World Economic Forum

In collaboration with Accenture

Shaping the Future of Energy and Materials
System Value Framework – India Market Analysis
October 2020

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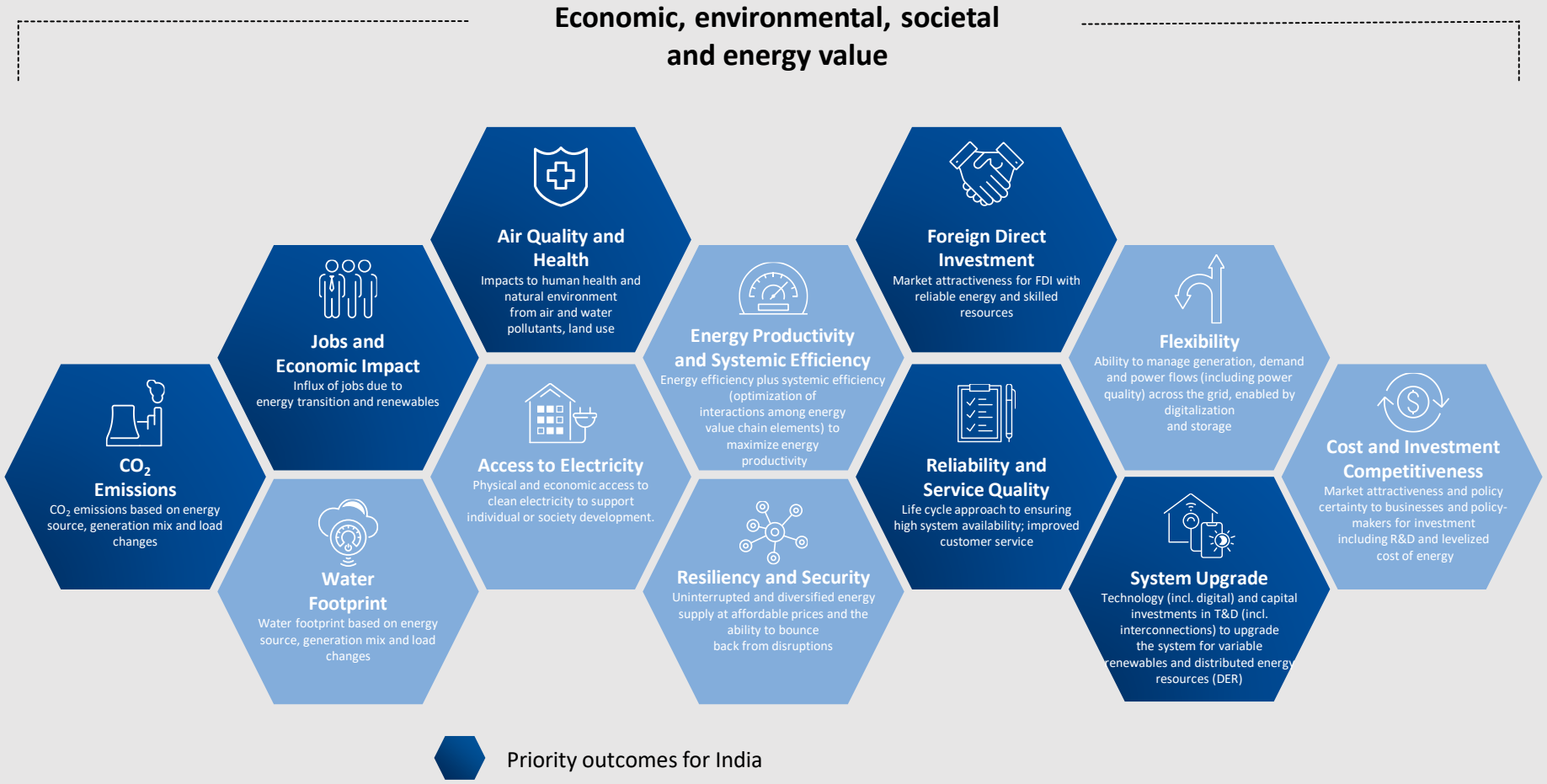
System Value of the clean energy transition in India

The System Value framework more holistically evaluates economic, environmental, social and technical outcomes of potential energy solutions across markets. The framework aims to **shift political and commercial focus beyond cost to include value**.

Using the System Value framework, the World Economic Forum, supported by Accenture, conducted analysis across several geographies as part of market evaluations **that examined recovery opportunities to accelerate economic growth and the clean energy transition**.

Key system value dimensions for India have been prioritized across the framework based on current market dynamics and its relative maturity of transition towards net-zero integrated energy system.



India recovery solutions

Solutions to accelerate renewables investment

Renewable Energy Zones

Accelerate utility-scale wind and solar (incremental +9 GW wind, +12 GW solar by 2025) through developing **renewable energy zones** that would take a **proactive approach to transmission** planning, thereby **lowering the project risks for developers**.

157 Mt
Less CO_2 emissions from electricity generation through 2025

>51k
Incremental wind and solar jobs in 2025

$14.3bn
Human health benefits from air quality improvements through 2025

Distributed Solar

Speed growth of the Indian distributed solar sector (incremental +6 GW solar by 2025) through **establishment of public-private partnerships** and **KPI-based incentives for states**.

38 Mt
Less CO_2 emissions from electricity generation through 2025

>149k
Incremental distributed solar jobs in 2025

$3.4bn
Human health benefits from air quality improvements through 2025

Transmission Investment

Invest in vital transmission infrastructure through **privatization efforts, renewable energy zones** and **acceleration of existing opportunities such as green energy corridors**.

63 Mt
Less CO_2 emissions from electricity generation through 2025

>40k
Incremental solar jobs enabled by additional transmission in 2025

$5.7bn
Human health benefits from air quality improvements through 2025

Efficiency Investment

Bolster efficiency through **improvements to air conditioning, agricultural pumps, industrial efficiency and building standards**, while increasing focus on reducing transmission and distribution losses.

151 Mt
Less CO_2 emissions from electricity generation through 2025

$13.4bn
Human health benefits from air quality improvements through 2025

Coal Plant Closures

Accelerating coal plant retirement for sites that are considered financially and operationally "stressed" would lead to 41% incremental increase over current planned closures by 2025.

143 Mt
Less CO_2 emissions from electricity generation through 2025

$13bn
Human health benefits from air quality improvements through 2025

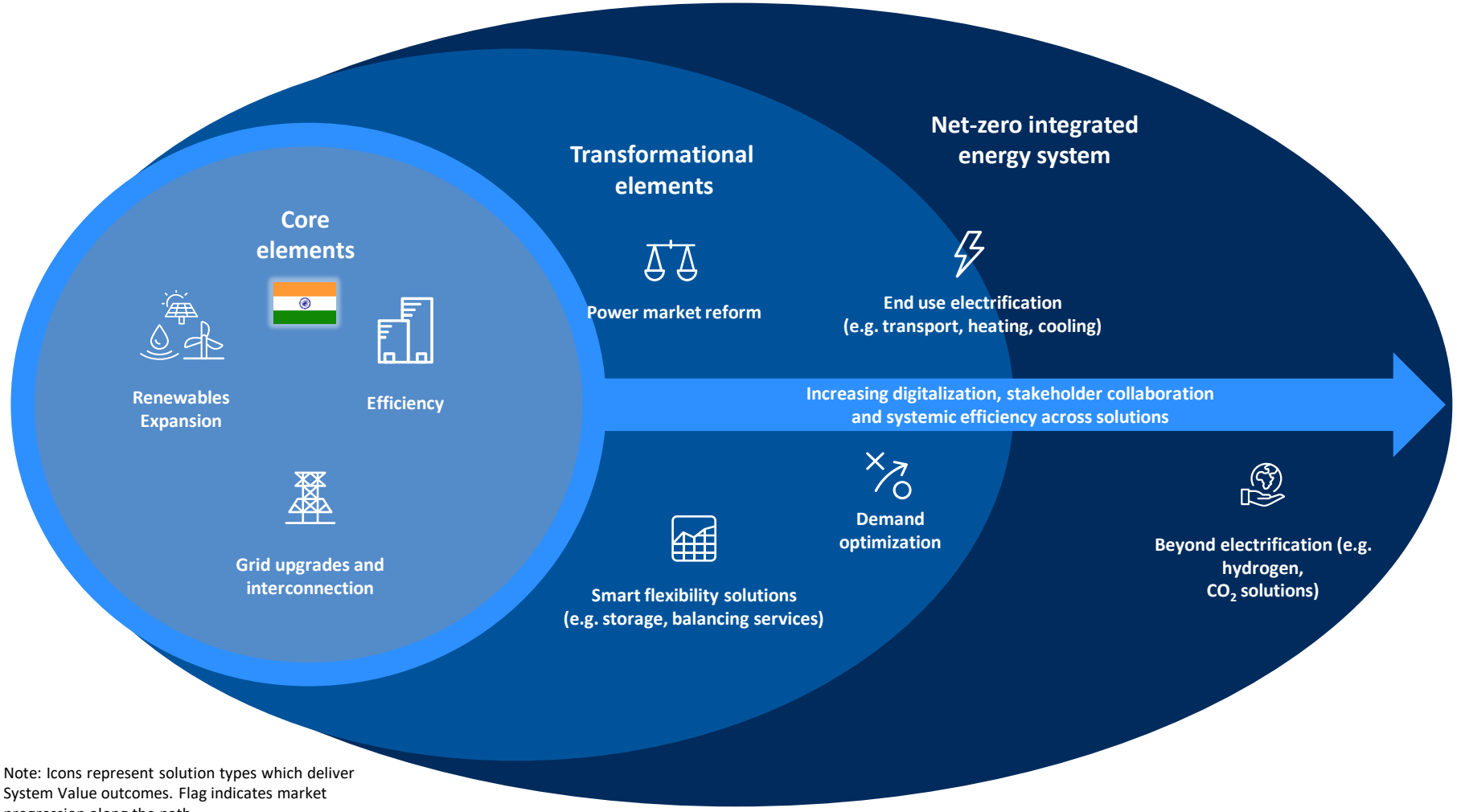
Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections.

India's path to maximize System Value

Markets are moving from addressing core elements of the electricity sector transition…

…through "pivot points" where generation mix hits 20-30% annual variable renewables (>50% instantaneous) and transformational elements enable…

… acceleration to a net-zero integrated energy system with a strong focus on systemic efficiency



India is progressing core transition elements

India's recovery solutions accelerate core transition elements of **renewables expansion, efficiency and grids**

The Indian government has set ambitious renewable energy goals to push towards a future integrated energy system delivering net-zero GHG emissions

Note: Icons represent solution types which deliver System Value outcomes. Flag indicates market progression along the path.

Analysis purpose and overview

The World Economic Forum, supported by Accenture, has developed the **System Value framework** to move beyond cost to a **more holistic evaluation** of energy sector opportunities **across economic, environmental, societal and energy system value dimensions**.

India's electricity market was one of several markets chosen to demonstrate how the System Value framework can be used to evaluate opportunities that **accelerate economic recovery and a clean energy transition**.

The following analysis of India's electricity market aims to answer several key questions for energy industry leaders and can be leveraged to consider opportunities to pursue and prepare for conversations with a range of stakeholders.

- What is the state of COVID-related stimulus and recovery activity for India?
- What short-to-medium term growth opportunities exist that can spur economic recovery and accelerate the clean energy transition?
- How can stakeholders move beyond a cost-centric dialogue to consider the value of outcomes to the economy, environment, society and energy system?

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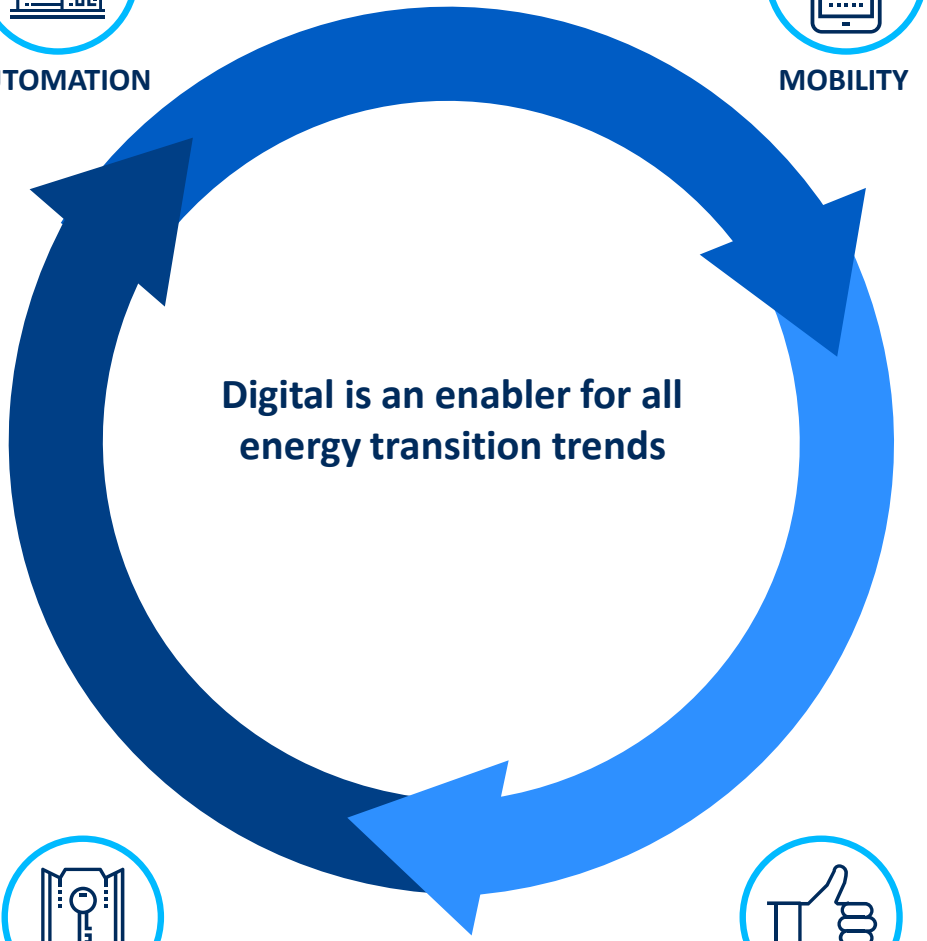
Energy transition trends shaping India's electricity industry

