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REVIEW OF INDIAN SOLAR AND WIND ENERGY INITIATIVES

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ABSTRACT

India, a country where the government has taken strong actions towards the UN Sustainable Development Goals at the most recent meetings of the United Nations Development Program, faces serious challenges in the renewable energy sector, despite its promises. These challenges, pertaining mainly to real estate procurement and grid distributions, are not unique to India; yet, they are magnified. Two of the most promising forms of renewable energy in India, solar and wind, are also possibly the only viable options for the country, and hence receive the most serious investment and policy measures by the current Narendra Modi government. Real estate aside, India has an almost archaic electric grid network; this is in strong addition to state governments which cannot seem to share energy amicably between high-energy development states and energy-deficient states. The issue is geographical, economic and political. Yet, foremost, the question is about the possibility for having sustainable energy development in India. In this paper, we analyse all the aforementioned factors, in the backdrop of the financial machinery that exists to promote the development in the renewable energy sector of India.

Keywords : Sustainability, Renewable Energy, Solar Power, WindPower, Development.

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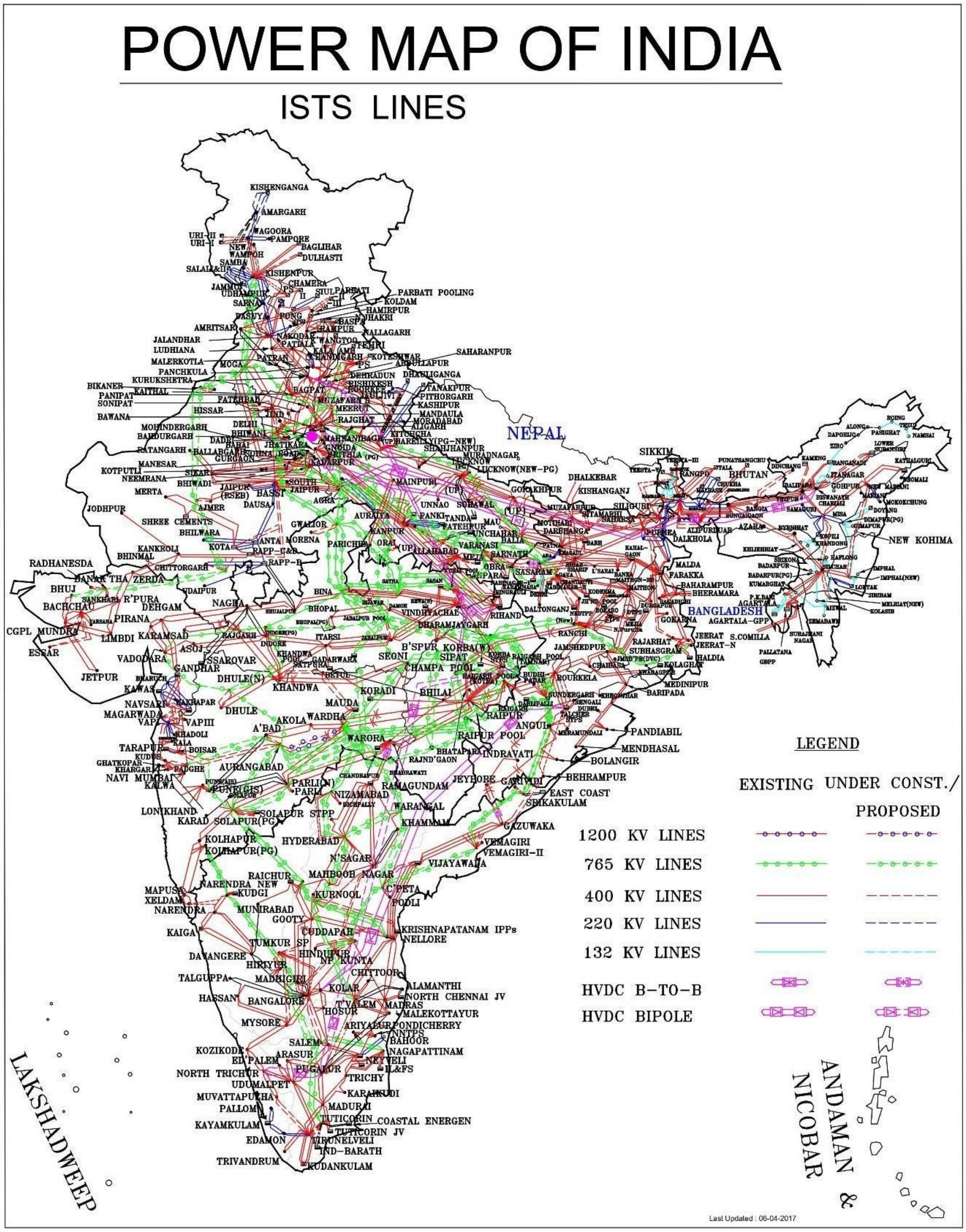

