

COVID-19 and Renewable Energy: Need for a Comprehensive Review

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Abstract

The outbreak of the Coronavirus disease (COVID-19) in the late 2019 and its eventual transformation into a global pandemic has caused a shock wave across the countries. The renewable energy (RE) sector, which has always been one of the leading areas for promoting the environmental sustainability, has not been spared from the epidemic. The integration of the effects of the epidemic on the global economy and the fluctuation of oil prices due to the global quarantines around the world has increased the impact of this disease on the RE industry. Although the COVID-19 crisis has had a negative effect on the efforts to develop RE, the analysts believe that in the future, more of the world's energy requirements will come from the RE sources. The International Energy Agency (IEA) has claimed that the RE consumption is likely to increase since the people tend to have clean and sustainable energy sources such as wind, water, and solar energy more than before. In the present work, the effects of the COVID-19 outbreak on the environmental changes, energy consumption, the need to use RE, the investments made in the field of RE, and the well-being of the people of the world are examined, and the details and the results obtained will be discussed. The main aim of the this work is to review the studies of the researchers on the impact of the COVID-19 disease on the environment and RE.

Keywords: COVID-19, Renewable energy, Environment, Sustainability.

1. Introduction

Coronavirus is a crown virus and an emerging phenomenon that has overshadowed all aspects of the people's life. Coronavirus is a virus that has called on the modern world, in which speed has become the norm, to reduce its activity, to reconsider, and to rebuild. REs and the activists in this field are no exception to this rule. Therefore, it is essential to think about the COVID-19 era and foresight to the post-COVID-19 era.

According to the reports, the outbreak of COVID-19 has had drastic environmental effects, on the one hand, such as an increase in the environmental waste, and on the other hand, has reduced the greenhouse gas (GHG) emissions. However, despite this reduction, more efforts are required to prevent air pollution [1, 2].

Due to the reduced travel and social interactions caused by the COVID-19, as well as quarantine measures, the economic activity has declined, leading to a reduced energy consumption and reduced emissions. The reports suggest that people are likely to tend to use RE. Given these cases and the fact that the COVID-19 crisis has

shown the extreme vulnerability of the current energy systems, conducting a comprehensive study of the impact of COVID-19 on the environment, energy consumption, investments, countries' actions, and programs to produce RE equipment seem very necessary. Therefore, in the present work, these issues have been addressed. The authors of this work hope that the energy policy-makers and decision-makers (especially RE) will use the results of the present work to prevent delays in converting the fossil fuel projects to the RE projects.

2. COVID-19 outbreak and global energy market

Gradually, the negative effects of this disease on the world energy market became clear. The energy production and demand, which had grown steadily over the past decade [3], were suddenly hit by a big shock caused by a major disorder to the world economy. The implementation of social distancing programs and public quarantine in most countries of the world faced the energy market

with an unprecedented recession. According to the IEA forecasting, the global energy demand will reduce by 6% this year (seven times higher than the 2008 global financial crisis) [4].

The oil market is a complex one that is influenced by various economic and political factors [5]. However, the issue that has plagued the market for more than a year is the COVID-19 pandemic. The COVID-19 disease has affected the price of oil barrels in various ways since its outbreak [6]. Figure 1 shows the route of oil price fluctuations from quarantine in Wuhan, China, and the declaration of pandemic conditions for the virus up to the Organization of the Petroleum Exporting Countries (OPEC) agreements and the discovery of a vaccine.



Figure 1. Changes in oil prices affected by COVID-19 outbreak.

The oil market, which before the outbreak of the COVID-19 was accompanied by oversupply and falling prices, after this epidemic and reducing the global demand, faced a severe oversupply and an unprecedented fall. Brent crude traded at around \$9 per barrel in April 2020, down 87% from its highest level this year (January 2020) [7]. During

this period, for the first time in history, the price of crude oil in the US became negative [8].

