Impact of the COVID-19 to the Energy Sector

Subjects: Economics

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Definition

In order to control the COVID-19 pandemic, the governments of the world started to implement measures regarding social distance and social contacts, including closures of cities, work and study relocations, and work suspension. The epidemical situation and the lockdown of the economy by governments in various countries caused changes in production, changes in the habits of energy consumers and other energy-related changes.

1. Impact on Air Pollution

The COVID-19 pandemic has had devastating consequences on both health and the economy in the last two years. At the same time, the restrictions and lockdown of economic activities were followed by a decrease in energy consumption and reduction in polluting emissions.

The level of fuel consumption decreased significantly. This decrease subsequently affected the decrease in air pollution. The significantly reduced emissions in the transport sector during the lockdown showed a real example of what may happen if behavioral change would be more sustainability-oriented. However, it is necessary to highlight the fact that political interventions are necessary to encourage the behavioral changes in the society [1]. New and effective technologies cannot, by themselves, solve the issues of the environment; the public acceptance and behavioral changes of the society are crucial.

Energy consumption in electricity and heating were reduced; however, energy consumption related to transport was increased. Overall, the total amount of energy usage was decreased and GHG emissions were reduced during the pandemic.

Despite the decrease in emissions inequality during the COVID-19 pandemic, emissions inequality will still exist in the future. In order to achieve progress in this regard, the targeted poverty measures should be implemented. Middle-income households increased air pollution by using more wood for heating purposes. While low-income and energy-poor households used less wood for energy generation and subsequently decreased the level of air pollution they emit

2. Impact on Investments in Renewables

Although the pandemic can act as an accelerator for the decarbonization of the economy and increase renewable energy generation by replacing fossil fuels, the pandemic affected the consumption of energy and the supply chain of renewables. The difficulties in manufacturing and the troubles in exports [2] caused a contraction in the renewable energy sector. Gebreslassie [3] analyzed the situation of solar energy during the pandemic in Ethiopia. It was found that COVID-19 brought big challenges to solar energy development in the country. First of all, the pandemic caused a decrease in solar technologies end-users' income; second, a lot of businesses were forced to close. The lack of technologies supply affected the development of renewable energy. At the same time, it affected the development of energy access in remote areas. Wang et al. [4] applied complex network theory and analyzed the global photovoltaic cell trade in the period of 2000–2019. According to the authors, the pandemic modified the relations and caused disruption risks to the global photovoltaic cell trade. The case study of offshore wind generation in China shows that the pandemic increased the cost of energy generation and decreased the profitability of investments [5]. In order to ensure stable development and achieve the minimum share of renewables in different provinces of China, Yu et al. [6] proposed a dispatching model for renewable energy. Shah et al. [7] analyzed the links between the pandemic, air quality, and electricity production from solar, wind, and nuclear energy in Sweden. It was determined that the pandemic slowed down the development of new wind projects due to difficulties in the supply. This affected air quality because it was not as improved as it could have been. Solar energy projects were not affected in the country.

Various papers determined the negative impacts of economic uncertainty on investments in renewable energy projects [8][9][10][11]. Zhang et al. [12] investigated the extent of solar photovoltaic market slowdown during the COVID-19 lockdown. The results showed that the monthly value-added loss was almost 70% and that the emission reduction capacity was decreased by almost 65% over the year. Shah et al. [13] examined the effect of the pandemic on renewable energy generation in Denmark. The authors applied advanced econometric framework and found that the generation of energy was negatively affected by the lockdown and by daily deaths from COVID-19. According to the authors, economic stability is an important factor for the development of renewable energy projects. Kudelin and Kutcherov [14] provided wind energy forecasts for Russia. According to the authors, the pandemic is a factor that can influence slow wind farm deployment in the country. Ziemba [15] applied multi-criteria evaluation for the identification of the most effective investments for wind development in Poland under uncertainty. Zeinalnezhad et al. [16] highlighted the importance of investments in renewable energy projects for the recovery of the post COVID-19 economy. The authors identified nine critical risks for wind farm development; all of them are strongly related to economic uncertainty. Political stability, the absence of sanctions, economic security, a stable interest rate, a stable exchange rate, a stable inflation rate, no feasibility risk, low capital risk, and low supplier risk are the main factors for the assessment of risk for wind farm development. According to Mohideen et al. [17], the current challenges of COVID-19 allow for the reshaping of the energy system, the rethinking of the initiatives used for renewable energy development and the lowering of future fossil fuel usage. The authors stressed the necessity to transform the transport sector and to invest in hydrogen and fuel cell technologies. Griffiths et al. [18] presented opportunities that the COVID-19 pandemic has created for sustainable mobility development. Saif-Alyousfi and Saha [19] examined the effect of the COVID-19 pandemic on the energy returns across more than a hundred global energy indices in thirty-four countries. The relationship between growth of confirmed cases and cases of death from the pandemic had a negative direct effect on global energy returns. The economic lockdown (closure and restrictions of workplaces) had a positive impact on global energy returns. Cancellation of public events, public transport restrictions, and campaigns of public information had a negative effect.

