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How will COVID-19 impact renewable energy in India? Exploring challenges, lessons and emerging opportunities

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ABSTRACT

The COVID-19 pandemic has hit the Indian renewable solar and power sector, supply chains, and businesses and severely hindered the sustainable energy climate transition. This paper assesses the impact of COVID-19 pandemic on power demand, the financial condition of power distribution companies, impact on electricity generation, increasing share of renewable energy sources, impact on the solar industry, under-construction solar projects and operational projects in India. This study further scrutinized the Indian renewable power and solar sector as a case study and explored issues and challenges currently being faced to manage the consumer load demand, including the actions taken by the utilities/power sector for the smooth operation of the power system. This paper also presents the different policies and regulations by the Ministry of New and Renewable Energy (MNRE), providing relief to renewable energy developers with a slew of support measures announced over the last few months. Finally, opinions on post-COVID era strategies for the Indian renewable energy sector are presented to support the government/policymakers/utilities not only to overcome the current crisis but also to overcome future unforeseeable pandemic alike scenario.

1. Introduction

COVID-19 has provoked unprecedented worldwide turmoil [1]. India reported the first case of the disease on January 30, 2020. Since then, the cases have slowly and considerably increased. Till June 19, 2020, India reported a total of 3, 81,537 confirmed cases and 12,606 deaths compared to other countries such as the United States (2,263,749), Spain (292,348), Italy (238,159), Germany (1, 90,126), France (1, 58,641), Iran (197,647) and the United Kingdom (300,469) amongst others [2]. India now stands amongst the top 5 countries in the world in terms of total confirmed COVID-19 cases.

To control the spread of COVID-19, the Government of India (GoI) implemented one of the most extreme lockdowns anywhere in the world, starting on March 25, 2020, prohibiting all ‘non-essential’ commercial, religious and social activities [2]. Fig. 1 presents the different phases of lockdown in India. Lockdown restriction started easing out from May 2020. Limited exemptions for construction activities and freight services have since been provided. Wide-scale suspension of economic activity, disruption of the supply chain, and concern for employee safety have contributed to the reduction of power demand and generated considerable risk for the entire value chain. The Indian renewable sector deals with rising uncertainties in the wake of the COVID-19 pandemic and subsequent lockdowns [3,4,5]. Due to the lockdown, the sector is dealing with falling demand for power, the poor financial health of DISCOMs, disruption of the supply chain for under-construction solar and wind energy projects, labour shortages, delays in the supply of equipment, delays in the acquisition of land. On April 9, International Monetary Fund Chief Kristalina Georgieva projected the worst economic slowdown since the 1930 s Great Depression for the year 2020, with more than 170 countries are likely to experience negative per capita growth in GDP owing to the COVID-19 pandemic [6]. IMF has forecasted a record low contraction of 4.5 percent for the Indian economy in 2020, but a robust 6 percent growth rate is projected for the year 2021 [7]. Before COVID-19, the Capital Year 2020 was anticipated to be

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1 The name of the virus causing coronavirus disease is SARS-COV-2 (Severe acute respiratory syndrome coronavirus 2) and is referred to as COVID-19. Therefore, we use COVID-19 to refer to the disease in our paper.

2 Data on Indian cases are from https://www.covid19india.org/ and the Ministry of Health and Family Welfare. Data on cases from other countries is sourced from World Health Organisation. Numbers in parentheses are total confirmed cases as of June 19, 2020.
| Date               | Description                                                                                                                                 |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| March 18, 2020     | Govt. of India (GoI) released preventive measures to contain COVID-19                                                                      |
| Janta Curfew      | Janta Curfew                                                                                                                                 |
| March 22, 2020     | Self-imposed restrictions of 14 hours.                                                                                                     |
| March 24, 2020     | GoI released instructions to be followed during Lockdown                                                                                   |
| Lockdown #1        | All India lockdown for 21 days except emergency and essential services                                                                       |
| March 25- April 14 |                                                                                                                                             |
| Lockdown #2        | All India lockdown extended for 19 days with the similar instructions as in Lockdown#1                                                      |
| April 15-May 3, 2020 |                                                                                                                                             |
| Lockdown #3        | All India lockdown for 14 days with small relaxations on the basis of COVID-19 cases                                                        |
| May 4-May 17, 2020 | All districts of the country are colour-coded in three zones namely: Red, Orange and Green                                                  |
|                    | No relaxation in Red zone but Govt. & Private offices are open with 33% staff in orange and green zone                                        |
|                    | All means of Public transport are still banned but private vehicles are allowed with some conditions                                        |
|                    | E-Commerce operations are allowed only for essential items                                                                               |
|                    | Restaurants, bars, school, colleges, religious sites, theaters, swimming pools etc., remain shut                                           |
| Lockdown #4        | More relaxations than Lockdown#3 and delineation of Red, Orange and Green zone is done by States/UTs                                        |
| May 18-May 30, 2020 | E-commerce activities are permitted for all goods along with all industrial units/construction sites                                         |
|                    | Sports complexes, stadiums, parks etc. are open for individual exercise in non-red zones                                                   |
|                    | Intradistrict bus service with maximum 50% capacity are allowed in non-red zones.                                                           |
| Un-Lock #1         | First of the 4 phase unlock plan but Lockdown is to continue in containment zones                                                          |
| June 1-June 30, 2020 | Religious places and places of worships for public, hotels, restaurants and other hospitality services will be permitted to open from June 8th, 2020. |
| Un-Lock #2         | Second of the 4 phase unlock plan but Lockdown to continue in containment zones                                                            |
| July 1-July 31, 2020 | All activities except running of educational institutions, religious/social gatherings, international air travel, metro rail, cinema halls, gymnasium, parks etc. permitted in areas outside containment zones. |
| July 17, 2020      | GOI invites feedback from parents regarding opening of schools.                                                                           |
| Un-Lock #3         | Third of the 4 phase unlock plan but Lockdown to continue in containment zones                                                             |
| Aug 1-Aug 31, 2020 | All activities except running of educational institutions, religious/social gatherings, international air travel, metro rail, cinema halls, gymnasium, parks etc. permitted in areas outside containment zones. |
| Un-Lock #4         | Fourth of the 4 phase unlock plan but Lockdown to continue in containment zones                                                             |
| Sept 1-Sept 30, 2020 | Activities permitted outside containment zones include no regular classroom teaching for students till 30th September, online learning permitted, states/UT may call 50% of the staff at a time w.e.f 21st September, students of 9-12 class may visit the school on voluntary basis, skill/entrepreneurship training to continue in training institutes, higher education institutes open for Ph.D/PG students for lab related work, metro rail to be allowed from 7th September in a graded manner, social gatherings with a ceiling of 100 persons to be effective from 21st September, open air theatres to be open from 21st September. |
| September 13, 2020 | GOI issues Post Covid management protocol                                                                                                   |
| January 27, 2021   | Guidelines for Surveillance, Containment and Caution issued by MHA                                                                          |