The natural gas and liquefied natural gas (LNG) prices, whose prices are affected by oil price fluctuations, also fell sharply so that the price of natural gas in June 2020 reached the lowest price since 1995 [9].

The demand and the electricity generation were also reduced after the COVID-19 epidemic, and many businesses around the world were closed. China is the largest consumer of electricity in the world. In this country, the amount of electricity production from the factories was reduced significantly because many employees in the electricity industry were unable to attend work. In Europe, electricity consumption fell. In Italy, Spain, and the UK, with the closure of restaurants, offices, and factories, energy consumption fell by an average of 10%. In Italy, there was a 20% drop in electricity demand in 2020 [10]. In India, the electricity demand fell by 25% to 30% [11].

3. Impact of COVID-19 outbreak in RE sector

According to the IEA report, the COVID-19 disease crisis has caused an annual decline in the capacity and number of new RE facilities for the first time in 20 years but has not stopped them [12].

IEA predicts that in 2020, the net increase in the renewable electricity capacity will decrease by 13% to 167 GW compared to 2019 (Figure 2) [13]. This decrease shows delays in the construction activities due to the supply chain disruption due to quarantine the restrictions and social distancing guidelines, and the emergence of financing challenges. However, the installed capacity of the RE power plants will grow by 6% by 2020.

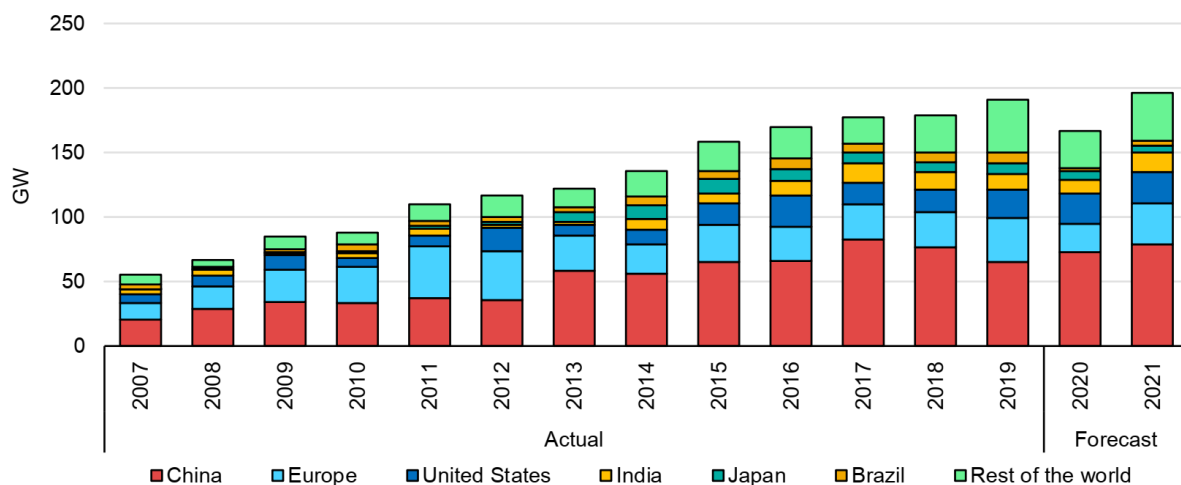


Figure 2. Forecast of RE capacity in 2020 and 2021 [13].

According to the IEA report, the impact of COVID-19 disease on the RE technologies such as hydropower, offshore wind, Concentrated Solar Power (CSP), and geothermal energy has been small [14, 15]. According to the report, the crisis caused by this pandemic has fundamentally changed the global context of biofuel use. Due to the quarantine restrictions, the transport fuel demand has fallen sharply and the global gasoline demand is projected to fall by 9%, and diesel demand by about 6%. The consumption of biofuels that are added to fossil fuels (FFs) by a certain percentage is limited by this matter. The total transportation biofuel production is projected to decline for the first time in the two last decades [16].

