Report on Green and Clean Technologies: India

Market Analysis, Key Policy Initiatives, Growth Drivers, Key Challenges and Standardization

Agenda

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  - The India-EU Clean Energy and Climate Partnership (CECP)
  - Global Gateway and the EU-India Connectivity Partnership
  - India-Middle East-Europe Economic Corridor (IMEC)
- Conclusion

Introduction

- **Fast-growing economy**: approx. 6–7% annual growth; 3rd largest (PPP) & most populous nation
- **High energy demand**: approx. 7% of global energy consumption (3rd largest)
- **Twin transition**: combining the move toward sustainable energy systems with increasing digitalization, aimed at enhancing efficiency, reducing emissions, and supporting long-term economic growth.
- **Green tech role**: enables emission reduction, resource efficiency & sustainable growth.
- India has announced the following key targets for 2030:
  - 50% of energy requirements to be met through renewable energy
  - 500 GW non-fossil fuel-based installed power capacity
  - Reduction of carbon emissions by 1 billion tonnes
  - Reduction of carbon intensity of GDP by 45% below 2005 levels

- ***This report presents India's progress and ecosystem developments across key green and clean technology domains including clean energy, smart grids, green hydrogen, energy storage, critical raw materials, energy efficiency, and climate action mechanisms.***

Renewable Energy

Renewable Energy: Installed Capacity

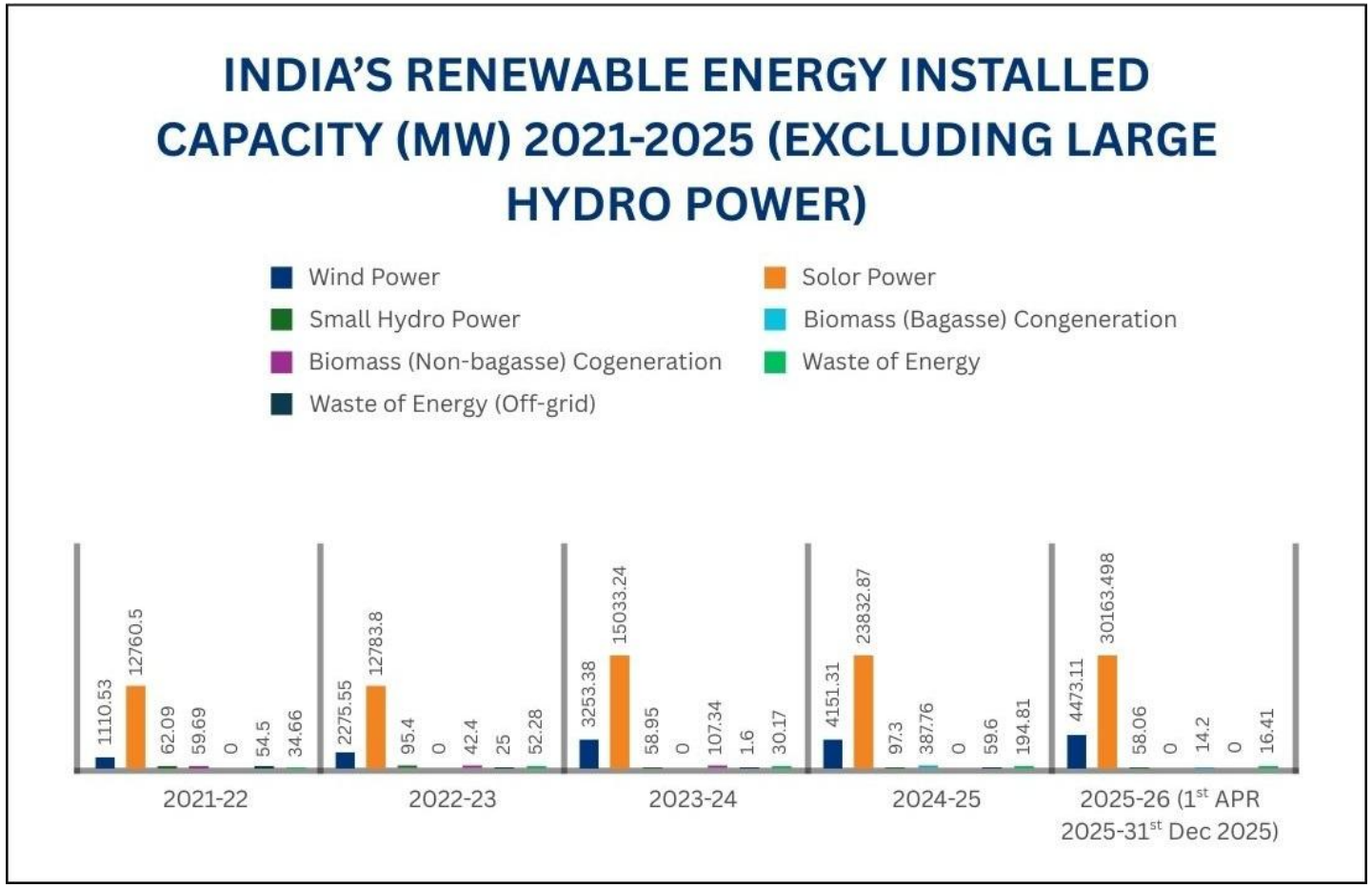
India Power Capacity (Dec 2025)

Total Installed Capacity: 513.7 GW

- **Fossil Fuels:** 246.9 GW
- **Non-Fossil:** 266.8 GW *(incl. 258 GW renewables)*

Renewable Mix:

- Solar: 135.8 GW
- Wind: 54.5 GW
- Hydro: 50.9 GW
- Biomass/Cogen: 10.8 GW
- Small Hydro: 5.2 GW
- Waste-to-Energy: 0.86 GW



Key Renewable Energy Policies & Schemes

- **Electricity Act 2003**: Enabled private participation & competition; supported by NEP for affordable & sustainable power.
- **Tariff Policy (2006/2016):** Mandated renewable energy procurement by DISCOMs.
- **National Solar Mission (2010):** Drove solar growth; aligned with ~450 GW RE target by 2030.
- **PM Surya Ghar Yojana (2024)**: Rooftop solar for 10M households; up to 300 units free/month.
- **Offshore Wind Policy (2016):** Framework for offshore wind development in EEZ.
- **Wind-Solar Hybrid Policy (2018)**: Promotes hybrid projects for efficient land & grid use.
- **Solar Parks Scheme**: Plug-and-play infra for large-scale solar deployment.
- **PLI Scheme (Solar)**: Boosts domestic solar manufacturing & supply chains.
- **Green Energy Corridors**: Strengthens transmission for RE integration.
- **Green Energy Open Access Rules (2022):** Enables direct RE procurement for consumers (>100 kW).
- **Renewable Purchase Obligations (RPOs)**: Mandates minimum RE share; ensures market demand.
- **VGF & Emerging Tech Support**: Funding for offshore wind, storage, floating solar.

Renewable Energy: Growth Drivers and Challenges

Growth Drivers:

- **Strong Policy Push**: 500 GW non-fossil target by 2030; NSM, RPOs, PLI driving deployment
- **Energy Security**: Reduces fossil fuel imports; enhances self-reliance
- **Corporate Demand & ESG**: Net-zero commitments boosting open access & captive RE uptake
- **Grid & Storage Investments**: Green corridors & BESS enabling higher RE integration

Key Challenges:

- Land acquisition delays & high project costs
- Transmission & evacuation constraints
- Grid flexibility issues due to RE intermittency
- Limited financing for storage & hybrid systems

Way Forward:

- Strengthen grid planning; accelerate BESS & pumped storage deployment

Renewable Energy: Standardization

Bureau of Indian Standards (BIS):

ETD 11 (Secondary Cells and Batteries)

- ✓ Responsible for developing standards for all rechargeable cells and batteries (starter batteries, stationary batteries, traction batteries etc.)

