India's Clean Power Revolution

A success story with global implications

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There's no doubt about it: the clean energy revolution is here, and local, state, and national governments are at the forefront. At Bloomberg Philanthropies, we believe that these forward-thinking local leaders can share lessons and strategies as they work to create strong, sustainable economies and usher us into the clean energy future. In partnership with BloombergNEF, Bloomberg Philanthropies has released India's Clean Power Revolution, outlining the current successes and future potential of India's clean energy economy.

India's commitment to renewable energy has made it the number one emerging market for clean energy investment, according to BNEF's Climatescope. The country has set ambitious renewable energy goals – 175 GW by 2022 and 450 GW by 2030 – and is making strong progress towards meeting those targets, thanks to supportive government policies, openness to investors, and the volume of renewables auctioned in recent years.

As nations seek to recover and restore economies in the wake of the COVID-19 pandemic, India's competitive clean energy auction market and impressive clean energy progress can offer lessons learned for economies looking to achieve a green recovery that maximizes economic, health, and environmental benefits. As this report outlines, investment in clean energy helps increase energy access and supply, creates jobs and fosters economic growth, and improves climate and air quality -- providing health benefits we sorely need right now.

Although challenges remain, India's renewable energy transition will serve as a model for transitioning economies all over the world. By learning from each other, we can continue to expand global investments in renewable energy, strengthen our economies, and achieve a sustainable, healthy future.

Antha N. Williams
Global Head of Environmental Programs
Bloomberg Philanthropies

Executive summary (1/2)

Ambitious targets, comprehensive government policies and economics have placed India amongst the most vibrant clean energy markets in the world. As the energy transition accelerates, this decade brings new challenges and opportunities for all the actors in India's clean power revolution.

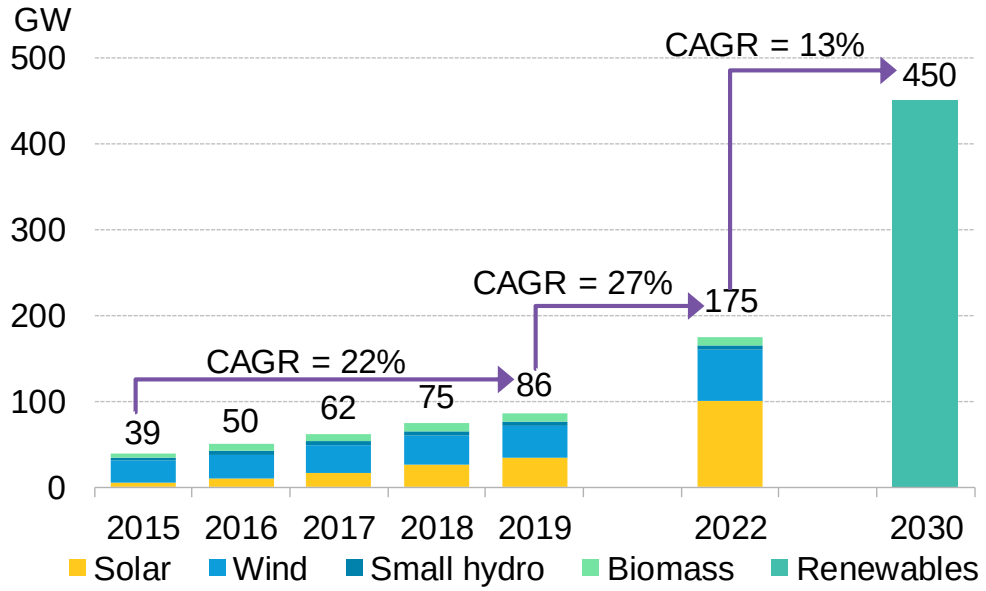
- **Targets**: In 2015, India announced a target of building 175GW of clean energy by 2022, a more-than-fourfold increase in installed capacity in just seven years. By 2030, Prime Minister Narendra Modi wants India to reach a new goal of 450GW of renewables.
- **Integrating** such volumes of variable generation will require a flexible power system. Apart from battery storage and peaker gas plants, lessons from around the world highlight the importance of demand-side measures, grid investments and market reforms for India.
- India is the **world's largest** and most competitive **clean energy auction market**, allowing it to procure some of the cheapest renewable power. New auction designs allow the replacement of fossil fuels through better integration.
- The 2030 target brings momentum to the goal of capturing more value from the transition domestically, spelled out in the '**Make in India**' strategy. The wind sector has already seen leading equipment manufacturers open factories to supply the national and international markets.

53% Drop in annual weighted average auction tariffs for utility-scale solar, over five years

1 India ranked as the most attractive emerging market for clean energy investment in *Climatescope 2019*

80% Expected growth in India's power demand from now till 2030

Renewables need to keep growing to meet national targets

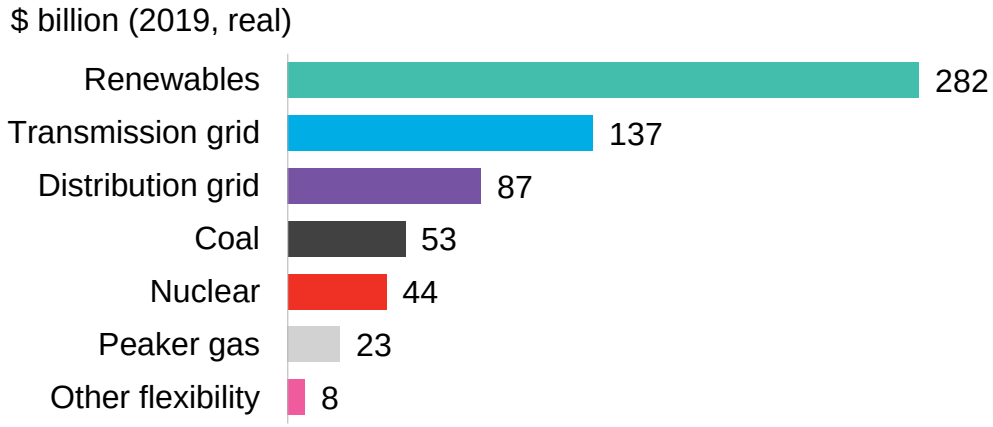


Source: BloombergNEF, Ministry of New and Renewable Energy. Note:. Solar capacity shown in AC. Note: Large hydro was excluded from the 175GW target. The breakup of the 450GW target is not known and it may include large hydro.

Executive summary (2/2)

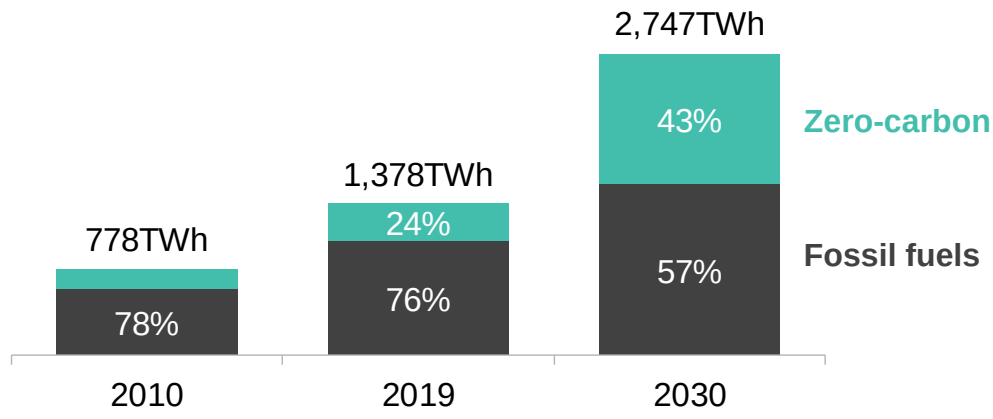
- The transformation of India's power sector in this decade brings a **$633 billion investment opportunity**. Capital is needed to build more power plants, and also to replace and expand grid infrastructure. Public and private finance will need to mobilize to deliver these investments.
- Accelerating deployment calls for **better coordination** on **land issues** to ensure that **grid availability** matches the commissioning of new power projects. Simplifying land acquisition procedures and digitizing land records would remove a bottleneck affecting the sector today.
- The **financial health** and resiliency of **power distribution companies** will also need to be improved to give investors confidence that they will not face payment delays and retroactive contract negotiation. Procurement of clean energy by corporates looking to reduce their costs provides an opportunity to offer alternative bankable offtakers for clean energy project developers.
- The continuation of India's clean power revolution is **critical to global climate efforts**. Coal's role in the mix will continue to drop despite rising power demand. Retiring older coal plants will improve utilization rates for the coal fleet and significantly reduce CO_2 emissions. New clean power generation will help India avoid more than 499 million tons of CO2 emissions a year by 2030, and bring peak emissions within reach in the next decade.

Projected power sector investments (2021-2030)



Source: BloombergNEF. Note: The values for grid investments are only for poles, wires, substations and transformers.

NEO 2019 electricity demand and generation mix



Source: BloombergNEF

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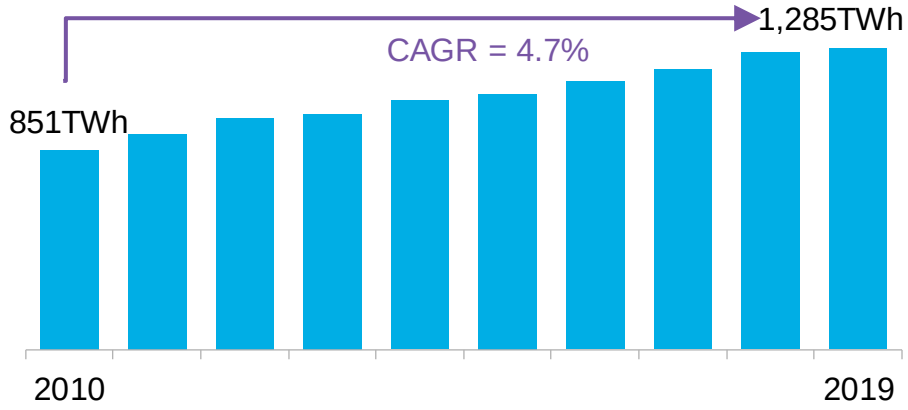
Introduction

India’s power demand grew by 50% in the last decade

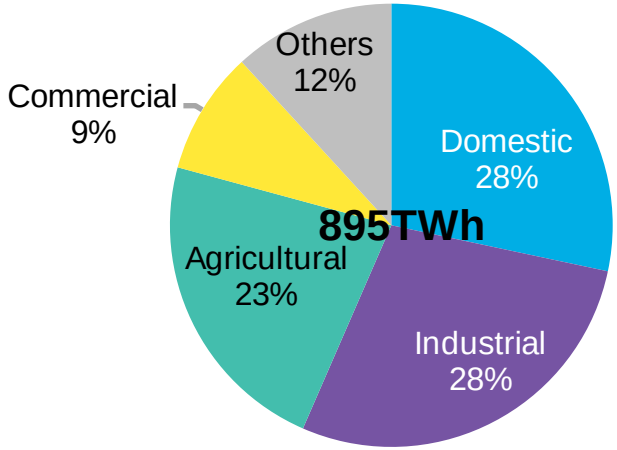
Electricity consumption has risen every year



Source: BloombergNEF, Central Electricity Authority. Note: CAGR – Compound Annual Growth Rate. Note: Consumption is shown at utility periphery.

- India’s power demand continues to rise, due to an expanding economy and growing population. In 2019, the country consumed 1,285TWh, up from 851TWh per year at the beginning of the decade.
- India has become the world’s third-largest power consumer, behind China and the United States.
- Even as power demand was expanding, the supply deficit narrowed from 79TWh in 2010 to 6TWh in 2019. This was a result of rapid expansion of generation capacity, fast rollout of transmission and distribution infrastructure, and the connection of millions of people to the grid.

Households and industries are the top power users

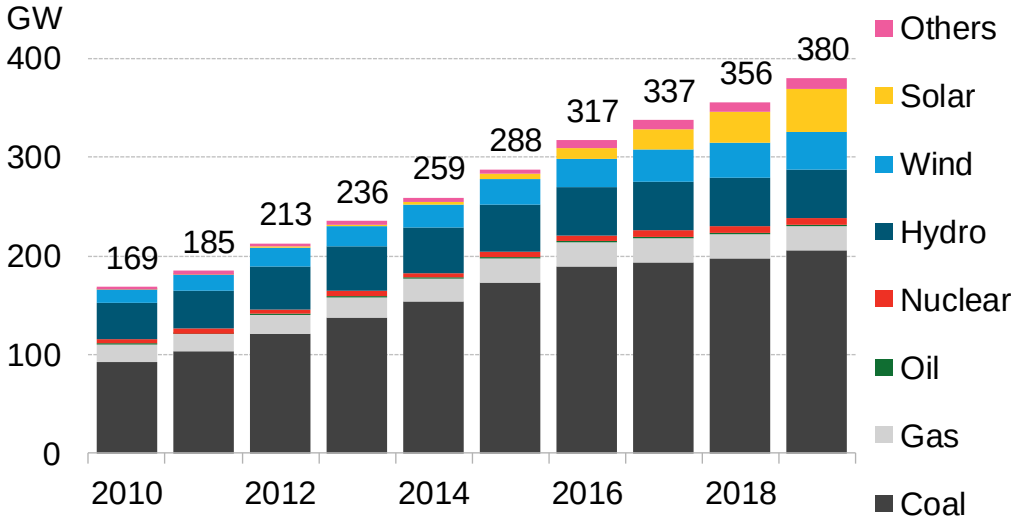


Source: BloombergNEF, Power Finance Corporation. Note: Latest available data for period April 2017 to March 2018 is shown. Data on power usage from privately owned discoms is excluded, with the exception of Delhi.

- Domestic and industrial consumers together constitute 56% of power demand, followed closely by agriculture.
- In March 2019, the government achieved 100% household electrification. The next goal is to deliver uninterrupted, 24x7 power for all.
- In June 2015, the federal government set a target to have 175GW of renewable generation capacity installed by 2022. Of these, solar PV’s target was 100GW, followed by 60GW wind, 10GW biomass and 5GW small hydro. Looking further ahead, the Prime Minister envisions 450GW of renewables by 2030.

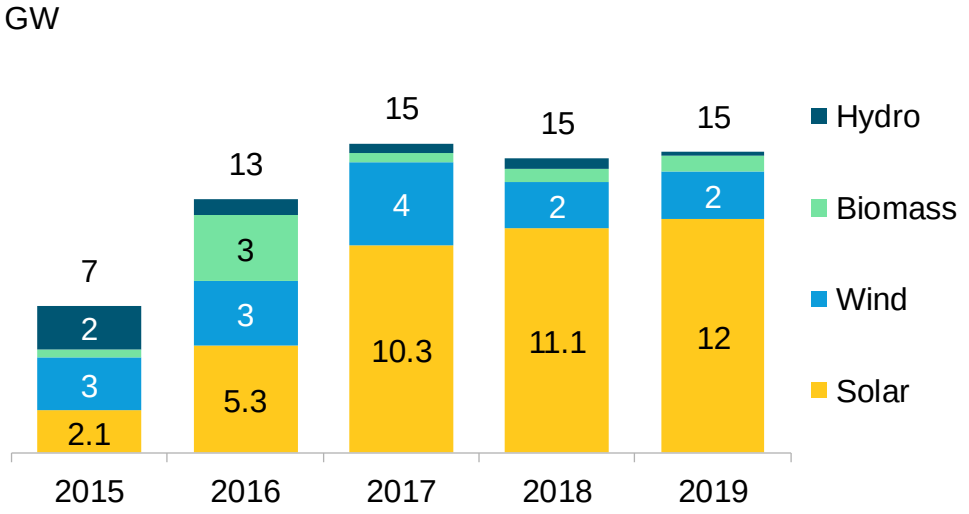
To service the demand growth, installed capacity more than doubled

Installed capacity is diversifying, but still dominated by coal



Source: BloombergNEF, Ministry of New and Renewable Energy, Central Electricity Authority. Note: Solar capacity is in DC.

Renewables deployment doubled over five years, with solar at the heart of this boom



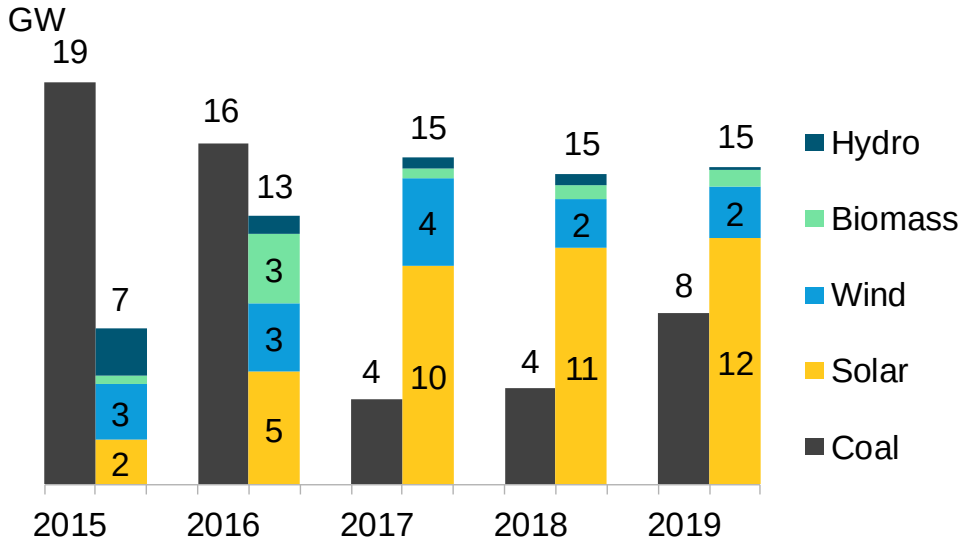
Source: BloombergNEF, Ministry of New and Renewable Energy. Note: Solar capacity is in DC.

- In the last decade, India's net power generation capacity increased by 212GW – nearly the total grid size of France. Roughly 42% of this addition came from renewable energy sources including large hydro.
- India's wind and solar installed capacity quadrupled in a decade, to reach 82GW by 2019. The two main reasons for the sharp jump in capacity have been falling technology costs and proactive government policies to achieve the target of 175GW renewables by 2022.

- Additions of renewables have risen from 2015 levels. From 2017, 15GW of renewables have been added each year. More than two-thirds of this came from PV, followed by wind. Installations of hydro power have remained low because of long construction timelines, environmental concerns and social pushback.
- At the end of 2019, the country had 143GW of clean generating capacity (including large hydro) – representing about 38% of all the power installed in the country.

Annual renewables additions surpassed coal, driven by the private sector

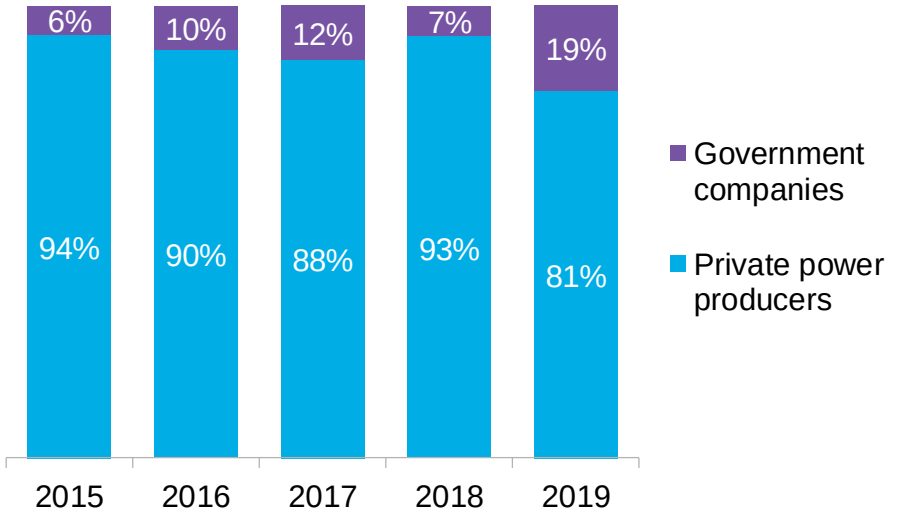
Coal additions dropped while renewables grew



Source: BloombergNEF, Central Electricity Authority, Ministry of New and Renewable Energy

- India has been one of the world's largest coal markets. At least 15GW coal generation capacity were added every year until 2016, driven by plentiful domestic coal supply and a large power deficit. From 2016 onwards, however, capacity additions tipped decisively toward clean power.
- The clear shift to renewables capacity is a lasting one as it is primarily driven by economics. The gap between the cost of new coal versus clean power generation continues to widen in favor of the latter.

Private companies are the main investors in India's clean power projects



Source: BloombergNEF

- The majority of coal power plants in India are owned by central government companies, such as NTPC Ltd. (erstwhile National Thermal Power Corp) and a variety of state government entities active in the power sector.
- In contrast, private independent power producers (IPPs) have built 90% of the wind and solar power projects in the past five years. This is a pattern not dissimilar to that of Europe, where incumbent generators were slow to join the clean energy sector. Government companies are now increasingly participating in clean energy auctions too.

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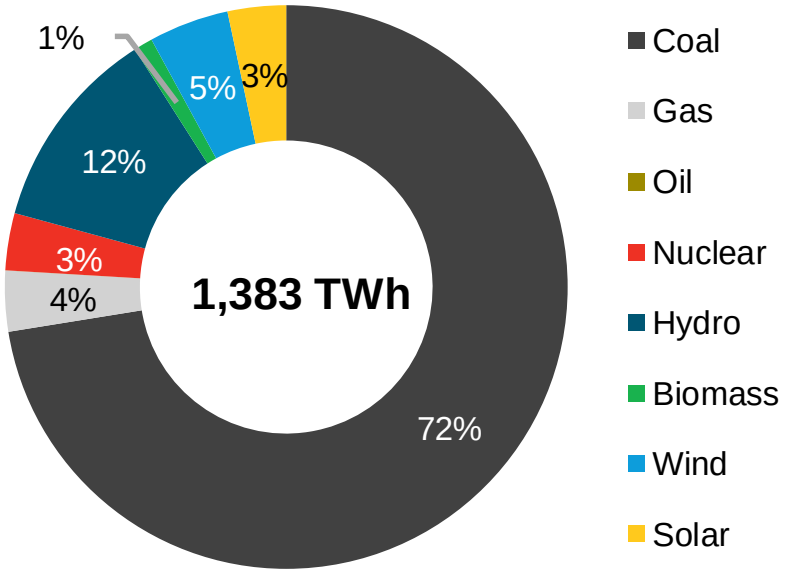
The growth of renewables has started eating into coal's share of generation

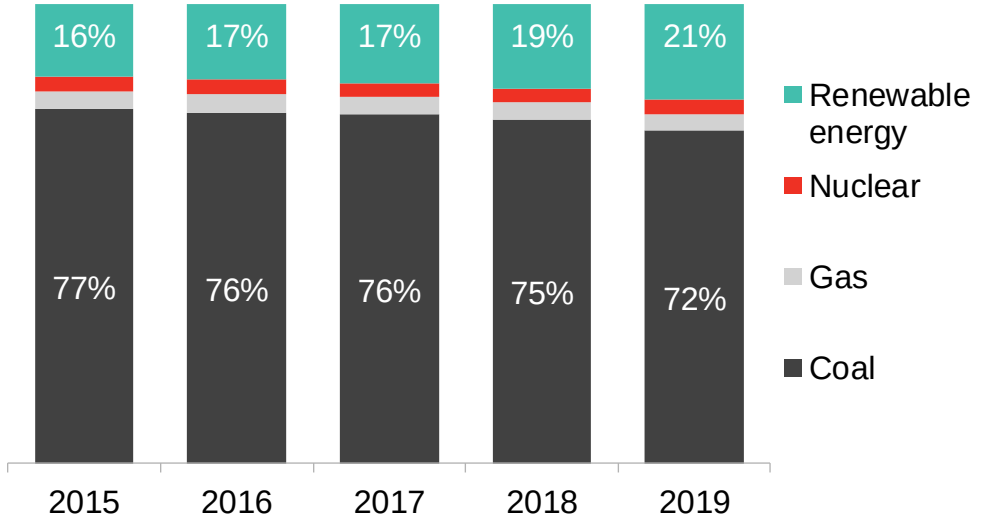
Coal was the dominant fuel for power generation in 2019



Source: BloombergNEF, Central Electricity Authority

- Coal remains the workhorse of India's electricity supply system, providing close to three-quarters of the country's power needs in 2019.
- But 2019 was the first year in which the absolute energy generated by coal saw a year-on-year decline. Slower growth in power demand, and record growth in clean power generation, were behind this fall.

