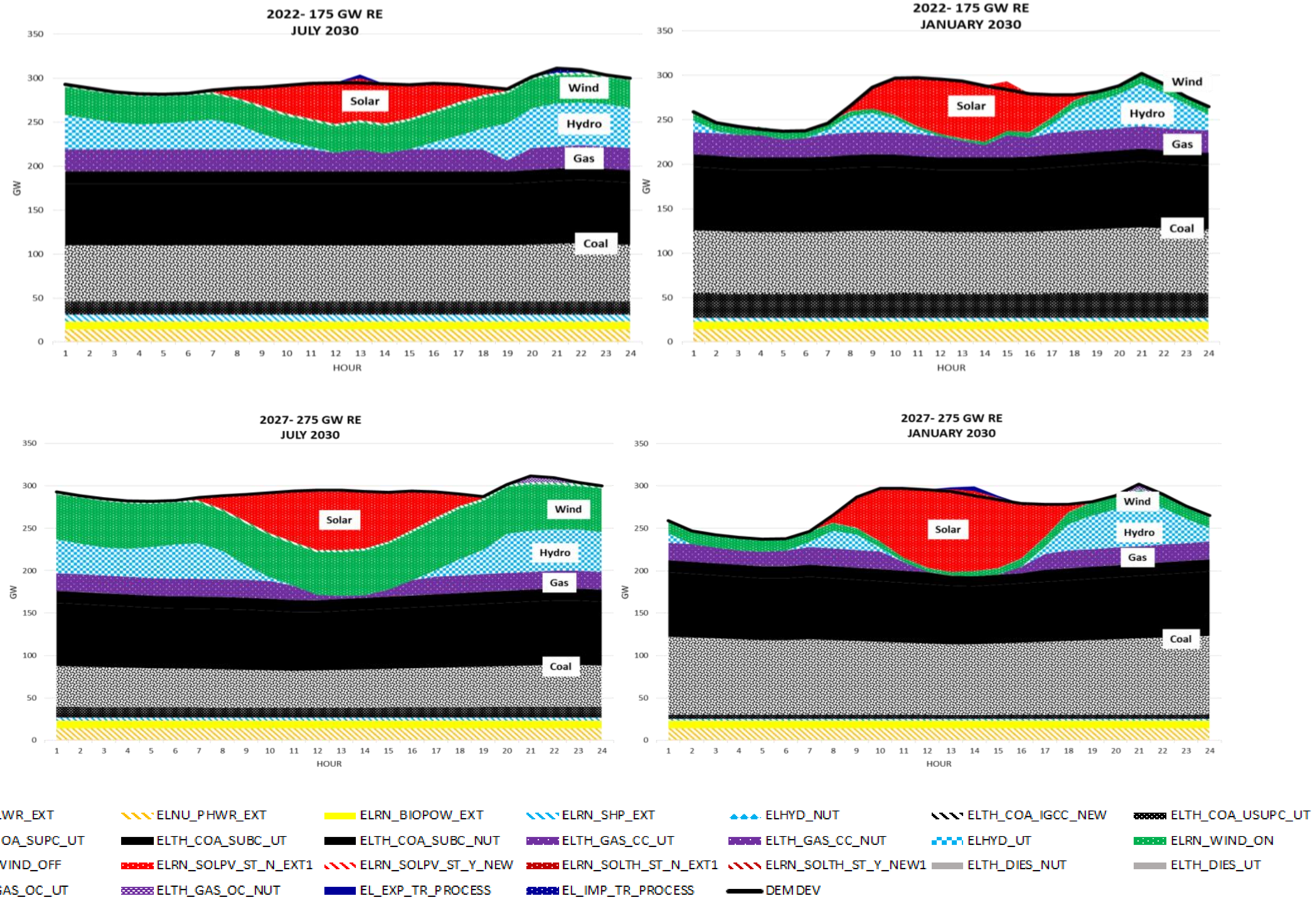
The emission reduction from the power sector is possible due to the change in the installed capacity mix--i.e., more installation of renewable capacities. The change in capacity mix under the four scenarios is shown in Table 0.5. It is to be observed that all the policy scenarios achieve a non-fossil capacity share of more than 40 percent by 2030. Hence, they are in line with the INDC Goal 4 target of achieving 40 percent non-fossil fuel capacity by 2030. Further, the installation of renewable capacities is highest in the 2027-275 GW RE due to more push for renewables. Nuclear and hydro capacities are as per CEA's National Electricity Plan of January 2018.