ETD 28 (Solar Photovoltaic Energy Systems)

- ✓ Responsible for developing standards for systems of photovoltaic conversion of solar energy into electrical energy and for all the elements in the entire photovoltaic energy systems In this context, the concept photovoltaic energy systems includes the entire field from light input to solar cell and including the interface with the electrical system(s) to which energy is supplied.

ETD 42 (Wind Turbines)

- ✓ Responsible for developing Indian standards for wind turbines that convert wind energy into electrical energy. These standards address design requirements, engineering integrity, measurement techniques and test procedures. Their purpose is to provide a basis for design, quality assurance and certification. The standards are concerned with all subsystems of wind turbines, such as mechanical and internal electrical systems, support structures and control and protection systems. They are intended to be used together with appropriate Indian Standards.

ETD 54 (Marine Energy Conversion Systems)

- ✓ Responsible for preparing standards for marine energy conversion systems. The primary focus will be on the conversion of wave, tidal and other water current energy into electrical energy, although other conversion methods, systems and products are included. a) terminology; b) management plans for technology and project development; c) performance measurements of marine energy converters; d) resource assessments; e) design and safety including re liability and survivability; f) deployment, commissioning, operation, maintenance, retrieval and decommissioning; g) electrical interface, including array integration and / or grid integration; h) testing laboratory, manufacturing and factory acceptance; i) additional measurement methodologies and processes.

Green Hydrogen

Green Hydrogen: Market Analysis

- In line with India's commitment to achieve net-zero emissions by 2070 and to become an energy-independent nation by 2047, green hydrogen is expected to play a pivotal role as an alternative to petroleum and other fossil-based fuels.
- In 2020, India's hydrogen demand stood at 6 million tonnes (MT) per year.
- According to **NITI Aayog** report titled "**Harnessing Green Hydrogen**" the demand for hydrogen is expected to see more than fourfold jump to 29 MT by 2050.
  - Almost 94% of hydrogen demand in 2050 can be met by green hydrogen, up from 16% in 2030.
  - Cumulative value of green hydrogen market in India could be $8 billion (approx. €6.84 billion) by 2030 and $340 billion (€296 billion) by 2050.

Green Hydrogen: Key Policy Initiatives

National Green Hydrogen Mission 2023:

- ✓ Launched by MNRE with objective to make India the Global Hub for production, usage and export of Green Hydrogen and its derivatives.
- ✓ Government approved initial outlay of INR 19,744 crore (approx. €1.85 billion), including an outlay of INR 17,490 crore (approx. €1.64 billion) for the Strategic Interventions for Green Hydrogen Transition' (SIGHT) programme, INR 1,466 crore (approx. €137 million) for pilot projects, INR 400 crore (approx. €37.4 million) for R&D, and INR 388 crore (approx. €36.3 million) towards other Mission components.

R&D Roadmap for Green Hydrogen ecosystem in India

- ✓ MNRE has unveiled a roadmap for Green Hydrogen ecosystem in India, which outlines R&D priorities for manufacturing and storing green hydrogen.

Green Hydrogen/Green Ammonia policy 2022

- ✓ Policy sets India's strategy to meet its goal of becoming a global green hydrogen hub.

Green Hydrogen Standard for India:

- ✓ Minimum standard for GH as having a well-to-gate emission of not more than 2 kg CO2 equivalent per kg of H2 produced.

Green Ammonia and Green Methanol Standards, 2026:

- ✓ Green Ammonia shall have a total non-biogenic greenhouse gas emission, arising from Green Hydrogen production, ammonia synthesis, purification, compression, and on-site storage, of not more than 0.38 kg CO_2 equivalent per kg of ammonia (kg CO_2 eq/kg NH_3), calculated as an average over the preceding 12-month period.
- ✓ Green Methanol shall have a total non-biogenic greenhouse gas emission, arising from Green Hydrogen production, methanol synthesis, purification, and on-site storage, of not more than 0.44 kg CO_2 equivalent per kg of methanol (kg CO_2 eq/kg CH_3OH), calculated as an average over the preceding 12-month period.

Green Hydrogen: Growth Drivers and Key Challenges

Growth Drivers:

- ✓ **Climate Goals:** India's commitment to reducing greenhouse gas emissions and transitioning to a low-carbon economy under the Paris Agreement is a significant driver for green hydrogen
- ✓ **Renewable Energy Potential:** Renewable energy resources can be harnessed to produce green hydrogen
- ✓ **Favorable Government Policies** such as National Green Hydrogen Mission, Green Hydrogen Policy etc.
- ✓ **International Collaborations**: India has also been actively engaging in international collaborations to promote green hydrogen.
- ✓ **Decarbonizing Sectors**: Sectors such as industry, transportation, and power generation can use green hydrogen as a clean alternative to fossil fuels.

Key Challenges:

- ✓ **High cost:** Currently, the production cost of green hydrogen from renewable energy is higher compared to hydrogen derived from fossil fuels.
- ✓ **Lack of investment and insufficient infrastructure**: Establishment of necessary infrastructure for producing, transporting, storing, and distributing green hydrogen requires significant investment.
- ✓ **Availability of water** for green hydrogen production could be a significant challenge in India.
- ✓ **Lack of harmonized standards and regulations** which is necessary to enable safe and rapid scaling up of projects for production, delivery, storage and use of green hydrogen.

Green Hydrogen: Standardization

- Standards related to green hydrogen value chain are broadly divided into four categories: Mobility, Production and Use, storage and transportation, and general requirement.

- As per NGHM portal, Many standards have already been adopted or developed in India across these categories.

✓ MNRE with CEEW as a knowledge partner, has also published a report titled "Green Hydrogen Standards and Approval Systems in India"

- ✓ It describes various dimensions of regulatory frameworks, standards, testing infrastructure and permissions required for setting up green hydrogen projects in India.
- ✓ It also offers insights into the current status quo and identifies actionable steps for implementing the National Green Hydrogen Mission (NGHM).
- ✓ Report also summarises that, out of the total 201 standards assessed, 87 standards have already been adopted or developed in India, 59 are under development by various issuing bodies, and 52 could be considered for adoption as these are potential gaps that are not assessed by issuing bodies

Green Hydrogen: Standardization Contd.