Coal power is losing share to renewables

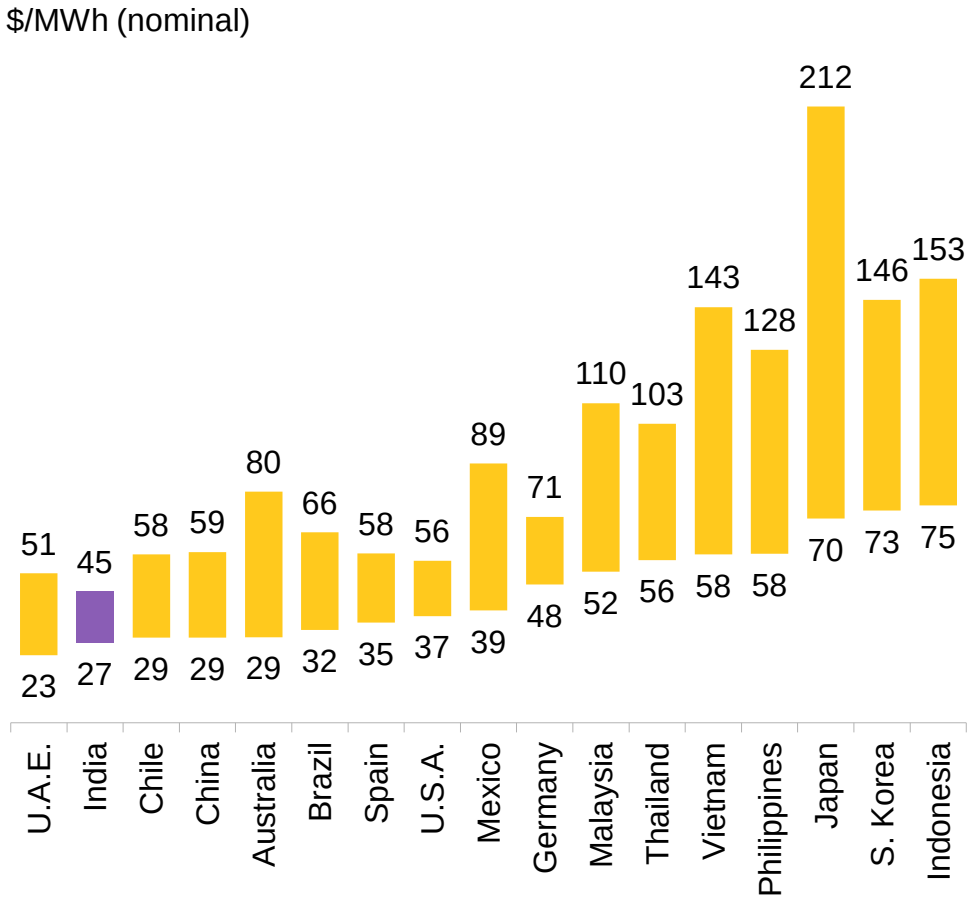


Source: BloombergNEF, Central Electricity Authority

- Renewable energy sources (including large hydro) supplied 21% of India's grid electricity needs in 2019. This share has increased by five percentage points in five years, driven by combined additions in solar and wind of between 5GW and 13GW annually.
- The share of gas power generation remains below 5%. High prices for natural gas, which has to be imported, and a lack of adequate gas distribution infrastructure make it more expensive than coal power plants.

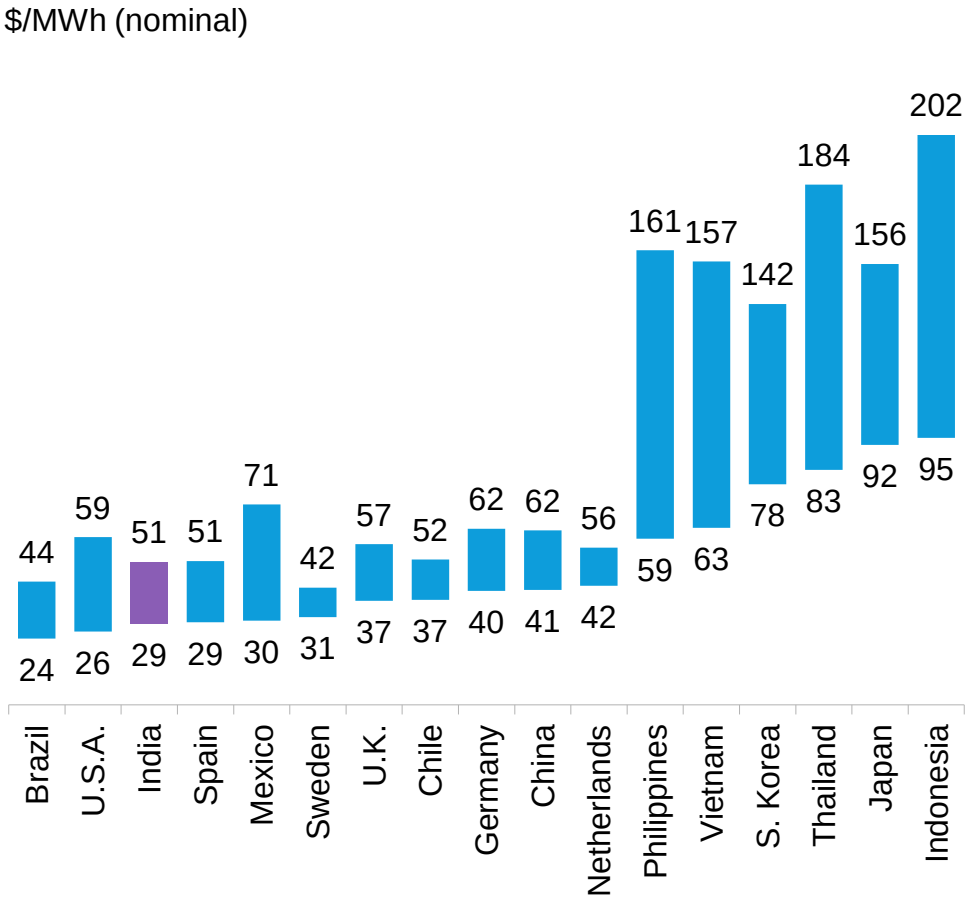
India’s renewables are now among the cheapest in the world

Levelized cost of energy for fixed-axis PV, 1H 2020



Source: BloombergNEF. Note: The range of the LCOE represents a range of costs and capacity factors. All LCOE calculations are unsubsidized and exclude curtailments and tax-credits.

Levelized cost of energy for onshore wind, 1H 2020



Source: BloombergNEF. Note: The range of the LCOE represents a range of costs and capacity factors. All LCOE calculations are unsubsidized and exclude curtailments and tax-credits.

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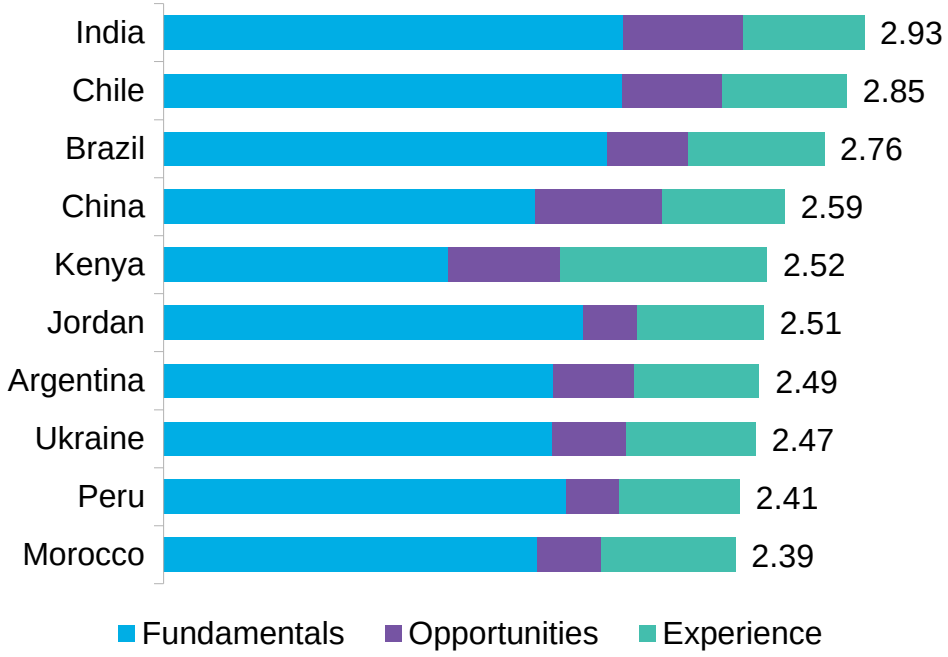
India became the most attractive emerging market for clean energy investment

Climatescope ranks India ahead of China, Brazil and Chile in 2019



Source: BloombergNEF

India has ranked in the top 10 of Climatescope ever since its first assessment in the 2014 edition. After coming second in the 2018 edition, India took top spots ahead of China for the first time. The key findings, interactive rankings and full report are available online at http://global-climatescope.org/

Analyzed 104 emerging markets

Accounting for 82% of the world's population

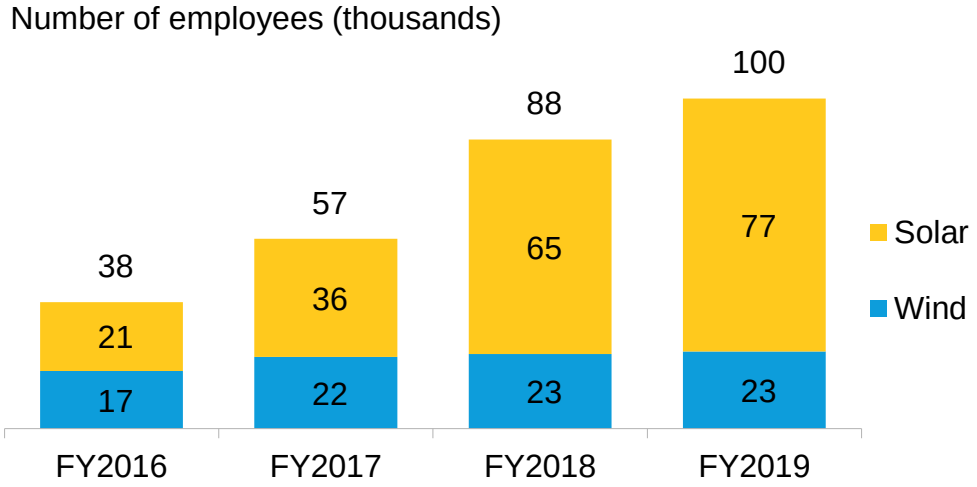
Covering two-thirds of global CO_2 emissions

Each nation was scored on 167 indicators

Fundamentals	Clean energy policies, power sector structure, regulations and barriers to renewables
Opportunities	Power demand, price attractiveness, short and medium-term prospects
Experience	Installed clean energy, historical investment, state of value supply chains

Renewables have also delivered on the economic imperative of job creation

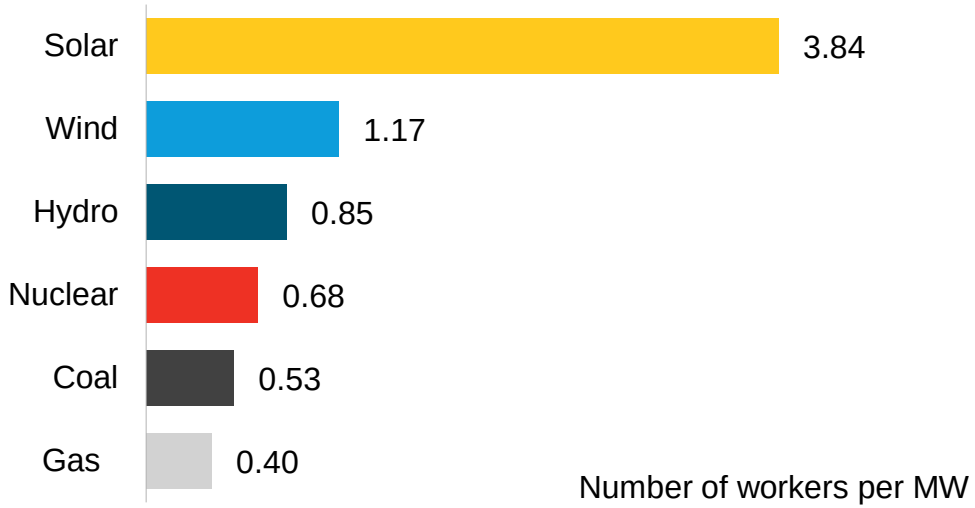
Renewable energy employment in India



Source: Council on Energy, Environment and Water, Natural Resources Defense Council, and Skill Council for Green Jobs. Note: Solar includes rooftop segment. FY2019 is the financial year from April 2018 to March 2019.

- Renewables growth is adding jobs at the fastest pace in the power sector. At the end of March 2019, 100,000 employees worked in India's wind and solar sector, according to a report on growth in green energy.
- On the other hand, efficiency gains and technology are reducing employment in the coal sector worldwide. The Council for Energy, Environment and Water together with the Skill Council for Green Jobs estimated that more than 105,000 jobs were lost in India's coal sector between the years 2000 and 2015, due to increasing mechanization.

U.S. data indicate a high renewable future could create more jobs



Source: U.S. Energy and Employment Report, BloombergNEF

- A report by the International Climate Initiative forecast that India's renewable energy sector could employ five times more people in 2050 than the entire Indian thermal generation sector (coal, gas, nuclear) employs in 2020. The study expects coal sector employment to decline by 52% in the next 30 years.
- Increasing the emphasis on decentralized small renewables and boosting domestic manufacturing have the potential to create more employment opportunities.

However, rapid growth of renewables also creates some challenges

Auction cancellations

- The insistence of electricity offtakers on low tariffs led to five solar auctions, totaling 4.7GW, being partly or fully canceled in 2018, after bidding had been completed. This created uncertainty for participating developers.
- However, the market has continued to grow and successfully completed auctions eased the concerns resulting from these cancellations. Newer auction designs to make power output closely match demand should reassure discoms.

Uncertainties with new taxes

- The introduction of a new Goods and Service Tax (GST) in July 2017 caused temporary confusion for the solar industry with regards to the applicable tax rate.
- Similarly, the safeguard duty (SGD) for cells and modules imported from China, Malaysia and developed countries introduced in July 2018 caused a spike in capex costs.
- IPPs whose projects were under construction complained that they were unfairly penalized by the GST and SGD after their tariff had been fixed. These developers are currently being compensated by the offtakers for the additional costs arising from these taxes.

Attempts to renegotiate contracts

- In 2019, the southern state of Andhra Pradesh sought to renegotiate renewable power purchase agreements to reduce the cost of power for its loss-making discoms.
- The federal Ministry of New and Renewable Energy strongly opposed the move, warning that future investment will dry up if contracts are not honored.
- The Andhra Pradesh High Court granted temporary relief to IPPs and the matter is still sub judice.

Concerns on asset quality for low tariff projects

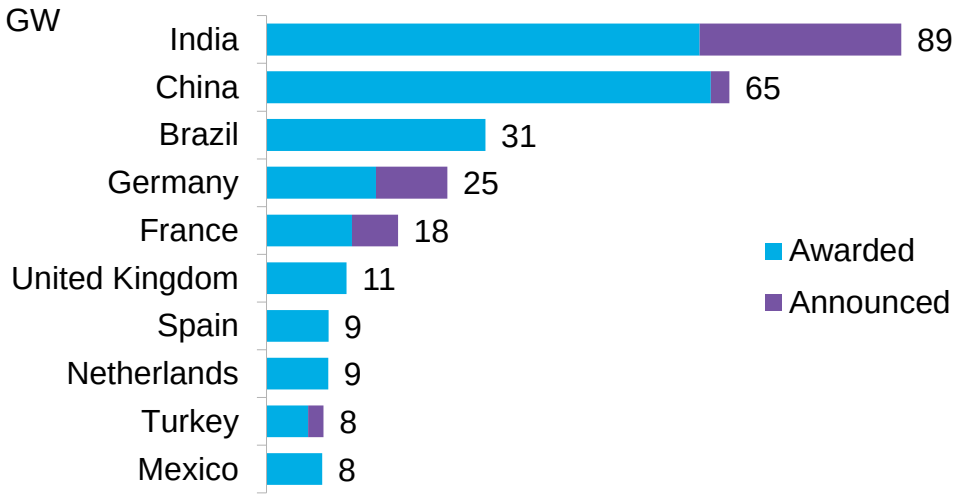
- The rapidly falling tariffs at renewable auctions have raised concerns that IPPs will be forced to build low-quality projects.
- The continual stream of mergers and acquisitions in India, typically involving international investors, suggests that sever under-performance of projects is not common.
- As most projects have been added in the past decade, it is still too early to make large-scale assessment of their long-term financial and operational performance.


REPLACE
LOCKING NUTS
AFTER REMOVAL

Explaining the Indian clean power revolution

Record volumes of auctions and competition have driven down tariffs

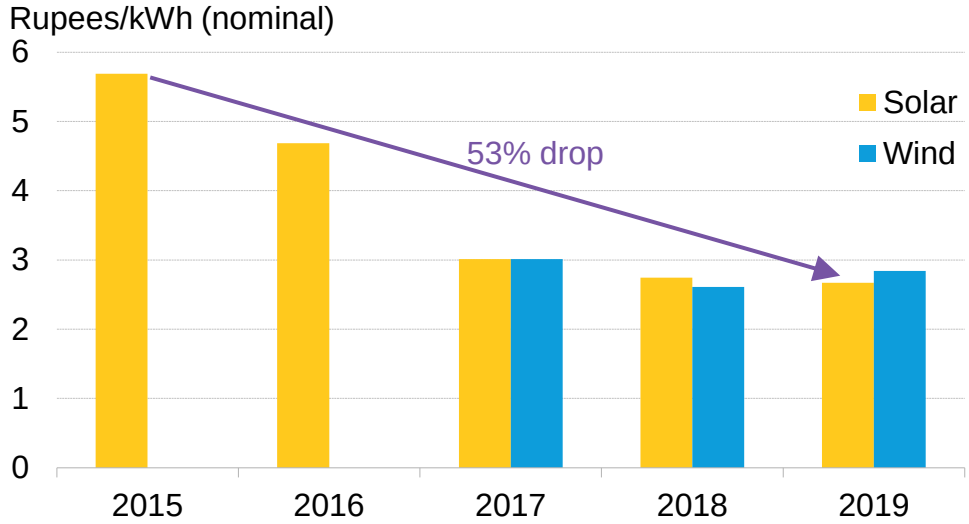
India is the world's largest renewables auctions market (cumulatively till 2019)



Source: BloombergNEF. Note: Figures are cumulative over 2003-19

- In India, utility-scale wind and solar projects are primarily contracted through competitive auctions. A national target of having 175GW renewables installed by 2022 has ensured that the volume of auctions remains high.
- India's renewables auctions are conducted in a transparent process that follows standardized guidelines issued by the federal government. Tenders can go through multiple rounds of stakeholder consultations and amendments to encourage participation and help IPPs make informed bidding decisions.

Average auction tariffs fell steeply

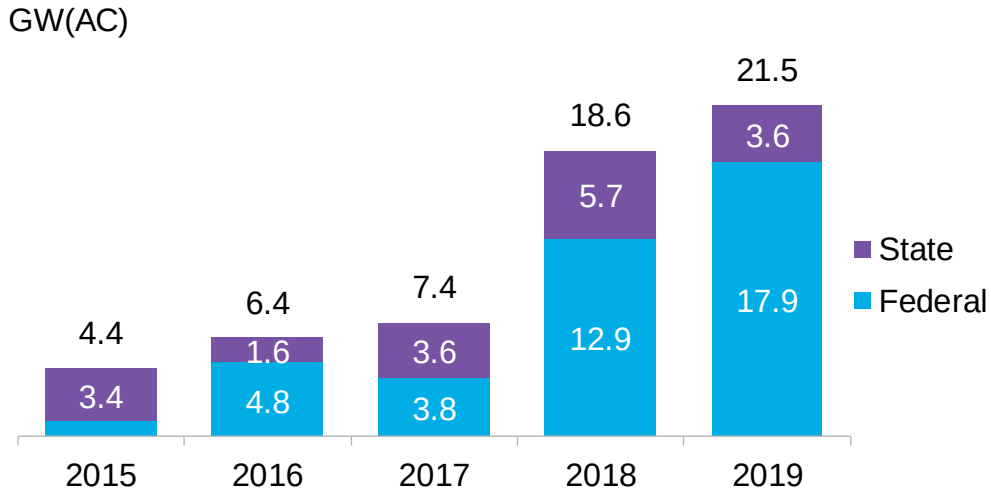


Source: BloombergNEF. Note: Volume weighted average tariffs shown. For solar, only utility-scale tariff based auctions are considered.

- The 2019 average auction tariffs for solar are less than half of their 2015 levels. The decline has been less steep for wind, but for both technologies, the average tariff in 2019 was below 3 rupees/kWh ($0.04 in June 2020).
- Extreme competition has led to IPPs optimizing each stage of project design, construction, maintenance and operation. They have devised complex financial strategies to lower their cost of capital, and India's large pipeline of tenders gives developers strong bargaining power when negotiating prices with equipment suppliers.

