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A perspective of COVID 19 impact on global economy, energy and environment

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ABSTRACT

COVID-19 or novel coronavirus is not only an international emergency for public health but also has significant consequences on energy, economy, and environment. Although much of the World's attention is understandably focused on COVID-19's human toll, the outbreak's economic toll also potentially has catastrophic implications and has disrupted all the leading economies. Consequently, the energy market has plunged, leading to an oil supply surplus and a decline in the price. Policymakers also examine the impacts of COVID-19 on the energy market and its relation to the ongoing transition to renewable energy. Against this backdrop, this paper helps in summarising the impact of COVID-19 on economy, energy and environment. Besides, it provides some critical recommendations and policy measures for the energy sector to overcome the challenges from the impact of COVID-19.

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COVID 19; pandemic; global economy; energy; environment

1. Introduction

COVID-19 is caused by the virus SARS-CoV-2 called 'corona virus' or 'novel corona virus'. The world at large has witnessed the destruction created by the novel coronavirus, which originally originated in China (Wang et al. 2020). Fundamentally, all people, countries, and problems are unified in one world. Similarly, the regional or physical boundaries to climate change, loss of biodiversity and financial destruction are not recognised. The coronavirus pandemic threatens to put the world in a great depression. The coronavirus pandemic is threatening to avoid overstepping the boundaries of the earth. Deforestation, climate change and loss of biodiversity ultimately make pandemics more likely (Saadat, Rawtani, and Hussain 2020). Deforestation is bringing wild animals closer to human settlements, and the COVID-19 crisis indicates that drastic improvements can be made overnight.

Commodity prices have been in free fall since coronavirus spread to more recently to the United States, Southeast Asia, parts of the Middle East, Africa, Europe, Latin America (Tahir and Batool 2020). As a result of decreased air traffic, lower economic activity, and shutdowns of refineries, it is hurling unprecedented risks to the energy and power sectors that have a significant impact on both generation and supply and infrastructure. Energy is one of the most critical enablers of modern life and has a profound influence on COVID-19 (Ghenai and Bettayeb 2020). Normalcy in the situation depends not only on the country itself but also on confinement across the whole globe. The outbreak of Covid-19 accepted as pandemic viruses by World Health Organization (WHO) deeply affects the global economy and social habits. The global economy is going through a sudden halt that is unprecedented in times of crisis. The threats to COVID-19 can only be resolved by determined

action, which should begin long before they become full-blown crises.

1.1. Overview of the pandemic situation

The novel virus blowout all over the world in a short time, with the first case of COVID-19 reported in China. The number of cases peaked in China during february 2020, from the outbreak of Covid-19 (as seen in Figure 1). Coronavirus cases have surged over the past few months in several regions of the world and large numbers of new infections are being reported daily. Around 80 million COVID-19 cases have been recorded worldwide as of 24 December 2020, resulting in more than 1.7 million deaths (BBC News, 2020–12)

The pandemic epidemic, which influenced the whole world, causes significant changes in economic, health of public as well as daily habits.

1.2. Energy situation pre-COVID 19

The Organization of the Petroleum Exporting Countries (OPEC) countries, which hold the majority of world reserves, owe almost all of their economical size to oil, as shown in Figure 2 (Organization of the petroleum exporting countries 2019). In addition to all these indicators, another factor affecting oil prices is the cross-country policies experienced by oil-exporting countries. Therefore, the prevalent attitude of the oil-exporting countries and their relations with other non-OPEC member countries doesn't have any influence on oil prices compared to COVID-19

The "Energy Return on Investment" (EROI) can be used to analyse how the price intensity of oil extraction has changed over time. Figure 3 shows the downward trend of EROI as

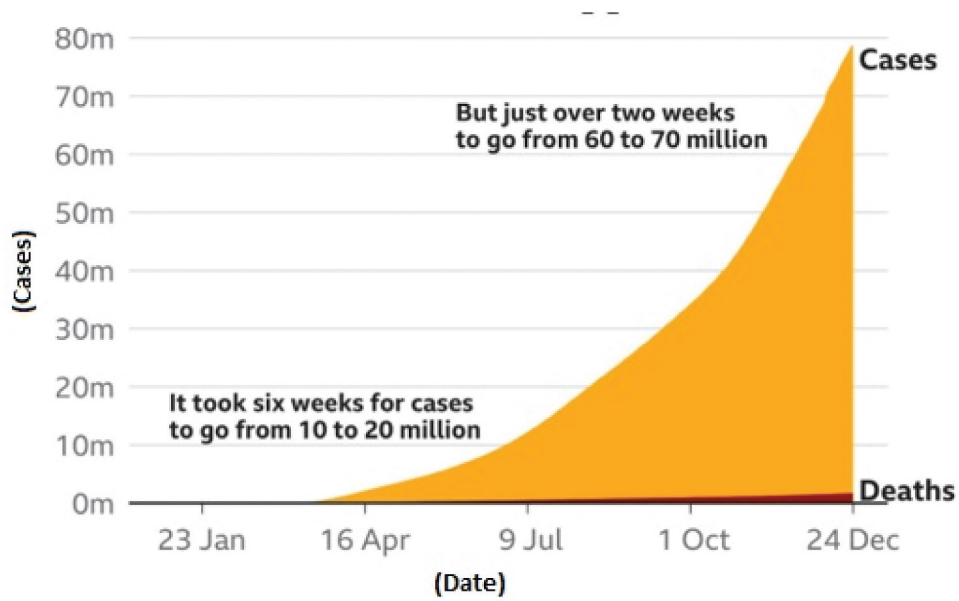


Figure 1. COVID-19 cases by date(BBC News, 2020–12).

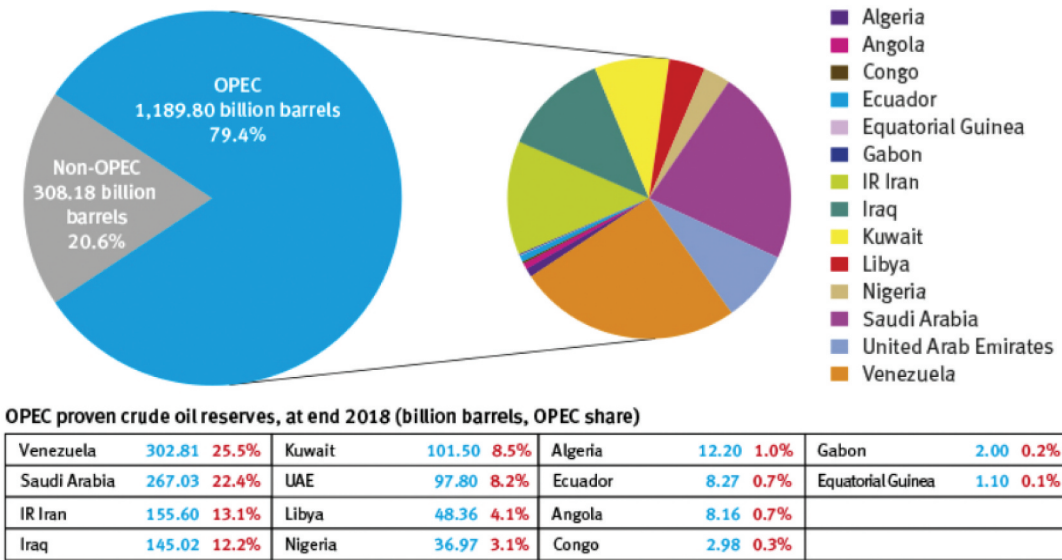


Figure 2. OPEC proven crude oil reserves, 2018 (Organization of the petroleum exporting countries 2019).