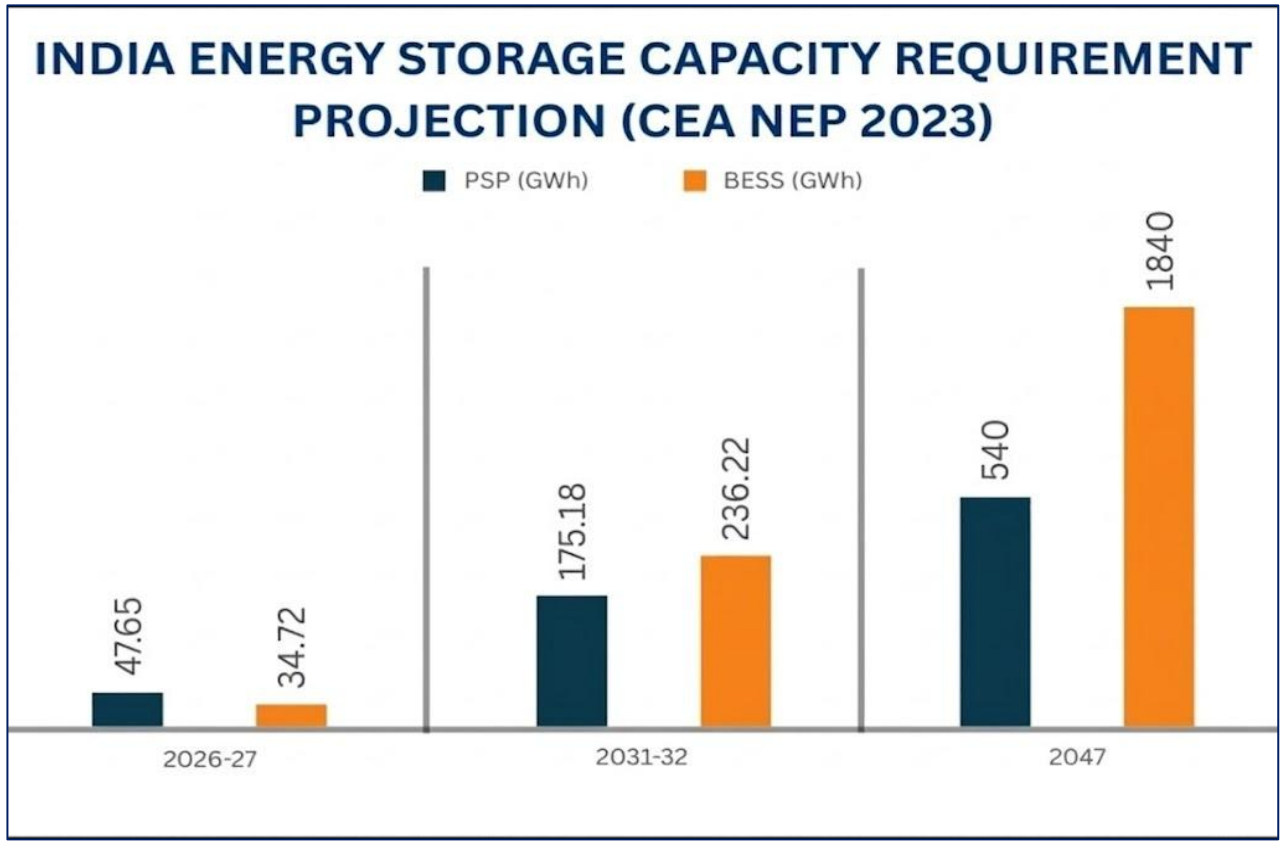
- Many EN Standards such as EN13458, CEN-EN 12245, EN135302:2002/A1:2 004, EN 17339, EN-14585-1 have been adopted by Petroleum and Explosives Safety Organisation (PESO) and is also in the process of adopting many other ENs such as EN13807, EN 720-1, EN 17649: 2022 etc. for Gas infrastructure.
- Many Other EN 17127, EN 303-3, EN 15502-22: 2014, EN 437 are under study for BIS adoption
- Following BIS Technical Committees are relevant, as they are actively working in this domains:
  - **MED1: Boilers And Pressure Vessels -** a) Formulation of standards for terminology, acceptance tests layout of boilers and other aspects not covered under the Indian Boilers Regulations. b) Preparation of code for Unfired Pressure Vessels c) Co-ordination of work with ISO/TC 11 Boilers and Pressure Vessels.
  - **MED16: Gas Cylinders -** Formulation of standards on gas cylinders for permanent, high pressure liquefiable low pressure liquefiable and dissolved gases; fittings of gas cylinder, namely valve fittings, pressure regulators; pipelines conveying gases; identification colours of gas cylinders; acetylene generators; filling ratios and developed pressures for different gases.
  - **MED23: Domestic And Commercial Gas Burning Appliances -** Domestic and commercial gas burning appliances (pressure type) such as gas stoves, oven, cooking ranges and water heaters, including gobar gas stoves
  - **MED38: MECHANICAL EQUIPMENT USED IN REFUELING STATIONS FOR PETROLEUM AND GASEOUS FUEL:** Formulation of standards in the field of mechanical equipment used in refueling stations for petroleum and gaseous fuels
  - **CHD6: Industrial Gases -** a) To formulate Indian Standards for terminology; methods of sampling and test; codes of practice and specifications for industrial gases including high purity speciality gases and gas mixtures other than LPG. b) To liaise with i) ISO/TC 158 Analysis of gases

Energy Storage System

Energy Storage Systems (ESS)

Energy Storage Projections – India (NEP 2023, CEA)

- **2026–27:**
  - Total: **82.37 GWh**
  - PSP: 47.65 GWh | BESS: 34.72 GWh
- **2031–32:**
  - Total: **411.4 GWh**
  - PSP: 175.18 GWh | BESS: 236.22 GWh
- **2047 (Long-term Outlook):**
  - Total: **2380 GWh**
  - PSP: 540 GWh | BESS: 1840 GWh
- **Key Insight:**
  - Rapid scale-up driven by renewable energy integration and net-zero target (2070)
- **Trend:**
  - Increasing dominance of Battery Energy Storage Systems (BESS) over time



ESS: Key Policy Initiatives

National Framework for promoting Energy Storage Systems (2023)

- Ministry of Power released guidelines to accelerate **energy storage adoption**
- Focus on enabling market mechanisms and deployment

BESS Procurement Guidelines (2022)

- Ensure **transparent & competitive procurement**
- Introduce **Intermediary Procurer model** (Aggregator/Trader/Implementing Agency)
- Facilitate **inter-state & intra-state power transactions**

Viability Gap Funding (VGF) – BESS

- **March 2024:**
  - INR 3,760 crore (~€352M) for **13.2 GWh**
  - Support: ₹27 lakh/MWh
- **June 2025:**
  - INR 5,400 crore (~€505M) for **30 GWh**
  - Support: ₹18 lakh/MWh (via PSDF)

ACC Battery Storage Programme (PLI)

- Led by Ministry of Heavy Industries (2021)
- Supports **GWh-scale Advanced Chemistry Cell (ACC) manufacturing** in India

ESS: Growth Drivers and Key Challenges

Growth Drivers:

- **Renewable Energy Integration**
  - Rapid growth in **solar & wind** capacity
  - Storage ensures **reliability despite intermittency**
- **Grid Stability & Reliability**
  - Supports **frequency regulation & voltage control**
  - Critical for **modernizing India's grid**
- **EV Market Expansion**
  - Rising EV adoption driving **battery demand (Li-ion)**
  - Boosts **domestic manufacturing & innovation**

Key Challenges

- **High Capital Costs**
  - High upfront investment for **advanced storage technologies** like lithium-ion batteries
- **Raw Material Constraints**
  - Dependence on imports of **lithium, cobalt, nickel, copper**
  - Exposure to **global supply chain risks**
- **Grid Integration Issues**
  - Challenges in **compatibility, standardization & operations**
- **Evolving Policy & Regulation**
  - Uncertainty in **tariffs, interconnection, ownership models & safety norms**
- **Financing Barriers**
  - Limited access to **affordable capital**
  - Lack of **risk mitigation & revenue certainty**

ESS: Standardization

Bureau of Indian Standards (BIS):

BIS through its technical committee "**ETD 52 on Electrical Energy Storage System**" is responsible for Standardization in the field of grid integrated Electrical Energy Storage (EES) Systems.

- It focuses on system aspects on EES Systems rather than energy storage devices and shall prepare Indian Standards dealing with the system aspects of electrical energy storage.
- EES to include any type of grid-connected energy storages, which can both store electrical energy from a grid or any other source and provide electrical energy to a grid.
- Sectional Committee to include Chemical ES as one of the ESS.
- Thermal storage to be included in the scope, only from the electricity exchange point of view.
- Unidirectional energy storages such as UPS not to be included in the scope of the sectional Committee.

