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Perspective

An outlook on the global development of renewable and sustainable energy at the time of COVID-19

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ABSTRACT

The outbreak of the novel COVID-19 has dominated the world stage, and its consequences, both direct and indirect, are expected to prove to be even more pervasive over time. The COVID-19 pandemic has struck the renewable energy manufacturing facilities, supply chains, and companies and slowed down the transition to the sustainable energy world. The global decline in economy-driven demand could damage the positive trend of green and low-carbon energy progress. Although it is too early to judge how profound the negative effects of the pandemic on the global renewable and sustainable energy systems will be, a significant short-run contraction to the development of renewables is inevitable. Therefore, the energy and climate policies may require to be restructured based on the new circumstances. In this context, several beneficial stimuluses should be offered by the governments to persuade the private sectors and society to invest on renewables. Undoubtedly, intelligent policies could convert the menaces of COVID-19 to the great opportunities for renewables and ultimately the world's sustainable energy scenario could return to its long-term trajectory toward green power generation and utilization over the next few years.

1. Introduction

The spread of the COVID-19 has both direct and indirect consequences which are expected to prove to be even more pervasive over time. The pandemic virus has resulted in the deaths of thousands of people, as well as the unemployment of millions of employees and workers. Furthermore, the high infection rate has put a marked strain on health care institutions and prompted governments to dedicate trillions of dollars to support their people. In a few short days, many factories and businesses have been shut down, and livelihoods and communications have been devastated [1]. The same as all civilization pillars, the coronavirus and its worldwide spread have had profound influences on the global energy systems. The world's health systems are overwhelmed by this virus leading members of society to practice self-isolation and social distancing in order to flatten the virus infection curve result in spontaneous mitigation of industrial production and fuel consumption. Due to this mandatory quarantine, the transportation systems, including road, rail, air and sea, are being utilized more sparingly, resulting in a drastic reduction in oil use globally. The reduction in transportation systems' fossil fuel consumption has led to a substantial fall in environmental pollution [2]. However, this greenhouse gas (GHG) emissions reduction has been obtained at the cost of thousands of deaths, adverse effects on people's physical and mental

health, economic stagnation, and an overall gloomy future due to the novel COVID-19.

2. Effects of COVID-19 on the ongoing renewable energy projects

The global renewable and sustainable energy scenario, which has burgeoned in the recent decades and enjoyed rapid growth, has encountered a serious challenge as a result of the coronavirus. The COVID-19 pandemic has struck the renewable energy manufacturing facilities, supply chains, and companies and slowed down the transition to the renewables. Even the well-established renewable energy policies are under question, particularly those that burden industries that are badly influenced by the crisis. Many countries' budgets will inevitably be tightened, and the implementation of new renewable energy projects will almost certainly be deferred. The development projects of manufacturers that make/install equipment for renewable energy technologies will be shelved amidst the adoption of austerity measures. As an example, the American-based Morgan Stanley company plans to decrease the installation of the US solar photovoltaics (PVs) in the second, third, and fourth quarters of 2020 by 48%, 28%, and 17% respectively [3]. The disruptions of the supply chain will interrupt accomplishment of the under-construction renewable energy projects worldwide, particularly solar power plants, as considerable parts of the solar panels,

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connectors, modules, and cells are manufactured in China and East Asia [4].

The coronavirus, rather than geopolitics, has weakened the main oil producers' control of markets [5] and driven the natural gas prices down into the \$2 range; as a result, the remaining coal-based power plants in Europe are going to switch to gas soon [6]. The fossil fuel price reduction is particularly worrisome in developing countries where the low-cost electrical power supply seems imperative due to their poor economic situation at the time of COVID-19. The high sensitivity of these nations to the energy cost will compel their governments to adopt cheaper conventional energy sources instead of renewable energy, which would be atrocious for global climate policy. This unpleasant situation could be prevented if the banks would promote ultra-low interest rates to address the economic stagnation that threatens the implementation of high capital cost, renewable energy projects that would prevent the energy market from shifting further towards the fossil fuel-based power generation.

Before this strange condition, the transition to renewable and sustainable energy was underway in many countries. The renewables have become significantly affordable due to substantial innovations, impressive policy frameworks, and technologies cost downturn. The solar and wind power have become cheaper in the recent years, and it was anticipated that erealong the renewables would outpace fossil fuels [7]. In a \$60-per-barrel oil price period, the fossil fuel players had commenced to invest in carbon mitigation strategies; however, due to the challenges of the COVID-19 and the oil price reduction, their investments in renewables has slowed down. For instance, Calgary-based oil sands giant Suncor Energy Inc. announced cutting its 2020 capital budget by \$1.5 billion (or 26%) and held off two cogeneration units that would have mitigated GHG emissions and a wind power plant located at the northern and southern Alberta respectively. Nevertheless, the evidences illustrate that both solar and wind energy continued to grow through the last oil price mitigation because most investment in renewables comes from outside the fossil fuel sectors [8].