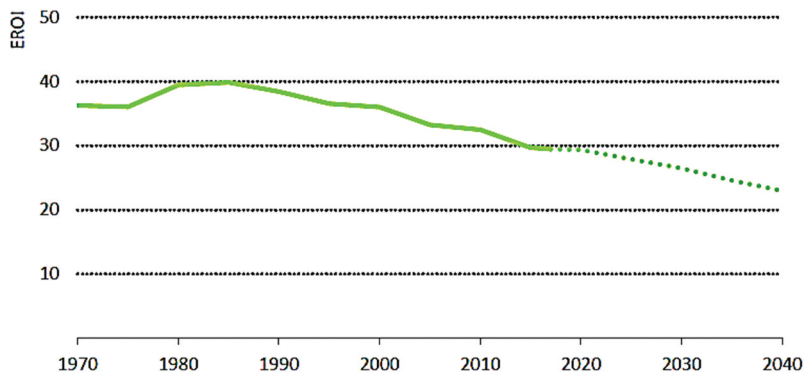


Figure 3. EROI trend

a result of depletion of resources and gradual inclination towards the use of more carbon-friendly energy sources.

Governments around the world place substantial confidence in renewable energies as an essential tool in overcoming the environmental problems associated with CO₂ emissions. Most of the support in this context is focused around the 'new' renewables, which are namely solar, wind, and modern biomass. One of the fundamental features of renewable energy is the diversity of technology and resource that it can integrate. Effective use of renewable resources has tremendous potential to improve the economy and to reduce emissions. With direct business benefits, it could strengthen the economy, the overall capacity of regional players to boost science and technology-based growth. The solar PV output addition all over the World was about 100 GW in 2018 (World Energy Outlook 2019). Solar photovoltaic cells and solar inverters are the primary constituents of solar electricity production, which cost almost 65–75 percent of total cost and are mostly dependent on Chinese imports (Das 2020). Estimated to supply almost 17% of world primary energy according to the International Energy Agency (IEA), Renewables has undergone remarkable worldwide development, with the maximum growth in solar photovoltaics with annual growth of 42 percent in the last decade and wind growth of 27 percent in the last decade (Scarlat et al. 2015). It is further expected to rise to about 55% – 75% of gross final energy consumption by the year 2050.

On the other hand, it is very difficult to make predictions about the coming years, since it is not known when the coronavirus epidemic will completely disappear from our lives or how effective it will be on a global scale in the near future. However, some assumptions can be made by researchers. A transition point is predicted to be reached if the rate of low carbon additions increases in 2022 and beyond and demand growth rates in 2022–2024 return to previous years' average levels. If low-carbon power generation slows significantly, fossil-based power generation and harmful emissions could increase to 2018 levels (Bertram et al. 2021).

1.3. Objective of the study

With the above prevalent situation of COVID-19, the study attempts:

- To discuss and underline COVID-19's global impact on oil prices, energy, economy and environment.
- To study energy sector problems and opportunities during the global spread of the COVID-19 pandemic
- To suggest suitable preventive, remedial measures and policy recommendations for minimising the impact on energy sector.

2. Impact on oil prices

In this period, when more than 80% of people stay in social isolation in their homes, the temporary break in the production network directly reduce energy consumption all over the World. Crude oil is the backbone of the gross domestic product (GDP) of many middle eastern countries (Hertog 2010).

It has become evident that COVID-19 has emerged as a significant threat to crude oil.

2.1. Decrease in oil demand

Oil prices have struggled to resist rising coronavirus lockdowns, resulting in estimates of a 20 percent drop in global demand. (Lu, Ma, and Ma 2019). As a consequence of the pandemic and control measures around the World, travel, transport, oil consumption is falling dramatically. In the pandemic of the World, minimising the transportation demands of people will continue to decrease the demand for oil as the process prolongs. The oil demand, including energy, transportation, and raw materials hitting the bottom level, causes sudden fluctuations in oil prices. World's oil supply dropped sharply by 11.8 mb/d in May, driven by track of OPEC+ cuts and economic shutdowns in the US, Canada or anywhere else (2020International Energy Agency 2020; International Energy Agency 2020). In particular, it is expected that the decline in global oil demand belonging to April 2020 is up to 29 million barrels in a day in comparing to the same period of 2019 (as presented in Figure 4). It is also stated that the level reaches to the oil demand in 1995. Furthermore, the demand of average daily oil is estimated to reduce by 9.3 million barrels per day over 2020 (2020PV Magazine 2020). Analysts estimate that global oil demand has fallen by 30% as people work from home and air travel all but stopped.

2.2. Drastic drop in oil prices

There is a sharp decline in energy demand and prices rise of essential commodities during this Covid-19. Low oil prices may result in less investment and thus causes production shortage and, consequently, high oil prices in the future (Soroudi 2020). Covid-19 has also stepped up the continuing decline in gas prices. The price of Brent oil, which was 165 dollars/barrel in 2008, started on 1 October 2018, with 84.11 dollars/barrel and 2020 with 68.1 dollars/barrel. In this case, it can be accepted that it is not possible to predict changes in oil prices in an uncertain market environment, but, inevitably, COVID-19 is indirectly affecting oil prices (Albulescu 2020a). It will continue to influence human life and economic activities in the future (Albulescu 2020b). The survey of 40 analysts predicted Brent oil prices to average 38.76 USD a barrel in 2020, down 36 percent from a survey predicted 60.63. USD Figure 5 shows the steep drop in per barrel oil prices up to May 2020. The effect turmoil hit its low point in the industry when the WTI crude for delivery went to –40 USD per barrel, which meant that storage of oil was deemed to be more expensive than the production rates. It marked the first time the oil price fell below zero and it came in the midst of social distancing measures which meant to contain the COVID-19 virus spread (Chiaramonti and Maniatis 2020).

2.3. Decline in oil transport

COVID-19 posed yet another threat to oil transporters already facing a fall in oil prices. The continuation of people's everyday life at home resulted in a decrease in the number of people who

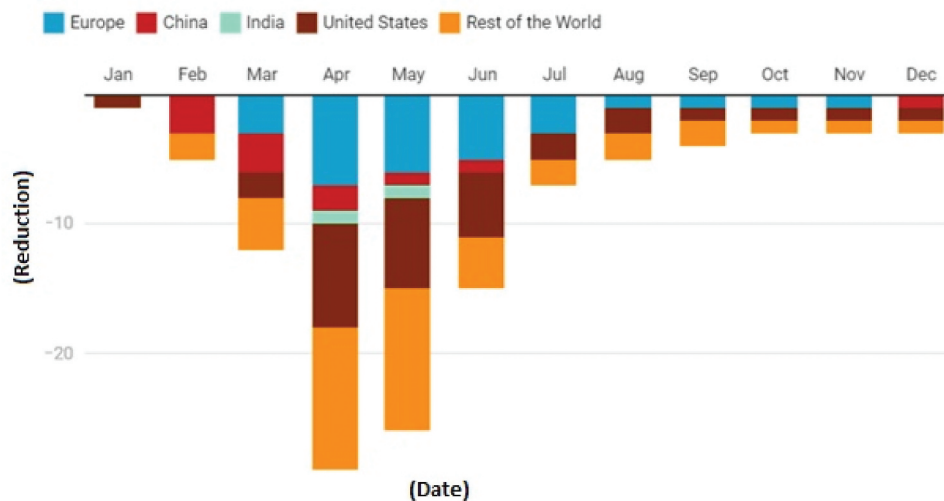


Figure 4. The reduction in oil demand in 2020 compared the demand in 2019 (2020International Energy Agency 2020)