Developed standards:

- IS 17092:2019- Electrical energy storage systems: safety requirements
- IS 17067 (Part 5/Sec 2):2021 (IEC TS 62933-5-2:201)- Electrical energy storage EES systems Part 5 Safety requirements for grid integrated EES systems Section 2 electrochemical based systems
- IS 17387:2020- General Safety and Performance Requirements of Battery Management Systems

Smart Grid/Meter

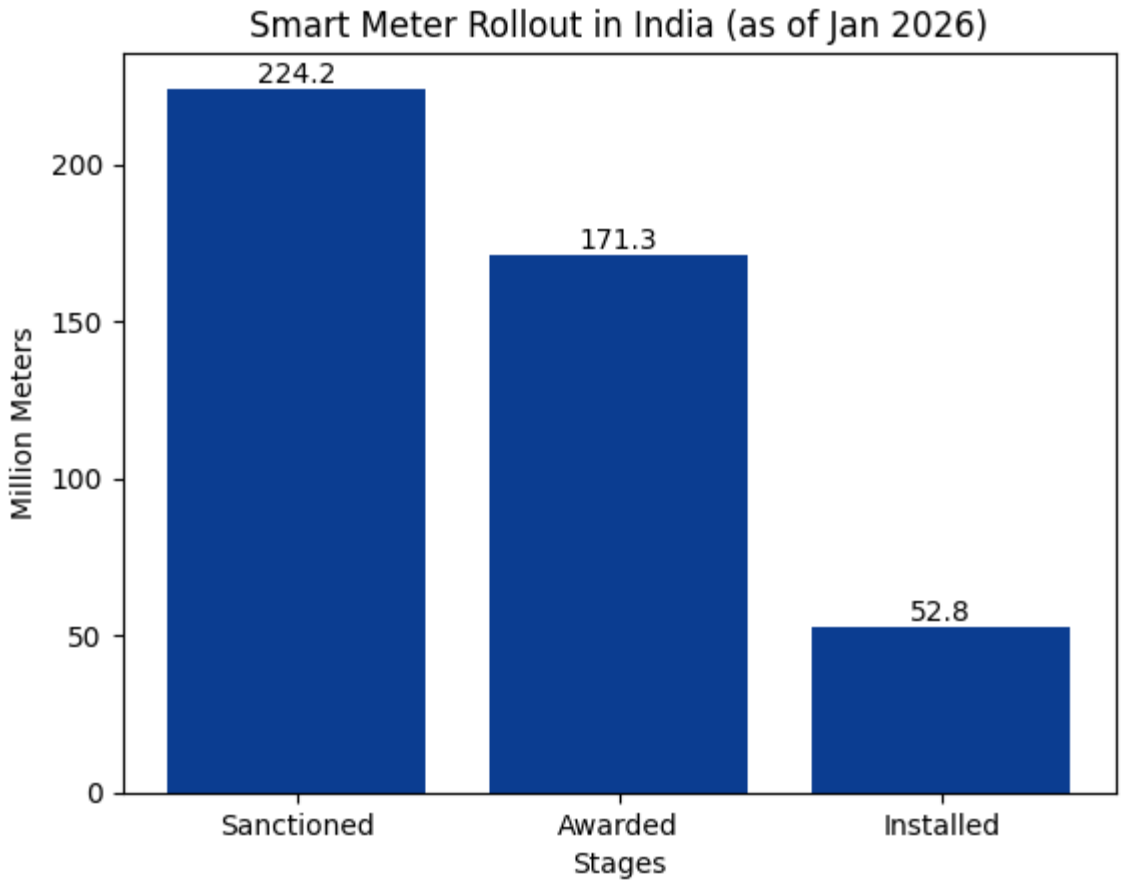
Smart Grid/Meter

Smart Meter Rollout – (Jan 2026)

- **224.2 million** smart meters sanctioned
- **171.3 million** meters awarded
- **52.8 million** meters installed

Key Implementation Schemes

- RDSS (Revamped Distribution Sector Scheme)
- DDUGJY
- IPDS
- NSGM & Smart Grid Pilots
- PMDP & Utility-led models



Smart Grid/Meter: Key Policy Initiatives

Smart Grid Vision and Road map for India released by Ministry of Power in 2013

- ✓ It offers a series of time-framed, specific, target driven measures, across these different areas, with which to enable the development of an Indian Smart grid model.
- ✓ The roadmap covers the 12th, 13th, and 14th 5-year plan periods from 2012 to 2027.

National Smart Grid Mission (NSGM)

- ✓ Ministry of Power (MoP) launched National Smart Grid Mission in 2015 with aims to accelerate Smart Grid deployment in India.
- ✓ So far, 11 Smart Grid pilot projects have been approved under NSGM,adopting the functionalities such as Advanced metering infrastructure, Peak Load Management, Cybersecurity, Distributed generation, Micro grid, Power quality measurement, Smart City Control Center, Smart homes, Advanced IT infrastructure, Renewable Energy Integration, EV with charging infra, Home energy management center, AMI (Smart Metering), Outage management system, Customer engagement social media for utility.

Revamped Distribution Sector Scheme (RDSS)

- ✓ Government of India launched Revamped Distribution Sector Scheme (RDSS) with the objective of improving the quality and reliability of supply to consumers through a financially sustainable and operationally efficient distribution sector.
- ✓ The scheme aims to reduce the AT&C losses and ACS-ARR gap at pan-India level. The scheme has a duration of 5 years i.e., from (FY 2021-22 to FY 2025-26).

Smart Grid/Meter: Growth Drivers and Key Challenges

Growth Drivers:

- ✓ **Energy Efficiency:** Smart grid/meter allows utilities to monitor and manage energy flow in real-time, reducing losses during T&D.
  It helps to address energy efficiency challenges and reduce energy wastage.
- ✓ **Renewable Energy Integration:** India has set an ambitious target of having 500 GW of installed renewable energy by 2030, which includes 280 GW of solar power and 140 GW of wind power.
  - Smart grids can integrate renewable energy sources like solar and wind more effectively by managing fluctuations in supply and demand. This makes the grid more reliable and resilient.
- ✓ **Policy reforms:** Government schemes such as DDUGJY, Integrated Power Development Scheme, NSGM etc. have boosted implementation of Smart Meter across the country.
- ✓ **Rising Electricity Demand and Urbanization:** Rapid urbanization, industrial growth, and increasing electrification of households are driving higher electricity demand.
  - Smart grid infrastructure helps manage peak loads more efficiently, improves reliability, and supports future-ready distribution networks
- ▪ **Growing concerns about environmental pollution and climate change**: Smart grids support the development of a more sustainable energy ecosystem and help in reducing carbon emissions

Key challenges:

- ✓ **Data Security and Privacy:** Smart meters and grids collect a vast amount of data about energy consumption patterns, posing a risk of unauthorized access and potential misuse.
- ✓ **Cybersecurity**: Smart grids and meters also pose significant cybersecurity risks.
  - In October 2021, Power ministry and CEA have released the guidelines for cybersecurity in the power sector to be adhered by all Power Sector utilities to create cyber secure eco system.
- ✓ **High capital investment:** Substantial upfront investment is required for the deployment/implementation of smart grid infrastructure and installation of smart meters.
- ✓ **Lack of Interoperability Standards:** Lack of interoperability standards lead to compatibility issues and hinder the scalability of the technology.

Smart Grid/Meter: Standardization

Bureau of Indian Standards (BIS):

ETD-13: Equipment for Electrical Energy Measurement and Load Control (Smart Meter): Standards for equipment for electrical energy measurement, tariff - and load control, customer information, payment, local and/or remote data exchange, using electromechanical and/or electronic, technologies for applications ranging from electrical energy generation to residential. It is a mirror technical committee of IEC TC-13 (P): Electrical energy measurement and control.