Federal auctions have provided a strong investment signal to investors

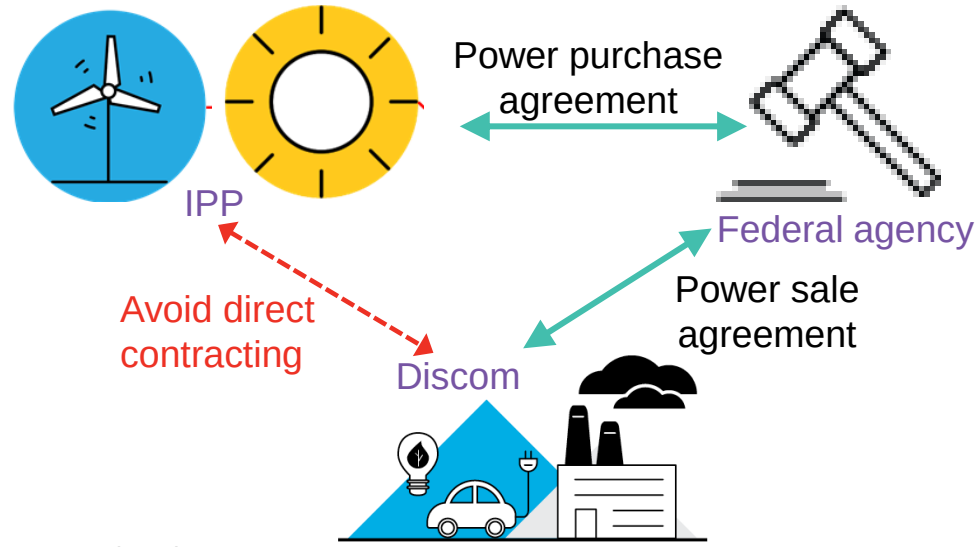
Federal auctions have far surpassed volumes of states' auctions



Source: BloombergNEF. Note: Excludes auctions where awards are known to have been canceled. For solar, only utility-scale tariff based auctions are shown.

- Federal auctions have overtaken state-level auctions since 2018. The poor financial health of state-government-owned electricity distribution companies makes IPPs reluctant to sign contracts directly with them. This led to state auctions being undersubscribed and delivering higher tariffs as IPPs factored in the bigger offtaker risks.
- At federal auctions, a federal agency such as Solar Energy Corp of India (SECI) acts as a intermediate procurer, and thus protects the IPPs from payment delays, giving them a quasi-sovereign guarantee.

Contracting structure for federal auctions

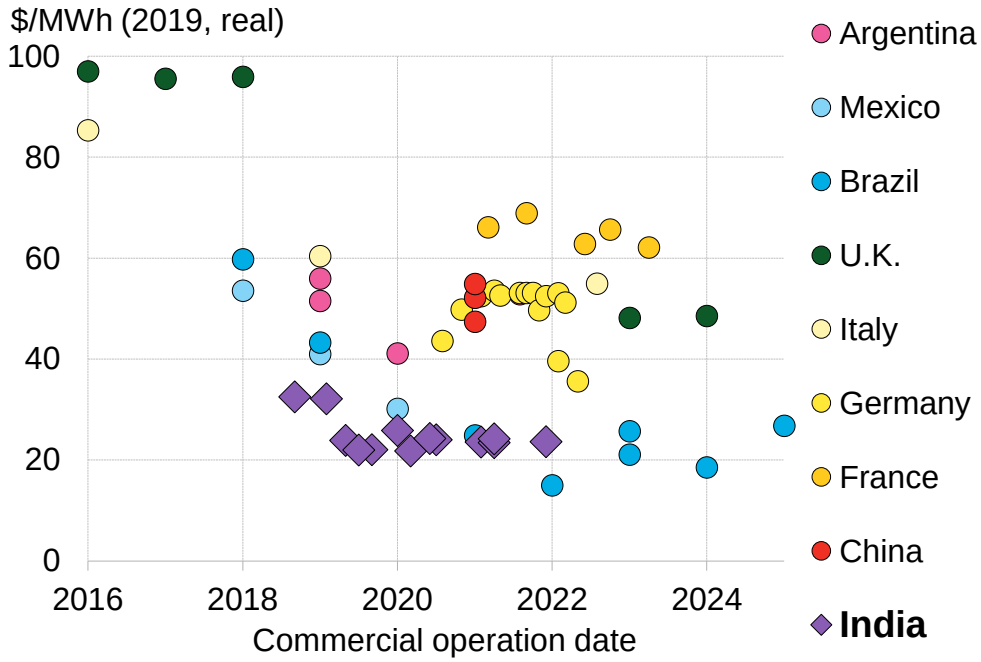


Source: BloombergNEF

- SECI maintains a payment security fund that can absorb the delay between the moment IPPs need to be paid, and that where power distribution companies can pay.
- As a last resort, federal agencies can also invoke the tripartite agreement between itself, India's central bank and the state governments. This arrangement allows the federal government to withhold financial assistance payments to state governments if distribution companies repeatedly fail to pay their dues to SECI for delivered power.

The levelized tariffs at India's auctions are among the lowest in the world

Levelized wind auction tariffs



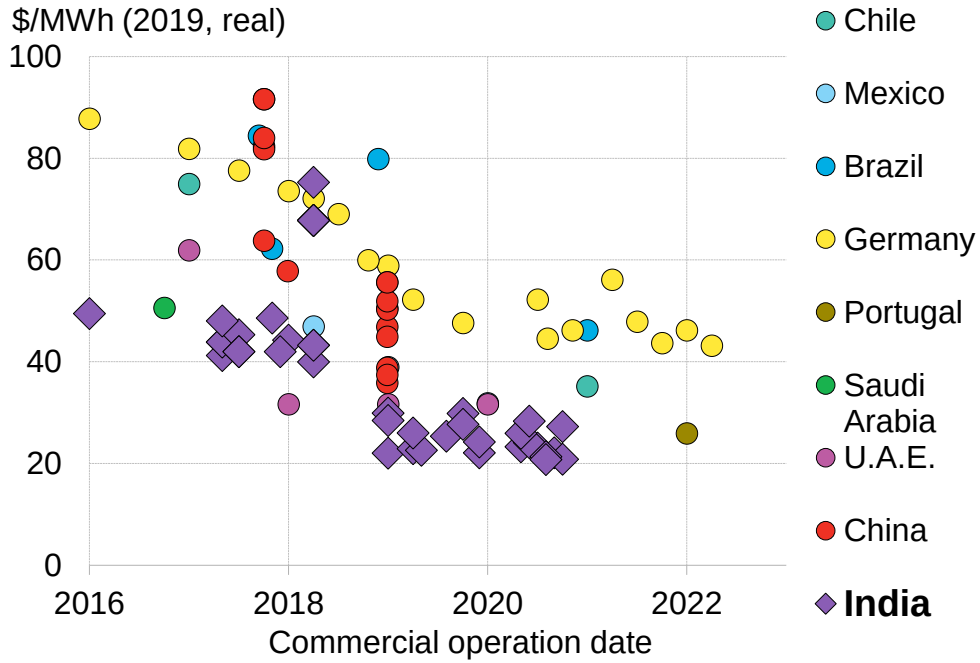
Source: BloombergNEF. Note: Representative 'inflation-linked' tariffs are shown.

What is a levelized auction tariff?

The levelized tariff calculation converts a local currency structured tariff to a common 2019 $/MWh base after accounting for inflation, currency of payment, project life and expected date of commercial operation.

This enables like-for-like comparison between auctions over time and different geographical locations.

Levelized solar auction tariffs



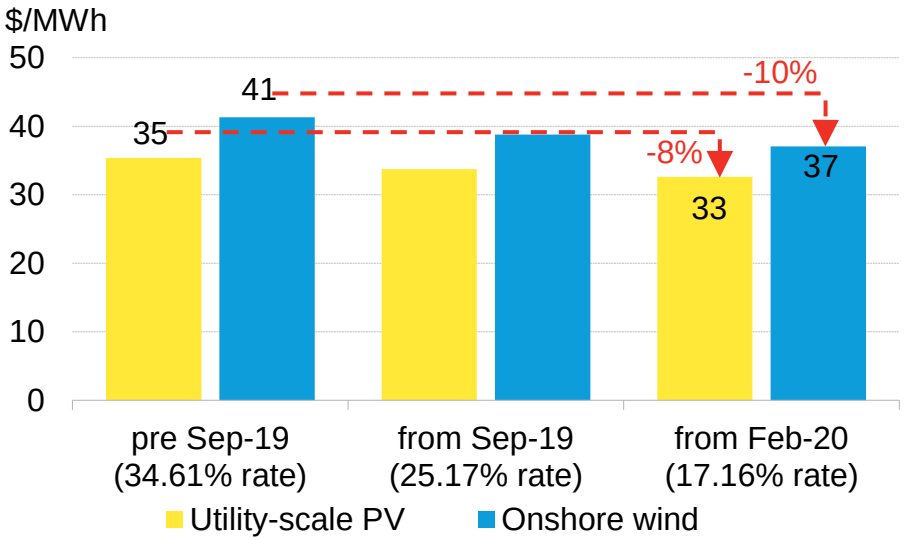
Source: BloombergNEF. Note: Representative 'inflation-linked' tariffs are shown.

- India's levelized auction tariffs for both wind and solar are among the lowest in the world, despite relatively higher borrowing costs and the absence of hidden subsidies.
- These prices are a reflection of India's hyper-competitive auctions and extreme project optimization by its IPPs. It is not uncommon for auctions in India to attract several times more bids than the capacity on offer.

Government policies have helped renewables become cost-competitive

Lower corporate tax	• The tax rate for new power generators is 17.2%, down from 34.6% prior to the renewables boom. • This reduces the levelized cost of electricity of solar and wind by 8% to 10%.
Accelerated depreciation	• An accelerated depreciation rate of 40% reduces the investors' income tax burden. • This encourages India's established corporations to diversify into clean power investments.
ISTS waiver	• Wind and solar projects commissioned before 2022 are exempted from Inter-State Transmission System (ISTS) charges and losses. • This reduces delivered cost of electricity for offtaker by up to 0.65 rupees/kWh.
Capital subsidy	• Residential rooftop PV installations are eligible for a 20% to 40% upfront investment subsidy. • Federal aid of 344 billion rupees ($5 billion in June 2020) for small-scale PV in agriculture was announced in 2019 under the PM-KUSUM scheme.
100% foreign direct investment	• Foreign direct investment is allowed without reviews. • Foreign utilities, VC/PE investors, sovereign wealth funds, pension funds and oil & gas majors have participated in India's clean power boom as a result.

Impact of lower tax rates on levelized cost



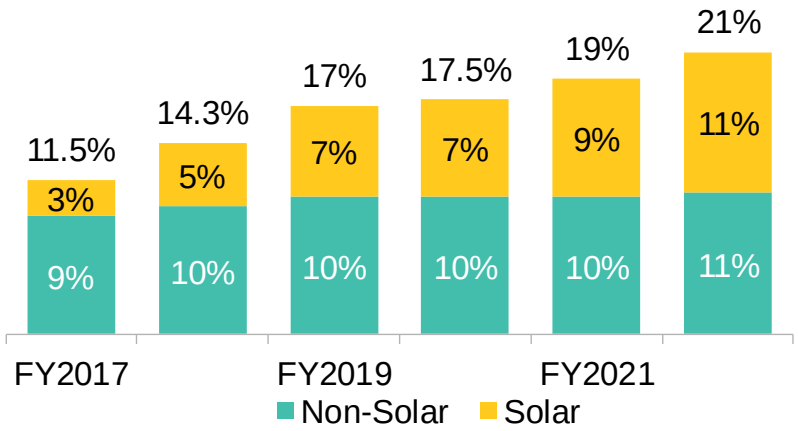
Source: BloombergNEF. Note: Comparison is done based on the benchmark levelized cost of energy for projects getting financed in 1H 2020.

- Accelerated depreciation attracted companies with taxable profits from other industries to invest in clean energy projects. As the sector matured, pure-play IPPs have taken the lead in building new capacity. The announcement of a further decrease in the tax rate will boost investor appetite anew.
- Capital subsidy are still be needed for segments that are relatively less developed, for example residential rooftop solar and small scale solar in agriculture.

Policies have also created demand for renewables and attracted investors

National targets	• India's large and regular wind and solar auctions are tied to the introduction of the target to reach 175GW of renewables by 2022, excluding large hydro. • A larger target of 450GW renewables has been set for 2030, this time with the option to include large hydro.
'Must-run' status	• Renewables have priority dispatch, which means they get access to the grid ahead of other technologies • Curtailment of renewables generation is not allowed except when required to preserve grid security.
Renewables Purchase Obligations	• Large power users (including discoms) are mandated to purchase renewables through a portfolio standard (RPO). • Although enforcement is weak, RPOs are the top reason cited for signing contracts for renewable energy
Green Energy Corridor	• Strengthening the intra-state transmission (ISTS) network as part of grid enhancement planning, covering eight states • In 2017, the federal government sanctioned 40.6 billion rupees ($630 million) as a financial grant for ISTS.
Solar parks	• Government agencies are responsible for identifying the land and building the grid connection infrastructure. • This gives IPPs access to large contiguous land zones without the risks associated with their acquisition.

Annual trajectory of national Renewables Purchase Obligations



Source: BloombergNEF, Ministry of Power. Note: Individual state regulatory commissions may have mandated different targets. Non-solar includes wind, biomass and small hydro.

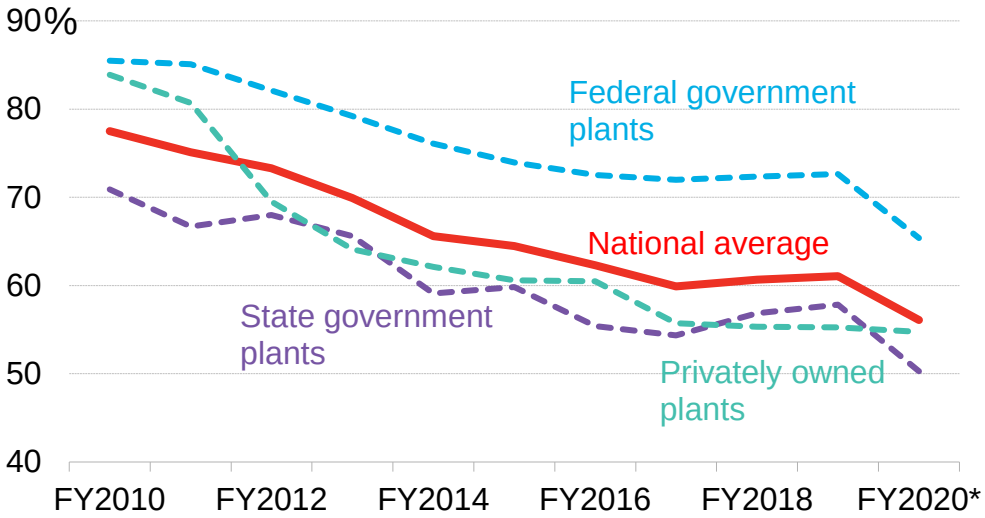
- The federal government's RPO trajectory has not been implemented by all states, but it remains a key driver of distribution companies signing long-term PPAs for renewables.
- The government is also considering a separate Hydropower Purchase Obligation to increase the utilization of existing large hydro plants and provide investment signals for new capacity.

The renewable energy sector in India has tremendous potential, and the government recognizes its ability to transform India's energy landscape. Hence it has tried to create an enabling policy framework to achieve the aggressive targets it has set for the sector. From trying to ensure easier availability of land through solar and wind parks, to setting up a dedicated public sector enterprise like SECI, many positive actions have been taken. The most recent being the removal of tariff caps on bids, reflecting the government's faith in the sector's maturity.

Sumant Sinha, chairman and managing director, ReNew Power

The coal power fleet is increasingly under-utilized and challenged by renewables

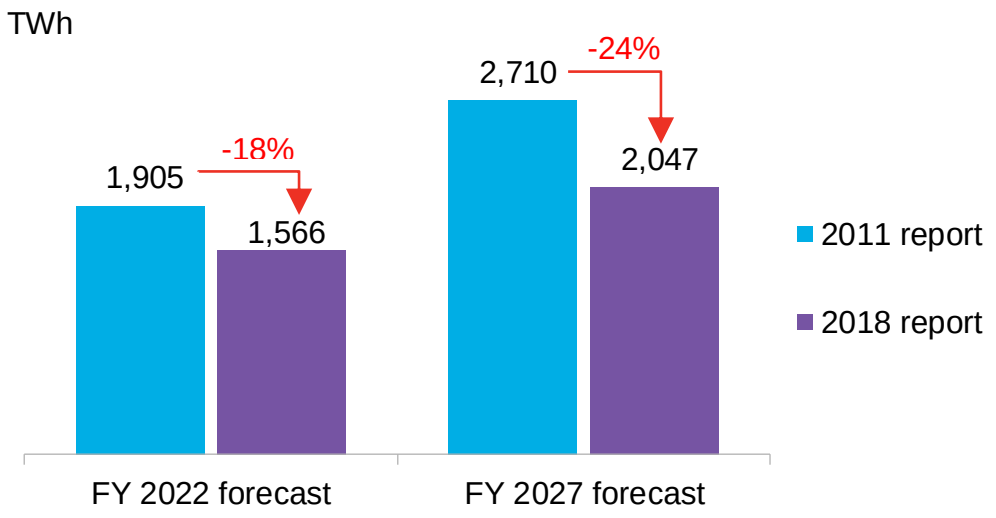
Utilization rates of coal plants



*Source: BloombergNEF, Central Electricity Authority. Note: FY2020 is the financial year from April 2019 to March 2020. *FY2020 data is provisional.*

- India's coal power fleet delivered just over half its maximum generation output in the fiscal year ending March 2020. This is a historical low, marking a 21-percentage point decline in a decade, from 78% in 2010.
- Projects owned by the federal government were used far more than those owned by private IPPs or state governments. This is because federal plants typically have lower fuel costs as they are located closer to the coal mines.

Official estimates of national power demand

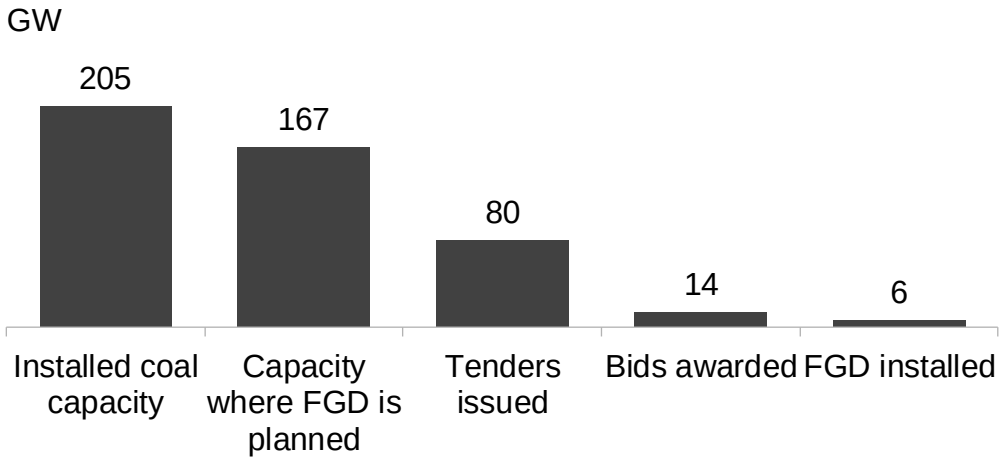


Source: BloombergNEF, Central Electricity Authority. Note: FY 2022 is the financial year from March 2021 to April 2022. Ex-busbar electricity demand is shown

- A key factor behind this overcapacity is the government's overestimation of the growth in national power demand, as seen from the downward revisions made in 2018. This led to over-investment in new coal capacity, with 96GW of coal plants added to the grid over 2011-2016 alone.
- At the same time, renewables capacity grew, with the introduction of the 2022 targets and its falling costs. Renewables have priority dispatch and the newer installations have lower levelized costs of energy, helping them secure a larger share of growth than coal.

More stringent emission norms, and water shortages, impact the outlook for coal

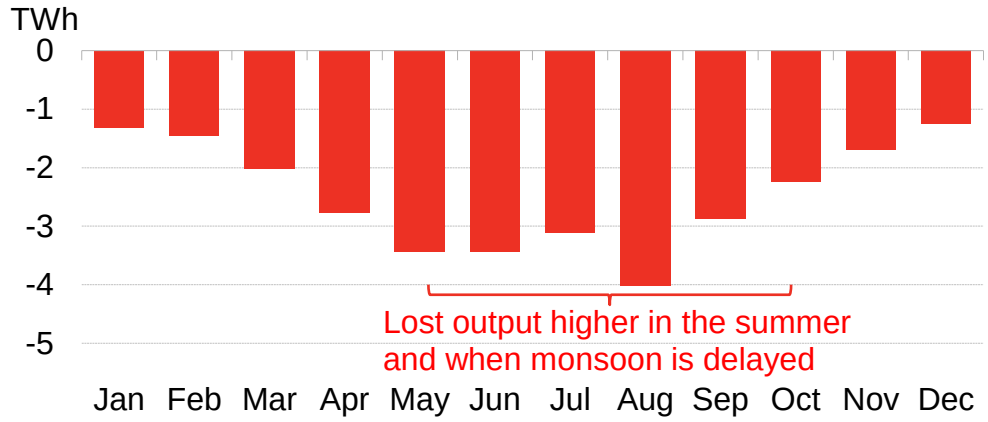
Status of flue gas desulphurization equipment (FGD) installations in India at the end of 2019



Source: BloombergNEF, Central Electricity Authority.

- India's emission norms for new coal and gas power projects are among the strictest in the world, but enforcement is weak. The initial deadline to meet these was December 2017. It has now been extended to December 2022 due to widespread non-compliance.
- The International Institute for Sustainable Development estimated that India's coal plants need $12 billion to install SO2, NOx and particulate matter control equipment. This may increase tariffs by 0.32-0.72 rupees/kWh, adding to coal's competitiveness challenge.

Cumulative monthly losses in potential power output caused by water shortage, 2013 to 2016

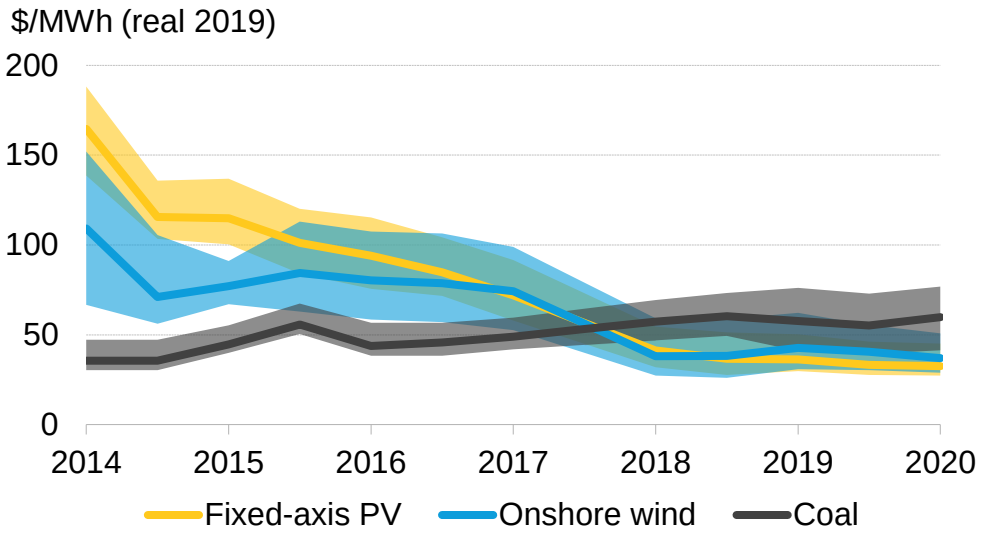


Source: World Resource Institute, BloombergNEF

- Nearly 90% of India's thermal fleet depends on freshwater for cooling and of these units, 39% are installed in high water-stress regions. The World Resources Institute calculated that 14 of India's largest thermal power companies lost over $1.4 billion in revenue between 2013 to 2016 because of water shortage related disruption.
- A government think-tank report suggests that 600 million Indians currently face high to extreme water stress. By 2030, the country's water demand could be twice the available supply, pointing to severe water scarcity. This creates risks for water availability for coal plants.