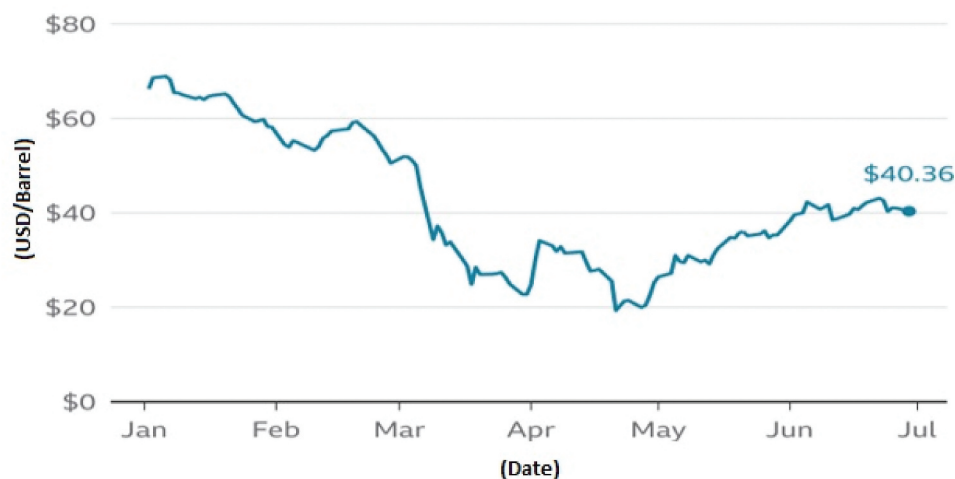


Figure 5. Oil prices in 2020 (USD/barrel) (Bloomberg 2020).

use the transport and in a reduction in the energy use of the manufacturing industry. Approximately 2% of vehicles in the World use electricity based vehicles, but the rest of them use gasoline-based vehicles in 2016 (2020International Energy Agency, COVID-19 2020). A downward trend has been observed here, too, with limited road transport, reduced freight transport, almost no current aviation, and railways.

2.4. Russia-OPEC price war

The outbreak led to a decline in demand for oil, leading to a fall in prices and production, especially following the price war between Russia and OPEC. The Saudi Oils War of 2020 between Russia and Saudi Arabia is Saudi Arabia's economic war (Gamal and Alex Lawler 2020). At the meeting held in Vienna on 6 March, after OPEC refuses Russia to reduce oil production, Saudi Arabia responds to buyers at a very low price by increasing oil production and increasing production (2020GlobalData Energy 2020). Later, the increase in Saudi Arabia's production drops the price of barrels to 34.7, USD

with a 24% decrease in oil prices, which has not been observed for 30 years (2020International Energy Agency 2020).

2.5. Impact on oil-rich economies

The COVID-19 has continued to have large scale impacts on the economies of a large number of OPEC countries too (Steffen et al. 2020). Countries that depend heavily on the oil they produce for income will feel the biggest impact. For example, Algeria, Nigeria, and Libya need some 100 USD per barrel of oil to balance national expenditure. The planned 1.5-million-barrel reduction per day would have counterbalanced lower demand due to coronavirus outbreak. Due to rising freight rates amid low demand, Saudi Arabia has struggled to sell additional crude to refiners. It also continues to rebound from the last big drop in 2014 oil prices. Therefore it might face a funding deficit of more than £100bn (Mua, Ph, and Henri 2020). The economic slowdown puts pressure on the global oil prices leading the OPEC to seek more production cuts. At a time of relatively low prices, it reduces demand for natural gas.

2.6. Reduced revenues and non-reliability of oil sources

Thermal plants that use oil as the source of fuel have suffered a decline in their revenues. The decline is mainly due to lower demand in the oil-based generation. It makes reliance on oil as a source of risky income, as oil prices have plummeted to around US\$ 20 and continue to fluctuate. The oil market instability has caused share prices in the Middle East and Asia to fall. Although lower oil prices can be a blessing for economies that rely heavily on imports for fuelling their industries, such as South Korea, Japan, and China, intense volatility can wreak havoc. Due to the dramatic drop in oil prices, the US stock market continued to plummet below 12.2%, its lowest drop since the 2008 financial crisis. Reduced energy consumption causes several reactions. Lower electricity demand if sustained would lead to an economic issue with reduced efficiency and lower revenues for fossil fuels generators. This might result in some private fossil-fuel power plants, especially older units, being closed early (Narayan and Sharma 2011).

According to the Mastepanov (Mastepanov 2021), Like 2020, 2021 is expected to be a year full of uncertainties in the world oil markets due to the direct impact of the coronavirus pandemic and unsolved problems on a global scale.

3. Impact on global energy consumption and production

The energy sector is also affected by this circumstance, as well. Energy demand is declining as people cut back on travel. The fear is the latest coronavirus would dramatically slow economies, meaning even less competition.

3.1. Changes in coal demand

Coal power plants account for over 40 percent of the world's electricity production. The decline in electricity demand leads to mitigate the energy generation capacity of coal power plants (2020GlobalData Energy 2020). The coal demand is also estimated to decrease by 8% in the first quarter of 2020 in comparison with the same period of 2019 (Figure 6) (2020IEA Global Energy Review, 2020). Nuclear power plants are

running at lower capacity due to the challenge of maintenance during ongoing-covid-19. In France, the energy generation from nuclear power has decreased by lower than the average of the last three years (2020GlobalData Energy 2020). Net additions to coal-fired plants rose for the first time in five years in 2019, driven by an uptick in newly commissioned plants in China and India.

3.2. Effects on natural gas production

With the ongoing outbreak of COVID-19, natural gas consumption is observed to decrease dramatically all over the World in 2020. The reduction in the USA is found to be 4.5% and 18% for total demand and residential and commercial demand, respectively. Moreover, Figure 7 depicts the comparison of natural gas demand concerning to first quarter of 2020 and 2019 (2020IEA Global Energy Review, 2020). Although the reduction in natural gas demand occurs in 2020, The production of natural gas increases unceasingly. The growth of production in the USA is reported to be 7%, and the increase in LNG trade is expected to be nearly 13%. Europe is responsible for 60% of globally importing liquid natural gas (LNG) in the first quarter period of 2020. The reason for the increase is due to the static natural gas production with the decrease of the gas unit-price (2020GlobalData Energy 2020).

3.3. Reduced energy demand

Globally, COVID-19 lock-down measures have resulted in a major reduction in energy usage including power, gas and oil. Energy demand is increasingly being reduced as people cut back on driving and travelling, shut down supermarkets and restaurants, as businesses go dark and their staff telework, and as factories scale back operations to protect their workers' health. When viewed global electricity demand, it is observed that the energy demand decreases by 2.5% during the first quarter of 2020. The most substantial reduction occurs in China because of adopting specific stringent health measures. The reduction in electricity demand is reported to be in the

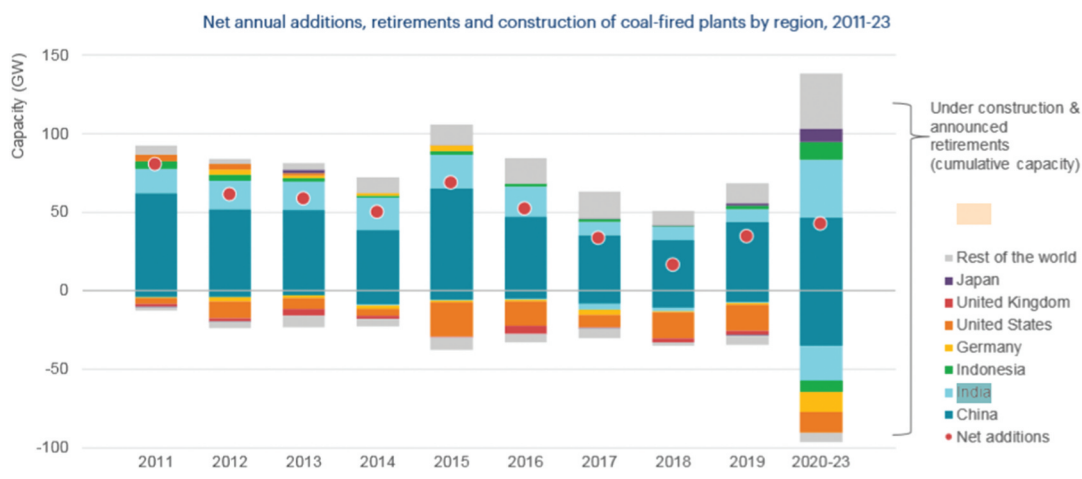


Figure 6. Coal fired plants status between 2011–2020 (Tahir and Batool 2020).