Fig. 1. Phases of Lockdown in India during COVID-19.
the year of growth for India’s solar and wind installations. However, due to the current COVID-19 crisis, approximately 2.5 GW of wind and 3 GW of solar projects whose scheduled commissioning timeline was 2020, are likely to be delayed [8]. The rooftop solar industry is the worst hit because of COVID 19 pandemic. In the current situation, the primary focus of the Commercial & Industrial segment (C&I), which contributes more than 70% of the total rooftop solar market in India) is to streamline its core business operations rather than investing in rooftop solar which is not a pressing need for them. In this hour of need, the Government of India has announced a slew of measures in support of the renewable energy (RE) industry. Given the supply chain issues from China and other countries, MNRE has introduced a provision that any delay in project commissioning due to COVID-19 be treated as ‘Force Majeure’ condition. The Ministry has provided a blanket extension of 70 days to all solar and wind projects under the pipeline. MNRE has also directed the DISCOMS to continue scheduling power from renewable energy sources on a ‘must-run’ status. Ministry of Power has provided relief to DISCOMs by reducing the Letter of Credit (LC) amount to 50% of power procured. There is enormous ambiguity around when and if the situation would return to normal. The industry stakeholders believe that the national government supportive measures amid the crisis will not dampen India’s clean-energy ambitions. Nevertheless, the short-term impact on renewable energy growth rates in India is inevitable. As we move into the post-COVID-19 era, the government has to come up with new significant reform measures that will be critical for the renewable energy sector to move towards a resilient and robust recovery. Overall, this paper examines the impact of the COVID-19 pandemic on the Indian renewable sector (operational and economic) based on various factors. This paper assesses the impact of COVID-19 pandemic on power demand, the financial condition of power distribution companies, impact on electricity generation, increasing share of renewable energy sources, impact on the solar industry, under-construction solar projects and operational projects in India. This study further scrutinized the Indian renewable power and solar sector as a case study and explored issues and challenges currently being faced to manage the consumer load demand, including the actions taken by the utilities/power sector for the smooth operation of the power system. Opinions on post-COVID era strategies for the Indian renewable energy sector are also presented to support the government or policymakers not only to overcome the current crisis but also to overcome future unforeseeable pandemic alike scenario. The paper is organized as follows: Section 2 describes the Indian Renewable sector before COVID-19 with an overview of current RE capacity installation trends. Section 3 describes the impact of COVID-19 on power demand, electricity generation, and the increasing share of renewable sources in the total power generation mix. Deteriorating financial condition of DISCOMs and relief measures provided by the government are discussed in Section 4. It also covers the critical reforms anticipated in 2020–21, which are delayed due to COVID-19. Section 5 describes the challenges faced by under-construction and operational solar projects. It also covers the different policies and regulations by MNRE, providing relief to renewable energy developers with a slew of support measures for handling the ongoing COVID-19 crisis. Also, the need for increasing the domestic manufacturing of solar equipment is to fulfill the government’s objective of self-reliance is covered in this section. Section 6 and 7 cover the impact on the wind energy sector and construction activities due to the COVID-19 crisis. Finally, in Section-8 conclusion is given, and post-COVID era strategies for the renewable energy sector are discussed.

2. Pre-COVID renewable energy sector in India

The energy sector plays a very critical role in the economic development of a country. India has a diverse power sector ranging from natural resources such as coal, oil, natural gas, and hydro to eccentric sources like solar, wind, and bio waste. Electricity demand has increased significantly over the years and is expected to grow in the future also. The government continues to accelerate capacity addition in the country with the promise to bring electricity to every home in the country. India stands third in the world after China and the United States for primary energy consumption and consumes 162-kilowatt hours of electricity per capita [9]. With the Copenhagen and Paris climate agreements, Indians are on the way to increased investments and clean energy installations. India has big Renewable Energy ambitions. The fast-growing country of nearly 1.4 billion people is in the midst of an energy transformation, crucial for achieving global decarbonisation. In recent years, the Indian government has increased its emphasis on environmental monitoring and has set ambitious RE goals over the next decade.

