Accelerating India's clean energy transition

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Foreword

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India is pioneering a new model of economic development that could avoid the carbon-intensive approach. The use of renewable energy not only helps in the primary objectives of advancing economic development and mitigating climate change but also improves energy security and access to energy.

The Hon'ble Prime Minister has laid out India's commitments towards climate action at CoP26 Summit in his 'Panchamrit statement' as five-point action agenda. India's commitment to energy transition and non-fossil energy capacity coupled with several positive steps taken towards sustainable development shows our country's leadership and strength. It also highlights on the firm intent of the Governments to move rapidly towards carbon reduction and net zero.

To achieve the targets envisaged, Energy Transition will be the most important pillar moving ahead. FICCI as the apex business organization in the country has been supporting the Government with its inputs and activities in this crucial area and we are now pleased to present a well-researched report – 'Accelerating India's Energy Transition' in collaboration with EY.

This report highlights the initiatives required to create a robust ecosystem to enable the energy transition. The report covers clean energy opportunities currently under development - project pipeline as well as signifies their impact on economic development, job creation and environment sustainability. It also provides key recommendations to overcome impediments to the clean energy growth in India.

We hope this report will provide useful inputs to the Government, Industry and stakeholders to drive next wave of energy transition in India and stimulate policy direction on the subject.

I take this opportunity to place on record our gratitude to FICCI Renewable Energy CEOs Council, FICCI Power Committee and others from the industry and government for their valuable insights.

Foreword

Mr. Somesh Kumar
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The impacts of COVID pandemic and the ongoing conflict in Ukraine is a stark reminder on how India's dependence on energy imports and other commodities linked to global supply chains can threaten its strategic interests. In this context, the ongoing energy transition is a boon for India's long term energy security, sustainability and self-reliance.

India's thriving renewable energy markets and enabling policy ecosystem has helped retain its position among the top 3 markets globally in the EYs 'Renewable Energy Country Attractiveness Index' (RECAI).

Decarbonization, decentralization, digitization and aatma-nirbharta are the four building blocks of India's energy transition. Equitable and affordable energy access for all to meet economic development objectives is non-negotiable in this transition. At the same time, energy efficiency and environmental sustainability remain the key drivers of this transition.

Power sector is currently leading the energy transition efforts globally including India enabled by rapid decline in the cost of intermittent solar and wind energy sources for electricity production. However, the availability of competitive long duration energy storage technologies will determine the speed and scale of the transition in this sector going forward. In the hard to abate sectors such as manufacturing (e.g. steel, cement, ammonia etc.) and transport that rely heavily of fossil fuels, green hydrogen is emerging as a promising low carbon feedstock / energy carrier. The competitiveness of these technologies along with enabling policy ecosystem will determine the speed and scale of the transition in future.

In this report, EY has identified over ~650 'shovel-ready' energy transition investment opportunities at various stages of development. This pipeline shows tremendous potential for capital deployment and other socio-economic benefits in terms of employment generation and avoided CO_2 emissions. Moreover, these projects are critical to accelerate India's energy transition and play a key role in achieving India's long term commitments towards climate change mitigation.

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Acronyms

AC	Alternate Current
ACC	Advanced Chemistry Cell
BCD	Basic Custom Duty
BESS	Battery Energy Storage System
C&I	Commercial & Industrial
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CFA	Central Financial Assistance
CPSU	Central Public Sector Undertakings
DCR	Domestic Content Requirement
DHI	Department of Heavy Industries
DISCOM	Distribution Company
DPR	Detailed Project Report
EESL	Energy Efficiency Services Limited
EPC	Engineering, Procurement and Construction
EV	Electric Vehicle
EY	Ernst & Young
FICCI	Federation of Indian Chambers of Commerce & Industry
GT&D	Generation, Transmission & Distribution
GW	Gigawatt
GWp	Gigawatt Peak
ICAR - CAZRI	Indian Council of Agricultural Research Central Arid Zone Research Institute

IEA	International Energy Agency
IREDA	Indian Renewable Energy Development Agency Limited
ISTS	Interstate transmission network
kW	kilowatt
LiB	Lithium ion Battery
LOA	Letter of Award
LTA	Long-term access
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MSME	Micro, Small & Medium Enterprises
Mt	Million tons
Mtoe	Million tons oil equivalent
MW	Megawatt
NHM	National Hydrogen Mission
NSEFI	National Solar Energy Federation of India
NTPC	National Thermal Power Corporation Limited
O&M	Operation and Maintenance
OEM	Original equipment manufacturer
OPEX	Operating Expenditure
PBI	Procurement based incentive
PERC	Passivated Emitter and Rear Cell
PHC	Primary Health Center
PLI	Production Linked Incentive
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan

PPA	Power purchase agreement
PSA	Power sale agreement
PSU	Public sector undertakings
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
RESCO	Renewable Energy Service Company
RPO	Renewable Purchase Obligation
RTC	Round-the-clock
RTPV	Rooftop Solar Photovoltaic
SCOD	Scheduled Commercial Operational Date
SECI	Solar Energy Corporation of India Limited
SERC	State Electricity Regulatory Commission
SPPD	Solar Power Park Developer
SPV	Special Purpose Vehicle
UMREPP	Ultra Mega Renewable Energy Power Park
UT	Union Territory
VGF	Viability Gap Fund
WHO	World Health Organization

Executive summary

1

Robust planning and predictable growth in demand for clean energy sources is essential for accelerating energy transition investments

Decarbonization, decentralization, digitalization and aatma-nirbharta are the building blocks of India's energy transition to ensure equitable and affordable energy access for all. Energy transition is fundamental to achieving long term economic development and sustainability objectives. Market outlook towards increasing share of electricity and other low carbon fuels in final energy consumption and gradual phasing out of coal and petroleum products in the primary energy mix are the defining characteristics of energy transition.

Rapidly evolving energy transition technologies rising demand for clean energy sources and policies are the key enablers for driving market-based investments. Power sector is leading India's energy transition driven by rapid decline in cost of intermittent solar and wind energy sources. However, availability of scalable long duration energy storage technologies at competitive prices will determine the speed and scale of transition in the power sector going forward. Energy storage is critical to build adequate flexibility across the power system value chain (GT&D) and integrate high shares of intermittent renewable energy sources. In this regard, viability gap funding for initial uptake of long duration energy storage technologies looking beyond Li-ion chemistry is necessary. Whereas, green hydrogen is rapidly emerging as an alternative low carbon energy carrier/vector to decarbonize manufacturing and transport sectors, which account for ~32% of India's GHG emissions. In the short to medium term, manufacturing industry will lead the way for scaling up production and end-use of hydrogen, while transport and power sector solutions, business models will evolve in the long term.

Robust and predictable growth in demand for clean energy sources is essential for accelerating energy transition investments. There is a need to restructure the framework of integrated resource and electricity demand planning in order to undertake technology, portfolio mapping and enhance coordination, especially at the state level for harmonization of techniques and reporting with greater degree of granularity. States must focus on conducting least cost generation expansion planning backed by optimal dispatch simulation at an hourly resolution for spot years (e.g., 2025/2030/2040). Such planning should also be accompanied by modelling network constraints and grid stability analysis for validating integration of high shares of renewable energy for spot years.

Incentives for fossil to electricity transition technologies and solutions, particularly for manufacturing industries can help accelerate inorganic growth of electricity demand in the economy. Further, implementation of reforms to improve financial health of electricity distribution sector is fundamental to the bankability of energy transition related investments. Implementation of 'Draft Electricity (Promoting RE through Green Energy Open Access) Rules, 2021' can help MSMEs and other consumers having 100 kW & above connected load with greater options for sourcing renewable energy.

Eventually, India's energy transition may leave coal and petroleum industries, communities and workers exposed to decline in demand for fossil fuel commodities in the long term. Understanding and addressing the social dimensions of energy transition is critical to ensure that fossil fuel communities are not overly disadvantaged or left behind. Taking action to address the potential disparity in the economic and social outcomes from the inevitable transition can be labelled a just or equitable transition. Globally, there is a growing recognition among institutional investors that these social considerations should form part of the broader response to the risks and opportunities inherent in the energy transition.

Theme: Robust planning and predictable growth in demand for clean energy sources

Policy interventions

- Coordinated and harmonised framework for integrated resource and electricity demand planning, particularly at the state level
- Incentives for fossil to electricity transition technologies and solutions, particularly for manufacturing industries to accelerate inorganic growth
- Implementation of reforms to improve financial health of electricity distribution sector
- Formulate national policy framework for closure / phase-out / re-purposing of coal-based power plants and mines focusing on Just Transition principles and goals
- Formulate energy storage policy with viability gap funding for initial uptake of long duration energy storage technologies

India must build resilience against forces threatening the affordability of energy transition technologies, raw materials and commodities used for domestic production

Rising cost of domestic solar PV panels could delay the pace of energy transition in India. Studies from leading market research firms show that solar module prices have increased between 30-50% in the past two years. Some critics may attribute the rise in solar module prices to imposition of BCD on imported PV cells (25%) and modules (40%) effective from April 2022. This is not entirely accurate. As per the data compiled by a leading solar PV market intelligence and research firm, solar module prices have become increasingly unpredictable and volatile since the inception of COVID in 2020. Solar module prices (mono PERC) in the global market increased from August 2020 to November 2021 by 42%. On similar lines, solar module prices (mono PERC) in India also increased from August 2020 to November 2021 by 40%.

One of the principal reasons behind the rising cost of solar modules is supply chain disruptions, especially raw materials and commodities used in the manufacturing of solar panels. Polysilicon is the critical raw material used in solar PV module manufacturing. Between July 2020 and April 2022, polysilicon price in the global markets increased 5-6 times. Other disrupting factors in the PV module supply chain include price hikes for commodities such as glass and basic metals (steel / aluminium), shortage of containers etc. Such disruptions exacerbated further due to various COVID-19 induced lockdowns across the world leading to halting of manufacturing activity.

The impact of BCD imposition on imported PV cells would taper down in the medium to long term term as India builds sufficient PV cell manufacturing capacity planned under the existing solar PLI scheme. However, sustained higher cost of commodities, raw materials (polysilicon) and logistics used in the supply chain of solar PV modules is a major threat to energy transition. Therefore, the current solar PLI scheme must focus on building sufficient manufacturing capacity of 98% grade silicon from quartz, polysilicon, ingots and wafers, all critical components used in the production of solar PV cells and modules.

Moreover, with the increase in GST rate from 5% to 12% on renewable energy equipment (at the project level) the new effective rate of GST on wind and solar energy services comes to around 13.8%. Government of India should explore reversing this increase in GST rate for providing partial relief from rising solar panel prices to the consumers.

The government of India recently announced import duty cuts for critical raw materials used in the iron, steel and plastic industries with the intention to reduce their prices for domestic consumption. Similar interventions could be explored to provide relief for critical commodities used in solar module manufacturing such as glass (e.g. soda ash) and aluminium (e.g. pet coke, caustic soda), which could benefit the consumers of solar PV panels.

Lithium-ion battery packs currently attract 30-40% taxes (import duty@15% and GST@18%) for consumers. These advanced chemistry battery packs will remain the dominant technology for electrification of mobility and stationary energy storage applications critical for integration of intermittent renewable energy sources through 2030. The ACC PLI scheme envisages to add 50 GWh of manufacturing capacity in the next 2-5 years with up to 60% of local value addition. The consumers could benefit from immediate relief from import duties and GST rates until the domestic manufacturing capacity is established for catering to the local demand. Any safeguard duties to protect the local manufacturers can be formulated in consultation with the industry.

Theme: Building resilience against forces widening the gap between sustainability and affordability of energy transition technologies

Policy interventions

- Re-imagine solar PLI scheme to focus on manufacturing critical raw materials (polysilicon) and upstream value chain components
- Reverse GST rate to 5% for providing partial relief from rising solar panel prices to the consumers
- Extend import duty cut reliefs for critical raw materials imported in the production of glass and aluminium, commodities used in solar panels
- Rationalize tax rates (import duty and GST rate) for lithium ion battery packs until the domestic manufacturing capacity is established for catering to the local demand

Methodology for building energy transition investment pipeline

EY is collaborating with the industry to inform the 'shovel-ready' energy transition investment opportunities in the pipeline. These opportunities help achieve the right balance between economic development and energy transition goals by Government of India. The principal objectives of this collaboration are as follows:

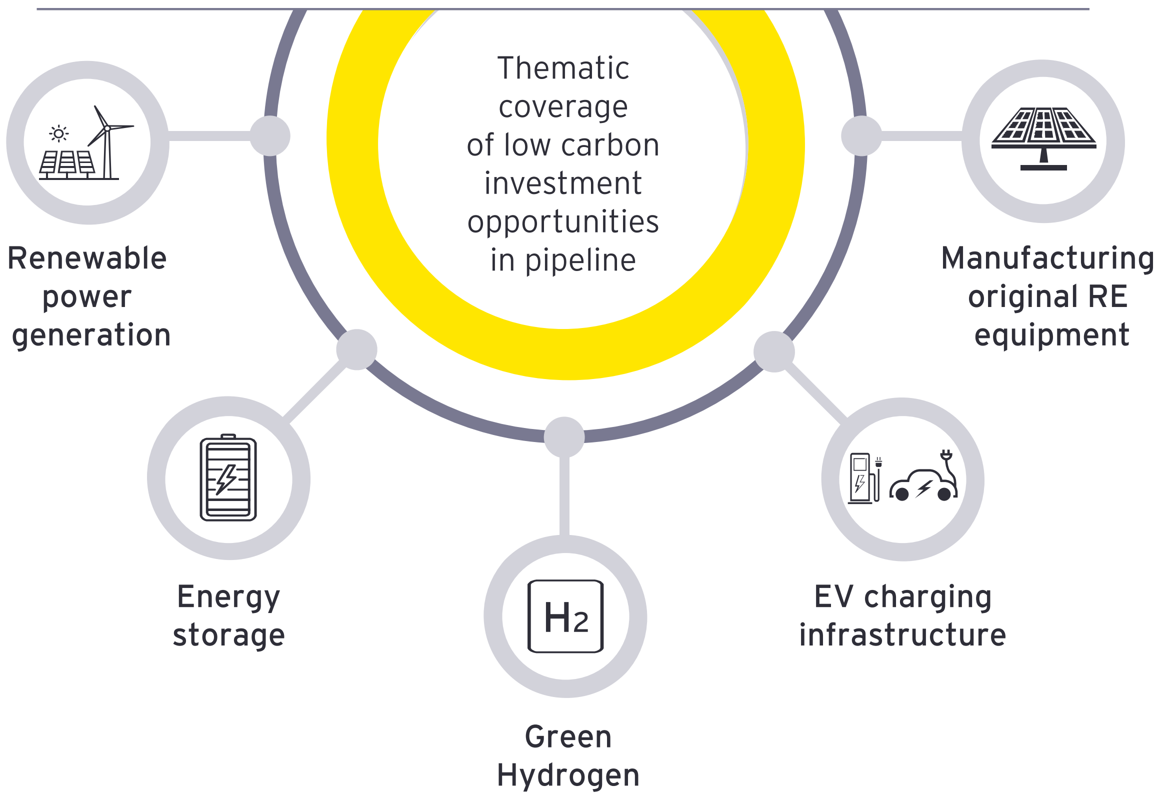
- Identify 'shovel ready' low carbon investment opportunities under development – 'project pipeline'
- Assess what is at stake in terms of impact on economic development, jobs and environment
- Build consensus on stimulus action to accelerate energy transition investments in the economic development plans

EY has identified over 650 'shovel-ready' energy transition investment opportunities in the pipeline with tremendous potential for economic development, jobs and ultimately contributing towards India's long-term climate objectives. Project level information was gathered from primary and desktop research tools including consultations / interviews with project developers, OEMs, investors etc. with the support of a leading market research agency. Proprietary databases were also leveraged to identify the long list of infrastructure projects in the pipeline. The "shovel-ready" projects identified are having the desired potential to create social, environmental and economic value in the immediate future. The assessment of employment potential in this report includes jobs created under supply chain (OEMs), construction / installation, commissioning, operations and maintenance of projects.

Limitations

The project pipeline identified in this report represent just a fraction of the overall low carbon infrastructure investment under development in India. The project pipeline was put together from our assessment of their status of development until March 2022. These projects illustrate the huge potential that exists across India to underpin the speed and scale of energy transition. This is only a fraction of all low carbon infrastructure projects under development in India. It is important to note that the project pipeline identified in this report is illustrative and should not be read as a full policy/commercial endorsement.

~650 low carbon infrastructure projects in the pipeline



Sources: EY and JMK Research's own tracking of RE auctions from central and state agencies, projects emerging from Government schemes promoting clean energy transition; National Infrastructure Pipeline hosted by Invest India; Other proprietary databases

Overview of energy transition investment pipeline

Theme: Utility scale RE power generation

Policy interventions

- Establish a national index along with regional sub-indices for RE pricing by pooling of prices / tariffs discovered from RE auctions
- Formulate model policy for aggregation and allocation of wasteland parcels for the development of gigawatt scale RE power parks
- Implement wholesale power market reforms, time of day pricing and demand response frameworks to enhance flexibility for RE integration
- Implement the 'Electricity Amendment Bill 2021'
- Enhance skilling initiatives to support RE industry for project execution

Project pipeline and impact

360 projects	103 GW of pipeline capacity	INR 1.12 lakh crore equity
INR 2.61 lakh crore debt	7.9 lakh fresh jobs	3,989 MT avoided CO_2 emissions

Theme: Distributed generation through rooftop solar PV systems

Policy inter..

- Adopt best practices from Gujarat and Kerala models of scaling up RTPV implementation, especially in the residential sector
- Frame policy and regulatory incentives to Promote utility owned / driven business models for RTPV capacity addition
- Promote enabling mechanism for aggregation of 'distributed energy resources' to provide grid-related services
- Design and implement credit risk guarantee mechanisms to support RTPV financing for MSMEs

Project pipeline and impact

99 Projects	2.0 GW of pipeline capacity	INR 913 crore equity
INR 2,129 crore debt	18,000 fresh jobs	80 MT avoided CO_2 emissions

Theme: Green Hydrogen production

Policy interventions

- Incentives to lower the cost of renewable power generation and supply for GH2 production
- GIS mapping and identification GH2 clusters for efficient infrastructure development
- Offtake guarantees similar to SATAT scheme for GH2 suppliers
- Prescribe GH2 purchase obligations / blending mandates for bulk consumers of hydrogen as industrial feedstock along with viability gap funding

Theme: Distributed RE generation under PM-KUSUM

Policy interventions

- Generation-based incentives for decentralized grid connected ground mounted solar PV systems co-located with crops on agriculturally productive land parcels
- Dedicated financing facility for improving farmer access to low cost debt funds and boosting commercial viability of 1-2 MW scale ground mounted Solar PV projects on CAPEX mode

Project pipeline and impact

23 Projects	**8.7 GW** of pipeline capacity	**INR 6,855** crore equity
INR 16,000 crore debt	**78,500** fresh jobs	**281 MT** avoided CO_2 emissions

Theme: Original RE equipment Manufacturing

Policy interventions

- Reimagine the ACC PLI scheme to promote local value addition via battery materials recycling industry
- Implement grand innovation challenges for solar PV and energy storage industry to pilot and demonstrate cost effective, durable technologies made from earth abundant materials
- Re-imagine solar PLI scheme to focus on manufacturing critical raw materials (polysilicon) and upstream value chain components

Project pipeline and impact

78 Projects	**78.2 GW/Year** Solar cell/ module pipeline capacity	**114 GWh/Year** Battery cell/ pack pipeline capacity
INR 1.48 lakh crore equity	**INR 3.48** lakh crore debt	**9.33 lakh** fresh jobs

Theme: EV charging infrastructure

Policy interventions

- Promote coupling of EV charging with low-cost renewable energy systems
- Rationalize GST on Lithium-ion batteries to improve competitiveness of energy storage services and support emerging battery swapping industry
- Promote electric utility-driven business models for setting up EV charging Infra
- Promote smart charging, time of day pricing, demand response and other alternate revenue levers for EV charge point operators and investors

Project pipeline and impact

70 Projects	**5 lakh** EV stations
INR 1.4 lakh crore capital investment	**15 lakh** fresh jobs

Setting the context for India's Energy Transition: Building blocks and policy enablers

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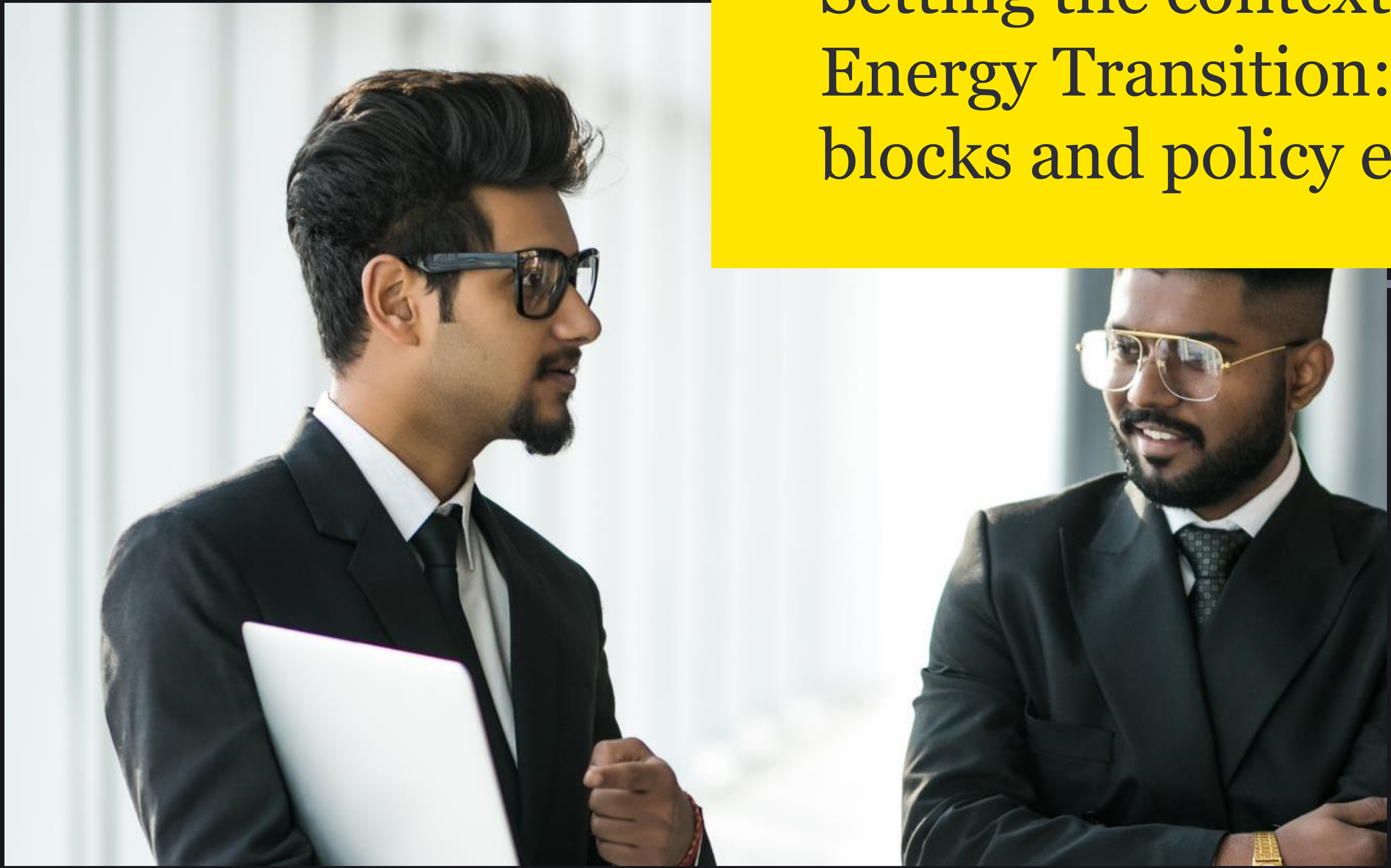
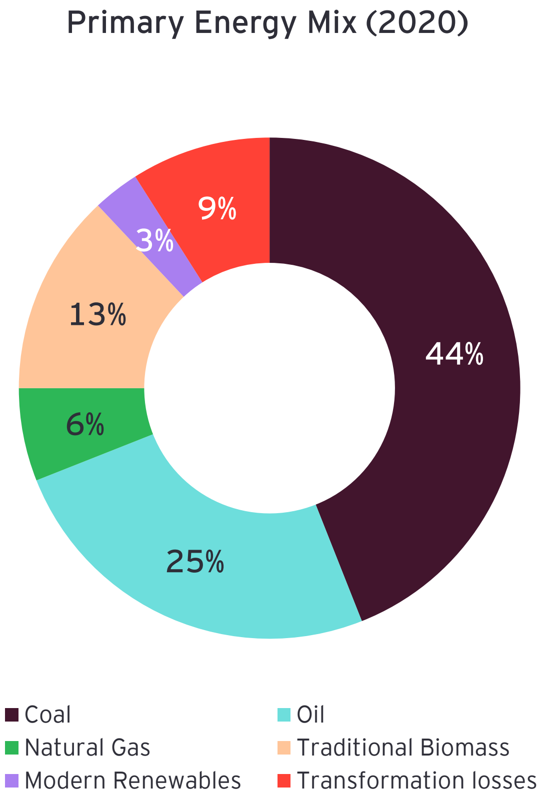


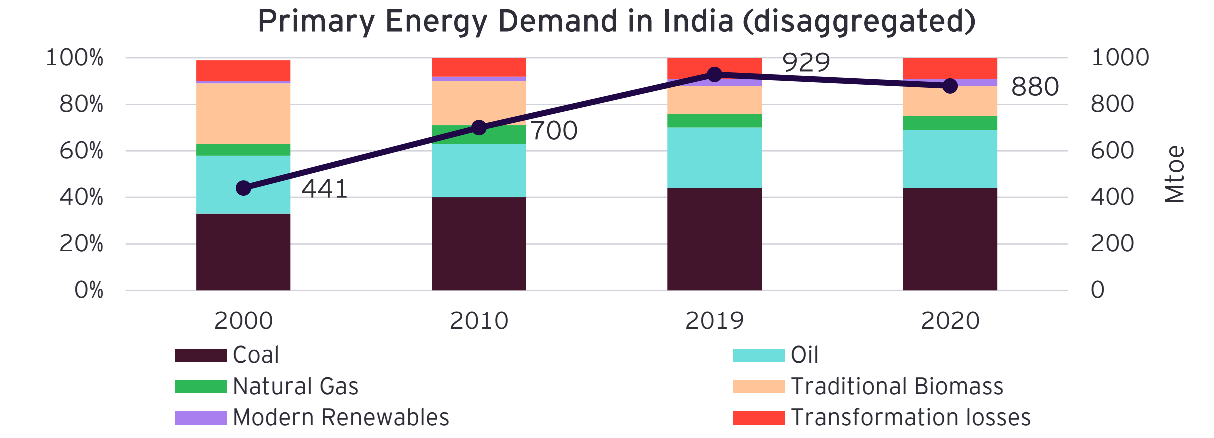
Self-reliance, energy efficiency and environmental sustainability are the key drivers of India's energy transition

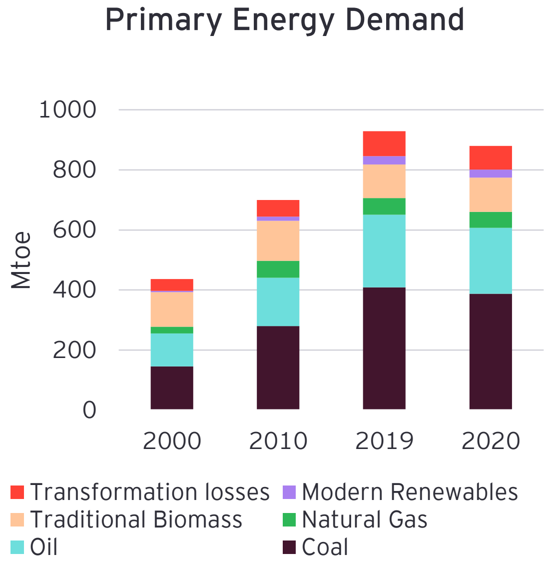
As per the IEA's 'India Energy Outlook 2021', the primary energy mix is currently dominated by coal and oil contributing ~44% and ~25% respectively in 2020. Modern renewables contribute only ~3% of overall primary energy demand in the present scenario. The share of traditional biomass, primarily used as cooking fuel, is gradually shrinking. The total primary energy demand has grown at ~4% (CAGR) in the last two decades. The industry, transport and building sectors witnessed the highest incremental primary energy demand in the last two decades. Coal is the mainstay for power generation and industrial energy use.