According to the reports, as the demand for other fuels decreased, the RE consumption increased by 3% in 2020. The principal reason for this growth was the increase of about 7% in the production of electricity from the RE sources, which includes long-term contracts, priority access to the grid, and continuous installation of new power plants despite a lower demand for electricity in many parts of the world. Accordingly, the share of RE in global electricity generation increased to 29% in 2020, while in 2019 it was 27% [17]. The bioenergy use in the industry grew by 3%, which partly offset the decrease in the use of biofuels as well as the combination of these fuels due to the declining global oil demand [17].

It is also expected that with the reduction of the commercial, industrial, and construction activities as well as the reduction of FF prices, the

consumption of renewable heat will decrease in 2020 [18].

At the time of the outbreak of COVID-19, the RE sources were experiencing an unexpected increase. About 40% of the electricity generated in the UK in March 2020 came from the wind farms and about 25% from the solar energy [19].

These situations led to the production of more RE. The recent decrease in electricity demand will lead to the rapid transition of some energy systems to RE consumption in the next 10 years, and the wind and solar energy find a wonderful position; otherwise, without the recent changes, such an investment in RE would have seemed impossible. Increasing the consumption of RE can even help some countries to figure out how to meet the challenges of RE production. Therefore, in a country like Brazil, some alternative RE sources such as biomass and wind still have a relatively small but growing share in the country's energy matrix [20]. During the epidemic, the FF sources saw the greatest decrease in the market demand. In April 2020, for example, Austria and Sweden announced the closure of their last remaining coal plants, and the UK grid operator announced that it had generated electricity for about 18 days without using coal. This has been unprecedented since the industrial revolution [21]. Figure 3 illustrates the daily consumption of coal from the six major energy companies in China. The red curve shows that coal consumption has decreased since the beginning of 2020 compared to the previous years [1].

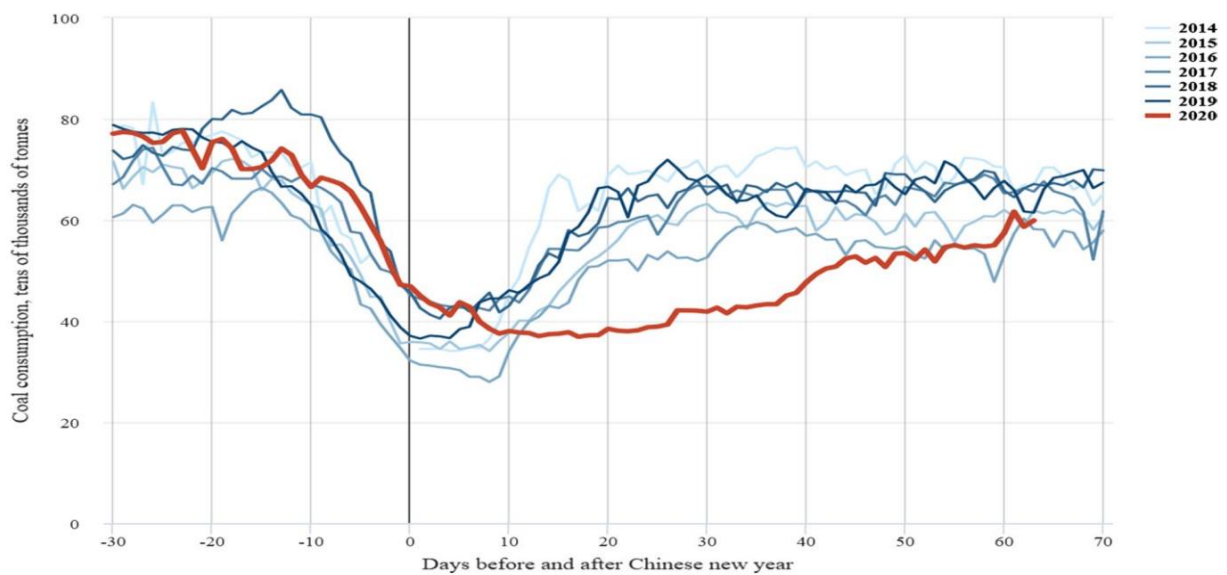


Figure 3. Daily coal consumption of 6 major energy companies in China [1].