- ✓ **IS 15959 (Part 2): 2016:** Data exchange for electricity meter reading tariff and load control - Companion specification Part 2 smart meter
- ✓ **IS 15959 (Part 3): 2017:** Data exchange for electricity meter reading tariff and load control - Companion specification Part 3 smart meter Transformer Operated KWh And KVarh Class 0 2 S 0 5 S And 1 0 S

ETD 46: Grid Integration: Standards in the field of Grid Integration comprising of LT (ON Grid, Off Grid and Hybrid with and without storage), HT and EHT for all capacities.

- ✓ **IS 18968:2025**: Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
- ✓ **IS 18969:2025**: Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces

ETD 50: LVDC Power Distribution Systems: Standards for: a) LVDC System Requirements, Safety and Installation Guidelines b) LVDC products including electrical wiring accessories and Applications c) Integration of DC Infrastructure d) Non-Traditional Distribution Networks/Microgrids.

LITD 10: Power system Control and associated Communications: Standards relating to: a) Power system control equipment and systems including EMS (Energy Management System) b) DMS (Distribution Management System) c) SCADA (Supervisory Control and Data Acquisition) d) Distribution automation, Smart Grid, tele-protection and associated communications used in planning, operation and maintenance of power systems.

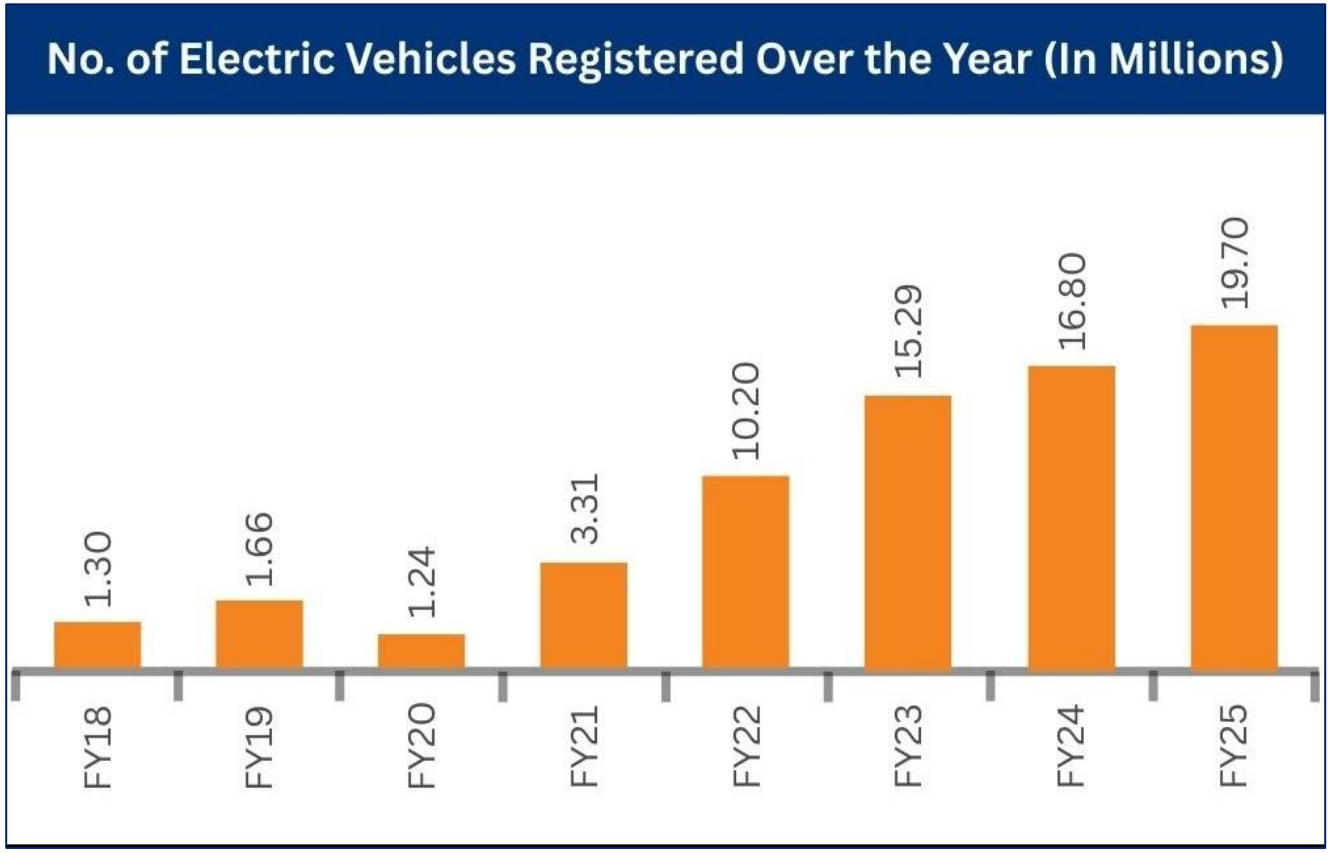
Telecommunication Engineering Centre (TEC):

- Essential Requirements (ERs) for "Smart Electricity Meter" under MTCTE- phase 3.

Electric Vehicle

Electric Vehicle

- Rapid growth trajectory driven by policy support, environmental awareness & technology advancements
- **Market expansion:**
  - EV market: US$ 2.36B (2024) → US$ 164.4B (2033) (CAGR 57.2%)
  - EV battery market: US$ 2.22B → US$ 13.9B | CAGR 22.6%
- **Rising adoption:**
  - 5.8 lakh EVs sold (Q2 FY26)
  - ~10% market penetration
- **Segment trends:**
  - 2W & 3W dominate (~90%) of total EV sales
  - E-goods carriers fastest growth (~159% YoY)
  - Increasing penetration across 2W, 3W & 4W segments
- **Passenger EV momentum:**
  - 17,783 units sold (Oct 2025)
  - +56% YoY, +9% MoM growth
- **Overall market context:**
  - Passenger vehicle sales crossed 5 lakh units (Oct 2025)



Electric Vehicles: Key Initiatives

PM EDRIVE Scheme:

- ✓ PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme with an outlay of INR 10,900 Crore (approx. €1.02 billion was notified on 29 September 2024.
- ✓ Replaced the older "FAME" scheme and will remain in force until March 31, 2026.
  - ✓ It aims to support electric vehicles including e-2W, e-3W, e-Trucks, e-buses, e-Ambulances, EV public charging stations and upgradation of vehicle testing agencies.
- ✓ PM E-Drive is the current primary scheme for EV incentives in India.

National Electric Mobility Mission Plan (NEMMP) 2020:

Launched in 2012 by the government, industry, and academia, NEMMP 2020 outlines a national vision and roadmap for accelerating EV adoption and manufacturing in India.

- **Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) India**
  - ✓ Initially, **FAME-I** (2015-2019) as part of NEMMP was launched by Ministry of Heavy Industries (MHI) in 2015 to support hybrid/electric vehicles market development and manufacturing eco-system
    - ✓ Approximately 2,55,305 EVs were supported and approximately 520 charging stations/infrastructure were sanctioned under this phase.
  - ✓ **FAME-II** (2019-2024) with an outlay 10,000 crore (~€1000 million), was announced for the development of charging infrastructure in the country.
    - ✓ Scheme supported sale of approx. 16.71 lakh EVs including e-2Ws, e-3Ws and e-4Ws and 6,862 e-buses were sanctioned for various cities out of which 5,195 e-buses have been deployed as of January 2026

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Scheme for Promotion of Manufacturing of Electric Passenger Cars in India (SPMEPCI):

✓ Scheme notified on 15th March, 2024 to promote the manufacturing of electric cars in India.

Guidelines for Installation and Operation of Electric Vehicle Charging Infrastructure-2024:

✓ Ministry of Power issued revised "Charging Infrastructure for Electric Vehicles — Guidelines and Standards" in September 2024.

