

## Challenges and Opportunities in Energy Transformation during COVID-19

Bansal, Megha  
National Institute of Technology Delhi

Agarwal, Anshul  
National Institute of Technology Delhi

Pant, Meena  
National Institute of Technology Delhi

Kumar, Harish  
National Institute of Technology Delhi

<https://doi.org/10.5109/4480701>

---

出版情報 : Evergreen. 8 (2), pp.255-261, 2021-06. 九州大学グリーンテクノロジー研究教育センター  
バージョン :  
権利関係 : Creative Commons Attribution-NonCommercial 4.0 International

# Challenges and Opportunities in Energy Transformation during COVID-19

Megha Bansal<sup>1</sup>, Anshul Agarwal<sup>1</sup>, Meena Pant & Harish Kumar<sup>1\*</sup>

<sup>1</sup>National Institute of Technology Delhi, Delhi 110040, India

\*Author to whom correspondence should be addressed:

E-mail: harishkumar@nitdelhi.ac.in

(Received January 15, 2021; Revised April 19, 2021; accepted May 17, 2021).

**Abstract:** There was a time in human history when global risks were feared because of nuclear wars, armed rebellions and their aftereffects. In January 2020, when the world was fearing a major war between USA and Iran, who knew that a micro-object would create such destruction that would lock the entire globe. In December 2019, Chinese city of Wuhan reported an increase in the number of patients showing pneumonia-like symptoms and the researchers identified it to be “novel- Corona virus”. This was a new virus strain that has not previously affected the human body. It did not discriminate between people on the basis of boundaries, financial status, race, religion, gender, age and any other aspect which a human can identify as a basis of discrimination. This virus has now wrecked almost two-hundred countries across the globe and has taken a heavy toll on the global economy. The pandemic has changed the lifestyle globally as work from home has become the new normal. The devastating situation has generated new challenges in the financial and technical activities of the power sector and hence most of the utilities around the world initiated a disaster management plan to tackle the threats. The report seeks to provide a comprehensive coverage of the prevailing untoward situation particularly in the energy sector, the challenges which have occurred and the various opportunities to uplift the countries by the use of renewable and green resources. The paper also highlights the importance of innovative technologies to be utilized as an alternative source of energy after Covid-19 crisis.

Keywords: COVID-19; Government Policies; Renewable Energy Sources

## 1. Introduction

According to the World Health Organization, corona viruses are a huge group of viruses causing ailments which can extend from a common cold to many severe diseases such as MERS- Middle East Respiratory Syndrome and SARS- Severe Acute Respiratory Syndrome<sup>1</sup>. Corona virus is large and roughly spherical with bulbous surface projections<sup>2</sup>. They have a genetic material core which is surrounded by an envelope of protein spikes<sup>2</sup>. Generally, they are “zoonotic” which means that they can be transmitted from animals to humans<sup>3</sup>. It is suspected that the new strain originated from bats that are sold in Huanan Wholesale Seafood Market in Wuhan city of China. It is therefore named “novel- corona virus (n-CoV)<sup>4</sup>. The visible symptoms incorporate respiratory disease symptoms such as high fever, dry cough, gasping (shortness of breath) and breathing difficulties<sup>5</sup>. In more extreme cases, the infection can cause pneumonia, severe acute respiratory syndrome i.e. SARS, kidney failure and even death<sup>5</sup>.

The World Health Organization announced a Public Health Emergency of International Concern (PHEIC)

that can be defined as an anomalous event constituting a public health risk to different states through the global spread of the disease and possibly requires a planned global response<sup>6</sup>. Meanwhile, the first case of covid-19 outside China was found in Thailand on January 13, 2020<sup>7</sup>. India reported its first case of covid-19 in Kerala on January 30, 2020<sup>8</sup> where on the other hand, the world had already witnessed 9,847 confirmed cases with 43 deaths.