Hence, the use of the clean energy (CE) technologies also contributes greatly to the

economic development. CE helps minimize dependence on the imported fuels. For example,

this increases energy consumption and access across Brazil to more than 4.1 million people who are not fully exposed to the RE sources [20]. Regarding the negative effects of COVID-19 disease on the development of RE in the world, the following can be mentioned [1]:

- The outbreak of COVID-19 caused the closure of a wind farm in North Dakota, one of the main examples of the effects of the outbreak on RE.
- Companies in Spain have declared that they have decided to stop the production of wind turbine blades. It was also stated that the installation of 100 wind turbines was interrupted due to the outbreak of COVID-19, and some parts were stopped during the delivery phase.
- The same is true in the solar industry, as in the wind energy industry. It is estimated that RE will be reduced by 28% by 2020 due to the outbreak of COVID-19.
- Solar workers have been fired over the outbreak of COVID-19. The results of a study on this subject are given in Figure 4. According to Figure 4, 55% of the sector workers participating in this study have been fired.

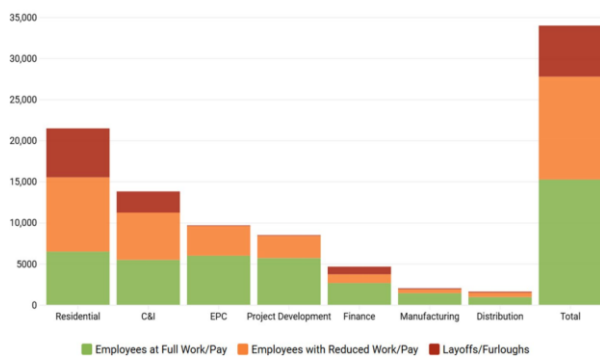


Figure 4. Survey of solar workers working in production sector [1].

The percentage of people who lost their jobs in various sectors of CE (due to the outbreak in the US) is shown in Figure 5 [1]. As it can be seen, 16.5% of the unemployed people were in the RE sector.

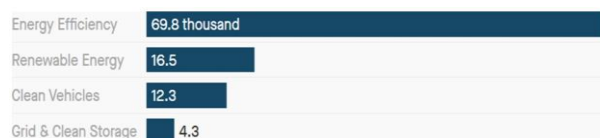


Figure 5. Distribution of eliminated jobs in CE sector in the US [1].

4. Advancement of RE systems in future

COVID-19 is said to pose a serious threat to about \$210 billion in the planned oil and gas

investments. This will, on the one hand, ultimately lead to an improvement in the gas and oil prices, as their supply decreases over time, and on the other hand, it affects RE and increases their supply in the market [22].

5. Effect of COVID-19 on emission of pollutants

During the outbreak of COVID-19, a decrease in the GHG emissions was observed during the quarantine restrictions in the countries such as China and Italy [23]. A nearly 25% reduction in carbon emissions has been reported in China [24]. Air pollution (such as NO₂ and CO₂) has also been reported to decrease in many areas [25]. Figure 6 shows the emission status of NO₂ in France and Italy, prepared by the satellite images during the epidemic [1].