Guidelines for Installation and Operation of Battery Swapping and Battery Charging Stations:

✓ In January 2025, ministry of power has issued comprehensive guidelines to promote battery swapping and charging infrastructure for EVs across the country.

Production Linked Incentive (PLI) Scheme for Automobile and Auto Component Industry in India (PLI-Auto)

✓ PLI-Auto Scheme aims to facilitate and promote deep localization for AAT products and enable creation of domestic as well as global supply chain

PLI Scheme for National Programme on Advanced Chemistry Cell (ACC) Battery Storage

✓ In June 2021, Government notified PLI Scheme for manufacturing of ACC with a budgetary outlay of Rs.18,100 crore (approx. €1.693 billion).

✓ Scheme aims to establish a competitive domestic manufacturing ecosystem for 50 GWh of ACC batteries.

Electric Vehicle: Growth Drivers and Challenges

Growth Drivers

- **Rising Demand**
  - Increasing environmental awareness & high fuel prices
  - Strong shift toward EVs → opportunity for domestic manufacturers
- **Government Support**
  - Incentives, subsidies & reduced road taxes
  - Investments in charging infrastructure
  - Strong policy push for **decarbonization & climate goals**
- **Low-Cost Manufacturing Advantage**
  - Large skilled workforce & established industrial base
  - Cost-efficient production attracting global OEMs
  - Potential to become a **global EV manufacturing hub**
- **Declining Battery Costs**
  - Advancements in battery technology & scale
  - Reduced EV costs → improved affordability
  - Key enabler for **mass adoption**

Key Challenges (Target: 30% EVs by 2030)

- **Limited Charging Infrastructure**
  - Inadequate coverage, especially in non-metro & rural areas
- **Raw Material Dependency**
  - Limited domestic reserves of lithium & cobalt
- **Long Charging Time**
  - Charging takes **30 mins to several hours** vs quick refuelling
- **Consumer Awareness & Price Sensitivity**
  - High upfront costs (battery-driven)
  - Price-sensitive market slows adoption
- **Lack of Standardization & Interoperability**
  - Fragmented charging ecosystem
  - Need for **common standards & fast-charging solutions**

Electric Vehicle: Standardization

Bureau of Indian Standards (BIS):

- ✓ **TED 27 on Electric and Hybrid Vehicles** is responsible for standardization of Electric and Hybrid vehicles and their components. It is national mirror technical committee of ISO/ TC 22/SC 37 and IEC/ TC 69.
- ✓ **ETD 51 on Electrotechnology in mobility** is responsible for standardization of electrotechnical aspects of totally or partly electrically propelled road vehicles.

Automotive Research Association of India (ARAI):

- ✓ **AIS-138 Part1, Part2 / IS 17017** standard applies for charging infrastructure**.**
- ✓ **AIS-038 – Electric Power Train Vehicles-Construction and Functional Safety Requirements:** It includes requirements of a vehicle with regards to specific requirements for the electric power train and requirements of a vehicle Rechargeable Electrical Energy Storage System concerning its safety.
- ✓ **AIS-039 – Electric Power Train Vehicles–Measurement of Electrical Energy Consumption:** It helps in measuring the consumption of electric energy by electric vehicles**.**
- ✓ **AIS-040 – Electric Power Train Vehicles – Method of Measuring the Range:** It is a range test for the electric vehicles.
- ✓ **AIS-041 – Electric Power Train Vehicles – Measurement of Net Power and The Maximum 30 Minute Power:** It helps in the measurement of the net power of the electric vehicle and explains the working and benefits of the maximum 30-minute power.
- ✓ **AIS-049 – Electric Power Train Vehicles – CMVR Type Approval for Electric Power Train Vehicles:** It is a test of grade-ability for electric vehicles.
- ✓ **AIS-131** type-approval procedure for electric and hybrid electric vehicles introduced in the market for pilot/demonstration projects intended for a government scheme.
- ✓ **AIS-123** on CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment.
- ✓ **AIS-102 (Part 1 & 2)** on CMVR Type Approval for Hybrid Electric Vehicles.

Circular Economy including Resource & Energy Efficiency

Circular Economy including Resource & Energy Efficiency: Key Policy Initiatives

Circular Economy Cell- NITI Aayog:

- ✓ CE Cell is a dedicated unit to work in the area of Circular Economy.
- ✓ 10 sectoral Circular Economy action plans were finalized in NITI Aayog for implementation by stakeholder Ministries/Departments

National Resource Efficiency Policy, 2019:

- ✓ Released by Ministry of Environment, Forests and Climate Change (MoEF&CC) with aims to drive the country towards circular economy through efficient use of available material resources, based on principle of 6R (reduce, reuse, recycle, redesign, re-manufacture and refurbish) and 'green public procurement'.

Mission LiFE (Lifestyle for Environment):

- ✓ Mission LiFE encourages individuals and communities to adopt environmentally conscious practices such as reducing waste, conserving energy and water, minimizing plastic usage, and promoting sustainable lifestyles.
- ✓ **Green Credit Program (GCP)** and **Ecomark Scheme**, seek to encourage environmentally friendly practices rooted in tradition and conservation; reflecting the ideas of LiFE concept.

TEC: Vision, Strategy, and Action Plan for Circular Economy in Telecom Sector:

- ✓ DoT is finalizing a "Vision, Strategy, and Action Plan for Circular Economy in Telecom Sector" to create a structured approach to waste management and resource efficiency.

Other Initiatives

Right to Repair Framework:

- ✓ Ministry of Consumer Affairs launched "Right to Repair Portal" empowering consumers to repair, reuse, and maintain products via accessible manuals, spare parts, and third-party services
- ✓ Aimed at boosting the circular economy and reducing e-waste, it forces manufacturers to share product details, reducing dependence on brand services.
- ✓ It also incorporates R3 concept i.e. Reduce, Reuse (repair) and recycle.

Carbon Credit Trading System (CCTS), 2023:

- ✓ CCTC provides an overall framework for functioning of Indian Carbon Market (ICM).
- ✓ Objective of CCTS is to reduce or avoid greenhouse gas emissions from various sectors of Indian economy by pricing the emissions through a carbon credit certificate trading mechanism.
- ✓ Government has notified GEI targets for some carbon-intensive sectors including Petroleum Refineries, Petrochemicals, Textiles and Secondary Aluminium etc. covering 490 obligated entities.

Waste management Rules by MoEF&CC:

- ✓ Waste Management Rules such as the Plastic Waste Management Rules, e-Waste Management Rules, Construction and Demolition Waste Management Rules, Battery Waste Management Rules 2022, Solid Waste Management Rules, 2016 etc. towards reducing waste generation and maximizing recycling of waste.

Circular Economy: Growth Drivers and Key Challenges

Growth Drivers:

- ✓ **Resource Scarcity**: India's growing population and economy put pressure on natural resources. Circular Economy minimizes resource depletion by maximizing the utilization of existing resources.
- ✓ **Increased awareness of Environmental degradation, pollution, and waste management issues** has led to a greater focus on sustainable practices like circular economy principles.
- ✓ **Increased demand for sustainable products and services** drives adoption of circular economy practices.
- ✓ **Economic Opportunities**: Circular Economy creates new business models, jobs, and economic growth by promoting recycling, remanufacturing, and value-added services.
- ✓ **Government Support**: Government policies, such as extended producer responsibility (EPR) regulations and waste management rules, drive businesses to adopt circular practices and reduce waste.