The number of confirmed cases witnessed an exponential increase to around 1.2 lakh across the world and more than 4000 deaths as recorded on March 11, 2020<sup>8</sup>. WHO announced covid-19 outbreak as a “pandemic” which is proclaimed when the viruses are able to contaminate individuals easily and spread from one individual to another individual in an efficient and sustained manner<sup>9</sup>. This pandemic is the fourth pandemic declared after the H<sub>1</sub>N<sub>1</sub> flu pandemic (2009), Cholera pandemic (1910-1911) and HIV/AIDS (1980s)<sup>3</sup>. The graph of the number of cases of covid-19 patients have been increasing exponentially since January, 2020. To steepen this curve, Western countries like the United

States of America, United Kingdom, German, and Iran along with the Asian countries like India, China, Indonesia and several others have imposed partial or complete lockdowns in the countries. The countries have issued various precautionary measures like mass testing, restricted movement across borders (both internal as well as external), social distancing norms, and restrictions on social and economic activities<sup>10-13</sup>).

The covid-19 outbreak has affected the complete globe in one or the other way. It has affected people from all the spheres of life, be it a business person or a migrant labourer, a 80-year old person or an infant, a scholar or an illiterate, signifying that almost the entire global population is affected due to the various containment measures directly or indirectly. The entire work cycle of the world seems to have stopped since March, 2020. This outbreak has given a backward jerk to the social, economic, political, cultural, infrastructural and technological developments of the world.

Energy access is perceived as a mainstay of universal collaboration as well as an immovable issue. Sustainable Development Goal focuses on guaranteeing “access to moderate, dependable, practical and modern energy for all”. While there have been large advancements towards encouraging energy access in eastern countries like Indonesia and China, there are a few areas wherein progress has been pitiful, especially nations in sub-Saharan Africa, portions of Asia and nations enduring extended clashes, for example, Yemen and Syria<sup>9</sup>). Energy access matters much more than ever at the time of Covid-19. To start with, energy access is firmly connected to our capacity to react to the pandemic. Specifically, energy is critical to health care services. Second, the various lockdown measures would have a severe impact on the individuals who are already struggling for electricity access. Thirdly, Covid-19 will impact the conveyance of supportable energy access, as streams of account and innovation rely upon a comprehensively interconnected world that do not appear practical at this point of time.

Countries like India, which are in the mid- phase of development have to suffer a severe impact of covid-19 outbreak. The stagnation of operation of industries, businesses and transportation has declined the energy demand pattern whereas the domestic load has increased significantly. This load pattern change has not only led to financial burden on the power sector but also upheld numerous issues concerning technical and socio-economic perspectives<sup>14</sup>). This report highlights the various challenges particularly in energy transformation faced by the countries like Western European countries and India and also the numerous opportunities that can be brought up amidst this crisis.

## 2. Challenges

Energy access has an empowering influence on delivery of healthcare and access to clinical innovations.

While emergency clinics in developed countries battle to give clinical assets to populations under the tensions developed due to covid-19, medical clinics and welfare offices in low and middle income nations face the pandemic along with the infrastructure and energy access challenges that go before it. Healthcare offices have two fundamental energy necessities: power for healthcare administrations and clinical gear, and warm prerequisites identified with sanitization, space and water warming, and incineration. Without access to dependable power, healthcare laborers have to work in haziness, depending on lamp oil lights, candles and cell phones. Immunizations and drugs requiring refrigeration can't be put away, and clinical hardware and gadgets can't be disinfected or utilized at all. Absence of energy access represents extra difficulties for the arrangement of crisis care administrations and the working of healthcare units. “The ventilator has become an image of the sort of concentrated consideration reaction that this pandemic requires. A brief crisis reaction additionally relies upon dependable energy access.

The covid-19 pandemic has raised the bars set by all the previous global health crises. As the spread of the pandemic is expanding, entities are encountering conditions frequently connected with a general monetary downturn, however not only restricted to budgetary market instability and disintegration of market esteem, weakening credits, liquidity concerns, further increase in government mediation, expanding joblessness, expanding stock levels, decreases underway in light of diminished interest and supply constraints, cutbacks and leaves, and other rebuilding exercises. The continuation of these conditions could have drawn out a negative effect on an entity's monetary conditions and supplies.