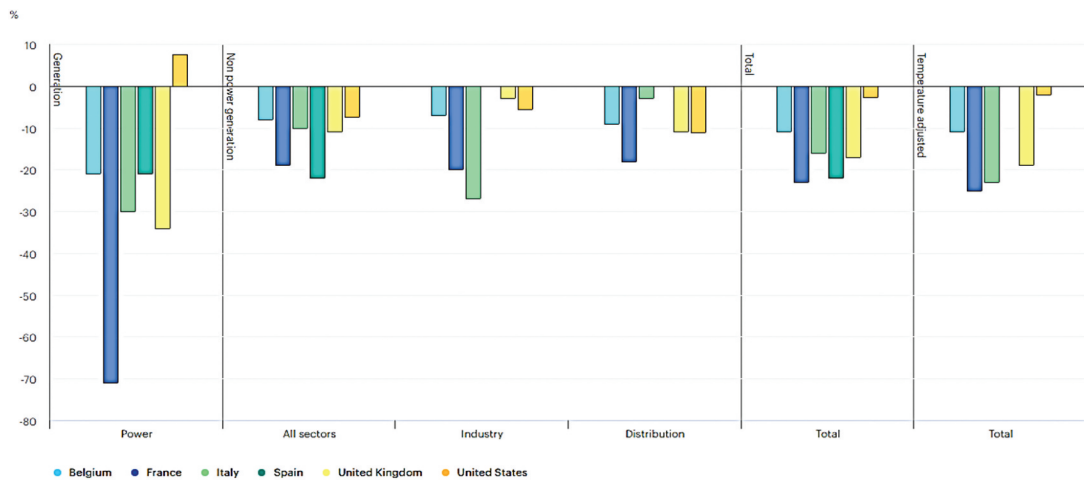


Figure 7. Effects of COVID-lockdown (from the first day to 15th April) on natural gas consumption (Tahir and Batool 2020).

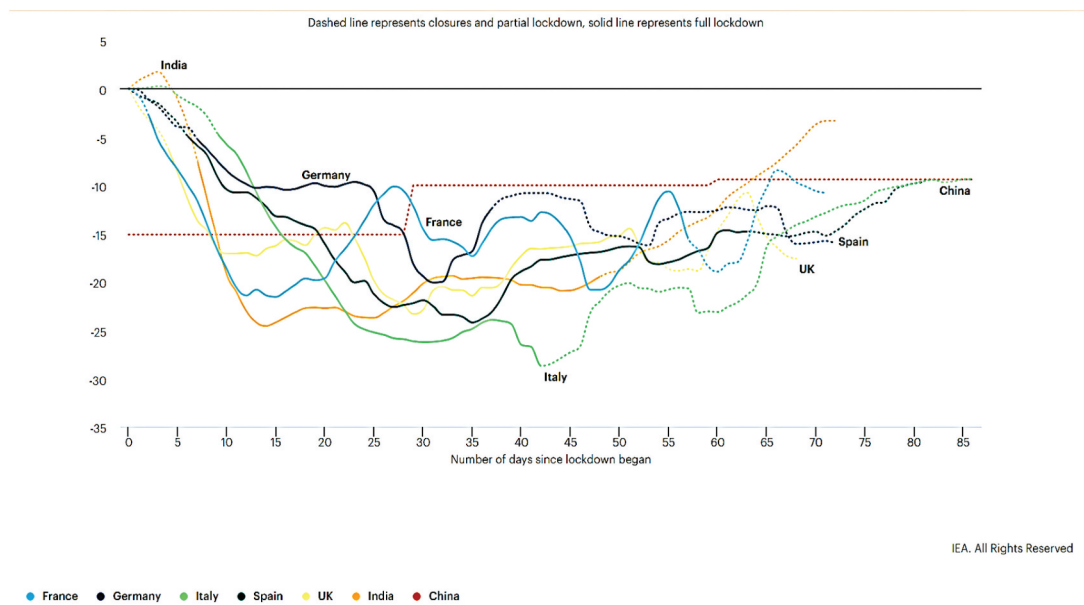


Figure 8. Electricity demand-reductions based on Covid-19 after lock-down measures (Tahir and Batool 2020).

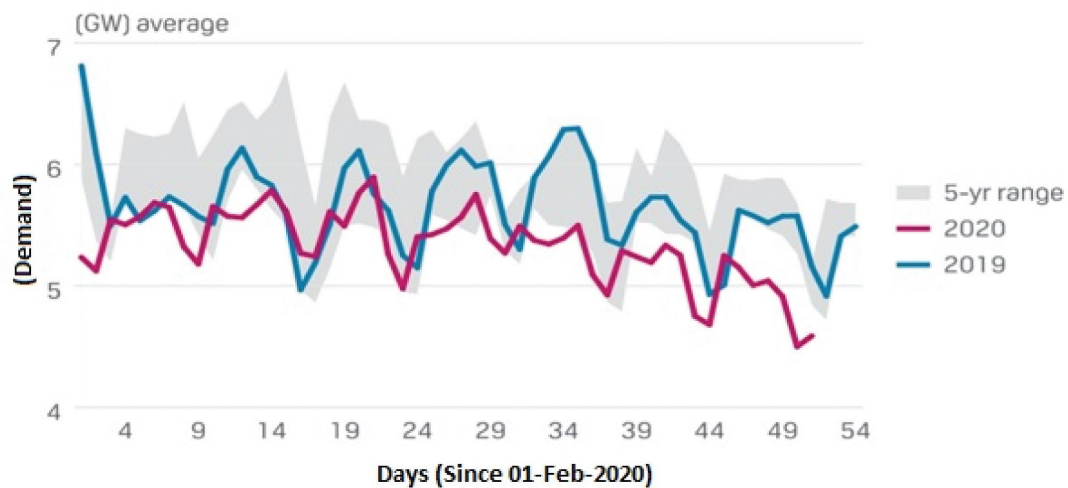


Figure 9. New York daily electricity demand (S&P Global Platts 2020)

range of 2.5% and 4.5% among Europe, Japan, Korea, and the USA relative to the first quarter of 2019. This data is depending on not only Covid-19 but also warmer weather conditions compared to 2019. Besides, [Figure 8](#) illustrates the reduction in electricity demand in proportion to only Covid-19 after removing the weather effects. With containment measures, the market for electricity has dropped rapidly and is increasing gradually now that policies are being softened. (2020IEA Global Energy Review, 2020).

Regular energy consumption has plummeted as market shutdowns continue across the World. One example of the demand for electricity in New York is shown in [Figure 9](#). During COVID-19, there was a substantial decrease in demand for electricity compared to the same month's value in the preceding year. In the USA alone, a 16% decrease in electricity demand compared to the same week of last year is an indicator of how much energy consumption has decreased (2020IEA Global Energy Review, 2020). The decrease of electricity consumption in EU has led to a reduction of the production of the costliest fossil-fired power plants (gas and coal), and to a much lesser extent that of nuclear power plants

3.4. Decline in energy production

Production decline can occur in all industries, but this is a short-term decline. The dramatic price drop in conventional energy resources (oil, gas) critically promotes the crisis and recession of the global economy. For a substantial period, most commercial buildings, offices, supermarkets, shops, markets remained close, resulting in a significant energy drop from that business.

3.5. Increase in residential consumption

Residential is the only industry to have reported a rise in energy usage. It is mainly because, for the most considerable portion of the day, people live within the house. Besides, the workers also do in-house jobs such as online teaching, e-trades, and so on.