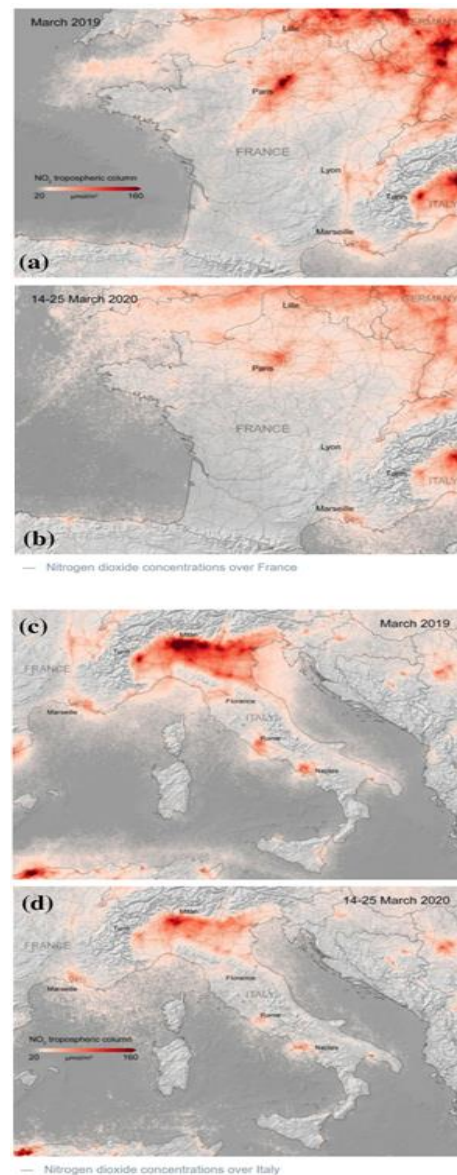


Figure 6. Comparison of NO₂ concentrations in France (a, b) and Italy (c, d) before (a, c) and after (b, d) epidemic of COVID-19 [1].

6. Necessity to use RE during COVID-19

The COVID-19 disease has highlighted the prominent role of access to sustainable electricity in protecting health, well-being, supporting necessary public services, key supply chains, people's livelihoods, and countries' economies. These benefits that 840 million people around the world are denied access, of which 570 million live in sub-Saharan Africa, areas where one out of every four medical centers does not have electricity and 28% of them do not have permanent access to electricity. A reliable energy source ensures that the key systems for managing health programs can function effectively. The CE technology is a cost-effective and accessible solution in the areas where the power grid is unreliable or even unusable and can be deployed quickly. As a result, the health care providers can work around the clock with a reliable and stable energy instead of relying on candles or flashlights [26].

During the crisis period, serious attention has been paid to the RE technologies and their role in increasing access to a safe energy. In a way, the use of RE is at the forefront of the fight against this disease in some countries. Declining the electricity demand due to the COVID-19 disease will also lead to the rapid transition of some energy systems to RE consumption in the next years, with the wind and solar energy gaining ground [27].

The researchers say that the efficiency of solar panels in the world in the home living caused by the outbreak of COVID-19, on average, has increased three to four times, and this opportunity should be used to the fullest. However, due to the low level of air pollution in the countries such as Germany and Britain, the function of solar panels in these countries has not changed significantly [28, 29].

Increasing RE consumption can even help some countries figure out how to meet the challenges of RE production [30, 31]. These CE fluctuations have been a major challenge for the energy producers and suppliers [32, 33]. The new findings also make reliable and often overlooked sources of green energy as important as hydropower. Continuous energy supply is more important in exceptional situations such as the COVID-19 epidemic because the fluctuations in energy supply can expose life and employment to more changes [34, 35].

A new report by IEA shows that the accelerating investment in RE could accelerate the economic recovery from this epidemic. RE is the driving force behind job creation. The record of 11 million people working in the RE sector in 2018 shows the ability of this sector in the economic development of countries. According to the International Renewable Energy Agency (IRENA), this number could reach 42 million jobs worldwide by 2050 (Figure 7) [36].