Table 0.4: Change in Energy Mix

	Actual	Scenarios			
		2022- 175 GW RE	**2027- 275 GW RE**	**2027- Solar Only**	**2027- Wind Only**
	2012	**2030**	**2030**	**2030**	**2030**
Coal	135	259	245	260	259
Gas	24	31	27	42	40
Diesel	11	11	11	11	11
Nuclear	5	18	18	18	18
Hydro	39	49	49	50	49
Renewable	24	197	279	195	162
Solar	1	100	150	150	19
Wind	17	64	104	35	133
SHP	3	15	7	4	4
Bio Power	3	18	18	5	5
Total	238	564	629	576	539
Share of Fossil	71%	53%	45%	54%	58%
Share of Non-Fossil	29%	47%	55%	46%	42%

The change in capacity will have an impact on electricity generation from power plants based on various technologies. Electricity demand and supply for a typical day in the months of January and July for 2030 for all the four policy scenarios is given in Figure 0.3.

15 IRADe Integrated Research and Action for Development



15 IRADe Integrated Research and Action for Development

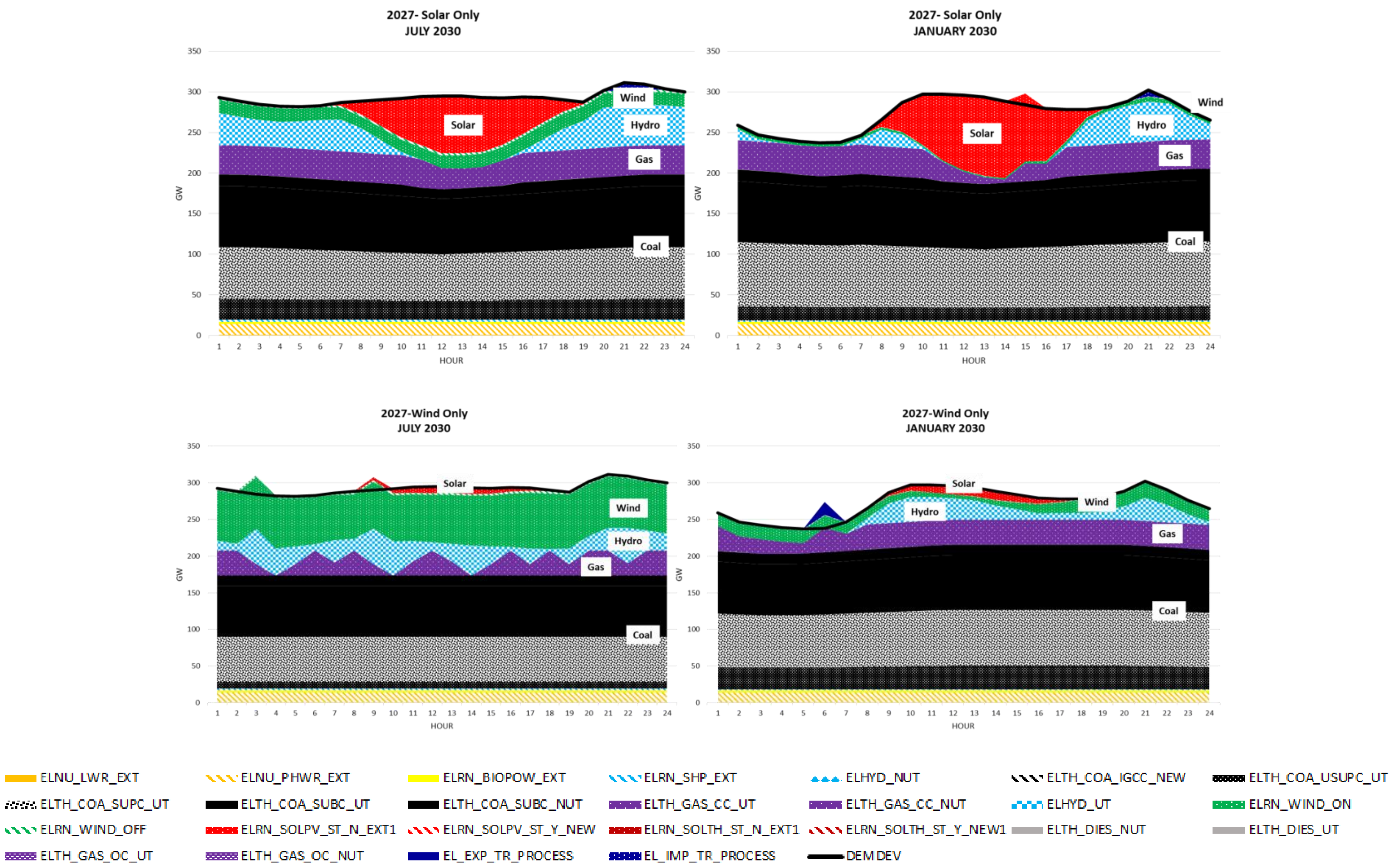


Figure 0.3: Electricity demand and supply for a typical day in the months of January and July for 2030 for all the four policy scenarios (2022-175 GW RE, 2027- 275 GW RE, 2027- Wind Only and 2027- Solar Only)

The change in capacity mix will require capital investments by the power sector. Table 0.6 shows the cumulated capital requirements by the power sector from 2012 to 2030 under the four policy scenarios. It is to be noted that the power sector investment requirements will be deeply impacted by the RE energy cost decline in future. Hence, the number will change as the RE cost declines.

Table 0.5: Cumulated Capital Requirements by the Power Sector from 2012-2030

Cumulated for 2012- 30	
Scenarios	Capex in Trillion INR (at 2011-12 prices)
2022- 175 GW RE	21.2