Key Challenges:

- ✓ Lack of awareness and understanding of circular economy concepts among businesses and consumers
- ✓ Inadequate waste collection and segregation
- ✓ Lack of infrastructure and recycling technologies
- ✓ Lack of support and incentives from Government
- ✓ Lack of R&D in adopting Circular Economy

Circular Economy: Standardization

Bureau of Indian Standards (BIS):

PCD 12- Plastics:

- ✓ To formulate Indian Standards for specifications for thermosetting and thermoplastic resins-bonded and moulding materials; natural and synthetic polymers, synthetic resin bonded laminates thermoplastic films and sheets, plasticizers cellular plastics, finished plastic articles, composites and reinforced plastics (excluding sanitary wares and plastic pipes for water supply and plastic packaging containers) safety of toys, and natural and synthetic adhesives (excluding for plywood industry and electrical tapes).

EED-1: Environmental management:

- ✓ Responsible for standardization in the field of Environment Management systems, Life Cycle Assessment, General Management of Green House Gases, Climate Change Management, Environmental labelling, Sustainability at Organizational Level.

EED-5: Environmental Services:

- ✓ Responsible for standardization in the field of various environmental services including sewage services, refuse disposal, sanitation and similar services, reducing emissions, noise abatement services, nature and landscape protection services and other environmental services.

EED-7: Sustainability In Built Environment:

- ✓ Standardization in the field of sustainability in new and existing buildings/constructions, responding to current and emerging concerns pertaining to climate change, environment toxicity and ecological disruption.

Continue..

EED-8: Waste Management

- ✓ Terminology, methods of sampling, method of test, characterization and categorization of waste (Excluding Nuclear waste).
- ✓ Handling and management of wastes including waste audits and data collection (Excluding Nuclear waste).
- ✓ Plant machinery and equipment related to waste management; iv) Services related to waste management.

EED-9: Circular Economy

- ✓ Responsible for Indian Standards on: Circularity framework, guidance, supporting tools and requirements; Circularity in design; Recovered critical materials / resources of national importance. Excluding: Aspects of Circular Economy already covered by other sectional committees.

EED-10: Carbon dioxide Capture, Transportation, Utilization and Storage:

- ✓ EED-10 is responsible for developing standards in the field of design, construction, operation, environmental planning and management, risk management, quantification, monitoring and verification, and related activities in the field of carbon dioxide capture, utilisation, transportation, and storage.

ETD 43: Standardization of Environmental Aspects for Electrical and Electronic Products:

- ✓ To prepare the necessary guidelines, basic standards, in the environmental area, in close cooperation with product committees, which remain autonomous in dealing with the environmental aspects relevant to their products; To liaise with product committees in the elaboration of environmental requirements of product standards in order to foster common technical approaches and solutions for similar problems and thus assure consistency in standards.

Telecommunication Engineering Centre (TEC):

- ✓ National Working Group (NWG)-5 in TEC corresponding to ITU-T Study Group-5 (SG5): Environment, Climate Action, Circular Economy and Electromagnetic Fields, comprises members from industry, academia, start-ups, research organizations and government organizations, under the Chairpersonship of DDG (Radio), TEC.

Telecom Circularity

Telecom Circularity: Key Policy Initiatives

E-Waste Management Rules 2022

- ✓ India's E-Waste (Management) Rules, 2022, effective from April 1, 2023, mandate strict Extended Producer Responsibility (EPR) for electronic equipment, including telecom and network hardware.
- ✓ Producers must register on a CPCB portal to manage collection, recycling, and safe disposal, aiming for a 70% to 80% collection rate by 2023-2024 onwards.
- ✓ These rules promote a circular economy, enforcing authorized, environmentally sound disposal.

Voluntary Code of Practice for Sustainable Telecom

- ✓ In October 2017, Telecom Regulatory (TRAI) had released **recommendations on Approach towards Sustainable Telecommunications** with aims to reduce carbon footprint of telecom sector.
- ✓ TRAI has recommended 40% reduction in carbon emissions in telecom networks by 2022-23 considering 2011-12 as the base year in order to make telecom sector greener.
- ✓ As a further step towards sustainable telecommunications, In January 2018, Department of Telecommunications (DoT) has issued a notification "**Approach towards Sustainable Telecommunications**" to implement it as a Voluntary Code of Practice.
- ✓ Telecom Engineering Centre (TEC) has finalized a document on "Voluntary Code of Practice (VCP)" to be adopted by Telecom Service Provider (TSP) for reduction in the Carbon Footprint".

Recycling of Critical Raw materials

Recycling of Critical Raw Materials

- ✓ Critical minerals (Lithium, Cobalt, Nickel, REEs, Graphite) are essential for:
  - ✓ EVs, renewable energy, electronics, telecom, defence
- ✓ Rising global demand: strategic importance of secure supply chains
- ✓ India is import-dependent for most CRMs
- ✓ Recycling from:
  - ✓ E-waste, Spent Li-ion batteries, Industrial scrap

Investments & Strategic Initiatives

- **REPM Manufacturing Scheme (2025)**
  - INR 7,280 crore (~€681M)
  - Target: **6,000 MTPA capacity** across value chain
- **Industry Investments**
  - Attero: INR 100 crore (~€9.36M) in magnet recycling
- **Overall Investment Push (2025–31)**
  - INR 34,000 crore (~€3.18B)
- Focus:
  - Reduce import dependence
  - Build domestic ecosystem
  - Strengthen supply chains

Policy Initiatives

National Critical Mineral Mission (NCMM)

- Launched by Government of India in 2025 for 7 years (FY 2024–25 to FY 2030–31) with aims to Build a self-reliant and resilient critical minerals ecosystem in India
- Budget: INR 16,300 crore (Government) & Expected Investment (≈ €1.542 billion): INR 18,000 crore from PSUs & stakeholders (≈ €1.703 billion)
- Under NCMM, Geological Survey of India (GSI) to undertake 1,200 exploration projects
  - ✓ GSI follows the United Nations Framework Classification (UNFC) classification and Minerals (Evidence of Mineral Contents) (MEMC) Rules, 2015, to carry out exploration activities for critical minerals.
- Targets **1,000 patents** by 2030, with the creation of **7 Centers of Excellence (CoE)** to drive breakthroughs in exploration and extraction.
  - **Guidelines** issued for Centre of Excellence on Critical Minerals (CECM) to align R&D with national priorities
  - 21 patents filed (May'25), 41 filed (June'25) and 10 patents granted (May'25–June'25)
- Recycling & Circular Economy
  - INR 1,500 crore Incentive Scheme approved by Union Cabinet (≈ €141.89 million)
  - Focus on recycling from e-waste & battery scrap
  - Support: 20% Capex subsidy + Opex support for 6 years (FY25–31)
  - Expected outcomes: new recycling capacity, jobs, and supply chain security

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- **Critical Minerals Identification**
  - ✓ Ministry of Mines committee (Nov 2022) identified **30 critical minerals**
  - ✓ **24 minerals included in Part D, Schedule I of MMDR Act, 1957**
  - ✓ Central Government granted **exclusive authority** to auction mining leases & composite licences
  - ✓ **List of Critical Minerals:** Lithium, Cobalt, Nickel, Copper, Graphite, REEs, PGE, Titanium, Tungsten, Vanadium, Gallium, Germanium, Indium, Niobium, Tantalum, Zirconium, Molybdenum, Potash, Phosphorus, Tin, Silicon, Selenium, Cadmium, etc.