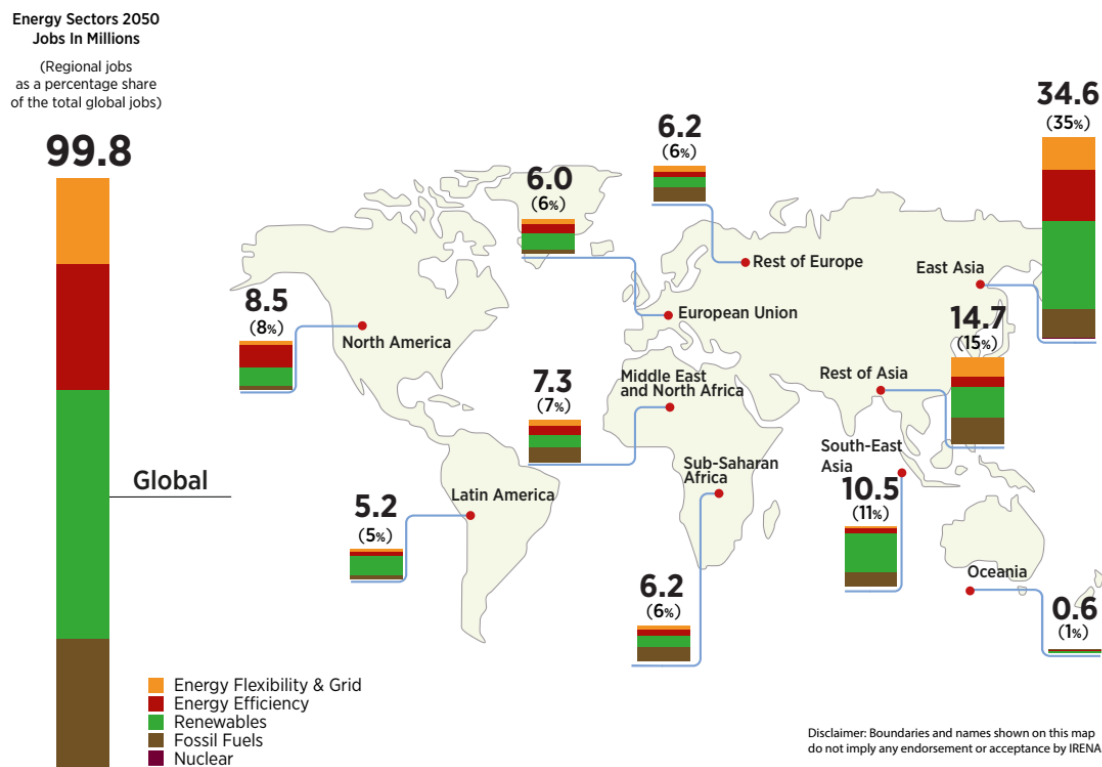


Figure 7. Employment scenarios in energy sector in 2050 [36].

7. Impact of COVID-19 on global electricity consumption and position of RE

During the COVID-19 epidemic, most governments implemented public quarantine, in

whole or in part. This has reduced electricity demand by 15% to 30% in many countries (Figure 8) [37].