Digitalization

Increasing electrification	• **Demand growth**: Electricity demand in India set to double by 2040 • **Greater access to electricity**: As of 2018, all Indian villages are deemed electrified according to the government (public buildings and >10% of homes connected to grid); however, World Bank figures show 200 million still lack access to electricity • **Mobility**: Government has set a 30% electric vehicle (EV) target for 2030, with current EV market penetration at 1% of sales
Growth of green technology	• **Ambitious government goals**: Targets of 175 GW of renewable capacity by 2022, 275 GW by 2027, and 450 GW long term • **Distributed energy generation**: 1.8 GW of rooftop solar was installed in 2019, up 72% from year prior, though distributed renewables only comprise 5% of India's total installed renewable energy capacity • **Energy efficiency policies**: Perform, Achieve and Trade scheme is key policy driving efficiency gains in the industrial sector
Network of the future	• **Debt-saddled distribution companies**: State-owned "DISCOMs" face over $56 billion in debt • **Flexibility need**: India will be among the countries with greatest need for additional flexibility in the coming decades • **Transmission hurdles**: Calls for removing land acquisition and transmission connectivity-related operational bottlenecks and inefficiencies to enable higher renewables
Enterprise customer goals	• **Science-based targets rise:** India has 5th highest number of companies with science-based emission targets, with 38 by the end of 2019 • **Local manufacturing**: High cost of power seen as impediment to local manufacturing • **PPA growth**: Increasing share of wind and solar farm development financed through I&C customer commitments
Consumer activism	• **Youth activism**: Youth-led climate activists campaign for action on air pollution and climate change • **EV adoption**: May 2019 survey indicates 90% of car owners in India are willing to switch to EVs if infrastructure available
Investor activism	• **Concentrated shareholding**: Average "free float" of publicly traded companies in India (50%) is low compared to advanced nations (95% in the US and 86% in Germany), thereby limiting the scope for material investor activism by private institutions • **Government-led advocacy:** Via the Life Insurance Corporation – largest domestic institutional investor – the Government of India can remain an activist investor and advocate for management decisions that promote clean energy transition
Cities in transition	• **Smart cities mission**: Indian government chooses 100 cities to implement smart city infrastructure and technology • **Air quality**: Twenty-one of the world's 30 cities with the worst air pollution are in India, with National Clean Air Programme aiming to reduce PM 2.5 and PM 10 air pollution in 102 cities by 20-30% by 2024 compared to 2017 levels • **EV infrastructure**: FAME India scheme provides funding to support city deployment of EVs and supporting infrastructure
Investment in clean energy technology	• **New technologies**: India stands to benefit from new clean energy technology with growing demand and flexibility needs, i.e. storage technologies beyond lithium-ion, new materials • **R&D spend lag**: India ranks third globally in the number of start-ups; however, India's R&D spending is 0.7% of GDP, one-third of China's percentage and one-sixth of South Korea

Sources: BBC (1, 2), Global Wind Energy Council, World Economic Forum, IEA (1, 2) Business Standard, IEEFA India, CDP, WBCSD, NRDC, Economic Times (1, 2, 3, 4), GreenTech Media, BNEF, CNN, Mint

Digitalization underpins the energy transition



AUTOMATION

Routine tasks executed without human intervention (e.g. substation inspections)

MOBILITY

Mobility solutions extending to customers and field workers

IT/OT

Integration of operations and information technologies across networks

ROBOTICS

Physical activities conducted by machines

PLATFORMS

Cloud platforms providing new ways of delivering energy services

ANALYTICS

Cognitive analytics and big data applications (e.g. generation and demand forecasting)

SECURITY

Protection for the connected ecosystem

SOCIAL

Premium collaboration and multidisciplinary decision-making

India COVID-19 impacts to energy transition trends

Digitalization	Increasing electrification	• **Demand drop**: Electricity demand falls 28% during three-week initial lockdown period in March and April 2020 • **Low gas prices hurt EV adoption**: Cost competitiveness of electric vehicles weakened by steep decline in gas prices
	Growth of green technology	• **Capacity additions fall**: 2020 solar projections revised down by 25% to 8.9 GW, wind revised down by 11% to 3.1 GW • **2022 renewables goal in doubt**: Goal of 175 GW renewable deployment by 2022 faces uphill battle with project delays • **Government extensions**: Ministry of New and Renewable Energy extended timelines for renewable energy projects to be completed for 30 days following the end of the lockdown to safeguard developers from penalties
	Network of the future	• **Distribution companies take financial hit**: Reduced demand hurts India's already struggling distribution companies, which were already faced with $56 billion in debt before the pandemic • **Confirmation of "must-run" status**: Government confirms renewable energy should not be curtailed except for grid security concerns, leading to lower coal generation
	Enterprise customer goals	• **Ability to pursue PPAs**: Many segments – products, manufacturing, financials, transportation, infrastructure – may not be in a solid financial situation to move forward with power purchase agreements (PPAs) • **Cost-cutting focus**: Indian companies take measures to cut costs and protect their bottom lines
	Consumer activism	• **Future of air quality**: As the Indian economy comes back online and emissions return close to pre-COVID levels, public opinion may influence policy-makers as citizens see stark air quality differences • **High popularity for PM Modi**: Polling as of mid-May 2020 has Modi's approval rating as high as 80-90%, though economic tests loom
	Investor activism	• **Company finance focus**: Post-COVID focus to be more on company financial health and improving operational efficiencies than additional capital expenditures
	Cities in transition	• **Air quality improves**: Reduction in coal generation (e.g. 11 of 12 coal plants within 300km of New Delhi temporarily were closed at one point due to low demand) combined with reduced traffic in cities causes air pollution to hit a 20-year low, with the Himalayas visible from northern Indian cities for the first time in decades
	Investment in clean energy technology	• **R&D expenditures likely to fall**: Balance sheet difficulties could curtail corporate R&D efforts in sectors such as automotives

Sources: GreenTech Media, World Economic Forum, Carbon Brief, Ministry of New & Renewable Energy, CNN, Economic Times (1, 2), GlobalData, New York Times, Reuters

Overview of India's electricity market

Structural components of India's market

- Indian power market is separated into generation, transmission and distribution as per the Electricity Act of 2003
- Generation is a mix of private (45%) and public (55%)
- Retail activities are largely operated by state-owned distribution companies (DISCOMs)

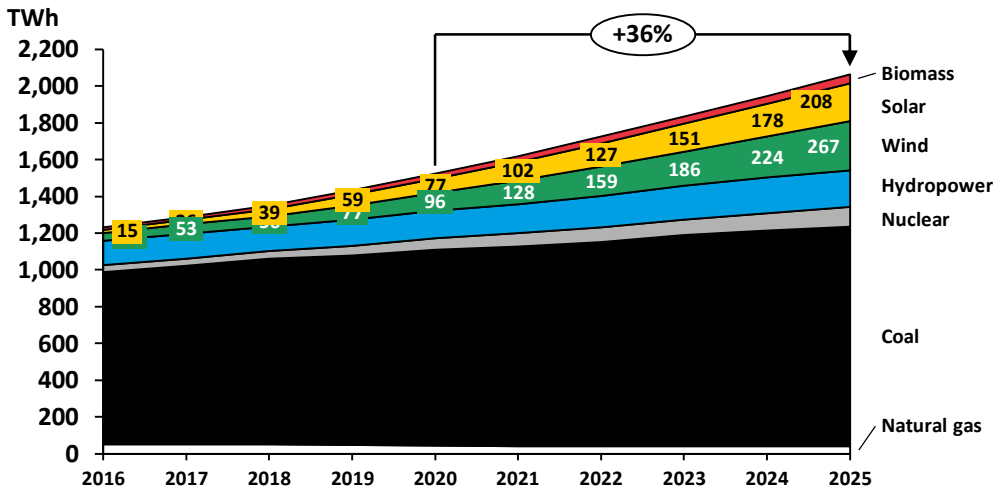
Growing demand and diversifying generation

- Electricity demand expected to double by 2040
- Share of coal generation projected to decrease from 70% in 2020 to 58% by 2025, while total coal generation maintains some growth
- Solar and wind generation projected to grow to 23% of generation mix by 2025, up from 11% in 2020

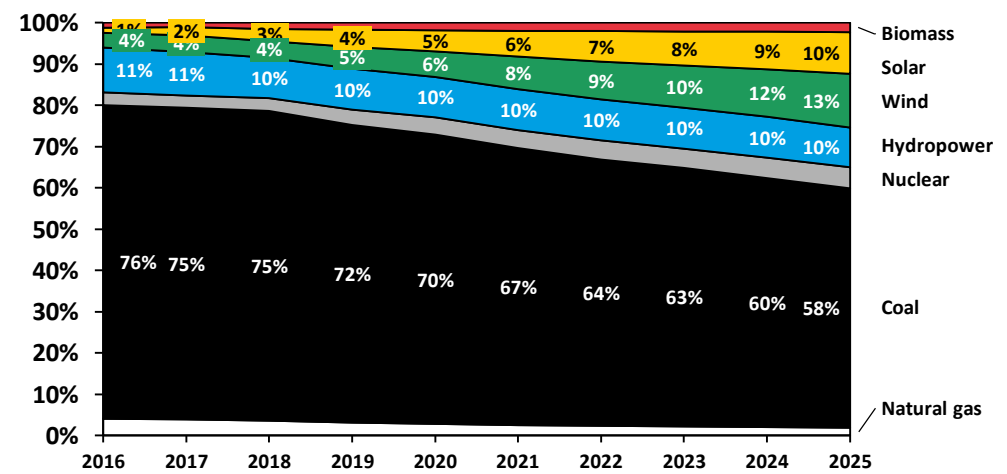
Ambitious climate and energy goals

- Renewable energy targets
  - 175 GW deployed by 2022 (86 GW as of end of 2019)
  - 450 GW deployed by 2030 (announced September 2019)
  - 40% power capacity from non-fossil fuel sources by 2030
- CO_2 emission goal
  - Reduce CO_2 emissions intensity of GDP by 33-35% from 2005 levels by 2030

India electricity generation projected to increase 36% by 2025



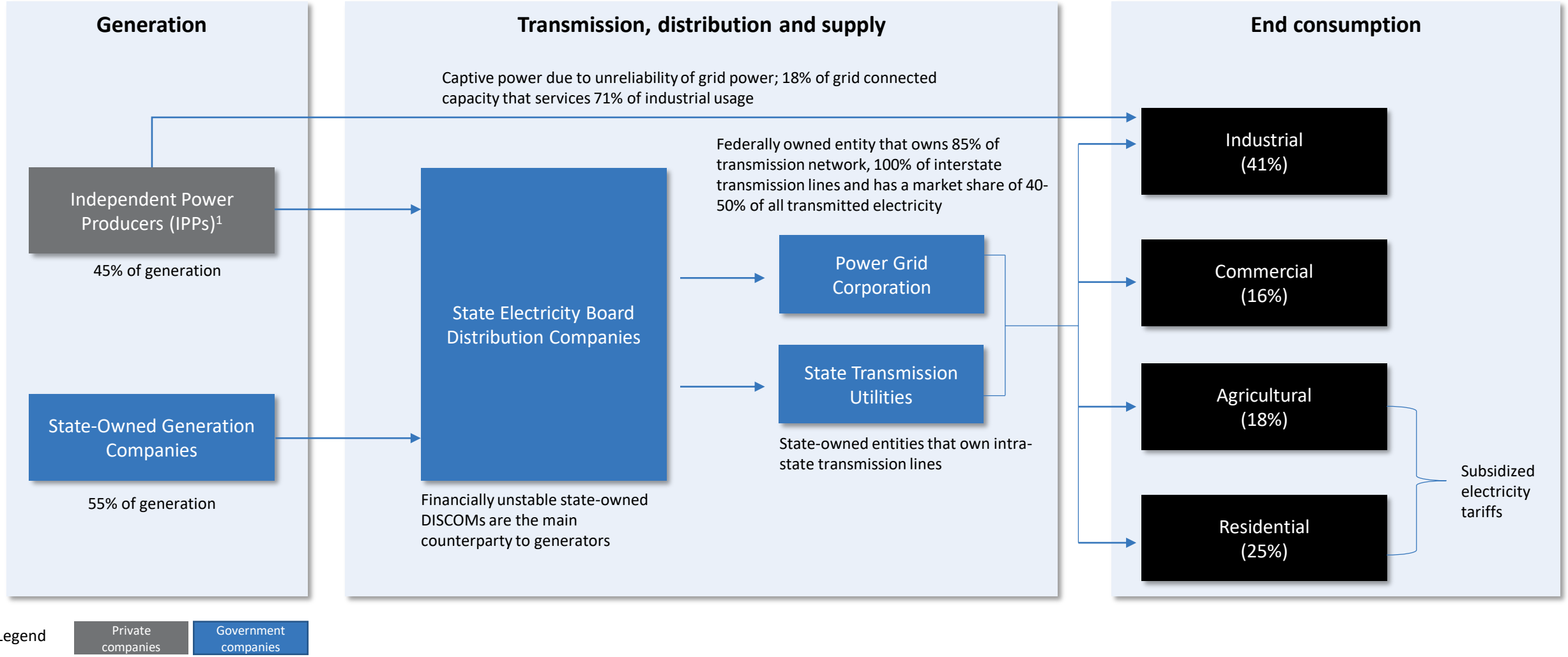
Share of wind and solar generation projected to double by 2025