In 2015, the Indian government under the leadership of Honourable Prime Minister Mr. Narendra Modi announced a short-term target of 175 GW (GW) of renewable energy capacity by the year 2022, aiming 100 GW from solar, 60 GW from wind, 10 GW from bio waste and 5 GW from hydropower [10]. In the long-term country has set an ambitious RE target of 450 GW by 2030 [11]. The country has seen a significant ramp up over the last decade with a goal of 100GW of solar power by 2022, with central and state governments auctioning tenders to construct large-scale solar projects. High acquisition cost associated with rooftop solar installations is the primary reason for not hitting off with the market quickly. The government had provided an impetus of INR 220 Billion for power renewable energy sector in the Energy Budget 2020, and it received a positive response from the stakeholders in power sector [12]. Some of the key provisions in Budget 2020 are:

- Lower corporate tax for new energy companies to attract new investments.
- Extension of the Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM- Kusum) scheme allows farmers to utilize their barren land for renewable energy generation and provide 2 million farmers to set up solar agricultural pumps and 1.5 million farmers to set up grid-connected pumps. This scheme will remove the farmer’s dependence on diesel and kerosene and link them to solar energy.
- Proposal for setting up large solar power capacity solar parks along railway tracks
- Focus on ensuring smart prepaid metering over the next three years to ease out DISCOM woes.

All these initiatives emerge to be a big push for renewables and rural economies through solar power.

2.1. Current renewable capacity trends in India

2.1.1. Cumulative renewable energy capacity installation trends

India’s renewable capacity installation reached 87 GW as of May 31, 2020. The wind is the major contributor with a 43% share in the total renewable mix, followed by solar with a 40% share. As of May 31, 2020, 35 GW of solar (including rooftop) and 38 GW of wind capacity were installed in India. The current renewable energy (RE) projects pipeline stands at 37 GW, which is expected to be completed in the next 2–3 years. An additional 34 GW of renewable projects are under the bidding phase (tenders issued), but auctions are pending [13]. Fig. 2 depicts the RE installation trends, as of May 31, 2020.

2.1.2. Quarterly RE capacity installation trend (Jan-March 2020)

In Quarter 1(Q1) 2020, 720 megawatts of solar and 188 megawatts capacity of wind energy renewable projects were installed, around 60–70% lesser than the previous four quarters of new solar and wind installations (~about 2 GW) [14]. It is speculated that there will be minimal installation activity at the end of Quarter 2(Q2) 2020 owing to the repercussions of the whole lockdown situation. The pace is expected to pick up from Quarter 3(Q3) 2020 onwards. As per the equipment shipment data for Q1 2020, about 650 MW of string inverters and 1,163 MW of central inverters are supplied in India. Modules of more than 1,537 MW are shipped in Q1 2020. Basis this, it can be speculated that in
the next two quarters, i.e., Q2 2020 and Q3 2020, about 1,700–2,000 MW of new solar capacity is likely to be commissioned.

2.1.3. Yearly RE capacity installation projections

Before COVID-19, 2020 was anticipated to be the year of growth for India’s solar and wind installations. However, because of COVID-19, the scheduled commissioning of nearly 3 GW of solar and 2.5 GW of wind energy renewable projects for the year 2020 is likely to be deferred. It is expected in FY 2021–20, about 1.5 GW of wind and nearly 5.5 GW of new solar capacity are to be added only. Whereas for Fiscal Year (FY) 2020–21, approximately 6.5 GW and 2.2 GW of new solar and wind capacity are likely to be installed.

3. Impact of COVID-19 on Indian renewable power sector

Unfortunately, over the last two years, the Indian renewable energy sector has been coping with various troublesome issues. Weak power demand from industrial and commercial customers, high transmission and distribution losses, delayed payments from state-owned power distribution companies, lending bottlenecks comprise the various issues faced by the RE sector [15]. The contraction in demand has had an impact on all the three stakeholders – the power producer, power distributor, and the lender (banks). The sector has also seen a considerable loss in growth momentum in the last two years owing to growing policy uncertainty, tariff glitches, and lack of regulatory uniformity. Uncertainty in policy and regulatory measures such as delay or rejection of permits, grid usage charges, withdrawal of net metering connectivity, and banking tariffs are likely to rise in the market. India has slipped from 3rd to seventh place in the latest global rankings of EY’s ‘Renewable Energy Country Attractiveness Index’ [16]. Consequently, the pandemic has hit the sector at a very unpropitious time. The rates on the short-term power market have plunged by 25 percent since the lockdown [17]. Thus, COVID-19 has adversely impacted the capacity addition targets for RE sector in the short run due to the following reasons:

- Halt in construction activities during the lockdown and will return to normalcy only after some time.
- Disruption in the global supply chain led to the non-availability of critical components, such as solar modules and inverters, causing delays in solar energy projects.
- Revenue deficit owing to weak power demand left the power distribution companies with less capacity left for capital expenditure.

These points are covered in detail in the subsequent sections.