The lower price of crude oil during the COVID-19 pandemic had a significant negative impact on the low-carbon economy. The analysis of crude oil price is showing significant volatility and historical lows during the pandemic [20]. Environmental policy in the post-COVID-19 era should focus on the adjustment of the price gap between fossil fuels and renewable energy, where the carbon taxes and tax benefits for renewable energy can be the main instruments for change. Volatility increased in all energy firms, but is stronger for oil firms than for renewable firms. Other scientists provide contrary results. The results of the study by Dmytrow et al. [21] show that sources such as crude oil, heating oil, and gasoline have a weak relationship with the pandemic, while natural gas, ethanol, CO_2 allowances, and palm oil have a strong association with the pandemic.

It has been observed that the penetration of renewables has increased. In order to forecast energy consumption and renewable energy generation under the COVID-19 pandemic, the authors applied machine learning and seasonal grey models. The decline of non-renewable energy generated was identified, in some countries reaching as much as a quarter of the previous generation. Lockdown restrictions reduced energy demand in the United Kingdom.

3. Impact on Consumption and Habits

The decrease in energy demand during the lockdown in multiple countries of the World was calculated in the study by Rajan et al. [22]. Abdeen et al. [23] analyzed households in Canada and found that the consumption in electricity during the COVID lockdowns increased by about 12%. The increase in the demand of electricity was mainly due to heating purposes. Furthermore, the results show that post-pandemic peaks are up to 20% higher than those pre-pandemic. The electricity demand decrease and shift in peak demand was determined in the study by Bielecki et al. [24], where electricity consumption in the residential sector in the capital of Poland during the COVID-19 lockdown was analyzed. Other study by Rouleau and Gosselin [25] evaluated the effect of the COVID-19 lockdown on the electricity, heating, and hot water consumption in Canada's residential sector. The results show that consumption patterns for hot water and electricity increased and were not concentrated in the evening, as they were before the lockdown. However, the analysis did not identify the changes in heating consumption. It can be assumed that the changes in heat consumption directly depend on the geographical data of the objects under the study. The importance of geographical features for energy changes during the pandemic has also been demonstrated in the study by Liu et al. [26]. The biggest decrease was found in the generation of electricity from coal and hydropower [27]. The analysis of statistical data from South Korea also showed a decrease in overall energy consumption [28], where the demand of electricity decreased more that 4% and the consumption of gas decreased more than 10%. The study gives ordinary tendencies: energy consumption correlates with the COVID-19 pandemic; the consumption of energy in the commercial sector decreased, but it increased in the residential sector. Tsai [29] analyzed the changes of energy consumption and supply in Taiwan during the pandemic. The decrease in both indicators was identified (4.3% and 4.7% respectively). Also, it was determined that petroleum consumption shows a decreasing trend; at the same time, the consumption of electricity has increased. The energy consumption behavior and the impact of the COVID-19 pandemic in a city of Spain was analyzed by Garcia et al. [30]. The social distancing, lockdown and home transformation (work and education at home) were the main factors influencing the changes in consumption. Furthermore, it was found that the lockdown of streets and public markets and psychological factors were also affecting the increase in energy consumption.

The decrease in energy consumption was more than 20% during the first lockdown and more that 10% during the second. The projections of post-COVID industrial production in Italy show that the impact of the shock of the COVID-19 pandemic may continue to 2040, and may decrease total industrial energy consumption by 5% [31]. The impact of the pandemic lockdown on the electricity consumption in Brazil municipal buildings was measured by Geraldi et al. [32]. The use of electricity reduced by around 10% in health centres, by around 40% in administrative buildings, and by around 50% in nursery schools and elementary schools. Other factors influencing the changes in energy consumption are recommendations for living and work environments for buildings [33]. Usually, the institutions prepared recommendations without considering the energy efficiency of buildings and the climate condition.

The changes in the energy consumption and reduction of CO_2 emissions during the lockdown period in India was detected by the study of Rajan et al. [22]. It was found that the energy demand increased in some regions of India and decreased in others during the lockdown. Such changes in energy consumption are linked to the economic and industrial development in each region, climatic conditions and the number of households.