Sources: IEA (1, 2); CNN; IEEFA

India electricity market structure

Despite several rounds of reform over the past two decades, the vast majority of the power sector value chain in India is government-owned and operated



Note(s): 1. IPPs refer to both, private standalone generation companies, as well private industrial companies that invest in generation capacity for captive purposes
Source: Central Electricity Authority

COVID-19 impact on India's electricity market

Electricity demand down across sectors

- Electricity demand fell 28% during initial three-week lockdown in March and April 2020, resulting in a revenue drop of nearly $2 billion
- Demand collapse exacerbated by industrial and commercial sectors that account for 52% of demand

Coal bears brunt of generation drop

- Coal-fired power generation fell 15% in March and 31% in the first three weeks of April, while renewables were up slightly over the same period
- Coal generation fell 43% from the period from 1 April 2020 to 4 May 2020, versus the same period in 2019
- Contribution to total power supply from coal fell from 72% in March to 65% in April, while solar and wind grew to 5.7% and 3.4% respectively vs 4.5% and 2.8% over prior year

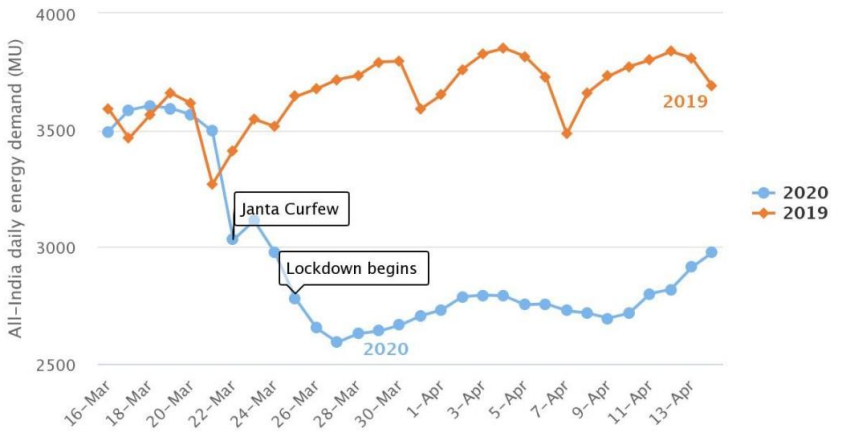
Deteriorating health of distribution and generation companies

- Collapse in power demand from industrial and commercial customers, which pay higher tariffs to subsidize residential and agricultural customers, contribute to cash flow deterioration for distribution companies
- Generation companies' receivables from distribution companies at $12.5 billion as of May 2020

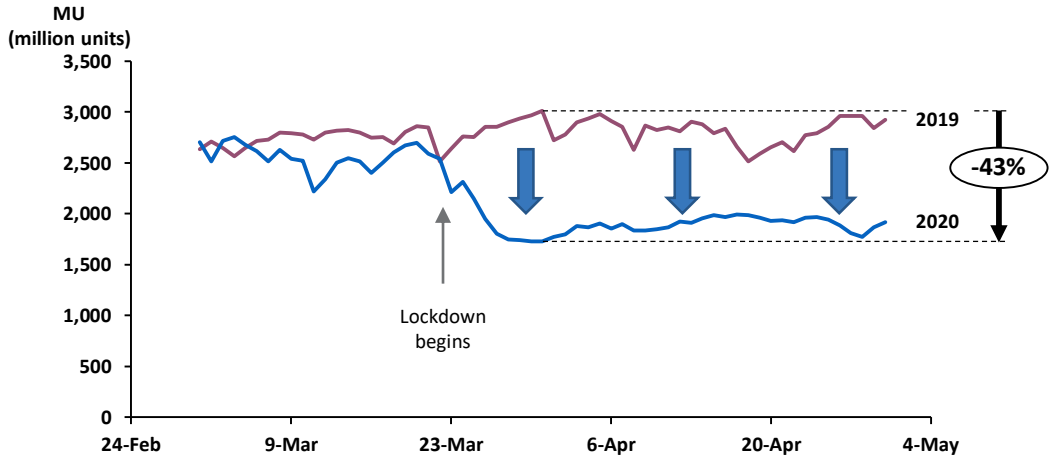
Falling CO_2 emissions

- CO_2 emissions estimated to have declined for the first time in four decades by 1.4% for the fiscal year ending March 2020
- Emissions fell 15% and 30% on a year-on-year basis in March and April 2020, respectively

India total electricity demand fell 28% year-over-year in early 2020



India coal generation dropped as much as 43% during lockdown



Sources: Council on Energy, Environment & Water; Carbon Brief; IEA; Economic Times; Carbon Brief; POSCO

COVID-19 impact on India's economy

Severe GDP impacts in Q2

- GDP projected to shrink as much as 45% from April-June 2020, according to Goldman Sachs
- IMF forecast for 2020 GDP growth cut to 1.9% in April 2020 from 5.8% previously
- Index of Industrial Production (IIP) shrunk by 16.7% year-on-year in March 2020 and 10% below the level recorded in February 2020

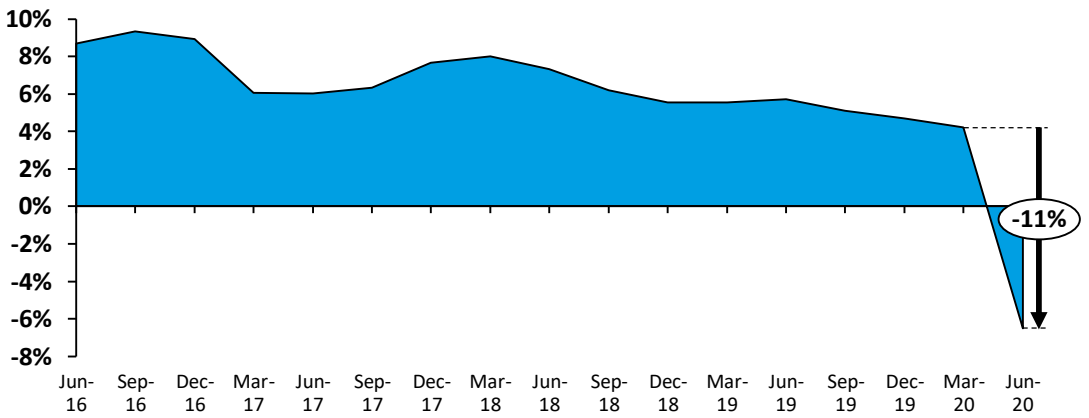
Fiscal deficit rises with stimulus packages and economic pain

- Budgetary target for fiscal deficit of 3.8% of GDP in FY 2020-2021 unlikely to be met
- Goldman Sachs estimates that fiscal deficit to slip to between 5.8% and 7% of GDP depending on the extent of further stimulus

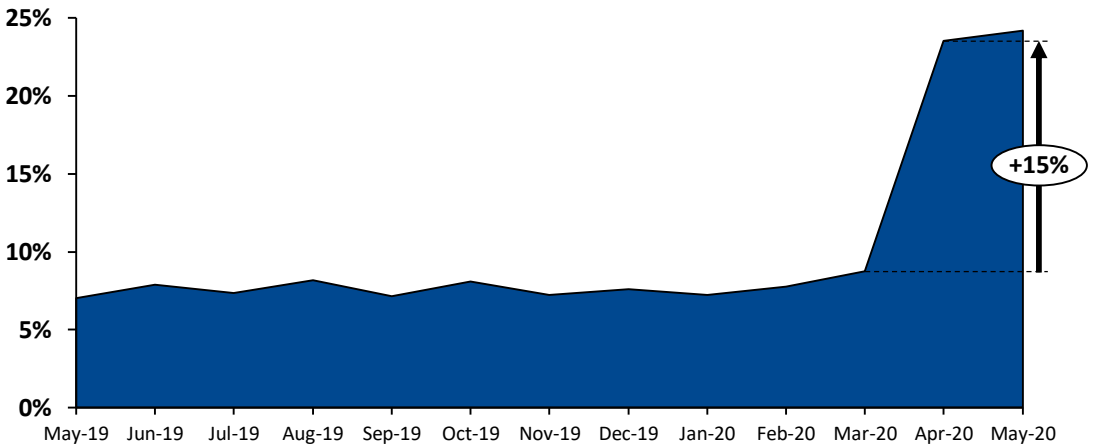
Unemployment more than doubles

- Unemployment rate in India as of 24 May, 2020 at 24% versus 10% in March 2020
- Urban unemployment has outpaced rural at 26.5% and 22.9%, respectively
- Labour force participation rate (LFPR) improved to 38.6% in May from a low of 35.6% in April; LFPR was at 49% at the end of 2019

Quarterly GDP turns negative in Q2 2020



India's unemployment rate nears 25%



Sources: Bloomberg, Economic Times, CNBC, Goldman Sachs, S&P Market Intelligence, CMIE

India COVID-19 stimulus timeline

India's $260 billion stimulus package is historic in nature, constituting 10% of the country's GDP

Lockdown

25 March – 14 April 2020: Government puts country under strict initial 21-day lockdown

15 April – 3 May 2020: Lockdown extended into early May

2019 | 2020 | Jan | Feb | Mar | Apr | May | Jun | 2021

Stimulus

26 March 2020: $22.5 billion economic stimulus package focused on food security measures for poor households and through direct cash transfers

12 May 2020: Modi announces $260 billion package (10% of India's GDP), larger than many economists predicted.

Several items related to energy were included in the stimulus package:

- Liquidity infusion of $12 billion from centrally owned NBFCs (non-banking financial companies) such as PFC (Power Finance Company) and REC Limited to ailing DISCOMs against their future receivables
- Publicly owned generation companies to provide a rebate to DISCOMs, which must be passed on to consumers
- Three-month moratorium on payments by DISCOMs, waiving of penalty fees for late payments
- Loan facility will be provided to DISCOMs with federal guarantees to ensure future payables to generation and transmission companies
- Development of digital payment facility by DISCOMs to consumers
- Acceleration of Uday 2.0 scheme that focuses on improving financial position and operating efficiency of DISCOMs

Sources: CNBC, The Economic Times, New York Times, CNN, GOI stimulus presentation

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Recovery solution selection criteria

Selected recovery solutions are required to meet the following criteria:

1 Accelerates the energy transition
The recovery solution moves the market closer to net zero

2 Stimulates economic recovery
Implementation of the recovery solution should stimulate job creation by 2021+

3 Enables meaningful System Value assessment
It should be possible to model and assess the recovery solution for meaningful results within a 2025 horizon

Five recovery solutions for India to support the economy and advance the clean energy transition

	Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closures
Solution overview	India can accelerate utility-scale wind and solar through developing **renewable energy zones** that would take a **proactive approach to transmission** planning thereby **lowering the project risks for developers**	The Indian distributed solar sector can speed growth through **establishment of public-private partnerships and KPI-based incentives for states**	Investment into vital transmission infrastructure through **privatization efforts, renewable energy zones and acceleration of existing opportunities such as green energy corridors**	India can pursue several opportunities to bolster efficiency including more efficient **air conditioning, agricultural pumps, industrial motor replacement and increased focus on building efficiency**	**Accelerating the closure of "stressed" coal assets** based on plant age, minimum efficiency criteria and financial obligations
Capacity and generation impact	• 12 GW incremental solar capacity through 2025, replacing 22 TWh of coal • 9 GW incremental wind capacity through 2025, replacing 24 TWh of coal	• 6 GW incremental distributed solar capacity through 2025, replacing 12 TWh of coal	• 12 GW incremental solar capacity through 2025, replacing 22 TWh of coal	• Demand and grid efficiencies reduce coal generation by 43 TWh	• Incremental 20 GW of coal plants closed by 2025
CO_2 emissions	157 Mt Cumulative total through 2025, 5-6% of total emissions per year	38 Mt Cumulative total through 2025, 1-2% of total emissions per year	63 Mt Cumulative total through 2025, 2-3% of total emissions per year	151 Mt Cumulative total through 2025, 13-15% of total emissions per year	143 Mt Cumulative total through 2025, 5-6% of total emissions per year
Water footprint	271bn litres Cumulative total through 2025, 2.1% of 2025 base case	61bn litres Cumulative total through 2025, 0.5% of 2025 base case	102bn litres Cumulative total through 2025, 0.8% of 2025 base case	268bn litres Cumulative total through 2025, 2.0% of 2025 base case	260bn litres Cumulative total through 2025, 2.0% of 2025 base case
Jobs impact	>51K Wind and solar jobs in 2025	>149K Distributed solar jobs in 2025	>40K[1] Utility-scale solar jobs in 2025	*Not included in analysis*	*Not included in analysis*
Air quality and health	$14bn Human health benefits through 2025	$3bn Human health benefits through 2025	$6bn Human health benefits through 2025	$13bn Human health benefits through 2025	$13bn Human health benefits through 2025

Notes: Figures in above recovery solutions assume each is enacted in isolation. CO_2 emissions represent cumulative reduction through 2025 relative to 2025 base case total from coal and natural gas. Water footprint represents cumulative reduction through 2025 relative to 2025 base case total, excluding biomass. Estimated human health benefits in USD from reduced coal generation and lower air pollution. Mt = million (metric) tonnes.