The covid-19 pandemic has not only impacted health but also the global economies and the energy use. The estimations show that the countries in complete lockdown have experienced an average decline of 25% in the per week energy demand whereas the countries in partial lockdown have experienced an average decline of 18% in the per week energy demand<sup>10</sup>). Almost all the sectors have suffered a huge impact on the part of investment but the worst hit sectors are the energy sectors. The reason being the restrictions on movement of people, goods and supply of equipment and machinery. It is estimated that the World Energy Investment would decrease by about 20% in the year 2020<sup>11</sup>). As a result of various restrictions on human activities, the demand-supply curve has been adversely affected leading to decline in the worldwide decrement of investment in the energy market. This is depicted in Fig. 1. The worldwide investment in the power sector, fuel supply and energy end use and efficiency fields have seen a significant decline where the worst hit sector is the fuel supply sector. The biggest hit is suffered by the Coal resources. Since many coal based economies like China have shut their services and operations. The other

possible reason for the decline of coal demand is the halt on the logistics activities in various parts of the globe.

The oil demand is reduced to such an extent that the prices have hit the negative side of the graph. The road transport activity was reduced by about 50% globally of the 2019 average by the end of March, 2020.

Electricity demand is reduced by around 20% because of the lock on various industries and the residential demands are much more outweighed by reductions in industrial operations. This can be seen in European countries and is evident by the data from one of Europe's leading power market- Nord Pool, regarding prices in the day-ahead markets<sup>13)</sup>.

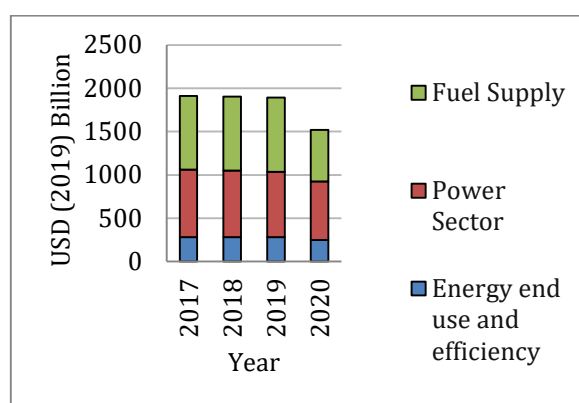


Fig. 1: Global Energy Investment 2017-2020<sup>12)</sup>. (Source- IEA)

Energy sector has also witnessed the reduced cash flows demand of the utility companies. The most crucial developmental projects under the various sectors have been put on halt because of the ceased capital. Non critical investments have been suspended. According to the Global Energy Review 2020 of International Energy Agency (IEA), the oil demand could reduce by 9% or 9 mb/d on an average over the year whereas the coal demand could decrease by 8% as the power demand would be nearly 5% lower over the year. This could also lead to the increase in demand of renewable energy resources because of the lower operating costs and hence, would lead to environmental damage. The restrictions on mobility of the population and the halted salaries have affected the demand-supply curve drastically. The development in the non-renewable energy sector in India has partially come to a halt due to lack of financial stability which can further be seen from the statistics provided in Table 1. The global recession caused by the various forms of lockdowns and restrictions on the social and economic activity of the people could not be estimated accurately because of the lack of reliable and digitally available data. Several initiatives such as the formation of National Data Sharing and Accessibility Policy and National Statistical Commission have been formulated for data collection but they do not explicitly cover the entire energy market. Although, the impact of covid-19 in 2020 can be

estimated to be around seven times more severe than the impact of the financial crisis of 2008 on global energy demand. The society is experiencing significant changes in personal behavior which include mobility and work which may further impact the energy demand-supply curve as well as the environment. The energy security has been put on stake amidst the prevailing pandemic. The successful generation of vaccine of covid-19 may be formed in the few upcoming days or so but countries have to move a long way to overcome the challenges that have curbed the energy market.