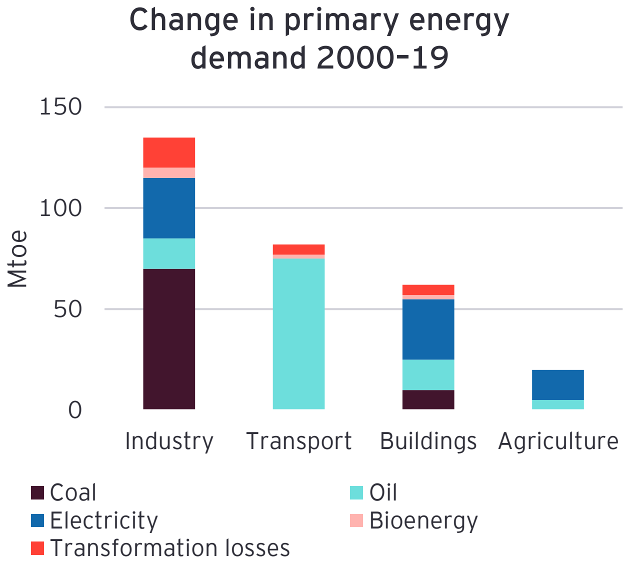
India's per capita energy consumption and emissions is less than half of global average in the present scenario. As per the 'India Energy Statistics 2021', net energy import dependency is a whopping 42% and the energy intensity has been gradually reducing at 2.56% (CAGR) in the last decade.

In the above context, energy security, energy efficiency and environmental sustainability naturally become the key drivers of India's energy transition.





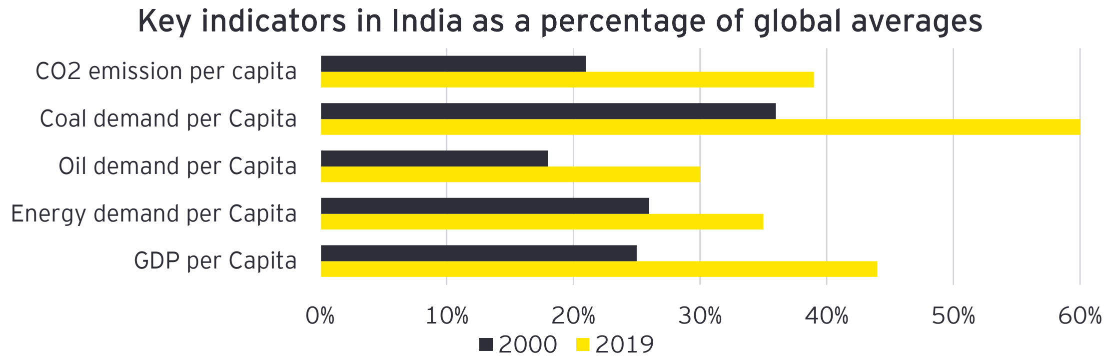


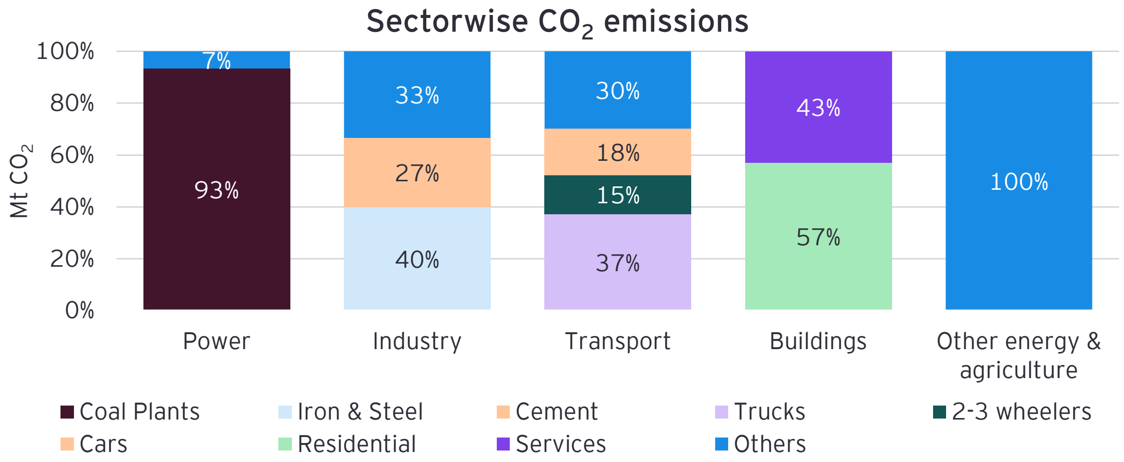


**Note that 'Modern Renewables' depicted in the charts above includes all uses of renewable energy (hydro, nuclear, solar, wind, modern biofuels etc.) with the exception of traditional use of solid biomass.*
Source: IEA 2021

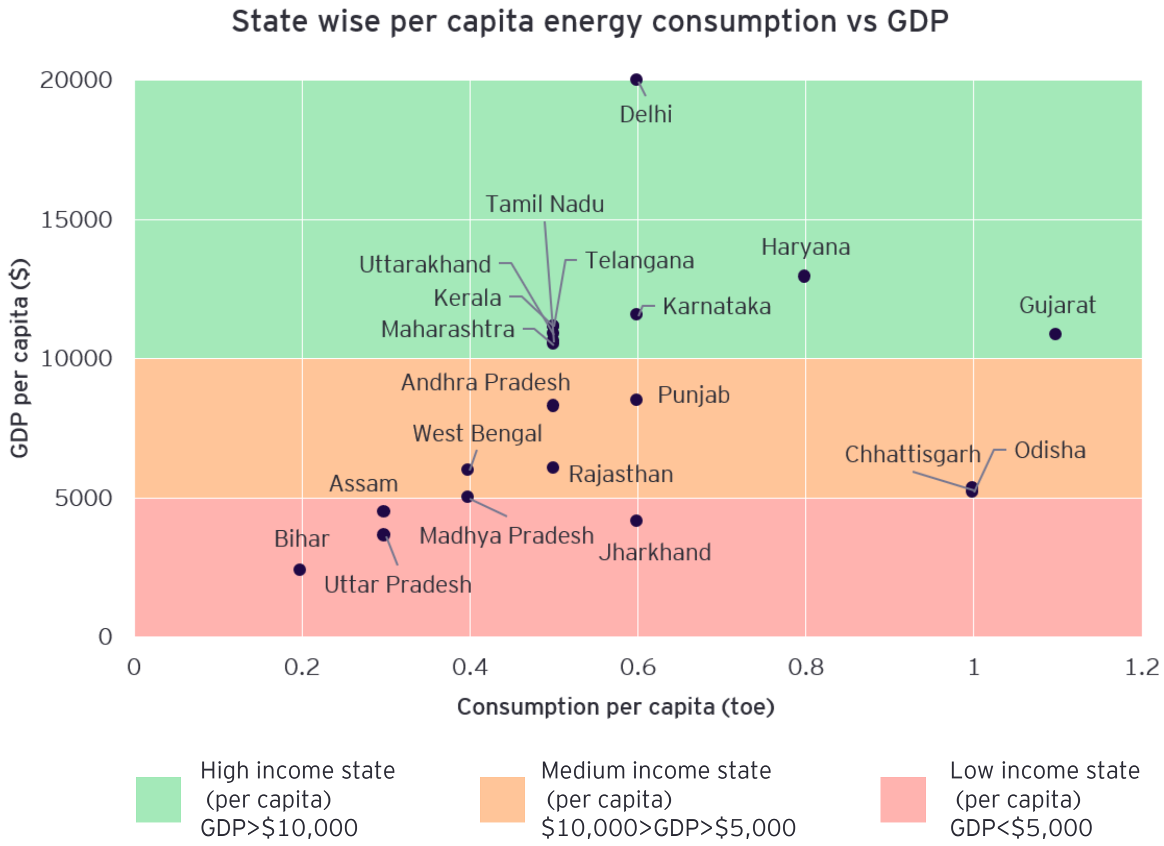
Energy transition must prioritize equitable and affordable energy access for all to meet economic development objectives

India's per capita energy consumption and emissions is less than half of global average in the present scenario. This is expected to rise substantially with rapid economic development as more people in the low income category are lifted out of poverty. The government must therefore prioritize equitable and affordable energy access for all in this transition. Further, India's CO_2 emissions has been increasing rapidly from 0.98 billion tons in the year 2000 to ~2.5 billion tons in 2019 as per IEA 2021. Energy transition in this context should support the decoupling of economic development and emissions intensity of primary energy consumption.





Source: IEA 2021

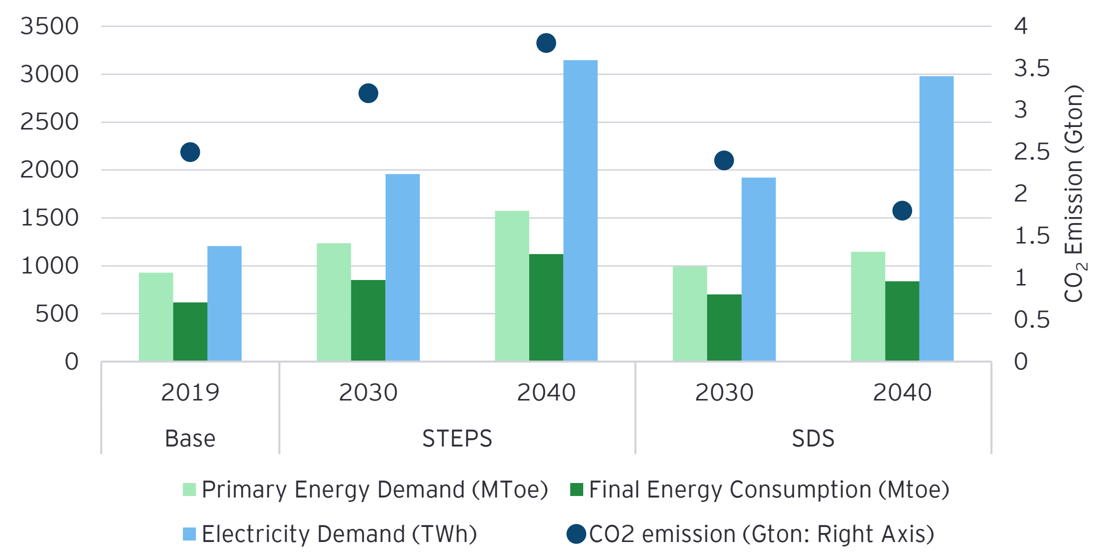


Source: IEA 2021

Market outlook towards India's energy demand and emissions indicate the speed and scale of energy transition

As per IEA's 'India Energy Outlook 2021', in the more optimistic sustainable development scenario, total primary energy demand and total final consumption will see a modest growth of 7% and 13% respectively by 2030. Whereas, electricity demand will see a robust growth of 59% by 2030 in that scenario, largely driven by renewable energy sources. CO_2 emissions from energy sector will contract by 4% indicating that energy related emissions may peak in this decade. Most importantly, the share of electricity in total final energy consumption is expected to rise up to 24% as electrification of mobility and industrial applications (fossil fuel to electricity) gains further momentum. By 2030, Coal's dominance in primary energy mix will end with a modest share of 46%. Low carbon gases such as compressed biogas and green hydrogen could contribute 2% of total final consumption by 2030.

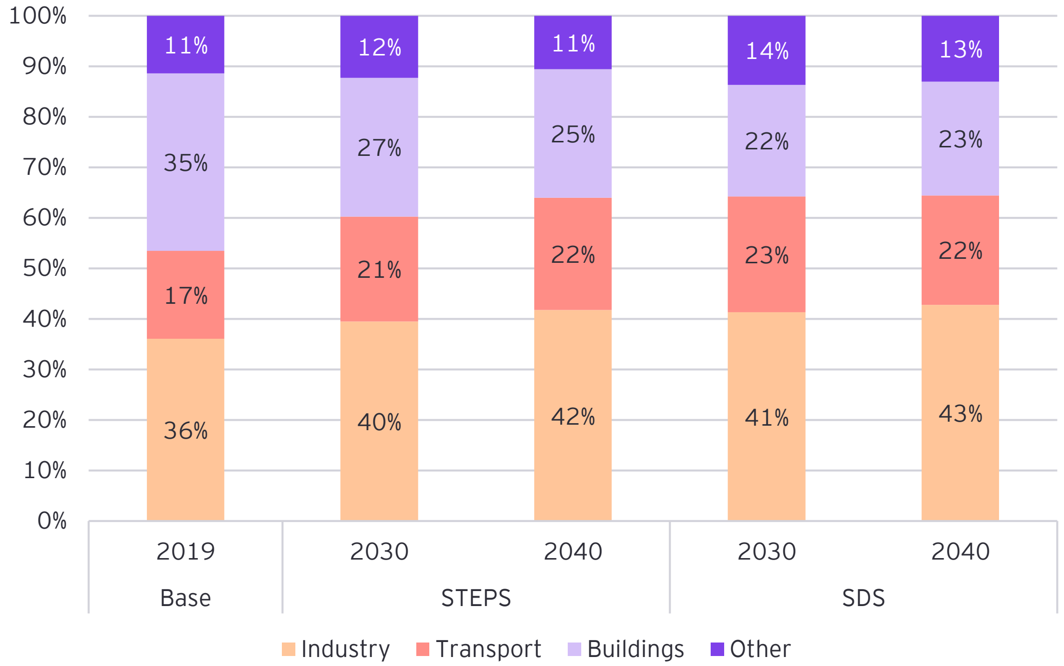
India's energy demand and emissions outlook



Source: IEA 2021

- The Stated Policies Scenario (STEPS) provides a balanced assessment of the direction in which India's energy system is heading, based on today's policy settings and constraints.
- The Sustainable Development Scenario (SDS) explores how India could mobilize an additional surge in clean energy investment to rapidly decline in emissions, consistent with a longer-term drive to net zero, while accelerating progress towards a range of other sustainable development goals.

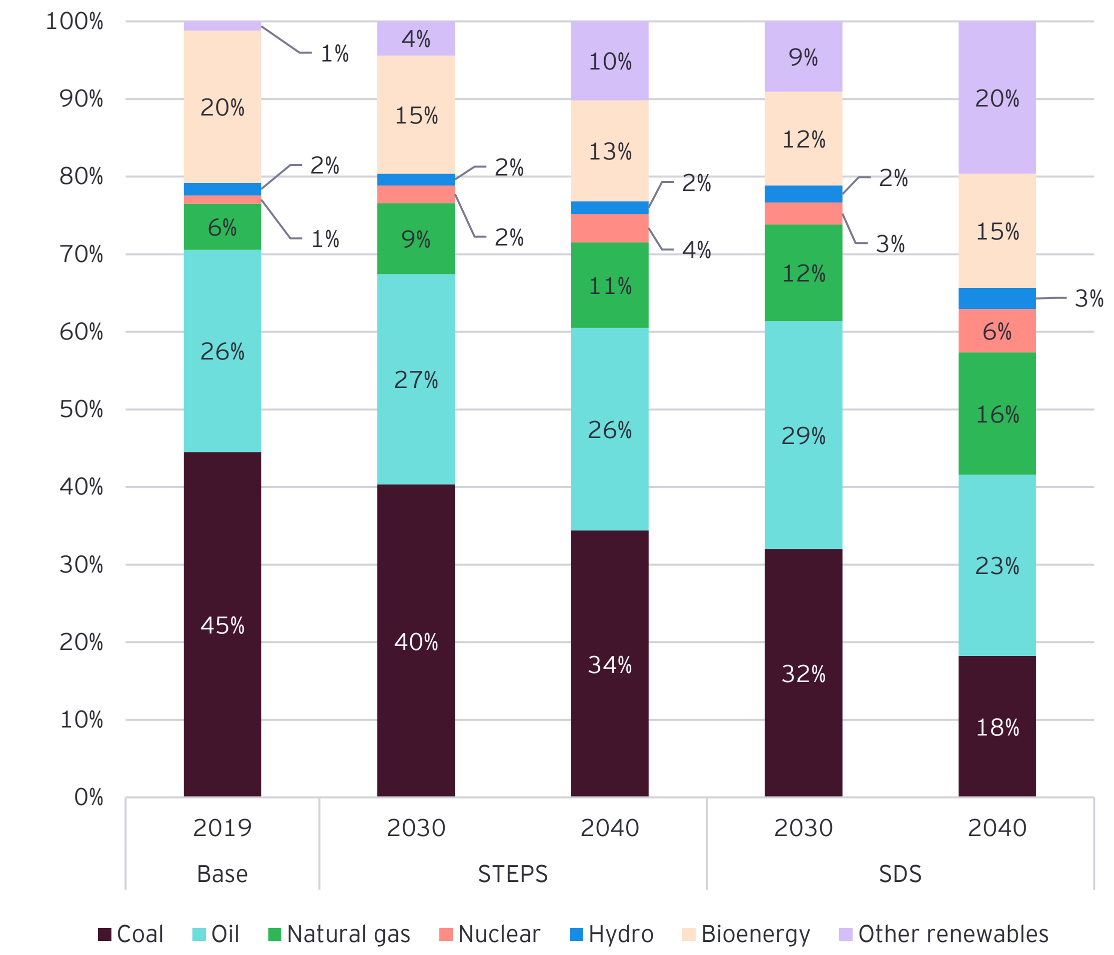
Sectoral share of total final energy consumption



Source: IEA 2021

Increasing share of electricity in final energy consumption and gradual phasing out coal in primary energy mix is the defining characteristic of India's energy transition

Source wise share of total Primary energy demand

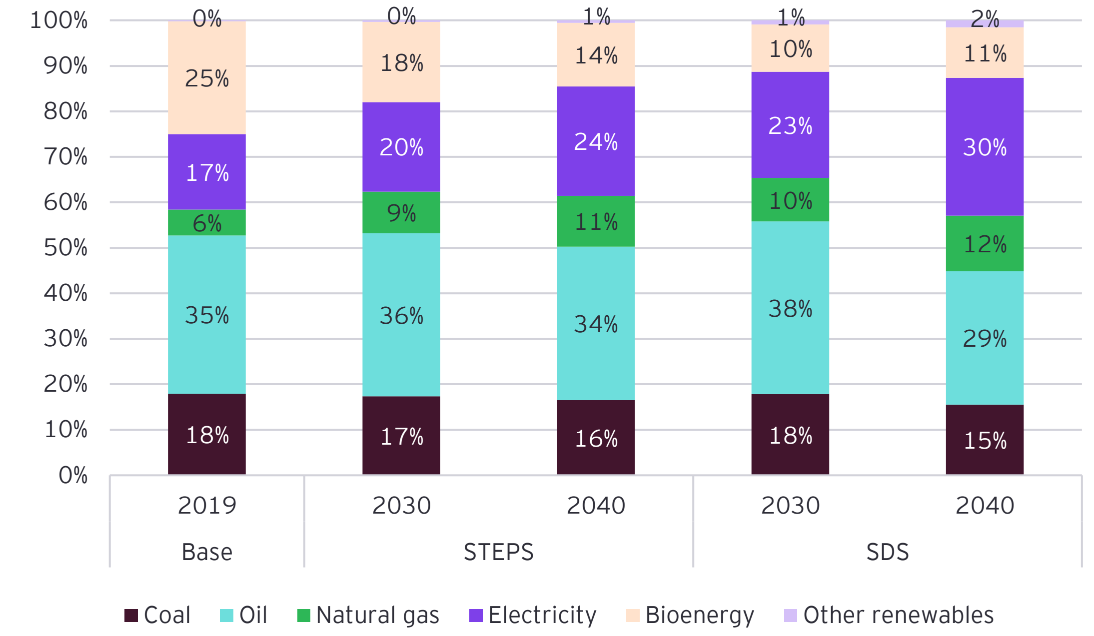


Source: IEA 2021

- As per the IEA India Energy Outlook 2021, share of coal in India's primary energy mix could reduce from 45% in the base scenario to 32% in the more optimistic SDS scenario by 2030.
- Similarly, the share of electricity in total final energy consumption could increase from 17% in the base scenario to 23% in the more optimistic SDS scenario by 2030.

**Note that in the charts depicting primary and final energy consumption, the share of 'bioenergy' is decreasing and may seem counter intuitive in the context of energy transition. However, this includes both traditional biomass (fuelwood, animal waste, charcoal used as cooking fuels) and other modern biofuels (bagasse, ethanol, compressed biogas etc.). The reduction in share of 'bioenergy' for the periods 2030 & 2040 is primarily driven by continued pivot away from traditional biomass and a steady uptake of appliances powered by electricity or other modern cooking fuels.*

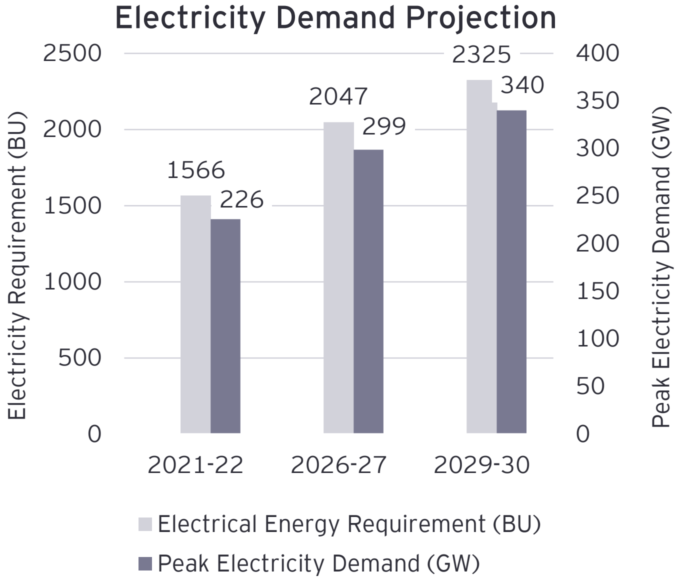
Total final energy consumption



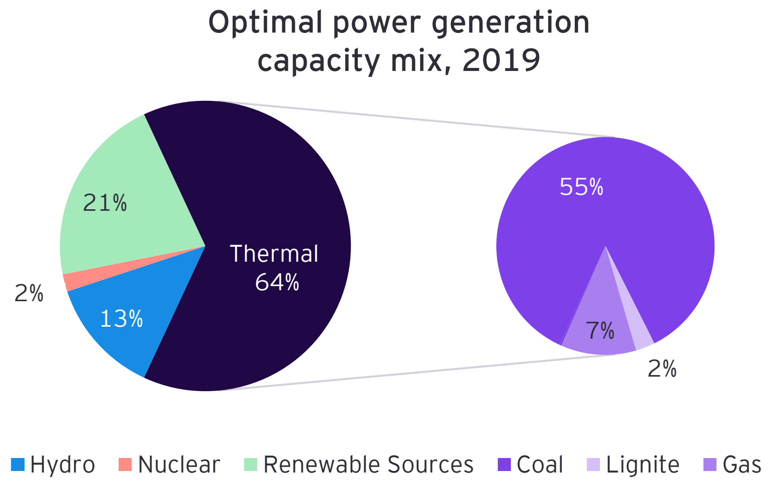
Source: IEA 2021

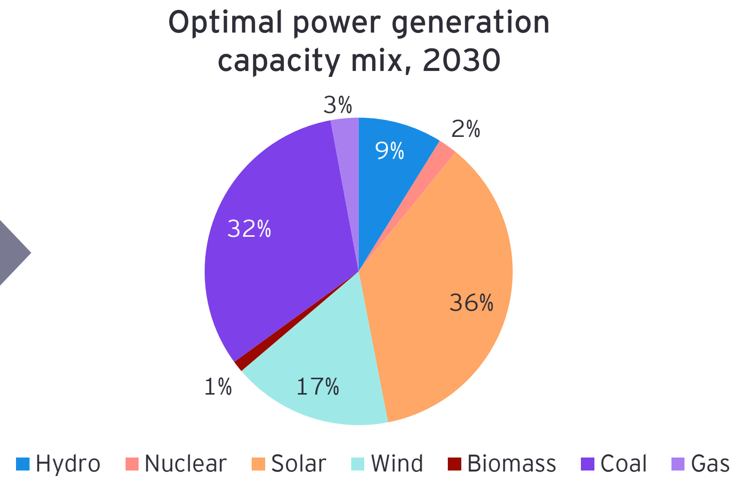
Role of nuclear energy as base load resource needs detailed examination to accelerate energy transition

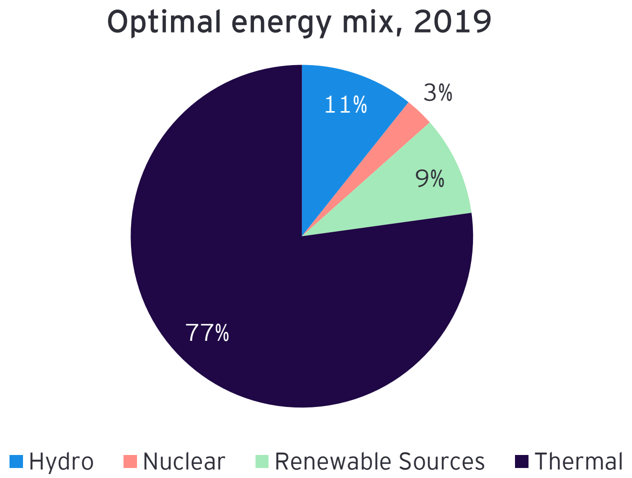
As per CEA's optimal generation mix report for 2030, electricity demand is likely to increase to 340 GW (peak) and 2,325 BU by 2030. Nuclear energy currently contributes 2% of the capacity and 3% of energy mix. It is worthwhile to explore the role of nuclear energy as baseload resource for aiding the clean energy transition through 2030 and beyond. This can reduce dependency on coal-based thermal generation which is the mainstay of baseload generation in the current scenario. The government should form a technical committee with relevant stakeholders to study the feasibility of this transition.

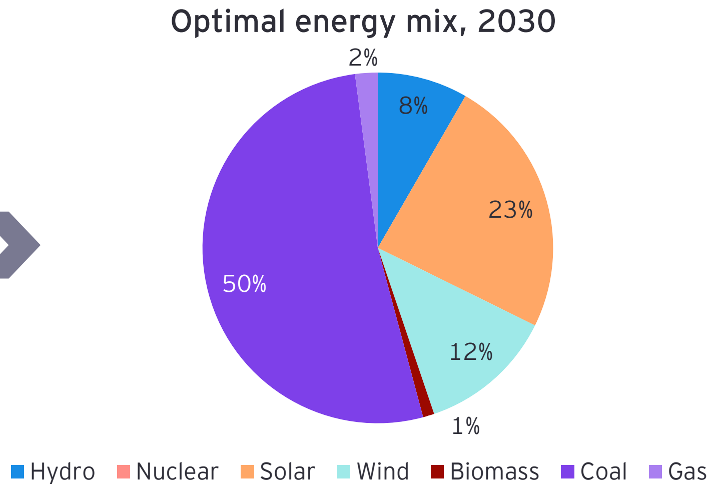


Source: CEA 2019









Source: CEA 2019

Role of Hydro Power for Grid Related Services to accelerate energy transition

As per CEA's optimal generation mix report for 2030, the capacity of hydro generation is expected to rise from 46209 MW in FY 21 to 71128 MW by 2029-30 [including 10151 MW of Pumped Storage Hydro plants]. It is worthwhile to expand the role of hydro power in providing grid-related services for aiding clean energy transition. There is a need to undertake identification of reservoir and pondage-based hydro capacities for delivering grid security services as outlined below, drawing a monetization plan by value stacking to generate multiple revenue streams basis plant characteristics, ramp rates and pricing strategies to maintain project viability and also, providing policy inputs for regulatory and market-based interventions as necessary:

- flexibility services for serving peak load, diurnal and seasonal variations and acting as both back-up and spinning reserve
- part load operations to meet system imbalances in real time and at 5 / 15 minute and hourly intervals
- primary response services, including frequency control and inertia, as grid ancillary operations
- reactive power support in synchronous condenser mode operation
- black start support to power plants to restore grid outages

Action Plan for Pumped Hydro Storage (PHS) Development

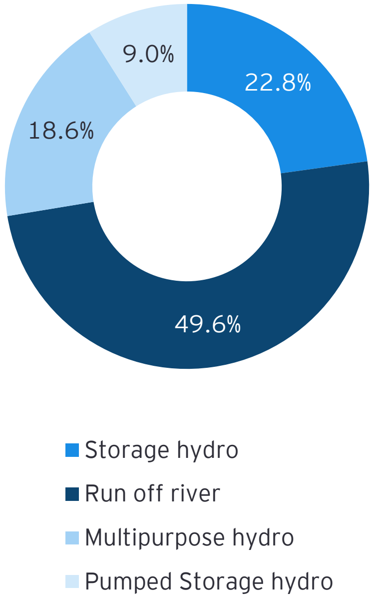
Till the time technology cost curve for battery storage systems improves, pumped storage will remain a viable alternative to provide grid balancing services. To develop the required emphasis, developing a road map is necessary for plotting new capacities at potential sites, which will provide the options of minimum displacement of habitats and damages to ecology and environment under the categories of both 'open loop' and off-river ('closed loop') PHS installations. Examining the scope of setting up PHS installations under existing sites with pondage and reservoir capacities is also an option that may be exercised. An enabling mechanism will be the introduction of dynamic pricing in wholesale markets so that a monetization plan reflecting the temporal grid-related services can be offered to PHS installations to allow commensurate cost recovery.

Pumped hydro storage (PHS) projects under pipeline are critical to enhance flexibility in the grid

As per CEA, the total hydro power generation capacity (Existing + Under construction + Planned) considered for optimal generation mix by 2030 is 64 GW, out of which ~9% is expected to be pumped storage type. The existing capacity of hydro power projects working in pumped storage mode (>25 MW) is ~3305 MW. Another ~1500 MW is under active construction, ~2200 MW capacity is under examination and ~3850 MW capacity is under survey and investigation where both reservoirs exist. Similarly, ~6400 MW capacity is under survey and investigation where one reservoir needs to be constructed and another ~6500 MW capacity where both reservoirs need to be constructed.