1) Jobs from transmission investment are understated as they do not include jobs created from construction, development and management of new transmission lines

Renewable Energy Zones

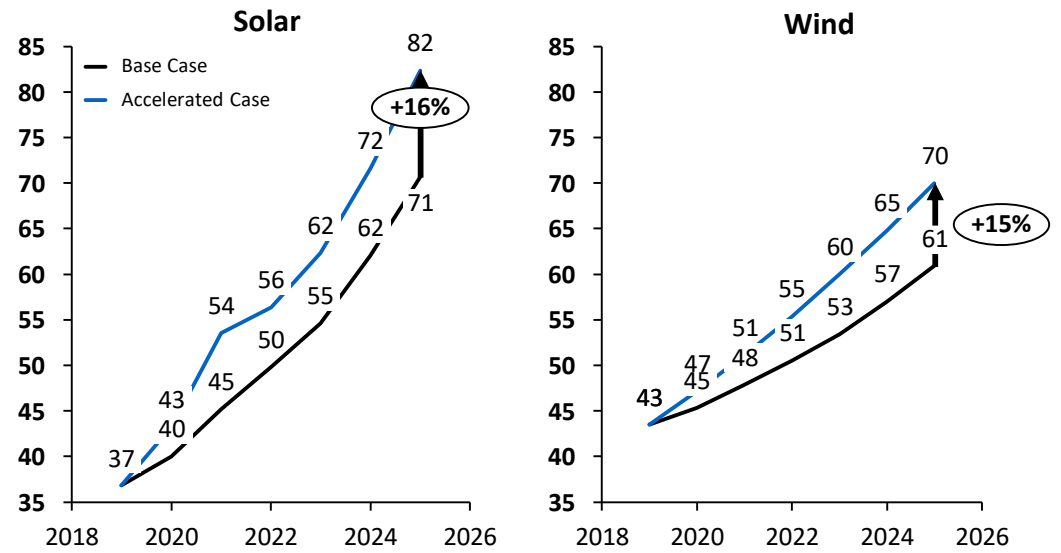
Overview
A key pillar to drive renewable capacity investment to achieve the ambitious goals set out by the Indian government has been the development of Solar Parks and Ultra Mega Renewable Energy Parks (UMREP). The goal of these initiatives was to remove impediments to investment such as land acquisition, evacuation infrastructure, counterparty risk, etc., and to provide developers with a plug and play infrastructure that would attract investment. Despite the initial success of these projects, developers have complained of lack of adequate power evacuation infrastructure that has caused grid congestion which impact project economics and limits future capacity deployment.

Renewable energy zones (REZ)
A REZ is a geographic area characterised by features that support cost-effective renewable energy development, including high-quality renewable energy resources, suitable topography, and strong developer interest. In addition to removing investment impediments such as land acquisition, a REZ allows power system planners to overcome the difference in timescales associated with developing high voltage transmission (up to 10 years) and renewable energy generation (1-2 years), thereby reducing project risks

The REZ concept would take an alternative approach by planning new transmission in conjunction with a group of stakeholders – regulators, private developers, environmentalists, social activists – to direct development to a region's best areas for RE generation. The goal of the REZ is to provide a "plug and play" infrastructure for developers which will attract private investment both domestically and from foreign sources

Benefits of REZ
1. Reduces project risk and attracts private investment due to participation of developers during planning and execution process, as well as alleviating risks of other investment impediments such as land acquisition
2. Proactive transmission network planning leveraging expertise from all stakeholders – regulators, developers, environmental activists, etc.
3. Provides platform to develop hybrid parks, i.e. "wind + solar + battery" technologies, which can be used to support large scale balancing units for system flexibility
4. Efficient auction process as developers have greater confidence in transmission infrastructure which provides visibility on costs
5. Improved transmission infrastructure reduces curtailment from congestion and opens up high capacity factor locations for new projects

Projected utility-scale solar and wind capacity additions (GW)



System Value Impacts

Benefits

157 Mt
Cumulative electricity base case CO_2 reduction through 2025

271 bn L
Cumulative reduction of water consumption compared to base case through 2025

51k
Utility-scale wind and solar incremental job impact in 2025

$14bn
Human health benefits through 2025

Sources: IEA, Economic Times, NREL, Carbon Brief

Distributed Solar

Overview

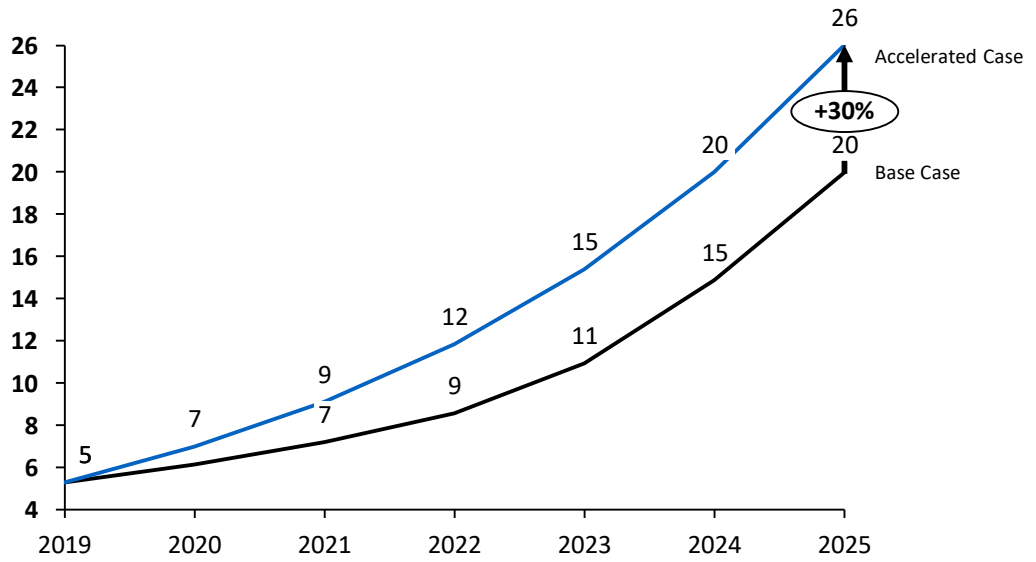
As of the end of 2019, India had deployed only 5.3 GW of distributed solar, with a 40 GW distributed solar goal set for 2022. Due to COVID-19, the rooftop solar market has taken a severe blow as it was not granted "essential service" status and was also hit by supply chain disruptions that are likely to persist for some time. Recent projections taking COVID-19 impact into account show only 300 MW of rooftop solar in Q1 2020 while Q2 and Q3 will be approximately 360 MW, respectively.

While the industry is expected to slow in the near term, India can still grow its distributed solar market over the medium-to-long term to better align with its renewable goals albeit likely to still fall short. Regulators must focus efforts on policy pushes to overcome challenges and improve market dynamics.

Opportunities to accelerate distributed solar in India

- *Public-private partnerships:* Establishment of special purpose entities (partially private) focused on accelerating installation of rooftop solar across the states via "op-ex model" that provides energy-as-a-service to residential and commercial customers
    - Combining enhanced execution (construction, installation, O&M etc.) and permitting capabilities
    - Scale benefits of procurement, construction, shared services to lower cost of installation
    - Enhanced financing options from public and private sources
    - Attractive route for foreign direct investment due to lower risks from government/state involvement
- *KPI-based incentive for states:* Providing states with favourable budgetary allowances as a result of achieving and/or outperforming targets for rooftop solar implementation
- *Tax/revenue incentive for captive power:* Providing additional tax incentives to captive power producers and self-generators

Projected Distributed Solar capacity addition (GW)



System Value impacts

Benefits

38 Mt
Cumulative electricity base case CO_2 reduction through 2025

61bn L
Cumulative reduction of water consumption compared to base case through 2025

149k
Distributed solar job impact in 2025

$3bn
Human health benefits through 2025

Sources: IEA, Economic Times, Carbon Brief
Note: Indian fiscal year begins in April

Transmission Investment

Overview

A key requirement to helping India achieve its ambitious renewable capacity targets is the implementation of transmission infrastructure, which will provide stability to a market where the generation share of variable resources is rising.

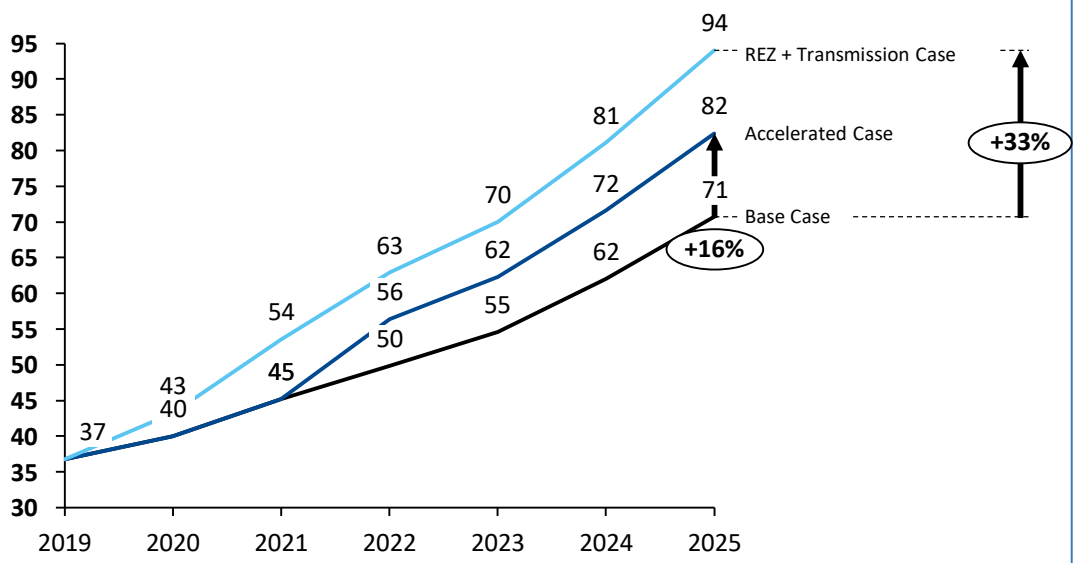
In 2016, India sanctioned investment into the **Green Energy Corridor** – a project with the goal of removing system integration barriers to large-scale variable renewable energy (VRE) by developing inter- and intra-state transmission lines between a handful of VRE-rich states. Phase I of the project was completed in 2020 and is able to integrate up to 33 GW of capacity. The project is funded with 20% equity from the central government, 40% from a grant from the National Clean Energy Fund and 40% debt from institutions such as the Asian Development Bank.

Despite the progress, further investment will be required to achieve the ambitious targets of 275 GW by 2027 and 475 GW beyond that. Transmission upgrades will also serve to improve utility of hydro in Northern India, which facilitate import/export of power with neighbouring countries. Additionally, IEEFA estimates that $60-80 billion of investments would be required to strengthen grid transmission infrastructure over the next 5 years.

Actions to accelerate transmission investment

- *Expansion of Green Energy Corridors*: Phase I has focused on inter- and intra-state connectivity in VRE-rich states. Phase II to be expedited and expanded to connect less irradiant/windy states and avoid curtailment of renewable sources
- *Expansion of inter-state transmission system (ISTS):* Extension of transmission charge exemption for renewable energy service capacities being developed by December 2022
- *Digitization of grid:* Implementation of smart grid technologies such as smart metering and internet of things (IoT) applications to improve grid efficiency and reduce technical/non-technical losses
- *Distributed energy resources:* Expansion of grid to include distributed energy resource technologies such as rooftop solar to create a two-way grid that would enhance grid flexibility and resiliency
- *Renewable energy zones:* Development of REZs would provide a longer-term solution to balancing transmission planning with timely capacity expansion

Projected utility-scale solar capacity addition (GW)



System Value impacts

Benefits

63 Mt
Cumulative electricity base case CO_2 reduction through 2025

102bn L
Cumulative reduction of water consumption compared to base case through 2025

40k*
Utility-scale solar job impact in 2025 enabled by transmission

$6bn
Human health benefits through 2025

Sources: IEA, Economic Times, Carbon Brief, Business Standard
*Note(s): Indian fiscal year begins in April; *Transmission Jobs are likely understated since they do not include jobs from construction//management of transmission lines*

Efficiency Investment

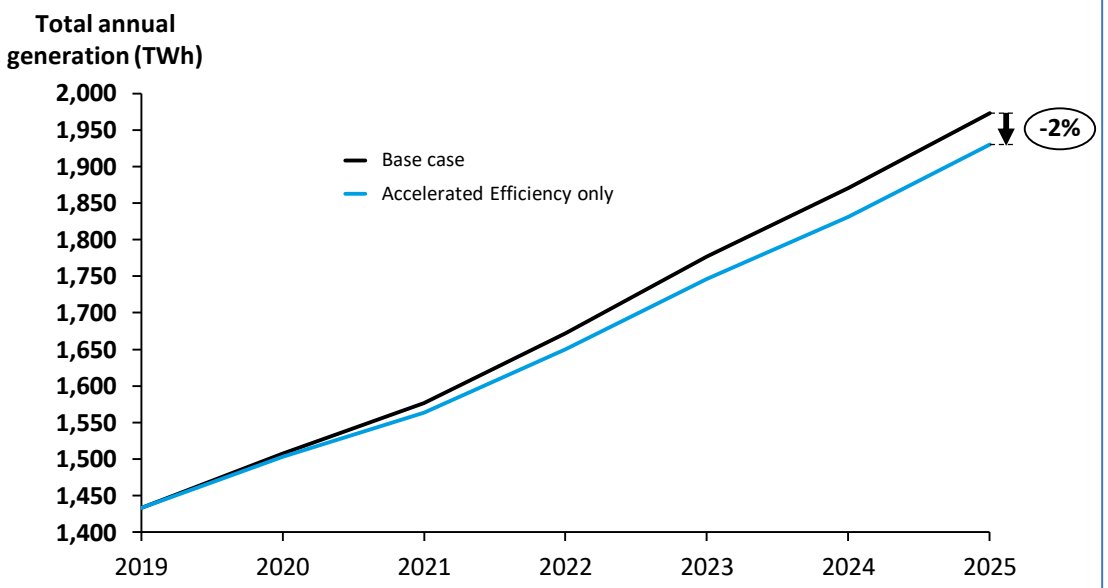
Overview

IEA analysis shows that India avoided an additional 15% of annual energy demand from 2000-2018 due to energy efficiency. Energy efficiency upgrades have been supported by the government's Perform, Achieve and Trade (PAT) scheme, currently in its second cycle. Efficiency investment economics are strong, as the investment amount required to save one kWh of electricity is less than half the cost of generating one kWh using thermal power.