Table 1. Generation and growth in conventional generation in India during 2009-10 to 2020-21 up to April 2020<sup>15)</sup>

Year	Energy generation from conventional source	% of Growth
2009-10	771.551	6.6
2010-11	811.143	5.56
2011-12	876.887	8.11
2012-13	912.056	4.01
2013-14	967.150	6.04
2014-15	11048.673	8.43
2015-16	1107.822	5.64
2016-17	1160.141	4.72
2017-18	1206.306	3.98
2018-19	1249.337	3.57
2019-20	1252.611	0.26
2020-21	91.913	-22.86

### 3. Opportunities

Apart from the numerous challenges that have been raised due to covid-19 crisis, there are some positive effects of it on nature. According to the Global Energy Review Report 2020 by IEA, the worldwide CO<sub>2</sub> outflows are relied upon to diminish by 8% or by about 2.6 gigatonnes<sup>15-16)</sup>. This would be the largest reduction in CO<sub>2</sub> emissions ever in the history of mankind. Be that as it may, the bounce back in discharges of CO<sub>2</sub> may shoot substantially more than the decrease, except if the flood of ventures to restart the economy is devoted to cleaner and stronger vitality framework.

Energy consumption is considered as the measure of progress and improvement of living standards of the population of the country. The need of the hour is to shift our methodology from human-driven to technology-driven resources. The restrictions on human-movement have explained that we cannot rely on the existing resources for a longer period. India and other countries have to look forward to Artificial Intelligence (AI) and Internet of Things (IoT) driven resources. The AI technology can be used for data collection and can be used at an optimized level. This would help in reduction on the reliability of manpower and further would create opportunities in the field of AI. IoT is a digital system

that includes a combination of machinery packed with sensors. IoT can benefit the oil and gas companies by providing a mechanism for management of supply chains, existing assets as well as customer relationships<sup>17)</sup>. The advanced use of Machine Learning can further help in upgrading various machines. These technologies can further be used to measure and identify the various energy storage possibilities around the country. Energy data can prove to be a critical helping hand for researchers and policymakers for analyzing and formulating crisis planning and performance evaluation of energy sector policies. The simulation of such data requires accurate mechanisms, validation and updation<sup>18)</sup>. Since time immemorial, mankind is largely dependent upon the traditional ways of energy production such as fossil fuels. We need a strong team of researchers to work on the field of generating power through other resources such as waste and biofuels which would have innumerable benefits to the environment as well as reduce the dependency on age-long processes. The forecast for the year 2019 and 2020 was made in October 2019. The calculated values for the year 2019 are up to September, 2019 as depicted in fig. 2<sup>18-20)</sup>.

According to IEA, the renewable energy expansion may witness a slow down due to the economic recession of the countries and hence could delay the further expansion of renewable energy sources in 2020. However, if managed skillfully, these resources can prove to be beneficial in a long-run. Photovoltaic Cells can be modified in a way so as to serve other processes. There is a possibility of expanding the energy market by providing an “On and Off Grid Renewable Energy”<sup>19)</sup>. This step can prove to be of immense help in uplifting the renewable energy market. According to an estimate of IEA, the use of renewable energy sources will increase by an amount of 1% globally<sup>20)</sup>. Hydrogen production can be increased by using other energy sources such as oil, biomass and renewable energy resources<sup>21)</sup>. Presently, most of the hydrogen production takes place by extraction from natural gas. But there is a possibility to extract “green hydrogen” by hydrolysis of water<sup>22)</sup>. This can prove to be a carbon-free and highly efficient method to extract hydrogen for energy production.

Initiatives can be taken for collaboration and development by making the use of block chain technology to enhance responsible sourcing for various industries since the material value chains are undergoing huge disruptions<sup>23)</sup>. This would further enhance the relations between the upstream and downstream members of the demand-supply chain and would help in standardizing industries.

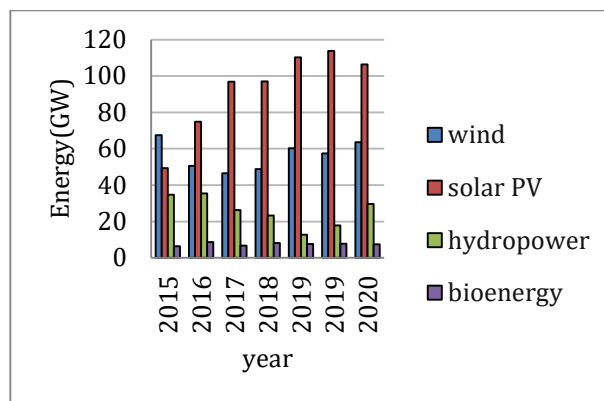


Fig. 2: Global renewable energy electricity additions by technology in the market 2015-2020<sup>20)</sup>.