<u>Recent Updates (Nov 2025): EoDB</u>

- Ministry of Mines has **withdrawn Quality Control Orders (QCOs) on seven key non-ferrous metals and alloys** that are classified as critical minerals:
  - ✓ Aluminium & Aluminium Alloys
  - ✓ Copper, Nickel
  - ✓ Primary Lead, Refined Zinc
  - ✓ Refined Nickel, Tin Ingot
- Removes mandatory **BIS certification** for imports, easing supply constraints

Recycling of Critical Raw materials: Growth Drivers & Challenges

Growth Drivers:

- **Clean energy & EV demand:** Rising need for lithium, cobalt, nickel, REEs
- **Import dependence:** Push for domestic supply security
- **E-waste growth:** Increasing electronics & battery waste streams
- **EPR regulations:** Mandatory collection & recycling by producers
- **Circular economy goals:** Supports sustainability & climate targets

Challenges:

- **Limited infrastructure & technology:** Low advanced recycling capacity
- **Informal sector dominance:** Inefficient & unsafe recovery practices
- **Weak collection systems:** Fragmented supply of recyclable materials
- **High costs:** Recycling sometimes costlier than imports
- **Skill gaps:** Shortage of trained workforce

Recycling of Critical Raw materials: Standardization

Bureau of Indian Standards (BIS):

- ✓ BIS is responsible for formulating Indian Standards (IS) for the quality and safety of recycled materials, particularly through its Chemical department (CHD), Petroleum, Coal and Related Products department (PCD).
- ✓ Under the new EPR framework for non-ferrous metals, BIS is specifically tasked with revising and issuing standards for recycled material quality.
- ✓ Bureau of Indian Standards (BIS), through various metal-specific technical committees has published over 400 standards.

Ministry of Environment, Forest and Climate Change (MoEFCC)

- ✓ The nodal ministry for environmental regulations, which notifies the Rules for E-Waste (Management) Rules, 2022, Battery Waste Management Rules, 2022, and Hazardous and Other Wastes Rules, 2016.

Central Pollution Control Board (CPCB)

- ✓ Responsible for developing technical guidelines, Standard Operating Procedures (SOPs), and managing the Extended Producer Responsibility (EPR) portal, which acts as the single point for registration of recyclers.

Ministry of Mines (MoM)

- ✓ Through the NCMM, this ministry is the lead agency for securing critical mineral supplies, including establishing an incentive scheme for recycling secondary sources (tailings, fly ash, red mud) and providing guidelines for Centers of Excellence (CoE) in critical minerals.

EU-India Cooperation

EU-India Cooperation: A Joint India-European Union Comprehensive Strategic Agenda

Towards 2030: A Joint India-European Union Comprehensive Strategic Agenda

Joint India-EU Comprehensive Strategic Agenda, endorsed at the 16th India-EU Summit held on 27 January 2026 in New Delhi, aims to further reinforce the strategic partnership by broadening, deepening and better coordinating EU-India cooperation to deliver mutually beneficial, concrete and transformative outcomes for both partners and for the wider world.

The strategic agenda covers key areas:

- ✓ **Advancing clean transition and resilience:** Strengthen cooperation under **India-EU Clean Energy and Climate Partnership**, including through energy technologies, smart grids, storage, electricity sector regulation, energy and climate diplomacy.
- ✓ **Reactivate Joint WG on Energy Security under the India-EU Energy Panel** which would inter-alia focus on dialogue on diversifying reliable and affordable energy sources and strengthen co-operation to promote energy efficiency improvement across sectors.
- ✓ **Organise an India-EU Wind Business Summit** to foster business and expert exchanges on wind energy technologies, know-how, auction design, tendering, investment and financing, research and innovation, and testing and demonstration facilities.
- ✓ **Operationalise the India-EU Task Force on Green Hydrogen** to foster cooperation on hydrogen production, storage, and distribution to support efforts to decarbonise hard-to-abate sectors.
- ✓ Explore further cooperation in sustainable mobility including **Sustainable Aviation Fuels (SAF), Compressed Biogas (CBG),** as well as on vehicles' energy certification methodologies, e-mobility, and electric vehicle charging standards.

Continue…

Towards 2030: A Joint India-European Union Comprehensive Strategic Agenda

- ✓ **Deepen cooperation under India-EU Partnership on Smart and Sustainable Urbanisation** including by furthering city-to-city cooperation and exchanges as well as investments.
- ✓ **Advance collaboration on sustainable finance instruments and corporate sustainability**, including under the EU's Global Green Bonds Initiative.
- ✓ Work together to make power markets stronger, using tools such as contracts for difference, smart meter insights, and offtake agreements.
- ✓ Cooperate on efforts towards industrial decarbonisation of heavy hard to abate energy intensive industries, including through exchanging best practices on low-carbon materials definitions such as steel and cement, while ensuring a level playing field.
- ✓ Work towards sharing experiences on the design and implementation of **India's Carbon Credit Trading Scheme (CCTS),** and the **EU's Emissions Trading Scheme (ETS)** and exploring further cooperation.
- ✓ Deepen collaboration on water resilience and security within the **India–EU Water Partnership** through organisation of regular EU-India Joint Working Group on Water Cooperation.
- ✓ Reinforce the **Resource Efficiency & Circular Economy Partnership**, including by establishing an India-EU Joint Working Group on Circular Economy.

EU-India Cooperation: India - EU TTC Working Group 2 (WG2)

India - EU TTC Working Group 2 (WG2) on "Green & Clean Energy Technologies"

- Fosters R&I in Green & Clean Technologies (Clean Energy, Circular Economy, Waste Management).
- Strengthens cooperation between EU and Indian incubators, SMEs, and start-ups.

Key Joint R&D Initiatives (2025–2026):

- **€60 Million Joint Fund:** Coordinated calls from Horizon Europe and Indian contributions.
- **EV Battery Circularity:** Focus on low-cost, flexible, and easy-to-recycle battery tech.
- **Waste-to-Hydrogen:** ₹90 Cr ($~€8.4M$) call to convert biogenic waste into renewable H2.
- **Marine Plastic Litter:** Technologies for detection, measurement, and mitigation.

Standards & Human Capital:

- Harmonizing EV charging infrastructure standards and e-mobility testing.
- Joint Task Force on Green Hydrogen safety and science-based standards.
- Building human resource capacity to meet 2050/2070 Net-Zero targets.

Other Partnership Instruments

India-EU Clean Energy and Climate Partnership (CECP), Phase III (2025-28)

- Accelerating renewable integration, grid stabilization, and offshore wind.
- Launch of the Green Hydrogen Task Force (Jan 2026), during the 16th EU-India Summit held in January 2026

EU Global Gateway Strategy & Connectivity:

- Mobilizing sustainable investment in digital, energy, transport, and health by 2027.
- A transparent, democratic alternative for high-quality infrastructure.
- Priority on Sustainable Urbanization and the green transition.

India-Middle East-Europe Economic Corridor (IMEC):

- Vision: Reshaping global trade by connecting India, the Middle East, and Europe.
- Key Pillars:
  - **Infrastructure**: State-of-the-art transport and digital logistics hubs.
  - **Sustainability**: Integration of renewable energy and eco-friendly trade routes.
  - **Innovation**: Leveraging AI and data analytics to streamline the flow of goods.

Conclusion

- India is steadily advancing a robust green technology ecosystem driven by policy, market forces & global partnerships
- Strong progress across renewables, green hydrogen, energy storage, EVs & circular economy
- Integrated approach: clean energy + resource efficiency supports decarbonization & economic growth
- Continued challenges in infrastructure, investment, and implementation need focused attention
- EU–India collaboration key for technology transfer, standards alignment & investment
- SESEI project supports clean tech areas: telecom circularity, smart grids/meters, EV charging ecosystem
- India is well-positioned to lead with sustained policy support, innovation & stakeholder coordination

Dinesh Chand Sharma

(Seconded European Standardization Expert in India)

Director – Standardization & Public Policy

AltF, 2ND Floor (TR-211 && 214), 101

Ishwar Nagar, Okhla, New Delhi 110044

Mobile: +91 9810079461, **dinesh.chand.sharma@sesei.eu**

www.sesei.eu ⇔ **www.sesei.in**