3.6. Lower electricity cost

Dropping prices for electricity generation because of low-cost fuel has made thermal electricity a better economical choice (Masson and Winter 2020). This is, however, a contrary measure, because it comes at the cost of many lives, unemployment, and economic decline

4. Impact of COVID-19 on global economy

COVID-19 may have adverse effects on the global economy (Nicola et al. 2020). The COVID-19 pandemic has triggered major macroeconomic instability in recent months, with countries on the verge of recession. It can affect the global economy in the following ways:

4.1. Economic contraction and loss of revenues

As per the International Air Transportation Association (IATA), if the epidemic cannot be swiftly controlled, the air

travel industry may pose a loss to the tune of US\$113 billion. Similarly, as a result of travel restrictions, a contraction of US \$200 billion could be observed in the tourism sector (Chiamonti and Maniatis 2020). Microsoft (MSFT.O) has been lost about 250 USD billion since Feb. 2019. Amazon (AMZN.O) lost 170 USD billion from its market value. There was a shrinking of over 200 USD billion for each of Apple (AAPL.O) and Alphabet (GOOGL.O) values. McKibbin and Fernando (2020IEA Global Energy Review, 2020) present in seven scenarios a study illustrating COVID-19's global macro-economic effect using a modelling technique developed in 2003. Lee and McKibbin (2020IEA Global Energy Review, 2020) predict that within the short term, an outbreak will have a huge impact on the global economy according to their scenarios. Severe shifts in global demand and supply, such as COVID-19, have the greatest chance of driving the real economy into a recession.

4.2. Direct impact on production

The shutdown has already significantly affected Chinese growth in Hubei province and other regions. A severe impact is also felt in all other countries as their authorities adopt similar steps. The World Bank claims that Korea, Japan and other Asian nations are China's leading sources of imports. China's downturn has implications for exporting goods. Thus, even without new disease outbreaks, in the first half of 2020, these areas are likely to experience slow development.

4.3. Supply chain disruption

The downward slowdown in economic activity and transportation restrictions in the countries affected would possibly impact on the manufacture and profitability of different global companies, in particular in manufacturing and raw materials. The transition may be more difficult for small and medium-sized companies to survive. As the virus slows down production and disables key goods in the supply chain, holes can become problems; progress can be stopped, and layoffs can occur. Economies and industries will differ enormously.

4.4. Financial impact on firms and markets

Global financial markets, which largely disregarded Covid-19 as it spread to China, tried to react strongly to the spread of the virus to Europe and the Middle East (Das 2020; Bachman 2020). Today, leaders of the business world are wondering if the market collapse points to a recession, how bad the Covid-19 recession will be, what scenarios for development and improvement are, and whether there will be a permanent impact from the resulting crisis (Ozili and Arun 2020). Covid-19 risks have been addressed in various asset classes, and scientists also provide various scenarios against the possible effect of this virus. Some companies, especially those with insufficient liquidity, may be stressed by temporary input and/or output disruptions. Delayed shipments and production delays are causing financial difficulties for heavy-debt firms. A future event (probably low probability) would be a significant disruption to the financial system as investors

are worried about the possibility. Concern over counter-party risk accelerates the downturn in financial markets and dries liquidity.

Ozili and Arun (Ozili and Arun 2020) study the distribution of the effect on the global economy of COVID-19. They discuss two key factors why this epidemic is turned into a global financial crisis. First of all, government social isolation measures to avoid the outbreak led to financial markets, businesses and offices being closed down. Second, as the pandemic's spreading rate continues, how long it will proceed, and the rate of increase cannot be determined precisely, as it has caused distrust and indecision in international investors and consumers. According to their findings, a 30-day social distance policy causes significant losses to the economy as it causes a decrease in general economic activities and a decrease in stock prices.

4.5. Inflation and GDP

The enormous effect of this on the global economy could result in the closing of several factories, the closing of the majority of banks, declining demand for industrial and commercial resources, changing supply chains, increasing mass unemployment, and this year's rapid decline in GDP. A divergence from the estimated GDP for 2020 has been observed in many countries. Owing to lack of efficiency and excessive spending on treating and rehabilitating COVID-19 victims and their families, most powerful economies today face the challenge of high inflation and rising unemployment.

Fernandes (Fernandes 2020) discussed the economic effect of the coronavirus outbreak on the global economy. First of all, economic news and data are summarised in this regard. Some car manufacturers in Europe, for example, were suspended from production. Euro 2020, Olympic Games in Tokyo, postponed until 2021. In the U.S., more than 10 million people lost their jobs, and McDonald's refused to take orders and so on. According to the International Monetary Fund (IMF), considering the usual 30 countries, an average decrease of – 3% in

GDP is expected in 2020 as shown in Figure 10. This situation was estimated by considering that the outbreak will be under control in approximately 1.5 months. If the process is extended to 3 months, this value is predicted to be more than 6.3%, and if it is extended to 4.5 months, it is more than 10.7.

Financially ill economies and especially less developed countries, the budgets to be allocated to protect public health can cause a significant economic contraction. In the short term, central banks and reserves should ensure that economies remain active while the epidemic continues. In the longer term, global collaboration is required to conduct for improving health and economic development.

4.6. Economy recovery path

The effect of the epidemic on the economy is viewed in three ways as it is unclear whether the epidemic is controlled or decreased in the time of study. The economic recovery, maybe swift and V-shaped, or drawn-out and U- or L-shaped, when it comes to – and it will.: Outlining the economy recovery path in three comprehensive situations is sensible, which is defined as V-U-L (Ozili and Arun 2020). The aforesaid economic recovery options are illustrated in Figure 11.

- V-shaped: This scenario describes the shock of the 'classical' real economy, a drop in production, but growth ultimately recovers. In this case, the shock may be entirely absorbed by annual growth levels. Although this may seem optimistic amid the present situation, it is possible.
- U-shaped: This situation is V's ugly equivalent – the shock persists, and although the original growth direction is restored, an irreversible loss of production occurs. The scenario is more likely based on the real harm caused by Covid-19.

L-shaped: This case represents a very disorganised relationship between V, and U. The Covid-19 will be able to cause significant structural damage, i.e. breaking everything on the supply side of the economy – the labour market, capital investment, or the role of productivity. This is based on pessimistic assumptions.



Figure 10. Global real GDP growth in 2020 (Economic Growth in 2020-2030 2020).