#### 4. Possibility for the world

It is an accurate time for the world to choose either a healthy and developing phase or only a developing and modernized phase of living. It is certainly clear from the existing covid-19 crisis that it is not possible to survive on this planet Earth, if the prime focus of us i.e. homosapiens is solely a modernized community. A healthy community is equally essential for the survival of all the living beings on the planet. The idea of colonization of Mars may seem enchanting but we must not forget that it is a thing of the future. Presently, we are living on Earth and have to live several hundred years on the same planet. Fortunately, the crisis made it clear that the Earth has a self healing tendency. If the world makes appropriate use of this power along with innovation in technology, then we can make a better place to live. The post covid-19 situation would not be the same as it was in pre- covid-19. Many people became unemployed, but there is a huge possibility to use the array of talent of those people to invest in creating new energy supplies from various renewable resources which require a unique path to develop and brought into picture. The energy from renewable sources such as hydro power, solar power, geothermal production, wind energy and biofuels must be enhanced in an effective manner<sup>24-26)</sup>. The world should now take a step towards integrated development rather than competitive development. Competition in the era of globalization, privatization and liberalization is healthy but this crisis has weakened the entire global demand-supply chain and thus, the countries have to join hands together to overcome this pandemic.



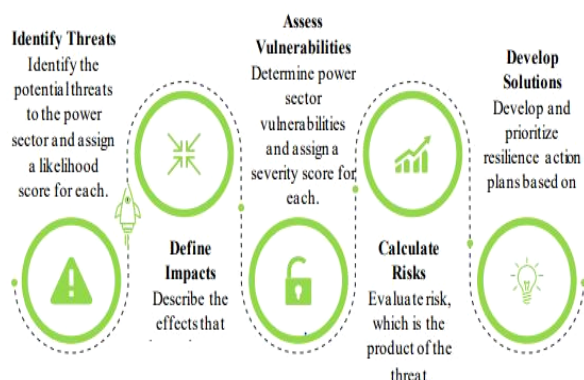


Fig. 3: Resilient Energy Platform, NREL<sup>27)</sup>

The post-pandemic world may see a transitional state to a new era. The countries should make suitable changes in the energy market policies and bidding systems so as to involve a healthy competition in development of technologies among various companies thus, leading to growth of the economy. The countries should make it mandatory for all the firms and companies to have a proper Corporate Social Responsibility (CSR) Model which would ensure that the companies are developing but without harming the society.

The governments across the world should provide a healthy economic stimulus package to curb the economic slowdown of the respective countries. Resilience relies on arrangement of secure, dependable and affordable power supply. The energy sector could confront a variety of dangers such as technological, operational and digital. Policymakers and market players must plan arrangements and put resources into improved resilience to guarantee coherence of supply and management of tasks. Resilience involves probability of possible dangers, capacity to react to unmitigated dangers and adjust accordingly. The representation in fig. 3 features an average procedure of planning. A portion of the territories which could be solidified are operational conventions, stress testing of new ventures, prioritization systems, disaster response and recovery, crisis reaction, cyber security etc. The present global emergency has highlighted the advantages of commodity enhancement, scale and balance sheet stability and strength. The allocation of capital of shareholder returns and growth could swing firmly to prioritize the shareholder returns<sup>24)</sup>. The major holders, by the use of continued prudent capital allocation and healthy dividends, have to keep the investors' trust intact along with growth opportunities

## 5. Future of India

The “Ministry of New and Renewable Energy” has proposed an interconnected global power grid plan called “One Sun, One World, and One Grid”. Through this initiative, India is planning the concept of - The Sun Never Sets, which means that it is consistent and geographically present in some of the locations at any

point of time<sup>25)</sup>. This initiative could be a source of attraction for investors and resulting in economic benefits and utilizing skills and resources. Since India is an agro-based economy, hence integrating the agricultural activities with the solar and hydro sources can contribute in reviving the economy of India. According to the analysis of Fraunhofer ISE, a horticulture photovoltaic system can provide sufficient solar radiation for the average yield of a variety of analyzed crops such as cotton, tomato and soybean to exceed by 83 %.