2027- 275 GW RE	24.2
2027- Solar Only	20.9
2027-Wind Only	20.7

Each policy option will have a cost implication and a CO_2 saving potential. The CO_2 saving potential for each policy scenario is calculated by comparing it with a baseline scenario that assumes no climate change measure and all the future electricity is generated from sub-critical and super-critical coal-based power plants only. Figure 0.4 shows the marginal abatement cost for the four-policy option compared with the baseline at 2011-12 prices. It is to be noted that although the 2027-275 GW RE scenario is the costliest scenario (in Billion INR/MT of CO_2), it also has the maximum CO_2 reduction potential compared to the baseline.

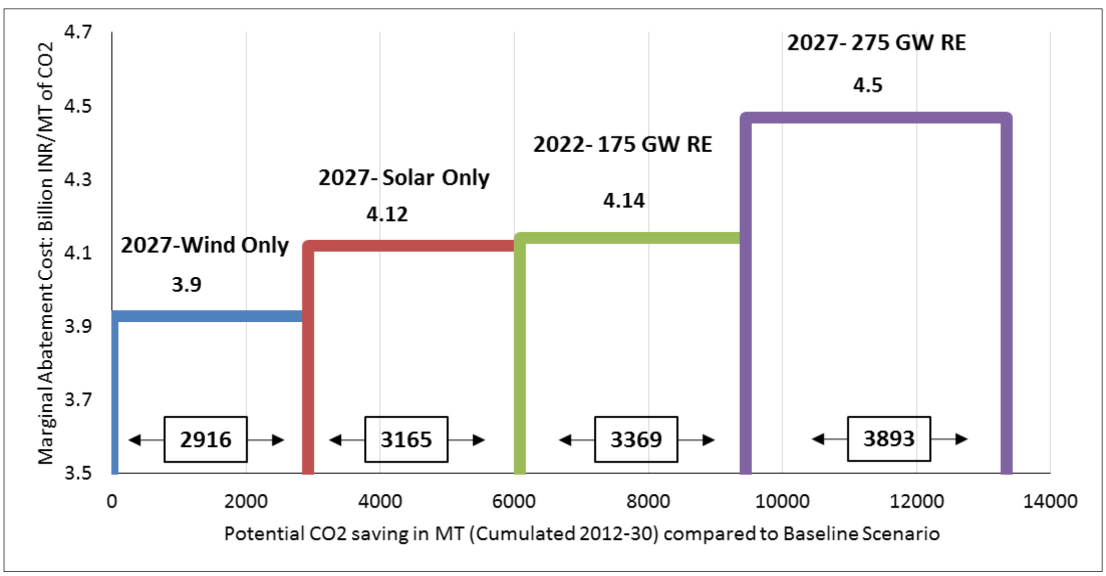


Figure 0:4: Marginal Abatement Cost for Policy Options (at 2011-12 prices)

** Baseline scenario assumes no climate change initiative and future electricity generation is achieved from coal (sub-critical and super-critical power plants) only.*

Annexure 3.4 Assumptions for IRADe India Technology Model (IITec Model)

A comprehensive list of technologies is considered for the future expansion of the Indian power system. This includes:

- Various coal technologies (sub-critical, super-critical, ultra-super-critical)
- Open cycle and combined cycle gas turbine using natural gas
- Solar technologies such as solar PV and solar thermal, with and without storage
- Wind--onshore and off-shore
- Large and small hydropower
- Biomass-based power
- Nuclear light and heavy water reactors

Assumptions used in the model on the technical, economic, and environmental performances of these technologies are presented in Table 8.7 to Table 8.8.