Opportunities to boost efficiency

- *Further improve air conditioner (A/C) efficiency:* Without improvements in A/C efficiency, electricity demand for space cooling could increase to nearly 200 TWh by 2030 and 1,350 TWh in 2050, as the number of A/Cs is set to grow from 36 million in 2018 to more than 1 billion by 2050. India can increase minimum A/C energy performance standards and spur increased funding to the winner of its Global Cooling Prize in late 2020.
- *Accelerate rollout of efficient agricultural pumps*: With more than 21 million grid connected pump sets in India, accelerating the deployment of efficient pump replacements could enable savings of over 4 TWh/year, cutting electricity subsidy expenditure by $3.2 billion.
- *Advancing industrial efficiency:* Creating programmes to improve existing electric motor systems has the potential to save 9 TWh annually.
- *Bolster building efficiency standards for new construction:* Residential and commercial buildings comprise nearly a third of India's electricity demand. The Energy Conservation Building Code can be further strengthened, and India's state and municipal governments should mandate and enforce its rules. Additionally, state-owned/leased buildings can be mandated to achieve a minimum efficiency KPI within a specified timeframe.
- *Grid optimization through reduced transmission and distribution (T&D) losses*: Electricity T&D losses amount to 19%, nearly 3 times the OECD average, due to technical inefficiency and theft. Accelerating distribution system digitalization, smart metre roll-out and infrastructure upgrades (e.g. transformers) can help DISCOMs identify high-energy loss areas, take action and improve financials.

Generation impact from Efficiency Investment



System Value impacts

Benefits

151 Mt
Cumulative electricity base case CO_2 reduction through 2025

268bn L
Cumulative reduction of water consumption compared to base case through 2025

$13bn
Human health benefits through 2025

Note: Quantified System Value benefits are based solely on generation impact from efficiency improvement. Potential benefits from T&D losses excluded due to data unavailability
Sources: IEA, Global Cooling Prize, UNIDO, Lawrence Berkeley National Laboratory, WEF, Brookings, EIA (1, 2), ABB, Carbon Brief, WRI, Ministry of Power

Coal Plant Closures

Overview

Coal power plants have a share of 65% in the generation mix and are therefore vital to the electricity supply of India. However, due to a variety of reasons such as shortages of domestic coal, the high price of imported coal, and competitive economics of alternative sources, a large portion (c. 33%) of coal plants are considered "stressed."

Stressed assets are operationally inefficient (i.e. plant load factor, PLF, of <50%), highly leveraged and are loss-making units. Given the Indian government's commitment to reducing emissions as per the Paris Accord, retirement of older coal plants is a key pillar of this strategy (c. 49 GW by 2030). Accelerating the closure of inefficient coal plants could not only help India achieve its emissions targets, but also create other System Value benefits such as reduced water consumption and health benefits from decreased air pollution.

Evaluation criteria for potential coal plant closures

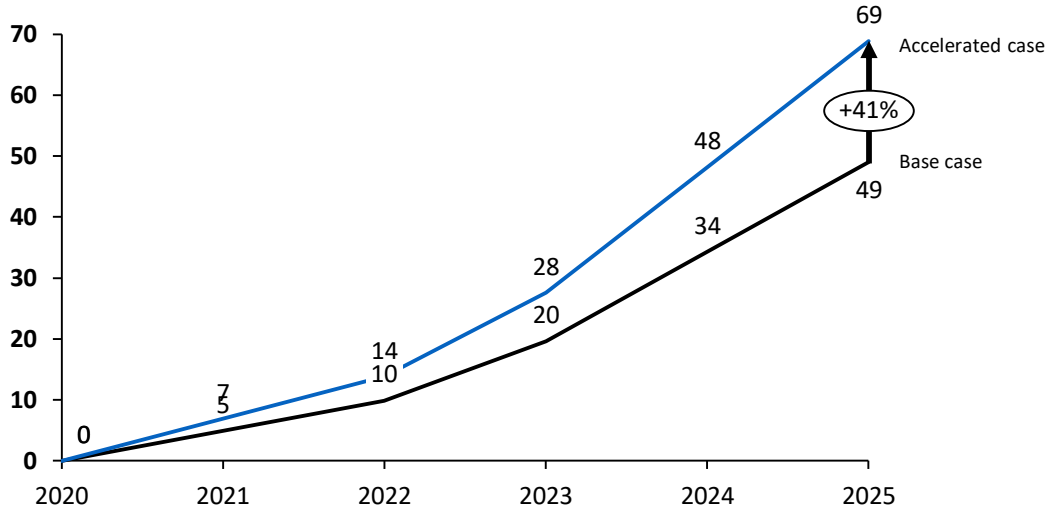
By focusing on the proportion of coal assets that are considered stressed, the set of capacities to be decommissioned over a five-year period can be isolated and ranked based on factors such as:

- Minimum efficiency standard based on chosen metrics such as heat rate; for example, a minimum heat rate to be maintained of 2600 kcal/mw, which equates to a capacity factor of approximately 33%
- Financial position – outstanding debt and other liabilities can be analyzed to assess overall economic impact of retiring coal plant

Economic/social impact of coal plant closures

Closure of highly leveraged coal plants would result in banks and other financial institutions having to write off significant portions of debt. Additionally, coal plants and supporting infrastructure (rail linkages, mines, etc.) represent politically sensitive areas where job losses may not be favourable without adequate retraining programmes.

Coal plant closures (GW)



System Value impacts

Benefits[1]

143 Mt
Cumulative electricity base case CO_2 reduction through 2025

260bn L
Cumulative reduction of water consumption compared to base case through 2025

$13bn
Human health benefits through 2025

Sources: IEA, NREL, IEEFA, Climate Policy Initiative, Reuters
Note(s): (1) Coal plant closures will result in some job losses which are not reflected due to data unavailability

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System Value of clean energy transition

System Value benefits are seen across all of India's recovery solutions

Economic, environmental, societal and energy value

System Value dimension with quantitative analysis

System Value dimension with qualitative analysis

Priority System Value dimension

	CO_2 Emissions: CO_2 emissions based on energy source, generation mix and load changes	Water Footprint: Water footprint based on energy source, generation mix and load changes	Access to Electricity: Physical and economic access to clean electricity to support individual or society development	Jobs and Economic Impact: Influx of jobs due to energy transition and renewables	Air Quality and Health: Impacts to human health and natural environment from air and water pollutants, land use	Resiliency and Security: Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruption	Energy Productivity and Systemic Efficiency: Energy efficiency plus systemic efficiency to maximise energy productivity	Foreign Direct Investment: Market attractiveness for FDI with reliable energy and skilled resources	Reliability and Service Quality: Life cycle approach to ensuring high system availability; improved customer service	Flexibility: Ability to manage generation, demand and power flows (incl. power quality) across the grid, enabled by digitalization and storage	System Upgrade: Technology (incl. digital) and capital investments in T&D to upgrade the system for variable renewables and DERs	Cost and Investment Competitiveness: Market attractiveness and policy certainty for investment, incl. R&D and levelized cost of energy
Renewable Energy Zones	↓ **157 Mt** Cumulative electricity base case CO_2 reduction through 2025	↓ **271bn L** Cumulative reduction of base case consumption through 2025	○	↑ **>52k** Wind and utility solar jobs in 2025	↑ **$14bn** Human health benefits in 2025 from decreased air pollution	●	◐	●	◐	◐	●	High range of utility-scale LCOE is less than low end of coal LCOE range
Distributed Solar	↓ **38 Mt** Cumulative electricity base case CO_2 reduction through 2025	↓ **61bn L** Cumulative reduction of base case consumption through 2025	●	↑ **>149k** Distributed solar jobs in 2025	↑ **$3bn** Human health benefits in 2025 from decreased air pollution	●	◐	◐	●	○	◐	
Transmission Investment	↓ **63 Mt** Cumulative electricity base case CO_2 reduction through 2025	↓ **102bn L** Cumulative reduction of base case consumption through 2025	◐	↑ **>40k** Utility-scale solar jobs in 2025	↑ **$6bn** Human health benefits in 2025 from decreased air pollution	●	●	●	●	●	●	
Efficiency Investment	↓ **151 Mt** Cumulative electricity base case CO_2 reduction through 2025	↓ **268bn L** Cumulative reduction of base case consumption through 2025	○		↑ **$13bn** Human health benefits in 2025 from decreased air pollution	◐	●	◐	●	●	◐	
Coal Plant Closures	↓ **143 Mt** Cumulative electricity base case CO_2 reduction through 2025	↓ **260bn L** Cumulative reduction of base case consumption through 2025	○		↑ **$13bn** Human health benefits in 2025 from decreased air pollution	◐	◐	◐	○	◐	○	

Analysis performed for given System Value dimension and recovery solution. For more detail, please see specific solution and/or relevant System Value dimension slide(s).

System Value dimension not as relevant to geographic market, or not considered with given recovery solution.

Relative System Value dimension benefit for given recovery solution within market

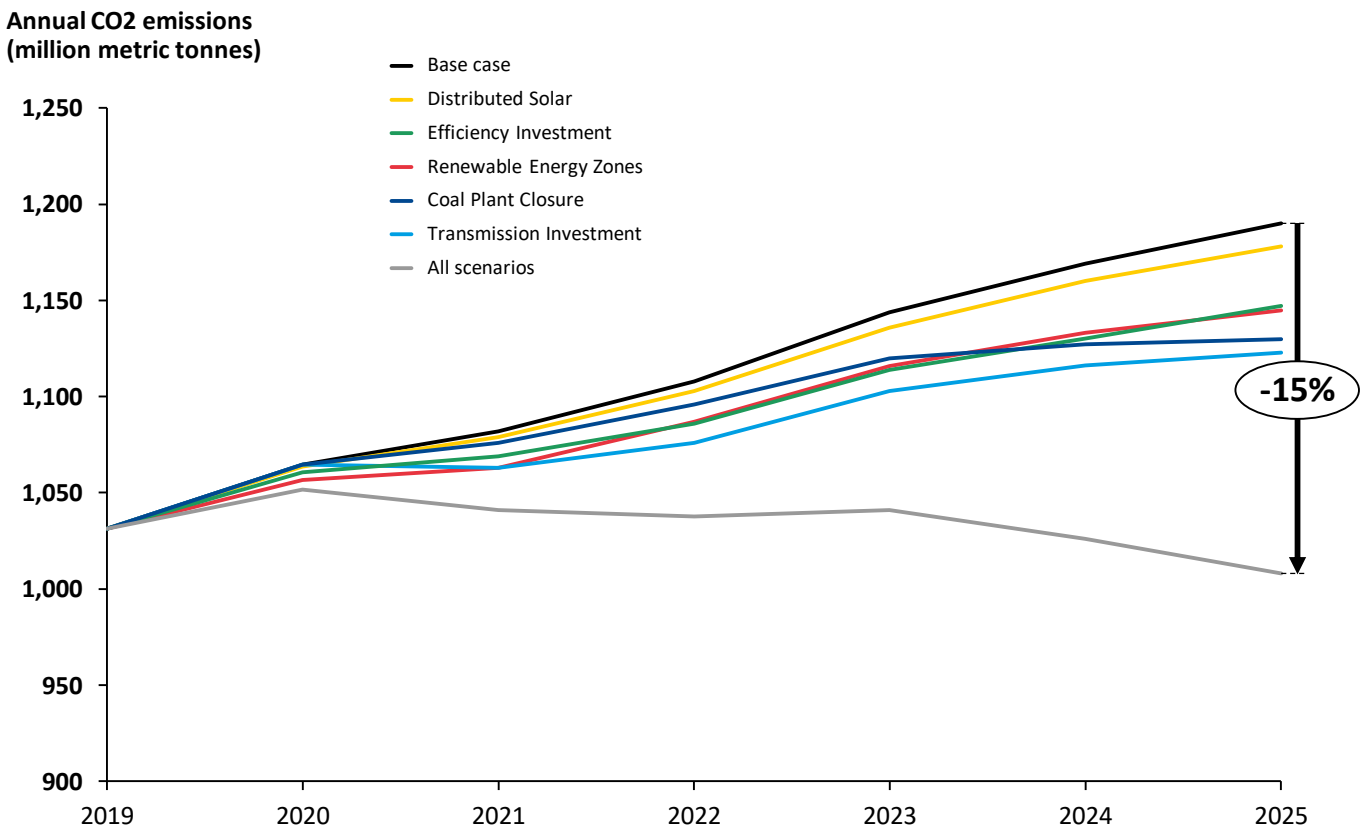
● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