In a meeting with the officials of the “Ministry of New and Renewable Resources”, Indian PM Sh. Narendra Modi laid emphasis on the setting of an entire ecosystem from silicon ingot to solar module manufacturing which could contribute in availing better power demands<sup>26)</sup>. He also highlighted that manufacturing of wafers, ingots, solar-panels and solar-modules would contribute in overcoming the economic slowdown of the country. He also further emphasized the need to adopt a holistic approach from solar water pumps to decentralized solar powered cold storage in the entire supply chain<sup>28)</sup>. Various proposals are being considered for integrating the various energy vectors such as electricity, cooling, heating, wastes and water which even include the numerous possibilities provided by electric and battery vehicles to interconnect them and optimize the combined operation with the higher share of renewable and energy efficiency<sup>29)</sup>. India should also focus much more in the field of atomic energy and nuclear energy because apart from the risk of human life, there are fewer disadvantages of these energies and have higher efficiency. It is high time to find alternatives for traditional methods of using coal generated electricity as the huge amounts of funds that are invested here can be shifted to some renewable sources creating three-tier benefits- economic growth, creation of job opportunities and environment protection<sup>30)</sup>. A body for energy regulation must resonate the outline frameworks and the conflicting priorities for a steady and stable energy transition.

Apart from creation of new energy sources, India needs to develop more strategies towards digital trade and cross-border trade payment for improving connections between digital economies of the world<sup>31)</sup>. There is a chance to reboot the framework in a manner to abstain from coming back to the past and put resources into a recuperation that fastens vitality progress. An orderly way to deal with the progress of vitality would require concurrent activities on different factors, for example, flowing of the economy, cutting outflows from fossil fuels, human capital structure and sustainable power source for the future energy frameworks<sup>32-35)</sup>.

## 6. Conclusion

The emergency caused due to covid-19 pandemic has influenced all the genres of the world and it would

further reshape the world permanently. Energy is one of the fundamental facilitators of monetary development and success and the strength of worldwide energy markets is crucial to support and establish the present day society. The huge disruptions caused due to covid-19 pandemic emphasized the importance of stability in energy markets. It also highlighted that instead of being an issue of concern only during emergencies, the stability must be embedded in the design of the system. Efficient and enduring results can just originate from a reasonable methodology which thinks about financial security, development and unwavering quality alongside delivering dependability and maintainability in the vitality markets. The concern should be raised to look forward for more secure alternatives for energy and bid a retirement to the traditional sources of energy to maintain a pace along with the growth and development. Renewable energy solutions provide a pathway to progress towards sustainable development goals and energy transition in an environmentally sustainable way. Their role needs to be recognized in national electrification and holistically planned to transform energy in under-served areas. An enabling environment is required to enhance access to renewable energy which needs to include customised businesses and financing models, capacity building and dedicated platforms for technology sharing. Participation of local communities, public-private partnership and end-use support are also required for project sustainability and favourable outcomes. The crisis has offered a comprehensive picture to the policy-makers about the provisional long term changes along with an inspiration to grasp the opportunities to improve the world.