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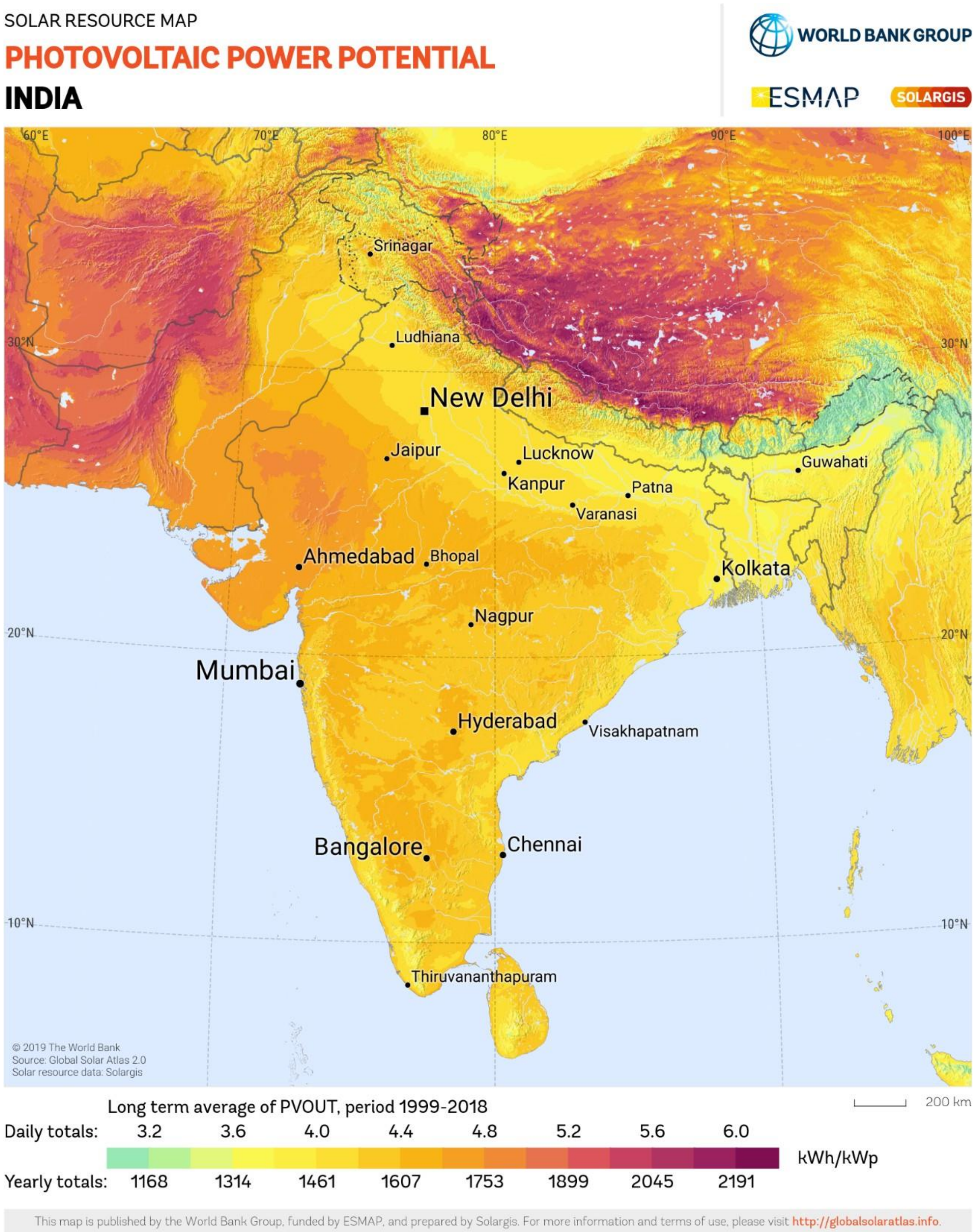

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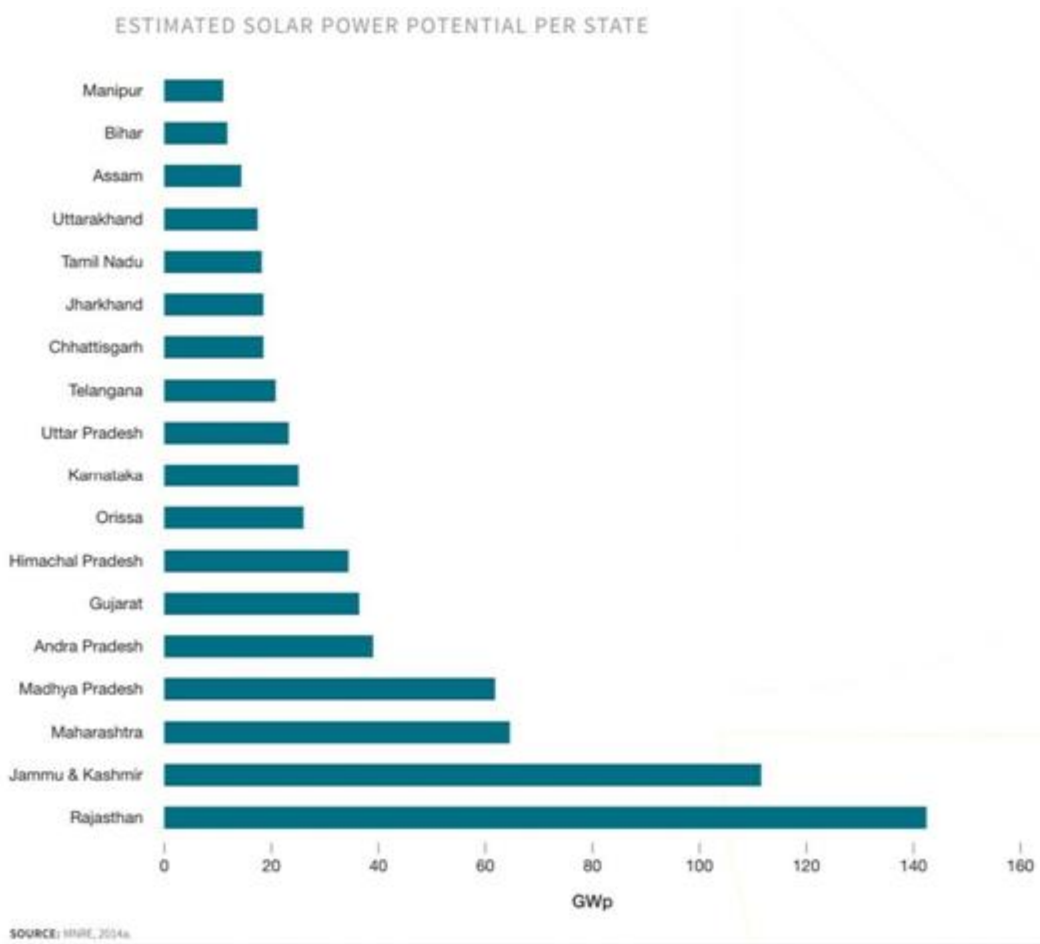
Solar Energy Context of India

India has immense potential to generate renewable energy (RE), especially solar photovoltaics (PV). India's natural conditions are estimated to offer a RE potential of 900 GW that are commercially usable. With an attributed potential of 750 GW, solar power is considered to be the very promising, followed by wind power (102 GW), biomass-energy (25 GW) and small hydroprojects (20 GW). However, the ability to generate solar power varies greatly. Dara from the National Institute of Solar Energy in India (NISE) sugests Rajasthan has the highest solar PV potential, followed by Jammu and Kashmir , Maharashtra and Madhya Pradesh. In fact, these four regions account for more than half of India's solar potential.