System Value dimension: CO_2 emissions

India can flatten and begin to decrease CO_2 emissions from fossil fuel electricity generation through five recovery solutions, with combined effect of 15% lower emissions compared to base case by 2025

Cumulative CO_2 emission impact through 2025 by recovery solution	
Renewable Energy Zones	**157 Mt** Cumulative electricity base case CO2 reduction through 2025
Distributed Solar	**38 Mt** Cumulative electricity base case CO2 reduction through 2025
Transmission Investment	**63 Mt** Cumulative electricity base case CO2 reduction through 2025
Energy Efficiency	**151 Mt** Cumulative electricity base case CO2 reduction through 2025
Coal Plant Closure	**143 Mt** Cumulative electricity base case CO2 reduction through 2025
All recovery solutions	**552 Mt** Cumulative electricity base case CO2 reduction through 2025

Total power sector CO_2 emissions from coal across recovery solutions

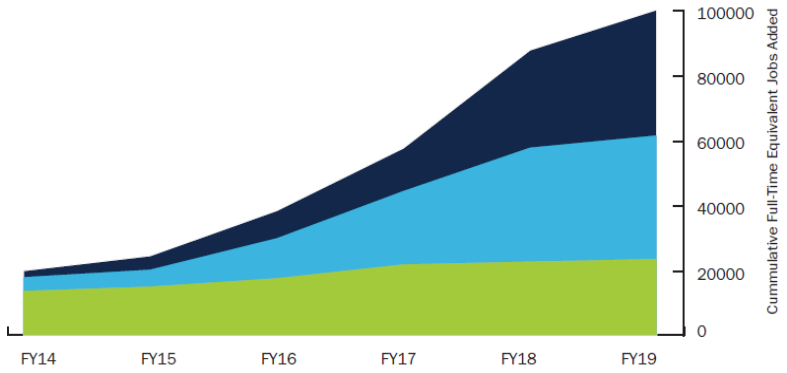


Note: Emissions from energy sources outside coal and natural gas were not evaluated for this analysis

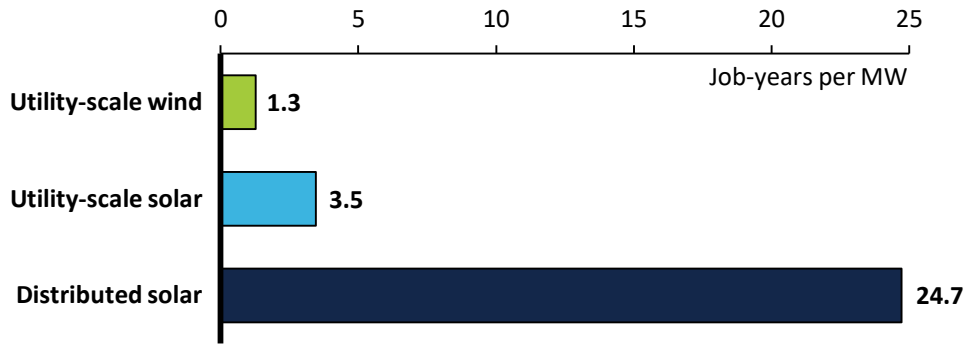
System Value dimension: Jobs impact

India's solar and wind sectors stand to see increased employment with increased capacity additions across recovery solutions, from under 100K jobs at the beginning of decade to 300-400K, largely due to the labour-intensive distributed solar sector

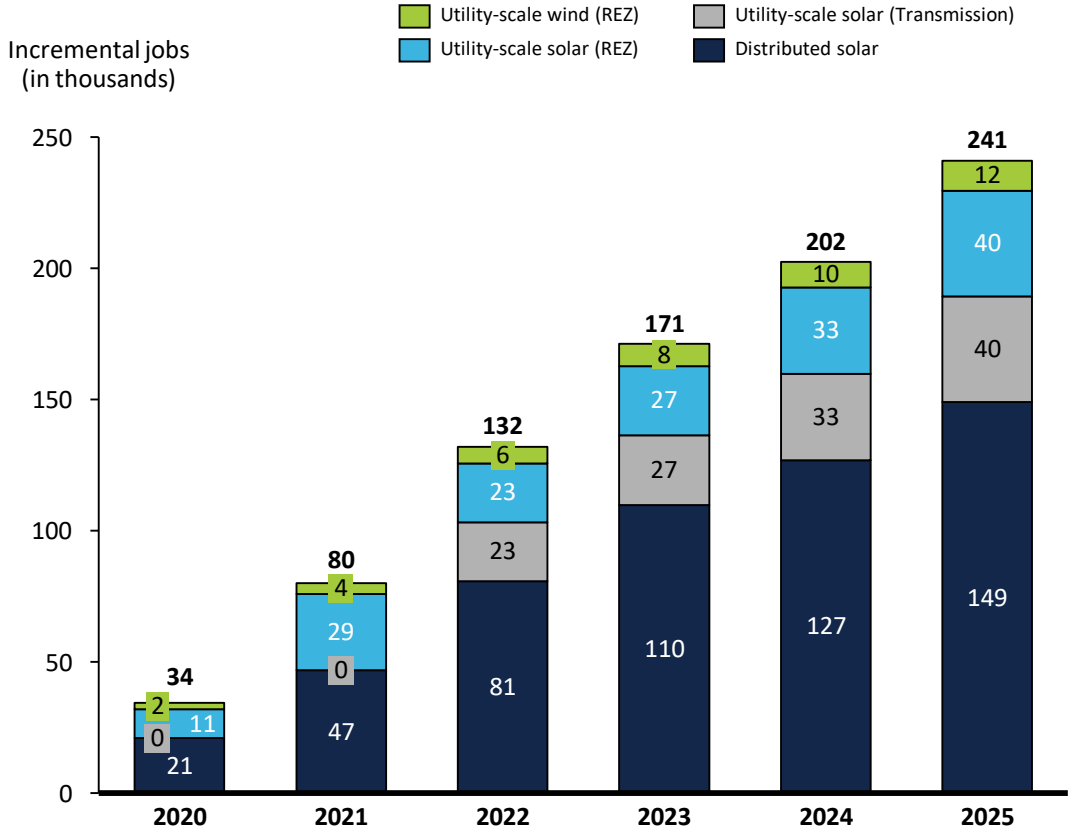
India's solar and wind sector neared 100k jobs in 2019



Distributed solar is a significant jobs creator



Incremental job impact across recovery solutions



Note: Employment figures are understated since they do not include job gains from efficiency investments, due to data unavailability

Sources: Council on Energy, Environment, and Water; Accenture analysis

System Value dimension: Air quality and health

Decreases to coal consumption can improve India's air quality, with the country having some of the highest air pollution levels in the world as few enforcement standards are currently in place

India overview

- India is home to six of the top 10 cities worldwide with the worst PM2.5 (particulate matter) air pollution.
- More than 40% of Indians are regularly exposed to five times the safe limit of PM, with worst affected areas in the north.
- The World Bank calculates India's annual losses from pollution-related healthcare expenditure at $221 billion, or 8.5% of GDP.
- Air pollution is estimated to have claimed 1.24 million Indian lives in 2017, or 12.5 % of total annual deaths.
- Exposure to PM2.5 from coal-powered plants contributed to 82,900 deaths in 2015, according to the Health Effects Institute.

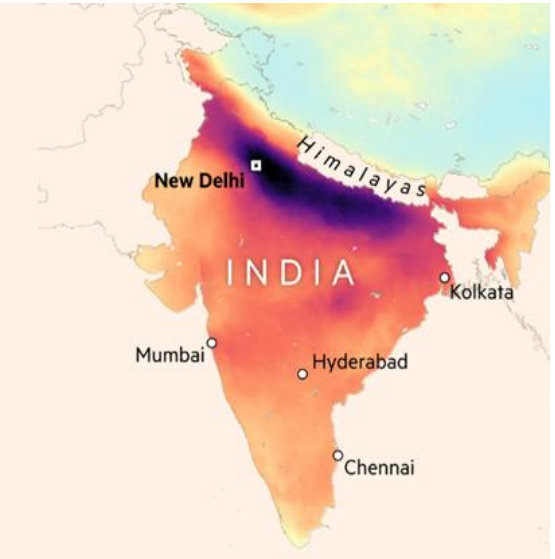
Policy and enforcement

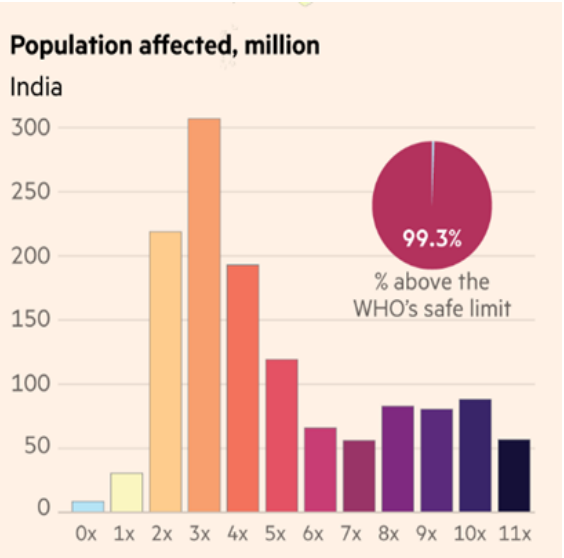
- India's government has strengthened rules to combat air pollution and adopted the National Clean Air Programme (NCAP), which focuses on monitoring and enforcement.
- However, progress has been limited by extensions of the enforcement, being pushed back from 2017 to 2021-2022.

COVID-19 impact

- Significant improvement to air quality was experienced in India during the COVID-related shutdown in late March and April 2020 due to decreased traffic and industry, with PM2.5 levels falling 60% in Delhi and the Himalayas being visible for the first time in decades.

Nearly all of India's population experiences air quality worse than WHO safe limit





Cumulative human health impact by recovery solution

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure	All Solutions
$14bn	$3bn	$6bn	$13bn	$13bn	$50bn
Human health benefits from air quality improvements through 2025	Human health benefits from air quality improvements through 2025	Human health benefits from air quality improvements through 2025	Human health benefits from air quality improvements through 2025	Human health benefits from air quality improvements through 2025	Human health benefits from air quality improvements through 2025

Sources: WEF, Financial Times, World Bank, International Council on Clean Transportation, Al-Jazeera, IEA, Resources for the Future

[1] *Based on health damage estimate for India of $190/ton of coal, 2014 IMF Study (Parry, et. al)*

System Value dimension: Foreign direct investment

FDI into the power sector – which has lagged behind other sectors – could play a vital role in helping India achieve its goals of 175 GW of renewables by 2022 and 275 GW of renewables by 2027

Overview

India has set ambitious targets of 175 GW and 275 GW of renewables capacity by 2022 and 2027, respectively. However, over the past three years, annual targets were missed with installations at 82%, 55% and 67% of planned capacity. COVID-19 is likely to further delays and dampen hopes of reaching the 2022 target.

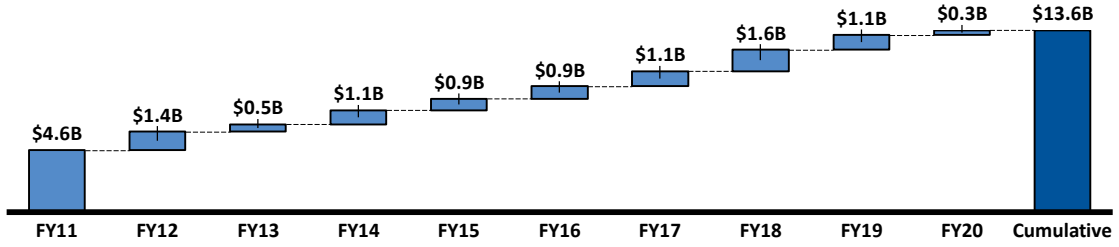
India has looked to leverage existing policies such as solar parks and permitting 100% FDI via automatic route to stimulate renewables deployment and reach its future goals.