Table 0.6: Assumptions on the Technical and Economic Performance of the Future Technology Options, India

	Gas Power Plant		Coal Power Plant				Diesel Thermal	Nuclear Power Plant		Hydro Power Plant		Solar Power Plant				Wind Power Plant		Bio Power Plant
Technology Data	OC	CC	IGCC	SUBC	SUPC	USUPC		LWR	PHWR	Large	Small	PV-With STG	PV-W/O STG	TH-With STG	TH-W/O STG	ON-SHORE	OFF-SHORE	
Net Efficiency (PJ output/ PJ input)	37.5%	55%	46%	30%	37%	43%	25%	163%	18%									25%
Fuel Type	Gas	Gas	Coal	Coal	Coal	Coal	Diesel	Enriched Uranium	Natural Uranium									Biomass
Availability Factor	90%(UP)	(55-90)%	(60-70)%	(55-70)%	(55-70)%	(55-70)%	70%	80%	80%	39%	41%	37%	18%	37%	18%	(21-28)%	(33-37)%	50%
Plant Availability Modelling Level	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Monthly	Monthly	Hourly	Hourly	Hourly	Hourly	Hourly	Hourly	Annually
Operational Life Time (Year)	40	40	40	40	40	40	15	50	50	50	30	25	25	25	25	25	25	20
Economic Data																		
Capital Cost ($/kW)	482	771	2143	1028	1136	1307	1071	4500	1778	2036	1393	Refer Next Table				1286	3857	964.2
O&M Cost ($/kW/yr)	39	31	54	26	28	33	107	112	44	67	42	Refer Next Table				19	29	39

Table 0.7: Capital Costs (US$/kW) Assumptions for Solar Technologies, India

	Storage	2017	2022	2027	2032	2037	2042	2047	2052
Solar Power Plant (PV)*	WO-STG	1,173.6	1,071.3	983.9	903.6	829.9	762.1	699.9	642.8
	With STG	3,526.1	3,223.7	2,959.2	2,716.3	2,493.3	2,288.7	2,100.8	1,928.4
Solar Thermal Plant (CSP)#	WO- STG	2,314.1	2,036.4	1,873.5	1,761.1	1,708.3	1,674.1	1,640.6	1,538.6
	With STG	3,373.4	2,968.6	2,731.1	2,594.6	2,464.9	2,366.3	2,295.3	2,111.7

(*) The Solar PV cost reduction is undertaken on the CERC benchmark cost for the financial year 2015–16, which is 6,010.4 US$/kW (CERC Benchmark Cost 2015). The reduction is undertaken as per the report, 'Current and Future Cost of Photovoltaics', of the Fraunhofer-Institute for Solar Energy Systems, Germany. From the report, we have considered a 20 percent cost reduction trajectory by 2025 and a 40 percent cost reduction by 2050, which is still on the conservative side as the other scenarios in the report consider a 36 percent reduction in 2025 and a 72 percent reduction in 2050.

(#) For Solar Thermal Plants, the cost reduction trajectory is as per the IESS 2047 V2.0 model of the NITI Aayog.

Table 0.8: O&M Cost Assumptions for Solar Technologies, Indi

	Storage	2017	2022	2027	2032	2037	2042	2047	2052	% of Capex
Solar Power Plant (PV)	WO-STG	17.6	16.1	14.8	13.6	12.4	11.4	10.5	9.6	1.5%
	With STG	88.2	80.6	74.0	67.9	62.3	57.2	52.5	48.2	2.5%
Solar Thermal Plant (CSP)	WO- STG	28.9	25.5	23.4	22.0	21.4	20.9	20.5	19.2	1.3%
	With STG	42.2	37.1	34.1	32.4	30.8	29.6	28.7	26.4	1.3%

- The current (January 2017) policy and measures that are in place have been included. The renewable capacity of 175 GW will be achieved by 2022. As indicated in India's INDC, the non-fossil capacity share would be 40 percent in 2030, linearly increasing to 50 percent by 2050. Until 2022, the capacity addition of large hydro, nuclear, and coal is according to the Draft National Electricity Plan published in December 2016. The potentials for large hydro and wind onshore are taken as 145 GW and 302 GW, respectively. Additionally, the potentials for solar PV and solar thermal are taken as 749 GW and 229 GW, respectively.