The falling costs of renewables challenge the economics of building new coal plants

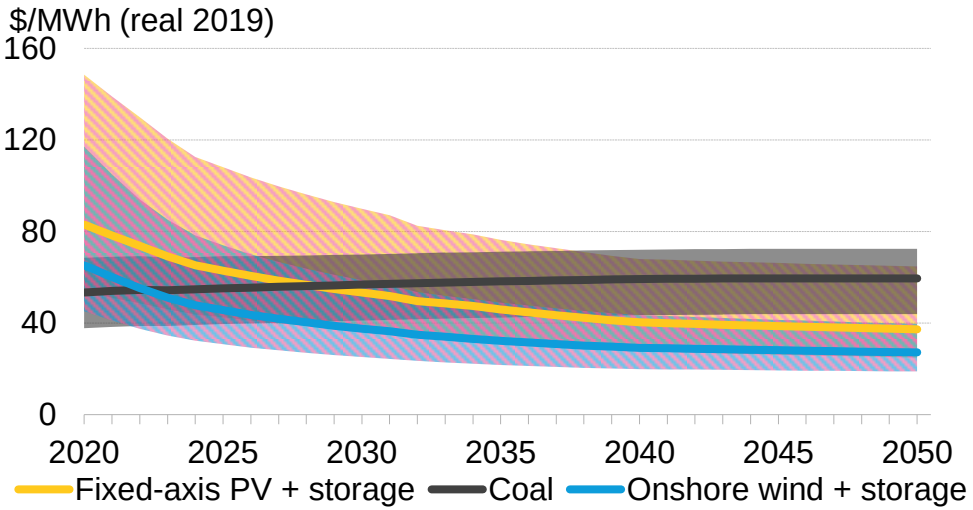
Historical trend of LCOEs in India



Source: BloombergNEF. Note: LCOE is levelized cost of electricity. Shaded areas show LCOE range.

- Solar and wind have been the cheapest sources of bulk power generation in India for the past three years. Since 2014, the mid-case levelized cost of energy (LCOE) has dropped by 80% and 66% for solar and wind respectively.
- In theory, the best-in-class wind farms and solar plants can generate power at $27-29/MWh, a third cheaper than our LCOE estimate for best-in-class new coal-fired power stations, at $41/MWh today.

LCOE of dispatchable renewables and coal



Source: BloombergNEF. Note: LCOE is levelized cost of electricity. Four hour battery storage is considered and size of the battery is 25% to 100% of the installed wind/solar capacity. Shaded areas show LCOE range.

- Renewables need to be associated with storage to displace coal more widely in the future. We expect that mid-case new onshore wind and new solar combined with battery storage will out-compete new coal plants on a levelized basis by 2023 and 2029 respectively. The coal LCOE includes the costs of meeting emission norms.
- Li-ion battery prices have fallen by 87% over the past decade. By 2024, BloombergNEF expects prices to be below $100/kWh on a volume-weighted average basis..

BloombergNEF

India’s clean power revolution from 2015 to 2019, by the numbers

65GW

New renewables capacity built

$50 billion

Asset financing for clean energy

1

India’s global ranking for volume of renewables auctioned

33%

Compound annual growth rate of generation from wind and solar

India has set an example, by making great strides towards transforming its energy sector by ensuring affordable, secure and clean energy access for all the citizens.

Looking at the expected upswing in the country's demand for energy, advances in grid integration, improved flexibility and well coordinated energy policy at federal and provincial levels, India will prove to be a great leader in global climate action. “

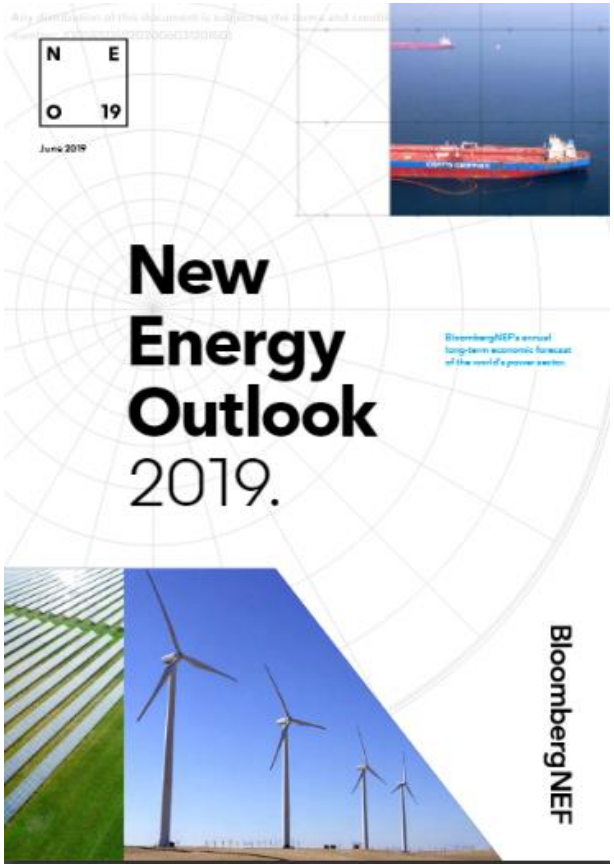
Upendra Tripathy, director general, International Solar Alliance

India’s power sector outlook to 2030

Comparing government projections and BNEF’s New Energy Outlook 2019

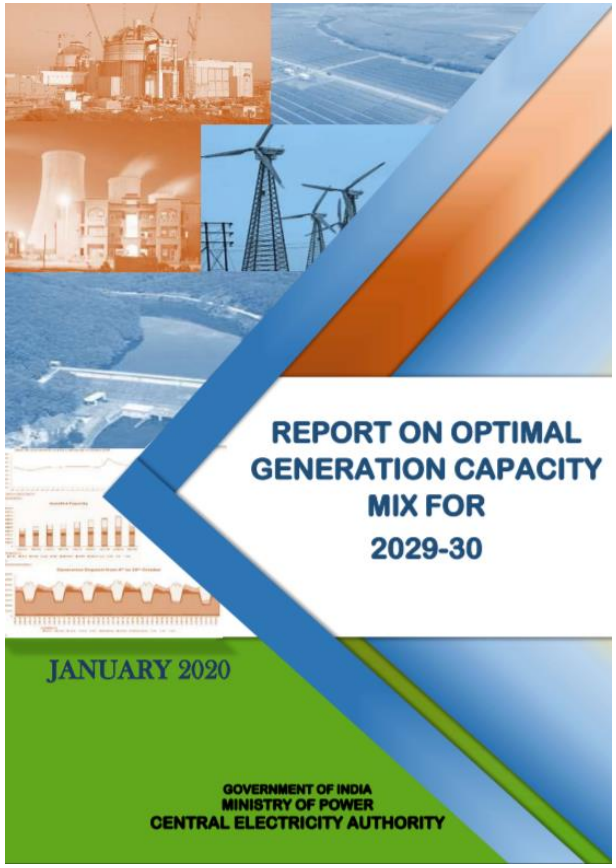
The world is looking at how India's power system may evolve

BloombergNEF's global long-term analysis



- The New Energy Outlook (NEO) is BNEF's annual long-term analysis of the global power system.
- It is an in-depth analysis of 20 countries, evaluating the economic drivers, tipping points and physical constraints that could shape the power sector until 2050.
- Our outlook is a based on least-cost technology options to meet future electricity demand.

Government's view on India's generation in 2030



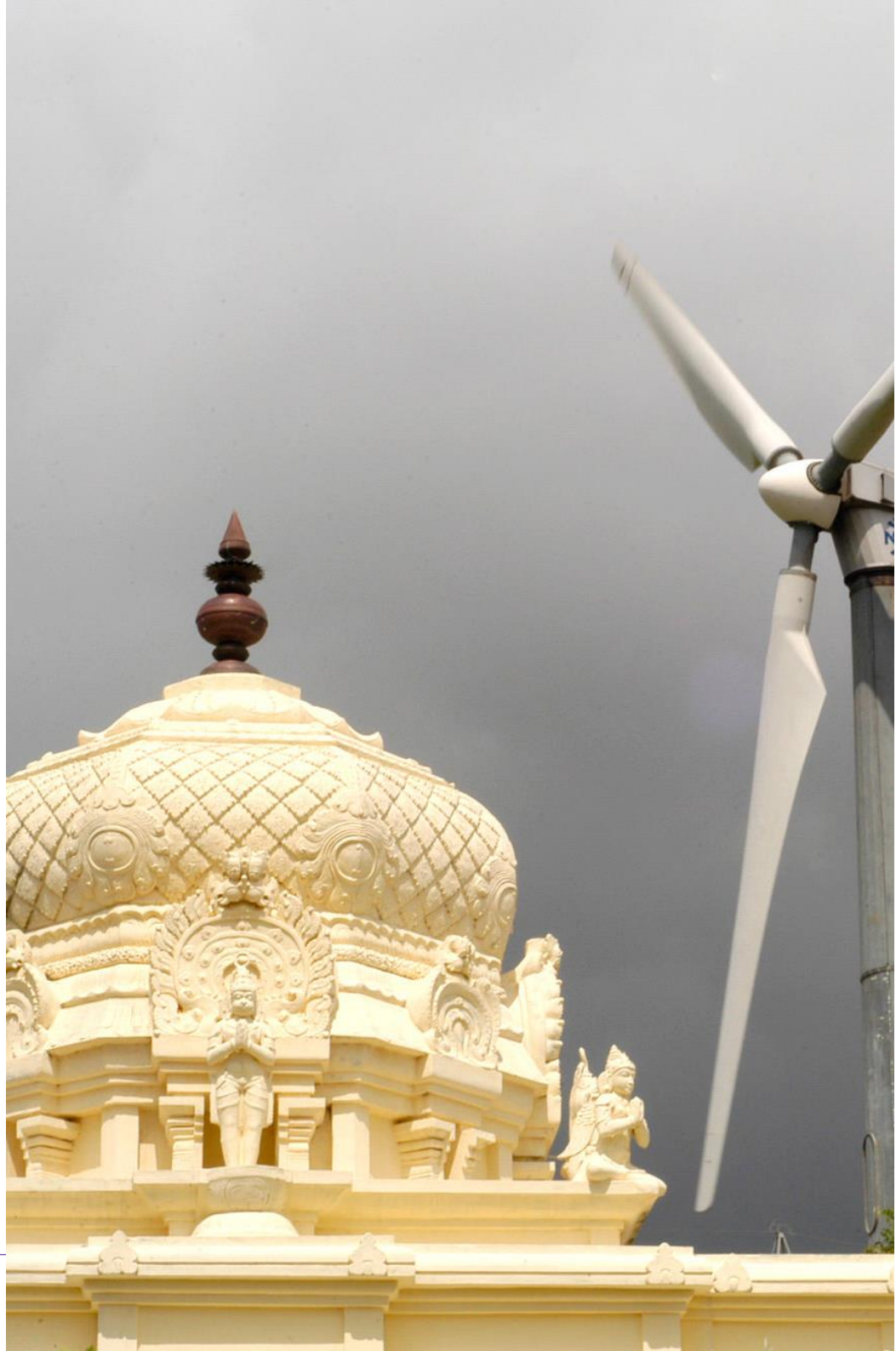
Source: Central electricity Authority

- India's Central Electricity Authority (CEA) projected the optimal capacity mix to meet the projected electricity demand in the year 2029-30
- It considers possible/feasible technology options, intermittency associated with renewables and other constraints.
- The study aims to provide a basis for planning policies and systems to meet growing electricity demand.

India pledged in Paris that by 2030, 40% of our installed capacity will be from non-fossil-fuel based resources. We have already crossed 37%, and are expecting to get to 55-60% by 2030.

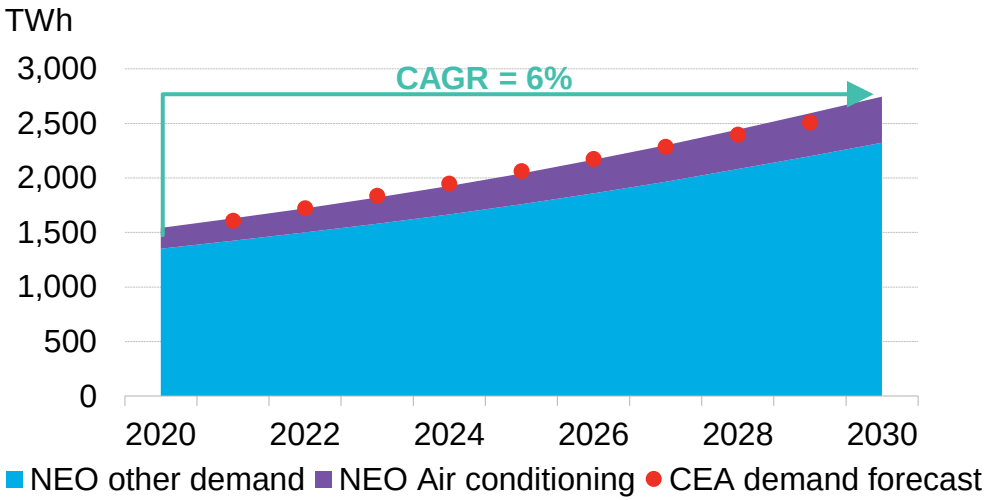
The question before us as a country, and as the world, is whether the environment is important or not, and whether we want to leave behind a livable world for our great grandchildren. “

Shri Raj Kumar Singh, Union Minister of State (Independent Charge), Ministry of Power and Ministry of New and Renewable Energy, and Minister of State, Ministry of Skill Development and Entrepreneurship



India's power demand is expected to grow by 80% in ten years

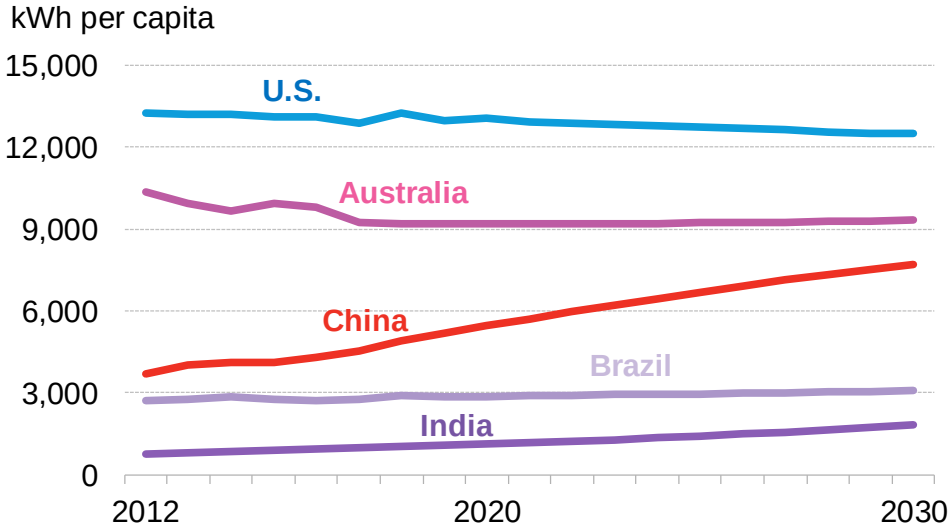
Demand projections in NEO and CEA follow similar trajectory



Source: BloombergNEF NEO 2019, Central Electricity Authority. Note: CEA forecasts are interpolated for years not available and offset by three months for calendar year comparison. CAGR = Compound Annual Growth Rate

- India's power demand in 2030 will be around 2,700TWh, up from 1,500TWh in 2020.
- Increasing population and GDP per capita will continue to drive power demand growth in the next decade. Newly connected rural consumers will also expand their use of electrical appliances. Rising demand for air conditioning will push up its power usage by 25% by 2030.
- The share of demand from electric vehicles is less than 0.5% by 2030 , despite early signs of growth by 2030.

Per-capita electricity use remains low by global standards even in 2030

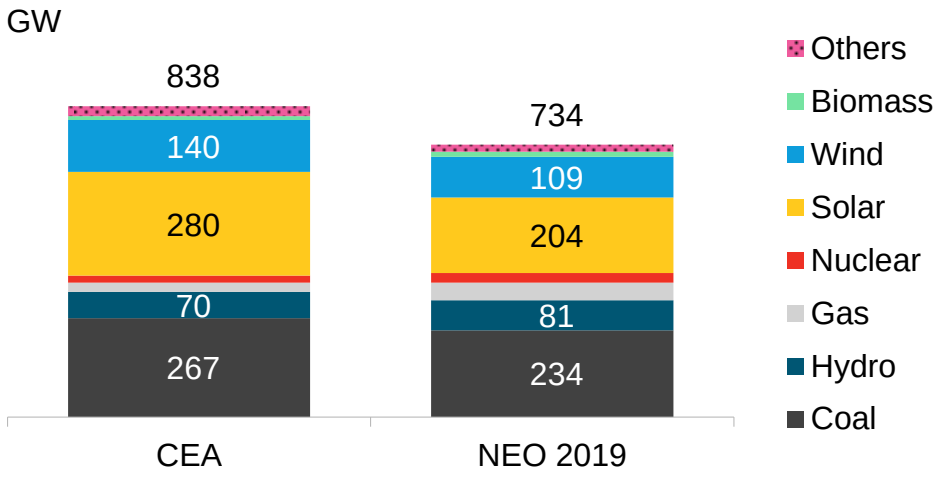


Source: BloombergNEF NEO 2019.

- Despite the rise in power demand, per-capita electricity consumption in India will continue to remain below that of many developed and developing economies. Even by 2030, India's per-capita demand is lower than Brazil's today.
- This suggests that there is room for power demand to grow well beyond 2030, as India catches up with global trends in per-capita electricity requirements.

Government's vision is more bullish than our least-cost system modeling results

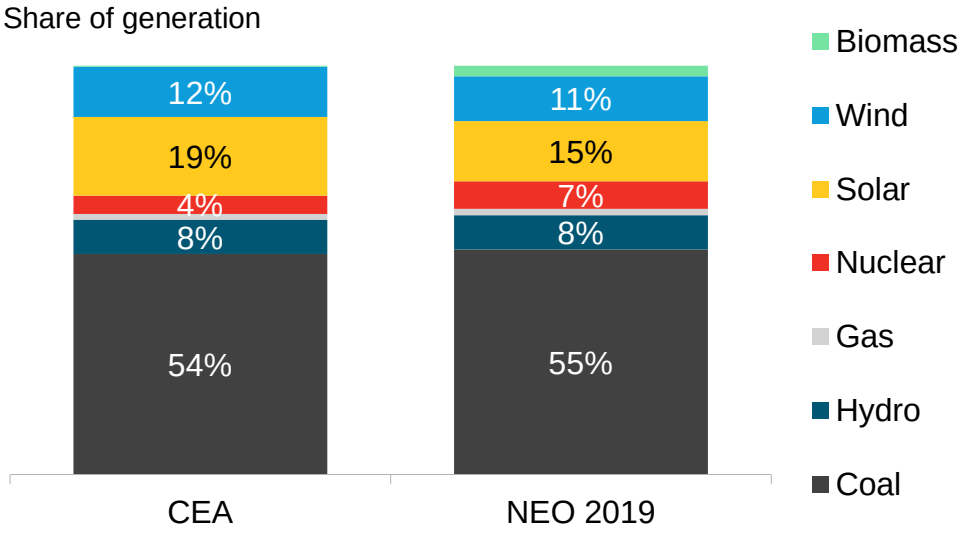
2030 capacity mix



Source: BloombergNEF NEO2019, Central Electricity Authority. Note: Solar capacity is in AC. An inverter loading ratio of 1.3 is assumed for NEO 2019. CEA's figure's for financial year ending March 2030. Others include batteries, demand response and oil.

- CEA estimates that the size of the Indian grid will expand to 838GW by FY2029-2030, compared to NEO 2019's projection of a rise to 734GW by 2030. CEA is more bullish on cumulative solar, wind and coal than BNEF.
- NEO 2019 predicts installed capacity of 204GW(AC) of solar, 109GW of wind (onshore and offshore) and 234GW of coal by 2030. By 2030, 62% of installed capacity would be non-fossil fuel based. This is significantly higher than the 40% India committed to under the Paris Agreement.

2030 generation mix

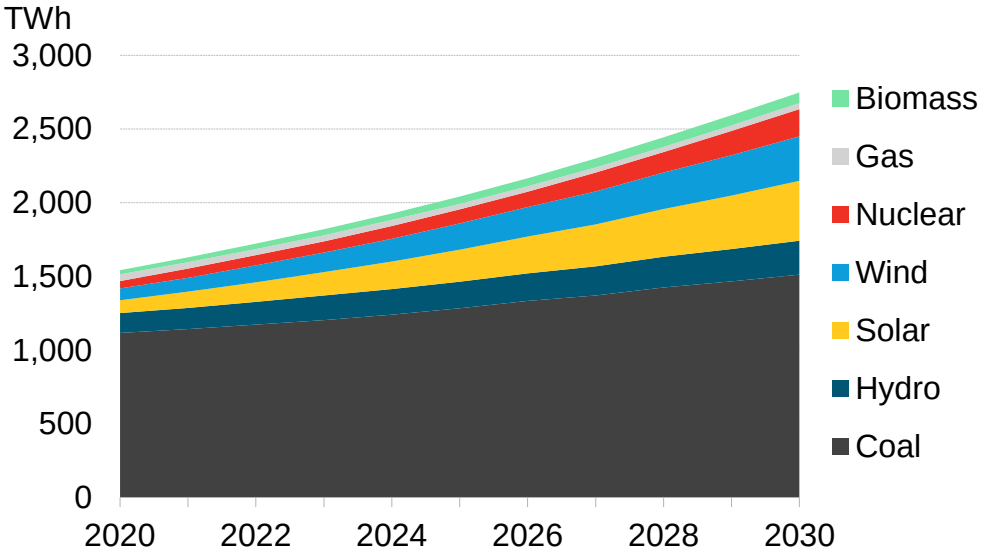


Source: BloombergNEF NEO 2019, Central Electricity Authority. Note: CEA's figure's for financial year ending March 2030.

- CEA projects 2,518TWh of gross electricity generation by FY2029-30, compared to a 9% higher figure of 2,747TWh for 2030 in NEO 2019. The plant capacity factors are higher in NEO 2019, leading to more generation from lower capacity compared to CEA projections.
- CEA expects India to source 54% of electricity from coal, 19% from solar and 12% from wind by 2029-2030. NEO 2019 projects that coal would supply 55%, and solar and wind just 15% and 11% respectively by 2030.