### References

- 1) "Coronavirus," *Wikipedia*, 03-Jun-2020. [Online]. Available: <https://en.wikipedia.org/wiki/Coronavirus#Structure>
- 2) M. A. Shereen, S. Khan, A. Kazmi, N. Bashir, and R. Siddique, "COVID-19 infection: Emergence, transmission, and characteristics of human coronaviruses," *Journal of Advanced Research*, 16-Mar-2020. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2090123220300540>.
- 3) "Origin of SARS-CoV-2, 26 March 2020," *World Health Organization*, 01-Jan-1970. [Online]. Available: <https://apps.who.int/iris/handle/10662/43497>
- 4) "Naming the coronavirus disease (COVID-19) and the virus that causes it," *World Health Organization*. [Online]. Available: [https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-\(covid-2019\)-and-the-virus-that-causes-it](https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it).
- 5) N. Pathak, "Coronavirus and COVID-19: What You Should Know," *WebMD*, 27-Feb-2021. [Online]. Available: <https://www.webmd.com/lung/coronavirus>.
- 6) "COVID-19 Public Health Emergency of International Concern (PHEIC) Global research and innovation forum," *World Health Organization*. [Online]. Available: [https://www.who.int/publications/m/item/covid-19-public-health-emergency-of-international-concern-\(pheic\)-global-research-and-innovation-forum](https://www.who.int/publications/m/item/covid-19-public-health-emergency-of-international-concern-(pheic)-global-research-and-innovation-forum).
- 7) "Archived: WHO Timeline - COVID-19," *World Health Organization*. [Online]. Available: <https://www.who.int/news/item/27-04-2020-who-timeline---covid-19>.
- 8) G. Unnithan, "Kerala reports first confirmed coronavirus case in India," *India Today*, 31-Jan-2020. [Online]. Available: <https://www.indiatoday.in/india/story/kerala-reports-first-confirmed-novel-coronavirus-case-in-india-1641593-2020-01-30>.
- 9) V. C. Broto and J. Kirshner, "Energy access is needed to maintain health during pandemics," *Nature Energy*, vol. 5, no. 6, pp. 419–421, 2020.
- 10) Iea, "COVID-19 – Topics," *IEA*, 01-Apr-2020. [Online]. Available: <https://www.iea.org/topics/covid-19>.
- 11) Iea, "Global Energy Review 2020 – Analysis," *IEA*. [Online]. Available: <https://www.iea.org/reports/global-energy-review-2020>.
- 12) Iea, "Total global energy investment, 2017-2020 – Charts – Data & Statistics," *IEA*. [Online]. Available: <https://www.iea.org/data-and-statistics/charts/total-global-energy-investment-2017-2020>.
- 13) T. Mylenka, "Impact of Covid-19 on the global energy sector," *pv magazine International*, 24-Apr-2020. [Online]. Available: <https://www.pv-magazine.com/2020/04/24/impact-of-covid-19-on-the-global-energy-sector/>.
- 14) R. Madurai Elavarasan, G. M. Shafiullah, K. Raju, V. Mudgal, M. T. Arif, T. Jamal, S. Subramanian, V. S. Sriraja Balaguru, K. S. Reddy, and U. Subramaniam, "COVID-19: Impact analysis and recommendations for power sector operation," *Applied energy*, 01-Dec-2020. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7458120/>.
- 15) "Policies and Publications," *Ministry of Power*. [Online]. Available: <https://powermin.nic.in/en/content/power-sector-glance-all-india>.
- 16) Iea, "Electricity – Global Energy Review 2020 – Analysis," *IEA*. [Online]. Available: <https://www.iea.org/reports/global-energy-review-2020/electricity>.
- 17) *IoT and the future of the energy industry*. [Online]. Available: <https://www.eni.com/en-IT/digital>.