3.1. Installed electricity generation capacity and increasing share of RE sources

India’s installed power generation capacity as of May 2020 at 370.5 GW was 3.8% higher than that in May 2019 (as per provisional data from Central Electricity Authority) [19]. The addition to generation capacity was led by renewable energy sources, which witnessed a year-on-year increase of 11.5%, taking its total installed capacity to 87 GW. Conventional energy sources capacity addition was around 2% during this period. Although conventional energy dominates electricity generation capacity in the country with a share of 76% (amounting to 283 GW), there has been a sustained increase in the share of renewable energy sources, which has come to account for nearly 24% of the overall installed capacity, a 2% increase from a year ago. The increase in generation capacity of renewable energy is being driven by solar power, which has witnessed a year-on-year growth of 22% (or 6 GW) in May 20, taking the solar power generation capacity to 35 GW. Wind power, which accounts for the largest share in renewable energy generation capacity at 38 GW, has added 2 GW to capacity in the last one year. Within conventional energy, thermal sources have added 4.36 GW of generation capacity on year on year basis in May 2020, while hydropower capacity addition was 0.3 GW. Fig. 3 depicts the all India generated installed capacity for May 2020. Fig. 4 represents the installed capacity for May 2019.

3.2. Electricity generation – A significant drop

According to provisional data from Central Electricity Authority (CEA), electricity generation declined by 19 percent to 201 billion units during April-May 2020 owing to lockdown conditions to contain the COVID-19 pandemic [22]. Data from Power System Operation Corporation Ltd (POSOCO) shows that coal-fired power generation witnessed a 28% decline in output during this period [21]. Domestic power
generation in the country is led by thermal power sources, of which coal accounts for a 64% share in total generation [20]. However, with the decline in demand for predictable and controllable power generation in the grid, unpredictable and intermittent renewable energy is increasing. On the other hand, renewable energy sources account for only 12% share in total generation witnessed output increase by 5.2% to 23.5 billion units during April-May 2020 on a year-on-year basis [22]. This increase in renewable energy share is mainly due to the mandated ‘must-run status’ for renewable energy generators. Nevertheless, generation from conventional sources (thermal, hydro and nuclear sources) was 18% lower than that in May 2019.

3.3. Reduction in power demand

The power demand in India has been falling in the wake of the nationwide lockdown in a bid to contain the spread of the COVID-19 pandemic. Within ten days of the first national lockdown, India’s daily power consumption reduced by 25–30 percent [18]. The decline in power demand led to the shutdown of several thermal power plants in the country to match demand with supply. Demand contraction has exacerbated the supply glut position. The plant load factor (PLF) of the thermal power plants declined to a record low of 45 percent in April-May 2020, which was 18 percent lower than a year ago [22]. Low PLF suggests coal plants were lying idle. Coal power plants need substantial fixed costs, and even if the plant lies idle, they incur these costs. Declining capacity utilization, exacerbated by weaker power demand, would further weaken these plants’ financial viability.

As the economic activities revive due to easing in lockdown restrictions, the sector will still take some time to cope with the losses incurred. Despite intense summer heat and rising temperatures, the all India power demand fell to 19 percent year-on-year during April-May 2020, at 188 billion units. Likewise, the peak power demand during these two months at 167 GW was 9 percent lower year-on-year. Demand rose to 103 billion units (by 20 percent) in May 2020 from 86 billion units of April 2020 with the easing of the lockdown restriction and the rise in temperature [22]. The intense heat waves caused the power demand to increase in the third week of June, and as of June 15, it hovered around 162 GW, and on June 19, it shot up to 164.64 GW, according to the power ministry data [20]. As the growth in demand and renewable energy growth is mostly dependent on each other, the question is whether DISCOMs will pause procuring new renewable energy. The DISCOMs may be hesitant to sign new PPAs if a reduction in demand persists. MNRE mandated the “must-run” status for renewable energy ventures due to the risk of potential curtailment by different states. Must-run status means electricity retailers are obliged to purchase all electricity produced from renewable energy projects regardless of cost or other parameters. The Indian government has been addressing the pandemic proactively from the beginning. Different measures have been announced on time to time basis providing relief to the renewable energy sector.

4. Power distribution sector (DISCOMs)

Indian power sector functioning is a three-stage operation. Firstly, electricity is generated at thermal, hydro or renewable power plants operated by either state utilities or private companies (also called independent power producers or IPPs). In the next stage, the electricity generated passes through a complex transmission grid network consisting of transformers, electricity substations, and power lines linking electricity producers and end-users. Lastly, the last mile connection comes in, i.e., Distribution companies or DISCOMs run primarily by state governments. DISCOMs effectively buy electricity from energy companies through Power Purchase Agreements (PPAs) and then sell it (in their distribution area) to their customers. DISCOMs have been the focal point of power sector reforms for decades and are often cited as the Indian power sector’s weakest link.

4.1. Problems faced by DISCOMs before COVID-19

Power distribution, the fulcrum of the renewable energy sector, has a significant impact due to COVID-19 [22,33]. DISCOMs financial condition has been a mounting concern for the last few years. Two fundamental problems are contributing to this issue. First, in India, electricity prices are cross-subsidized by industry and the commercial sector for agriculture and the domestic segments. Years of cross-subsidization have steered more prominent industrial users towards self-sufficiency in power, causing significant revenue loss to the sector. In other words, the system of payment in India’s power sector now depends on the C & I users paying higher tariffs, subsidizing the cost that was to be paid by the agricultural and domestic consumers. Secondly, the aggregate transmission and distribution losses represent the difference between the electricity costs that the DISCOM collects from the power generating businesses, the bills it raises, and the final realization from the end-consumer collection process. Consequently, the DISCOMs are perennially short of funds and even pay their power suppliers, resulting in a cascading effect on the value chain. Therefore, years of divisive tariff policies, mounting AT&C losses, liquidity shortfalls, and operational inadequacies have adversely affected the financial condition of DISCOMs that are presently plagued by humongous unpaid debts.