Political context in India

India has a stable government, a positive for investors. The current ruling party of India, the Bharatiya Janata Party (BJP), renewed its parliamentary strength with a majority in the 2019

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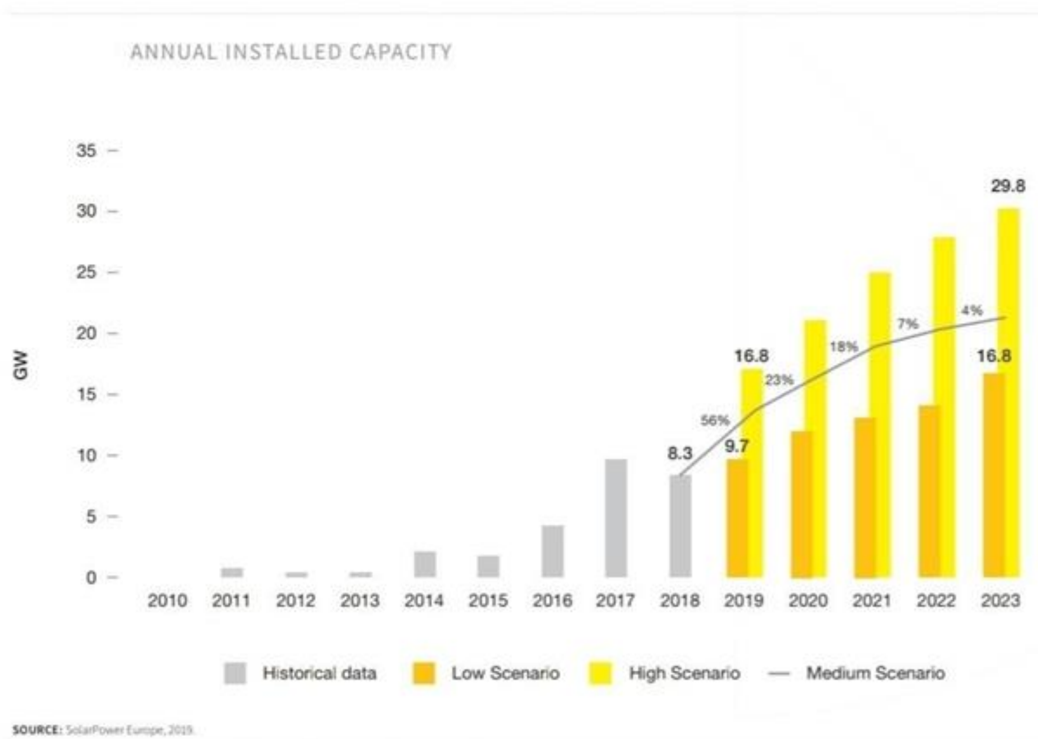
general election (bringing the respective National Democratic Alliance, NDA, to hold 353 out of 542 seats). This makes it easy for the party to implement policy decisions. Under Prime Minister Narendra Modi, there is currently also a substantially positive political climate to support RE development in India.

Indeed, the procurement of renewable energies has become a matter of prestige for Prime Minister Modi, having introduced several government initiatives and incentives to promote renewable energies in the past few years. For instance, in its first electoral mandate (2014-2019), Prime Minister Modi scaled up the country's renewable energy target from 20 GW to 100 GW by 2022, with wind targets of nearly 60 GW.

However, at a social level, awareness of the benefits of renewable energies as well as government incentives remains limited. This partly explains why the development of rooftop solar energy procurement has not yet accelerated as envisioned per government targets. More than concern for sustainability, private PV installations in India are driven by financial pursuits. For now, rooftop solar is most viable for commercial and industrial (C&I) clients since their tariff rates are much higher than for residential energy procurers. Moreover, despite the existence of government subsidies, many residents are slow to decisionmakers and are reluctant to participate in long-term commitments because of a rather untrustworthy ambience.



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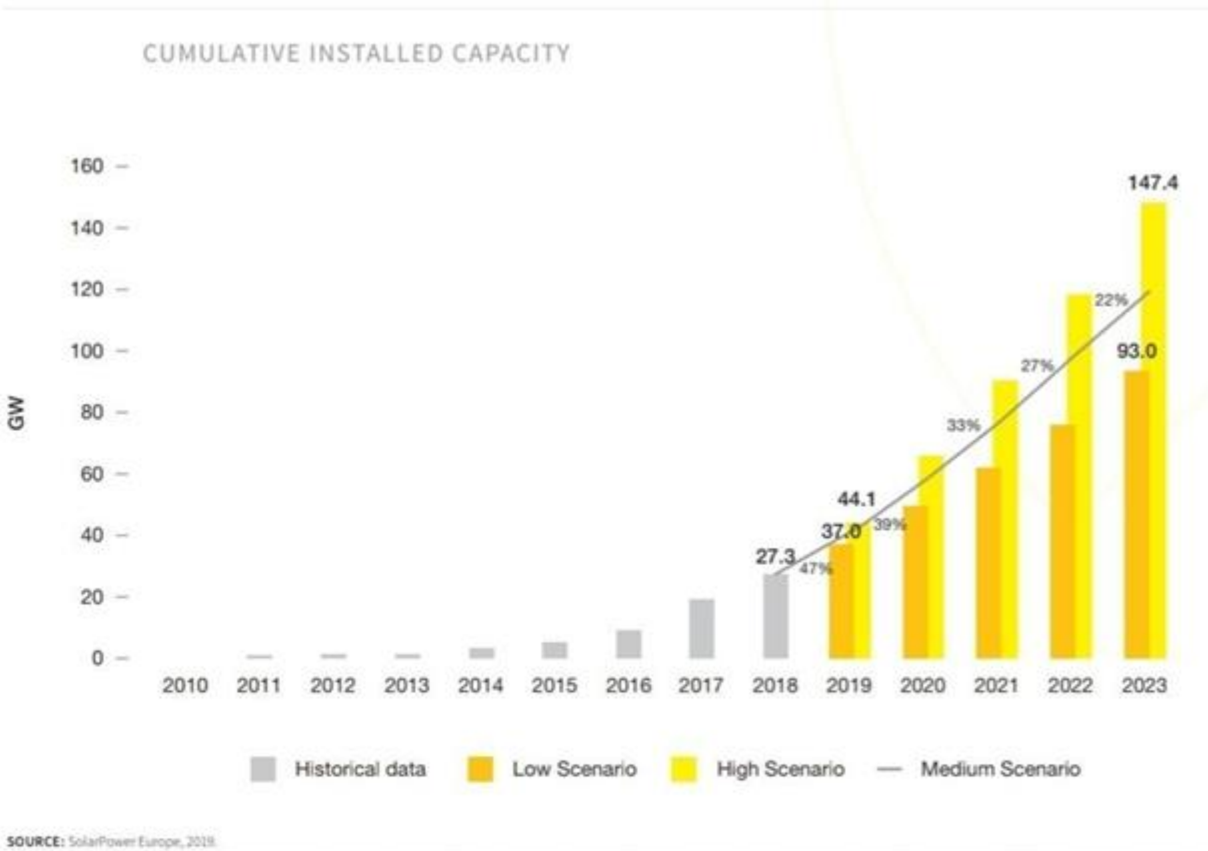