In order to examine the impact of the pandemic on the European electricity markets, Drabecki and Kulak [34] analyzed statistical data before and during the pandemic. The significant impact on electricity demand and on share prices of energy companies was identified. Although the changes on energy price was not detected. Ghenai et al. [35] analyzed the changes in EU electricity generation mix during the lockdowns and its linkages to clean energy transition. The changes in fossil and renewable energy supply, energy demand, and GHG emissions were calculated by performing a statistical analysis of the data. According to the results, the decrease in energy demand has led to these changes in the energy mix: the share of fossil fuels decreased significantly, while the penetration of renewables has grown by up to 9%. The COVID-19 pandemic decreased not only energy consumption, but also energy prices. The decrease in power prices were also identified in the study by Abadie [36]. According to the research by Bento et al. [37], the disruptions caused by pandemic lockdowns had a strong affect on the load consumption in Spain and Portugal. The study proved the effects observed in other studies in terms of energy consumption, generation mix, and electricity prices. Several indices have also been developed to predict the price of electricity under conditions of uncertainty. Norouzi et al. [38] presented a framework for prediction of electricity prices during shifting periods. Olubusoye et al. [39] introduced an information-based index for the forecasting of energy prices under uncertainty.

In order identify the relationship between gross domestic product and electricity consumption in Romania, Soava et al. [40] used a linear regression model. The significant impact of commercial energy consumption on gross domestic product in the pandemic was determined. Hu and Li [41] sought to examine the spillover effects of the United States' economic decline caused by COVID-19 on economic development and energy consumption in other countries.

The prediction for energy demand in Turkey also was proposed by Ceylan [42]. Several advanced machine learning approaches were applied for the calculations and forecast of electricity demand. Bin Amin et al. [43] applied seasonal autoregressive integrated moving average model (SARIMA) for the forecasting results of electricity demand and generation in Bangladesh. The results show that the decrease in consumption will be 8–10% and 6% in the upcoming two years. Kim et al. [44] applied a machine learning model with artificial neural networks for the prediction of hot water demand in the residential sector in South Korea. The model is based on multi-objective optimizers and was applied for the case study of the United States. Huang et al. [45] presented a prediction method for the analysis of the gap in electricity consumption due to the pandemic. According to the results, the impact of the pandemic on electricity consumption is related to the local lockdown policies and measures implemented. Cvetkovic et al. [46] analyzed people's energy consumption behavior during the pandemic and used EnergyPlus software for the simulation of the consumption of electricity, natural gas and water in a few residential houses in Serbia. Bazzana et al. [47] tried to measure the possible effect of the COVID-19 pandemic to the energy sector in Italy. The authors applied a multidisciplinary approach and created different scenarios in order to forecast market reactions and energy consumption.

4. Impact on Energy Poverty of Households

The COVID-19 pandemic has caused big challenges for low-income people, especially those that suffer from energy poverty or face other risks. Another important aspect in identifying the impact of COVID-19 on the sustainability of the energy sector is to identify the linkages between the pandemic and the level of energy poverty of households.

The increase of overall living costs and inappropriate temperature due to big energy costs were the main factors that affected the increase of energy poverty among students. The inability to meet basic energy needs can have health consequences. Memmott et al. [48] found that the pandemic increased energy risk and energy poverty. Furthermore, it may have extended existing racial disparities among people suffering from energy poverty. The decline of households' income during the pandemic had affected the households' habits and possibilities to use clean energy in Kenya. According to the study by Shupler et al. [49], 95% of households faced a decrease in income, which led to a change in cooking fuels to polluting ones (kerosene or wood). Ambrose et al. [50] analyzed the linkages between fuel poverty and the pandemic in the United Kingdom. The results showed that the number of fuel-poor households had risen by 600,000 during the pandemic period.

Graff and Carley [51] provided suggestions for decision-makers on how to fight against the potential growth of energy poverty among households in the context of the United States. Bienvenido-Huertas [52] analyzed the measures for alleviating energy poverty in order to reduce the risk of energy poverty among Spanish households during the lockdown. The discount in the electricity bill based on the month and income would reduce the risk of falling into energy poverty.

5. Impact on Energy System Flexibility

The changes in daily life, the economy, energy and other sectors caused by the pandemic should not stop efforts to combat climate change. The transition to a low-carbon society and economy is mainly based through the development of renewable energy. Therefore, to ensure energy system flexibility is a challenge to each country's energy system.

Alvarez [53] introduced a multi-objective framework that enhances the operations of energy systems under COVID-19 circumstances. The presented framework considers geographical aspects that are affected by virus cases and their effects on the employees of power plants. Schwidtal et al. [54] analyzed the first months of the COVID-19 pandemic and provided insights for modelling future renewable energy scenarios. Heffron et al. [55] created the projections on possible impact of the pandemic for the economy and society in Europe and provided five policy recommendations for European countries in order to ensure energy system flexibility. Flexibility improvement measures under the COVID-19 pandemic were provided in the study by Luo et al. [56].

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Keywords

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