4.2. Impact on power distribution sector (DISCOMs) during COVID-19

The already stressed power distribution sector in India is going through a tumultuous period behind high accrued dues to be compensated to generators, liquidity problems due to reduced cash flow, steady low power demand, uncertain revenues due to the closure of C&I operations in the sector following the ongoing COVID-19 outbreak lockdown. The revenue deficit for the DISCOMs due to closure of C&I units during lockdown would in turn adversely impact the liquidity profile of the DISCOMs in the form of debt service reserve and undrawn working capital limits, thereby increasing subsidy requirement and lead to delays in payments to the power generation and transmission companies. The liquidity crunch will inevitably burden power generation companies. India’s commercial and industrial sector consumes about 52 percent of electricity, followed by domestic households at 24 percent and agriculture sector at 18 percent [23]. To make electricity affordable for the agricultural sector and domestic households, pricing by distribution utilities is set below the real costs for them. A combination of direct subsidy transfers and higher-tariff cross-subsidy is extended to the industrial and commercial sectors for filling the gap. Thus, it is expected that the lockdown would significantly affect the financial position of DISCOM due to

- persistent less demand from industrial and commercial utilities;
- higher-than-expected AT&C losses;
- more reliance on direct collections as compared to the subsidy from consumers.
We expect that COVID-19 will exacerbate the financial burden on electricity utilities due to the continuous decline in power demand from C&I consumers by about 18–20 percent this year. On the other hand, a rise in demand is seen from residential consumers by about 5–7 percent. So, owing to the COVID-19 crisis, the consumer mix has changed unfavourably, thereby impacting collections and the overall tariff design. Furthermore, the Metering, Billing, and Collection (MBC) operations have been severely hampered. Drop-in sales (−20 percent during the lockdown) led to a drop in revenue from the remunerative segments (C&I), and revenue collections declined by over 80 percent, significantly affecting the financial and liquidity position of the companies [24]. According to data sourced from the PRAAPTI portal, the DISCOMs owe INR 1077.85 Billion as of end April 2020 to the generation companies. The worst affected are DISCOMs at Rajasthan, Tamil Nadu, Uttar Pradesh, Haryana, and Maharashtra.

Increased power sales to agricultural and domestic consumers are set to increase AT&C losses. Credit Rating Information Services of India Limited (CRISIL), India’s leading RE firm, estimated average AT&C losses in FY 2020–21 to rise by 2.5 percent. As per the data, AT&C losses in India stand at 19.08 percent above the UDAY (Ujjwal DISCOM Assurance Yojana) target of limiting the losses to 15% by FY19. Power distribution utility debt is expected to be INR 4500 Billion by the end of FY 2020–21, according to CRISIL [25]. The significant challenges faced by renewable projects are delays in payment and curtailment, which will further deteriorate with increasing losses. So, there is a requirement to raise the tariff structure swiftly and proportionately. However, MNRE pressure on DISCOMs to honor the ‘must run’ renewable power status has kept a check on curtailment, but the risk is bound to deteriorate in the coming times.

4.3. Government initiatives to mitigate the financial woes of DISCOMs

Before COVID-19, there have been many attempts by the government from time to time for financially overhauling the DISCOMs. The flagship scheme of Ujjwal DISCOM Assurance Yojana (UDAY) launched in 2015 to fix the problems of DISCOMs under which state governments took over 75% of the debt of DISCOMs, but this scheme was not entirely successful. So far, several steps have been taken to tackle the DISCOMs financial woes in the wake of COVID-19. These include:

- Reduction of late payment surcharge, from 1.5 percent to 1 percent per month on non-payment to generation and transmission firms until June 30, 2020.
- Liquidity infusion: On top of that, the stimulus package declared by the government earmarked INR 900 billion liquidity injection into power distribution firms. The move is intended to help the DISCOMs clear their outstanding dues with electricity generation companies, which can clear their levies with suppliers.
- Moratorium to DISCOMs: Because of ongoing COVID-19 emergency and enormous DISCOM debts, the Reserve Bank of India announced a moratorium in March 2020, which allowed DISCOMs to defer payments to electricity generation companies for three months.
- Moratorium to consumers: Few states such as Goa, Rajasthan, and Uttar Pradesh provided moratorium to consumers for an electricity bill payment to alleviate their financial stress.
- The real-time market for electricity: On June 1, 2020, the Indian Energy Exchange launched Real-Time Electricity Market (RTM). The main aim of the launch is to help DISCOMs plan their power requirements. The market, thus, will help distribution companies manage their power demand–supply variation. It will help to save substantial deviation-related penalties. Also, it effectively integrates renewables. The market will facilitate utilities to reduce their dependency on the deviation framework.

4.4. Delayed key reforms

The significant reforms anticipated in 2020–21, which may get delayed due to the developing COVID-19 situation are as follows:

- UDAY 2.0/ADITYA: A new scheme for the financial reversal of DISCOM was expected in 2020. The scheme would have provided smart meters installation and incentives for tariff rationalization. However, due to anticipated economic slowdown, and most of the government funding is utilized in combating the effects of COVID-19, how this proposition will work out remains to be seen.
- The Coal Ministry was considering auction of coal mines for commercial mining in 2020. In coal mining, 100 percent of FDI was permitted to sell coal commercially to attract foreign players. Nonetheless, the global economic downturn can mean that both international and domestic players may not generate enough interest from the auctions.