- Keeping in mind the regulatory guideline on the technical minimum scheduling for the operation of power plants,[8] we have imposed the technical minimum schedule for operation as 55 percent for coal power plants. In addition, an increase in the station heat rate and an increase in auxiliary consumption, with decreasing unit loading, have also been incorporated according to the CERC regulations. The cost of secondary oil consumption concerning hot/warm/cold types of plant startup/shut down has also been incorporated in the model.

- The price of fuels used for power generation is assumed to be constant at the 2012 level for the entire study horizon and is presented in Table 0.10.

Table 0.9: Fuel Price Assumptions

Fuel	Fuel Source	Unit	Year	Price in Model	Calorific Value	Data Source
Natural Gas	Dom	INR/ SCM	2012	8.387	10,000 Kcal/ SCM	GAIL
	Imp	US$/ MMBTU	2012	10	10,000 Kcal/ SCM	GAIL
Coal	Dom	INR/tonne	2012	1,317.35	3,541 Kcal/kg	Coal Directory, MOC
	Imp	INR/tonne	2012	5,119	5,500 Kcal/kg	Coal Directory, MOC
Natural Uranium	Dom	INR Cr/tonne	2012	0.78		IESS
	Imp	INR Cr/tonne	2012	0.78		IESS
Enriched Uranium Cost	Dom/Imp	INR Cr/tonne	2012	14.486		IESS
Biomass	Dom	INR/kg	2012	2.4	3,751 Kcal/kg	IRADe Analysis

[8] Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Fourth Amendment) Regulations, 2016

Transport Sector

Annexure 4.1

(i) Vehicle Annual Kilometers

Table 0.10: Average Annual Kilometers for different types of vehicles

2W	3W	LDV_C	LDV_T	Buses	LCV	MCV	HCV
7381	35405	11724	36343	94275	47966	89690	131450

(ii) Fuel Technologies Assumed

	LDV_C						2W		3W				
YEARS	PETROL	DIESEL	CNG	LPG	FCV	ELECTRIC	PETROL	ELECTRIC	PETROL	DIESEL	CNG	LPG	ELECTRIC
1990	77%	23%	0%	0%	0%	0%	100%	0%	40.0%	60%	0	0	0
1995	77%	18%	2%	2%	0%	0%	100%	0%	40.0%	42.2%	9.8%	7.0%	1.0%
1999	77%	18%	2%	2%	0%	0%	100%	0%	40.0%	42.2%	9.8%	7.0%	1%
2000	77%	18%	2%	2%	0%	0%	100%	0%	40.0%	42.2%	9.8%	7.0%	1%
2010	77%	18%	2%	2%	0%	0%	100%	0%	40.0%	42.2%	9.8%	7.0%	1%
2030	75%	18%	2%	2%	0%	3%	70%	30%	20%	21%	5%	4%	50%
2050	73%	18%	2%	2%	0%	5%	70%	30%	0%	0%	0%	0%	100%

	LDV_T				Bus				LCV/MCV/HCV			
YEARS	CNG	LPG	DIESEL	ELECTRIC	DIESEL	CNG	FCV	ELECTRIC	DIESEL	CNG	LPG	ELECTRIC
1990	0%	0%	100%	0%	100%	0%	0%	0%	100%	0%	0%	0%
1995	3%	2%	96%	0%	100%	0%	0%	0%	100%	0%	0%	0%
1999	3%	2%	96%	0%	99%	1%	0%	0%	99%	1%	0%	0%
2000	3%	2%	96%	0%	99%	1%	0%	0%	99%	1%	0%	0%
2010	3%	2%	96%	0%	99%	1%	0%	0%	99%	1%	0%	0%
2030	2.4%	1.7%	92.9%	3%	89%	1%	0%	10%	99%	1%	0%	0%
2050	2.4%	1.6%	91.0%	5%	79%	1%	0%	20%	99%	1%	0%	0%