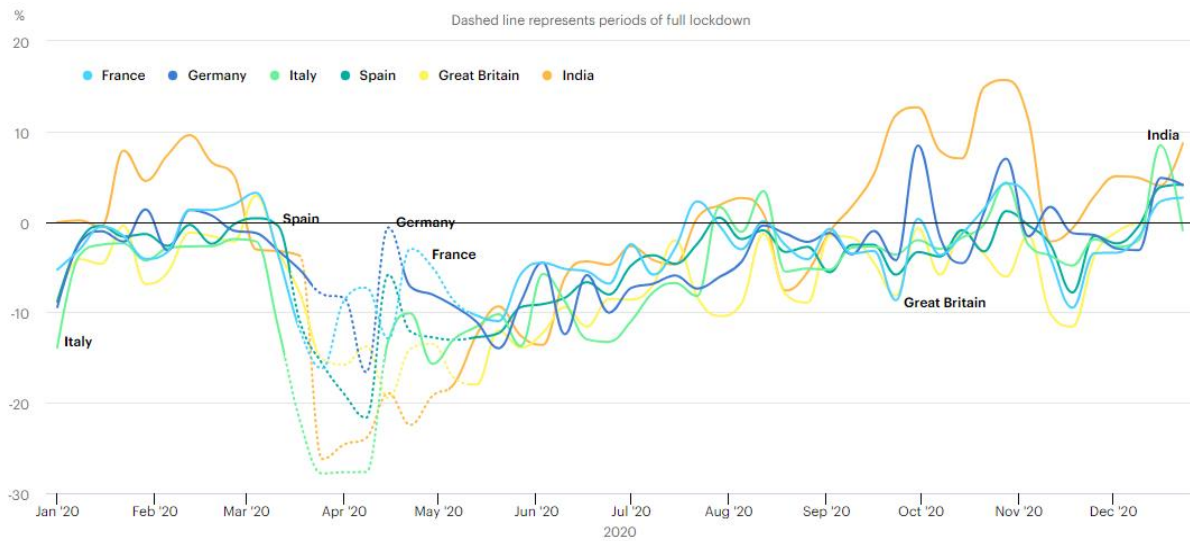


Figure 8. Reduction of electricity consumption during quarantine period in different countries [37].

Due to the crisis, the countries' national electricity grid operators were looking for the cheapest and cleanest source of supply for this low demand. Therefore, the share of RE in relation to thermal electricity increased significantly. During these few months, it seems that the production of electricity from FFs has reached a breaking point; in other words, COVID-19 disease has accelerated the end of the use of FFs in the electricity generation because the composition of electricity generation in most parts of the world has changed to RE [38].

In many national grids, electricity is first sent from the RE power plants, meaning that they can continue to sell their energy indefinitely. As a result, many power grids are observing a significant increase in the share of RE (mainly wind and solar), the amount that has been expected for the next decade. For example, in less than 10 weeks from the start of quarantine, the RE consumption increased to approximately 40% in the US and to 45% in India (Figure 9). Italy, Germany and Spain also set new records for the integration of RE variables into the grid [39].

Although the COVID-19 pandemic was unusual and unexpected, the steady increase in the share of RE in the grid is not. This increase is due to a mix of the past policies, regulations, incentives, and innovations in the field of electricity generation from RE in many leading countries in this field. Innovation in RE has made this type of energy the cheapest energy source in the world. IEA has

recently reported that the price of building and operating solar power plants has dropped by 82% over the past 10 years. At the same time, Bloomberg NEF (BNEF) has stated that RE is now the cheapest source of electricity generation in two-thirds of the world (Figure 10) [40].

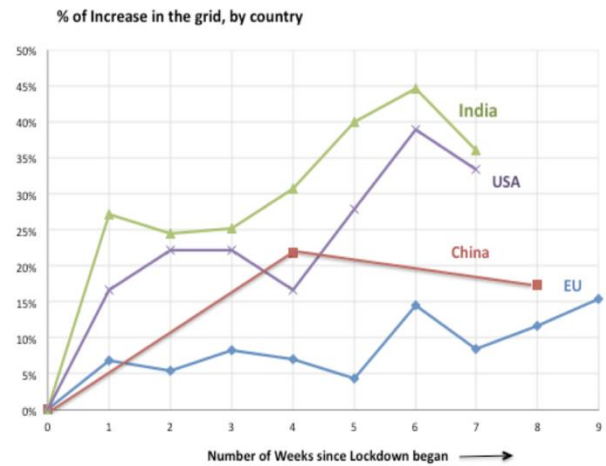


Figure 9. Increasing share of RE in days of COVID-19 in power grid of different countries [39].

During the COVID-19 epidemic, the interaction of technology development, market regulation, and conditions has led to a rapid paradigm shift in the electricity sector (the fundamental replacement of clean sources with FFs). However, the long-term impact of the crisis is still unclear because with the gradual lifting of the quarantine conditions, there are signs of improving demand in the electricity sector [41].