These measures ensure that the power sector does not collapse in the short term but is not fully able to address the imbalance of payment that has been deepened by the lockdown. The Indian government COVID-19, policy relief package, is based on a significant objective of self-reliance or ‘Aatmanirbharbha.’ The liquidity infusion announced by the government has eased out the immediate cash stress. So, to achieve long-term solutions for the self-reliance of DISCOMs, there is a pressing need to identify conditions under which specific reforms could yield positive results. Power sector reforms cannot follow the one-size-fits-all method. Therefore, experimental measures need to be taken to determine the conditions under which a specific reform achieves the desired goals. Thus, self-reliance for the power distribution sector in India needs to be explored strategically if the financial sustainability of DISCOMs is to be achieved.

5. Impact of COVID-19 on the solar industry

The solar energy sector in India is not insulated from the pandemic’s effect. The country has an ambitious target of attaining 100 GW of solar energy installations (including 60 GW of rooftop solar) by 2022. The COVID-19 has hit the sector at an inopportune time when the country’s solar project implementation is at its peak in the final quarter of the financial year. Thirty-five gigawatts of solar energy projects have already been installed in India as of January 2020 [10]. The pandemic has severely affected the under-construction and operational solar projects due to disruption in supply and construction activities. The rooftop solar is the worst affected segment as it comprises smaller firms that lack the economic capacity to absorb the losses. Although the Indian government has provided the sector with a slew of measures, there is still a need to plot intelligent strategies both at the ground level and policy level to deal with the aftermaths of the pandemic.

5.1. Impact of COVID-19 on under-construction solar projects

The COVID-19 pandemic has impacted the developers of under-construction solar projects in India majorly. Solar modules account for nearly 70 percent of the cost of a solar project, and Chinese firms supply around 80 percent of the modules and solar cells along with other equipment like inverters, prefabricated structures, and raw materials. Fig. 5 and Fig. 6 depicts major Chinese suppliers for the module and inverter-based utility solar projects. COVID-19 outbreak has also coincided with the actual execution schedule of the solar projects, as maximum execution occurs in India in the last quarter of the financial year. CRISIL reports that about 3GW renewable energy projects of INR 160 billion were delayed due to lockdown in the first quarter [25]. According to the Confederation of Indian Industry (CII), about 2.3 GW of solar plants scheduled to be installed from June to August 2020 are
severely impacted as the module supplies were received by March. Capacity addition and future solar bids are likely to be more impacted in the current situation. CII urged Indian PV manufacturers to find it as an opportunity for the solar sector to achieve government objective of “Make in India” and to develop a robust and competitive domestic solar industry. As China’s situation began to improve, India entered the nationwide lockdown, which also impacted the sector. China has shown a rebound in solar photovoltaic panel exports, as its average production capacity has improved. However, the cost of solar modules is bound to increase for the short term because of Indian currency depreciation. Implementing new solar projects will face delays, which will cause developers to miss their deadlines for completion. In response to industry concerns, the Indian government suggested that undertakings with disrupted supply chains from China due to COVID-19 could declare a ‘force majeure’ clause that releases them from contractual compulsions due to unpredictable events. The pandemic is likely to impact the solar installations in the first quarter of FY 2020–21 and is expected to show signs of revival only by the end of the third quarter. Most of the solar project scheduled launches will now be deferred by at least six months. The delay in scheduled launches will change the solar industry’s working capital cycle with delayed payments. Smaller businesses in the solar sector may get viciously affected due to severe cash crunch, while the more significant players may be able to stay through this and rebound sooner.

5.2. Possible mitigants to counter the damage on under construction projects

MNRE has already declared that supply chain disruption due to COVID-19 spread will be considered a natural disaster, and the ‘Force Majeure’ clause may be invoked anywhere it is deemed necessary, and deadlines for completion can be relaxed. Such an extension will shield the developers from the risk of penalties, missing deadlines, bank encashment guarantees and will offer them much needed relief. Some other measures are shown in Table 1.

5.3. Impact of COVID-19 on operational renewable energy projects

COVID-19 has a limited effect on operational renewable energy projects due to its reliance on natural resources such as wind and solar
Table 1
Government measures to mitigate COVID-19 impact on under-construction RE projects.

| MNRE grants blanket extension of lockdown plus 30 days for RE projects | To provide relief to RE stakeholders due to the COVID-19 outbreak, MNRE has granted a blanket extension of the lockdown plus 30 days to standardize all RE projects. MNRE will treat this as Force Majeure and may provide an appropriate extension to RE projects. No case to case evaluation will be done, and no evidence will be required for extension requirement. |
| --- | --- |
| The time extension is provided to RE projects due to supply chain disruption because of the COVID-19 outbreak as the Force Majeure event. | According to MNRE, all RE implementing agencies to treat delay on account of disruption of supply chain due to COVID-19 spread in China or any other country as Force Majeure. |
| MNRE clarifies BCD at the rate of 20% on import of solar photovoltaic cells and modules | During this year’s budget, the finance ministry notified that basic customs duty would be 20% for FY 2020–21. However, MNRE clarified that basic customs duty (BCD) would be nil till the safeguard duty is applicable. Due to COVID-19, the government should not levy any duties for the next year as solar projects are already facing delays. Moreover, in all likelihood, it is expected that Basic Custom Duty (BCD) would be exempted entirely for this year; however, the government’s final notification is yet to be issued. |

Additional initiatives by the Indian government for operational RE projects are shown in Table 2.