Figure 0.5: Fuel Technologies assumed in the Transport Sector

(iii) Fuel Efficiency

	Petrol (Kms/Ltr)			Diesel (Kms/Ltr)					CNG (Kms/Ltr)				LPG (Kms/Ltr)		
Year	LDV_C	2W	3W	LDV_C	3W	LDV_T	Buses	Goods Veh	LDV_C	3W	LDV_T	Buses	LDV_C	3W	LDV_T
2000	11.0	47.1	34.7	9	28	10	5	7	10.9	34.7	11.9	3.5	11.0	29.7	11.9
2005	11.5	47.3	34.9	10	28	10	5	6	11.4	34.9	12.0	3.5	11.5	29.9	12.0
2010	12.0	47.5	35.0	10	28	10	5	6	12.0	35.0	12.0	3.5	12.0	30.0	12.0
2015	12.6	47.8	35.2	10	28	10	5	6	12.6	35.2	12.1	3.5	12.6	30.2	12.1
2020	13.2	48.0	35.4	11	28	10	5	7	13.3	35.4	12.1	3.5	13.2	30.3	12.1
2025	13.8	48.2	35.6	11	28	10	5	7	14.0	35.6	12.2	3.6	13.8	30.5	12.2
2030	14.5	48.5	35.7	12	29	10	5	8	14.7	35.7	12.3	3.6	14.5	30.6	12.3

Figure 0.6: Fuel Efficiency Assumptions

S. No	Strategies for Decarburization	Strategy Description	Current and Proposed Policies of Government of India
1	Electrification of the transport sector	Electrification of road transport: This strategy encompasses the increased penetration/adoption of Battery Electric vehicles (BEVs) for passenger movement by road	The government launched the National Electric Mobility Mission Plan (NEMMP) 2020 in 2013 with an ambitious target to promote 6-7 million sales of Hybrid and Electric Vehicles year-on-year from 2020 onwards. With the support from the government, the cumulative sale is expected to increase to 15-16 million by 2020. In this regard, the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles [FAME] scheme was introduced by the Department of Heavy Industry to incentivize the purchase of Hybrid and Electric vehicles (xEV system) through reduction of upfront reduced purchase price to the buyers of electric/ hybrid vehicles. This incentive is applicable to 2-wheelers, 4-wheelers, 3-wheelers, buses and LCVs
		Railway electrification: With respect to rail movement, the strategy captures the accelerated electrification of railways for both passenger and freight movement	Under Mission Electrification, the target is to make Indian Railways greener by electrifying another 24,000 km of rail tracks to the existing 28,000 km in the next few years

S. No	Strategies for Decarburization	Strategy Description	Current and Proposed Policies of Government of India
2	Modal Shares	Increased share of public transport for passenger movement: This strategy is characterized by increased share of public transport (buses and 3-wheelers) for passenger movement	India has almost 8,000 towns and cities as of 2011. Only 65 of these urban centers have any semblance of a formal public transport system. The coverage of local commuter rail services is available only in the seven metropolitan cities in India: Mumbai, Delhi, Chennai, Kolkata, Bengaluru, Hyderabad and Pune. India is rapidly urbanizing, with a young population with increasing shares of disposable incomes. The absence of urban public transport systems would continuously lead to a declining share of traffic on public modes, and increased penetration of private vehicles at high economic and environmental costs. The National Urban Transport Policy 2011 focuses on accelerating the usage of public transport
		Increased share of railways: This strategy is characterized by the increased share of railways vis-à-vis road transport for both passenger and freight movement	The current (2011) share of railways in total national mobility is: Passenger- 15% (1,047 BPKM) and Freight--- 39% (668 BNTKM). This share has been continuously declining. Without any focused action, the share of railways is expected to continue to decline. The reports of the National Transport Development Policy Committee, 2014 focus on specific policy measures for the railways to increase their share in both passenger and freight transport

S. No	Strategies for Decarburization	Strategy Description	Current and Proposed Policies of Government of India
2	Increased fuel efficiency for various vehicle categories	This strategy is characterized by the early and increased adoption of increasingly fuel-efficient vehicles in the vehicle fleet through efforts such as the fuel-economy standards and fuel-efficiency labelling efforts. A higher penetration of the newer and more efficient vehicles in the vehicle stock would lead to reduced energy intensities of the transport sector	A progressive reduction in fuel intensity for all categories of vehicles for passenger and freight. The new fuel-efficiency standards for passenger cars are expected to come into force in April 2017. These standards envisage passenger cars to be 10% more fuel-efficient between 2017 and 2021 and 30% more fuel efficient from 2022