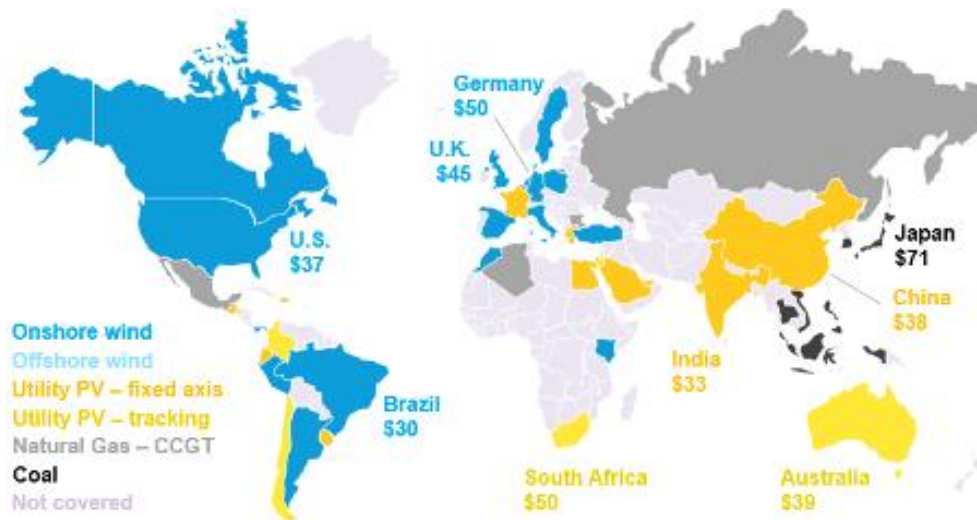


Figure 10. Cheapest sources of electricity generation in different countries of world [40].

8. Effects of COVID-19 on investments in energy supply

The outbreak of the COVID-19 virus has been reported to threaten \$210 billion in planned investments in the oil and gas industry. It has been stated that \$110 billion of investment is almost overdue, and another \$100 billion is at risk. However, it should be noted that reducing investment and increasing the risk of return on investment in this market will eventually lead to improved oil and gas prices over time and with the reduced supply [22].

China is home to many of the world's largest manufacturers of solar panels, batteries, and wind turbines. With the introduction of quarantine and restrictions on the COVID-19 disease in China, the supply chains for the RE construction projects around the world were disrupted. Therefore, the delays in the delivery of equipment and parts increased the cost of the RE projects. In the solar industry, for example, the exports of panels and other solar components were delayed, and the factories in the solar energy supply chain were disrupted as the factories closed and production was disrupted across China. Disruption of the solar supply chain has become costly for a country like India, which relies on China for 80% of its solar modules, and 3 GW of solar projects across India may face delays and higher costs [42, 43].

9. Conclusion

COVID-19 has been the game changer and the catalyst for the countries turning to a clean and low-carbon energy. This disease has taught many lessons in the field of RE policy, changing the pattern of demand and knowledge of green networks without compromising energy security.

The outbreak of the virus is causing the governments to pay more attention to RE, and make it possible to raise more capital in a near future. On the other hand, the gradual weakening of the oil and gas industry after the COVID-19 crisis has been a good opportunity for RE to flourish. Given the current situation, the need for a comprehensive study of the impact of the COVID-19 disease on energy consumption, use of RE, and investment is seen more in the programs of the leading countries. Therefore, in the present work, a comprehensive review was done on the work done in the field of the COVID-19 impact on energy consumption, and especially the use of RE. The authors of the present work hope that these results can help improve the living conditions and social welfare of the people in the COVID-19 disease crisis, and provide a perspective for the decision-makers and policy-makers in this field.

10. Nomenclature

RE	Renewable energy
IEA	International energy agency
GHG	Greenhouse gas
OPEC	Organization of petroleum exporting countries
UK	United Kingdom
US	United States
BNEF	Bloomberg NEF
CE	Clean energy
LNG	Liquefied natural gas
FFs	Fossil fuels
CSP	Concentrated solar power
COVID-19	Coronavirus disease
IRENA	International renewable energy agency

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