- transformation/smart-energy-iot.html.
- 18) R. R. (Advisor-Energy), "Covid-19: Challenging times underscore the importance of energy planning and data management," *pv magazine India*, 13-Apr-2020. [Online]. Available: <https://www.pv-magazine-india.com/2020/04/13/covid-19-challenging-times-underscore-the-importance-of-energy-planning-and-data-management/>.
  - 19) U. Gupta, N. Arora, E. Bellini, M. Das, M. Hall, U. Gupta, D. Thakur, G. L. Somani, K. Nandan, R. Ram, S. Aiyer, PV Diagnostics, IB Solar, and Pib, "Photovoltaic Markets and Technology," *pv magazine India*, 03-Jun-2020. [Online]. Available: [https://www.pv-magazine-india.com/?utm\\_source=crossdomain&utm](https://www.pv-magazine-india.com/?utm_source=crossdomain&utm)
  - 20) Iea, "Renewables - Fuels & Technologies," *IEA*. [Online]. Available: <https://www.iea.org/fuels-and-technologies/renewables>.
  - 21) N. Filatoff, "IEA report outlines 'Future of Hydrogen'," *pv magazine International*, 17-Jun-2019. [Online]. Available: <https://www.pv-magazine.com/2019/06/17/ieas-future-of-hydrogen-report-charts-a-way-through-fossil-fuelled-isles/>.
  - 22) N. Chestney, K. Abnett, Reuters, and Reuters, "Green hydrogen's time has come, say advocates eyeing post-pandemic world," *World Economic Forum*. [Online]. Available: <https://www.weforum.org/agenda/2020/05/green-hydrogens-time-has-come-say-advocates-eying-post-pandemic-world/>.
  - 23) "Our new partnership will accelerate the responsible sourcing of raw materials via blockchain," *World Economic Forum*. [Online]. Available: <https://www.weforum.org/our-impact/the-responsible-sourcing-of-raw-materials>.
  - 24) R. Bocca, Future of Energy & Materials, and Exec Committee, "COVID-19 shocked the economy – and the energy sector. Is now the time for a new energy order," *World Economic Forum*. [Online]. Available: <https://www.weforum.org/agenda/2020/04/energy-oil-gas-electricity-sustainability-economy-covid19-coronavirus-pandemic-market-stability/>.
  - 25) The world after Covid-19: Scenarios for the future of energy," *BIC Magazine*, 12-May-2020. [Online]. Available: <https://www.bicmagazine.com/departments/fire-rescue/the-world-after-covid-19-scenarios-for-the-future-of-energy/>
  - 26) U. Gupta, "MNRE seeks consultants for the global supergrid plan," *pv magazine India*, 28-May-2020. [Online]. Available: <https://www.pv-magazine-india.com/2020/05/28/mnre-seeks-consultants-for-the-global-supergrid-plan/>
  - 27) Bruguera, Maya, Molly Hellmuth, and Derina Man. 2019. "Power Sector Resilience: Integrated Resource and Resilience Planning." Resilient Energy Platform. New York: ICF. [https://resilient-energy.org/training-andresources/quick-reads/19514\\_usaidnrel\\_irrp\\_factsheet-v7-release.pdf/view](https://resilient-energy.org/training-andresources/quick-reads/19514_usaidnrel_irrp_factsheet-v7-release.pdf/view)
  - 28) U. Gupta, "Integrating agriculture and solar energy production," *pv magazine India*, 27-May-2020. [Online]. Available: <https://www.pv-magazine-india.com/2020/05/27/integrating-agriculture-and-solar-energy-production/>.
  - 29) U. Gupta, "Modi calls for a rooftop-solar-powered city in every state," *pv magazine India*, 28-May-2020. [Online]. Available: <https://www.pv-magazine-india.com/2020/05/28/pm-modi-stresses-on-vertically-integrated-solar-supply-chain/>.
  - 30) C. Downie, "Strategies for Survival: The International Energy Agency's response to a new world," *Energy Policy*, vol. 141, pp. 111452, (2020).
  - 31) Connecting Digital Economies: Policy Recommendations for Cross-Border Payments," *World Economic Forum*. [Online]. Available: <https://www.weforum.org/reports/connecting-digital-economies-policy-recommendations-for-cross-border-payments>.
  - 32) G. D. Nugraha, B. Sudiarto and K. Ramli, "Machine Learning-based Energy Management System for Prosumer". *Evergreen*, 7(2), 309-313, (2020).
  - 33) M. A. Habib, K. M. A. Kabir and J. Tanimoto, "Do humans play according to the game theory when facing the social dilemma situation A survey study". *Evergreen*, vol. 7(1), pp. 7-14, (2020).
  - 34) V. K. Yadav, V. K. Yadav, J. P. Yadav, "Cognizance on Pandemic Corona Virus Infectious Disease (COVID-19) by using Statistical Technique: A Study and Analysis". *Evergreen*, vol. 7(3) pp. 329-335, (2020).
  - 35) P. Bhatnagar, S. Kaura and Sanjeev Rajan. "Predictive Models and Analysis of Peak and Flatten Curve Values of CoVID-19 Cases in India". *Evergreen*, vol. 7(4), pp. 458-467, (2020).