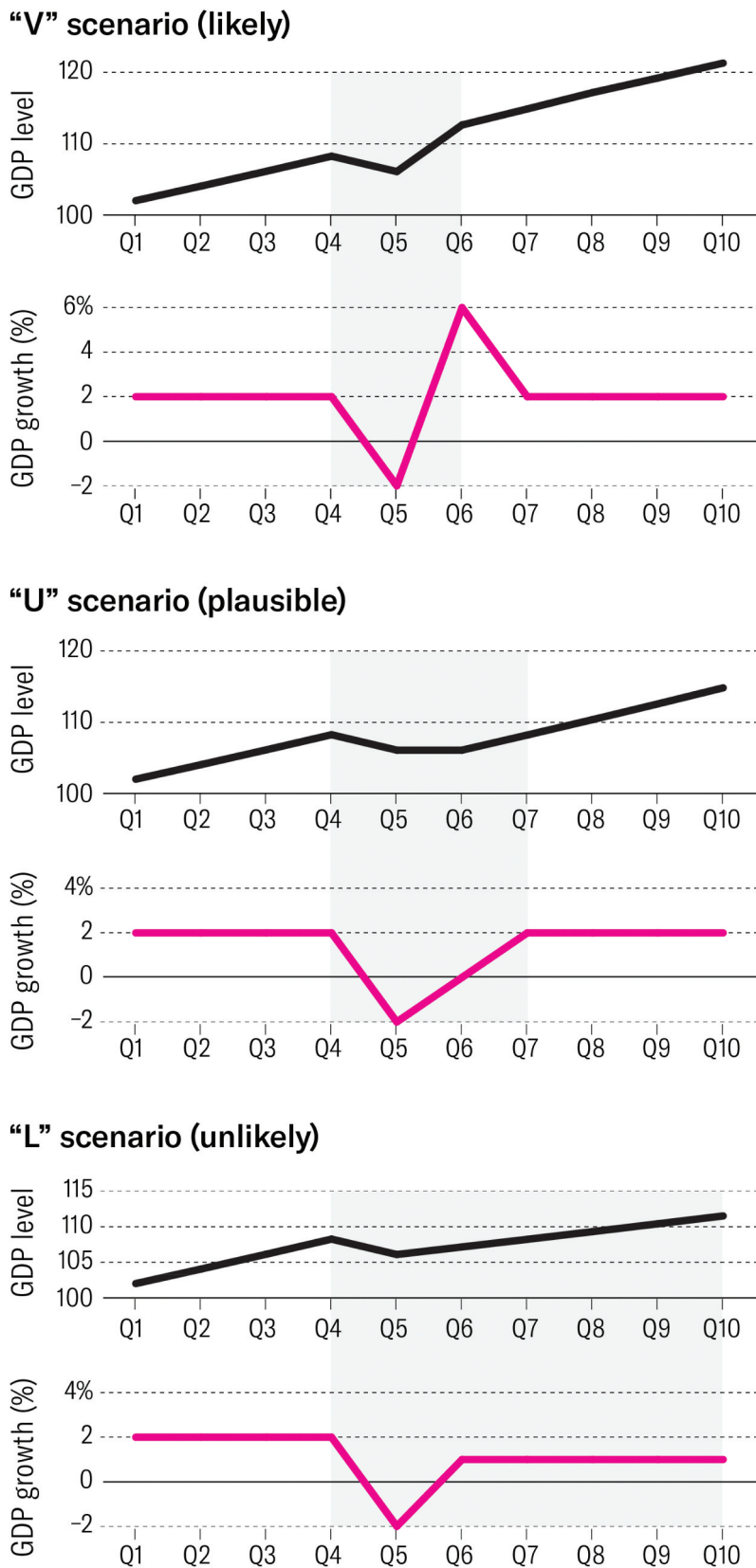


Figure 11. Economic shock: three scenarios (What Coronavirus Could Mean for the Global Economy 2020)

The danger of the outbreak on general judgements and perceptions cannot be overlooked even though there may be a pointed V-shaped recovery. A sluggish U-shaped

recovery or a longer L-shaped financial crisis would have far greater implications. Irrespective of the path ahead, the future development will be unique, and enterprises really

have to move on to a new standard.

5. Impact on environment

5.1. Reduced GHG emissions

Between COVID-19's conditionally positive effects, the related short-term reduction in the environmental effect is noteworthy (Bobylev 2020). This year CO₂ emissions may be reduced as a result of the coronavirus' effect on economic activity, especially transport. In this period, as corona rages, emissions of greenhouse gases will be reduced in certain parts of the globe due to increasing ground, air, and sea traffic (Klemeš et al. 2020). Minimising the number of flights and their high GHG emissions can also be attributed to the positive effect of reducing air traffic on the atmosphere (Masson and Winter 2020). But it is very significant to recognise that this would not be the result of governments and companies adopting new policies and strategies. In December 2020, global emissions from road transport were still 10 per cent below 2019 levels and aviation pollution was 40 per cent lower than last year. World's emissions are 7% (2.4 billion tonnes) lower in 2020 than it was in 2019. The brief dip in greenhouse gas emissions will not significantly influence long-term forecasts.

5.2. Emergence of new viruses

The emergence of the virus can be linked to the impacts of habitat destruction: The spread of the deadly Covid19 from sub-humid to tropical regions is observed. To compare climate change with Covid19 much needs to be researched and understood. The Intergovernmental Panel on Climate Change warns that the presence of new viruses that worsen global warming (Wang et al. 2020). Scientists suggest that degraded environments can promote faster evolutionary processes and disease diversification because pathogens quickly spread to animals and humans.

5.3. Economic stimulus for industries

Following study, the growth of the emissions in some of the major emerging economies, especially those in China and India, was caused by the 2008 recession (Figure 12). High fossil-fuel prices were a part of the cause. But stimulus packages, such as construction, were also deliberately intended to promote carbon-intensive areas of industry (Klemeš et al. 2020). Sadly, indicators of a widespread pattern of adverse environmental triggers are now emerging. Canada, for example, expects a multibillion-dollar bailout for its oil and gas industries. Airlines are crying for help too. Several Chinese provinces have announced plans to spend 25 trn yuan on building.

5.4. Improved environment and cleanliness

Economic crisis, business restriction or closure, rising transportation operations under conditions of diminishing demand, and living standards have enhanced the climate.

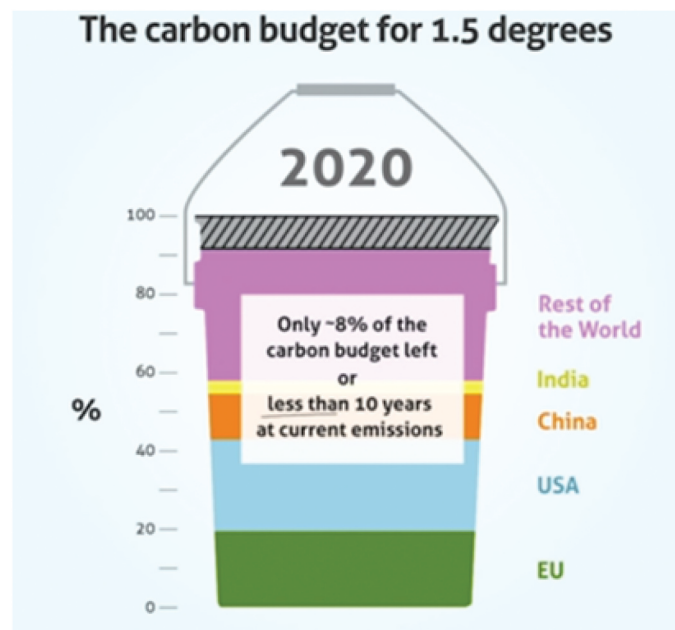


Figure 12. Carbon Budget (Daily Mail Online 2020).

The people experience a luminous sky in many big cities for the first time in their lives (Gillingham et al. 2020). An increase in the category of online employment, remote work outside, at home, etc. will help to reduce urban pollution. The decline in transport, in particular for vehicles, has a positive impact on the climate.

5.5. Reduced waste

The non-working of industries (Fever 2020) greatly reduced industrial waste emissions. Reducing the number of hotels, public services, restaurants, transport trips etc. can also be related to reducing the impact of air emissions, waste and waste in tourist areas.

5.6. Growth/Survival of endangered species

Recent studies show that endangered sea turtles hatched on abandoned beaches in Brazil, India, amid COVID-19 lockdown (Manzanedo and Manning 2020). People also found a perfect view of the sandy shore in the canals of Venice with tiny fish shoals, scuttling crabs and multi-coloured plant life.

6. Impact on renewable energy generation and penetration

The pandemic economic effect is far-reaching, with negative effects on renewables similar to other industries (Das 2020). The study on the global renewable energy industry is spread into the solar panel industry, the wind energy industry, the hydropower industry, and other industries (Klemeš et al. 2020). Out of which solar panel industry is projected to get impacted significantly due to the pandemic. Nevertheless, the effect could be different for a variety of reasons than in other economic sectors. Renewable energy has to be something here

to live, and society has accepted it this way in general (Gillingham et al. 2020). No doubt, the planet will need more renewable energy in either case. Nonetheless, for renewable energy developers and installers, this time is unpredictable, as power demand rises, supply chain volatility continues, and tax credits expire (Fever 2020). Globally, countries in these markets are at various levels of the Covid-19 outbreak affecting solar installations in different ways. COVID-19 is increasingly projected to affect zero-carbon energy growth globally this year.