Overall, the solar industry has been dramatically affected by the COVID-19 pandemic with issues such as cash flow shortage, payment recovery from distribution firms, working capital demand, workforce availability, and primarily supply chain disruptions. The initiatives taken by the government can help the industry in short-term but post COVID-19 to reduce such vulnerabilities and ensure energy security. India needs to focus on improving solar equipment domestic manufacturing.

5.4. Impact of COVID-19 on end-consumer driven markets (rooftop solar segment)

The major wrath of the COVID-19 pandemic is faced by the rooftop solar segment, as these are small firms lacking the financial capacity to

Table 2
Governments measures to mitigate COVID-19 impact on operational RE projects.

| MNRE addresses Invoicing Issues faced by RE Generators due to COVID-19 | While addressing the problems that are being faced by RE generators due to this COVID-19 pandemic situation, MNRE issued guidelines for invoicing and billing for solar, wind, small hydro, hybrid power generating stations. It asked them to submit hard copies of invoices within 15 days of the lift of national lockdown. In the lockdown owing to COVID-19 pandemic all over India, MNRE issued a ‘must-run’ status for renewable energy generating stations. In addition to this, |
| --- | --- |
| Clarification regarding timely payment and ‘Must run’ status for RE plants. | MNRE stated that regular payment to RE generators needs to be done regardless of the three-month moratorium’s earlier notice to make payments. |
| The essential operation of renewable energy generating utilities and permission for material movement needed during COVID 19 outbreak | The must-run status will remain the same throughout the lockdown period, and Ministry reiterated that any curtailment but for the grid, safety reason would lead to deemed generation. |
| Renewable Energy Generating Stations (REGS) are crucial for maintaining electricity supply across the country in a COVID-19 outbreak situation where conventional power plants may not operate at optimum levels due to logistical constraints regarding fuel supply such as coal, natural gas, and diesel. Therefore, power generation through these REGS is considered as ‘essential services. Some of the critical steps taken by MNRE are: |
| | Direct DISCOMs to accept the soft copies of bills for processing the payments submitted by RE developers. |
| | Payment for power procured from the RE project needs to be done on a timely and regular basis (no moratorium is applicable for power procured through RE project). |
| | It directed the distribution companies to continue scheduling power from renewable energy sources on a ‘must-run’ status. |

Opening and Maintaining Letter of Credit as Payment Security Mechanism under PPA by DISCOMs

...Keeping in view the financial position of the DISCOMs in this emergency, when power demand is at an all-time low (no demand from C&I consumers) and delayed payments from consumers (all categories), Ministry of Power has provided relief to DISCOMs by reducing the LC amount to 50% for power procured.
bear huge losses. Rooftop solar will be impacted more than grid-connected, which is under essential services. Commercial & Industrial (C&I) consumers account for a dominant share of distributed renewables in India. In the current situation, the C&I segment (which contributes more than 70% of the total rooftop solar market in India) is likely to streamline its core business operations now rather than look at rooftop solar is not a pressing need for them. Consumers are likely to delay or abandon plans to install solar systems in the face of economic instability and the possibility of income losses. The major blow will be to the residential sector, which was supposed to ramp up this year because of increased government funding and 20–40 percent capital subsidies available [14].

The industry will have to face the aftereffects post lockdown, as new rooftop solar is not a consumer necessity. For consumers grappling with various financial challenges, rooftop solar will be the least priority contributing to delays in solar rooftop installation decisions. The rooftop solar market accounts for nearly 50 percent of small, local installers. Many of these players may struggle to survive in the face of financial distress due to contraction in demand, higher working capital, and delays in payments.

5.5. Stress on domestic manufacturing of solar equipment’s

India has a strong manufacturing base for wind equipment, but supply chain interruptions and halt on import of solar equipment from China have shown India’s heavy reliance on external factors to implement solar energy projects efficiently [31,34,35]. Post the COVID-19 era, India needs to focus on improving the domestic manufacturing of solar equipment to safeguard energy security and reduce such vulnerabilities. The present scenario is pushing Indian manufacturers to expand their sourcing and increase their domestic production. This scenario necessitates an interest subsidy for domestic solar power equipment manufacturers to remain competitive in the marketplace and give foreign firms a hard competition. This signifies subsidy or rebate on which loans are granted to domestic manufacturers by the banks. In India, for setting up a solar manufacturing unit, lending rates range from 10 percent to 12 percent, while the lending rates in China range from 3 percent to 5 percent [26,27]. Chinese manufacturers can set-up mass production units and have an additional benefit of component pricing at a cost-effective rate. India’s present manufacturing capacity for solar cells stands at 3 GW to 4 GW, on the other hand, module manufacturing capacity stands at 9 GW to 10 GW annually [28]. India is targeting roughly 20 GW to 25 GW of capacity to accomplish its domestic needs [29].