PHS is a mature and scalable energy storage technology, accounting for over ~90% of installed global energy storage capacity in the present scenario. PHS is a type of hydroelectric energy storage which uses a two-reservoir system (upper and lower) to store energy and generate electricity. It is of two types: 'open loop', which is connected to a natural-water source for one or both the reservoirs; and 'closed loop' (or off-river PHS), which has no outside water bodies connected to both reservoirs.

Optimal hydro power generation capacity mix by 2030

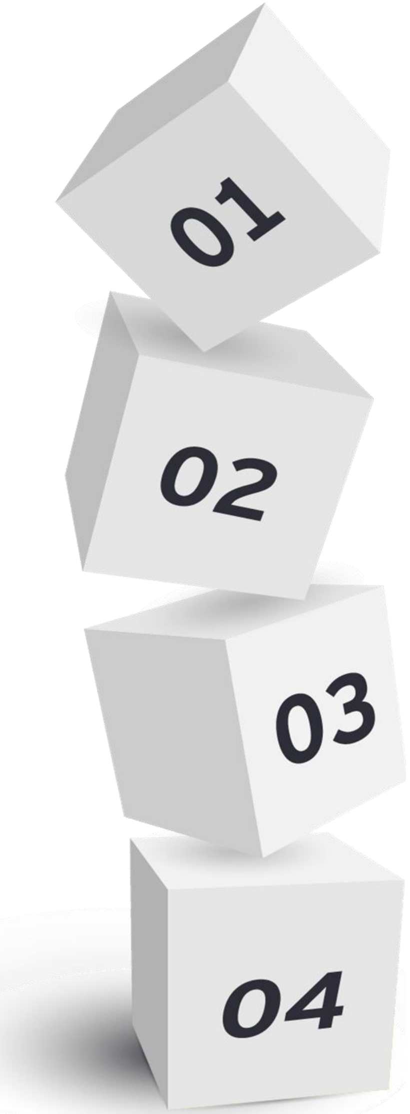


Source: CEA 2019

PHS can store surplus renewable energy and supply electricity during peak hours continuously for 6-10 hours, depending on the storage capacity of the upper reservoir. PHS systems have a lifetime of over 40 years, with roundtrip efficiency of 70 – 80%. Also, when compared to the conventional thermal generators, PHS has a higher ramping capability (ability of quick start-stop). These features enable PHS to provide multiple services to integrate high share of renewables to the grid at competitive prices. But there are challenges too, including a high initial investment (USD 600- 2000/kW), topographical requirements like the range for elevation (20-1000 m) between the two reservoirs, proximity to a large water body, and environmental impacts like loss of wildlife habitats and issues of resettlement and rehabilitation of human population. The Central Electricity Authority of India has estimated a PHS potential of 96 GW, but only 3.3 GW is currently operational in India. This slow pace can be attributed to the high cost associated with the commissioning of PHS plants, the long gestation period due to delays in obtaining environmental clearances, and the low recovery from the existing pricing mechanism of PHS. The high cost and environmental clearance issues can be resolved using a closed-loop PHS system that utilizes less water, has a low gestation period, and minimal impact on the environment. A 2019 study by Australian National University (ANU) estimates that there are 16,000 closed-loop PHS sites in India,
with a combined energy storage capacity of 56,000 gigawatt-hours.

Introduction of dynamic pricing in wholesale markets and concurrent TOD retail tariff to reflect time value of energy will be necessary to enable PHS to respond to grid-related services in real time operations and benefit from a monetization plan for cost recovery.. Today the bulk of wholesale electricity markets in India are governed by long term purchase agreements with DISCOMs. These agreements do not differentiate the value of electricity supplied on the basis of time of day and / Or season. Part of the problem is that the retail prices (end–user tariffs) are fixed round the clock for most categories of consumers. Time of day tariffs are mandated selectively for high tension category industries only with options for voluntary adoption in few other categories in select states. With rising share of low cost intermittent renewable energy sources supplying abundant electricity during day time and monsoon months, dynamic pricing is essential for rewarding discharge of surplus/excess renewable electricity from PHS at times the grid needs most – evenings, early mornings etc. More importantly, dynamic pricing mechanisms are essential for enhancing the arbitrage value of electricity storage.

Building blocks for India's energy transition



Decarbonization

India has set a target of 500 GW non-fossil, fuel-based energy generation by 2030 and economy wide net-zero emissions by 2070. Power sector is currently leading the decarbonization drive with approx.105 GW of installed RE capacity dominated by Solar and wind energy sources. Another ~112 GW of RE projects are in the pipeline under various stages of development. In the hard to abate sectors such as iron and steel, cement, chemicals, fertilizers, other manufacturing, and transportation, there are a multitude of promising clean energy technologies (e.g., electrification enabled by heat pumps, batteries, fuel cells and other energy storage systems, green hydrogen, biofuels such as methanol, ethanol, biogas, and bagasse) competing for transition from fossil fuels. Energy efficiency in transformations and end-use, achieving cost parity with conventional fossil fuels will determine the speed and scale of this transition.

Decentralization

Renewable energy sources, inherently distributed in nature, can be utilized efficiently, when harnessed locally at the point of consumption. Distributed RE generation will grow to contribute substantially more than the utility scale systems, which are constrained by land, evacuation infrastructure build out and suboptimal capacity utilization. Energy utilities will need to rapidly embrace this transition and diversify with new business models and services in order to remain relevant. The Government programs promoting rooftop solar PV, rural micro-grids and decentralized RE systems under PM-KUSUM will further accelerate this transition. The centralized power grid will gradually transition from being the main source of power supply to a flexible reserve for banking surplus energy from distributed RE systems. C&I consumers will find decentralized RE services more competitive in the immediate future. Emphasis on evolution of grid edge technologies and compensatory frameworks will be necessary to enable large-scale onboarding of distributed energy resources in providing grid optimization services. Going forward, value streams will be generated by offering the range of services through aggregation of decentralized distributed resources and grouping them as Virtual Power Plants (VPP).

Digitalization

The digitalization of energy system through the deployment of information and communications technologies is gaining rapid momentum with decentralization. This digitalization is making it easier to compute and communicate the value of energy services with finer temporal and spatial granularity. This will enable energy demand to become increasingly responsive to changes in the prices of those services and participate actively in their provision. Digitalization in combination with the new clean energy resources, is enabling networks to become more actively managed, potentially ending the passive network management paradigm, in which networks are sized to meet the aggregate peak demand of passive consumers. Also, the energy utilities will need to ramp up cyber security systems and capabilities to manage the vulnerabilities from this transition.

Aatmanirbhar Bharat

The speed and scale of India's energy transition will rely on building robust self-reliant supply chains for critical clean energy technologies and solutions. The Production Linked Incentives (PLI) announced for manufacturing high efficiency solar PV cells and modules, advanced chemistry battery cells and electric vehicles are steps in the right direction to accelerate this transition. The approved list of models and manufacturers of solar PV cells and modules is continuously evolving and expanding its scope. More importantly, India's energy transition will leave coal and petroleum industries', communities and workers exposed to decline in demand for fossil fuel commodities. Understanding and addressing the social dimensions of the clean energy transition is critical to ensure that particular communities, workers and their families are not overly disadvantaged or left behind.

Ecosystem enablers: Technological advancements driving energy transition

Long Duration Battery Energy Storage – a key enabler

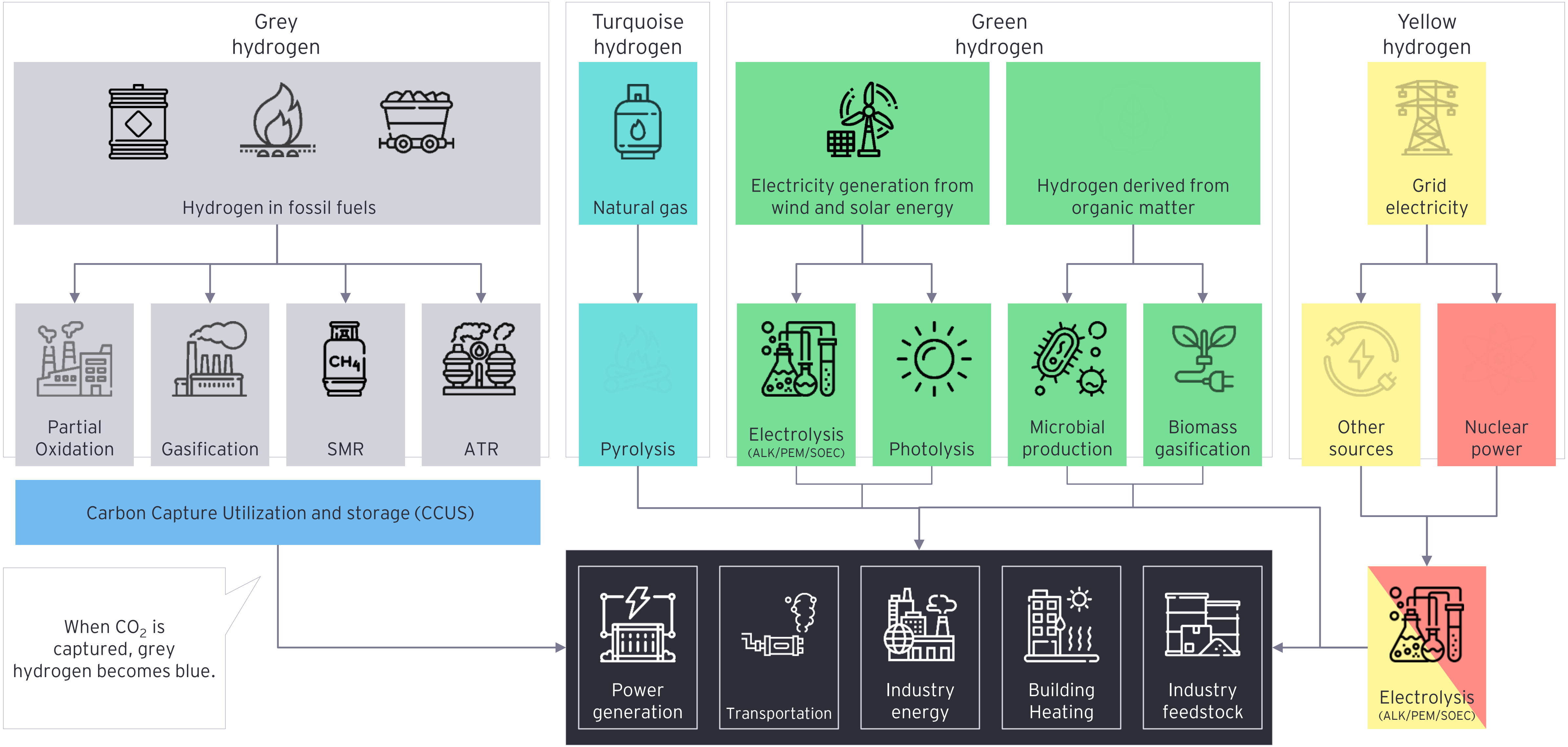
Battery energy storage enhances large-scale renewable generation dispatching ability in order to meet the demand which was traditionally supplied by conventional baseload generation. By virtue of having quick discharge capabilities and round trip efficiencies, battery storage systems can support grid balancing by participating in wholesale capacity, energy and ancillary services markets and in particular, are an effective tool for both frequency control and voltage regulation in real time operations. Additionally, they provide the benefit of capex deferral in T&D infrastructure and is a non-wire alternative in the hands of the utility to optimize system and fuel costs, reduce congestion costs, firm up RE capacities against intermittencies and decarbonize the energy mix.

Battery storage can store renewables at times of low demand and dispatch during high demand periods when energy cost is high.

Battery energy storage for stationary grid applications must evolve beyond lithium-ion technologies for long duration storage capabilities and competitiveness

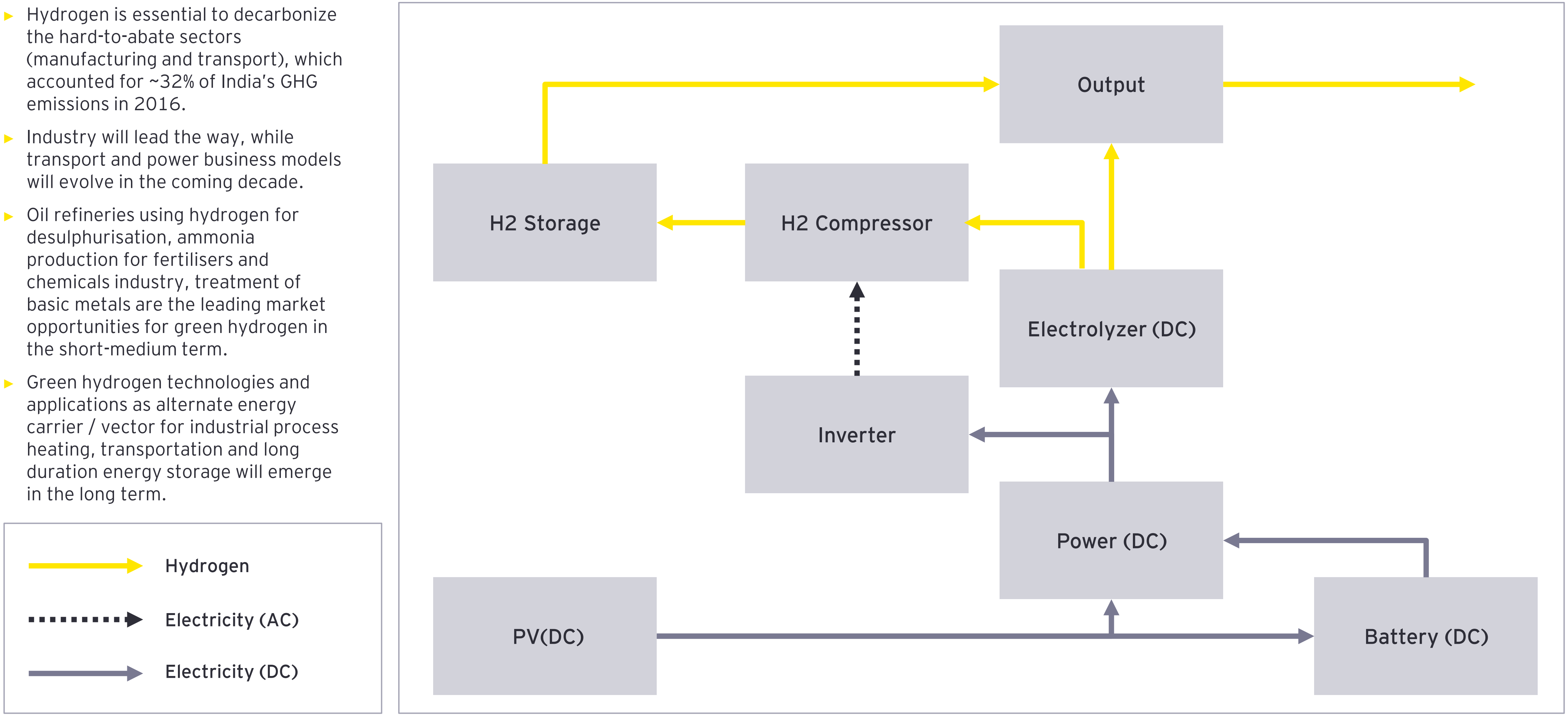
The stationary storage industry will need advanced chemistry battery cells enabling long duration storage cycles (>15 hours per cycle), and long life (number of charge – discharge cycles) at competitive prices for boosting demand. High performance Li-ion batteries with high energy density and round trip efficiency are more suited for mobility applications and less suited for multiday and beyond storage. Levelized cost of energy storage is a key performance parameter for stationary BESS solutions and has to compete with levelized cost of energy from fossil fuels for scaling up adoption in India. In the near future, short duration (up to 10 hours per cycle) energy storage applications are likely to be satisfied with continued reduction of Li-ion batteries. In the long term, increasing penetration of solar and wind power sources in the energy mix will drive development of new, ultra low cost battery chemistries made from earth abundant elements.

Technological advancements driving energy transition: Hydrogen production nomenclature



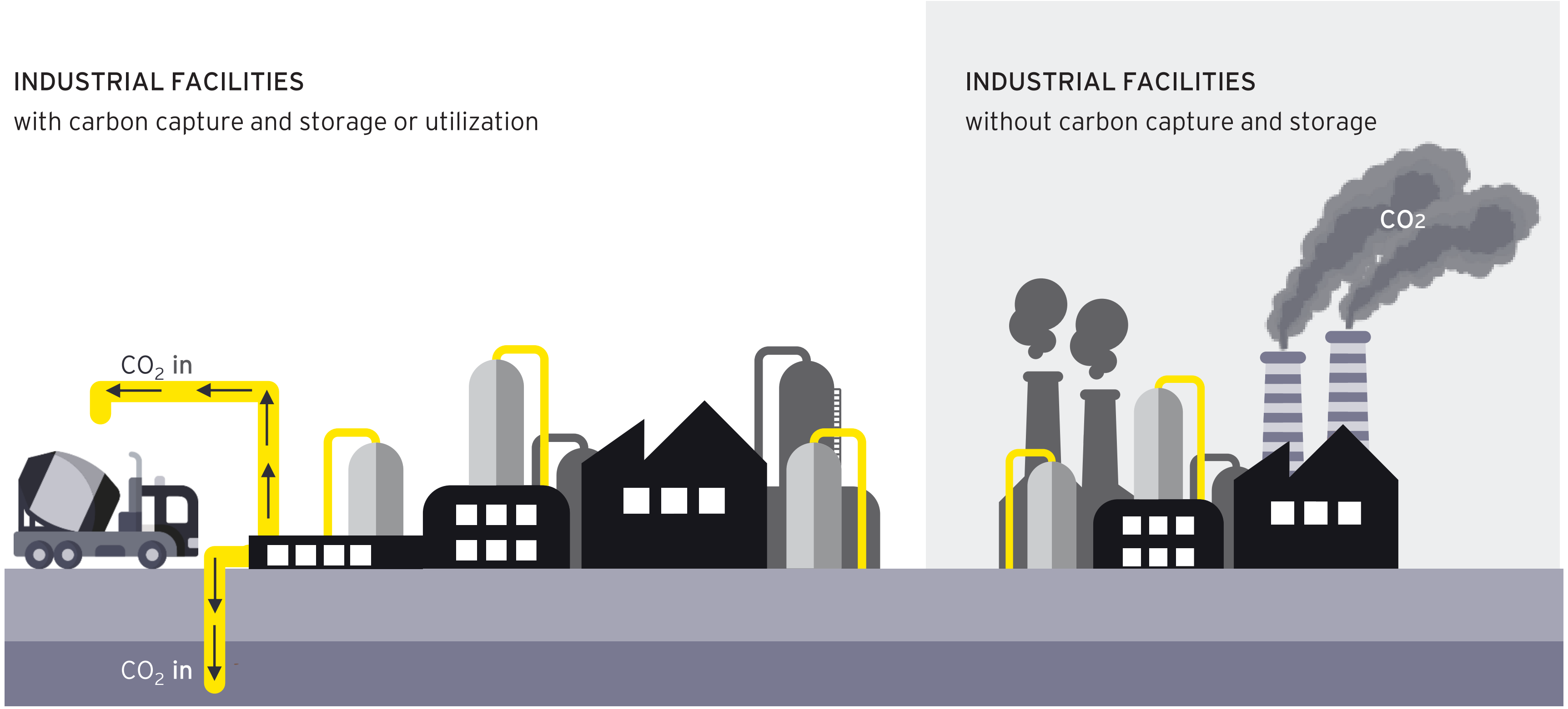
Technological advancements driving energy transition: Electrolysis for Green Hydrogen

- Hydrogen is essential to decarbonize the hard-to-abate sectors (manufacturing and transport), which accounted for ~32% of India's GHG emissions in 2016.
- Industry will lead the way, while transport and power business models will evolve in the coming decade.
- Oil refineries using hydrogen for desulphurisation, ammonia production for fertilisers and chemicals industry, treatment of basic metals are the leading market opportunities for green hydrogen in the short-medium term.
- Green hydrogen technologies and applications as alternate energy carrier / vector for industrial process heating, transportation and long duration energy storage will emerge in the long term.



Carbon Capture, Utilization, and Storage (CCUS)

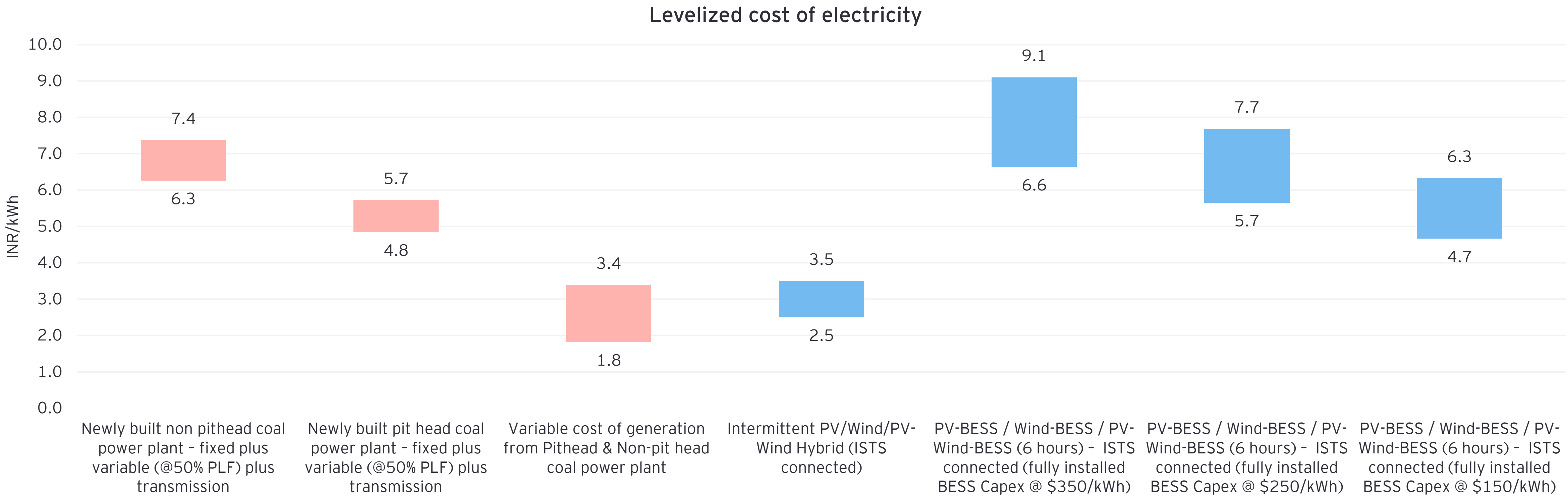
- As per the IEA, Carbon Capture, Utilisation, and Storage (CCUS) refers to a suite of technologies that can play an important and diverse role in meeting global energy and climate goals. CCUS involves the capture of CO_2 from large point sources, including power generation or industrial facilities that use either fossil fuels or biomass for fuel. The CO_2 can also be captured directly from the atmosphere. If not being used on-site, the captured CO_2 is compressed and transported by pipeline, ship, rail or truck to be used in a range of applications, or injected into deep geological formations (including depleted oil and gas reservoirs or saline formations) which trap the CO_2 for permanent storage.
- A challenge to be overcome is to locate appropriate geological formations and abandoned mines / well heads which can offer the facility of storing or sequestrating CO2.
- Indian industries and public sector undertakings (PSUs) are leading the way towards the promotion of CCUS facilities while recognizing the need to stay carbon-neutral in the broader context of sustainability.



Source: CEEW, 2021

In India, CCUS technology is far from becoming mainstream. The industry is currently exploring ways to study and improve techno-economic feasibility and scalability of this technology.

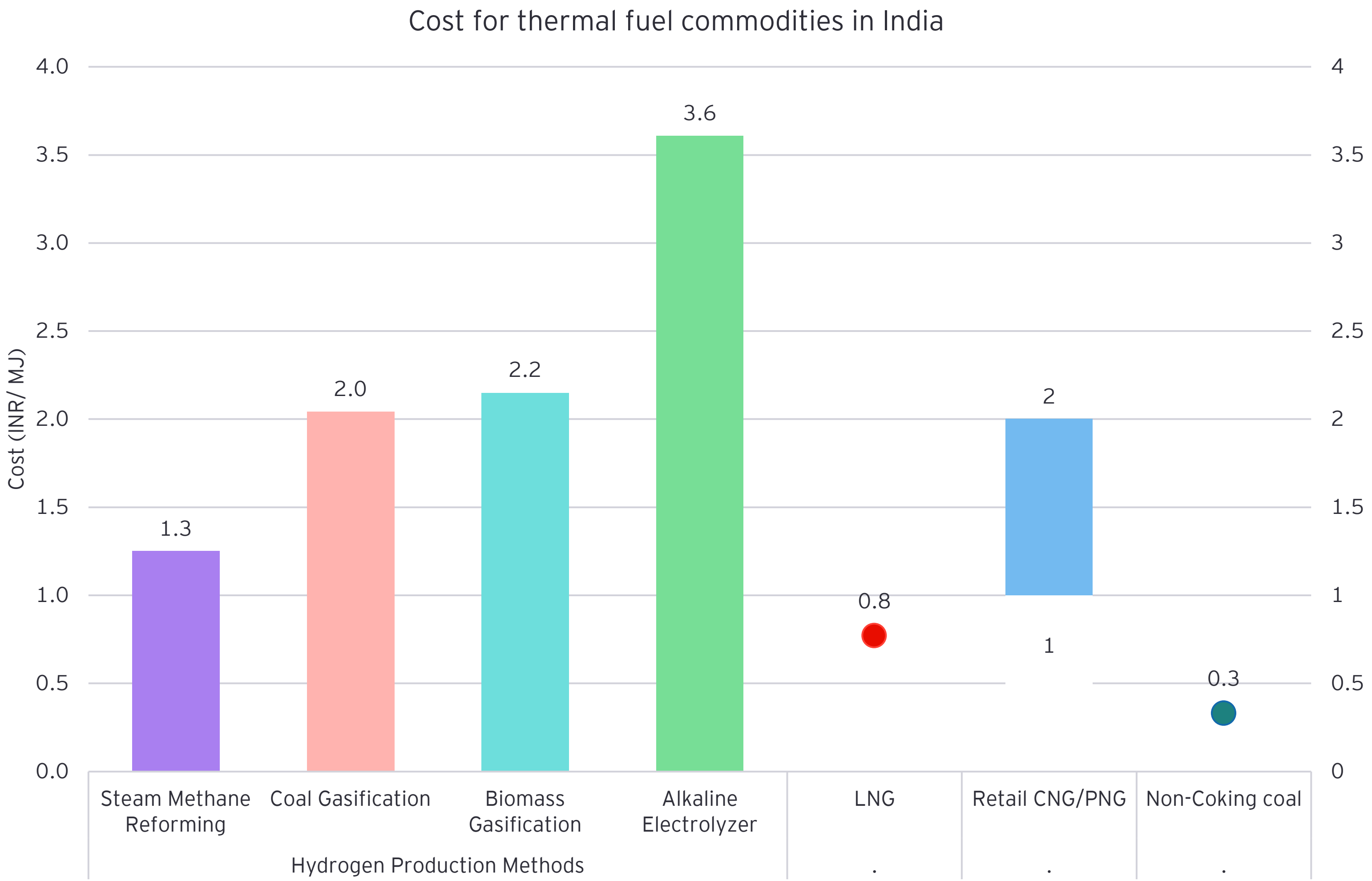
Tipping points for energy transition in the power sector



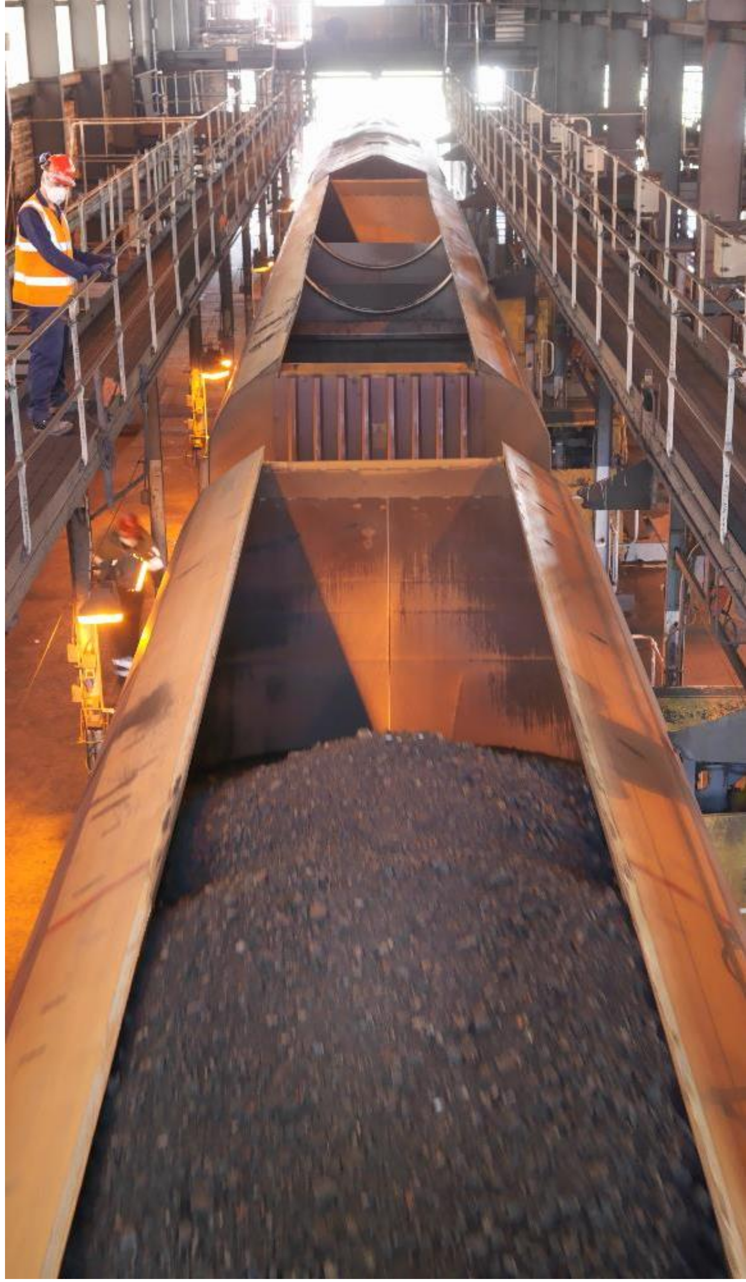
Source: EY Analysis
Note: Fully installed BESS capex is exclusive of duties & taxes

The cost of energy storage as a service when integrated with intermittent PV/Wind/PV-Wind hybrid systems will need to reach parity with the levelized cost of procurement from conventional baseload generation. This will determine the speed and scale of energy transition in the power sector going forward. Similarly, grey hydrogen production costs vary approx. 75-150 INR/kg depending on the price of natural gas in the current scenario. The domestic retail CNG / PNG prices vary approx. 40-90 INR/kg, which translates to approx. 1-2 INR/Mega Joules of energy considering the lower heating value of this fossil fuel commodity. Achieving parity with these prices will determine the speed and scale of green hydrogen adoption in hard to abate sectors.