6.1. Increase in renewable electricity generation

Although global electricity generation is stated to decline by 2.6% during the first quarter of 2020 relative to 2019, the increase in electricity generation from renewable sources is declared to be 3%. It is undeniable that renewable energy is the rising star over the year of 2020 (Soroudi 2020). It is also informed that the renewable energy-based electricity supply reaches 28% in 2020. Shortly, among sources of electricity production, renewables are not adversely affected by Covid-19-based situations (Aslam and Sheikh 2020).

6.2. Decline in solar manufacturing

COVID-19 has a major impact on the clean energy sector in all fields including America, Europe, Asia Pacific and the rest of the world. China is known to be the largest solar PV manufacturing country in the World (Kanda and Kivimaa 2020). The pandemic has brought production to a halt leading to lower consumption of power manufactured by solar PV. COVID-19 has walloped major producers of solar photovoltaic and energy storage equipment in China, the Republic of Korea and the US.

6.3. Decline in new clean energy projects

Prices of plummeting oil have expanded the scope of cheap oil that impedes renewable energy development. The shift to low-carbon production and renewable energy seems to be halted temporarily around the world. Meanwhile, BloombergNEF study, a clean-energy research company, estimates that solar power will decline as policymakers concerned with battling the virus delay decision-making to build new plants and agree on renewable energy growth goals (Manzanedo and Manning 2020). Indeed, China has already postponed an auction to entitle many large solar farms to be build. BloombergNEF therefore suggests that, for the first time in decades, the amount of solar-energy capacity installed this year may be smaller. The reduction in oil prices and the challenge in the delivery of renewable energy equipment can be seriously resulting in the decline of clean energy growth. It is stated that, Covid-19 could be a potential barrier in 2020 for developing renewable energy. This issue can be dealt with contributing clean energy by declaring economic stimulus packaging (Ghenai and Bettayeb 2020; Organization of the petroleum exporting countries 2019).

6.4. Shortage of raw material and equipment

Some of the main issues relates to providing power plants with machinery. China, one of the countries most impacted by coronavirus, is the world's leading producer of various renewable energy technologies, such as solar panels, wind turbines and batteries. Since coronavirus has delayed deliveries from China, renewable energy firms are unable to reach deployment deadlines. As renewable energy supply chains cover the globe, questions about the slowdowns in the renewable energy sector due to product shortages have emerged. As a result of these disruptions in the supply and lockout of crucial workers, 2020 may see a major decrease in renewable energy supplements. On the other hand, the renewable energy sector feels the negative effects of Covid-19 such as unable to be supplying the equipment used in power station-installations. Due to being the largest player in renewables energy technologies, China could not make any deliveries of pieces of equipment, like the countries supplying renewable energy systems. In addition, shortages in supply and workforce are likely to interrupt 400 MW of projects by 2021. In India, 3000 MW of renewable power plant projects can be delayed as a consequence of COVID-lockdown (Wang et al. 2020; Ghenai and Bettayeb 2020; Shah 2020).

6.5. default payment of utilities

The energy authorities and governments have advised customers in many countries (including all but two contracting parties to the energy group) to delay payment of electricity bills. Payment defaults cause ripple effects and effects on the entire renewable energy market. A shortage of working capital is expected to fund short-term routine operating liabilities within two to three months if the condition continues.

6.6. Delay in project development

Significant problems in the sustainable energy sector relate to global supply chains, which considerably delay development. Sectors like the global wind industry have already said they are experiencing logistical delays. Due delays in project development are also a matter of concern for the solar power industry, given the current unpredictable and volatile situation, mainly because solar panel shipments have stopped coming from leading suppliers like China. China accounts for almost 80% of the country's solar cells and modules imported, and COVID-19 has resulted in a substantial pause in many of these imports. Around 2022 India is targeting 100 gigawatts of solar power generation. For example, the coronavirus lock-down causes 3,000 MW of solar and wind energy projects in India alone to face delays. According to Wood Mackenzie's report, India, for example, is expected to face delays in establishing up to 21.6 % or 3GW of solar and wind power projects because of the current lock-down (Figure 13).

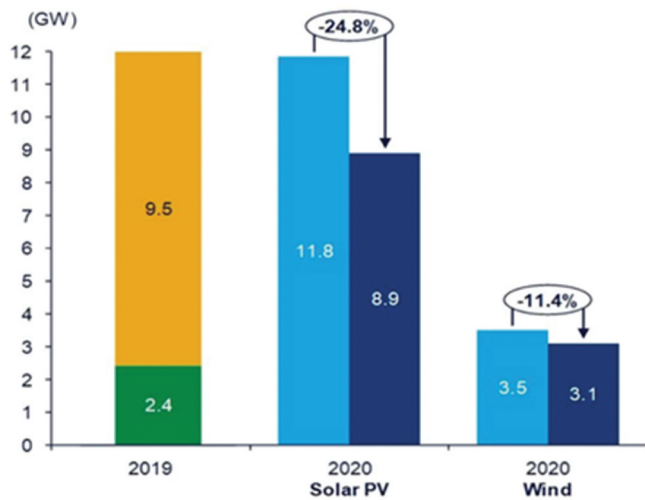


Figure 13. Impact of COVID-19 on Solar/Wind Installations: 2019 vs pre- and post-virus 2020 (Wood Mackenzie 2020)

6.7. Decline in global solar markets

Joint Solar Powers in partnership with EUPD Research launched the Covid-19 Solar & Storage Business Climate Index (SSBCI) survey to help solar and energy storage companies, regional markets, and stakeholders across the value chain by providing credible market development information (Figure 14). The

survey results revealed that booming global solar markets are likely to decline. Seventy-seven percent of respondents indicated that facilities in their respective markets are expected to decline in 2020 versus 2019. Besides, more extreme impact on installations is expected in April than in March, due to the continuing strict limitations of public life and movement. When the world enters the post-pandemic era, PV is expected to recover and prices to fall across the supply chain – with projects deferred by the crisis contributing to demand growth.

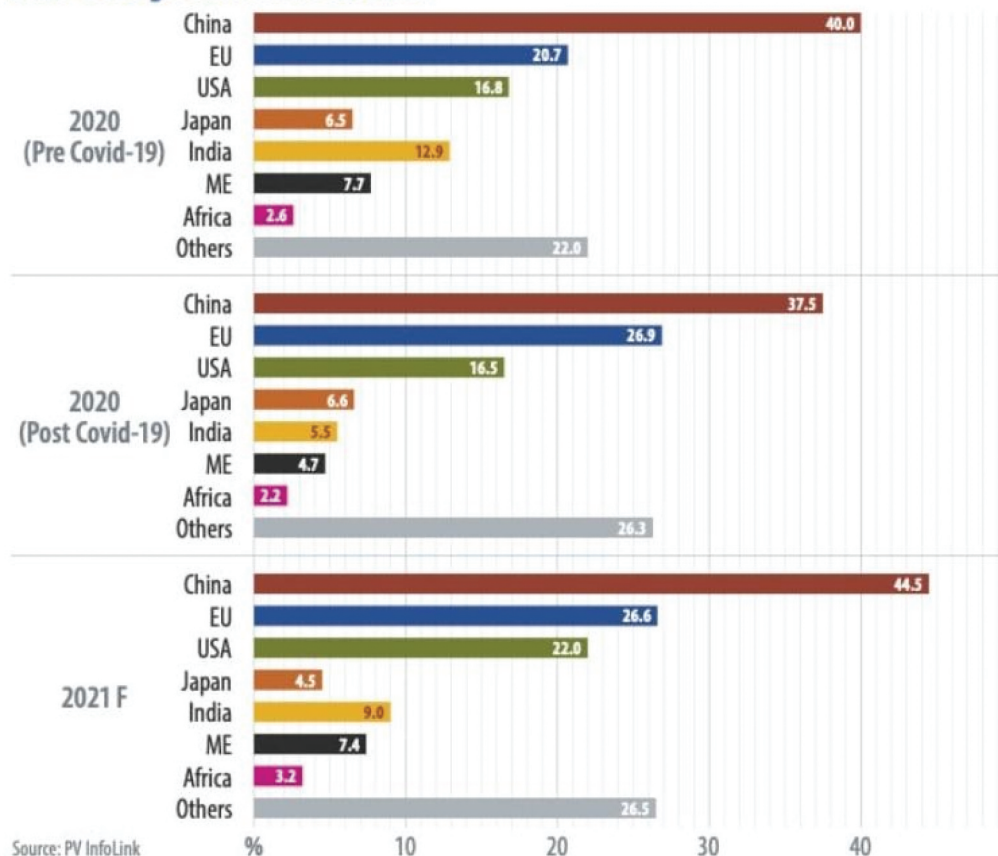
6.8. Increase in capital cost of renewable energy projects