Industry Sector

Annexure 5.1

1. Method of Estimation

- Energy Demand

$$ED_i = P * \{S_l * SEC_L + (1 - S_L) * SEC_O\} * \left(1 - SEC_{red_j}\right)$$

Where,

ED_i = Energy Demand for the year i (TWh) (i=2005, 2010…... 2030)

P = Production of the industry (MT)

S_L = Share of large industries in total production (fraction)

SEC_L = SEC of large industries (TWh/MT)

SEC_O = SEC of other industries (TWh/MT)

SEC_{red_j} = Reduction in SEC by the low carbon pathway j (fraction)[9]

- Emission Intensity in the year i is the weighted sum of emissions by different fuels over the sector's GDP

$$EI_i = \frac{ED_i * \sum(Sf_x * EF_x)}{GDP_i}$$

Where,

EI_i = Emission intensity of GDP for the i (MT CO_2e/GDP in INR Billion)

Sf_x = Share of fuel x (x=electricity, solid, liquid and gaseous hydrocarbon) (fraction)

EF_x = Emission Factor for the fuel x (Mt CO_2/TWh)

GDP_i = GDP at constant prices (base year: 2011-12) for the year i

- Incremental Cost

$$IC_j = \left(ED_{BAU,i} - ED_{INT,i}\right) * CF_j$$

Where,

IC_j = Cumulative incremental cost for the low carbon pathway j (for the year i, where i = 2015, 2020, 2025 and 2030)

[9] In BAU, this factor assumes zero as the default value

$ED_{BAU,i}$ = Energy demand in the BAU scenario for the year i

$ED_{INT,i}$ = Energy demand in the LCP scenario for the year i

CF_j = Cost factor for the LCP scenario is obtained from Niti Aayog's IESS scenario and reflects the cost of introducing measure j

The methodology described above is followed for the cement and iron & steel sectors.

2. Assumptions

For the model, SEC of large industries, SEC of other industries, Reduction in SEC due to LCPs and Emission Factors for the fuel have been referred from the IESS 2047 version 2.1.

Here, LCPs are disruptive technological interventions that, when adopted, would alter the energy consumption patterns of the industry. The SEC reduction from each LCP in the cement and iron & steel sector are given in Table 0.13.

Table 0.11: SEC Reductions for Various EE Interventions in the Cement and Iron & Steel Sectors

Year	Cement			Iron & Steel			
	SEC Reduction (%)			SEC Reduction (%)			
	Increased WHR	Increased AFRM	Increased Grid Electricity	Increased Gas based DRI	Increased Scrap Utilization	Increased Electricity from Grid	Electric Furnace
2015	4%	2%	3%	4%	2%	3%	5%
2020	5%	4%	6%	6%	6%	6%	5%
2025	6%	8%	10%	7%	10%	10%	5%
2030	6%	13%	13%	9%	14%	13%	7%

In addition to this, in the BAU scenario, penetration of the above schemes in the base year 2015 has also been considered. The Indian cement industry had a capacity of 237 MW in the form of WHR plants in 2015. In addition to that, the industry had a share of 3.7 percent of AFR in its fuel mix (WBCSD, 2018).

Agriculture Sector

Annexure 6.1

(i) Emission Factors

Table 0.12: Emission Factors for Various Fuel Sources

Emission Factors	CO_2	CH_4	N_2O
Solid hydrocarbons	0.3471	0.0010	0.0030
Liquid hydrocarbons	0.2667	0.0003	0.0047
Gaseous hydrocarbons	0.1989	0.0003	0.0004

(ii) Constant Parameters

Table 0.13: Constant Parameters for the Agriculture Sector

Year	Demand Reduction due to efficiency improvement in pumps (%)	Diesel Pump Rating (KW)	Annual hours of pump usage (hrs)
2005	1.00	3.7	1000
2010	0.98	3.7	1000
2015	0.96	3.7	1000
2020	0.94	3.7	1000
2025	0.92	3.7	1000
2030	0.92	3.7	1000

Annexure 6.2

The methodology adopted for carrying out the analysis has been illustrated below:

$$TEC_i^j = DP_i^j \times SP_i^j \times DR_i^j$$

Where,

TEC_i^j= Total Annual Energy Consumption by all j type of pump sets (TWh) in i[th] year
(j = diesel, electric and solar pump sets; i= 2005, 2010, 2015, 2025, 2030)