Encouraging domestic manufacturers by providing enough support measures from the government would take India towards achieving its objective of self-reliance. Also, there is a need to facilitate the manufacturing of not just modules, but also a need to develop ancillary equipment (back sheet, glass, steel frames, inverters, and batteries). India faces fierce competition from China, but this initiative can give fruitful results by providing the industry with a conducive environment to invest in conjunction with a technical and innovation-based approach. Also, there is a golden opportunity for the Indian solar equipment manufacturers to export their equipment to Africa and South Asia, which are upcoming RE markets. Recently, a leading Indian RE firm with a sovereign rating “Adani Green Energy Ltd (AGEL)” has won first domestic manufacturing linked solar contract to build 8 GW of the photovoltaic power plant at an investment of INR 450 billion. This project comprises 8 GW of solar power along with 2 GW of solar modules and cell manufacturing capacity and is expected to create a large number of jobs [30]. This move is a significant step in taking the country towards self-reliance in the sector. To encourage solar manufacturing in the country government of India is taking various steps, such as:

- MNRE has suggested imposing a basic customs duty on imported solar cells and modules for protecting the domestic solar manufacturing industry.
- In a recent move to encourage domestic manufacturing, India’s government is considering imposing an import tax of 20–25% on solar modules and 15% on solar cells for a year from August 2020.
- Also, the Ministry has initiated manufacturing-linked solar bids where the subsidy is inbuilt.
- MNRE has advised states and ports to identify suitable land for establishing RE production units and hubs for export services. This land acquisition step is a long-overdue but much-required move to boost domestic solar equipment manufacturing in India. Several incentives have been provided by the government since then to states for setting up solar parks. Few states such as Madhya Pradesh and Odisha have shown their interest in setting up such parks. MNRE has also gotten in touch with several countries’ trade representatives to invest in this emerging sector in India.
- To facilitate investment in this promising sector, a “Renewable Energy Industry Facilitation and Promotion Board” has been set up by MNRE.
- Power Purchase agreements (PPAs) clauses are reinforced by the government to increase investor confidence.
- In another positive move to strengthen the renewable sector, MNRE has issued an order for setting up a Project Development Cell (PDC) within the Ministry for attracting investments in India by the development of investible projects in coordination between the Central Government and State Governments.

The government’s response to this situation has been very constructive in reducing the sector’s negative consequences. COVID-19 could be a triggering factor for the government and the associated stakeholders of the renewable energy sector to chart a strategic roadmap for achieving India’s solar energy targets.

6. Conclusion and perspective on Post-COVID era strategies for the renewable energy sector

In the renewable sector, the short-term effect of the pandemic was reasonably mild. With the easing of COVID-19 restrictions and opening of economy, construction of utility-scale projects should be catching up extensively in the coming months. India’s renewable power sector is expected to see a substantial fall in 2020–21, due to the expected continued disruptions triggered by the COVID-19 pandemic. The recovery of the sector would be contingent on the recommencement of economic activity. Renewables came in as a bright spot with an increase in the relative share in the total generation mix. In 2020, we expect a drop in rooftop and open access installations by approximately 18–20 percent. These markets would also be at risk from growing policy uncertainty in 2021 and 2022. Demand has started to rebound with the easing of lockdown and opening of facilities. Also, the Government’s planned liquidity injection has eased the immediate cash crunch. The liquidity crunch, coupled with the sector’s already uncertain position, requires a transformed commitment and focus on forming well-thought-out reforms that are to be executed at a fast-tracked pace. From our point of view, as we are moving into the post-COVID-19 era, here are the essential reform measures suggested that will be critical for the power sector to move towards a resilient and robust recovery.

- The focus on lower-carbon and green growth need a central space in the policy and planning processes and in incorporating action. The green energy transitions will require making selections associated with lower-carbon vehicles, industrial and building efficiency, cleaner fuels, and renewable energy.
- The provision of good quality and reliable power supply in the rural/ non-urban areas needs to be a priority.
- Investment in grid and utility modernization needs to be actively pursued to upgrade the infrastructure. This investment can be a crucial driver for economic recovery and job creation.
• Structural reforms must be undertaken at a speedier pace. Indian government correctly identified private-sector participation as a vital lever for improving the power sector.
• Emphasis on energy efficacy and regulatory reforms is a must. On the efficiency side, there is a need for constant focus on increasing efficiencies across the supply chain from fuel and transportation costs to power purchase cost and also power generation companies’ efficiency. On the regulatory side, there is a need for improved tariff design reflecting market developments and promoting flexibility in providing subsidies.

It is time that India evolves its rankings for power distribution companies (DISCOMs). The ranking system will help create peer pressure and prepare, as a sample of DISCOMs in such rankings will definitely expand from private DISCOMs to a broader sample of public DISCOMs.

• Power systems are susceptible to human-induced, environmental or technology-based threats. At times the effects of these risks may be devastating, leading to critical services being disrupted. Throughout the power sector, there is a strong need for contingency preparation to handle and minimize the potential effects of such events.
• Ease of supply constraints in terms of land and transmission capacity for the renewable sector.
• Providing long-term vision and the domestic manufacturing strategy roadmap.

Creating flexibility in the energy system by making coal plants more versatile, widening the market for ancillary services, and introducing demand-side management steps.

Today’s decisions will set the right strategic directions for the future. On a positive note, there is tremendous hope regarding future renewable energy prospects. Overall, we feel that there are short-term challenges; however, if the renewable energy sector takes suitable measures with government support such as proper incentivization, distributed generations, DISCOMs financial discipline, and technology development, then it is an excellent prospect for the renewable sector in India. The COVID-19 crisis has refocused worldwide governmental and policymakers’ attention on fighting climatic changes and localizing energy supply. Both of these goals play to renewable power advantage. Investors in conventional energy are expected to accelerate the shift towards renewable power, suffering huge losses due to reduced output and lower prices. Lastly, grid managers have learned essential lessons in addressing rising variability in power demand–supply.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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