Tipping points for energy transition in the hard to abate sectors



Source: DST 2020; IEA 2021; Indraprastha gas limited; National coal index (December 2021)
Note: Cost of hydrogen is exclusive of storage and transportation



India must build resilience against forces threatening the affordability of energy transition technologies, raw materials and commodities used for domestic production

Rising cost of domestic solar PV panels could delay the pace of energy transition in India. Studies from leading market research firms show that solar module prices have increased between 30-50% in the past two years. Some critics may attribute the rise in solar module prices to imposition of BCD on imported PV cells (25%) and modules (40%) effective from April 2022. This is not entirely accurate. As per the data compiled by a leading solar PV market intelligence and research firm, solar module prices have become increasingly unpredictable and volatile since the inception of COVID in 2020. Solar module prices (mono PERC) in the global market increased from August 2020 to November 2021 by 42%. On similar lines, solar module prices (mono PERC) in India also increased from August 2020 to November 2021 by 40%.

One of the principal reasons behind the rising cost of solar modules is supply chain disruptions, especially raw materials and commodities used in the manufacturing of solar panels. Polysilicon is the critical raw material used in solar PV module manufacturing. Between July 2020 and April 2022, polysilicon price in the global markets increased 5-6 times. Other disrupting factors in the PV module supply chain include price hikes for commodities such as glass and basic metals (steel / aluminium), shortage of containers etc. Such disruptions exacerbated further due to various COVID-19 induced lockdowns across the world leading to halting of manufacturing activity.

The impact of BCD imposition on imported PV cells would taper down in the medium to long term term as India builds sufficient PV cell manufacturing capacity planned under the existing solar PLI scheme. However, sustained higher cost of commodities, raw materials (polysilicon) and logistics used in the supply chain of solar PV modules is a major threat to energy transition. Therefore, the current solar PLI scheme must focus on building sufficient manufacturing capacity of 98% grade silicon from quartz, polysilicon, ingots and wafers, all critical components used in the production of solar PV cells and modules.

Moreover, with the increase in GST rate from 5% to 12% on renewable energy equipment (at the project level) the new effective rate of GST on wind and solar energy services comes to around 13.8%. Government of India should explore reversing this increase in GST rate for providing partial relief from rising solar panel prices to the consumers.

The government of India recently announced import duty cuts for critical raw materials used in the iron, steel and plastic industries with the intention to reduce their prices for domestic consumption. Similar interventions could be explored to provide relief for critical commodities used in Solar module manufacturing such as glass (e.g. soda ash) and aluminium (e.g. pet coke, caustic soda), which could benefit the consumers of solar PV panels.

Lithium-ion battery packs currently attract 30-40% taxes (import duty@15% and GST@18%) for consumers. These advanced chemistry battery packs will remain the dominant technology for electrification of mobility and stationary energy storage applications critical for integration of intermittent renewable energy sources through 2030. The ACC PLI scheme envisages to add 50 GWh of manufacturing capacity in the next 2-5 years with up to 60% of local value addition. The consumers could benefit from immediate relief from import duties and GST rates until the domestic manufacturing capacity is established for catering to the local demand. Any safeguard duties to protect the local manufacturers can be formulated in consultation with the industry.

Ecosystem enablers:
New policy instruments driving energy transition

Policy instrument					
COP26 commitments under Paris Climate Agreement	500 GW of non-fossil energy deployment by 2030	50% of the energy requirements from renewable energy sources by 2030	Reduce the total projected carbon emission by one billion tonnes by 2030	Reduce 45% carbon intensity by 2030	Achieve net-zero emissions by 2070
Waiver of inter-state transmission charges	Waiver of ISTS charges for 25 years for solar, wind, hydro PSP, BESS and green hydrogen projects commissioned until 2025				
Electricity (Right of Consumers) Rules 2021	Net metering by any Prosumer for up to 500 kW or sanctioned load whichever is lower for RTPV installations				
Electricity (Promotion of Generation of Electricity from Must-Run Power Plant) Rules, 2021	Conditions for curtailment or regulation of generation or supply of electricity from solar, wind, hybrid, hydro	Compensation for curtailment			
Draft Electricity (promoting renewable energy through Green Energy Open Access) Rules, 2022	Uniform RPO obligations on all obligated entities within distribution licensee area	Eligibility for 100 kW and above consumers; No capacity limit for captive consumers	Single window procedure for grant of green energy open access through a central nodal agency		
PLI schemes for domestic manufacturing of high efficiency solar PV and ACC battery cells & modules	INR 24,000 crores outlay for PLI scheme focusing on high efficiency solar PV cells and modules	Advanced Chemistry Cells (ACC) Battery PLI scheme focusing on 50 GWh of annual manufacturing capacity			
Electricity (Timely recovery of costs due to change in Law) Rules 2021	Formula for determination of impact on tariffs due to change in law	Mechanism for timely adjustment of tariffs			

Ecosystem enablers:
New policy instruments driving energy transition

Approved list of models and manufacturers of Solar PV modules (ALMM)

11 GW of solar PV domestic manufacturing capacity covered under ALMM	Over 1,000 enlisted models of PV modules from 39 different manufactures

Domestic content requirement for government projects, assisted projects

Government schemes including CPSU scheme, phase 2 of grid connected rooftop solar program and PM-KUSUM scheme mandate domestic content requirement for sourcing solar PV modules.	Only models and manufacturers enlisted under ALMM will be eligible for use in government projects, government assisted projects, projects under government schemes and programmes, open access and net metering projects including all projects set up for sale to government

National Hydrogen Mission and Green Hydrogen Policy

Waiver of ISTS charges for producers for GH2 and green ammonia	Provision of 30 day banking facility to park surplus renewable energy in the production of GH2	Single window portal for facilitating clearances and permissions required for manufacture, transportation, storage and distribution of GH2

Sustainable Alternative Towards Affordable Transportation (SATAT)

Target production of 15 MMT of compressed biogas (CBG) from 5000 plants by 2023	CBG produced will be transported through cascades or through pipelines to the fuel station networks of Oil PSUs for marketing as a green transport fuel alternative.	Oil PSUs have offered Rs 46/- per kg basic price for procurement of CBG meeting IS 16987:2016 standard compressed at 250 bar and delivered at their Retail Outlets in cascades.

Battery Swapping Policy (proposed)

Technical, regulatory, operations, financing, and institutional arrangements for battery swapping ecosystem

Ethanol blending

Raise pan-India ethanol production capacity from the current 700 to 1500 crore litres	Phased rollout of E10 fuel by April 2022	Phased rollout of E20 from April 2023, its availability by April 2025	Rollout of E20 material-compliant and E10 engine-tuned vehicles from April 2023
Production of E20-tuned engine vehicles from April 2025	Nationwide educational campaign	Encourage use of water-sparing crops, such as maize, to produce ethanol	Promote technology for the production of ethanol from non-food feedstock.

Frameworks for energy demand planning and ‘JUST’ transition

3

Energy demand planning needs greater coordination between union and states, especially in the electricity sector

Coordinated and harmonized framework for electricity demand planning

The central and state level institutions involved in power system planning should coordinate more effectively and adopt integrated resource planning (IRP) with following assessments:

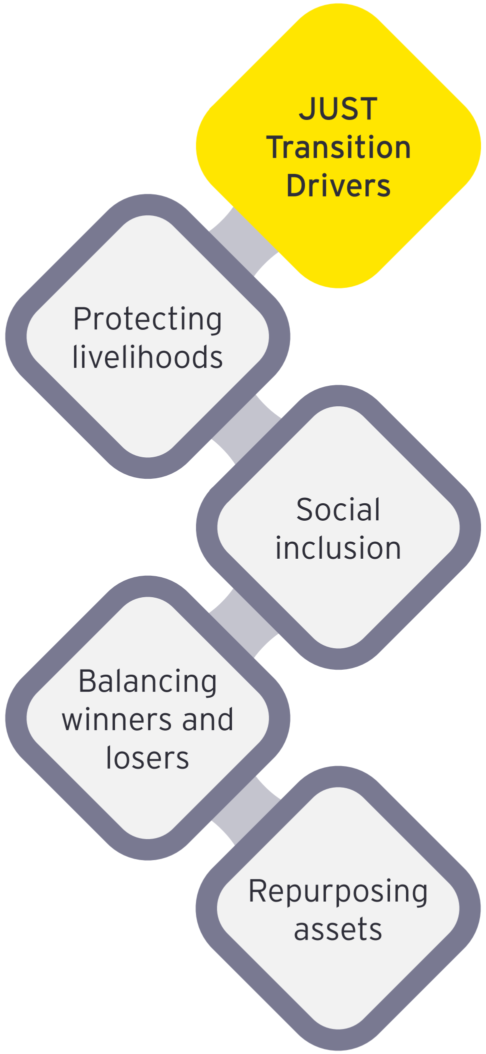
- Technology and capacity mapping for portfolio design
- Developing demand scenarios net of DER / DR / DSM impacts with inputs from States, aggregating at regional / national levels and merging the data sets under EPS
- Drawing the framework of resource adequacy for load-generation balance on hour-on-hour, year-on-year and aggregated basis
- Providing broad guidance for transmission planning, network strengthening and corridor identification, including juxtaposition of green corridors

Robust and predictable growth in demand for clean energy sources is essential for accelerating energy transition investments. There is a need to restructure the framework for electricity demand planning, especially at the State level in order to enhance coordination and harmonization of techniques and reporting with greater degree of granularity. States must focus on conducting least cost generation expansion planning backed by optimal dispatch simulation at an hourly resolution for spot years (e.g., 2025/2030/2040). Such planning should also be accompanied by modelling network constraints and grid stability analysis for validating integration of high shares of renewable energy for spot years.

Institutional reforms for 'JUST' transition and portfolio diversification of public sector energy conglomerates

Understanding and addressing the social dimensions of the clean energy transition is critical to ensure that communities, workers and their families are not overly disadvantaged or left behind. Taking action to address the potential disparity in the economic and social outcomes from the inevitable transition can be labelled a just or equitable transition. Globally, there is a growing recognition among institutional investors that these social considerations should form part of their broader response to the risks and opportunities inherent in the net zero transition.

India's clean energy transition will leave coal and petroleum industries, communities and workers exposed to decline in demand for fossil fuel commodities. There are ~1.2 million workers in India's coal sector, including employees of CIL and private producers, as well as informal workers in the mining and generation sectors, but excluding those from coal transport, which comprises both rail and road transport. Coal accounts for ~40% of India's rail network revenue and the rail sector formally employs 1.3 million people. The coal trucking industry hires about 0.5 million people: truck drivers, coal loaders, and maintenance workers for around 150,000 trucks. Clustered around these core activities are substantial secondary employment opportunities in both the formal and informal sectors. Much of this employment is focused in coal-producing states consisting of Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, and Telangana. It is estimated that for every formal job in coal, 3–10 additional jobs/livelihoods are dependent on coal in the coal mining districts.



Economic diversification in coal-dependent communities and business diversification of coal/petroleum industries can accelerate JUST transition

In an article titled 'Bureaucracies for the Better' authored by an expert, it is argued that the energy transition policies and technologies, new business models, have been converging for some time in India with electricity as a common-denominator. The existing institutional framework governing India's energy sector faces conflicting incentives. The problem of conflicting incentives at the institutional level is acute at India's Ministry of Coal, which has the mandate to ensure that enough of the black rock is mined domestically to continue feeding India's growing electricity demand. Meeting these targets provides essential income to central and state governments, while also carrying both revenue and purpose to other connected public sector corporations, like Indian Railways, the NTPC, and Coal India Limited, the mining conglomerate that controls 90% of coal reserves in the country. But this model is unsustainable.

Indian railways has already achieved great strides in electrifying its network, adoption of renewable energy for captive use and also announced its ambition to achieve net zero emissions by 2030. NTPC and Coal India both are pursuing renewable energy investments aggressively to diversify their portfolio and reduce the risk of locking in fossil fuel investment. The Indian Oil Corporation is pursuing rapid solarization of fuel retail stations, considering adding EV charging at thousands of locations, and has started venturing into the hydrogen space. Bharat Heavy Electricals Limited, the largest power generation equipment manufacturing firm, has announced plans to making components for EV charging infrastructure and renewable energy value chain that the country so desperately needs.

Renewable power generation, green hydrogen production, storage and transportation, upstream manufacturing of polysilicon wafers, ingots, mining of critical minerals essential for energy transition such as nickel, cobalt, molybdenum, chemical processing for production of advanced chemistry battery cathodes etc. are the emerging value chains for business diversification for energy conglomerates. In summary, policy packages should determine JUST Transition pathways and a governance structure with adequate institutional capacity to implement the measures. A whole-of-government approach will be necessary involving dialogues at the Central, State and local government levels and actively engaging with communities, labour unions and civil society organizations in order to ensure that re-skilling, redeployment and realignment of livelihoods follow an orderly direction and have broad public acceptance.

Coal dependent states in focus	Estimated potential of renewable energy (MW)		
	Solar (Ground + Rooftop)	Small Hydro Power	Wind
Jharkhand	18,180	228	-
West Bengal	6,260	392	2
Madhya Pradesh	61,660	820	10,484
Maharashtra	64,320	786	45,394
Chhattisgarh	18,270	1,098	77

Source: MOSPI, 2021

State	Reserves of Nickel Ore	Reserves of Cobalt Ore	Reserves of Molybdenum Ore
Odisha	175 million tons	31 million tons	-
Jharkhand	9 million tons	9 million tons	-
Nagaland	5 million tons	5 million tons	-
Tamil Nadu	-	-	10 million tons
Madhya Pradesh	-	-	8 million tons
Karnataka	-	-	1.32 million tons

Source: Indian Bureau of Mines, 2019

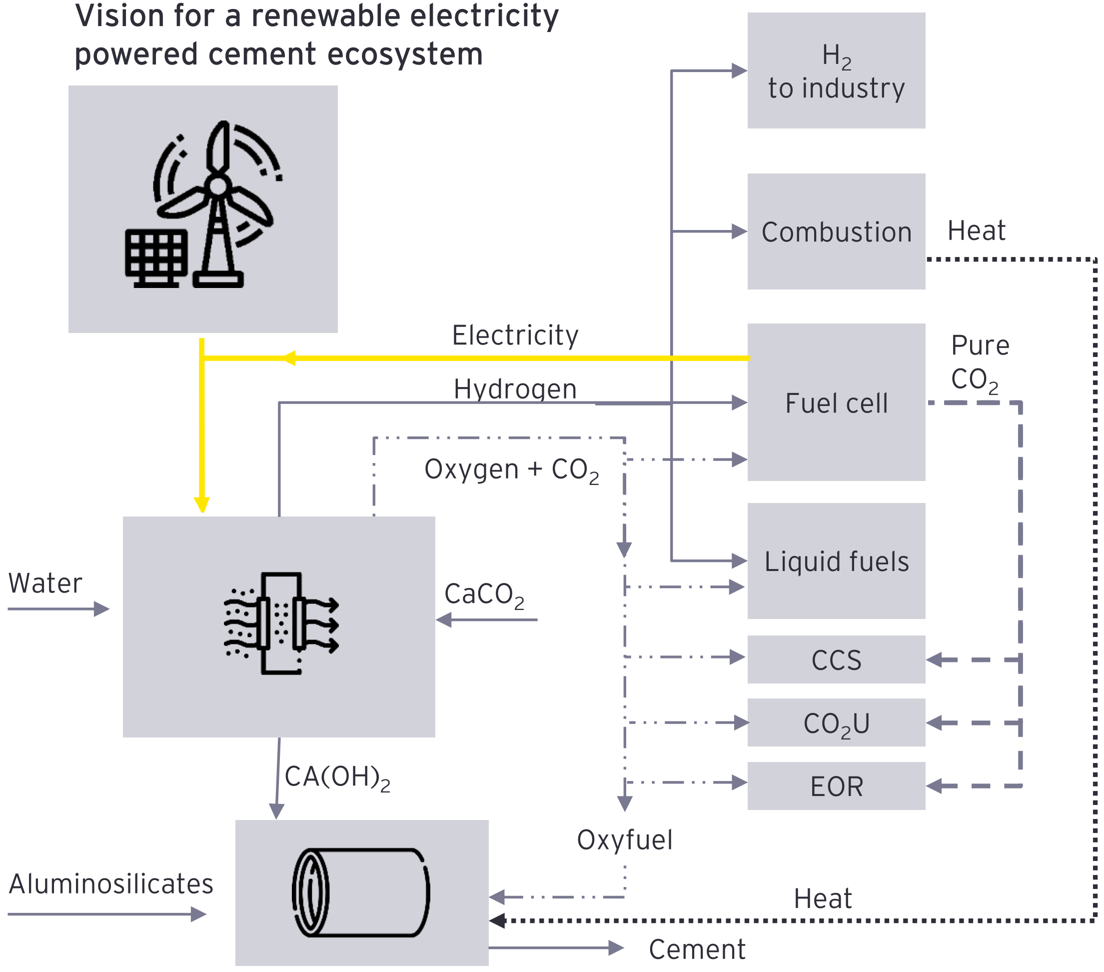
Incentives for fossil to electricity transition technologies and solutions for manufacturing industries can accelerate inorganic demand growth for electricity

For the manufacturing industries, renewable powered electric heat pumps, boilers and electric arc furnaces could replace fossil fuel furnaces for process low-medium temperature applications . However, total decarbonization of this sector, particularly that requires high-grade heat may be difficult purely by means of electrification. This challenge could be addressed by green hydrogen produced from renewables.

As per CEEW analysis in 2019, the green hydrogen based steel production would support scaling up of production in meeting the strong domestic demand and provide for about 4 million direct manufacturing jobs by 2050. Further, it would create another 1.6 million jobs along the hydrogen supply chain, far replacing the fewer jobs involved only in the import and transport of coking coal. Supporting transition of the domestic cement manufacturing to low-carbon cement would ensure that the sector would support 0.54 million jobs in 2050, and zero import dependency on limestone imports. In 2019, MIT researchers demonstrated an electrochemical processes for low carbon cement manufacturing. The new process centers on the use of an electrolyzer, in which oxygen-evolving electrode produces acid, while the hydrogen-evolving electrode produces a base. In the new process, the pulverized limestone is dissolved in the acid at one electrode and high-purity carbon dioxide is released, while calcium hydroxide, generally known as lime, precipitates out as a solid at the other. The calcium hydroxide can then be processed in another step to produce the cement, which is mostly calcium silicate. The carbon dioxide, in the form of a pure, concentrated stream, can then be easily sequestered, harnessed to produce value-added products such as a liquid fuel to replace gasoline, or used for applications such as oil recovery or even in carbonated beverages and dry ice.

To provide the required fillip for investments in transitioning to carbon-neutral processes, it will be important to develop and scale voluntary carbon markets by incentivizing target industries to opt in till such time a mandatory carbon market is introduced in the economy. The measure may prove critical to maintaining the competitiveness of Indian industries if the proposal of introducing 'Carbon Border Adjustment Tax' is implemented by EU and its member countries. Secondly, to unlock the potential in energy-intensive industries, government facilitation will be necessary to support R&D in low carbon technologies as well as develop the framework for innovative financing, institute credit enhancement and partial risk guarantee mechanisms and deploy public funds to attract private capital at scale.

Vision for a renewable electricity powered cement ecosystem



Source: MIT Energy Initiative

Other measures to enable clean energy demand growth

Reforms to improve financial health of electricity distribution sector

The central financial assistance to state power utilities for promoting performance improvement and reforms should be conditioned upon implementation of Direct Benefit Transfer, corporate governance, and recovery of government outstanding to DISCOMs – both subsidy and electricity dues. Structural reforms separating carriage and content should be a priority to improve last mile efficiencies and governance structure, facilitate consumer empowerment and provide the effective interface for decentralized distributed generation.

Formulate a national policy framework for coal plant and mine closures / phase out

The Ministry of Power should formulate a national policy framework for coal plant and mine closures / phase out by adopting JUST transition principles for all. The framework should include provisions for using land, water, existing transmission networks and re-skilling employees for building and operations of renewable energy facilities. Feasibility of repurposing end-of-life coal-based power plants should also be examined for on-site deployment of either stand-alone or a combination of solar panels, battery storage and synchronous condensers upon assessment of economic benefits and social trade-offs.

Formulate energy storage policy with viability gap funding for initial uptake

The stationary storage industry can compromise on energy density and round trip efficiency of advanced chemistry battery cells if other performance parameters such as long duration storage (>20 hours per cycle), and useful life (no. of charge – discharge cycles) are superior to existing technologies at competitive prices. The levelized cost of energy storage is a key performance parameter for stationary ESS solutions as they have to compete with levelized cost of energy from fossil fuels for scaling up adoption in India. In this regard, energy storage policy must look beyond lithium-ion technology and focus on development of cost effective long duration capable advanced chemistry battery cells made from earth abundant elements. Viability gap funding should be provisioned for initial uptake and demonstration of cost-effective technologies.

New regulatory paradigms

New regulatory paradigms will be necessary to usher in the concepts of utility engagement in decentralized service models and demand side measures, dynamic pricing in wholesale power markets to monetize grid-related services and build value streams, expanded application of TOD retail tariff and aggregation of distributed energy resources for providing grid-interactive services. A prudent approach will be to set up Regulatory Sand Boxes for testing these concepts and providing the basis for informed decision making.

Decarbonizing India's electricity grid with utility scale RE power generation

4

Shovel-ready pipeline of utility scale RE power generation projects

India's renewable energy (RE) based grid interactive power generation capacity has increased ~7 times since 2010 taking the cumulative installed capacity to ~104 GWp (as of December 2021). Wind and solar PV constitute 48.55 GWp and 40.03 GWp of the installed power generation capacity respectively in the current scenario. So far in the current fiscal (FY 22), India has commissioned ~10.6 GW of renewable power generation capacity with another quarter remaining. India is also leading the global transition towards renewable energy with initiatives such as 'One Sun One World One Grid' and 'World Solar Bank' for harnessing solar energy on a global scale.

There are over 360 utility scale RE based power generation projects in the pipeline led by both public and private sector. These projects include solar PV, wind, biomass, battery energy storage systems (BESS) and hybrid RE projects under different stages of development. Together these projects constitute ~103 GW of contracted capacity in the pipeline.

Over ~37.6 GW of utility scale RE power generation projects in the pipeline currently was announced / tendered / auctioned in the year 2021. In recent times, the scale of Hybrid RE projects announced has increased, indicating that the demand for Hybrid projects is gaining rapid momentum. By blending solar PV, and wind energy sources at a single location or multiple different locations/injection points in the national grid, Electricity Distribution Companies (DISCOMs) / bulk buyers can better manage the intermittency / variability otherwise associated with plain vanilla RE projects. BESS projects are increasingly announced to integrate high share of variable/intermittent renewable energy sources into the grid. Open access RE projects are increasingly adopted by corporates and businesses for optimising power purchase costs, build resilience from climate change impacts and further accelerate towards net zero emissions. The ease of doing open access RE projects has improved significantly over the last one year, which is another key contributing factor.

Contracted capacity of utility scale RE power generation projects in pipeline (MW)

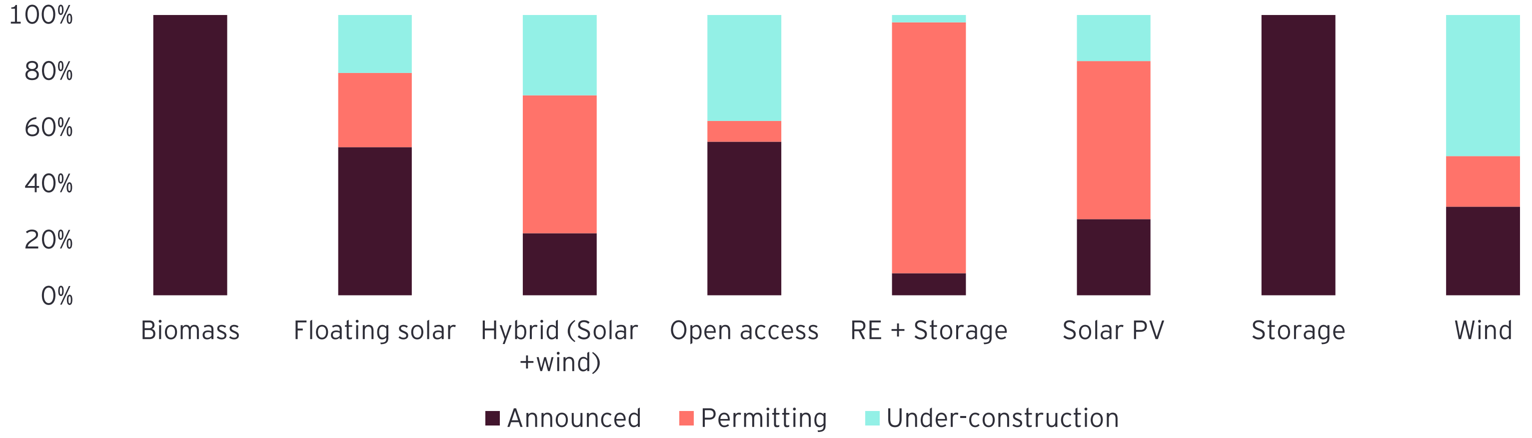
RE Technology	Project announcement year					Total (MW)
	2018	2019	2020	2021	2022*	
Biomass		6		15	40	61
Floating solar	170	70	34	1,045	360	1,679
Hybrid (Solar +wind)	840	1,820	2,395	2,900	750	8,705
Open access		170	45	7,172	866	8,253
RE + Storage		1,200	20	146		1,366
Solar PV	1,390	17,508	9,764	21,336	10,961	60,959
Storage				1,000	6,490	7,490
Wind	5,725	1,423		4,058	3,045	14,251
Grand Total	**8,125**	**22,197**	**12,258**	**37,672**	**22,512**	**1,02,764**

*Source: EY Analysis based on JMK Research; *Only projects announced in Jan'22 is included*

Contracted capacity of utility scale RE power generation projects in pipeline (MW)				
RE Technology	Project pipeline status*			Total (MW)
	Announced	Permitting	Under Construction	
Biomass	61			61
Floating solar	890	444	345	1,679
Hybrid (Solar +wind)	1,950	4,270	2,485	8,705
Open access	4,540	605	3,108	8,253
RE + Storage	111	1,220	35	1,366
Solar PV	16,717	34,269	9,973	60,959
Storage	7,490			7,490
Wind	4,545	2,558	7,148	14,251
Grand Total	**36,304**	**43,366**	**23,094**	**1,02,764**

Source: EY Analysis based on JMK Research

Current status of utility scale RE projects in pipeline



Source: EY Analysis based on JMK Research

A majority of Solar PV projects are in different stages of permitting – signing power purchase agreement (PPA), power sale agreement (PSA), tariff adoption and power procurement approvals from regulators, financial closure, land acquisition and permission for grid interconnection. Whereas, a majority of Hybrid RE projects and BESS projects are yet to complete price discovery through reverse auctions. About 23 GW of projects have progressed to construction stage which includes ~7 GW of wind power projects auctioned over the years. This indicates that India will add significant capacity of wind power projects in the next fiscal. Reforms focusing on improving ease of land acquisition for low carbon infrastructure projects, grid connectivity and open access will determine the speed and scale of transition.