New Developments for Solar Power

Solar PV is considered to be India's most able renewable energy source. This is due to India's rather favourable climatic conditions which give the country an average solar irradiation of 4-7 kWh/m2/day, with around 300 sunny days a year. To use this resource, the Union Government has identified solar energy as a key pillar for its power supply strategy and ha committed to one of the largest solar energy capacity creation programmes in the world. While wind is still the major contributor to renewable energy sources, solar PV is expected to overtake wind in the near future. Along with falling cell-panel prices and creation of government subsidies, solar power is increasingly being received in a positive light and is promoted in both on- and off-grid regions.

At present, India's solar market is driven by large-scale, ground-mounted projects, with very small scale roof mounted establishments. As of September 2019, 82.3% of India's installed solar capacity created came from utility-scale plants. India has a procured and installed capacity of around 28.9 GW ground-mounted and 2.2 GW rooftop solar PV electricity.

With many utility-scale projects coming up in India, this trend is likely to continue. Ground-

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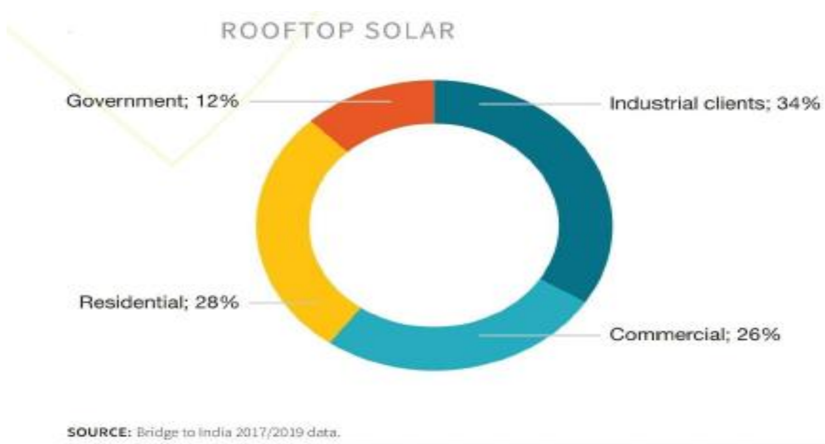
mounted solar projects – which have mainly been developed under the Solar Parks and Ultra Mega Solar Power Projects scheme – are developed through tender by the government through a reverse bidding process. In the rooftop solar clientele, commercial and industrial clients contribute to the major portion of the installations. While India will undoubtedly manage to achieve its ground-mounted solar target of 60 GW by 2022 – as envisioned by the National Solar Mission – meeting its rooftop solar target of 40 GW continues to be a challenge.

This is not unusual for emerging and developing markets. Installing large quantities of utility-scale solar is much simple than establishing a distributed PV rooftop market, which requires a substantial period of educational time with the consumers. This is why emerging markets usually begin their solar development with tenders for utility-scale solar and then continue to struggle to set up the distributed rooftop segment.

A rapid modernisation of India's electric metering infrastructure could accelerate this process. Net metering was first started in India in 2012 to facilitate the connectivity of small home systems with the grid in order to incentivise domestic, non-industrial rooftop installations. Today, almost all states have developed their regulations to provide net metering infrastructure. Implementation, however, is still an issue.

Taxes, import duties and organisational systemic barriers have made development slow for solar in India. According to estimates by the National Solar Energy Federation of India (NSEFI), the country's newly installed solar capacity creation was closest to SolarPower Europe's 'low scenario' as outlined in the figures below. Yet, India remains on its growth path and is expected to become the second largest PV market over the next five years, with close to 90 GW of newly installed capacity created between 2019 and 2023. The Indian government also recently approved a total of 1.7 billion USD in funding for phase 2 of its grid-connected rooftop solar programme, which is very likely to also improve the pace of installations in this segment.