Coal fleet grows more slowly, but it is utilized much better

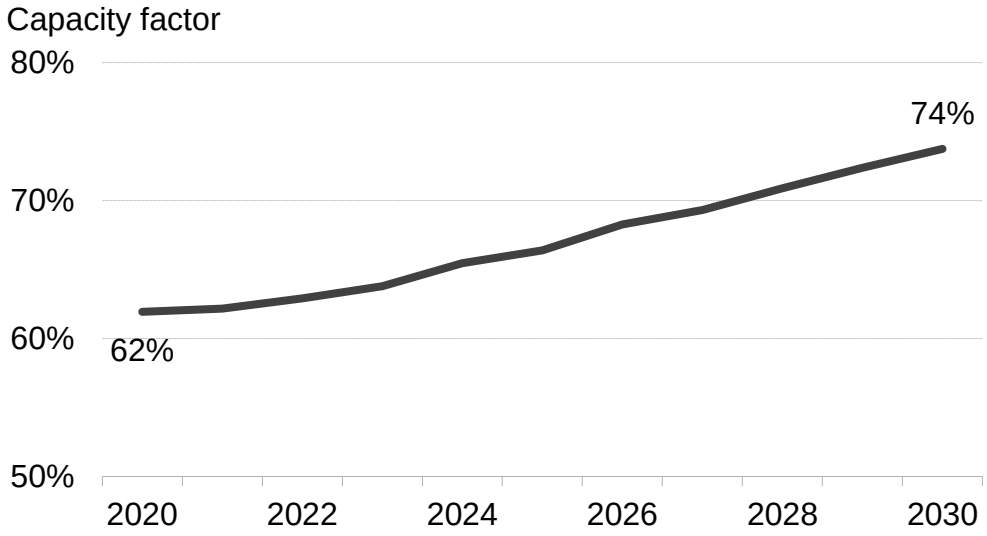
The next decade will see more generation from renewables, but also coal



Source: BloombergNEF NEO 2019.

- In NEO 2019's least-cost pathway, generation from solar and wind grows by 365% and 281% respectively between 2020 and 2030, to reach 26% of all electricity produced.
- Coal power generation also rises, but at a considerably slower pace of 35% over ten years.

Coal fleet utilization rises by 12 percentage points



Source: BloombergNEF NEO 2019.

- However, NEO 2019 shows that coal plants' capacity factor would improve markedly from now to 2030, as fewer coal plants are added in a market with rapidly growing power demand.
- Coal plant portfolio owners may decide to retire older plants in order to improve the utilization rate, and hence efficiency and return, of their newer plants.

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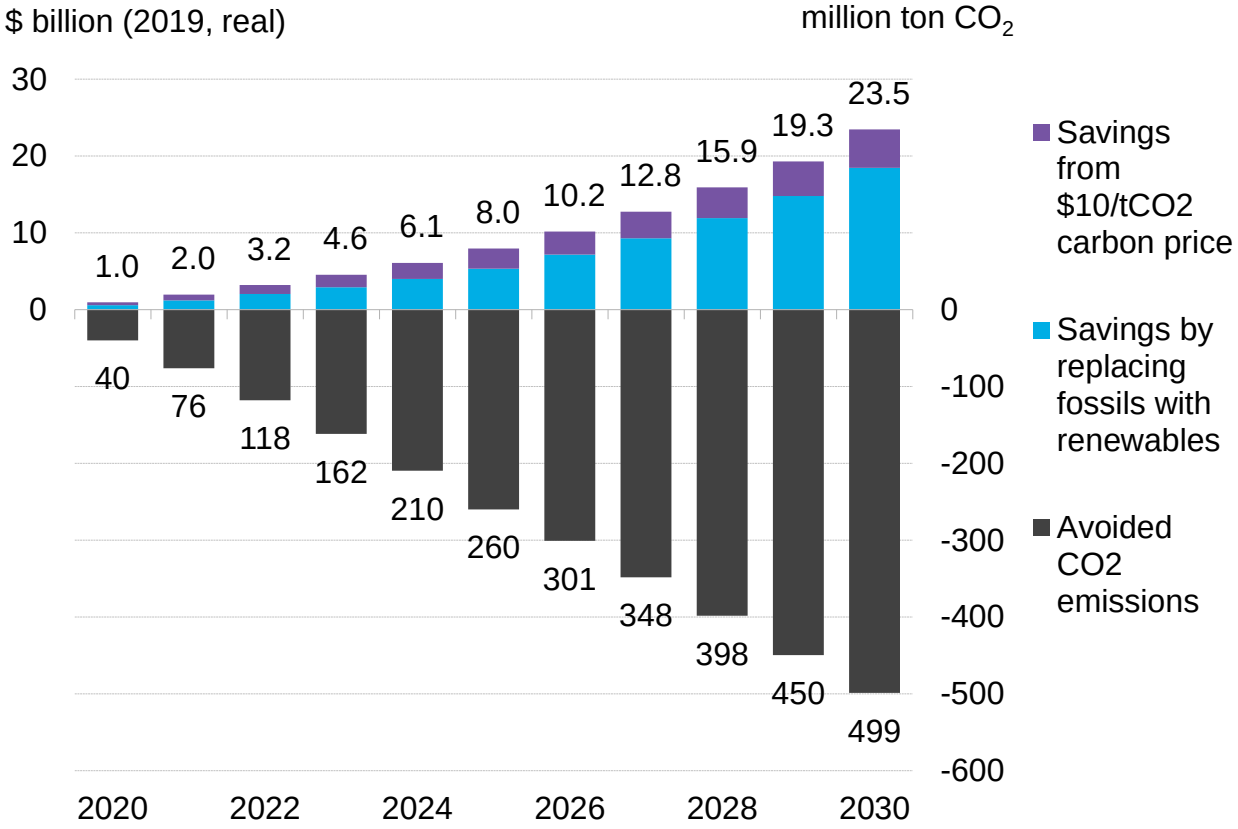
The least-cost path saves money, and lowers CO_2 emissions considerably

Keeping the momentum on building renewables produces rising benefits each year as their cost declines

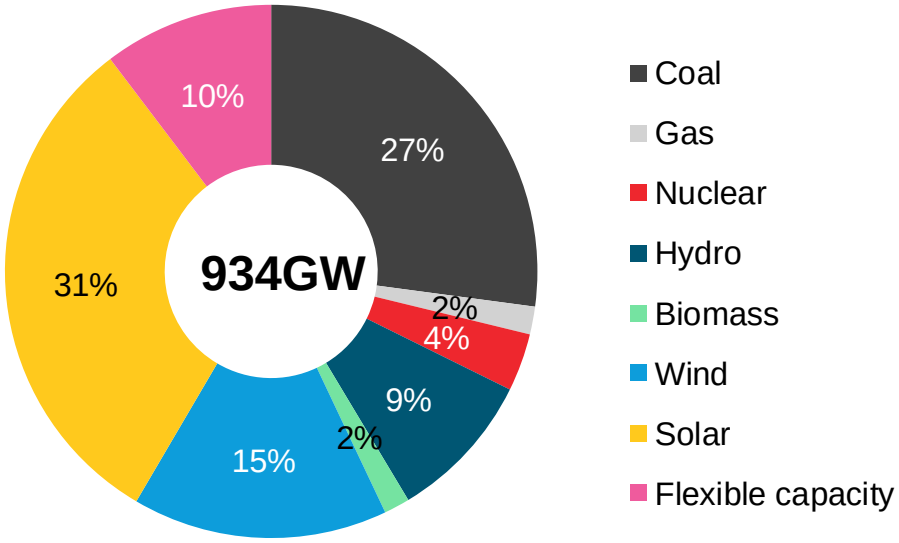


Source: BloombergNEF. Note: Annual savings and avoided CO2 emissions are shown based on the comparison of generation in NEO 2019's least cost projections and a scenario where no new renewables are built from 2020 onwards. The cost of transmission, distribution and real time balancing of demand-supply is not considered.

- We compare the outcomes of a no-new-renewable build scenario to the least-cost approach modelled in NEO 2019.
- We find that India saves $78 billion cumulatively in electricity generation costs from now to 2030 by following the least-cost path to meeting electricity demand. This is a estimate based on the low-case forecast LCOEs for all technologies. It also does not account for any additional grid requirements or balancing for the intermittency of renewables. To put saving in context, India's banks had $79 billion of credit deployed to the power sector at the end of 2019.
- In addition, India also avoids 2,860 metric tonnes of CO_2 emissions with the expansion of renewables capacity. To compare the scale of abatement, 2,771 MtCO2 were emitted by all of India's power plants put together from March 2017 to March 2019.
- Even at a low nominal carbon price of $\$10/tCO_2$, the avoided emissions would be worth $29 billion over the period.

India builds 450GW renewables by 2034 and will need 10% flexible capacity in NEO 2019

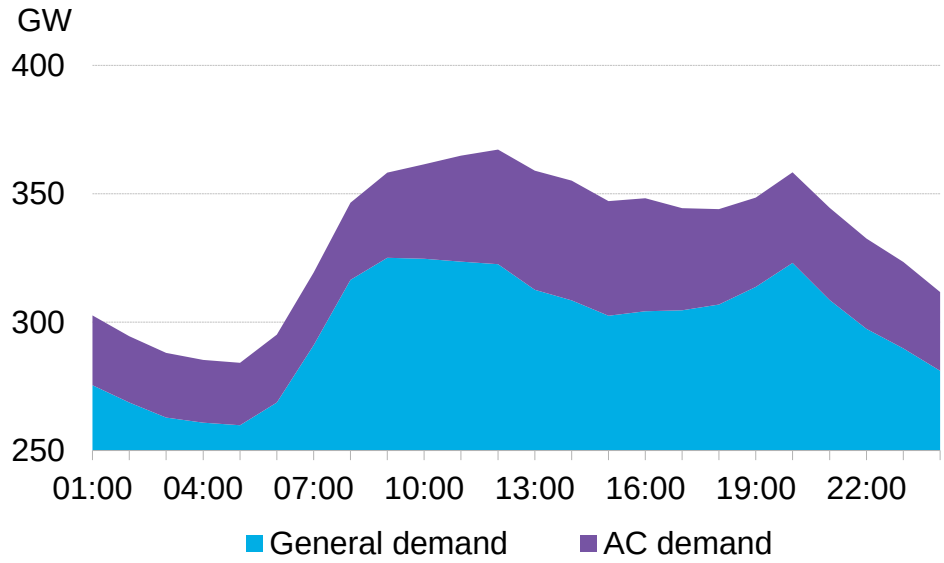
2034 – grid connected capacity mix



Source: BloombergNEF NEO 2019. Note: Flexible capacity includes peaker gas, pumped hydro, batteries and demand response. Solar capacity is in AC.

- NEO 2019 shows that India could reach over 450GW of renewable energy (excluding hydro) by 2034, close to the 2030 target. About 48% of the total capacity mix could be made up of solar, wind and biomass by then.
- India's total grid-connected capacity would reach 934GW by 2034, with more than 10% made up of flexible capacity sources which aid in renewables integration.

Typical demand profile on high air conditioner use day in India in 2034

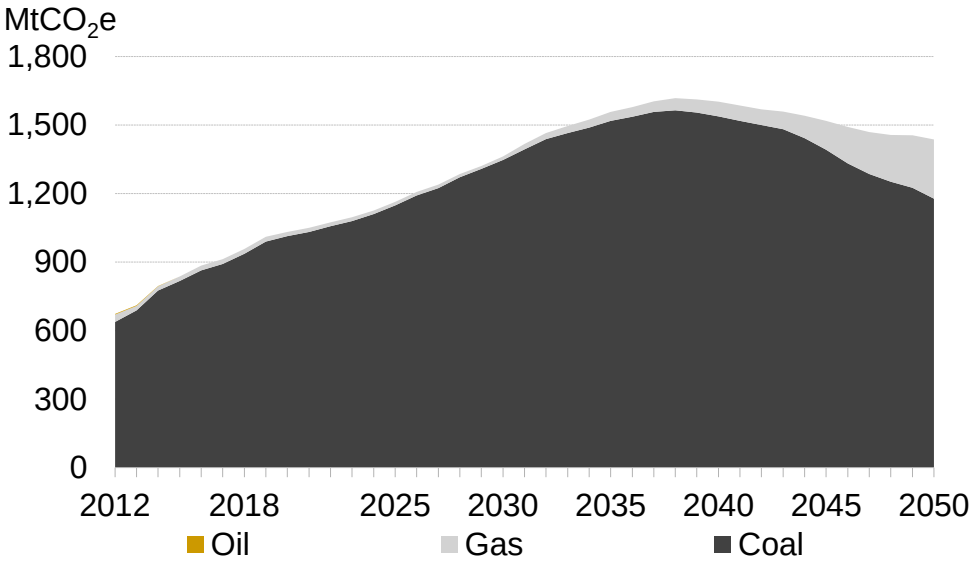


Source: BloombergNEF NEO 2019

- India's power demand is expected to peak at midday by 2030s instead of early evenings today, because of higher residential and commercial demand for air-conditioning.
- This fundamental shift in peak demand to midday (coinciding with peak solar generation), from a pre-dominant evening peak now, will require additional sources of flexibility. These would preserve system stability in periods of sharply shifting demand and supply.

450GW of renewables would keep India on track to meet peak power sector emissions

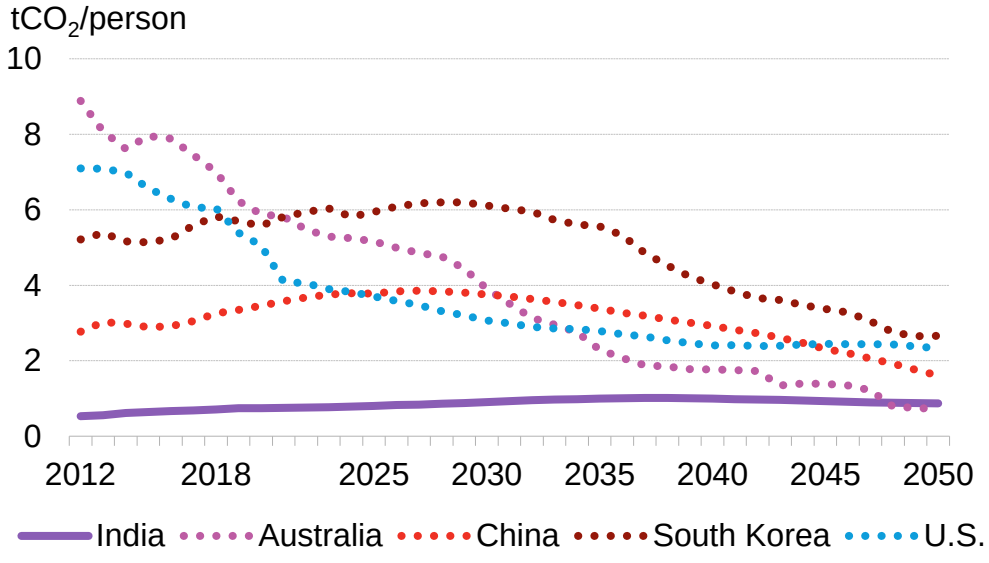
Power sector carbon emissions in India



Source: BloombergNEF NEO 2019

- High renewable energy penetration in the Indian grid could help the country reach peak power sector carbon emissions by 2038.
- India's emissions trajectory closely follows the fate of its coal plants, as 98% of current power sector carbon emissions originate from there.

Per-capita power sector carbon emissions



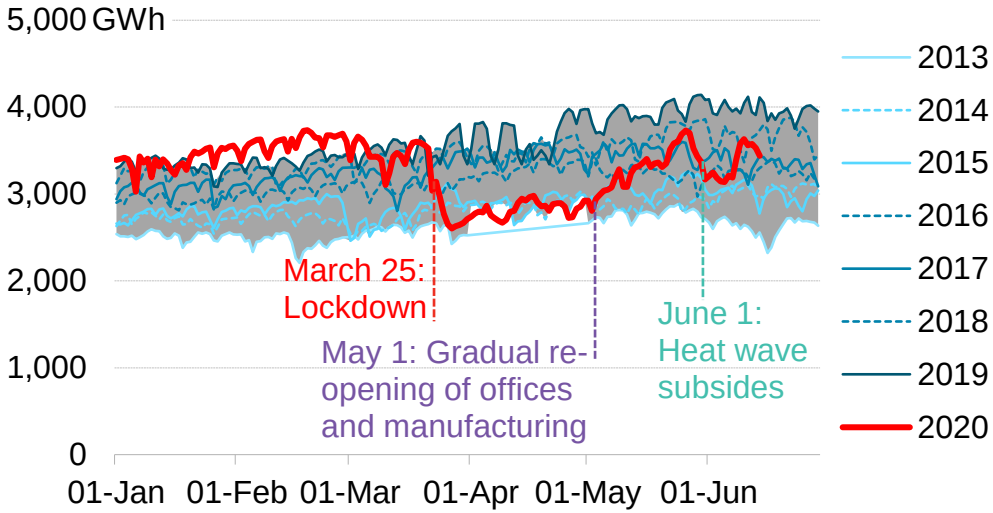
Source: BloombergNEF NEO 2019

- Emissions from power plants are expected to rise by 69% to 1,617MtCO2 by 2038, from an estimated 958$MtCO_2$ in 2018. By 2050, emissions are expected to decline by 11% from the peak, to 1,437$MtCO_2$ if India's energy sector can continue to invest in more clean capacity.
- High renewable energy penetration would also mean that, even though India's absolute power sector carbon emissions increase, per-capita emissions only rise marginally to 2038, after which they decline.

BloombergNEF

Covid-19: slowing power demand growth, but not the energy transition

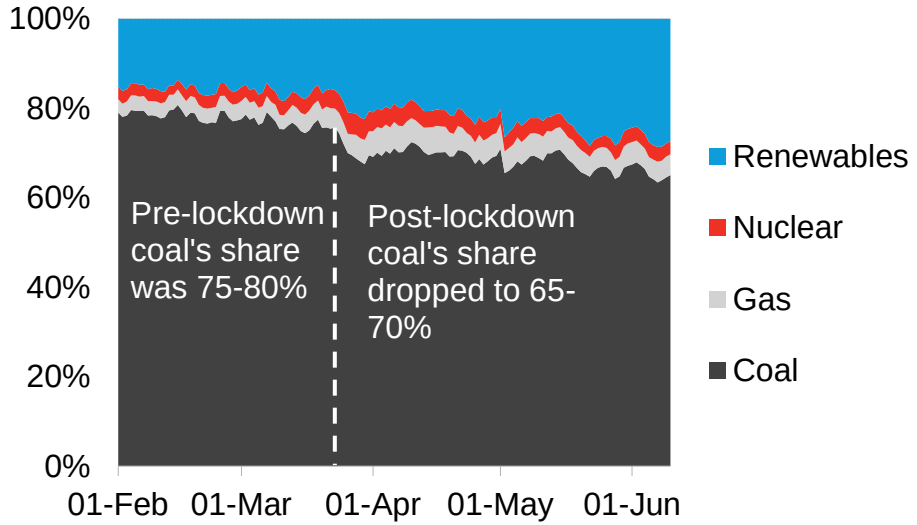
Power demand is recovering slowly



Source: BloombergNEF, Ministry of Power, Power System Operation Corp Ltd.

- India's power demand fell by 36% in the first week of the Covid-19 national lockdown as commercial and industrial users shut operations. Demand started to pick up after the economy began to gradually re-open.
- The share of renewables in the generation mix before India's virus lockdown was 14-18%. After March 25, the drop in power demand led to lower utilization of coal plants. Wind and solar generators were protected by their priority dispatch. This led to the share of renewables going up to nearly 30%.

Share of renewables went up post-lockdown

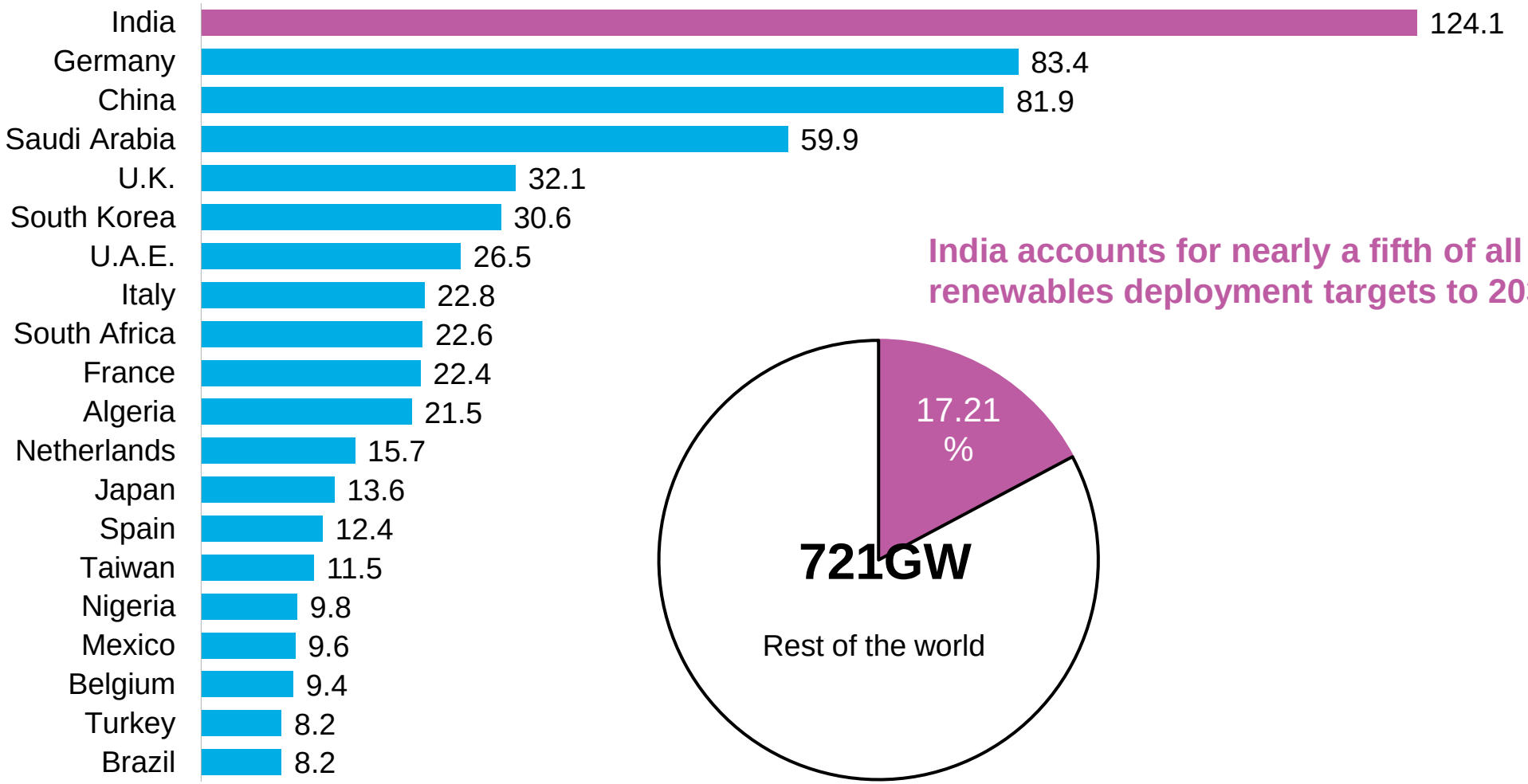


Source: BloombergNEF, Ministry of Power. Note: Renewables includes large hydro, small hydro, biomass, solar and wind.