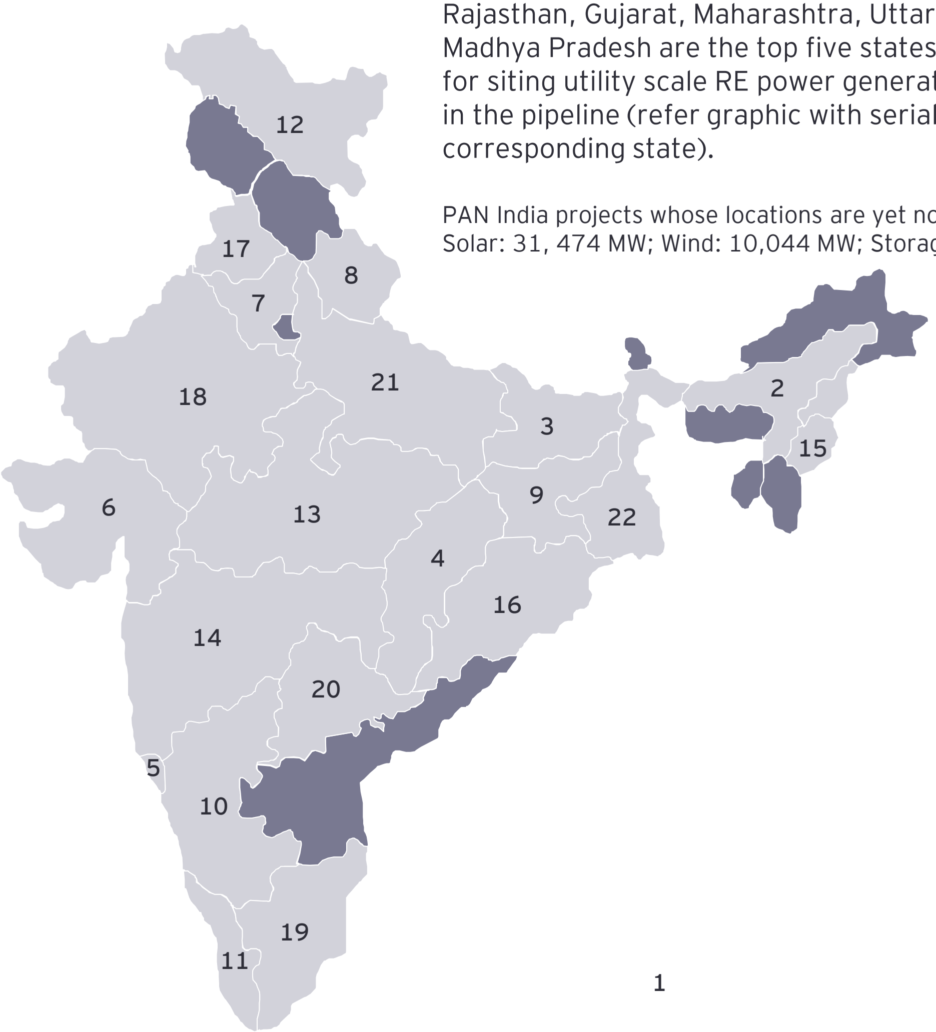
~6.8 GWh of utility scale BESS is in the pipeline, most of which are undergoing the reverse auction process for competitive price discovery. The CEA in its optimal generation mix report for FY 2029-30 has estimated all India BESS capacity addition of 34MW / 136 GWh by end of this decade. Most of the MWh scale BESS projects under pipeline aim to provide renewable energy integrated with BESS as a service in remote areas of Leh, Chhattisgarh, UP etc. Whereas, the recently announced GWh scale standalone BESS projects aim to provide round the clock (RTC) renewable energy as a service and also optimise capacity utilisation of ISTS (transmission system) set up for RE integration.

Therefore, the top use cases emerging of standalone BESS projects are RE firming, RTC RE supply and better capacity utilisation of transmission systems connecting massive RE projects to national grid.

Utility Scale BESS Project Pipeline				
Project name or scheme (Auction / Tender)	Date of announcement	Project capacity (MW AC)	BESS capacity (contracted) (MWh AC)	Project Location
GSECL 35 MW with 57 MWh BESS Solar(EPC) Gujarat	Sep-2021	35	57	GUJARAT
NIT for procurement of 2,000 MWh battery energy storage system	Jul-2021	1,000	2000	PAN INDIA
NTPC 4 MW Solar (EPC) + 1 MW/1 MWh BESS Uttar Pradesh	Jun-2021	4	1	UTTAR PRADESH
REMCL Solar with 7 MW/ 14 MWh BESS Maharashtra (Railway Land)	May-2021	7	14	MAHARASHTRA
SECI 100 MW Solar with 50MW/120 MWh BESS Storage Chhattisgarh	Dec-2021	100	120	CHHATTISGARH
SECI 20 MW Solar with 20 MW/ 50 MWh BESS Storage Leh	Dec-2020	20	50	LADAKH
SECI, 1,200 MW, ISTS -Tranche VII, RE with storage	Aug-2019	900	-	PAN INDIA
SECI, 1,200 MW, ISTS -Tranche VII, RE with storage	Aug-2019	300	-	PAN INDIA
NTPC 500 MW MW with 3000 MWh ESS Pan India	Jan-22	500	3000	PAN INDIA
SECI 500 MW with 1000 MWh BESS Rajasthan	Apr-22	500	1000	RAJASTHAN
NTPC 10 MW/40 MWh BESS (EPC) Telangana	Apr-22	10	40	TELANGANA
NTPC 250 MW with 500 MWh BESS Rajasthan	Apr-22	250	500	RAJASTHAN
5230 MW Renewable Energy Storage Project in AP	Oct-22	5,230	-	ANDHRA PRADESH

Source: EY Analysis based on JMK Research

Project location for utility scale RE power generation capacity in pipeline



Rajasthan, Gujarat, Maharashtra, Uttar Pradesh and Madhya Pradesh are the top five states emerging for siting utility scale RE power generation projects in the pipeline (refer graphic with serial number for corresponding state).

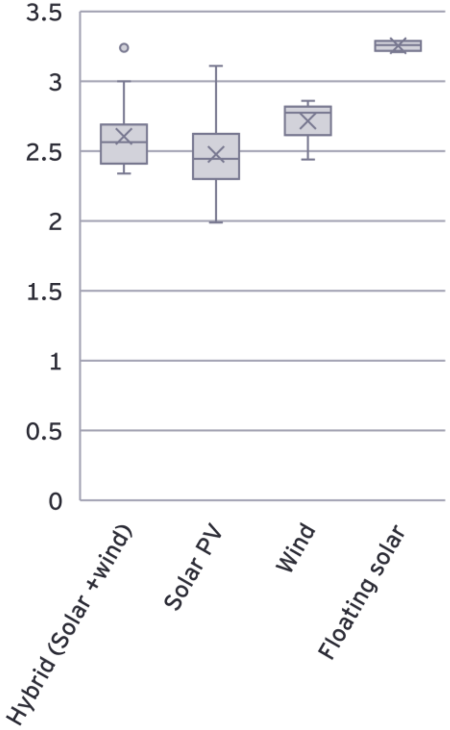
PAN India projects whose locations are yet not finalized
Solar: 31, 474 MW; Wind: 10,044 MW; Storage: 5,000 MWh

Source: EY Analysis based on JMK Research

S. No	States/ UTs	Solar capacity (MW)	Wind capacity (MW)	Storage capacity (MWh)
1	Andaman & Nicobar islands	4		
2	Assam	25		
3	Bihar	230		
4	Chhattisgarh	1,278		120
5	Goa	70		
6	Gujarat	6,750	4,401	57
7	Haryana	120		
8	Himachal Pradesh	15		
9	Jharkhand	130		
10	Karnataka	2,230	480	
11	Kerala	320		
12	Ladakh	20		50
13	Madhya Pradesh	3,005	638	
14	Maharashtra	5,837	1,595	14
15	Nagaland	20		
16	Odisha	150		
17	Punjab	1,150		
18	Rajasthan	19,618	1,580	1500
19	Tamil Nadu	1,150	352	
20	Telangana	285		40
21	Uttar Pradesh	2,737		1
22	West Bengal	105		

PPA executed capacity in pipeline (MW)	
RE Technology	**Total (MW)**
Floating solar	240
Hybrid (Solar +wind)	6,255
Open access	1,198
Solar PV	24,981
Wind	8,348
Grand Total	**41,022**

Tariff discovery in RE auctions (INR/kWh)



Investment mobilization

Utility scale RE projects in pipeline would need INR ~3.73 lakh crore (US$ ~48 billion, 1 INR = 0.013 US$) of capital infusion for operationalization. This translates into INR1.12 lakh crores (US$ ~14.1 billion) of equity infusion and INR2.61 lakh crores (US$ ~33.6 billion) of debt infusion at 30:70 ratio. Much of this capital infusion is expected from the private sector increasingly backed by private equity investors, sovereign wealth funds and other specialised institutional investors.

Capital Investment - Equity

~INR 1,11,902 crores

For 103 GW of Utility scale RE projects in pipeline

Capital Investment - Debt

~INR 2,61,105 crores

For 103 GW of Utility scale RE projects in pipeline

Capital infusion for utility scale RE projects in pipeline (INR crores)

RE technology	Estimated CAPEX outlay	Viability gap funding	Equity Mobilisation	Debt financing
Biomass	1,098		329	769
Floating solar	5,877		1,763	4,114
Hybrid (Solar +wind)	39,546		11,864	27,682
Open access	29,166		8,750	20,416
RE + Storage	5,144		1,543	3,601
Solar PV	2,13,357	2,244	63,334	1,47,779
Storage	9,810		2,943	6,867
Wind	71,254		21,376	49,877
Grand Total	**3,75,251**	**2,244**	**1,11,902**	**2,61,105**

Source: EY Analysis based on JMK Research

Employment potential

~7.93 lakh fresh jobs will be created for operationalizing the 103 GW pipeline of utility scale RE projects. 52% of total jobs would be local job pertaining to project planning, O&M and commercial, whereas 48% would be supply chain jobs catering manufacturing, transportation and decommissioning.

Fresh jobs created

~ 7,92,747 jobs

For 103 GW of Utility scale RE projects in pipeline

Fresh jobs created from utility scale RE projects in pipeline

RE technology	Total no. of Fresh Jobs
Biomass	2,623
Floating solar	15,217
Hybrid (Solar +wind)	65,262
Open access	74,033
RE + Storage	12,381
Solar PV	5,52,492
Wind	70,739
Grand Total	**7,92,747**

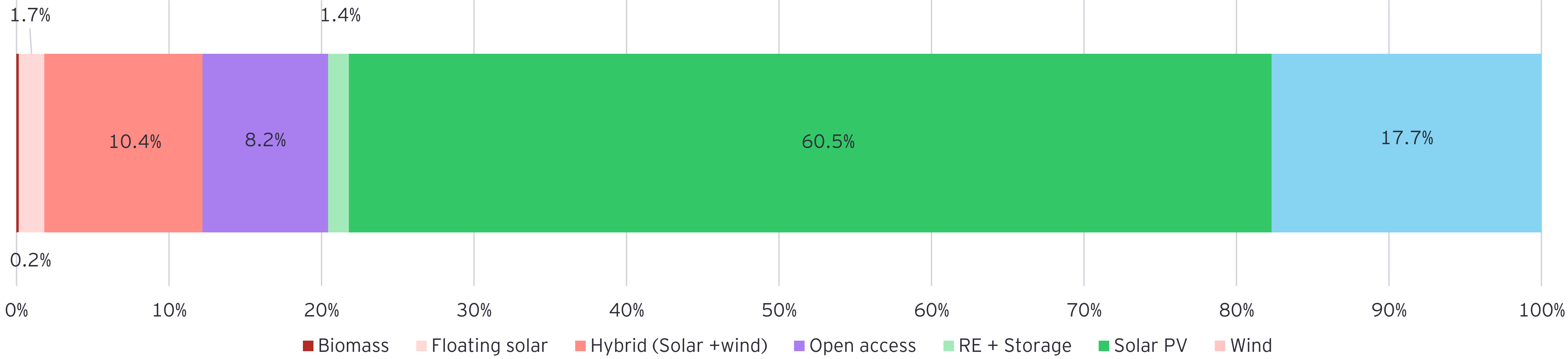
Environmental benefits

~4 billion tonnes of cumulative CO_2 e emissions can be avoided over a lifetime of 103 GW capacity of grid connected utility scale RE projects.

Avoided CO_2 emissions (cumulative over project lifetime)

~3,989 million tonnes CO_2e

For 103 GW of Utility scale RE projects in pipeline



Source: EY Analysis based on JMK Research

Recommendations

1. *Establish a national index along with regional sub-indices for RE pricing by pooling of prices / tariffs discovered from RE auctions*

Many utility scale RE projects in the pipeline remain stranded without PPAs even after completing price discovery through auctions and this scenario is likely to persist. This is largely because the DISCOMs, who are the ultimate buyers of renewable electricity from these projects, expect the tariffs to fall perpetually as a function of time and therefore delay signing power supply agreements hoping to find better deals from future auctions. One way to address this challenge is that the central PSUs, which plan and conduct renewable energy auctions as intermediary off-takers can take in principle approval from the DISCOMs, agreeing on acceptable range for tariff discovery. The same agreement can be captured in the Tariff filing applications submitted to respective state regulatory commissions. This would enable the timely execution of Power Sale Agreements.

Also, in this context, pooling of prices/tariffs discovered from multiple auctions conducted over a pre-defined period could help both buyers and sellers with a single benchmark cost for negotiating PPAs and PSAs. SECI and other central PSUs acting as intermediary off-takers can collaborate to formulate a national index with regional sub-indices based on pooling of prices/tariffs discovered from multiple RE auctions. Such an index will help periodically benchmark the competitive price / tariff for RE based power generation and guide negotiations for PPA signing between parties. Such an index will also help investors and financial institutions inform their outlook and evaluation of utility scale RE projects.

2. *Formulate a model policy for aggregation and allocation of wasteland parcels for the development of ultra mega utility scale RE power parks*

Access to contiguous land parcels is still a challenge for the development of Megawatt scale RE projects in several states. Wasteland categories like land with dense scrub, land with open scrub, shifting cultivation, degraded pastures/grazing land, degraded land under plantation crop may be good fit for development of RE projects.

However, there is lack of uniform approach for states with abundant wasteland resources to allocate such land among RE developers by way of a transparent competitive mechanism. MNRE scheme for development of ultra mega RE power parks could embed such mechanisms for development and implementation of projects. There is a need to formulate and implement uniform land acquisition policy with provision of single window clearance mechanism for projects awarded through auctions conducted by central PSUs as intermediary off-takers. Simultaneously, the model policy could also specify the framework for aggregation of large privately owned wasteland parcels with right incentives for landowners to lease their assets for development of ultra mega RE power parks.

3. *Dynamic pricing in wholesale markets and expanded scope of TOD retail tariff necessary for creating commercially attractive use cases for deployment of utility scale BESS*

Today the bulk of wholesale electricity markets in India are governed by long term purchase agreements with DISCOMs. These agreements do not differentiate the value of electricity supplied on the basis of time of day and / Or season. Part of the problem is that the retail prices (end-user tariffs) are fixed round the clock for most categories of consumers. Time of day tariffs are mandated selectively for high tension category industries only with options for voluntary adoption in few other categories in select states. Lack of smart metering infrastructure is another key bottleneck in this regard to enable time of day pricing. Advanced Metering Infrastructure (AMI) of smart meters increase opportunities for implementing TOD tariff, enabling multiple pricing options to be offered to customer.

The central government has notified the timelines for replacement of existing meters with smart meters with prepayment features. By 2023, a significant number of urbanized states and UTs with high AT&C losses (>15%) is expected to replace, whereas remaining states may take until March 2025 for the same. With rising share of low cost intermittent renewable energy sources supplying abundant electricity during day time and monsoon months, dynamic pricing is essential for rewarding discharge of surplus/excess renewable electricity from BESS at times the grid needs most – evenings, early mornings etc. More importantly, dynamic and time variant pricing mechanisms are essential for enhancing the arbitrage value of electricity storage. Dynamic time variant tariffs are key to maximize the profitability of BESS projects and investments.

Recommendations

4. *Implementation of the Electricity Amendment Bill 2021*

The draft 'Electricity Amendment Bill 2021' is welcomed by the industry in its present form and can be a game changer in transforming the power sector to become more investor friendly by improving ease of doing business, enforcement of contracts, cost reflective tariffs, direct benefit transfer of subsidies, national renewable energy policy, strengthening of institutions such as APTEL and electricity regulatory commissions, expansion of NLDC functions etc.

The implementation of 'Electricity Amendment Bill 2021' will likely boost the investor confidence for driving energy transition investments and galvanise the full spectrum of stakeholders in the power sector for a better future.

5. *Scale up skilling and training efforts to boost availability of skilled professionals for project execution*

Over the years, the government of India through 'Skill Council for Green Jobs' has scaled up skilling and training activities for the youth of India to support the industry's ambition and investments towards energy transition. Occupational mapping, skill gap analysis, development of qualification packs for various job roles expected from energy transition investments, curriculum and courseware development, strengthening the quality of training infrastructure, certification of candidates, improving linkages with industry for job placements are all streamlined for better outcomes.

Given the scale of energy transition investment pipeline and resulting employment potential, the above activities will need to be ramped up involving the academia, industry, civil society organisations and other partners. A comprehensive monitoring and evaluation framework focusing on meeting the industry needs, improving livelihoods and other positive socio-economic outcomes should be adopted for the skilling and training activities and programs.

6. *Retrofitting / repowering existing solar and wind power installations*

In order to ramp up solar and wind energy generation at existing sites which provide the option of replacing vintage generating plants with equipment deploying advanced technology and resulting in higher CUF, following measures are relevant:

a. Examine the scope for retrofitting end-of-life solar power plants with new technology options to improve efficiency, by application of:

- dual Axis Active Solar Trackers for increasing generation
- silicon based Passivated Emitter and Rear Cell (PERC) panels having high purity to improve cell efficiency
- bifacial solar cells to increase generation
- half cells panels to improve overall module durability

b. Identify wind power projects / capacities to be augmented by repowering and initiate following activities:

- selecting sites that would maximize harnessing of wind resources
- choosing appropriate designs to improve the power output, viz. rotor height and diameter, turbine capacity etc.
- assessing site constraints / ROW and enablers for refurbishing

c. Repositioning the solar and wind installations with higher capacity and output efficiency would entail addressing commercial arrangement, viz.:

- framework for bidding / rebidding
- termination clause / recompensing provisions for incumbent developers
- off-take arrangement with buyers

Recommendations

7. *Policy Coordination and Implementation*

Integrative approach between MOP and MNRE will be necessary at apex level for synchronizing technology selection, resource allocation and capacity addition plans. In particular, following tasks are important:

- ensuring cross-sector linkages and policy coordination
- enshrining the six pillars of PM Gati Shakti and removing the silos for portfolio expansion – comprehensiveness, prioritisation, optimization, synchronization, critical analysis, and dynamic review
- driving synergies of objectives and tasks across GOI initiatives, viz. National Energy Solar Mission, National Hydrogen Mission, National Energy Storage Mission, etc.
- aligning incentive schemes for providing impetus under domestic manufacturing and supporting R&D to facilitate technology adaptation / collaboration / partnerships
- addressing supply chain constraints and removing the bottlenecks, encompassing technology upgrade, raw material sourcing, import options and strategic investments, e.g. positioning technology for solar cells, electrolysers, etc., and minerals including rare earth metals for advanced chemistry battery cells
- channelizing project finance by introducing appropriate schemes under credit enhancement mechanism, partial risk guarantees, first loss guarantees, etc. and leveraging public / blended finance for attracting private capital.

8. *Project Monitoring*

To reinforce inter-ministerial coordination, an Apex Body under aegis of MOP and MNRE can be formed to monitor project implementation and develop work plans for addressing:

- build-up of domestic manufacturing
- design of fiscal incentives and their applicability
- technology upgrades and collaborations
- raw material sourcing and supply chain issues
- streamlined project clearances and approvals
- policy support for project finance, planning and implementation

Joint Working Groups (JWGs) under MOP and MNRE are proposed to enable knowledge exchange, support work plans basis identified projects and facilitate a coordinated approach across the full spectrum of technology deployment, project development and capacity expansion.

A dedicated Project Monitoring Panel is suggested for reviewing progress of projects under implementation, including but not limited to those under thermal, hydro including pumped storage, renewables and BESS categories. It will act as the effective interface between the Working Groups, the Apex Body and the administrative Ministries for addressing project-specific bottlenecks and fast-tracking execution, as will be necessary.

Decentralization of power system through distributed generation

5

Shovel-ready pipeline of grid connected rooftop PV (RTPV) projects in residential, commercial and institutional sectors

Introduction

RTPV markets in India witnessed the highest ever capacity addition (~2654 MW) in the last calendar year 2021.The states of Gujarat, Maharashtra and Kerala are leading the RTPV capacity addition growth in the country. The Ministry of New and Renewable Energy (MNRE) has launched Grid Connected Solar Rooftop Program – Phase 2 in August 2019. The Component-A of this program aims to deploy 4 GW of RTPV systems in the Residential Sector with Central Financial Assistance (CFA) up to 40%. Approximately ~3.2 GW RTPV capacity is already allocated by MNRE for implementation in various states. Whereas the Component-B aims to incentivize state DISCOMs for performance that is evaluated by incremental RTPV capacity addition (up to 18 GW) in any sector.

Shovel ready projects for implementation

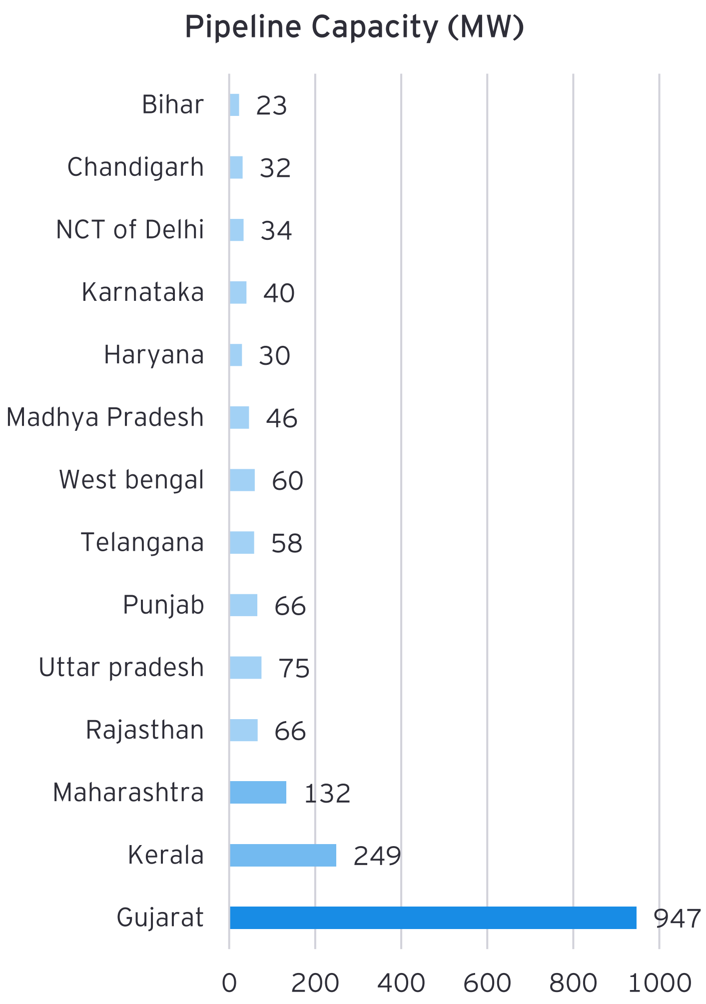
~2.0 GW of RTPV capacity in residential and ~144 MW in C&I segments is currently under pipeline. Approximately, 1.2 GW of RTPV has been commissioned under the MNRE scheme as of January 2022. CAPEX model of development is currently dominating the project pipeline under both components. Whereas, Renewable Energy Service Company (RESCO) model of development leveraging private sector investments is increasingly tested for faster adoption. A variety of other innovative business models such as rent a roof/lease model, community model, utility model through a Special Purpose Vehicle (SPV), plug-in Rooftop Solar (RTS) model and others are also being explored. Currently Gujarat is leading in pipeline capacity for rooftop projects with 947 MW followed by Kerala and Maharashtra with 249 and 132 MW respectively.

Simplified procedure for RTPV installations under MNRE scheme, Jan 2022

A national portal for registering applications from the beneficiaries, approvals thereof and tracking progress will be developed. Further, the beneficiary can install RTPV systems from any vendor fulfilling the conditions of DCR, enlistment under ALMM and inverters certified by BIS. Model standards and agreements for supply with vendors will be notified. This will significantly improve ease of doing RTPV across the country.

Electricity (Right of Consumers) Amendment Rules 2021

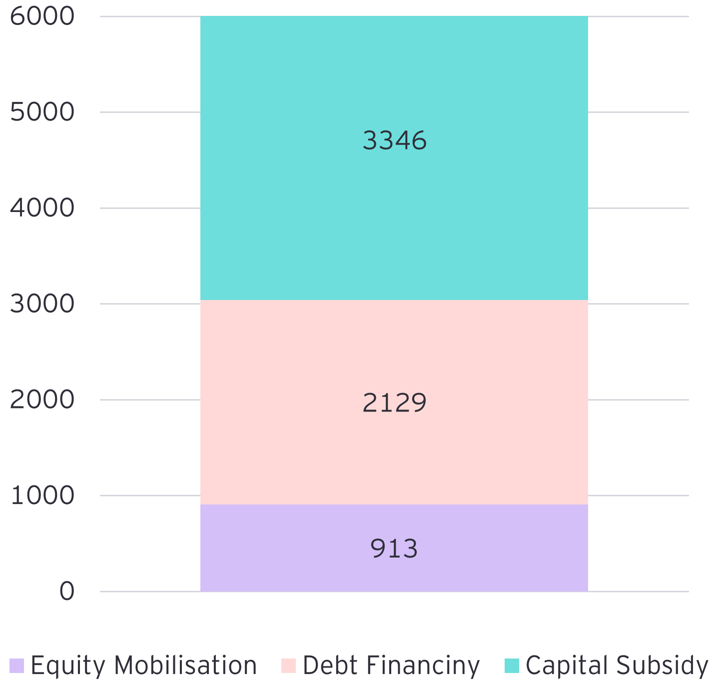
These rules allowed up to 500 kW Or sanctioned load whichever is lower for RTPV installations availing net metering by any Prosumer. This is a significant policy driver for accelerating RTPV project pipelines across the country when properly enforced by state electricity regulatory commissions.



Investment mobilization

For the allocated capacity of 2.0 GW under development, ~INR 3,042 crores (US$ ~0.4 billion) of capital investment will be mobilized (excluding the subsidy). Further, another INR 1,259 crores (US$ ~0.2 billion) is expected to be mobilized for building the remaining capacity announced under the MNRE program. The Government of India through MNRE could provide total capital subsidies of ~INR 6,600 crores (US$ ~0.9 billion) under component A.

Investment mobilization for allocated capacity (INR crores) – Component A



Source: EY analysis based on MNRE SPIN portal

Capital Investment – Equity
~INR 913 crores
For 2.0 GW of current allocation under Phase II component A

Capital Investment – Debt
~INR 2,129 crores
For 2.0 GW of current allocation under Phase II component A

Socio economic benefits

Over 18,000 fresh jobs will be created in building 2.0 GW capacity of grid connected RTPV systems under the program. These jobs will emerge in both public and private sectors along the value chain of project development, construction and commissioning, operations and maintenance of rooftop solar PV systems all across the country.

Fresh jobs created
~18 thousand jobs
For 2.0 GW of current allocation under Phase II component A

Environmental benefits

Over ~80 million tonnes of CO_2e emissions are expected to be avoided over the operating lifetime of 2.0 GW capacity of grid connected RTPV projects commissioned under the program.

Avoided emissions (cumulative over project lifetime)
~80 million tonnes CO_2e
For 2.0 GW of current allocation under Phase II component A

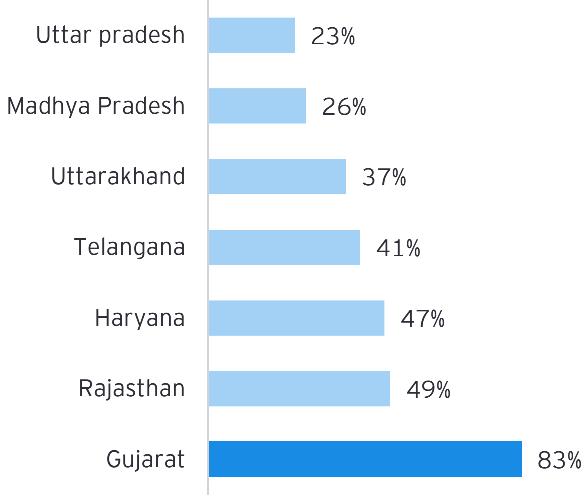
1. Adopt best practices from Gujarat and Kerala models of scaling up RTPV implementation in residential sector

We examined the ratio of commissioned RTPV capacity to allocated capacity by MNRE in order to benchmark the progress in each state. Before current allocations by MNRE, Gujarat had achieved 83% of its allocated capacity of ~1.2 GW. States such as Rajasthan, Haryana and Telangana achieved between 40%–50%, whereas other moderately performing states namely Uttarakhand, MP and UP achieved 20–30% of allocation.