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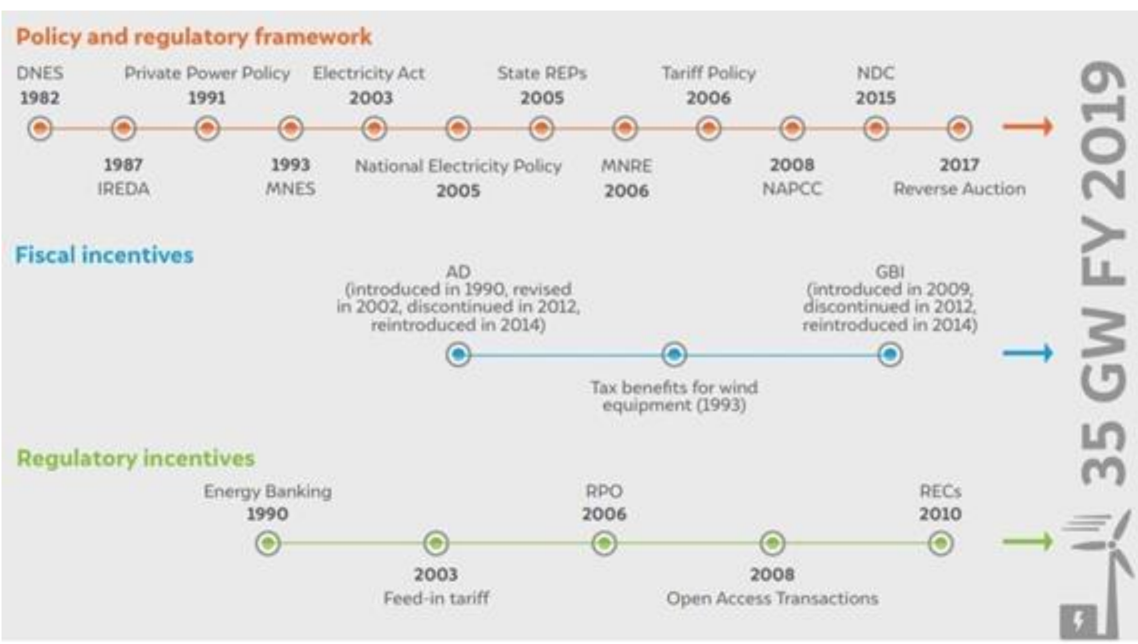
Wind energy generates 60 gigawatts (GW) to India's target of reaching 175 GW of renewable energy by 2022. However, in the last few years, the sector has observed a strong slowdown. The annual capacity creation of wind energy was below 2 GW for 2018 and 2019, prior to the pandemic—a 60% decrease from the financial year 2016–17. Numerous policy changes, lack of infrastructural preparedness, and poor consensus amongst stakeholders have damaged the growth of the sector, thereby jeopardising the achievement of national targets, in due time. In order to revamp the sector and achieve the 60 GW target by 2022, we need to examine its evolution over three decades and present challenges. Thereafter, we may develop three scenarios that showcase different pathways to achieve the minimum capacity required to reach 60 GW goal by the year 2022.

Evolution of the Wind Energy Sector

Over the last thirty years, the wind energy sector has grown steadily to achieve a total capacity of 35 GW, making India the fourth-largest wind energy consumer globally. The first development was in 1983, when a comprehensive wind resource assessment was conducted by the Indian Institute of Tropical Metrology. Various regulatory interventions and monetary incentives encouraged the private sector to invest in the sector, resulting in its fast growth. The figure illustrates the direction and policy/regulatory frameworks that have shaped the India wind energy sector since 1982.



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Problems faced by the Indian Wind Energy Sector

The wind energy sector in India faces a harsh future. Due to the stagnation in the trajectory of its growth, the sector has just about come to a standstill, with an annual installation of less than 1,500 MW (2018). While the transition to an auction-based system has coincided with this plateau, the realimpediments to its growth are essentially systemic.

Wind resources in India are concentrated in the southern and western regions, with 93% of all installations being located in primarily seven states. These regions also hold vast potential for solar power. This has led to large wind and solar deployments in the region, which also leads to pressures on the availability of real estate. The absence of an effective mechanism for inter-state cooperation on electricity exchange has led to the problem of over-production, with discoms having surplus power leading to stresses on thermal power stations. Further, wind power producers are burdened by the poor financial strength and operational issues of their off-takers, the discoms. Payment shortcomings, delays in signing Power Purchase Agreements(PPAs), and PPA renegotiations have created an atmosphere of uncertainty in the space.

The impact of these challenges increased once it moved to the auction regime. The sector continues to struggle without timely corrective measures and sufficient policy support. To worsen the situation, recent issues have increased the thought-to-be risk in the sector and has made affordable debt significantly inaccessible.

Land and infrastructure availability

Wind energy production is land intensive. On average, a 2MW turbine system usually requires 1 hectare of land. This is in addition to the land needed for roads, maintenance and evacuation infrastructure In most SECI tenders, developers have the freedom to choose the site. However, with the announcement of several large solar and wind tenders, acquiring suitable land with high wind speeds and grid connectivity in a time-efficient manner has proven to be an difficult task for developers. The recent SECI tender for 1,200 MW ISTS-connected wind power under Tranche - VII (announced in February 2019) was left undersubscribed by 50% due to the unavailability of good sites with pre-existing evacuation facilities.

Timely procurement of land is an important challenge for developer. Land, being a state subject under the Constitution, has different legal regulations across states. Revenue land – which is usually fallow and unutilised land – has to be leased from the state government on the proper recommendation of the state nodal agency. Private land has to be either long-leased or purchased. However, utilising private land, which is mostly agricultural land, would require it to be converted to non-agricultural land, which requires an intensive legal process yet again.

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If there are grid substations available close by, approvals from the relevant state transmission utility (STU) would be needed. If sufficient capacity is unavailable in the existing infrastructure, the existing substation needs to be augmented or new substations need to be setup. In that case, there will be a delay of 18–22 months in executing the project. While the usual timeframe for wind power plant commissioning is 18 months, commissioning new substations – from application to approval and then development – usually takes around three years.

Another existing issue is the under-utilisation of connectivity bays granted for wind and solar generation projects. As per the Connectivity Regulations, the Central Transmission Utility (CTU) can provide connectivity to substations with energy-plant capacities between 50 and 250 MW. As the connectivity applicant is not obligated to sign an agreement, submit any fiscal guarantees, or fulfil any other financial obligation, there have been multiple instances of grantees making no use of the connection, thereby blocking other entities from using the connection facility or the real estate nearby.

Transmission Infrastructure

More than 9 GW of wind power generation was planned to be deployed between 2019 and 2020 and an extr 15 GW of capacity needs to be commissioned to achieve the 60 GW target. According to the National Electricity Plan of the Central Electricity Authority (CEA), the current plan for transmission system expansion (2017–2022), which includes the Green Energy Corridor, is adequate to absorb the planned capacity addition until 2022, including the aimed 175 GW of renewables. However, the progress of the project has been disappointing. The Green Energy Corridor aims to establish substations with an total capacity of 19,000 mega volt amperes (MVA) and install 8,500 circuit kilometres of transmission lines in over seven states. According to the report by the Parliamentary Standing Committee on Energy, a mere 13% of the targeted transmission lines were setup with commissioning still pending. This indicates that the remaining 77% of the work needs to be completed within under two years to meet the established targets.

The growing installed capacity with slow expansion of transmission facilities can lead to the non-commissioning of granted projects and curtailing of renewable power. Currently, several instances of grid curtailment due to such traffic have been reported in the industry. In fact, monthly curtailment at the substation level has gone as high as 35% in Gujarat with an annual average of 5%. Such detriment would lead to a 17% decrease in the project's expected returns on equity.