DP_i^j = Demand for Pumping (TWh) by j type of pump in i[th] year

SP_i^j= Share of j type of pump in i[th] year

DR_i^j= Demand Reduction due to efficiency improvement of j type of pump (fraction) in i[th] year

$$EC_i^j = PR_i^j \times PU_i^j \times CU$$

Where,

EC_i^j= Annual energy consumption (TWh) by j type of pump in i[th] year

PR_i^j= Pump Rating (KW) of j type of pump in i[th] year

PU_i^j= Annual hours of pump usage (hrs) for j type of pump in i[th] year

CU= Conversion Unit (KWh to TWh i.e. 1 KWh = 10^{-9} TWh)

$$NP_i^j = \frac{DP_i^j \times SP_i^j}{EC_i^j}$$

Where,

NP_i^j= Number of j type of pumps in i[th] year

$$FD_i^j = DP_i^j \times FS_i^j$$

Where,

FD_i^j = Fuel Demand of j type of pump in i[th] year

FS_i^j= Fuel Split share for j type of pump in i[th] year

$$TE_i^j = \{(FD_i^j \times EF_{CO2}) + (FD_i^j \times EF_{CH4}) + (FD_i^j \times EF_{N2O})\}$$

Where,

TE_i^j= Total Emissions (Mt CO_2e) by j type of pump in i[th] year

EF_{CO2} = Emission Factor for CO_2

EF_{CH4} = Emission Factor for CH_4

EF_{N2O} = Emission Factor for N_2O

$$EI_i^j = \frac{TE_i^j}{GDP_i}$$

Where,

EI_i^j = Emission Intensity (Kg CO_2e/GDP) of j type of pump in i^{th} year

GDP_i = Gross Domestic Product (Rs. Billion) in i^{th} year

$$COC_i^j = TEC_i^j \times OC_i^j$$

Where,

COC_i^j= Cumulative Operational Cost of j type of pump set in i^{th} year (INR Million)

OC_i^j= Operational Cost of 5HP j type of pump set in i^{th} year (INR Million/TWh)

$$CCC_i^j = TEC_i^j \times CC_i^j$$

Where,

CCC_i^j= Cumulative Capital Cost of j type of pump set in i^{th} year (INR Million)

CC_i^j= Capital Cost of 5HP j type of pump set in i^{th} year (INR Million/TWh)

Annexure 7.1

EM_t denotes the emissions in million tonnes in time t, EMB_{2030} is the emissions in 2030 in the Baseline scenario and $EMLC_{2030}$ is the emissions in 2030 in the scenario of low carbon interventions of GoI schemes listed in Table 1.1. ΔEM_{2030} is the reduction in emissions in 2030 due to Low Carbon programs and policies. GDP_t is the GDP in the year t and CI_t is the carbon intensity in period t. Then,

$$CI_{2005} = \frac{EM_{2005}}{GDP_{2005}} \quad \ldots\ldots (1)$$

$$CI_{2030} = \frac{EM_{2030}}{GDP_{2030}} \quad \ldots\ldots (2)$$

$EMLC_{2030} = EMB_{2030} - \Delta EM_{2030}$

$$\Delta CI_{2030} = 1 - \frac{CI_{2030}}{CI_{2005}} \quad \ldots\ldots (3)$$

$$\text{Or } \Delta CI_{2030} = 1 - \frac{EMLC_{2030}}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}}$$

$$\text{Or, } \Delta CI_{2030} = 1 - \frac{(EMB_{2030} - \Delta EM_{2030})}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}}$$

$$\text{Or } \Delta CI_{2030} = 1 - \frac{(EMB_{2030})}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}} + \frac{\Delta EM_{2030}}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}} \quad \ldots\ldots (4)$$

Thus, reduction in emissions intensity by 2030 in the Baseline scenario is as computed below.

$$1 - \frac{(EMB_{2030})}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}} = 0.21 + (1 - 0.005)^{15} = 0.2824 \quad \ldots\ldots (5)$$

The value of the second term in Eq 4 which denotes reduction due to all GoI programs and policies,

$$\frac{\Delta EM_{2030}}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}} \quad \ldots\ldots (6)$$

Substituting 1251 (the aggregate reduction that can be obtained by the successful implementation of all schemes reported in table 7.1) for ΔEM_{2030} in Eq 6, we obtain the additional emissions intensity reduction achieved by implementing all the government policies and programs:

$$\frac{\Delta EM_{2030}}{EM_{2005}} \times \frac{GDP_{2005}}{GDP_{2030}} = 0.1490$$

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