In our opinion, Gujarat has shown tremendous progress because of following interventions:

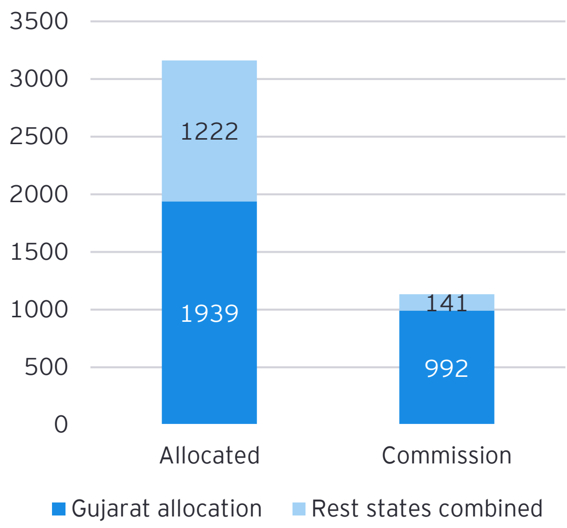
- Additional subsidy sponsored from state up to 10kW projects
- A unified web portal for processing consumer RTPV applications, single window approvals and tracking
- No capping of the RTPV capacity with respect to sanctioned load
- Reduction of security deposit payable by developer to the DISCOM from 25 Lakhs to 5 Lakhs
- Banking charges, cross subsidy and additional surcharge exempted for residential prosumers
- Consumer awareness and outreach programs

Commissioned out of allocated capacity till December 2021



Source: EY analysis

Allocated and commissioned capacity (MW)



2. Frame policy and regulatory incentives to promote utility owned / driven business models for RTPV capacity addition

Under the Grid connected Rooftop Solar Program – phase 2 component A, most of the DISCOMs have largely adopted the consumer owned model with utility acting as an aggregator to implement the sanctioned RTPV capacity. Going forward, DISCOMs must look beyond consumer owned models to attract more households, especially in the lower slabs of consumption (less than 100 units per month).

Kerala State Electricity Board (KSEB) has successfully aggregated over 200 MW of RTPV demand from households in the lower slabs of consumption by offering compensation for access to roof space in the form of monthly energy credit. DISCOMs in other states must take a cue from this success and act fast to unlock value in the RTPV market. Perceived threats from revenue loss can be turned into a growth opportunity if DISCOMs channel their CAPEX into supplying RTPV electricity to individual households.

Changes in regulatory paradigm will be necessary to incentivize DISCOMs to partake in decentralized generation activity and provide the platform for system integration by investing in grid-edge technologies requiring advanced computational power and optimization modelling software. An earning adjustment mechanism linking revenue to efficiency targets is a measure implemented in other jurisdictions that compensates DISCOMs against flat-to-declining load growth and provides for recovery of programme expenses and lost distribution revenue as well as a share of the net economic benefits and / or a rate of return on capex in non-wire solutions.

Recommendations

3. Demand aggregation for RTPV deployment in the institutional sectors (e.g. health, education and all government buildings) integrated with storage

As per the Parliamentary Standing Committee's latest assessment, only 56.45% schools have adequate electricity access. Rural Health Statistics (2019) indicates that 26.3% of the rural sub-centers and 4.8% of rural Primary Health Centers (PHCs) do not have access to electricity supply, which is not only imperative for the functioning of healthcare facilities but also a vital determinant of essential healthcare services delivery.

Rural health centers and schools are largely vulnerable to irregular power supply and frequent interruptions adversely impacting the delivery of essential healthcare and education in rural communities. Despite having diesel generators for power backup, their operations are restricted due to inadequacy of funds for diesel. Sometimes in remote locations, the supply of diesel is interrupted during monsoons or bad weather. As per the World Health Organization (WHO), unreliable electricity access leads to vaccine spoilage, interruptions in the use of essential medical and diagnostic devices, and lack of even the most basic lighting and communications for maternal delivery and emergency procedures. The quality of energy access in healthcare and education facilities may have crosscutting impacts, for example, retention of health workers, improved enrolment / attendance of students and teachers in government schools who often live right alongside these facilities.

Experience from Chhattisgarh, Odisha (Kalahandi) and Karnataka (Karuna trust) have shown that health centers with rooftop solar systems provide 24-hour healthcare services treating a greater number of patients. Regular access to electricity has also enabled them to have reliable supply of water, safe refrigeration for vaccines, and powered theatre equipment, fans, and baby warmers.

There are ~1.5 lakh health centers (viz. sub-centers, primary health centers and community health centers) across the country with potential for ~564 MW of rooftop solar deployment. Similarly, there are approx. 6,82,000 rural primary schools managed by government with potential for ~2 GW of rooftop solar deployment.

Stimulus options

- Dedicated capacity allocation for rooftop solar deployment in rural schools (2 GW) and health centers (500 MW) with generation based incentives
- Extend low cost credit line for financing rooftop solar projects in the institutional sectors
- Set up institutional mechanism at central and state levels for demand aggregation and investment related actions under OPEX mode in both health and education sectors

Stimulus benefits -
(Cumulative over Solar PV system operating lifetime)

Direct savings in electricity costs of health centres	Direct savings in electricity costs of rural government elementary schools	Fresh jobs created in rural communities
INR 5,875 crores (US$ ~0.8 billion)	INR 21,284 crores (US$ ~3 billion)	61,800 fresh jobs

Avoided CO_2 emissions	Total capital investment towards rooftop Solar PV systems in health centres and rural government elementary schools
86 million tons of CO_2e	INR 11,200 crores

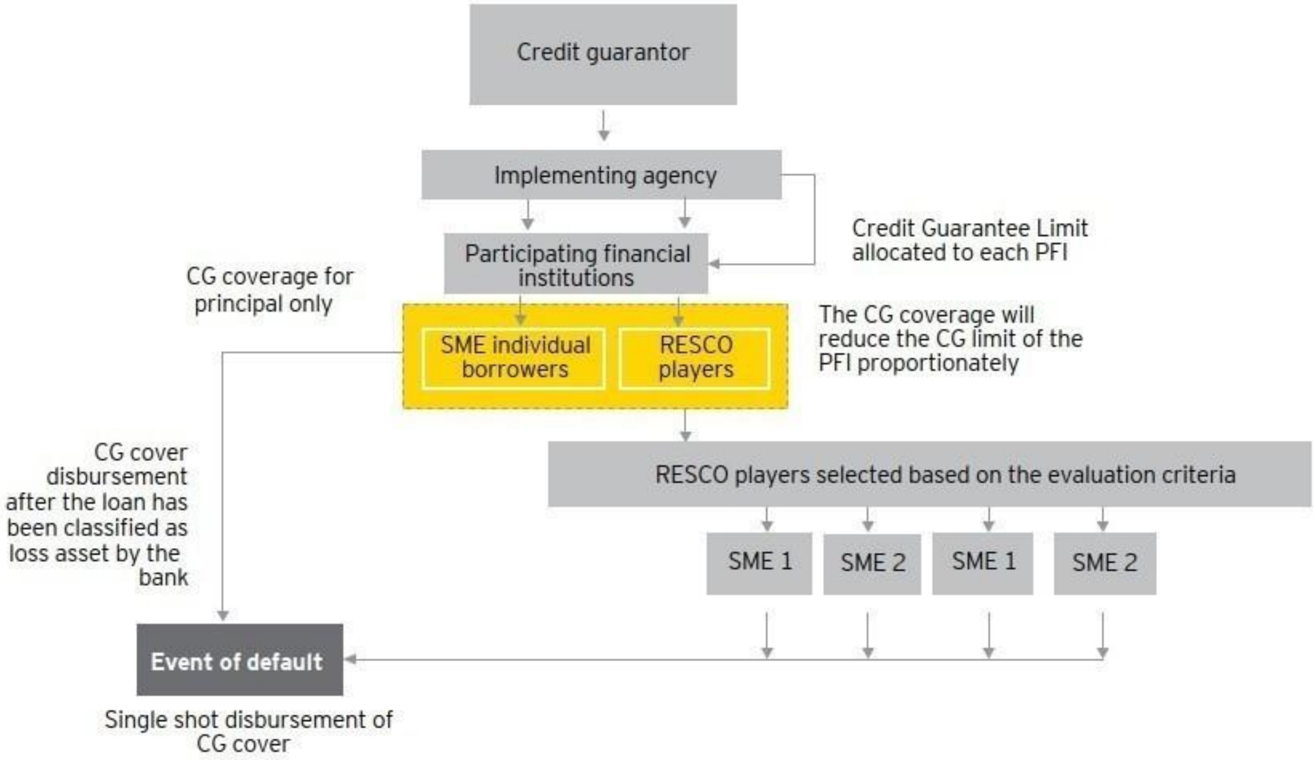
Source: EY analysis

4. *Design and implement credit risk guarantee mechanisms to support RTPV financing for MSMEs*

Many financial institutions lending for MSMEs perceive huge risks related to payment delays and defaults while evaluating RTPV loans and its benefits manifesting largely as operational cost savings / energy cost savings. To help mitigate these risks, credit risk mitigation measures can be explored which will provide the requisite cushion to financial institutions.

A credit guarantee (CG) mechanism provides guarantees on loans to borrowers by covering a share of the default risk of the loan. In case of default by the borrower, the lender recovers the value of the guarantee from the guarantor.

A fixed CG cover to the participating financial institutions is envisaged. Under this, the evaluation of both the borrowers and final power off-takers will be the responsibility of the financial institutions. The CG cover gets activated and disbursement takes place once the loan gets classified as loss asset by the lender. A fixed cover of up to 50% of the loan amount under the CAPEX and RESCO mode can be considered depending on the risk profile of the borrower on a case to case basis.



Source: EY analysis

Shovel-ready pipeline of decentralized grid connected renewable energy systems under PM-KUSUM component - A

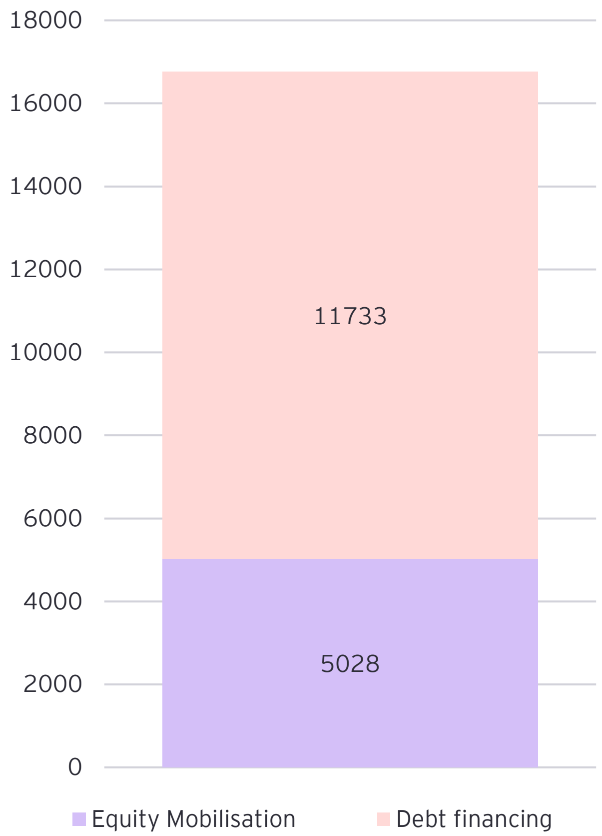
Introduction

The simplified guidelines for implementation of PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme, notified in Dec'21, allows states 24 months for implementation of sanctioned capacity. The Component-A supports setting up of 10 GW of decentralized ground mounted grid connected renewable energy power plants for providing additional source of income for land owning farmers. The grid connected renewable energy plant size is capped to a capacity up to 2 MW. MNRE will provide procurement based incentive (PBI) to the DISCOMs @ 40 paise/kWh or Rs.6.60 lakhs/MW/year for first five years, whichever is lower, for buying renewable power under this scheme. The PBI will be given to the DISCOMs for a period of five years from the commercial operation date of the plant.

Shovel-ready projects for implementation

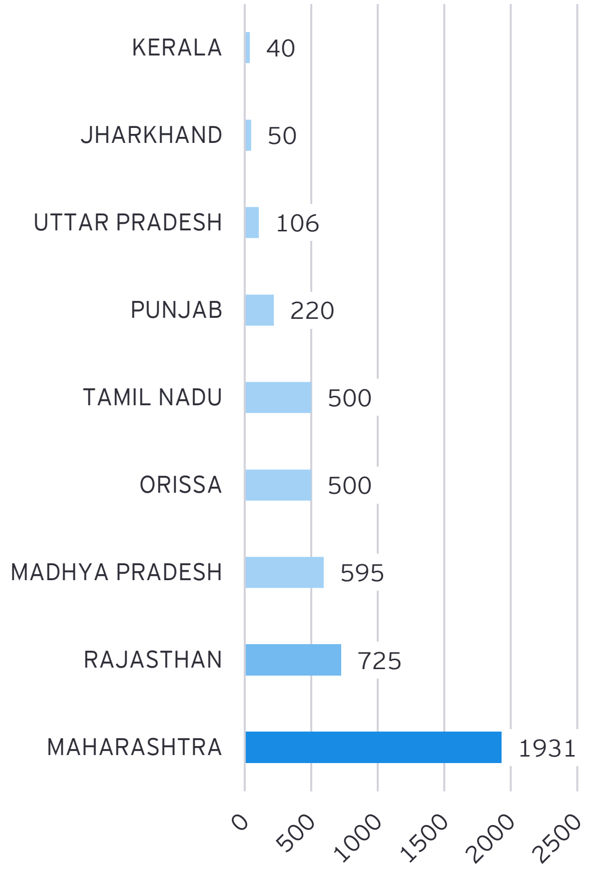
~4.8 GW capacity of decentralized ground mounted grid connected renewable energy power projects are currently sanctioned by MNRE to various state nodal agencies (mostly DISCOMs) for implementation under component A. A majority of these projects are still under development with nodal agencies inviting landowners/farmers, Solar EPC companies and developers to gauge their interest in project financing and development. Both CAPEX and OPEX models are allowed for maximum participation from stakeholders. Landowners are allowed to develop ground mounted grid connected Solar PV power projects on agriculture farmlands for dual use of power generation and farming. DISCOMs will identify substations for grid interconnection, allocate capacity from auctions, and enter into power purchase agreements with qualified landowners for aggregated demand.

Investment mobilisation for sanctioned capacity (INR crores) - Component A



Source: EY analysis based on JMK Research

State wise pipeline capacity (MW)



Investment mobilization

Currently, the state nodal agencies are testing and streamlining the process for solicitation of market participants, capacity allocation, PPA execution, construction and commissioning, monitoring and evaluation before rapidly scaling up capacity addition. For the sanctioned capacity already under development, a total of INR 16,762 crores (US$ ~2.25 billion) of capital investment will be mobilised from the landowners and other project developers. Private sector funds will be largely utilised to meet this massive capital expenditure.

Capital Investment - Equity

~INR 5,028 crores

For 4.8 GW of ground mounted solar PV projects announced under KUSUM-A

Capital Investment - Debt

~INR 11,733 crores

For 4.8 GW of ground mounted solar PV projects announced under KUSUM-A

Socio economic benefits

~43,400 fresh jobs will be created in building 4.8 GW capacity of decentralized ground mounted grid connected renewable power projects announced under KUSUM component A. These jobs will emerge in rural areas with private sector investments along the value chain of project development, construction and commissioning, operations and maintenance of solar PV systems all across the country.

Fresh jobs created

~43,400 jobs

For 4.8 GW of ground mounted solar PV projects announced under KUSUM-A

Environmental benefits

Over ~190 million tonnes of CO_2e emissions are expected to be avoided over the operating lifetime of 4.8 GW capacity of grid connected ground mounted solar PV projects commissioned under the program.

Avoided emissions (cumulative over project lifetime)

~190 million tonnes CO_2e

For 4.8 GW of ground mounted solar PV projects announced under KUSUM-A

Shovel-ready pipeline of standalone solar powered agriculture pumps under PM-KUSUM component - B

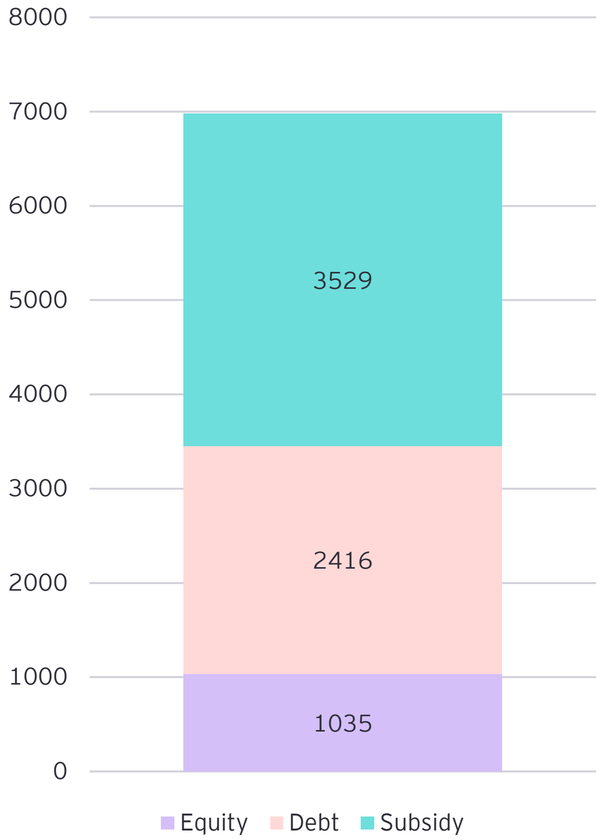
Introduction

The simplified guidelines for implementation of PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme, notified in December 2021, allows states conduct competitive price discovery of standalone Solar Powered Agriculture Pumps on their own. Under Component B, 17.5 lakhs standalone solar irrigation pumps are targeted for installation with CFA of 30% of the benchmark cost or the tender cost, whichever is lower. The State Government will give additional subsidy of min. 30% and the remaining will be financed by participating farmers / beneficiaries.

Shovel-ready projects for implementation

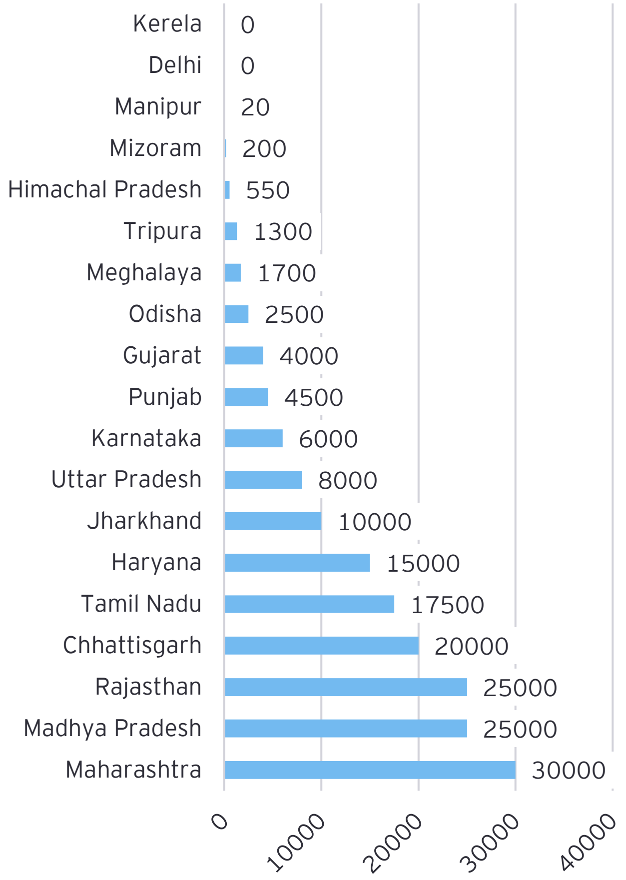
~2.0 GW capacity from 3,56,453 stand alone solar pumps are currently sanctioned by MNRE for implementation under component B. Maharashtra, Madhya Pradesh, Rajasthan and Chhattisgarh are the leading states with sanctioned pumps more than 20,000 and above.

Investment mobilization for sanctioned capacity (INR crores) - Component B



Source: EY analysis

Number of pumps sanctioned State wise



Source: MNRE

Investment mobilization

For the sanctioned capacity already under development, a total of INR 3,451 crores (US$ ~0.47 billion) of capital investment will be mobilised in 2021-22 from the participating farmers.

Capital Investment - Equity

~INR 1,035 crores

For 3.5 Lakhs standalone solar pumps projects announced under KUSUM-B

Capital Investment - Debt

~INR 2,416 crores

For 3.5 Lakhs standalone solar pumps projects announced under KUSUM-B

Socio economic benefits

~18,000 fresh jobs will be created for deployment of ~3.5 Lakh stand alone pumps under KUSUM component B. These jobs will largely emerge in the rural areas along the value chain of construction and commissioning, operations and maintenance of solar pump systems.

Fresh jobs created

~18,000 jobs

For 3.5 Lakhs standalone solar pumps projects announced under KUSUM-B

Environmental benefits

Over ~16 million tonnes of CO_2e emissions are expected to be avoided over the operating lifetime of 3.5 Lakh stand alone solar PV projects commissioned under the program.

Avoided emissions (cumulative over project lifetime)

~16 million tonnes CO_2e

For 3.5 Lakhs standalone solar pumps projects announced under KUSUM-B

Shovel-ready pipeline of standalone solar powered agriculture pumps under PM-KUSUM component - B

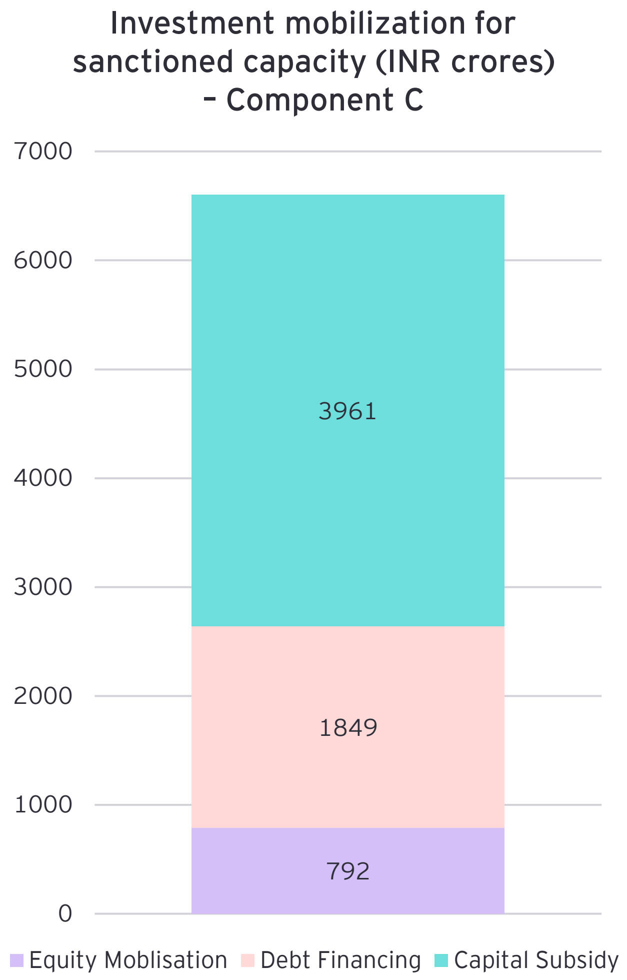
Shovel-ready pipeline of decentralized grid connected solar PV systems under PM-KUSUM Component - C

Introduction

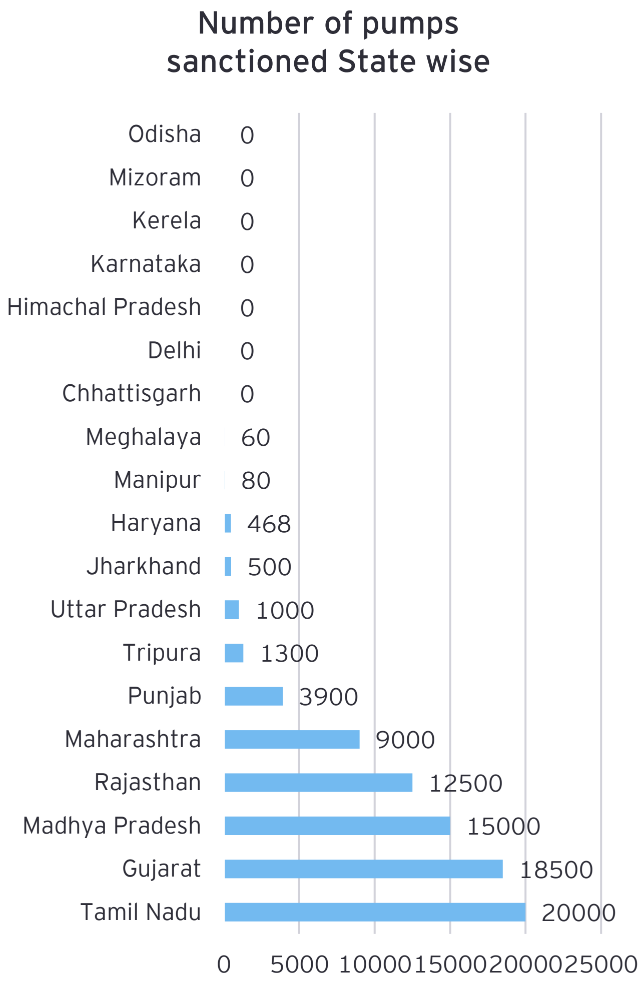
The Component C targets solarization of 10 lakh grid connected pumps. Up to 50% can be solarized at feeder level under this component. MNRE will provide CFA of 30% of the benchmark cost for solarization of grid connected pump sets. The State Government will give additional subsidy of min. 30% and the remaining will be financed by beneficiaries. The feeder solarization capacity can be twice as much as the connected load on dedicated agricultural feeders.

Shovel-ready projects for implementation

~1.9 GW capacity is currently sanctioned by MNRE to various state nodal agencies (mostly DISCOMs) for implementation under component C. A majority of these projects are still under development with nodal agencies aggerating land, inviting developers / Solar EPC companies to gauge their interest in project financing and development. Both CAPEX and OPEX models are allowed for maximum participation from stakeholders. Under CAPEX mode, DISCOM will make its own investment towards solar PV power plants by arranging own funds, collaborate with empaneled EPC contractors / System Integrators for setting up grid connected ground mounted solar PV power plant on turnkey basis, operate and maintain the plant during the PPA tenure. Under RESCO mode, DISCOM will purchase power from a third-party developer selected after competitive tariff discovery through reverse bidding/auctions.



Source: EY analysis based on JMK Research



Source: MNRE

Shovel-ready pipeline of decentralized grid connected solar PV systems under PM-KUSUM Component – C

Investment mobilization

For the sanctioned capacity under development, a total of INR 2,641 crores (US$ ~ 0.35 billion) of capital investment will be mobilized.

Capital Investment - Equity

~INR 792 crores

For 1.9 GW of ground mounted solar PV projects announced under KUSUM-C

Capital Investment - Debt

~INR 1,849 crores

For 1.9 GW of ground mounted solar PV projects announced under KUSUM-C

Source: EY analysis

Socio economic benefits

~17,100 fresh jobs will be created in building 1.9 GW capacity of decentralized grid connected solar powered feeders under KUSUM component C. These jobs will emerge in rural areas with private sector investments along the value chain of project development, construction and commissioning, operations and maintenance of solar PV systems.

Fresh jobs created

~17,100 jobs

For 1.9 GW of ground mounted solar PV projects announced under KUSUM-C

Environmental benefits

Over ~75 million tonnes of CO_2e emissions are expected to be avoided over the operating lifetime of 1.9 GW capacity of grid connected solar PV projects commissioned under the program.

Avoided emissions (cumulative over project lifetime)

~75 million tonnes CO_2e

For 1.9 GW of ground mounted solar PV projects announced under KUSUM-C

1. *Generation-based incentives for decentralized grid connected ground mounted solar PV systems co-located with crops on agriculturally productive land parcels (hereinafter referred as agro-PV projects)*

PM-KUSUM component A is designed to provide alternate / additional source of income and livelihood from decentralized renewable power generation for:

i. Farmers of cultivable land
ii. Farmers or landowners of wasteland / barren / uncultivable land

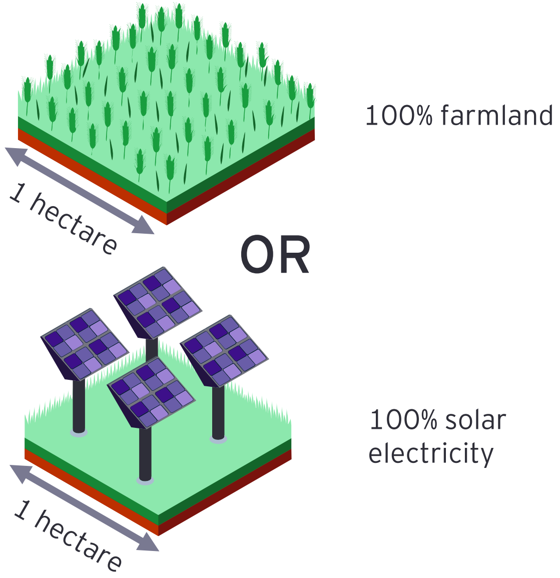
The first category of farmers would have to design and develop solar PV systems for co-location with crops on agriculturally productive land parcels. This will require elevated structures and a more dispersed solar PV array arrangement to permit sufficient sunlight for crop cultivation, thereby increasing the capital cost. A variety of innovative agro-PV solutions are emerging from successful demonstrations in Germany, Japan, South Korea, China, France, the United States and India. The Indian Council of Agricultural Research – Central Arid Zone Research Institute (ICAR-CAZRI) has successfully commissioned Solar PV systems co-located with a variety of crops in Jodhpur.