Conversely, seasonal variations in wind energy generation also result in the low utilisation of transmission infrastructure dedicated for wind. 51% of the wind energy generated in Gujarat in

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2015 was generated in only 34% of the generating days in the year. The average monthly wind generation over the rest of the year was 67% lower than the highest monthly power generation, which was in the month of July. This indicates that transmission infrastructure dedicated to evacuating wind energy over long distances, such as the Green Energy Corridor, would remain improperly utilised for most of the year.

Mechanism for Regional Cooperation

Huge wind energy capacity additions in a few regions have caused the problem of surplus power andrather usual back down of thermal power plants. Studies suggest that even if states meet 60% of their renewable capacity targets by 2022, distribution companies will be challenged by surplus power, which will lead to a sizeable numbers of stranded assets.

In fact, recently the Karnataka Electricity Regulatory Commission (KERC) asked the state nodal agency to stop solar auctions as power generation in the state exceeded the demand. The lack of an effective mechanism for regional cooperation that would enable the seamless exchange of power between states is one of the major reasons for the existence of power surplus and power-deficit regions at parallel. This could further damage the demand for wind power from discoms in India.

The Renewable Purchase Obligation (RPO), which was created as a mechanism to compel discoms to procure renewable power, has been ineffective. This is because the current regulatory framework does not mandate adherence to RPOs. As many as 27 of the states and union territories (UTs) met less than 60% of their RPOs and 25 out of these 27 are non-Renewable Energy-rich states and UTs. While the ISTS-connected auctions conducted by SECI and NTPC are a way for the non-RE-rich states to procure large quantities of renewable energy, there is no real and effective framework for electricity exchange between the states.

Discom Financial Health

Discoms in India have traditionally been the weakest link in the electricity value-proposition chain due to the steep losses they incur from continuously deferring tariff rate hikes and due to delayed subsidy reimbursements. The financial mires of discoms are now spilling over to the rest of the chain. As of March 2019, state discoms owe over INR 41,000 crores in energy procurement charges to generation companies (gencos) according to the data provided on the PRAAPTI tification and Analysis in Power procurement for bringing Transparency in Invoicing of generators portal. More than half of the power generation companies are private IPP companies. IPPs with wind power assets listed in the portal, along with other wind IPPs who face the same challenge, are at risk of being classified as NPAs due to the working capital shortfalls

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caused by delays in payment from discoms. The delays vary from 12–24 months between states, with most of the Renewable Energy-rich states having overdue bills from nearly 2 years ago.

Discoms across states have also tried making wind PPA renegotiations. This could have serious adverse effects such as irreversibly dampening investor reliance towards the sector. While it is encouraging that the respective regulatory commissions and bodies have consistently denied such requests, this kind of action from the discoms create uncertainties over the sanctity of PPAs.

Transition to Reverse Bidding (Market Design)

The slowdown in capacity creation can also be attributed to the implementation issues faced by developers under the reverse auction regime. The low ceiling tariffs (below INR 2.85/ kWh) are not viable and can only be achieved at the highest wind speeds. Most sites with high wind speeds are located in Tamil Nadu and Gujarat, with Tamil Nadu already having utilized most of the available revenue land for wind energy generation. Developers are facing delays in accessing land from a procurement perspectiv and accessing connectivity to the ISTS network – as the majority are concentrated within the same region– which is putting stress on the real estate and the connectivity in the region.

Since 2017, a total capacity of around 18GW has been auctioned off by the SECI and the states. However, the annual capacity creation has remained lower than 2 GW for the last two years. The low annual capacity creation means that the turbine manufacturers are operating below 20 per cent of their real maximum capacity, which severely affects their cash flow. The wind industry also comprises around 4,000 domestic small and medium enterprises (SMEs) along its value and production development chain. They are engaged in parts manufacturing for specialized services such as transport, resource assessment, designing and consultancy, and material development and civil works; they are now having to rethink their businesses as it is impossible to sustain their businesses at such a low demand level.

Moving ahead to reach 60GW by 2022

Historically, wind installations have been focussed in a few states. Currently, nearly all the projects being commissioned under the reverse auction process are in Tamil Nadu and Gujarat. This is because the high average wind speeds required to achieve tariffs below the current ceiling tariffs are accessible only in sites in these two states. This has put lot of pressure on the pre-existing land and evacuation facilities in these states, thereby delaying plant commissioning.

The underlying real reason for the existing challenges in the wind energy sector comes down to the issue of concentrated wind energy resources. In this case, scaling up the variable wind energy

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capacity without a long-term solid plan can lead to higher costs for grid integration, higher cost for investment, alongside project delays, etc. There is a need for a long-term strategy to plan the scaling up of the sector, as well as for consistent policy measures for adequate procurement and development to see it through.

Broadly, there can be two approaches to manage the problem of concentrated wind resources. One option is to have energy generation plants concentrated in wind-rich or high WPD(Wind Power Density) regions, which will generally include the high Renewable Energy states, and have robust physical and market or regulatory mechanisms to enable the efficient transfer of the energy generated. The second option is to distribute the capacity from high to medium and low WPD regions. Repowering and restructuring after repairs of old wind plants is also an option to increase capacity.

Each approach has its merits and demerits. There is a need to quantify the trade-offs with accurate data between the different approaches, develop a long-term strategy, and support it with policy measures at a national level alongside, regulatory, and budgetary support. This is imperative to enable sustainable growth in the sector and achieve the country's short- and long-termdecarbonisation and renewable energy goals.

The scenarios developed are three routes to achieve the 60 GW target by 2022 and are termed as follows:

I. Base case scenario

II A. Medium to low WPD sites – fallow land only

II B. Medium to low WPD sites– fallow and agricultural land

III. Medium to low WPD sites – with repowering of old power plants

Methodology to build the scenarios

The three scenarios have been built for around 18.8–19 GW of capacity creation and have been normalized for easier comparison. This capacity has been estimated after deducting the capacity of installed projects and those under construction or in the coming pipeline from the 60 GW target. However, there is no information or data available on the location or whereabouts of about 3.5 GW of auctioned capacity. Therefore, it has been added to the remainder of the capacity required while building the scenarios by allocating it to various states.