- The pandemic has given grid operators and discoms the experience of operating the power system with higher shares of intermittent generation. This should help them plan the flexibility requirements and dispatch procedures for a 450GW renewables future.
- The underlying economic drivers of LCOEs for wind and solar remain largely unchanged. With the governments supportive policies, the Covid-19 pandemic is not expected to alter India's path to 450GW renewables.

India’s renewables ambition in perspective

Top 20 largest legislated government renewables additions targets with deadlines between 2020 and 2030



India accounts for nearly a fifth of all renewables deployment targets to 2030

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF. Note: Includes only solar, wind, biomass and geothermal. India has a target of 175GW renewables by 2022.

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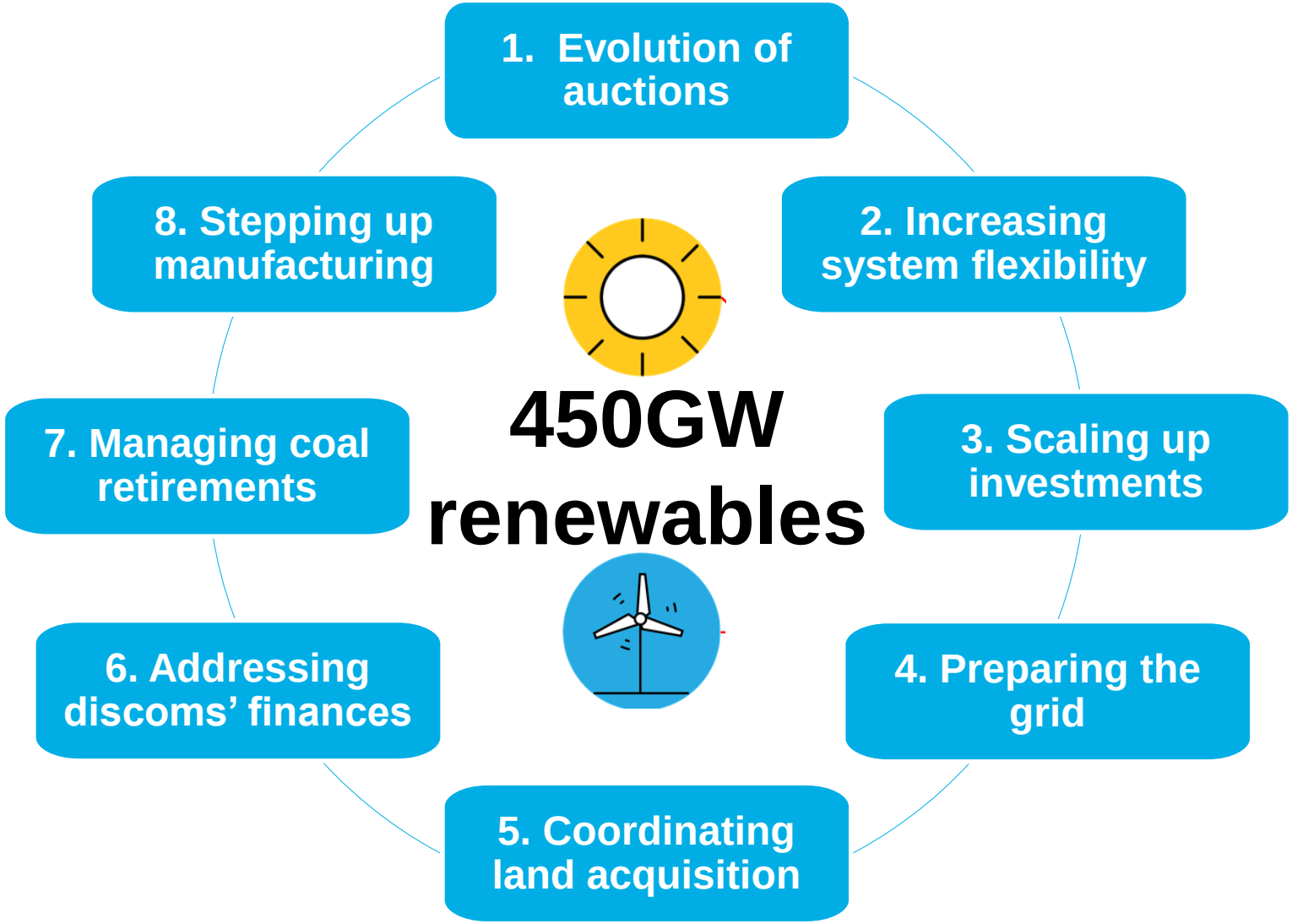
Opportunities and challenges ahead

Fulfilling India’s 2030 ambitions

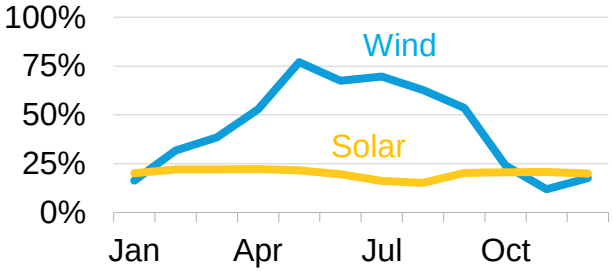
Eight areas of focus to get to 450GW of renewables



Source: BloombergNEF

New auction designs force renewables to compete against dispatchable coal

Standalone wind, solar do not provide high output all year round



Source: BloombergNEF. Note: 1MW(DC) solar and 1MW wind modelled for a high resource site in Kutch, Gujarat..

- India initially auctioned only standalone wind and solar projects, as the focus was solely on increasing renewables capacity. Of course, solar projects do not generate through the night, but wind output is also highly seasonal.
- Load balancing has become more difficult for grid operators and discoms, as the share of intermittent renewables increased rapidly in the past five years. At the same time, India's distribution companies are being pushed by the regulators to procure more renewable energy to meet the mandated purchase obligations. Thus, the discoms are now driving the next stage of auctions through 'demand-driven' tenders.
- These new tenders put more responsibility on developers, by defining hours and volumes of supply and transferring balancing responsibilities to IPPs.

Auction Configuration	Match supply to demand	Increase transmission use	Increase capacity factor	Reduce intermittency	Other reason	Capacity auctioned
Wind-solar hybrid					-	1.440MW in two auctions
Renewables peak power supply					Mandate use of storage	1,200MW in one auction
Round-the-clock renewables					Likely to need storage	400 MW in one auction
Bundling coal with renewables					Use stranded coal plants	Draft policy published.

Source: BloombergNEF. Note: Qualitative assessment where green shows main benefit, yellow shows other benefits, grey is not applicable.

The renewable industry, especially solar, has progressed tremendously in the last decade and is continuously evolving. With the increase in the renewable energy share in the energy mix and the drop in storage prices, the sector is moving rapidly towards 24/7 supply from renewables power sources. With the recent integrated bids, like RE hybrids, round-the-clock supply and peaking power supply, designed to serve the needs of the grid, the sector is set for a massive leap forward. Providing dispatchable power to the grid is the only way the renewables sector will sustain its growth in years to come.

Ranjit Gupta, CEO, Azure Power

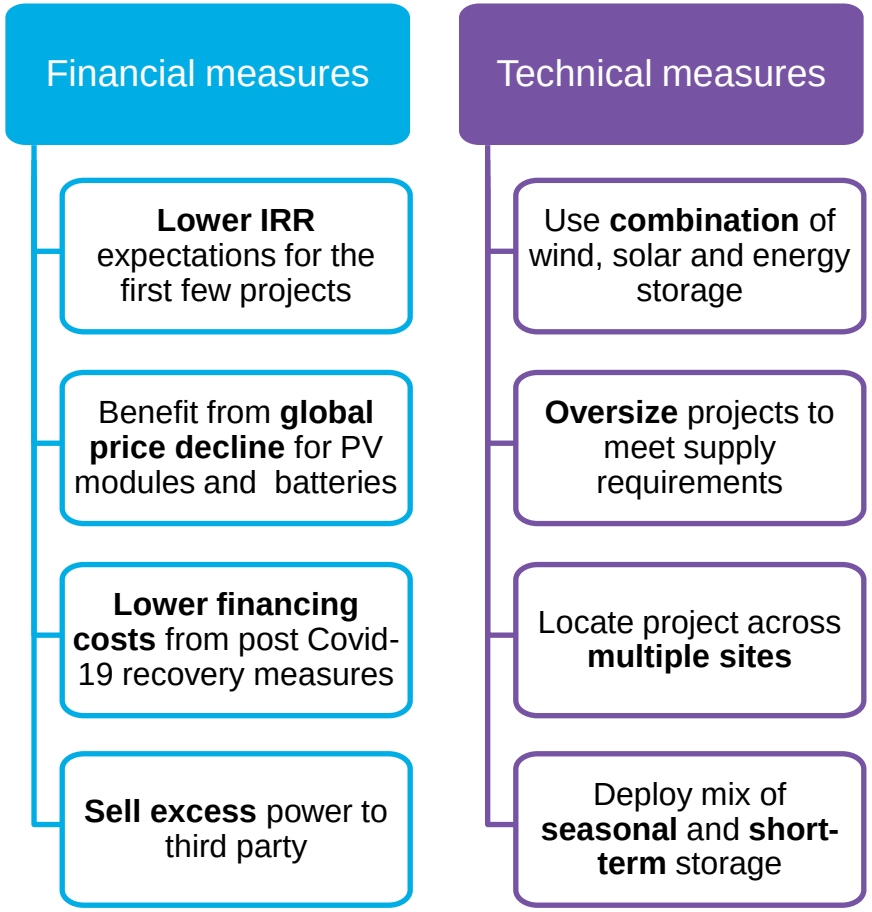
India's auctions are taking renewables closer to 24x7 power

Comparing the two auctions in 2020 that move beyond procuring standalone renewables

Parameter	Peak power supply auction	Round-the-clock auction*
Renewable capacity	1,200MW with no constraints on wind-solar ratio	400MW with no constraints on wind-solar ratio
Energy storage	Mandatory deployment of at least 600MWh but no technology constraints.	Not mandatory, but likely to be used to meet capacity factor requirements.
Supply requirements	3MWh/MW of project capacity to be supplied for six of the nine defined peak hours. Annual capacity factor (CF) at least 35%.	No time-of-day supply constraints. Minimum annual CF 80% with monthly CF of at least 70%.
Tariff structure	Off-peak tariff set at 2,880 rupees ($38.12)/MWh. Average peak hour tariff from auction was 6,303 rupees ($83.42)/MWh. No escalation to tariffs.	Levelized tariff of 3,600 rupees ($47.65)/MWh for 25 years, assuming 9% discount rate.

Source: BloombergNEF, tender documents. Note: The round-the-clock auction does not mandate 24x7 dispatch. It is rather an auction requiring high capacity factors.

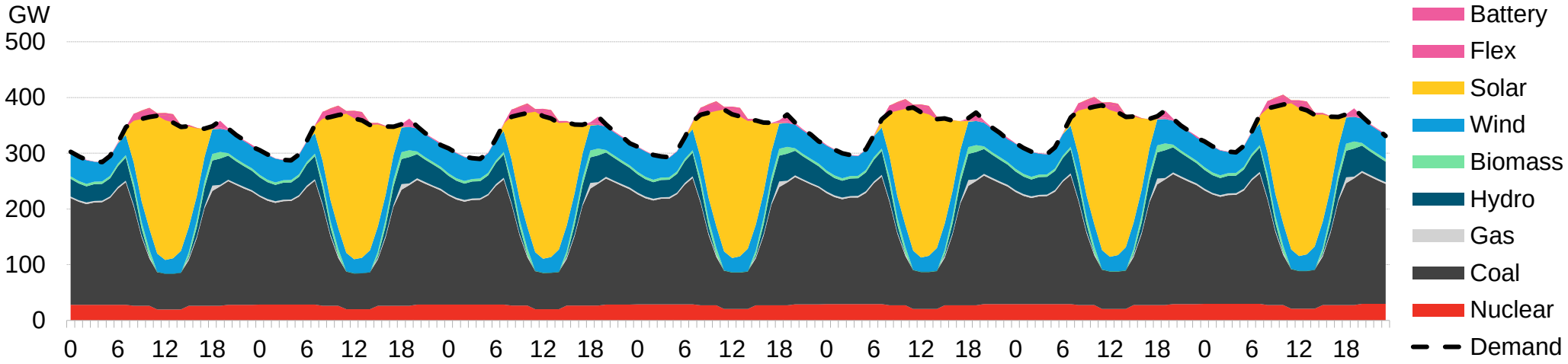
IPP strategies to keep tariffs low at the newer types of auctions for renewable power



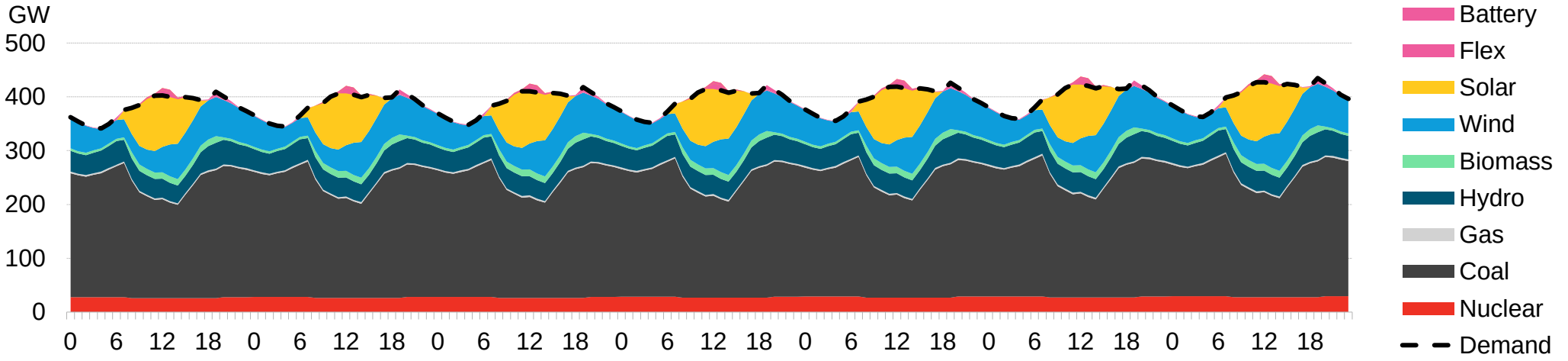
Source: BloombergNEF

Daily and seasonal variation of 450GW renewables grid highlights flexibility needs

High renewable energy generation week – 2034



Low renewable energy generation week – 2034

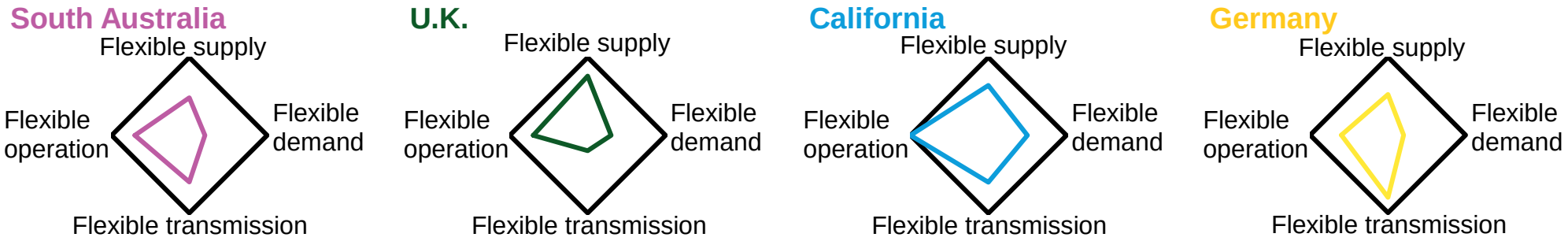


Source: BloombergNEF NEO 2019

BloombergNEF

India can draw on global best practices to ramp up its system flexibility

Different global approaches to increase power system flexibility



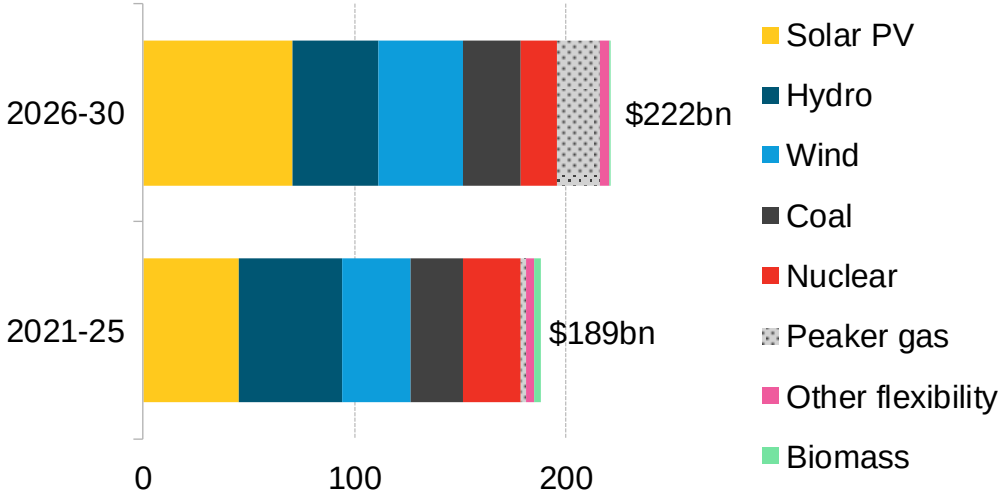
Source: BloombergNEF. Note: Data for 2018 shown.

Measure	Global example	Adoption in India
Interconnection and larger balancing areas	China's Gansu province has 8GW ultra-high voltage transmission line, which is 71% of its 2018 peak load	Limited potential to increase regional interconnection but need to accelerate work on the Green Energy Corridor
Shorter dispatch intervals	South Australia dispatch at 5-minute intervals	Shortening the current 15-minute dispatch needs changes to IT infrastructure and market rules
Market pricing for ancillary services	The U.K. introduced a sub-second frequency response product in 2016.	India's reforms of the ancillary services must allow for price discovery and technology-neutral participation for providers
Demand response	California conducts auctions to procure demand response	Needs wider adoption of dynamic pricing, smart meters and compensation mechanism for large power users
Energy storage	Australia's market for ancillary services has ensured batteries are effectively providing frequency control	Clear market rules needed for the different uses of energy storage – from instantaneous to long-term balancing of demand-supply.

Source: BloombergNEF

Over $400 billion will be needed for the new power plants being built to 2030

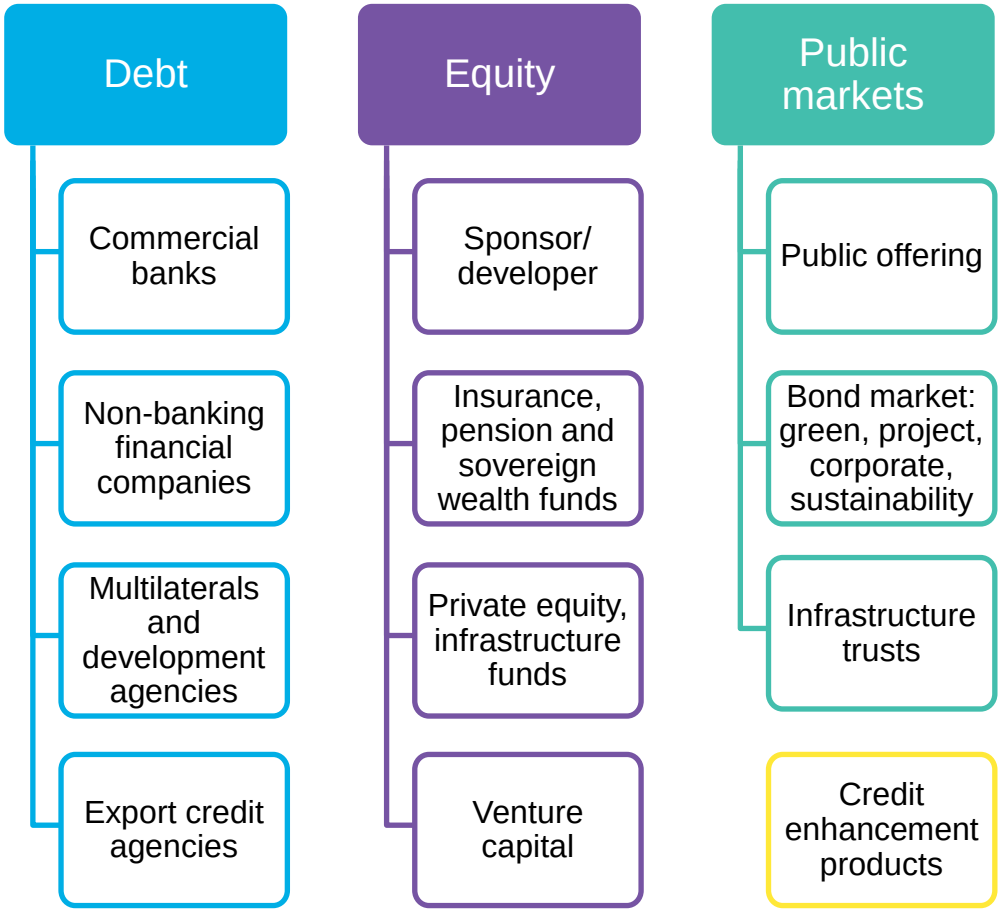
Zero-carbon sources of power attract 80% of investments from now to 2030



Source: BloombergNEF NEO 2019. Note: Measured in investment year, not construction year.

- NEO 2019 projects investment requirement of $410 billion to 2030, of which $281 billion is in renewables. India attracts 9% of the world's total investment in generation and energy storage. This makes it the second-biggest investment destination after China.
- Wind and solar put together need $188 billion of capital. To put this in context, new-build asset finance for the two technologies totaled $77 billion from 2010 to 2019. So, India will need to mobilize different sources of capital to finance the power sector's expansion till 2030.

All sources of capital need to pitch in to meet projected investment needs

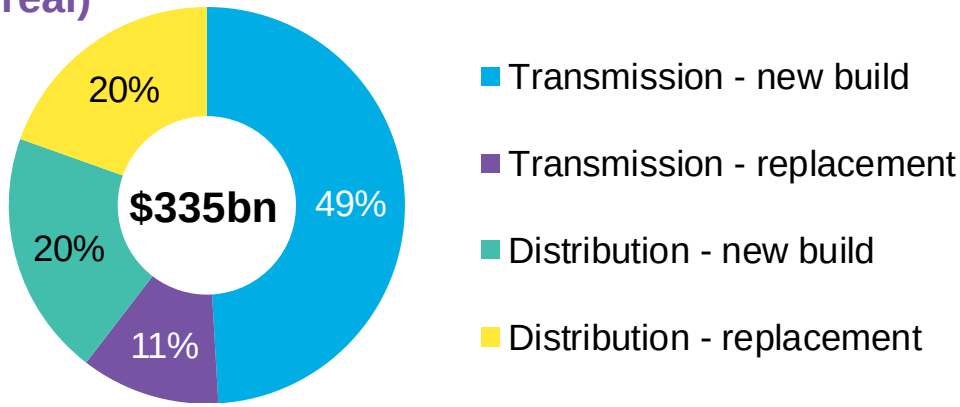


Source: BloombergNEF

BloombergNEF

A robust grid is essential to integrate 450GW renewables and serve end-users

Cumulative 450GW renewables grid investments ($ real)



Source: BloombergNEF. Note: These figures are for poles, wires, substations and transformers only so are likely to underestimate actual spend if we also consider investment in new software systems and equipment to make the grid smarter and manage growing numbers of behind-the-meter PV systems, as well as the wider adoption of electric vehicles.