Key impediments to investment in capacity development

- *Power price ceilings:* State mandated price ceilings by distribution companies limit project returns and increase risk
- *PPA bankability:* Delays in signing PPAs and fixed price nature increase project execution timeline and risk of cost escalation
- *Counterparty risk:* Risk of payment delays, default and activation of forced majeure clauses in contracts by financially vulnerable state-owned distribution companies
- *Transmission and evacuation infrastructure:* Insufficient exchange of electricity and system services of states, which hamper balancing as well as availability of grid connection/network that is uncertain
- *Land acquisition:* Lack of clarity over land titles, with outdated records and fragmented landholdings
- *Financing:* Limited FDI in sector due to above concerns; reliance on risk averse banks and NBFCs that result in high cost of capital

FDI inflows into the Indian power sector ($ billion)

Cumulative FDI inflows into the power sector have accounted for only **4%** of total FDI during the same period



Recovery solution impact on System Value dimension

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure
Solar/wind parks would drive both domestic and foreign investment into renewables given the easing of impediments such as land acquisition	Limited FDI given small ticket size and limited room to scale operations nationally due to differing state level regulations	Improved transmission infrastructure would accelerate investment into new capacity, flexibility services, ancillary markets	Corporate investment into energy efficiency programmes from CSR initiatives or regulatory changes	Coal plant closures would improve overall health of power sector making it a less risky industry for investors

Relative System Value dimension benefit for given recovery solution within market: High benefit; Medium benefit; Minimal-to-no benefit

Sources: IEA, IBEF

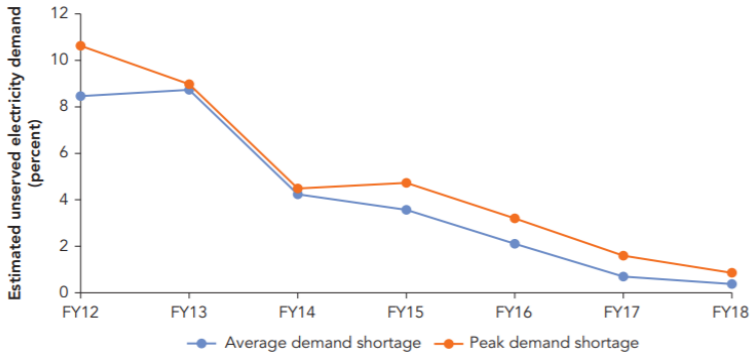
System Value dimension: Reliability and service quality

Renewables and efficiency investments can help meet growing electricity demand and create a more reliable grid, as India struggles with coal shortfalls and water shortages

Overview

- The 2018 Global Competitiveness Report ranked India 80th among 137 economies in electricity supply reliability
- The World Bank estimates that power sector distortions cost India $86 billion, or 4% of GDP, in 2016
- India's state governments have signed memorandums of understanding with the Ministry of Power for the provision of 24/7 quality and reliable power by March 2022
- Renewables can help meet growth of electricity demand, whereas India already struggles to source and supply coal plants and ensure water supply for coal plants during droughts

Unserved electricity demand has declined over the past decade

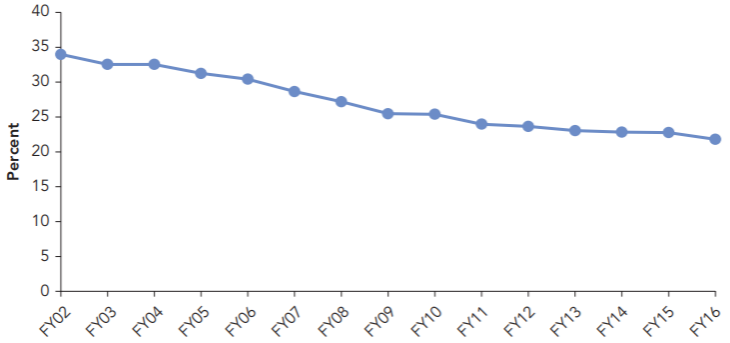


Source: World Bank

Recovery Solution impact on System Value dimension

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure
Wind and solar can help meet growing demand to ensure sufficient supply on the system	Distributed solar can supplement grid energy, particularly in areas that suffer from frequent outages	Improved transmission infrastructure would enhance reliability of the grid by reducing congestion	Efficiency can lower demand when the grid is strained, helping to prevent outages	No material benefit

Transmission and distribution losses are high, indicating poor reliability



Source: World Bank

Source: World Bank (1, 2)

Relative System Value dimension benefit for given recovery solution within market: High benefit; Medium benefit; Minimal-to-no benefit

System Value dimension: System upgrade

Overview

Given the ambitious targets set by the Indian government for achievement of renewable capacity over the next two decades, the risk of investment in generation capacity outpacing transmission investment remains high.

Recognizing the aforementioned risk, the Indian government has successfully built out its interstate transmission system and has operated a single nationally synchronized grid. Despite the success of programmes such as the Green Energy Corridor, the grid investment required over the next five years is estimated to be between $60-80 billion.

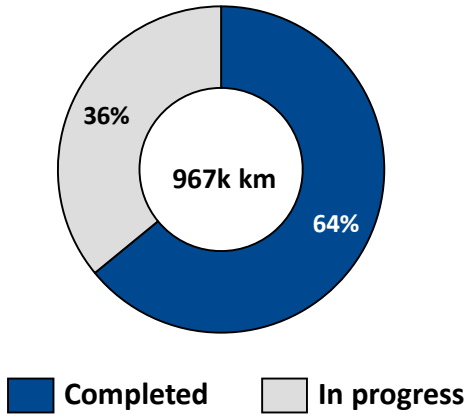
Case example: Green Energy Corridors

- Green Energy Corridors were sanctioned in 2015-2016 as a scheme of "national importance" aimed at removing system integration barriers for large-scale renewable energy projects.
- The project is being implemented across a variety of variable renewable-rich states such as Maharashtra, Rajasthan and Kerala, and incentivizes wind and solar developers to connect directly by promising no transmission charges for a period of time.
- To date, Phase 1 (integrating 33 GW of renewables) has been implemented with Phase 2 underway. Phase 2 aims to connect 100 GW of solar and 60 GW of wind by 2022.

Distributed sources

- The ambitious targets for rooftop solar (40 GW) pose a near-term challenge to system integration since the majority of installations are unregistered.
- To improve system integration, policies such as appropriate remuneration for injections into the grid are being considered to incentivize registration, compliance and visibility of plants.
- Alternatively, India can pursue off-grid solutions to improve quality of electricity access and affordability in remote and/or urban areas.

Green Energy Corridor Phase II progress



Recovery solution impact on System Value dimension

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure
Heightened investment into solar/wind parks would drive need to improve regional and state interconnection infrastructure	Growing share of distributed sources in generation mix to drive upgrades to interconnection infrastructure	Improved transmission would upgrade the interconnection infrastructure	Energy efficiency can reduce or push back the need for system upgrades by reducing congestion and strain on the grid	No material benefit

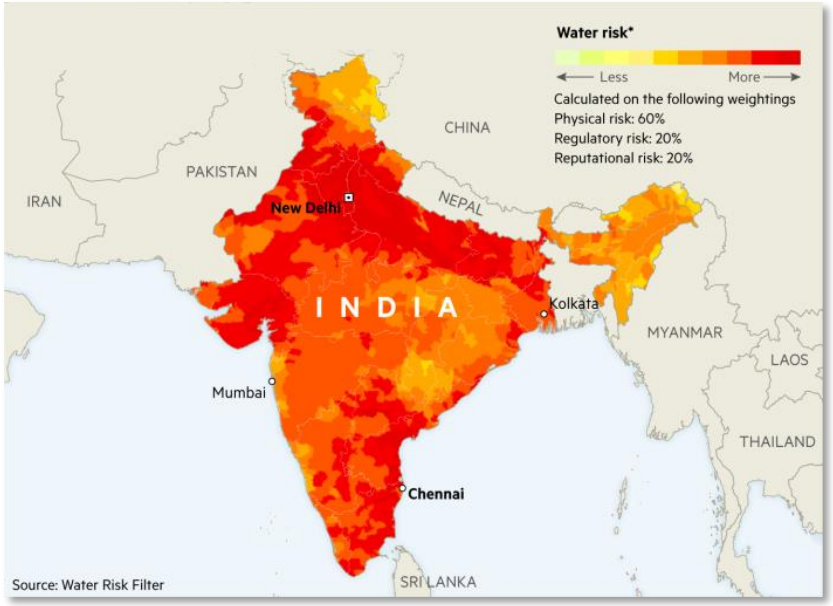
Relative System Value dimension benefit for given recovery solution within market: High benefit; Medium benefit; Minimal-to-no benefit

Sources: IEA, IEEFA

System Value dimension: Net water footprint

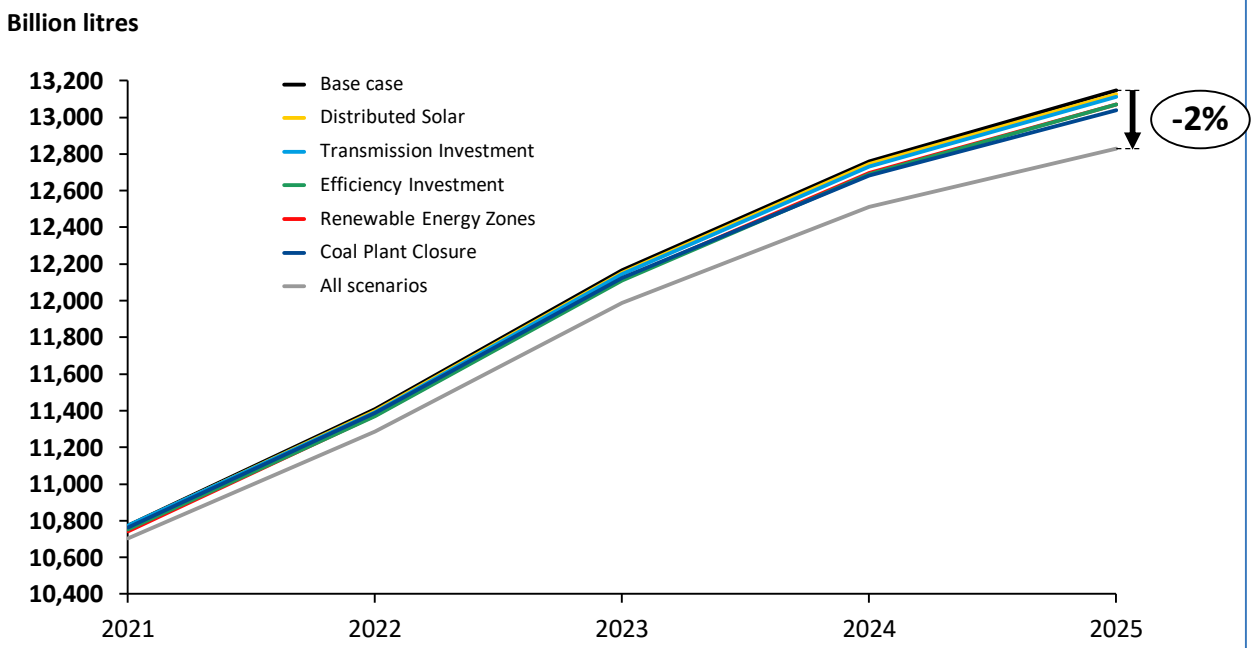
India experiences high levels of water scarcity that can impact coal and hydroelectric plant generation, with the five recovery solutions able to curb water footprint growth by shifting away from coal

Water risk across India



- India is the world's largest user of groundwater, with subsidized electricity fueling agriculture and water usage
- 2016 drought led to numerous coal and hydroelectric plants to temporarily shut down
- Millions of people in Chennai experienced severe water scarcity in June 2019
- Given water constraints, government and energy providers should consider moving away from biomass towards low water intensity options

Total power sector annual water footprint across recovery solutions[1]



Cumulative water footprint impact by recovery solution

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure	All solutions
271bn litres	61bn litres	102bn litres	268bn litres	260bn litres	962bn litres
Cumulative reduction of water consumption compared to base case through 2025	Cumulative reduction of water consumption compared to base case through 2025	Cumulative reduction of water consumption compared to base case through 2025	Cumulative reduction of water consumption compared to base case through 2025	Cumulative reduction of water consumption compared to base case through 2025	Cumulative reduction of water consumption compared to base case through 2025

Source: Royal Society of Chemistry, World Bank, The Guardian, CNBC, Power Magazine, Accenture analysis
[1] Note: Biomass excluded from above analysis

System Value dimension: Access to electricity

India has made great strides in electricity access over the past two decades, yet many households are still left without reliable or any electricity access despite the significant success of government schemes aimed at improving rural electrification

Growing access in recent years, though gap remains

- Hundreds of millions of people in India gained access to electricity between 2000 and 2019, with the rate of national access having grown to more than 95% in 2019.
- Despite major successes of government-led programmes, c. 200 million people in India still lack access.

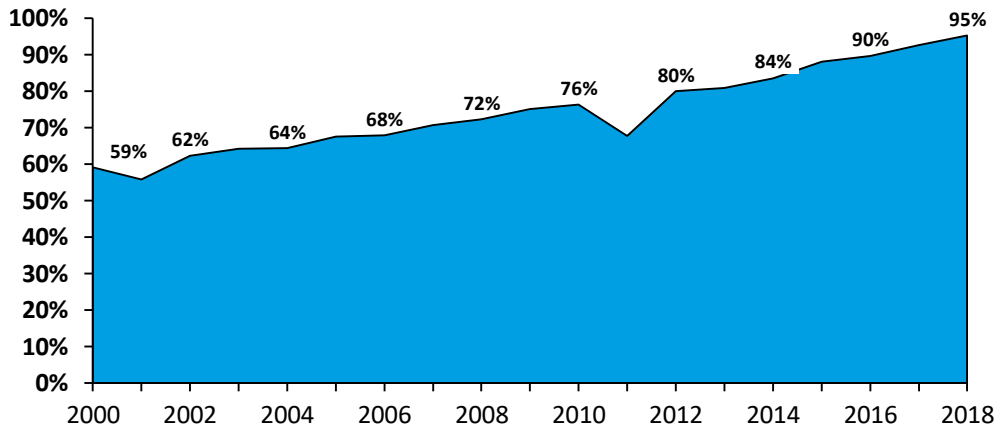
Challenging the generally accepted three-step process to improving rural electricity access:

1. *Extend infrastructure to villages:* Grid connectivity to remote areas can be uneconomical in some cases
2. *Connect households to the grid:* Utilize micro grid/rooftop solutions in remote areas where last mile connectivity is uneconomical
3. *Ensure reliable and affordable supply*: Invest at scale to drive down costs as well as into training programmes in rural areas to install, operate and maintain off-grid power solutions

The Indian government has achieved step 1 above and is nearing completion of step 2, leaving the third and most critical step as the focal point

- Unreliability of power supply in villages has led to the adoption of "off-grid" solutions such as mini grids and rooftop solar.
- A study conducted by Smart Power India (part of the Rockefeller Foundation) showed that rate of dissatisfaction among rural grid power users was at 40%, citing reliability as the main issue.
- Similarly, the study also showed that the satisfaction rate among mini-grid and rooftop solar users was at 80% despite the affordability concerns and only harnessing an average of six hours of daily uninterrupted power supply.
- Overall, non-grid sources form an important part of rural electricity mix, with 16% of households and 40% of enterprises using non-grid sources.