Green energy ventures are facing instability as a direct result of COVID-19 even during the global pandemic. Wind producers GE, Vestas, and Siemens Gaemsa are reportedly preparing to close their factory. For solar, a shortage of construction components such as inverters and modules are pushing up costs by as much as 15 percent for markets such as the US.

6.9. Electric vehicle and storage

COVID-19 is also expected to dramatically affect energy storage and electric vehicle (EV) in the near term as ongoing disruptions in demand and supply. Sustainable low price of crude oil will affect the use of biofuels for the use of electric vehicles, and potentially ensure a lower

2020–2021 global module forecast



Source: PV InfoLink

Figure 14. Effect of COVID-19 on selling price of goods and services by regions (Solar set to shine in a post-pandemic world – pv magazine International 2020)

cost of transport involving renewables. Different battery manufacturers have all warned of an impact on their market. This is expected to have a major and long-term impact on EV deployment.

6.10. Penetration coefficient of renewable energy

Since covid-19 decreases overall electricity consumption, the reduction is obviously forced on non-renewable energy sources. Therefore, there is also a higher chance of increasing the renewable energy penetration coefficient.

6.11. Incentives for renewable energy

Renewable energy will thrive in the long run, not only because of an economic turnaround but also because of a strong history of the current days in its favour. Much-improved air quality can be expected if pollutant industries such as traditional power plants and fossil-fuelled transport are reduced.

7. Challenges and opportunities in clean energy sector

7.1. Challenges

- A drop in oil prices could slow renewable energy growth, especially solar power.
- There may be a shortage of skilled workers as a result of the pandemic and temporary closure of manufacturing units in China, South Asia, Southeast Asia, and Korea.
- Sustaining renewable energy projects is a challenge. Future project installations will depend on the availability of equipment or sub-components such as racks, inverters, transformers, and batteries.
- The diversified supply chain from raw materials to the shipping of finished goods in the solar market is problematic to handle.
- COVID-19 continues to squeeze liquidity; as a result, new investment in the clean energy sector could deteriorate.
- Smaller developers of renewable energy may be hit as their funding is scarce and may face difficulties in the implementation and maintenance of existing projects.

7.2. Opportunities

- A historically unparalleled level of fiscal spending announced internationally. Stimulus packages offered by different governments provide an exceptional opportunity to safeguard that the crucial task of building a secure and sustainable future energy is placed on top of other critical priorities.
- The current crisis gives long-term capital providers, market players, including investors and financiers, the ability to accelerate and grow their presence in the renewable energy field.
- The commitments of corporate and policymakers to reduce renewable energy and carbon emissions have not

changed, and the industry remains committed to using cleaner energy.

- A fall in the crude oil market is expected to generate extra demand for renewable energy.
- Tax credits are usually extended last minute. Pension funds, investment companies, and insurance firms will tend to be willing to finance projects at reasonable capital costs.
- Renewable power can be a viable source, because of its decentralisation, in the present crisis situation. Solar and wind projects will add employment to promote green and clean economic development.

8. Recommendations and future outlook

Few guidelines and measures are presented in this section to overcome the impact of COVID-19 on the energy sector (Figure 15).

- **Intervention in supply-chain of raw materials:** The primary focus should be safeguarding and stabilising processes, resources, assets, supply chains, and markets. Besides, ensuring the supply of raw material, shipping, and continuous operation of manufacturing industries. Early intervention is vital in reducing the economic crisis, recession and associated risks. Developers must identify the weak supply chain which might face significant operational or financial difficulties. In addition, investors need to identify the appropriate alternative options.
- **Economic reforms:** In the post-COVID period, new economic and administrative structures are needed in the world to accelerate the growth of GDP and renewable energy. Governments should take practical action steps to combat the forthcoming energy and economic crisis.
- **Green stimulus package:** The COVID-19 economic stimulus packages drawn up by all national governments around the world should include large-scale spending on IT-based green solutions. Additional investments and more expenditures on sustainable mobility, renewable



Figure 15. A framework for tackling impact of COVID-19 on energy sector

energy, green building, science and innovation, reforestation, digital technologies, and green low-carbon circular economy etc are necessary to revive the economic growth rather than spending money on accumulation of nuclear arms.

- **Recovery plan for green growth:** It is vital to establish a detailed recovery plan combining green transition and digital transformation. A new growth plan has to be developed, which can offer the twin benefits of growing economies and creating employment while speeding the green transition cost-effectively.
- **Prioritise green energy transition and global commitments:** Long-term renewable energy goals set by global economies should not be abandoned due to temporary hardships. Governments should turn to a clean energy transition to put in a variety of solutions at this challenging time. The world should unite to bring forward their most determined proposals to tackle the issue of growing greenhouse gas emissions during COP26. Actual, sustainable emission cuts can only occur if governments and businesses fulfil the commitments already announced.
- **Increased cooperation & awareness on environmental sustainability:** Further, It is important to teach people and make them aware of public health, the environmental sustainability by limiting the amount of greenhouse gas emissions and managing carbon foot print.

9. Concluding remarks

COVID-19 has triggered a range of setbacks, which have adverse effects on human health, economies, the global energy market, and the environment.

- Countries will seek to raise their oil-reserve potential as much as possible due to the fall of oil prices. And, even after the pandemic, low oil prices can last for a while. Based on the current outlook, fluctuations in oil prices and rapid decline are not only due to the COVID-19 affecting the World, but also due to the unstable environment caused by the pandemic and the anxious expectation about the future in the markets.
- COVID-19 has brought global financial contraction, contributing to a more dynamic domestic energy market. The oil market's sharp downturn will threaten renewable energy transitions. This can be prevented by raising the incentive for energy efficiency policies and projects.
- COVID-19 is clearly a short-term phenomenon that would have less effect on the renewable energy growth trend in the long term. Yet when the world returns to the regular routine, there will always be a great deal of concern in renewable energy. Cost reduction, improved efficiency and carbon neutrality/grid parity will drive the growth of renewables especially solar in the post pandemic period.
- The pandemic has shown its hostile effect on human civilisation by way of its significant loss on the one hand, but its positive effects on the global environment on the other.

- The global response to the pandemic and economic growth primarily depends on our ability to work in solidarity. Covid-19 along with the environmental impacts caused by human civilisation, the task of reviving the ecology must be established as a culture of mankind.
- Lastly, we were able to transit to a new paradigm through the pandemic: digital economy, knowledge economy, sustainable economy, industry 4.0. with less environmental impact.

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Nomenclature

WHO	World Health Organization
CO ₂	Carbon Dioxide
EROI	Energy Return on Investment
GDP	Gross domestic product
GHG	Greenhouse Gas
IATA	International Air Transportation Association
IEA	International Energy Agency
IMF	International Monetary Fund
LNG	Liquid Natural Gas
OPEC	The Organization of the Petroleum Exporting Countries
PV	Photovoltaic
SSBCI	Solar & Storage Business Climate Index (SSBCI)

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