- We estimate it would need $335 billion of investment in the grid by 2034 to cater for 450GW of renewables. Almost 60% of this money would be needed in the transmission grid, the remainder in distribution network.
- Grid expansion and building of interconnectors for new generation units will require about $231 billion by 2034. Meanwhile, replacement of ageing existing transformers, substations and cables will require another $104 billion.
- A lot of additional investment would be required to digitalize future grids.

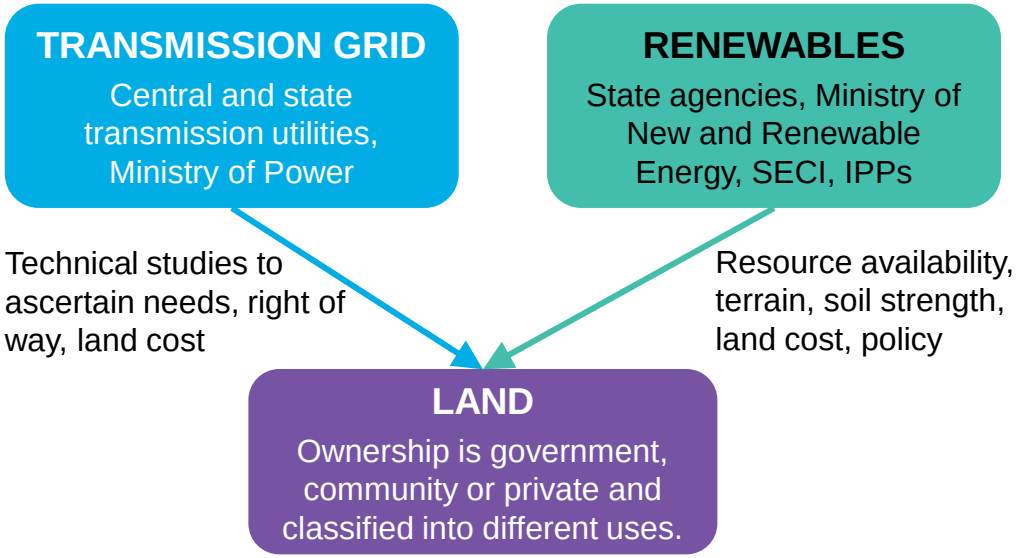
State of digitalization of grid and future needs

	Status today	Future needs
Transmission	Moderately advanced	Algorithms to balance supply and demand, full roll out of predictive maintenance
Distribution	Early stage	Deployment of automated tools, transparency of behind-the-meter assets
Decentralized energy	Pilot projects	Machine learning and blockchain platforms to enable automated trading
Consumers	Commercial & industrial users: early stage Residential: pilot projects	Energy management algorithms, behind the meter optimization for industrials, smart homes, pairing of smart devices

Source: BloombergNEF

Development of the grid and renewables projects calls for coordination on land issues

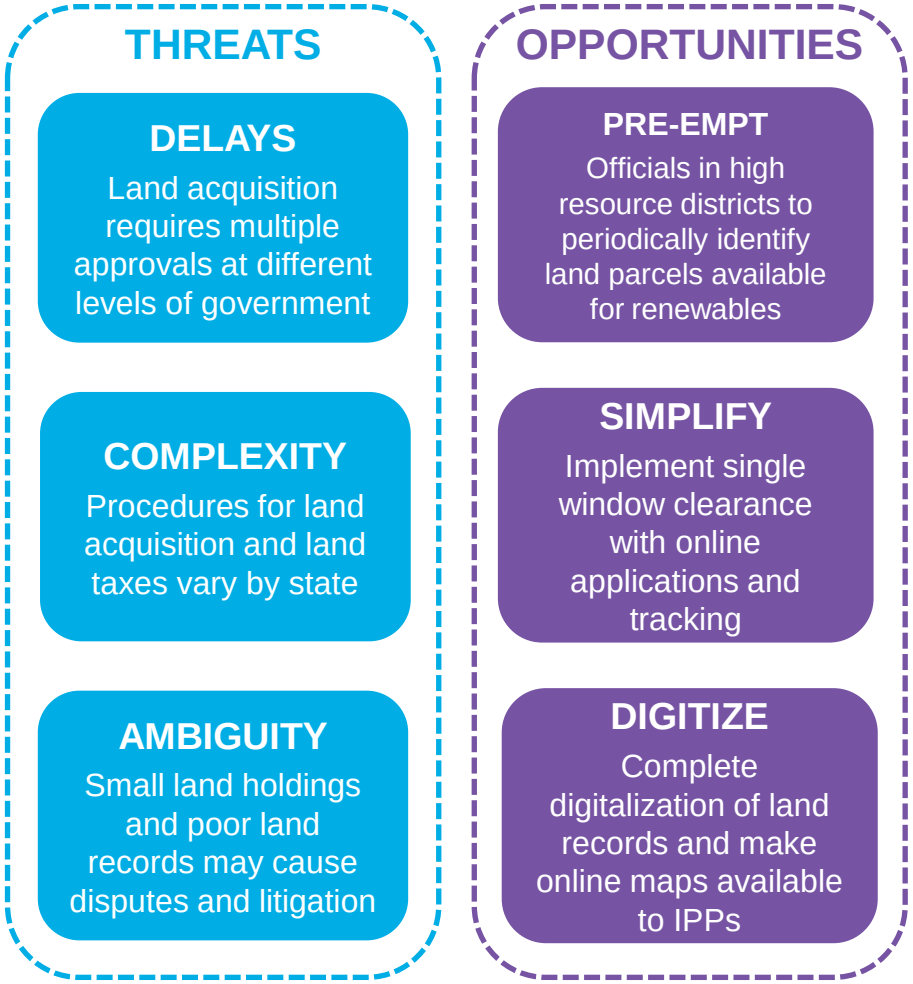
Need for coordination among stakeholders of transmission grid and renewables



Source: BloombergNEF. Note: SECI is Solar Energy Corp of India.

- The construction periods for transmission networks and renewable projects can differ a lot, but both need to come online at the same time. Difficulties in acquiring land are a common bottleneck for clean power plants and grid projects.
- Clear 5-10 year plans for transmission build must be published, in which the government identifies available land sites, in consultation with different stakeholders. IPPs would get clarity for future investments and transmission utilities could be held accountable for the plans.

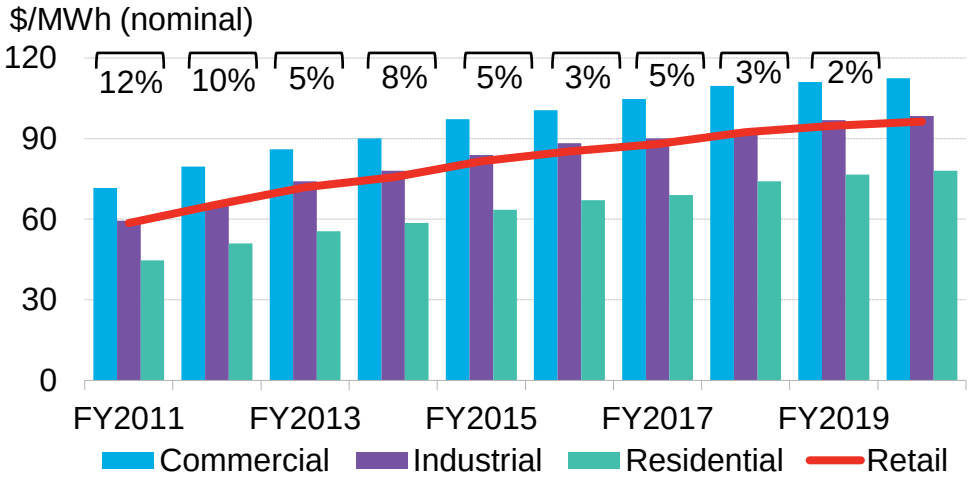
Addressing the threats to land acquisition



Source: BloombergNEF.

The financial health of discoms could jeopardize the outlook for renewables

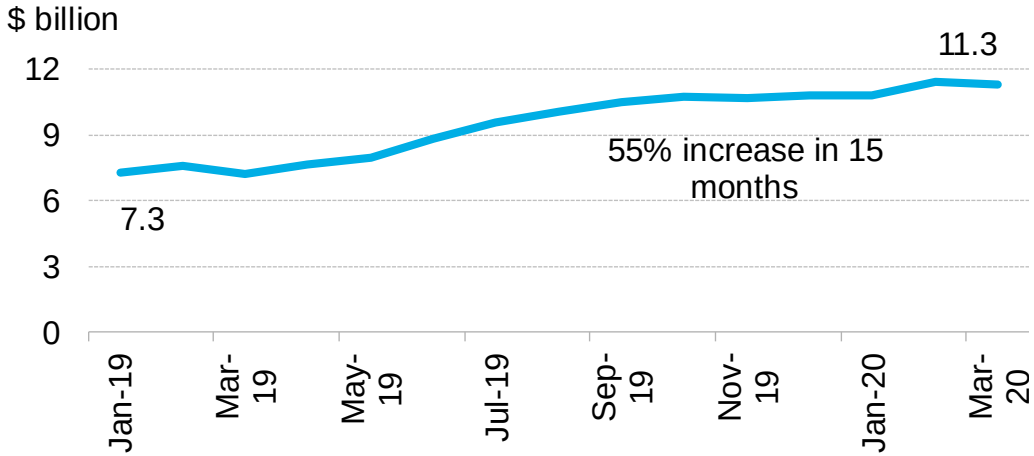
Slower rise in consumer tariffs hits discom revenue



Source: State Electricity Commissions, BloombergNEF. Note: FY2011 is the financial year from April 2010 to March 2011. CAGR = Compound annual growth rate. $1=75.6 rupees.

- Retail electricity tariffs rose by 1.5% in the financial year ending March 2020, the slowest in a decade. Residential tariffs continue to be subsidized by industrial and commercial customers, despite the Electricity Act recommending cross-subsidies to be capped at 20%.
- Most state-owned discoms are financially stressed as modest tariff hikes do not cover the rising cost of supply. Poor metering and bill collection efficiency leads to high technical and commercial losses.

Discoms' overdue payments exceed $11 billion



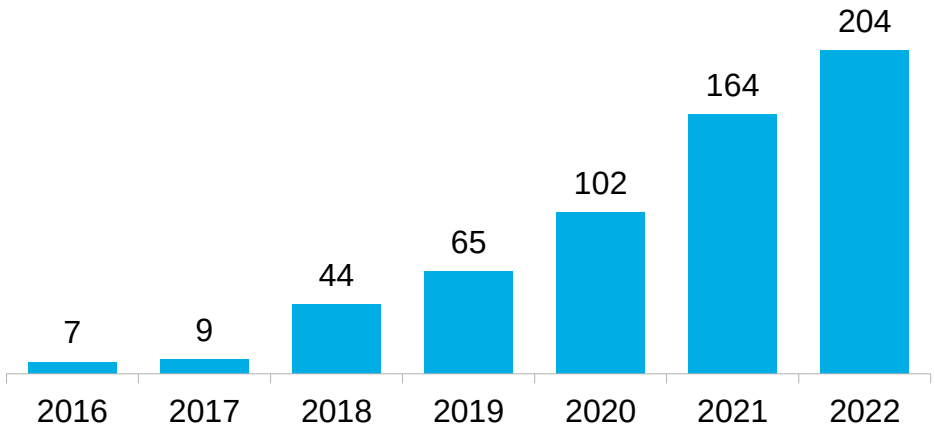
Source: BloombergNEF, PRAAPTI portal. Note: Only payments which are unpaid for more than 60 days are shown since these are overdue.

- As a result of mounting losses, discoms defer payments to IPPs, creating a series of delays through the value chain. Discoms have also attempted to renegotiate signed PPAs or curtail power to lower their costs. This dents investor confidence because of the threat to their project returns, and may dampen future investments.
- Direct benefit transfer to replace current subsidies, discom privatization or franchises,, and clear legal precedence against contract renegotiations are urgently needed to scale up renewable capacity additions.

Reducing renewables' reliance on public finance calls for robust discoms

SECI's payments to IPPs more than triple from 2019 to 2022

billion rupees, nominal



Source: BloombergNEF. Note: Figures are estimates based on SECI auctions from 2014 to 2019. Commissioning times of 30 months and 24 months from date of auction is assumed for wind and solar respectively. Capacity factors for wind and solar are assumed to be 35% and 22% respectively.

- The annual amounts that SECI must pay IPPs rises rapidly as new contracts are added to the existing commitments. These PPAs are all for 25 years, which could put SECI's finances under strain if discoms do not make timely payments for the power purchased.
- Weak discom finances may also lead to curtailment of the more expensive renewable generators. Most PPAs do not allow IPPs to claim for the lost generation.

The changing role of public finance

SECI plays a central role in India's clean energy transition. This enables investors to gain confidence in the market despite the uncertain financial situation faced by several of the country's offtakers.

Over time, however, it is important that the financial imbalances of the system are resolved. Saddling SECI with last-resort liabilities for hundreds of gigawatts of projects without improving the creditworthiness of discoms poses a risk to public finance and taxpayers.

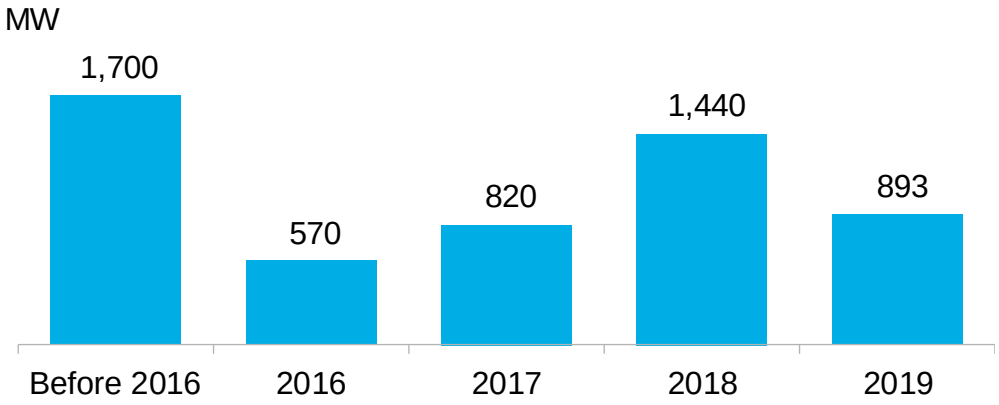
The wave of retroactive cuts to clean energy investment incentives that shook clean energy investors in a number of European markets in the aftermath of the 2008 financial crisis provides an example of this risk.

Governments decided to reduce their obligations to clean energy project owners, as part of an effort to manage public spending, or reduce pressure on rate payers where this mechanism was already in place.

To avoid liabilities accumulating on the balance sheets of governments, the European Union introduced new rules that ensure that clean energy incentives are always financed through a levy on ratepayers, or a tax.

Corporate PPAs are emerging as a new source of clean energy supply

India's corporates have a growing appetite for clean energy PPAs



Source: BloombergNEF. Note: PPA = Power Purchase Agreement

- India's corporates have signed over 5GW of clean energy procurement deals, making it the largest market in Asia. Corporate demand for clean energy will rise further as more Indian companies see the financial upside of switching to renewables, and pay heed to the stringent supply chain requirements of global manufacturers and investors' insistence on sustainable business practices.
- Clean energy can come from captive projects or third-party PPAs. The renewables plants can be located onsite or even in other states. This gives procurers the flexibility to address their power demand and risk appetite.

Corporates could do with some help from the government

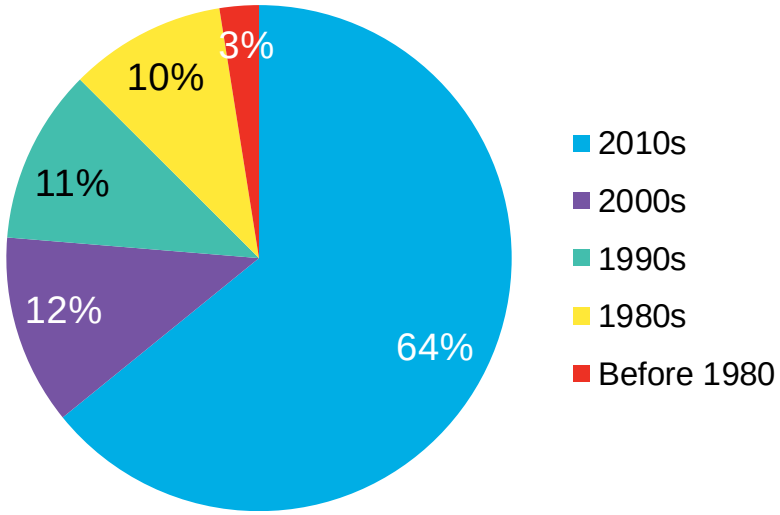
5-10 year roadmap	• States to provide clarity on level of charges for corporate procurement • Eliminate retrospective changes that threaten investor confidence
Time is money	• Discoms to issue clear limits on rooftop and 'open access' projects they will permit • Applications to be cleared in a timely manner if they are within these limits
New products	• Create regulatory frameworks and incentivize innovative solutions such as virtual PPAs and green tariffs
Demand aggregation	• Government agencies such as SECI can act as demand aggregators to help pool sufficient volume from smaller firms.

Source: BloombergNEF.

- Financially stressed discoms may continue to charge high tariffs for commercial and industrial customers. This makes it even more attractive for firms to procure a part of their electricity from other sources.

Economics and sustainability make a case for early coal retirements

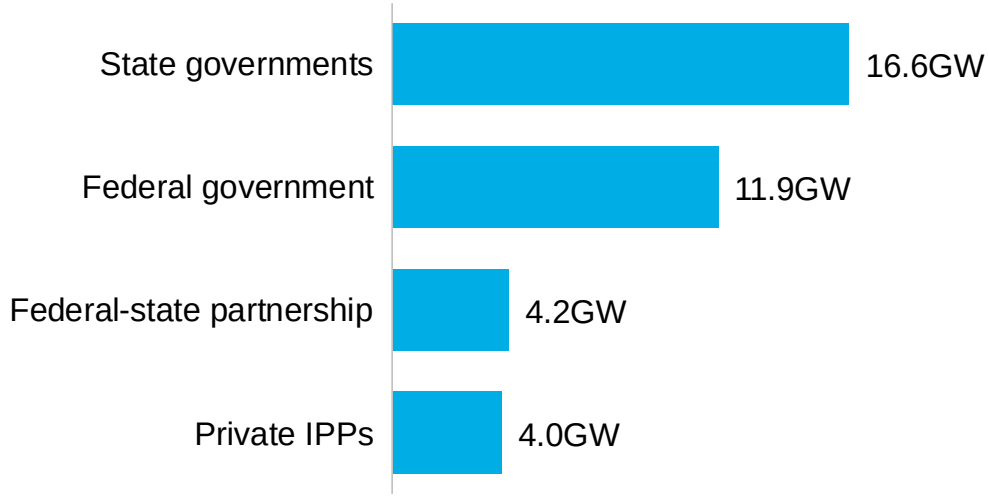
India's coal fleet by decade of commissioning



Source: BloombergNEF, Central Electricity Authority. Note: Data as of March 2019

- The low capacity factors (CF) of coal plants and the ambitious targets for renewable capacity may make it economic to retire coal plants built before 2000. These plants would have already recouped most or all of their fixed investment. This represents nearly one-fourth of the current installed capacity.
- By retiring older plants, the emissions intensity of the grid would improve, as plants built in the 2010s are using higher-efficiency super-critical technology.

Coal plants under-construction, by ownership

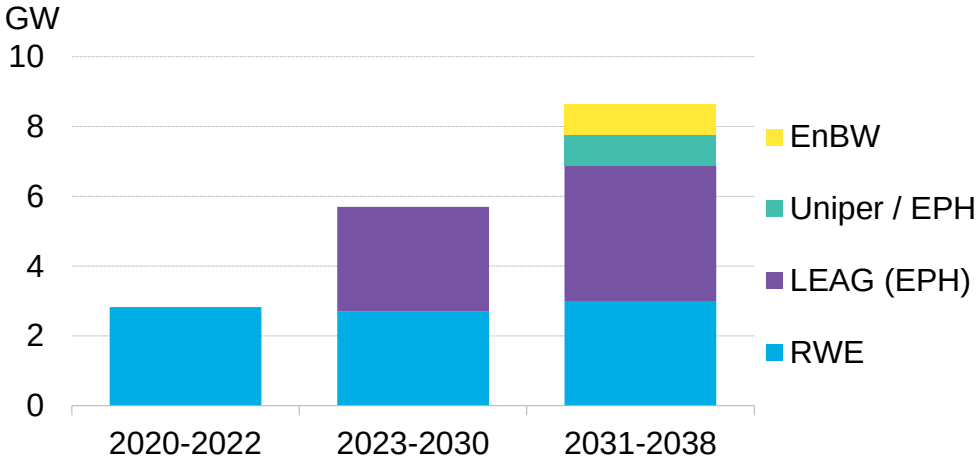


Source: BloombergNEF, Global Energy Monitor. Note: Data as of January 2020

- At the beginning of 2020, there were 36GW of coal plants under construction, of which 90% were being built by government-owned companies.
- If all or most of this capacity comes online, the coal fleet CF will fall further. This will put additional pressure on coal plants, even those built after 2000, to close down.
- Alternatively, some of the plants currently under construction may be abandoned, leading to investment write-downs by the equity holders.

India can learn from global approaches, to manage its coal plant retirements

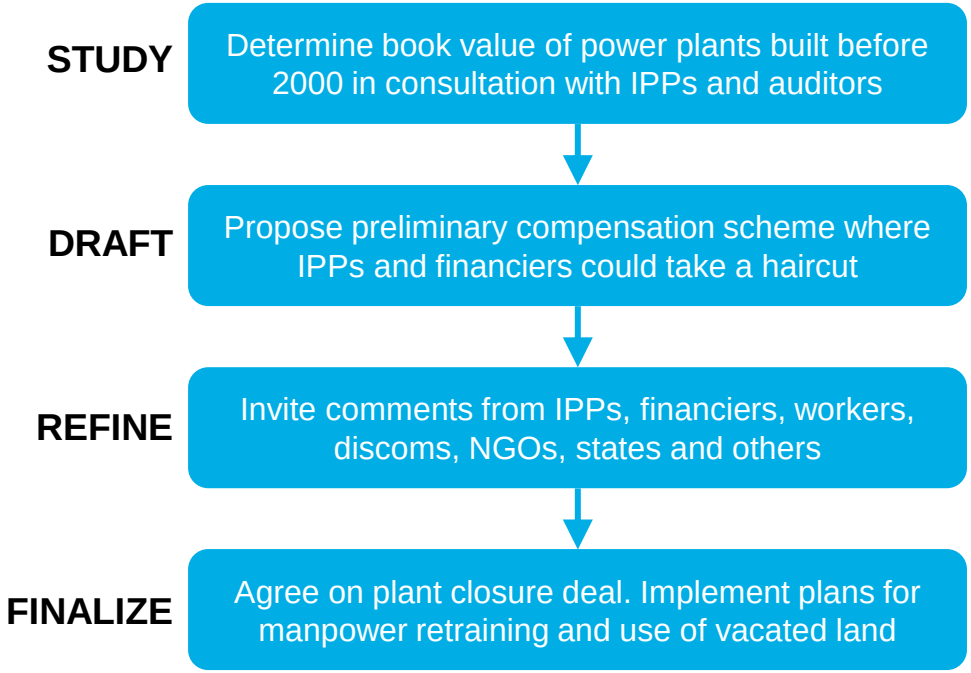
Germany's lignite phase-out deal



Source: BloombergNEF, Federal Ministry for Economic Affairs and energy (BMWi)

- Germany has an agreement to close down all its lignite power plants by 2038. The coal regions and IPPs will receive compensation for early closure, but less than what they originally expected.
- In 2013, Spain also considered addressing overcapacity by incentivizing the mothballing of gas power plants. This would have been Europe's first ordered liquidation of stranded generation assets.
- The use of concessional loans and innovative structures, such as ratepayer-backed securitization, can make possible coal plant retirements in regulated markets where new renewables are cheaper than existing coal.