As per a recent IRENA report (2019), agro-PV systems combine solar PV and agriculture on the same land and consists of growing crops beneath ground mounted solar panels. Although the concept was in existence for long, it has received little attention until recently, when several researchers have confirmed the benefits of growing crops beneath the shade provided by the solar panels. These include higher electricity production, higher crop yields and less water used. Many types of food crops, such as tomatoes, grow better in the shade of solar panels, as they are spared from the direct sun and experience less water loss via transpiration, which also reduces water use while maintaining the same level of food production. A key advantage for solar panels is that their efficiency is increased. Cultivating crops underneath reduces the temperature of the panels, as they are cooled down by the fact that the crops below are emitting water through their natural process of transpiration.

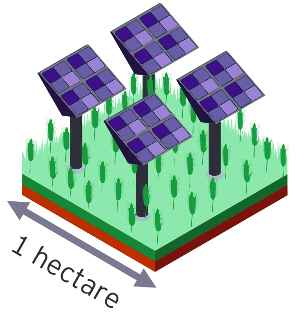
The land use impact from solar energy expansion is likely to have cross cutting implications on the food security and land productivity of the country. In this regard, it is worthwhile to examine the alternative use cases of land acquired for solar energy generation and device policy pathways to reduce the land use impact. KUSUM scheme Component A can be a perfect test bed to scale up adoption of agro-PV solutions.

Ideally, DISCOMs have to conduct the competitive auction process in two separate tranches of capacity allocation for projects proposed on barren and agriculturally productive land parcels. This will ensure level playing field for all the participants. DISCOMs may also shy away from higher cost of power procurement from co-located agro-PV systems developed on agriculturally productive land. In this scenario, generation based incentives for promoting co-located agro-PV systems will reduce the burden on DISCOMs and at the same time make these investments economically attractive.

Separate Land Use on 1 Hectare land: 100% Farmland or 100% Solar Electricity



Combined Land Use on 1 Hectare land: 186% land use efficiency



Source: Fraunhofer Institute for Solar Energy Systems ISE

2. *Dedicated financing facility for improving farmer access to low-cost debt funds and boosting commercial viability of 1–2 MW scale ground mounted Solar PV projects on CAPEX mode (own investment from farmers)*

A major impediment reported by the states for implementing PM-KUSUM component is the inability of individual farmers/ group of farmers/ cooperative societies/ panchayats/ FPO/ WUA to raise funds (approx. 2.45 crores per MW in case of component A, 40% of project cost in case of components B and C) for implementing the projects on their own. MNRE should conduct a detailed review of currently available schemes of NABARD and commercial banks, analyze adequacy of these schemes, and suggest any modifications necessary to improve effectiveness of these financial products for financing KUSUM scheme. Public sector banks such as 'Bank of Baroda', 'Central Bank of India', 'Union Bank of India' have notified lending terms and conditions for financing projects under KUSUM scheme. These banking products require 150% of project value as collateral for loan security apart from primary security obligations such as hypothecation of plant and machineries, mortgage of land, third party guarantee, exclusive charge over PPA and escrow account through tripartite agreement between DISCOM, Bank and farmer enterprise etc. Farmers can also avail benefits of credit guarantee coverage under CGTMSE if registered as MSME and having obtained Udyam Registration certificate. These loans (for components B&C) can also be converged under Agriculture Infrastructure Fund scheme for interest subvention as the projects are considered as community farming assets. Payment risk of DISCOMs may affect the volume of commercial financing that can be raised for this scheme. Therefore MNRE in consultation with states can explore alternatives like sale of power to intermediary CPSUs (e.g., SECI, EESL) who can use open access to contract with Farmer Enterprises for back to back sale with large public sector energy intensive consumers at-least for the duration of loan. More importantly, MNRE could also explore policy amendments to make component A as attractive as component C for DISCOMs and farmers after considering subsidies.

Establish a dedicated financing facility of ~INR 25,000 crore on the lines of Agri Infrastructure Fund to enable farmers access low cost debt financing for setting up 5 GW of decentralized renewable energy projects on CAPEX mode under PM-KUSUM component A.

Direct annual savings in access to electricity **INR235 crores**	Fresh jobs created in rural communities **61,800 jobs**
Avoided CO_2 emissions **86 million tons**	Investment to boost rural economic activity **INR9,000 crores**

Source: EY analysis

Advancing self–reliant supply chains for sustainable energy transition

6

High efficiency solar PV cell and module manufacturing

Enlisting manufacturers and models of solar PV modules

As per the latest (April 2022) approved list of manufacturers and models of Solar PV Modules (ALMM), the current enlisted capacity for manufacturing solar PV modules in India is ~13.2 GW. The installed capacity for manufacturing solar PV cells is ~3 GW as per MNRE.

In order to boost demand for locally manufactured solar PV modules, the government schemes including central public sector undertaking (CPSU) scheme, phase 2 of grid connected rooftop solar program and PM-KUSUM scheme mandate domestic content requirement for sourcing solar PV modules. The government has also issued amendments to ALMM order, 2019 clarifying that only the models and manufacturers enlisted under ALMM will be eligible for use in Government Projects / Government assisted Projects / Projects under Government Schemes & Programmes / Open Access I Net Metering Projects, installed in the country, including projects set up for sale of electricity to Government under the Guidelines issued by Central Government under section 63 of Electricity Act, 2003 and amendment thereof.

Production linked incentives for domestic manufacturing

To enhance India's solar PV manufacturing capabilities and exports, MNRE issued the Scheme Guidelines for 'National Programme on High Efficiency Solar PV Modules' with an initial outlay of INR 4500 crores in April 2021. The scheme has provisions for supporting integrated manufacturing units of high efficiency solar PV modules by providing Production Linked Incentive (PLI) on sales of such solar PV modules. Budgetary outlay for the scheme was increased from INR 4500 crores to INR 24000 crores to accommodate more players and ramp up domestic manufacturing capacity. On average 4-6% of the production value is provided as incentive to promote competitiveness among global markets. In Feb'22, IREDA announced the updated list of successful bidders to set up 10 GW of vertically-integrated manufacturing capacities of high-efficiency solar modules under the PLI program.

As per media reports, the draft guidelines for Tranche II envisages INR 12000 crores reserved for bidders setting up vertically-integrated capacities of polysilicon, wafers, cells, and modules; INR 4500 crores for those setting up wafers, cells, and modules capacity, and INR 3000 crores for cells and modules capacity. The implementation of the PLI program (Tranche-II) is now handed over to SECI. The applicant manufacturer will have to commit to a minimum level of integration across solar cells and modules to qualify for the bid. Based upon the extent of integration proposed, the bidder can opt for bidding for any of the three baskets. The applicant will have to set up a minimum 1 GW manufacturing unit to qualify for the bid. The maximum capacity to bid is 10 GW for polysilicon, wafer, cell, and module; 6 GW for wafer plus cell and module; and 6 GW for cell and module categories. However, the maximum capacity awarded to one bidder under the PLI program would be 50% of the bid capacity.

Shovel-ready projects for implementation

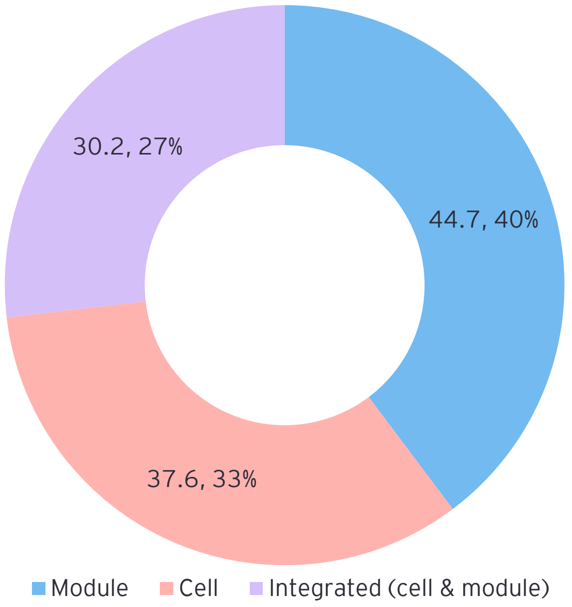
Approximately 112.5 GW/year capacity for manufacturing solar PV cells and modules are in the pipeline at various stages of development. These projects are spread across 8 states with Gujarat leading 14.7 GW/year capacity. However, location for ~78.1 GW/Year capacity under pipeline is not available. About 48.6 GW/Year capacity under pipeline is committed for PLI scheme. This indicates that there is substantial manufacturing capacity under pipeline not expecting incentives under the PLI scheme. As the global supply chain pivots away from China these projects would likely cater to the export markets, thereby positioning India as a key exporter of solar PV cells and modules.

Approximately 30.2% of total pipeline capacity is expected to have integrated cell and module facilities, 44.7% with only module manufacturing and 37.6% with only cell manufacturing.

Location of PV cell and module manufacturing facilities	Manufacturing capacity under pipeline (GW/year)
Gujarat	14.7
Tamil Nadu	7.0
Karnataka	3.1
Maharashtra	2.5
Rajasthan	2.5
Uttar Pradesh	1.8
Telangana	1.7
Andhra Pradesh	1.2
NA*	78.1
Grand Total	**112.5**

Source: EY analysis based on JMK Research
** Information not available*

Value chain of pipeline capacity (GW/year)



Source: EY analysis based on JMK Research

Investment mobilization

A total of INR 3.55 lakh crores (US$ ~ 45.8 billion) of capital investment will be mobilized to operationalize these projects in the pipeline.

Capital Investment - Equity
~INR 1.06 lakh crores
For 112.5 GW/year capacity of solar cell/module manufacturing

Capital Investment - Debt
~INR 2.49 lakh crores
For 112.5 GW/year capacity of solar cell/module manufacturing

Social benefits

The total pipeline of solar PV cell and module manufacturing facilities will create direct employment for ~5 lakh professionals.

Fresh jobs created
~5 lakhs
For 112.5 GW/year of capacity of solar cell/module manufacturing

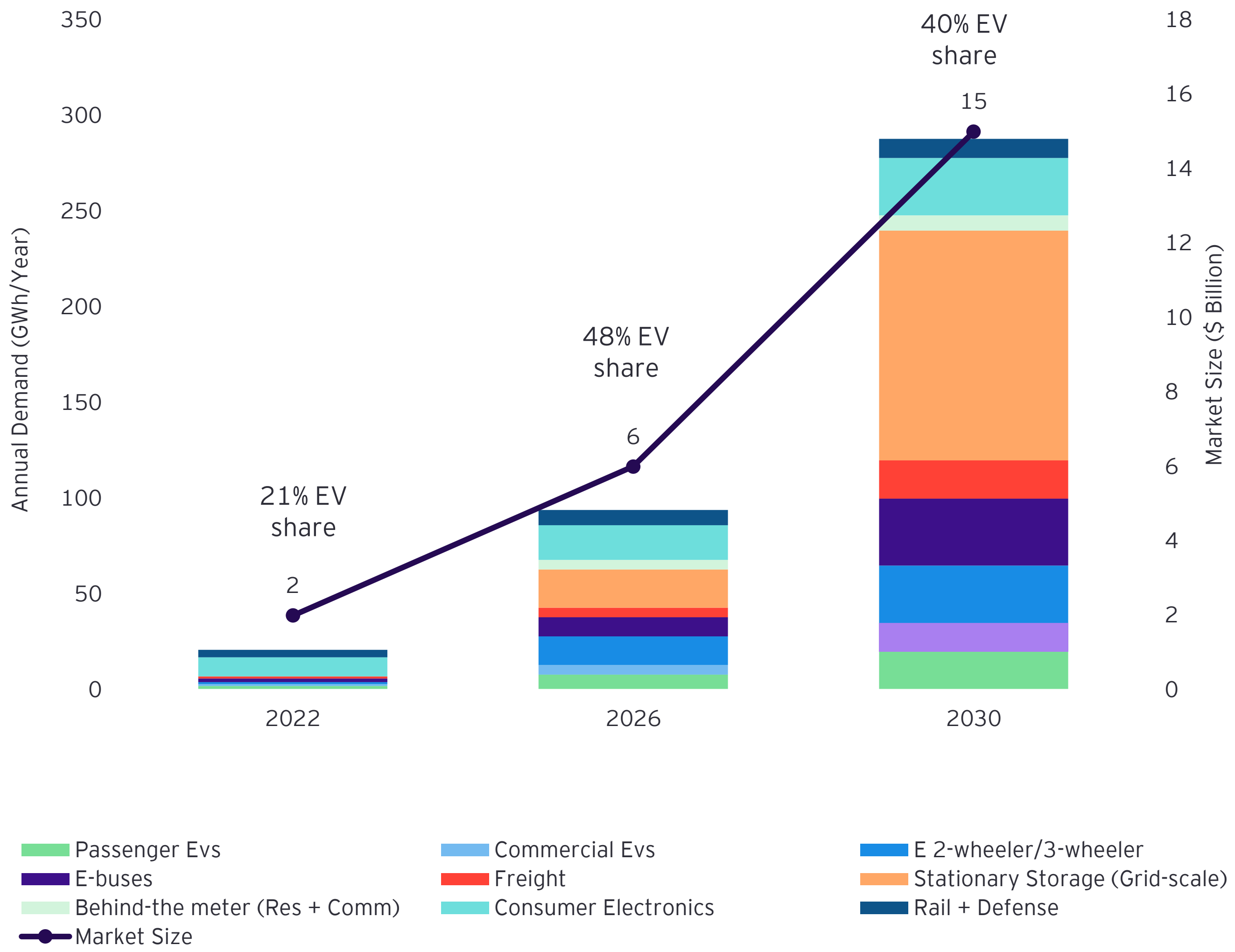
Advanced chemistry battery cell manufacturing

Short and long term demand outlook

The demand for advanced chemistry battery cells in India will be driven largely by electric mobility transition in the short-medium term and stationary grid storage applications in the long term. As per NITI Aayog, the annual market for stationary and mobile batteries in India could surpass US$15 billion by 2030, with almost US$12 billion from cells and US$3 billion from pack assembly and integration.

In the transport sector, India is among a handful of countries that support the global EV30@30 campaign, which targets to have at least 30% new vehicle sales electric by 2030. This presents India with a powerful opportunity to emerge as a global leader in new mobility solutions and battery manufacturing, positioning for sustainable economic growth and global competitiveness. India is uniquely positioned to deploy EVs at scale, leapfrogging traditional mobility models that perpetuate air pollution and oil import dependence while driving down the costs of batteries through economies of scale.

In the energy sector, India announced a target of 500 GW of non-fossil fuel energy deployment by 2030 as commitment to tackle climate change at COP 26. Achieving high levels of intermittent renewable energy penetration in the grid will naturally create a large market opportunity for stationary storage. The CEA in its optimal generation mix report for FY 2029–30 estimates ~136 GWh of energy storage capacity in the grid to integrate high share of intermittent renewable energy sources. Stationary energy storage systems (ESS) can provide a variety of services to stakeholders at all levels of the electricity system, including GT&D utilities and end-use customers. With the historical rate of cost decline in the lithium-ion battery industry, the government and industry together is currently betting on this advanced chemistry battery technology for stationary energy storage applications.



Source: NITI Aayog, 2022

Understanding energy storage systems (ESS) in the context of India's energy transition

The Ministry of Power, Govt. of India recently issued a detailed clarification regarding the usage of ESS in the power sector. The Ministry clarified that ESS can be advanced chemistry battery systems, pumped hydro systems, thermal phase change systems, green hydrogen and green ammonia-based storage systems. The Ministry also clarified that ESS can be used for grid balancing services providing fast response ramp up and down, peaking power support, enhancing flexibility in the power system operations, firming up of RE power generation at the source, energy shifting, enabling optimum capacity utilization of T&D network and CAPEX deferral, arbitrage, peak shifting etc. The government also clarified that standalone ESS as a service does not need any license for operations.

ACC PLI scheme

The department of heavy industries notified the Production Linked Incentive (PLI) scheme, 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage' in 2021 for implementation of giga-watthour scale ACC manufacturing facilities in India with a budgetary outlay of INR 18100 crore. The scheme envisaged setting up of a cumulative ACC manufacturing capacity of 50 GWh and an additional cumulative capacity of 5 GWh for Niche ACC Technologies.

The beneficiary must ensure achieving a domestic value addition of min. 25% and incur the mandatory investment (₹ 225 crore /GWh) within 2 Years (at the Mother Unit Level) and raise it to 60% domestic value addition within 5 Years, either at Mother Unit, in-case of an Integrated Unit, or at the Project Level, in-case of "Hub & Spoke" structure (the "Project"). To ensure a single-window mechanism for the potential investors, a state-level grand- challenge is being planned, including provision for encumbrance-free land, trunk infrastructure facilities, power at rationale rate to the potential investors for attracting the Projects.

A total of 10 bids with capacity ~130 GWh was received under the ACC PLI scheme. The incentive structure is designed to encourage industry to promote fresh investments in indigenous supply chain and deep localization for ACC battery manufacturing in the country. Finally, 4 bidders got selected for incentives under the scheme for a cumulative capacity of 50 GWh per year.

Shovel-ready projects for implementation

Several projects targeting different segments of lithium-ion battery manufacturing value chain are currently in the pipeline. All of these projects are led by private sector and located in Karnataka, Tamil Nadu, Telangana, Haryana, Gujarat and Himachal Pradesh. The total manufacturing capacity of battery cells and components in the pipeline is ~105 GWh/year, along with 2 GWh/year battery recycling and ~7 GWh battery pack assembly.

Project Category	Project Capacity (GWh/year)
Battery Pack Assembly	7
Battery Pack Recycling	2
Battery cell / cell component Manufacturing	105

Source: EY research

Investment mobilization

~INR 1.41 Lakh crores of investment is expected for operationalizing 114 GWh/year capacity of the advanced chemistry battery manufacturing project pipeline till 2025.

Capital Investment - Equity

~INR 42,418 crores

For 114 GWh/year of capacity of battery cell/pack manufacturing

Capital Investment - Debt

~INR 98,975 crores

For 114 GWh/year of capacity of battery cell/pack manufacturing

Social benefits

The total pipeline of battery cell and battery pack manufacturing facilities is estimated to generate ~4.33 lakh direct-indirect employment.

Fresh jobs created

~4.33 lakhs

For 114 GWh/year of capacity of battery cell/pack manufacturing

Recommendations

1. *Reimagine the ACC PLI scheme to promote local value addition via battery materials recycling industry*

India being a resource constrained region for critical ACC battery materials (a.k.a cathode active materials) such as lithium, recycling should naturally gain prominence in shaping policy. The ACC PLI scheme currently mandates up to 60% local value addition within five years. Upstream requirements for ACC battery cell production include sourcing raw materials and chemical refining for production of cathode active materials, a critical step in the production of cathode, which is the largest cost centre (~54%) in the Li-ion battery bill of materials.

Moreover, the explosion in number and capacity of battery giga-factories globally has not been met with comparable growth in supply chain of active materials. Therefore, a competitive recycling industry is a crucial component for achieving India's objectives of self reliance in ACC batteries. Recycling used batteries, especially without domestic natural reserves, is India's best alternative to boost domestic battery materials production and further enhance opportunities in other sectors of the supply chain. Indian companies can develop a competitive edge in sourcing critical battery materials through recycling and establish an important foothold in the rapidly expanding EV ecosystem. It is critical that battery raw material production is achieved through setting up sizeable recycling capacity, but also that it is done in the most eco-friendly and sustainable ways.

In fact, setting up large-scale capacity to recover valuable metals from used batteries has become a key milestone for all major governments throughout the globe. India should also embrace this view and seize the recycling opportunity to mitigate key supply chain risks.

2. *Implement grand innovation challenges for solar PV and energy storage industry to pilot and demonstrate cost effective, durable technologies made from earth abundant materials*

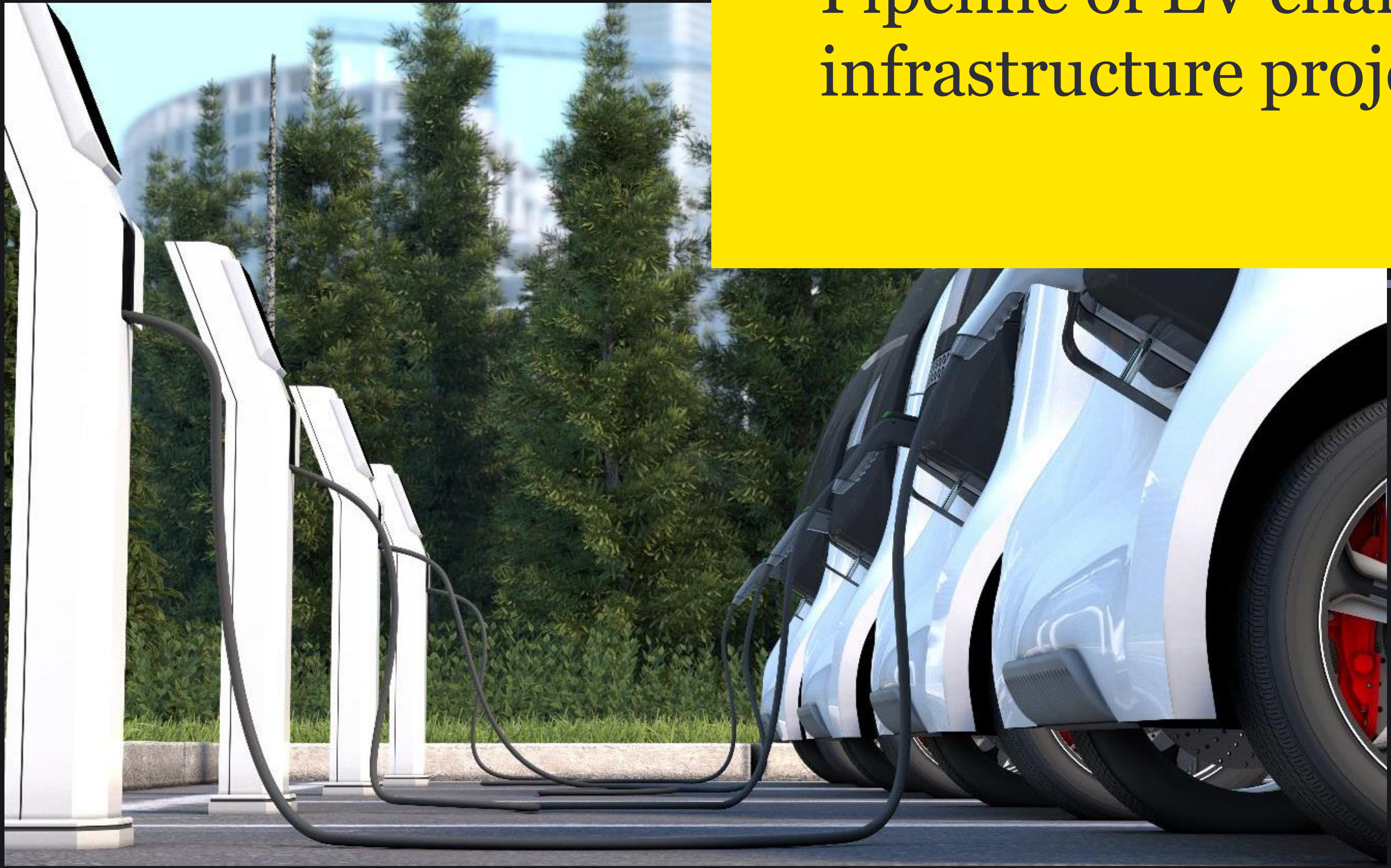
The stationary storage industry can compromise on energy density and round trip efficiency of advanced chemistry battery cells if other performance parameters such as long duration storage, levelized cost / kWh and life (no. of charge – discharge cycles) are superior to existing technologies. Levelized cost of energy storage is a key performance parameter for stationary ESS solutions and has to compete with levelized cost of energy from fossil fuels for scaling up adoption in India.

The Government through CSIR (Council of Scientific and Industrial Research) could invite applications from both domestic and international players to conduct joint R&D initiatives with premier academic institutions for building advanced chemistry battery cell prototypes made from earth abundant elements that enables long duration storage (>20 hours per cycle) and lasts much longer that existing ACC batteries. The grand challenge should aim to launch commercially viable products that cost < 50 USD / kWh when produced at scale.

Likewise, due focus is necessary to prepare technology blueprints and invest in emerging as well next generation technologies governing solar cells, examples being:

- Monocrystalline Interdigitated Back Contact (IBC) Cells
- Monocrystalline Hetero-Junction (HJT) Cells
- Monolithic Solar Cells
- Perovskite PV Cells

To provide boost to domestic manufacturing, setting aside dedicated funds for investing in R&D and providing incentives for indigenous production is recommended.



Pipeline of EV charging infrastructure projects

7

Pipeline of electric vehicle (EV) charging infrastructure

Introduction

India is among a handful of countries that support the global EV30@30 campaign, which targets to have at least 30% new vehicle sales electric by 2030. As per ACMA, India's EV market in FY21 comprises 61% electric two-wheelers, 37% electric three-wheelers and light commercial vehicles, 2% electric four-wheelers, and 0.2% e-buses. To support mass adoption of EVs, India will need to deploy a robust electric vehicle public charging infrastructure. Currently, 19 states have dedicated EV policies for encouraging mass adoption and investments.

EV charging infrastructure rollout under national programs

Phase-II of FAME scheme was launched in 2019 with an outlay of Rs. 10,000 Crore for a period of three years initially and the same is now extended until 31 March 2024. Out of total budgetary support, about 86 percent of fund has been allocated for demand incentives to create demand for EVs in the country. There are currently 164 EV models registered for FAME II purchase incentives, 2.5 lakh EVs sold with incentives to the tune of ~INR 935 crores. The Department of Heavy Industries (DHI), Government of India, which is the nodal agency for administering incentives under FAME II, invited proposals for deployment of 174 EV charging stations on 1,775 kms stretch of expressways and 1,370 stations on 13,370 kms stretch of highways in October 2020. The Ministry of Power has sanctioned 2,877 charging stations in 68 cities across 25 states and UTs and 1576 charging stations across 9 expressway and 16 highways as of December 2021. Currently, the project pipeline for EV charging stations under Fame II scheme accumulates to a total of 5131 stations.

Scheme	No. of EV charging stations under pipeline	CAPEX outlay (INR crores)	Sum of number of job years created
FAME-II	5,131	1,462	15,393
Private Contracts	3,41,098	97,213	10,23,295
State Tenders	1,55,140	44,215	4,65,421
Grand Total	**5,01,370**	**1,42,890**	**15,04,109**

Revised consolidated guidelines and Standards for charging infrastructure for Electric Vehicles (EV)

In January 2022, the Ministry of Power promulgated the 'revised consolidated guidelines and standards for charging infrastructure for Electric Vehicles (EV)'. Among many issues, these guidelines have fixed the timelines for providing grid connectivity for installation of public charging stations, which is a right step for ease of setting up this critical infrastructure. The state electricity regulatory commissions will have to enforce these guidelines in letter and spirit. The guidelines lay down the following locational density targets for deploying public EV charging stations:

- At least one charging station in every 3x3 km grid
- One charging station every 25 km on both sides of highways and roads
- One fast charging station every 100 km on highways / roads for long range / heavy duty EVs

Many factors including EV penetration in the 2W/3W/4W markets, optimal capacity utilization of charge points, ease of setting up charging stations, economics of operating EV charging stations etc., determine the speed and scale of achieving the EV charging infrastructure density targets with industry support. The need for EV charging investment and deployment is irrefutable. But the demand and other uncertainties combine to make public charging infrastructure risky and an unattractive investment. To achieve scale, debt financing is critical and the industry must gradually reduce dependence on policy driven subsidies. Simply put, the business case needs to improve substantially. It is critical to understand the levers that can increase revenues and reduce costs to make the business case more appealing to mainstream debt investors. There are significant commercial, structural and operational levers to reduce latency, enhance revenues and cut costs. Smart charging services, advertisement, retail colocation and network interoperability are levers for revenue enhancement.

In this context, the guidelines promote revenue sharing model for setting up public charging stations. Land available with the Government/Public entities can be monetized for installation of Public Charging Stations on a revenue sharing basis at a fixed rate of ₹ 1 / kWh (used for charging). This is a step in the right direction if adopted widely with transparent and competitive bidding mechanisms.