According to the International Renewable Energy Agency's (IRENA) report, the global renewable energy capacity hit 2,537 GW (GW) at the end of 2019, which illustrates a 176 GW increase compared to 2018. The statistics indicate that 72% of all electrical power expansion in 2019 was due to development in the renewables, of which the wind and solar energies grew 60 GW and 90 GW respectively and together were responsible for 90% of renewable additions [9]. Based on the Global Wind Energy Council's (GWEC) report, 70% of the wind power new capacity in 2019 was installed in China, the U.S., U.K., India and Spain, all of which are suffering from ongoing COVID-19 pandemic. The GWEC have postulated that disruptions to worldwide supply chains due to the COVID-19 will certainly influence the implementation of wind energy projects in 2020 [10]. Furthermore, the projections for solar power plants installation for 2020, which was 129.5 GW, has been cut down to 106.4 GW, indicating an 18% drop compared to pre-COVID-19 levels. In India, the three GW wind and solar PV Wood Mackenzie project has encountered a delay due to the COVID-19 lockdown. Further delay in installation of wind power equipment is expected if the lockdown is extended to the monsoon season. Moreover, since the solar PV modules were to be imported from China, which has been extensively disrupted by coronavirus outcomes, the installation of solar PVs is expected to be hit hard [11]. The same situation happened in Europe on February 2020, when the supply chain of wind power industry was disrupted due to the failure to import the components and materials from China.

The promising news from Europe is that the wind industry is ramping back up again, and 96% of the wind manufacturing sites remain open despite the ongoing crisis; just 18 wind factories are currently closed and are mostly located in Spain and Italy, the two European countries that have suffered particularly severe effects of the pandemic [12]. In the second week of April 2020, the Spanish-based company Iberdrola sent the first megawatt (MW) hour of its 500 MW

solar PV electrical power capacity to the grid, which is a promising bright spot for the global renewable energy market [13].

In spite of the COVID-19 spread in Europe, the share of renewables in the first three months of 2020 was reported at 41% (16% more than the amount generated in the first quarter of 2019) due to a steep fall in demand and prices. On February 2020, Germany, Ireland, and Denmark supplied 50% of their electricity demand by the wind energy [14].

3. Renewable and sustainable energy scenario in the post-COVID-19

The economic consequences from the COVID-19 are extensive, with an adverse influence on the development of renewable energy. However, an intelligent reaction can convert this menace to a great opportunity. The recent oil price reduction and the unpredictability of returns on fossil fuel investment could make the renewable energy businesses even stronger. The fluctuations in oil and gas markets could further attenuate the viability of fossil fuel resources and jeopardize the long-term oil and gas contracts. Basically, the mitigation of the price of natural gas, which is extensively employed for electrical power generation, would have a positive impact on the economic growth due to the increase in power demand as a result of electricity price reduction. However, in the complicated post-COVID-19 era, the influence of gas and oil prices mitigation on the renewables will be complicated and differ notably by region and by the type of renewables.

Adopting renewables can bring substantial solutions during the post-COVID-19 dilemma moments. Industries can be revived by ramping up the renewable energy technologies and creating several new jobs for unemployed people. Employment in the renewable and sustainable energy sectors, which passed 11 million jobs worldwide in 2018, could expand to more than 84 million jobs in all fields of renewables by 2050 [15].

Since 2010, approximately one-third of the total US coal power plants (102 GW) have been terminated, and it is projected that 17 GW more will be retired by 2025 [16], which presents a great opportunity for renewables to be substituted in the post-COVID-19 era. Thanks to the support of states' policies and federal tax credits, the renewables could completely retire the coal-fired power generation by 2030.

The decentralized nature of the most renewable energy technologies will involve a great range of communities in the decision making of the energy realm, with transformative economic and social impacts. Furthermore, most of the renewables offer an approach for the remote control, which plays a crucial role in the pandemic circumstances such as the COVID-19. The experience of the coronavirus pandemic has demonstrated that the development of renewable and sustainable energy in the invention of future infrastructure of energy generation and utilization is an ingenious safe strategy. Deployment of sustainable energy technologies and green energy carriers such as hydrogen, fuel cell engines for transportation vehicles, the innovative projects such as the fuel cell drones (for delivery purposes, prompt ambulance for critical moments, remote control of the urban circumstances and agricultural), and improvement of energy storage and power grids can safeguard society against similar difficulties. In this context, investigation and innovation are vital to ameliorate the sustainable technologies and abate the costs. These forward-looking schemes in the green energy production and utilization could conduct the public policies towards low-carbon economic deployment. To manage the influences of COVID-19 on the renewable energy strategies, the energy policy makers should determine which renewable energy policies should be modified in the short term and prioritize the strategic actions towards sustainable energy transition. Losing time for sustainable energy policy re-establishment could jeopardize the clean energy targets. In contrast, temporary waivers or postponements could be a remedy to ease the burden for sustainable energy industries [17]. In order to return to a normal condition and keep sustainable energy projects on track in the post-COVID-19 exotic world, the governments should support renewables

cutting or extending investment and production tax credits. These opportunities could be helpful for the private sectors to develop low-carbon technologies in the midterm horizon. The interest rate level has substantial impacts on the cost of renewable-based electrical power and leveled interest rates could improve their competitiveness to fossil fuel-based electricity [18]. The COVID-19 pandemic has demonstrated that large economic shocks have crucial effects on the transition to renewable energy world and establishing policies adaptive to shocks through designing the mechanisms that mitigate the investment risks could be helpful.