The wind potential data used in this study is from an independent study conducted by the Centre

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for Study of Science, Technology and Policy (CSTEP) and WinDForce Management Services Limited. Current estimates by the National Institute of Wind Energy (NIWE) puts the total wind potential at 100 metres of hub height at 302 GW. However, several independent studies have estimated this potential generation to be over 2,000 GW. The separate studies undertaken by CSTEP and WinDForce, as part of a committee formed by Ministry of Renewable Energy, have estimated a total potential of 2,760 GW and 2,161 GW, respectively, at 100 metres of hub height. The data for suitable state-wise real estate has also been adopted from the same.

The wind pace/speed data at 100 metres of hub height was used to estimate the capacity utilisation factor (CUF) for each state. CUFs are calculated at the average wind speed for 30% of the windiest areas in the state with minor adjustments for the local terrain and elevation.

In our case, the specifications for a standard genuine turbine in the market with a hub height of 120 metres, rotor diameter of 120 metres, and rated capacity 2.1 MW is used to approximate the CUF.

Based on the CUF thus estimated, the states are divided into low, medium, and high WPD

High WPD states	Mean CUF	Medium WPD states	Mean CUF	Low WPD states	Mean CUF
Tamil Nadu	44%	Maharashtra	36%	Chhattisgarh	31%
Gujarat	43%	Rajasthan	36%	Kerala	31%
Karnataka	40%	Andhra Pradesh	35%	Madhya Pradesh	31%
		Telangana	35%	Odisha	31%
				Uttar Pradesh	31%
				West Bengal	31%

The assumptions on state-wise new capacity creations and installed developments are derived in such a way that each scenario achieves the remaining capacity required to reach 60 GW – around 19 GW.

In Scenario I, which is the base case, the installations are focussed in three high Wind Power Development states– Tamil Nadu, Gujarat, and Karnataka – with sectional deployment in medium WPD states. The base case is developed assuming that the current reverse auction process will continue, in which ISTS-connected projects will be found to be dominant and the auctions will not be location specific. Given these circumstances, developers will be keen on building plants in the windiest locations first. Therefore, in the base case scenario, 20% of the suitable fallow land in the considered high WPD states is considered for total capacity

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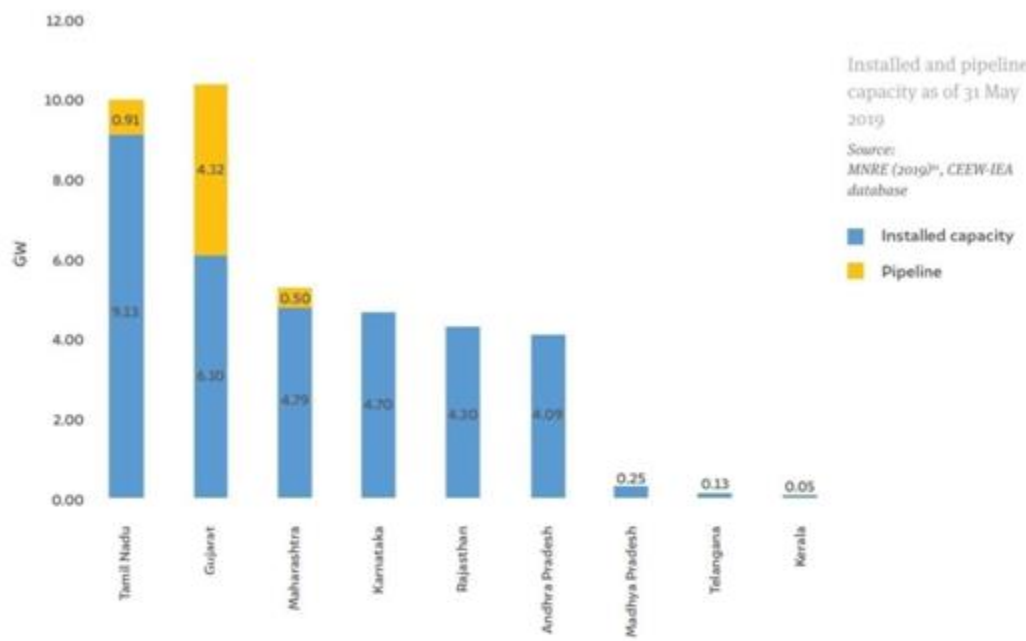
deployment along with 4% of fallow land in medium WPD states. Since Tamil Nadu has an installed capacity equivalent to more than 30% of the suitable fallow real estate, there is no new capacity creation in the state. After considering the existing installations in the medium WPD sites, only Telangana and Rajasthan are designated for new capacity additions. Also, following the existing trend, it is assumed that most of the new installations will be ISTS network connected, as a higher fraction of new deployments will be from ISTS-connected SECI auctions.

Scenario II as sub parts – first, deployment only in fallow land (II A) and second, deployment in fallow and agricultural land (II B). Scenario II A is developed in such a way that wind power will not take up more than 8.5% of the suitable fallow land in the medium Wind Power Development states (Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Telangana) and 4% in the low Wind Power Development states (Kerala and Odisha). Gujarat and Tamil Nadu have already exceeded this 8.5% limit of land use (Rank 1 real estate), with the existing installations occupying 12.6% and 31.8% , respectively, of the total fallow real estate in the states. Hence, Scenario II A assigns no new installations to both the states. However, Karnataka is assigned new capacity creation projects based on the same criteria as for medium WPD states. Scenario II B achieves the required capacity by considering 3% of the suitable fallow and agricultural real estate in medium WPD states (same as II A) and 2% in the low WPD states (Chhattisgarh, Uttar Pradesh, and West Bengal are, in this scenario, to add nominal capacity in addition to Kerala and Odisha). Gujarat and Tamil Nadu do not have additional capacity in this scenario either.

Scenario III considers the potential for repowering and repairing old wind power plants. The repowering potential in India is about 1.58 GW between seven states. Assuming a 100% increase in installed capacity creation with repowering, in Scenario III, 1.58 GW of new capacity is created and re-installed from repowering. The rest of the capacity is to be developed in medium to low wind speed states, where only 8% of the fallow land is to be used for the installations.