State level initiatives for EV charging infra roll out

Some states like Andhra Pradesh, Assam, Delhi, Telangana, and Uttar Pradesh have set concrete targets for EV charging infrastructure rollout. The Andhra Pradesh and Uttar Pradesh EV policies have targets of 0.1 and 0.2 million charging stations, respectively, to be built by 2024. Delhi and Kerala aims to have chargers located every 3 km in urban areas and every 25km on highways, whereas Bihar, Haryana, Karnataka, Madhya Pradesh and Telangana aims to have chargers located at every 50 km on all highways. State EV policies primarily rely on capital subsidies to realize these targets. Tamil Nadu aims for installing at every 25 km on highways along with 10% public parking in commercial areas. Whereas Punjab specifies to setup 1 of 5 parking in residential/non residential buildings. Reimbursement of the net state's goods and services tax (SGST) and exemption on electricity duty & stamp duty are provided in states like Andhra Pradesh, Haryana, Tamil Nadu, Telangana, Uttar Pradesh, and Karnataka. Interest free loans are also provided by the Karnataka state government to those setting up charging stations. Eleven Indian states provide special EV tariffs for public charging stations whereas twelve states are providing capital subsidy to charging manufacturing industries of various scale. State governments in 15 states are providing subsidies for initial build out of public charging stations @25% of capital cost or INR 10 lakhs/station whichever is lower. The Delhi government provides a grant of up to 100% on charging equipment set up by building owners, whereas Uttar Pradesh provides 25% rebate on the market rate for land procured for setting up charging points.

Socio economic benefits

The EV charging infrastructure under pipeline would require a capital outlay of INR1.4 Lakh Crores, and is expected to generate approximately 15 lakh skilled/unskilled jobs.

Capital Investment

~INR 1.4 Lakh crores

For 5 Lakhs electric vehicle charging stations

Fresh jobs created

~15 Lakh jobs

For 5 Lakhs electric vehicle charging stations

Project Pipeline (sanctioned) for setting up EV charging stations

Project location	No. of EV charging stations	Total CAPEX Outlay (INR crores)	Equity (INR crores)	Debt (INR crores)	Number of Jobs created*
Andaman & Nicobar Islands	20	6	2	4	60
Andhra Pradesh	1,00,610	28,674	8,602	20,072	3,01,830
Assam	20	6	1	3	60
Chhattisgarh	25	7	2	5	75
Delhi	30,277	8,629	2,589	6,040	90,831
Gujarat	195	56	11	25	585
Haryana	1	0	0	0	3
Karnataka	1,350	385	103	240	4,050
Kerala	442	126	27	63	1,326
Madhya Pradesh	200	57	7	15	600
Maharashtra	414	118	23	53	1,242
Meghalaya	11	3	0	1	33
Odisha	25	7	1	2	75
Tamil Nadu	162	46	14	32	486
Telangana	800	228	68	160	2,400
Uttar Pradesh	100	29	3	6	300
Uttarakhand	10	3	1	2	30
Pan-India	3,66,708	1,04,512	28,158	65,703	11,00,123
Grand Total	**5,01,370**	**1,42,890**	**39,611**	**92,426**	**15,04,109**

** Supply chain and operation related jobs are considered*
Source: EY research, Department of Heavy Industry

1. *Promote coupling of EV charging with low-cost renewable energy systems*

There is need to reimagine ways for promoting ease of charging EVs with low-cost renewable energy (RE) systems. Coupling EV charging with low-cost renewable energy systems can go a long way in improving the economics of both EV and RE adoption. The guidelines notified by Ministry of Power has taken its first step in this direction for public charging stations by allowing open access, stipulating the timelines for open access applications and applicable open access charges.

2. *Rationalize GST on Lithium Ion batteries to support battery swapping facilities*

There is immense potential for battery swapping facilities to reduce upfront cost of EVs (decouple batteries from vehicles) and at the same time allow for seamless battery powered operation of EVs through swapping facilities. The Government of India recently announced its intentions to formulate battery swapping policy to enable this transition.

The policy should aim to resolve following major concerns for EV suppliers and battery swapping investors :

- Lack of uniform specs / standardization of battery form factors for seamless interoperability / fitting of batteries at service centres
- 18% GST on lithium ion batteries can make the entire business model unattractive

3. *Promote electric utility-driven business models for setting up EV charging Infra*

There are ample opportunities for Indian DISCOMs to gradually diversify services towards EV charge point operations, leverage synergies with renewable energy integration and generate sustainable alternate revenue streams. DISCOMs should plan and initiate asset monetization drives by simply leasing the real estate located in prime locations identified by private players. DISCOMs can also opt for revenue sharing models wherein utility investment can be targeted towards setting up electrical infrastructure components such as transformers, transformer pads, service meters, service panels, cables, conductors, smart grid devices etc. Strategic public private partnerships with OEMs of automotive components and EV chargers / EV supply equipment can be explored for leveraging the benefits from higher economies of scale.

Type of Business Models	Investment / cost items				Revenue items			
	Land/ location	EVSE equipment	Electrical infrastructure	Other add on services (e.g. advertising, parking)	Revenue from rent / lease of location	Revenue from sale of electricity	Revenue from EV charging stations	Revenue from other add on services
Utility fully-owned (end-to-end)	Utilities	Utilities	Utilities	Utilities	Utilities	Utilities	Utilities	Utilities
Utility providing access to location only	Charging operators	Charging operators	Charging operators	Charging operators	Utilities	Utilities	Charging operators	Charging operators
Utility providing access to location and investing in electrical infrastructure	Charging operators	Charging operators	Utilities	Charging operators	Utilities	Utilities	Charging operators	Charging operators, Utilities
Utility investing in land and electrical infrastructure	Utilities	Charging operators	Utilities	Charging operators	NA	Utilities	Charging operators, Utilities	Charging operators, Utilities

● Utilities ● Charging operators

Stimulus measures for accelerated economic recovery

4. *Promote smart charging and other alternate revenue levers for EV charge point operators and investors*

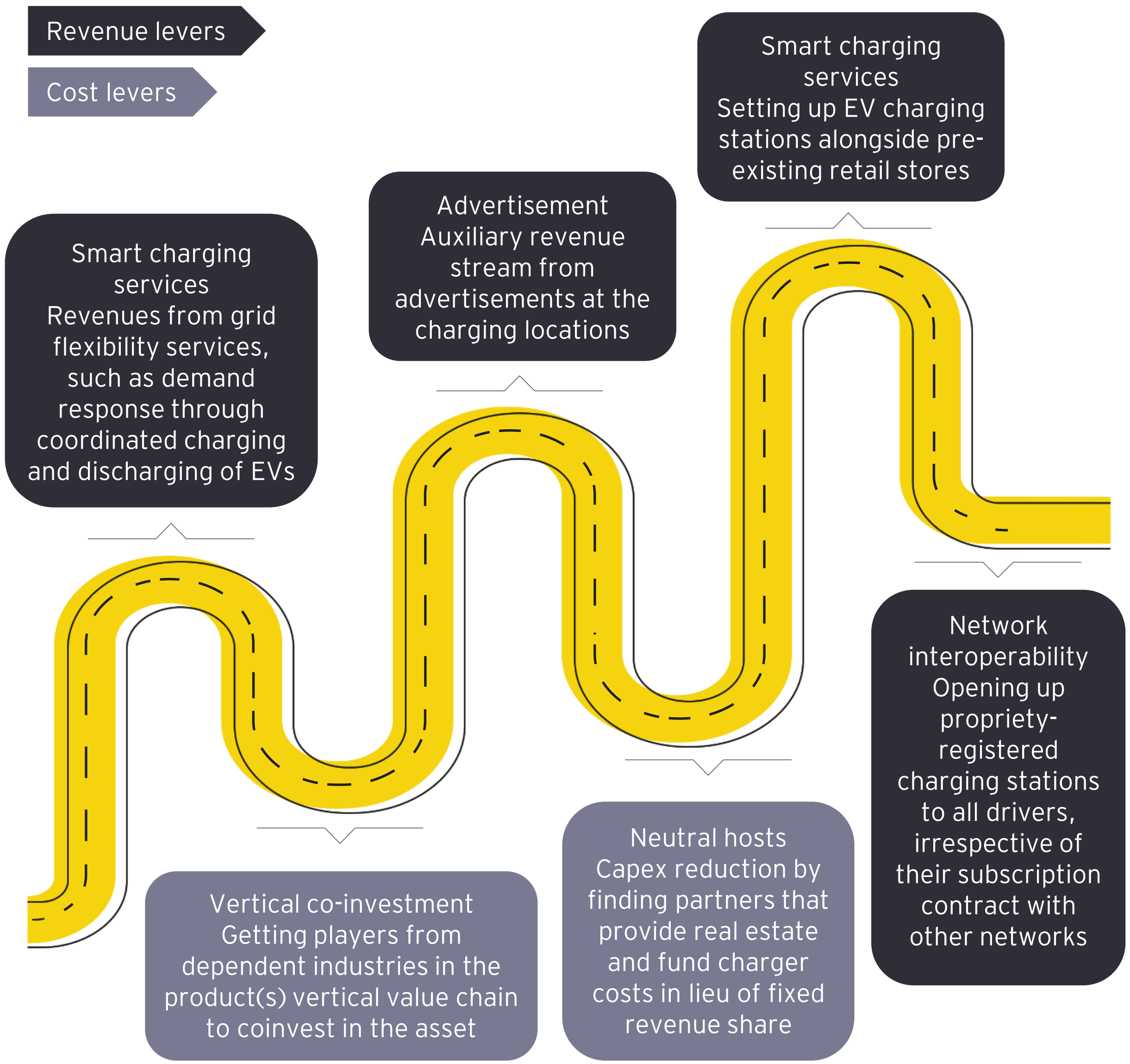
The principal challenge for setting up EV charging infra is that the business case for investment may not stack up in the traditional sense. Understanding how to position the business case, and which levers to pull, can unlock investment channels to accelerate infrastructure rollout. And that is a trigger in the national journey toward decarbonization.

On an average, the payback period for an investment in public EV charging infrastructure is 10+ years. The business case needs rethinking to support predicted EV growth. There are significant commercial, structural and operational levers to reduce latency, enhance revenues and cut costs. Re-modelling the business case can boost the investment risk profile, give greater appeal to mainstream debt financiers and enable infrastructure to scale.

The conventional business case struggles to justify EV charging infrastructure investment. Poor cashflow and returns are jeopardizing the case for investment in public EV charging infrastructure. EY research finds that a typical charging station, with two slow (6.6kW) and two fast (50 kW) chargers, will take five years to yield positive cashflow. Our analysis shows that the payback periods for charging infrastructure investments are longer than 10 years.

The need for EV charging investment and deployment is irrefutable. But the uncertainties combine to make public charging infrastructure risky and an unattractive investment. In fact, more than three-quarters (76%) of total capital inflows into EV charging companies in 2019 is equity, grants/subsidies or venture capital. To achieve scale, debt financing is critical. Simply put, the business case needs to improve.

Revenue enhancement and cost-reduction levers



It is critical to understand the levers that can increase revenues and reduce costs to make the business case more appealing to mainstream debt investors.

Impact of Levers

Levers	Revenue enhancement	Cost reduction	IRR Improvement
Smart charging services	32%		8%
Advertisement	6%		7%
Retail colocation	12%		6%
Network Interoperability	20%		4%
Vertical co-investment		35%	5%
Neutral hosts		47%	12%

** In the figure above, revenue enhancement accounts for the incremental revenue each lever adds in the 10th year. Cost reduction takes into account the capex reduction achieved under these levers. Smart charging services considers Internal Rate of return (IRR) improvement when compared with the base case.*

Enabling Green Hydrogen policies to decarbonize manufacturing sector

8

Green hydrogen policy enablers:

Panchamrit of India's climate actions announced during COP26 Glasgow	500 GW of non-fossil energy capacity by 2030	50% of electrical energy capacity from renewable energy sources by 2030	Reduce total projected carbon emission by one billion tonnes by 2030	Reduce 45% carbon intensity of economy by 2030	Achieve net-zero emissions by 2070
Definition of 'Green hydrogen / ammonia'	Produced by way of electrolysis of water using renewable energy including production from biomass				
Waiver of inter-state transmission (ISTS) charges	Granted for a period of twenty five years for projects commissioned before 30th June 2025				
Grant of Open Access	Open access for sourcing renewable energy will be granted within fifteen days of receipt of application complete in all respects	Open access charges as per existing rules			
Banking of surplus renewable energy	Banking permitted for a period of 30 days for renewable energy used in the production of green hydrogen/ammonia	Banking charges fixed by state commissions not more than cost differential between average tariff of procurement and market clearing price in DAM			
Grant of ISTS connectivity	Connectivity granted on priority under the Electricity (Transmission System Planning, Development and Recovery of Inter State Transmission Charges) Rules 2021				
Land acquisition for green hydrogen production	Allotment of land in renewable energy parks for green hydrogen/ammonia production				

Source: Ministry of Power, Government of India, 2022

Green hydrogen policy enablers (cont.):

Manufacturing zones	Manufacturing zones proposed to be set up for cluster based development of green hydrogen supply chain
Bunkering and storage	Manufacturers of green hydrogen / ammonia allowed to set up bunkers near ports for storage and exports by shipping. Land to be provided for storage by port authorities at applicable charges.
RPO compliance	Renewable energy consumed for production of green hydrogen / ammonia shall count towards RPO compliance of the end-user entity. Renewable energy consumed beyond obligation of end-user shall be counted towards RPO compliance of DISCOM in whose area the project is located.
Single window portal	MNRE will establish a single window portal for all statutory clearances, permissions required for manufacture, transportation, storage and distribution of green hydrogen / ammonia preferably within 30 days of data of application
Demand aggregation	MNRE may aggregate demand from different sectors and have consolidated bids for procurement of green hydrogen / ammonia through designated implementing agencies
'Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022'.	Cross subsidy surcharge and additional surcharge shall not be applicable if green energy is utilized for production of green hydrogen and green ammonia

Source: Ministry of Power, Government of India, 2022

Green Hydrogen Policy notified in Feb'22 is a timely intervention for the industry betting on the promise of establishing competitive supply chains

India's 'Green Hydrogen Policy' will kick start energy transition efforts, particularly in the emission intensive industrial sectors.

One of the key highlights of this policy, the waiver of inter-state transmission charges for green hydrogen production plants commissioned up to June 2025 sourcing electricity produced from renewable energy sources was already existing from the order dated 23rd November 2021. However, this order had provisioned waiver for first 8 years of operations only. The 'Green Hydrogen Policy' has extended the waiver for 25 years of plant operations, which is a welcome step in ensuring long term cost reduction of green hydrogen production for the industry. One must note that green hydrogen production units must be connected with ISTS network at the point of GH_2 production to fully realize the benefits of this waiver. Otherwise, respective state transmission charges may still apply. ***Therefore, States which extend similar waivers for intra-state transmission could become preferred locations for green hydrogen production units.***

The policy also provides 30 days banking facility and limits the applicable banking charges for the renewable energy used in the production of green hydrogen. This is also a significant step, especially when the restrictions on banking provisions for renewable energy are increasing in many states. Banking is permissible only for intra-state transactions and therefore the industry will benefit from this provision only when the state electricity regulatory commissions amend their banking regulations accordingly. Renewable energy systems designed for green hydrogen production are typically oversized to account for variability. Banking allows green hydrogen producers to supply excess renewable electricity to the grid, with the option of drawing back the same amount of power within a certain period and against the banking charges specified by State Electricity Regulatory Commissions. Until recently, many States offered annual banking provisions but have now moved to a monthly banking period, and in some cases have completely withdrawn banking facilities for renewable energy projects. Therefore, the industry will watch closely on how the States which have already restricted banking provisions will adopt the 30 days banking facility and the formula specified for limiting banking charges specified in the green hydrogen policy.

Similarly, the effectiveness of few other provisions in the green hydrogen policy such as granting open access for renewable energy sourced within 15 days and land allocation in renewable energy parks will depend on the efforts from State governments towards proper adoption and enforcement.

The ***'Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022'*** notified recently is a step in the right direction to lower the cost of open access renewable energy supply for green hydrogen production. As per these rules cross subsidy surcharge and additional surcharge shall not be applicable if green energy is utilized for production of green hydrogen and green ammonia. India's green hydrogen policy framework must further evolve to boost demand for green hydrogen through purchase obligations/blending mandates particularly for bulk consumers of hydrogen as industrial feedstock or process gas. Viability Gap Funding should be extended along with such purchase obligations for bulk consumers of hydrogen as feedstock. Green hydrogen blending with piped natural gas is another major market for boosting demand. The policy must focus on boosting R&D investment with public private partnerships (PPP) and grand challenges to demonstrate efficient and cost effective GH2 electrolysers, storage and delivery solutions using earth abundant electrocatalysts and materials. A concrete roadmap towards developing testing facilities and certification mechanisms relying on globally harmonised standards and regulations for Green hydrogen production, storage and delivery is needed. VGF may also be provided for projects where green hydrogen could act as alternate energy carrier for enabling low carbon steel, cement, trucking and maritime shipping. The policy must also endeavour towards creating world class talent in the value chain of green hydrogen by way of introducing dedicated academic programs/ degrees and establishment of national research institutes. This is important to kick start the indigenization of technology development and support the industry ambitions towards R&D, product development and services in the entire value chain.

Overall, the supporting ecosystem required for indigenization of GH2 production needs parallel efforts with incentivizing the end-users for demand creation.

Recommendations for sub-national green hydrogen policy frameworks

The following sections highlight key policy interventions to be adopted by states (sub-national actors) until green hydrogen supply chain and adoption achieves sufficient economies of scale.

1. *Reducing the cost of renewable power generation and supply for GH2 production*

Round the clock renewable power generation accounts for 40-50% of the levelized cost of green hydrogen production and storage (LCOH). Sub-national policy frameworks should aim to minimize the cost of this critical supply chain component and significantly improve the ease of doing open access transactions. In this regard, the draft Electricity (promoting renewable energy through Green Energy Open Access) Rules, 2021 notified by Ministry of Power, Government of India in August 2021 is a step in the right direction. However, the responsibility of facilitating open access lies with the State Electricity Regulatory Commission as per Section 42 and Section 86 of the Electricity Act, 2003. Therefore, the central rules and other State level policy interventions should ultimately manifest as amendments to existing open access regulations at state level for meaningful outcomes.

- Waiver of Intra-state transmission charges for GH2 production

The national green hydrogen policy notified in Feb'22 has announced the waiver of inter-state transmission charges for a period of 25 years for green hydrogen production units commissioned before 30th June 2025. However, green hydrogen production units must be connected with ISTS network at the point of GH_2 production to fully realise the benefits of this waiver. Otherwise, respective intra-state transmission charges may still apply. In this regard, States that extend similar waivers for intra-state transmission charges will enable industry to gain competitive advantage in the production of green hydrogen. Such waivers can extended for limited periods Or limited for first 0.5 – 1 million tons of annual GH_2 production to help achieve economies of scale. Open access regulations could explore mechanisms to socialize the cost of this waiver to reduce fiscal burden.

- Waivers, clarity and certainty of open access charges for GH2 production
- State governments should extend waivers for levy of open access charges (e.g. banking, cross subsidy, additional surcharge etc.) for the first 0.5 – 1 Million tons of GH2 production to reduce cost and encourage GH2 adoption. If not viable, open access charges should be kept at minimum with clarity and certainty of its validity period in the regulations.
- Allow banking of surplus energy in the production of GH2
- Existing open access regulations should be amended for allowing banking of at least 10% annual generation for min. 30 days in line with national green hydrogen policy.
- Fungibility of green hydrogen and renewable purchase obligations
- Open access regulations should specify mechanisms for monitoring, verification, certification and accounting to enable such fungibility of purchase obligations.

2. *Improve ease of doing renewable energy open access (REOA) transactions*

Rule#6 and 7 in draft Electricity (promoting renewable energy through Green Energy Open Access) Rules, 2021 focus on streamlining, centralizing and standardizing open access approval processes for renewable energy transactions. Given delays in processes and existing complex processes, such an approach is needed. A centralized registry is proposed to enable single window clearance for REOA applications. The applications are to be routed through the state nodal agency which as per Rule 6 (2) would either be the SLDC for STOA and the CTU/STU for LT/MTOA. As per Rule 7 (2) complete applications are to be uploaded by the nodal agency and in order to prevent delays, applications are deemed approved after 15 days subject to technical requirements specified by the ERC. Further as per Rule 7 (4) and (5) denial of open access should take place with a written order and the applicant has the right to be heard. Further appeal against orders by the nodal agencies are to be processed by the State Commission. Existing open access regulations should be amended suitably with above provisions.

3. GIS mapping and identification GH_2 clusters for efficient infrastructure development

States should undertake GIS mapping of renewable energy resource rich locations, GH_2 demand centres - for example crude oil refineries, fertilizer industries, iron and steel manufacturing units, ports, industrial SEZs and transport corridors (roadways, railways, inland waterways), land use – land cover (LULC) in the vicinity of GH_2 demand centres, water bodies for sourcing fresh water used in the production of electrolysis etc. GIS mapping along with other geospatial characteristics, potential demand for GH_2 and other relevant attributes should be gathered to rank / prioritise various clusters with respect to their inherent capability of supporting a GH_2 economy, supply chain and consumption.

4. Establish State level mission for advancing GH_2 economy, formulate and adopt GH_2 production targets separately for industries, transportation and other sectors of the economy

States must establish GH_2 mission with a governance mechanism for interdepartmental coordination, monitoring and evaluation of policy interventions. The governance mechanism should include be represented by energy, industries, and transport departments at the minimum.

Robust and predictable demand for GH_2 is essential for accelerating investments in the supply chain. In this regard, States must adopt short, medium and long term GH_2 production targets separately for crude oil refineries, fertiliser industries, iron and steel manufacturing units, other industries, transportation sectors etc.

5. Single window portal for all statutory clearances, permissions required for manufacture, transportation, storage and distribution of green hydrogen / ammonia

States should establish single window mechanisms in coordination with central institutions for facilitating all statutory clearances, permissions required for manufacture, transportation, storage and distribution of green hydrogen / ammonia.

6. Production linked incentives and fiscal benefits for high efficiency and durable electrolyser systems

Electrolyser systems account for 30-40% of the levelized cost of green hydrogen production and storage (LCOH). Sub-national policy frameworks should aim to minimize the cost of this critical supply chain component. Therefore, States should offer additional incentives (apart from national PLI scheme if any) linked to production of high efficiency and durable electrolyser systems. Electrolyser systems used in the production of GH_2 should be brought in the lowest GST slab or waived off completely. Import duties must be kept at minimum until the emergence of local manufacturing industry.

7. Enhance public funding support towards R&D programs calling for demonstration of projects that support competitiveness of GH_2 supply chain and end-use

State budgetary resources should be allocated towards creating centres of GH_2 excellence, robust coordination mechanisms to aggregate demand, cutting edge R&D calling for demonstration of following projects:

- Cost effective high efficiency durable electrolysers made with earth abundant electrocatalyst materials
- Hydrogen based direct reduced iron (H2-DRI) and electric arc furnace steel projects
- Cost effective Hydrogen fuel cell powered transportation solutions capable of competing with conventional ICE engine and / Or battery electric systems
- Cost effective hydrogen storage materials and solutions made from earth abundant materials

Annexures

ANNEXURE I: Battery and component manufacturing projects

Project Pipeline for Manufacturing Advanced chemistry Battery Cells					
Promoter type	Government support	Production Capacity (MWh/year)	Project Status	Expected Capital outlay (Crores INR)	Year of announcement
Private	PLI scheme	10,000	Announced	7,000	Jan-2022
Private	PLI scheme	5,000	Announced	-	Jan-2022
Private	PLI scheme	20,000	Planning	-	Jan-2022
Private	PLI scheme	-	Planning	-	Jan-2022
Private	PLI scheme	5,000	Announced	-	Jan-2022
Public	PLI scheme	-	Planning	-	Jun-2021
Private	PLI scheme	20,000	Announced	-	Jan-2022
Private	PLI scheme	20,000	Announced	2,000	Jan-2022
Private	PLI scheme	5,000	Announced	4,000	Jan-2022
Private	PLI scheme	5,000	Announced	2,000	Jan-2022
Private	PLI scheme	-	Announced	2,000	Jan-2022
Private		-	Announced	2,000	Mar-2021
Private		5,000	Announced	4,015	Jul-2021
Private	PLI scheme	10,000	Under construction	2,500	Aug-2021

Project Pipeline for Assembling Advanced Chemistry Battery Packs					
Promoter type	Location	Production Capacity (MWh/year)	Project Status	Expected Capital outlay (Crores INR)	Year of announcement
Private	Haryana	220 million pieces per year	Planning	7,083	Aug-2020
Private	Himachal Pradesh	240	Under construction	-	Feb-2021
Private	-	1,000	Announced	300	Jul-2021
Private	Telangana	2,400	Under construction	-	Nov-2020
Private	Uttar Pradesh	1,000	Announced	185	Oct-2021
Private	Gujarat	-	Announced	4,000	Mar-2021
Private	Tamil Nadu	500	Announced	500	Nov-2021
Private	Haryana	240	Under construction	200	May-2021
PPP	-	-	Planning		Feb-2021
Private	Tamil Nadu	-	Under construction		Nov-2021
Private	-	-	Announced		Feb-2021
Private	Tamil Nadu	1,200	Announced	100	-
Private	Tamil Nadu	400	Announced		-

ANNEXURE I: Battery and component manufacturing projects

Project Pipeline for Manufacturing advanced chemistry battery cell components					
Category	Promoter type	Production Capacity	Project Status	Expected Capital outlay (Crores INR)	Year of announcement
Cathode manufacturing	Private	-	Announced	2,000	Oct-2021
Synthetic Graphite Manufacturing	Private	40,000 tonnes of graphite anode by 2025	Announced	2,000	Oct-2021
Anode precursor material manufacturing	Private	15,000 TPA	Under construction	-	Aug-2020
Recycling	Private	-	Planning	-	Jun-2021
Recycling	Private	11,000 tons	Announced	300	Dec-2021
Recycling	Private	2000 MWh/year	Announced	300	Jul-2021

ANNEXURE II: Green Hydrogen Projects

Green Hydrogen production projects			
State of Project Location	Date of announcement	Project Promoter (Public / Private)	Hydrogen production or Electrolyzer capacity
PAN India	Mar-21	Private	
Tamil Nadu	Mar-21	Public	500 kW – 1000 kW
Uttar Pradesh	Jun-21	Public	50kW, 0.13 TPD
Andhra Pradesh	Jul-21	Public	1.25 MW solar plant for green electricity generation source
Ladakh	Jul-21	Private	
PAN India	Jul-21	Private	Electrolyzer manufacturing plant: 0.5 to 2GW/year
Karnataka	Aug-21	Public	25 kW
Ladakh	Aug-21	Public	
PAN India	Aug-21	Private	Electrolyzer Manufacturing plant: 2.5 GW/year
Gujarat	Sep-21	Private	
PAN India	Oct-21	Private	2 MW Solar plant to be used for electricity production for electrolyser
Gujarat	Oct-21	Public	5 MW PEM Electrolyzer project- 2TPD Hydrogen production plug power make
Madhya Pradesh	Oct-21	Private	
-	Oct-21	Public	4.3 Ton per day (TPD) Hydrogen production
Madhya Pradesh	Oct-21	Private	50 kiloton per annum
Madhya Pradesh	Nov-21	Public	100 MW in the first phase + a 25 kW self-developed Fuel cell pilot project
PAN India	Nov-21	Public	20 MW

ANNEXURE II: Green Hydrogen Projects

Green Hydrogen production projects			
State of Project Location	Date of announcement	Project Promoter (Public / Private)	Hydrogen production or Electrolyzer capacity
Madhya Pradesh	Nov-21	Public	40 MW/5000MT per annum (Uttar Pradesh) and 15 MW/2000 MT per annum (Haryana)
Uttar Pradesh and Haryana	Nov-21	Public	200MW - 2GW
PAN India	Dec-21	Private	
PAN India	Dec-21	Public	
PAN India	Dec-21	Private	>2 GW
PAN India	Dec-21	Public	
Maharashtra	Jan-22	Private	1 GW
PAN India, Europe and UK	Jan-22	Private	1 GW
PAN India	Feb-22	Private	
PAN India	Apr-22	PPP	
Not reported	Apr-22	Public	1 GW
PAN India	Apr-22	Private	
PAN India	May-22	Private	

ANNEXURE II: Green Hydrogen Projects

Green Hydrogen research and development projects				
Project Category	Project name	Date of announcement	Estimated date of project commissioning	State of Project Location
Green Hydrogen	Bio-Inspired Hydrogen Evolution from Water: Troubleshooting Practical Limitations	2019	Jun-22	West Bengal
Green Hydrogen	Development of efficient and robust working electrodes/photocatalysts for solar energy conversion to hydrogen via photoelectrochemical/ photocatalytic splitting of water: Next level up-scaling of laboratory experience	2020	Dec-23	Uttar Pradesh
Green Hydrogen	DEEP: Development of an Efficient Photoelectrode for Hydrogen Fuel from Water	Jan-19	Jun-22	West Bengal
Green Hydrogen	Demonstration and validation of hydrogen ecosystem for stationary power backup application for telecommunication towers	Feb-19	Jun-22	Tamil Nadu
Green Hydrogen	Improved hydrogen production from biogas using sorption enhanced reforming	Feb-19	Jun-22	Maharashtra
Green Hydrogen	2D Transition Metal Layered Double Hydroxides: A CostEffective Catalyst for Hydrogen Production by (Photo)Electrochemical Water Splitting	Jul-21	Mar-24	West Bengal
Green Hydrogen	Development of first-of-its-kind mobile device for production of ultra pure green hydrogen	Nov-21		PAN India
Hydrogen Storage	Unraveling the potential of graphene quantum dots for hydrogen storage in fuel cells, DST, India	2019	Jun-22	Madhya Pradesh
Hydrogen Storage	Hydrogen Storage Materials: Optimization of known materials, developing new storage materials and finding exploratory application	Feb-20	Jun-23	Uttar Pradesh

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