Roadmap for India's early closure of coal plants

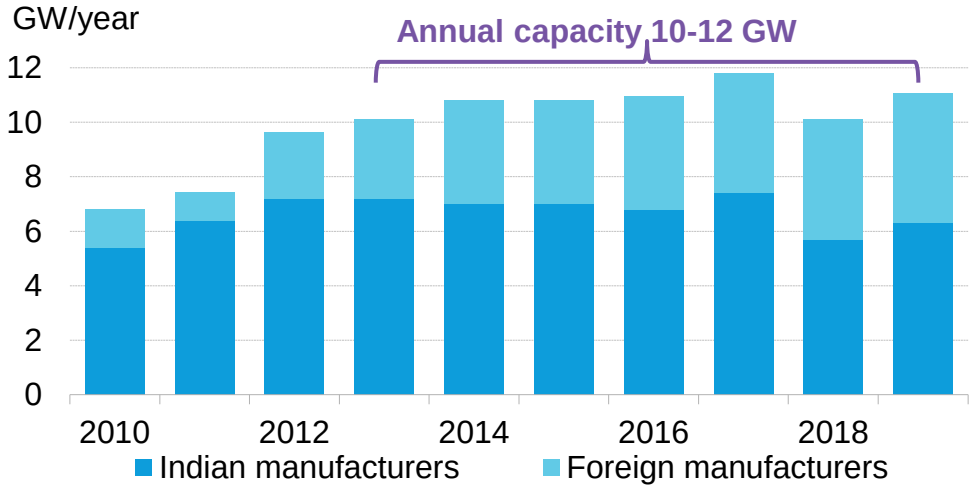


Source: BloombergNEF

- In 2020, India's finance minister announced that the government would advise utilities operating old and high-emission thermal power plants to close them. However, no list of power plants or timeline was provided.
- A government-directed orderly closure of older coal plants would reaffirm the official commitment to India's clean energy transition.

A clean energy future is an opportunity to step up on ‘Make in India’

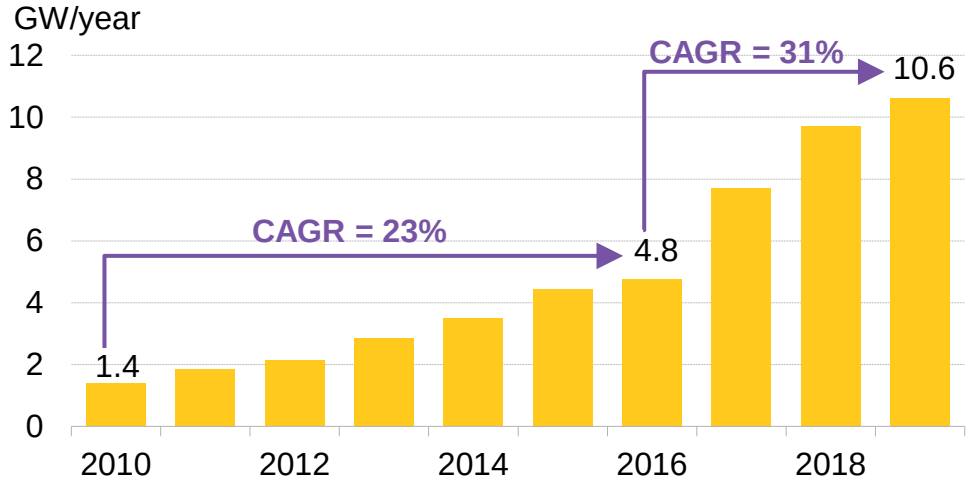
Wind nacelle manufacturing capacity in India



Source: BloombergNEF, company reports. Note: Data as of June 2019.

- India has developed a mature base of manufacturing for the wind industry, from blades to nacelles and their related upstream components.
- The presence of well developed supply chains, highly skilled labor and relatively low costs has attracted foreign firms to set up factories in India. The annual manufacturing capacity is 3-4 times domestic demand, increasingly making India an exporting nation.
- India now has the opportunity to ramp up manufacturing of energy storage technologies, as global demand will come from the power and automotive sectors.

Solar module manufacturing in India



Source: BloombergNEF, company reports.

- India’s solar module manufacturing capacity picked up pace from 2016 as firms were buoyed by the national installation targets. However, capacity utilization remains below 50% for most manufacturers. The domestic market for modules is still heavily reliant on imports.
- The government is trying to support manufacturing by putting out tenders with domestic content requirements, import duties and lower corporate taxes for new units.
- The government intends to offer dedicated manufacturing parks to attract foreign firms with advanced technology and a will to diversify their global manufacturing bases.

Conclusion

How to start a clean energy revolution and keep it growing

The next decade of India's power sector transformation, by the numbers

$410 billion

Investment opportunity for new power generation capacity

$223 billion

Investment needed into power transmission and distribution

60%

Non-fossil fuel based installed capacity, exceeding COP21 commitment

2038

Year of peak power sector emissions in the least-cost pathway

India's clean power revolution has made a good start toward 450GW

A strong start: looking back over 2010-2019

- In the last decade, India's power demand has grown by 50% and installed capacity has more-than-doubled.
- Although coal plants remain the top supplier of electricity, their utilization and share in the generation mix is declining. Since 2017, annual additions of renewables have outstripped coal. Three factors explain this shift.
  - A focus on cost made India the **world's largest renewables auction market** at the end of 2019. The massive auction programs have allowed Indian developers to optimize their projects, and have attracted private sector investment. Levelized auction tariffs in India are among the lowest in the world.
  - Solar and wind have been the **cheapest sources of bulk power** generation in India since 2018. The success of auctions, and falling equipment prices globally, have made wind and solar cheaper than new coal plants on a levelized cost of energy basis.
  - The government complemented its goal for 175GW of renewables by 2022 and its auction programs with policies that have given a wide group of investors, national and international, private and public, the confidence to commit for the long term.

The road to reaching 450GW by 2030

- India's auctions are taking renewables closer to 24x7 power. The newer types of auctions will force **renewables to match coal plants** on dispatchability.
- The 450GW renewables future will need a **flexible power system** to manage daily and seasonal variation. Global best practices serve as a useful guide in achieving this.
- The power sector's growth offers a **$633 billion investment opportunity** across generation and grid networks. Different sources of capital need to be mobilized to finance these needs.
- The acceleration of renewables will be aided by reforms that address two issues – improving the **financial health of discoms** and better coordination between stakeholders on **land acquisition**.
- Economics and sustainability make a strong case for early **coal plant retirements**, but this will need the government to play a proactive role.
- India's strong demand for renewables equipment provides a reason for ramping up domestic production, in tune with the Prime Minister's **Make in India** initiative.

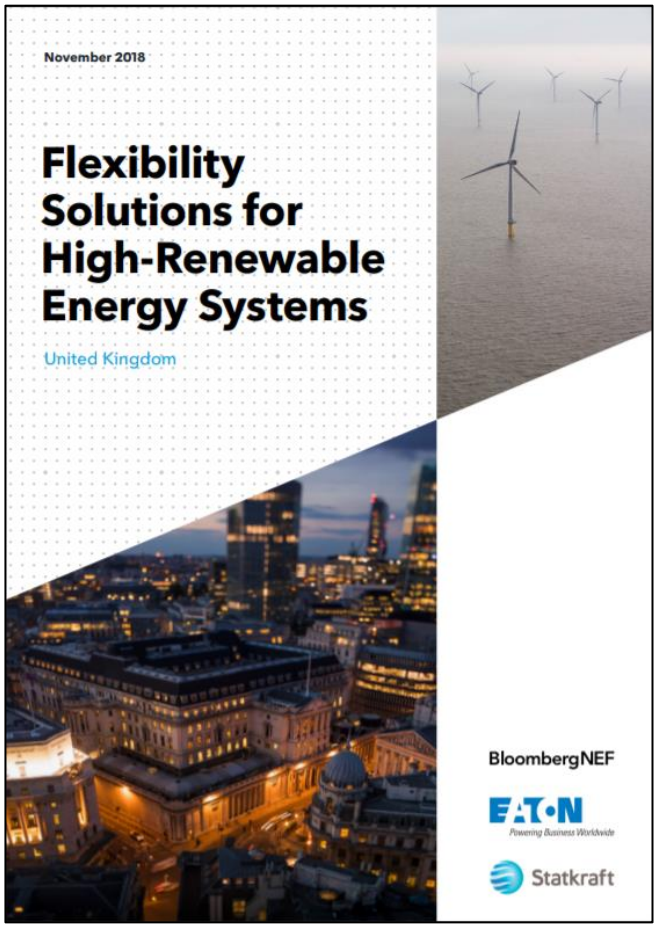
Appendix

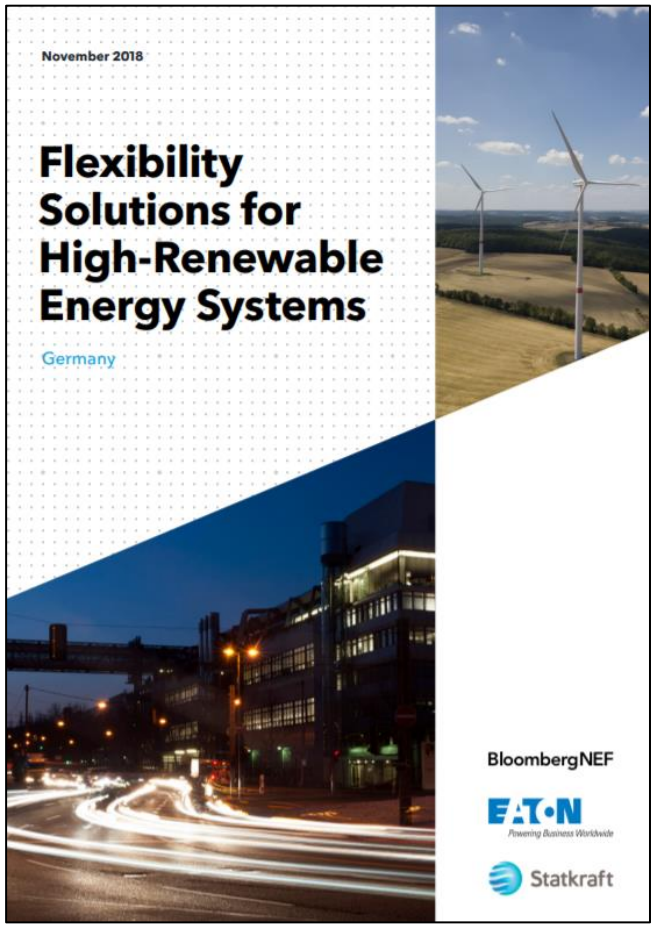
Methodology for calculating the levelized cost of energy

- The LCOE is the long-term offtake price on a MWh-basis required to recoup all project costs and achieve a required equity hurdle rate on the investment.
- The LCOE is calculated using BloombergNEF's proprietary Energy Project Valuation Model. It is based on a project finance schedule that runs through the full accounting life of the project, based on a set of inputs that allows us to capture the project cost impact of the timing of cash flows, development and construction costs, multiple stages of financing, interest and tax implications of long-term debt instruments and depreciation, among other drivers.
- For each technology, we consider the development costs, equipment costs, balance of plant costs, fixed opex and variable opex.
- In the case of India, we make bottom-up capex assumptions, paired with data for financing and resource quality. These inputs are based on multiple industry interactions, government benchmarks, regulatory filings, company disclosures, market reports and analyst experience.
- Our 1H 2020 analysis covers more than 7,000 projects across 20 technologies and 46 countries around the world. Read more here.

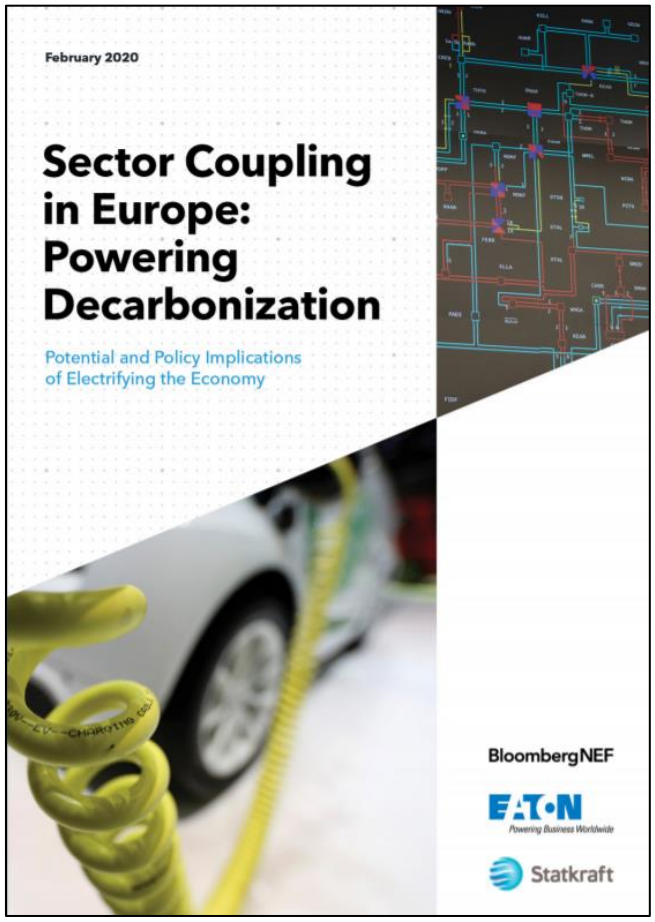
Assumptions	Description
Revenue indexation	Project revenues are inflation-linked, starting from the LCOE which is the nominal offtake price in the first operation year.
Macroeconomics	For each country analysis, we apply the standard corporate tax rate and an inflation rate from the International Monetary Fund's forecast consumer price index (CPI) annual rate for that country. Currency exchange rate assumptions are based on a preceding three-month average.
Subsidy exclusion & corporate tax	The analysis excludes all subsidies and incentives (accelerated depreciation, grants, production/investment tax-credits, feed-in tariffs) where these benefit specific technologies over others. Our calculations do include corporate tax.
Utility-scale focus	Our calculations are for the levelized costs of major technologies at utility scale.

Further reading material (1/3)





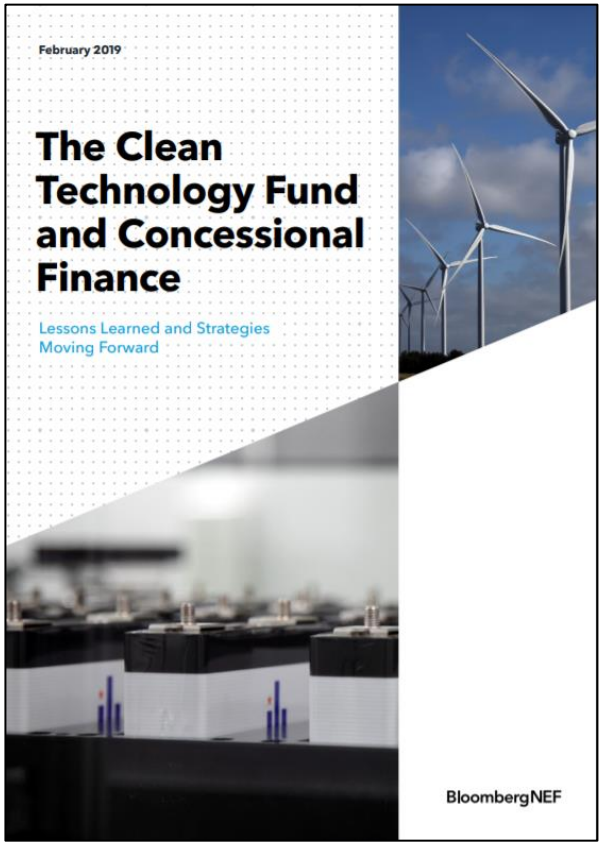
A pair of reports published by BloombergNEF in partnership with Statkraft and Eaton, explores the possibilities for solving the power system flexibility challenge in the U.K. and Germany. The full reports are available here.



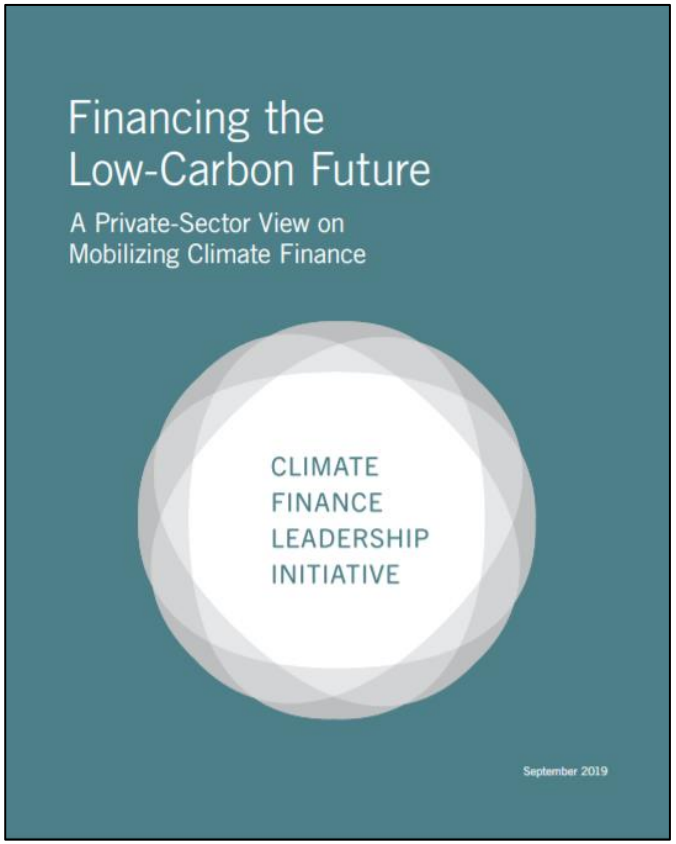
The report explores how the transport, buildings and industrial sectors in Europe could be electrified. Read more here.

Further reading material (2/3)

Report by the UN Environment Programme (UNEP), the Frankfurt School-UNEP Collaborating Centre and BNEF, analyzing 2019 investment trends, and clean energy commitments made for the next decade. Read more here.



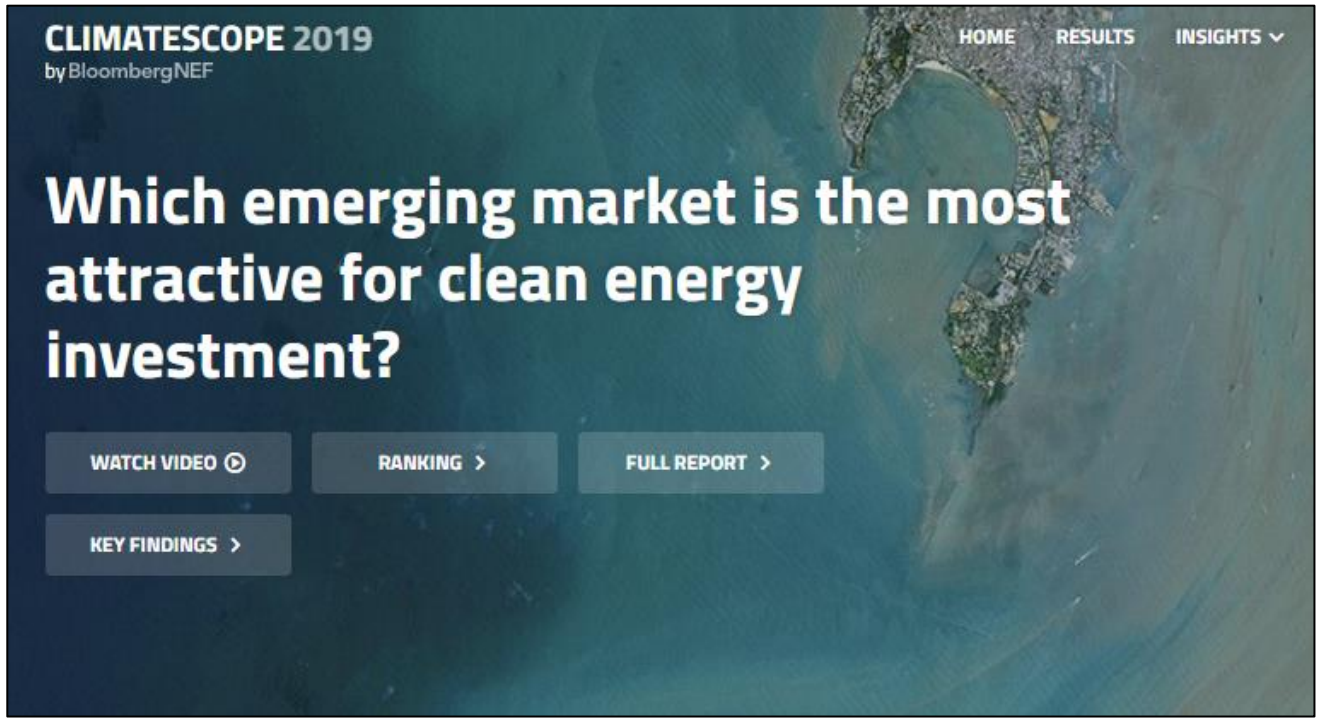
Using the lens of the Clean Technology Fund experience, the report explores the best new opportunities for deploying concessional capital. Read more here.



A report by the Climate Finance Leadership Initiative that identifies opportunities for leadership by the public and private sector to meet the objectives of the Paris Agreement. Read more here.

Further reading material (3/3)

This report aims to improve understanding of the current solar market in ISA member countries and the financing of these projects to date. It also presents how the solar markets may evolve out to 2030. Read more here.



Climatescope is a unique country-by-country assessment, interactive report and index that evaluates the investment conditions for clean energy in emerging markets. It profiles 104 markets worldwide and evaluates their ability to attract capital for low-carbon energy sources while building a greener economy. Climatescope is a snapshot of where clean energy policy and finance stand today, and a guide to what can happen in the future.

In 2018, the project was expanded and updated in two key ways. The total number of countries surveyed was expanded significantly. The methodology was also update to learnings from BNEF's seven years of conducting research in emerging markets. Discover Climatescope's analysis and tools here.

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