Percentage of Indian population with electricity access



Recovery solution impact on System Value dimension

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure
No material benefit	Rooftop solar and mini grids would be used to provide electricity access in remote areas	Enhanced transmission infrastructure would improve connectivity of remote areas	No material benefit	No material benefit

Relative System Value dimension benefit for given recovery solution within market: High benefit; Medium benefit; Minimal-to-no benefit

Sources: IEA, World Bank, Forbes, BBC, Smart Power India

System Value dimension: Energy productivity and systemic efficiency

Efficiency improvements to remove waste and optimize the electricity system across the value chain can be achieved through identified recovery solutions

Energy productivity and systemic efficiency benefits by recovery solution		
Renewable Energy Zones	◐	• Optimizes efficiency of renewable energy production and the interface to transmission
Distributed Solar	◐	• Increased penetration of distributed solar has potential to lower T&D losses due to more local generation in remote areas
Transmission Investment	●	• Improved transmission and interconnection infrastructure to reduce congestion and thereby alleviate curtailment and technical losses • Digitization initiatives such as smart metering would reduce non-technical losses as well as improve efficacy of invoicing and bill collection for DISCOMs
Efficiency Investment	●	• End consumer efficiency improvements can be achieved across sectors through smart appliances, agricultural pumps, greater building efficiency and energy conservation, achieving same work or economic output for less electricity
Coal Plant Closure	◐	• Retiring of inefficient (i.e. plants that utilise a high heat rate in production process) and/or stressed (i.e. highly leveraged, operationally loss making) coal plants can improve overall operational and financial efficiency level of coal capacities

Source: US Department of Energy (DOE), MIT Center for Energy & Environmental Policy Research

Relative System Value dimension benefit for given recovery solution within market: ● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

System Value dimension: Flexibility

System flexibility will become more vital as generation share of renewables increases; however, India faces short- and medium-term challenges to balancing its ambitious targets with the needed flexibility of its current power system

Flexibility challenges to India's electricity sector

Ambitious renewable energy targets heighten need for system flexibility

- If targets are met, renewables' share of generation in India is expected to grow from 11% in 2019 to 25% in 2025, creating a greater need for system flexibility

Short-, medium- and long-term challenges and opportunities exist

Short term

- Increase in stressed coal assets to weigh on overall Indian economy as debts sit with public banks
- Shifting existing thermal plants to provide flexibility services in the short term by reducing minimum operating levels to 40% (currently 55%)

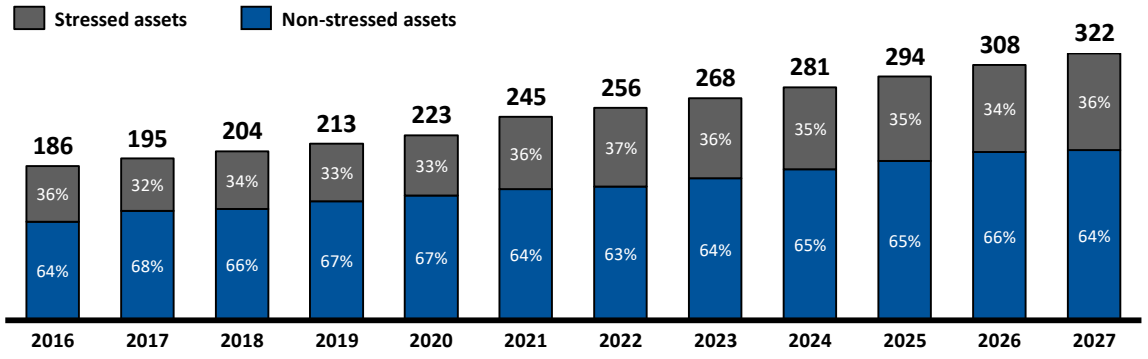
Medium term

- Managing grid flexibility requirements through operating reserves would allow for faster and more efficient ramp up/down of generation capacity used to provide balance
- Despite the CERC proposing various interstate reserve markets, there is currently no efficient mechanism for accessing operating reserves at the state or regional level

Long term

- REZs provide opportunity to develop larger balancing units, particularly with the advent of hybrid plants (wind + solar + battery)
- Storage technology will be vital for India to transition to a sustainable low carbon electrical system over the long term
- IEA projects that India will account for 27% (60 GW) of global battery storage (220 GW) by 2040

Proportion of stressed assets in total coal assets (GW)



Recovery solution impact on System Value dimension

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure
REZs provide long-term opportunity to develop large-scale grid balancing units	No material benefit	Investment into transmission infrastructure would create opportunities to provide flexibility services	Energy efficiency programmes would lower demand and smart meters would aid in grid flexibility	Old and inefficient coal plants can be used to provide flexibility services prior to phase-out

Relative System Value dimension benefit for given recovery solution within market: High benefit; Medium benefit; Minimal-to-no benefit

Sources: IEA, Climate Policy Initiative

System Value dimension: Resiliency and security

India's electrical grid faces challenges from natural disasters and a reliance on coal imports, with increased renewables able to help boost resiliency in the face of both challenges

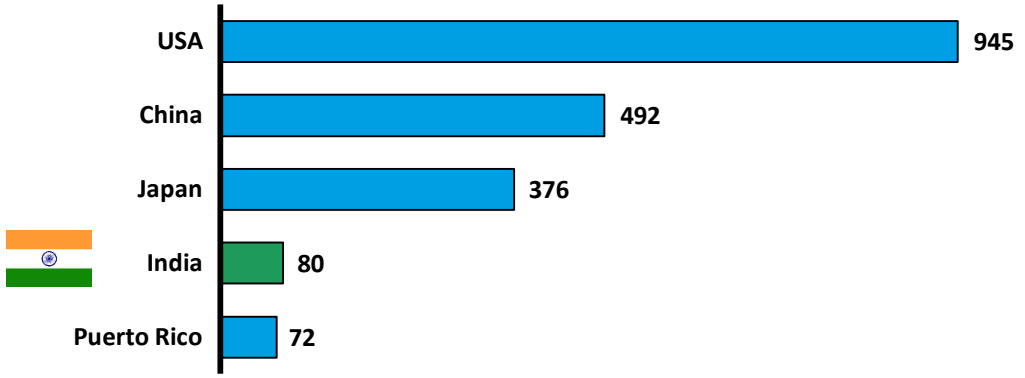
Challenges to India's electrical system resiliency

- *Natural disasters:* India is prone to cyclones, earthquakes and drought, with the country ranking fourth in economic losses from natural disasters, suffering $80 billion in economic damages from 1998-2007.
- *Dependence on imported coal*: India cannot meet its coal demand through domestic sources and is reliant on imports, which subjects it to additional energy security risk. For example, coal shortfalls and railroad constraints led to the stranding of ~48 GW of generation capacity in 2014, equivalent to 15% of the entire coal fleet. Some newer coal plants were built to only run on grades of coal that must be imported.
- *COVID-19*: The current pandemic places additional strain on generation plants where a larger worker presence is needed, such as coal, nuclear and natural gas.
- *Cyber resiliency*: Increased investment in digitalization of electricity systems and higher penetration of distributed generation will increase the potential for cyber threats.

How the clean energy transition can bolster system resiliency

- Increasing renewables lowers the dependence on fossil fuel imports and fluctuating prices as supply chain or geopolitical issues arise
- Renewable energy is significantly less reliant on on-the-ground workers to operate, facing less challenges in a pandemic
- A more distributed, digital system can be sectionalized as problems arise from natural disasters
- DERs such as EVs and storage can form the basis for solutions to support local resiliency where the network itself has failed

Top five countries with highest economic damage from natural disasters, 1998-2017 ($ billion)



Recovery solution impact on System Value dimension

Renewable Energy Zones	Distributed Solar	Transmission Investment	Efficiency Investment	Coal Plant Closure
Domestic production from renewables reduces reliance on imports	Distributed solar aids quick recovery from natural disasters and foreign shocks	Improved transmission infrastructure would enhance resiliency of the grid by reducing congestion	Reduced load lowers the impact of disruption	Reduces the reliance on coal imports

Relative System Value dimension benefit for given recovery solution within market: High benefit; Medium benefit; Minimal-to-no benefit

Source: UNISDR, World Bank

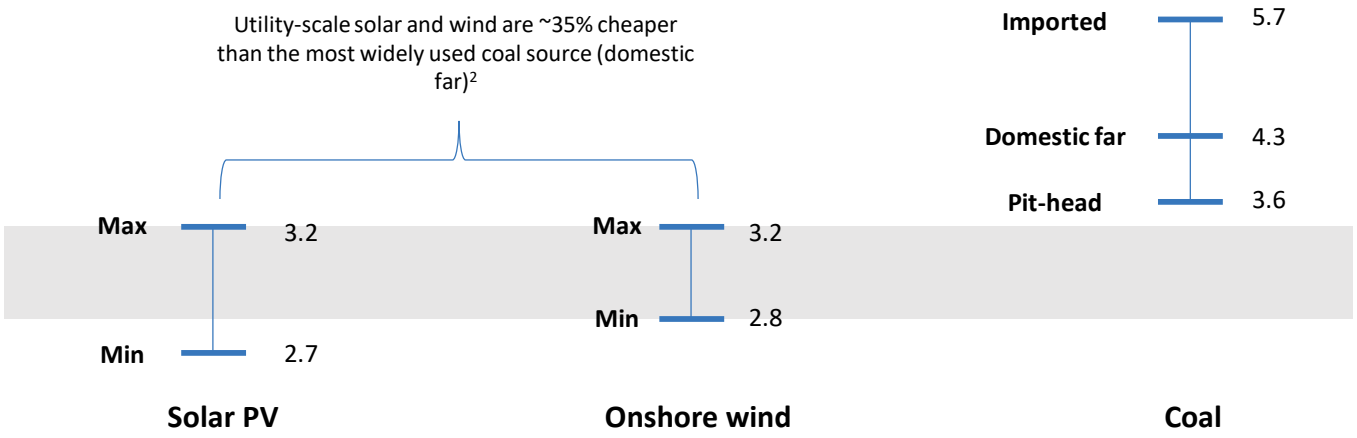
System Value dimension: Cost and investment competitiveness

Onshore wind and solar remain competitive versus traditional sources of coal and are expected to widen the gap in the near term

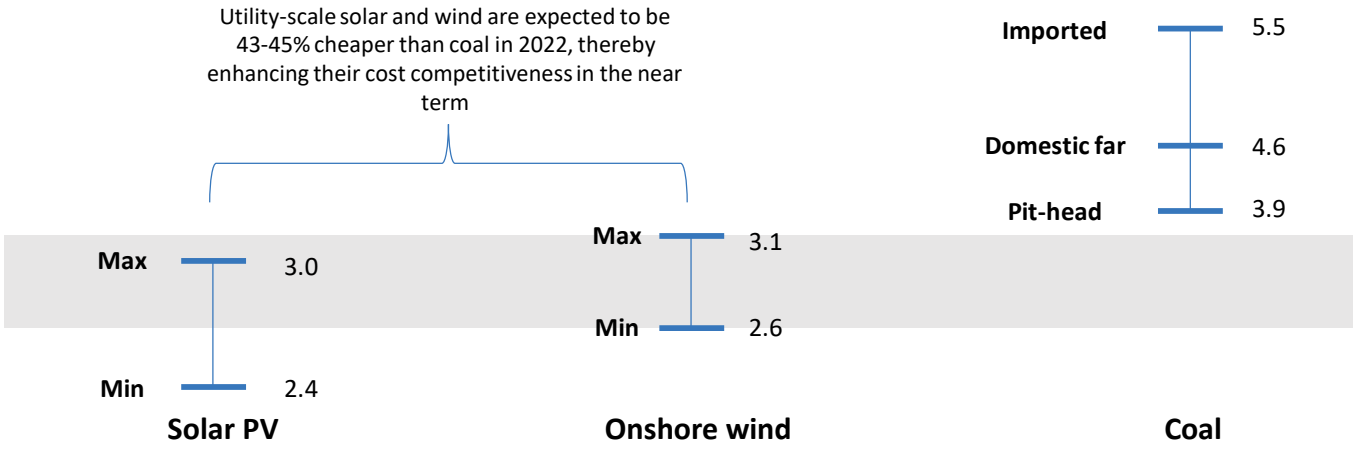
Levelized cost of energy (LCOE) [$/MWh]

- The costs of wind and solar energy are expected to decline by 7% and 11% by 2022, respectively, driven by the reduction in technology costs and operating expenses.
- While overall solar costs and trending downwards, the Modi government has extended a ~15% import duty on solar cell and module import costs from China, Vietnam and Thailand through mid-2021.
- Coal, on the other hand, is expected to get costlier by 9% over the next three years, driven by increased equipment costs to meet new environmental standards and escalating domestic raw material costs.
- The cost of equity and debt financing amounts to 60% of the LCOE for solar PV and wind projects.
- LCOE can be driven down further through lower cost of capital from foreign institutional investors if risks associated with renewable projects are mitigated.

2019 LCOE[1] (INR/KWh)



2022 LCOE[1] (INR/KWh)



Notes: (1) LCOE costs do not include transmission; (2) Domestic far includes all coal that is sourced from plants that are located at least 500km from the point of consumption
Sources: Global Wind Energy Council, Mercom India