In Scenarios II and III, a higher proportion of the new installations is assumed to be connected to intra-state networks as state bodies will be better placed to drive the new capacity creation in these scenarios. The distributed capacity addition might also cause in the new capacities being closer to demand centres compared to the base case scenario and hence can be used within state or regional boundaries.



Overall, the Indian Renewable Energy sector is aspirational. The commitments and realignments made by the Indian government, in fact, under the Pakistan 2021 Agenda and the UN Decade of Restoration plans are promising. Yet, the goal of reaching 100GW in RE by 2022 seems like distant. At present, the government's refashioning of the energy policies under the Monsoon session of Parliament (2021) is a suggestion that the policymakers recognise the challenge and are hence shifting gears to RE based transport policies, EV (electric vehicle) based automobile regulations and environmentally sustainable scrappage (including shipbreaking) policies. While the efforts seemingly exist, and the goals continue to make seeping progress, a lot remains to be covered.

References

Bloomberg's Climatescope report, 2017. Which emerging market is the most attractive for clean energy: http://global-climatescope.org/

CEA, 2018. Annual Report 2017-18:http://cea.nic.in/reports/annual/annualreports/ann ual_report-2018.pdf

CEA, 2019. Power Transmission Maps of India: http://cea.nic.in/powermaps.html

CIA Factbook, 2019. South Asia: India:https://www.cia.gov/library/publications/the-worldfactbook/geos/in.html

ISSN: 2455-8834

Volume:06, Issue:09 "September 2021"

Climate Investment Fund, 2018. Rooftop Solar in India – Looking back, looking ahead: https://www.climateinvestmentfunds.org/sites/cif_enc/files/rooftop_solar_pv_in_india_ctf_pwc._v8pdf_0.pdf

COFACE,2019. Economic Study, India: https://www.coface.com/Economic-Studies-andCountry-Risks/India

EIA, 2015. India aims to reduce high electricity transmission and distribution system loss: https://www.eia.gov/todayinenergy/detail.php?id=2 3452

Global Energy Network Insitute. India Energy Summary: https://www.geni.org/globalenergy/library/national_energy_grid/india/indiannationallectricitygrid.shtml

Global Solar Atlas, 2019. https://globalsolaratlas.info/downloads/india IBEF, 2019. Business Opportunities in India: https://www.ibef.org/archives/industry/renewableenergy-reports/indian-renewable-energy-industryanalysis-september-2019

IEA, 2019. India Energy Outlook: https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf

IRENA, 2017. REMAP, Renewable Energy Prospects for India: https://www.irena.org/DocumentDownloads/Publications/IRENA_REmap_India_paper_2017.pdf

Macrotrends, 2019. India GNI per Capita 1962-2019: https://www.macrotrends.net/countries/IND/india/ gni-per-capita

MNRE, 2014a. State Wise estimated Solar Power Potential in the country: https://mnre.gov.in/filemanager/UserFiles/Statewise-Solar-Potential-NISE.pdf

MNRE, 2019a. Guidelines for Implementation of the PM KUSUM Scheme: https://mnre.gov.in/sites/default/files/webform/noti ces/KUSUMguidelines.pdf

OECD, 2019. Economic Outlook for Southeast Asia, China and India 2019: https://www.oecd.org/development/asiapacific/01_SAEO2019_Overview_WEB.pdf

PV-Magazine India, 2018. Summary: Central subsidies for solar PV https://www.pv-magazineindia.com/2018/01/15/summary-central-subsidiesfor-solar-pv/

SolarPower Europe, 2019. SolarPower Europe Global Market Outlook 2019-2023.

ISSN: 2455-8834

Volume:06, Issue:09 "September 2021"

https://www.solarpowereurope.org/global-marketoutlook-2019-2023/

Vikaspedia, 2019. Jawaharlal Nehru National Solar Mission: http://vikaspedia.in/energy/policysupport/renewable-energy-1/solarenergy/jawaharlal-nehru-national-solar-mission

World Bank, 2019. India, Country Profile: https://databank.worldbank.org/views/reports/rep ortwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&co untry=IND

World Bank, 2019a. GDP Growth annual – India: https://data.worldbank.org/indicator/NY.GDP.MKTP. KD.ZG?locations=IN

World Bank Group, 2019. Doing Business 2019 report: https://www.doingbusiness.org/content/dam/doingBusiness/media/AnnualReports/English/DB2019- report_web-version.pdf

Calculation of the CUF of a wind turbine For Suzlon S120 model

specifications

Wind class IIIA Rated power = 2,100 kW Cut-in speed = 3 m/s(uc)
Cut-out speed = 18 m/s (uf)
Rated speed = 9.5 m/s (ur)
Rotor diameter = 120 m
Hub height = 120 m

Assumptions

Location = Karnataka
average wind speed = 6 m/s (at 100 m)
k = 2 (shape parameter)
CUF = 0.087*average wind speed – Rated power/ (Rotor diameter) ^2
Putting all the values above CUF = 0.40

Calculating the cost of the new power plant

Based on the available literature, it was estimated that 7 per cent of the total cost of a new power plant goes towards land acquisition and the construction of peripheral roads. Thus, for the

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repowered plant, this part was deducted from the total cost of a new plant. Additionally, the recovered scrap value of the old power plant, assumed to be 10 per cent of the original capital cost and discounted to current terms, was also deducted from the upfront capital cost.

Input	Unit	CEEW assumption
Useful life	Years	25
Power plant cost	INR Lacs	750.00
Debt	%	70%
Equity	%	30%
Total debt amount	INR Lacs	455.00
Total equity amount	INR Lacs	195.00
Total cost	INR Lacs	650.00
Loan amount	INR Lacs	455.00
Moratorium period	Years	0
Repayment period (including moratorium)	Years	13
Interest rate	%	9.50%
Equity amount	INR Lacs	195.00
Post-tax weighted average of ROE	% p.a	16%
Discount rate (post-tax WACC)	%	9.15%
Income tax	%	34.61%
Depreciation rate for the first 12 years	%	5.28%
Depreciation rate from the 13th year onwards	%	1.78%
O&M charges	Months	1
Maintenance spare (% of O&M expenses)	%	15%
Receivables from debtors	Months	2
Interest on working capital	%	12.26%
O&M charges	INR Lacs/MW	10.00
O&M expense escalation	%	5.00%