4. Conclusion

It is too early to judge how profound the negative impacts of the pandemic on the global renewables will be; however, a significant short-run contraction to the deployment of sustainable energy is unavoidable. Nevertheless, ultimately the world's renewable energy scenario could return to its long-term trajectory toward green power generation over the next few years. In the post- COVID-19 era in which the economy bounces back, the experience of this pandemic period could convince governments to expedite the renewable energy policy efforts before another worldwide economic shock emerges due to other disease or an unknown weather event.

Declaration of Competing Interest

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

References

- [1] M. Nicola, Z. Alsafi, C. Sohrabi, A. Kerwan, A. Al-Jabir, C. Iosifidis, M. Agha, R. Agha, The socio-economic implications of the coronavirus and COVID-19 pandemic: a review, *Int. J. Surg.* (2020), <https://doi.org/10.1016/j.ijssu.2020.04.018>.
- [2] K. Chen, M. Wang, C. Huang, P.L. Kinney, A.T. Paul, Air pollution reduction and mortality benefit during the COVID-19 outbreak in China, *MedRxiv.* (2020) 2020.03.23.20039842. doi:10.1101/2020.03.23.20039842.
- [3] P. Fox-Penner, Will the COVID-19 Pandemic Slow The Global Shift to Renewable Energy? | The Brink | Boston University. <https://www.bu.edu/articles/2020/will-the-covid-19-pandemic-slow-the-global-shift-to-renewable-energy/>, n.d. (accessed April 11, 2020).
- [4] US Renewable Energy Projects & COVID-19 Impacts. <https://www.natlawreview.com/article/covid-19-impact-us-renewable-energy-projects>, n.d. (accessed April 11, 2020).
- [5] Oil and Coronavirus Shocks Add Pressure for MEA Sovereigns. <https://www.fitchratings.com/research/sovereigns/oil-coronavirus-shocks-add-pressure-for-mea-sovereigns-10-03-2020>, n.d. (accessed April 10, 2020).
- [6] M. Fulwood, \$ 2 gas in Europe is here : who will blink first?, 2020. <https://www.oxfordenergy.org/publications/2-gas-in-europe-is-here-who-will-blink-first?v=7516fd43adaa>.
- [7] S.E. Hosseini, M.A. Wahid, Hydrogen production from renewable and sustainable energy resources: promising green energy carrier for clean development, *Renew. Sustain. Energy Rev.* 57 (2016), <https://doi.org/10.1016/j.rser.2015.12.112>.
- [8] Big Oil's interest in renewable energy investments expected to waver, report says - The Globe and Mail. <https://www.theglobeandmail.com/business/article-big-oils-interest-in-renewable-energy-investments-expected-to-waver/>, n.d. (accessed April 10, 2020).
- [9] IRENA – International Renewable Energy Agency. <https://www.irena.org/>, n.d. (accessed April 10, 2020).
- [10] Global Wind Energy Council. <https://gwec.net/>, n.d. (accessed April 10, 2020).
- [11] Wood Mackenzie | Energy Research & Consultancy. <https://www.woodmac.com/>, n.d. (accessed April 10, 2020).
- [12] Renewable energy news & research | Renewables Now. <https://renewablesnow.com/>, n.d. (accessed April 10, 2020).
- [13] "Europe's largest" solar power facility comes online. <https://www.cncb.com/2020/04/09/europes-largest-solar-power-facility-comes-online.html>, n.d. (accessed April 11, 2020).
- [14] Renewables achieve clean energy record as COVID-19 hits demand - Renewable Energy World. <https://www.renewableenergyworld.com/2020/04/06/renewables-achieve-clean-energy-record-as-covid-19-hits-demand/>, n.d. (accessed April 11, 2020).
- [15] Fact Sheet - Jobs in Renewable Energy, Energy Efficiency, and Resilience (2019) | White Papers | EESI. <https://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-energy-efficiency-and-resilience-2019>, n.d. (accessed April 10, 2020).
- [16] More U.S. coal-fired power plants are decommissioning as retirements continue - Today in Energy - U.S. Energy Information Administration (EIA). <https://www.eia.gov/todayinenergy/detail.php?id=40212>, n.d. (accessed April 11, 2020).
- [17] B. Steffen, F. Egli, M. Pahle, T.S. Schmidt, Navigating the clean energy transition in the COVID-19 crisis, *Joule.* (2020), <https://doi.org/10.1016/j.joule.2020.04.011>.
- [18] T.S. Schmidt, B. Steffen, F. Egli, M. Pahle, O. Tietjen, O. Edenhofer, Adverse effects of rising interest rates on sustainable energy transitions, *Nat. Sustain.* 2 (2019) 879–885, <https://doi.org/10.1038/s41893-019-0375-2>.