ISSN 2320-9984 (Online)
Volume 11 Issue 3 | September 2023
International Journal of Modern Engineering & Management Research
Website: www.ijmemr.org

COVID-19 Pandemic's Impact on Electricity Consumption and Forecasting Accuracy: from the State of Madhya Pradesh

Shreyash Shrivastava
M.E.
Electrical Engineering,
Jabalpur Engineering College
Jabalpur, (M.P.) India
Email: shreyash29shrivastav@gmail.com

Hemant Amhia
Assistant Professor
Department of Electrical Engineering,
Jabalpur Engineering College
Jabalpur, (M.P.) India
Email: hemant_dreamzin@yahoo.co.in

Abstract*—The goal of this study is to use the MPPKVVCL DISCOM data to examine the influence of the COVID-19 pandemic on electricity usage and electricity demand forecasting accuracy in buildings in India over time and across sectors. Furthermore, this study statistically investigates the relationship between building electricity consumption and the number of daily infected cases in the State of Madhya Pradesh. The effect of the pandemic on electricity usage was quantified during various periods of the pandemic years. Around 17 million electricity meter readings per year were considered for MP East DISCOM usage between the years 2018 and 2023 The findings indicate that there was a gap between the actual and simulated electricity consumption during the pandemic years. Furthermore, the results show that the fluctuation in electricity consumption was correlated with the COVID-19 Pandemic in some socioeconomic sectors. The changes in the pattern of electricity consumption during the pandemic years (2020–2021) affected the accuracy of the Forecasting models in predicting electricity consumption in 2022.*

1. INTRODUCTION

Since the global prevalence of the COVID-19 pandemic, societies around the world have witnessed multiple waves of highly infected cases of the disease in different periods. To contain the spread of the disease, governments imposed a variety of measures, such as strict lockdown, limited travel, social distancing, and limited capacity in workplaces, among others [1–4]. These measures forced societies to change their normal life patterns, and consequently, they have had a direct impact on how, when, and where electricity is consumed, and they have increased/decreased electricity demand and supply [5–9]. Understanding the impact of the pandemic on electricity demand and consumption can therefore provide additional insights into how governments and consumers will respond to future unexpected extreme events.

Although the propagation of the COVID -19 pandemic and the associated societal, governmental, and individual responses have been unprecedented in nature in modern history, the possibility of different natural or human disruptive events, such as extreme weather events fuelled by climate change, recessions, and other pandemics, may greatly affect the electricity sector at the national, regional, and international scales. In addition, understanding the impact of the pandemic on the electricity sector can indicate the significance of governments and policy-making to alter long-standing consumption patterns. The imposed policies and restrictions and individuals' choices around mobility have been suggested to be potential drivers

underlying changes in electricity consumption; however, the stringency of these restrictions varied over time between and within countries [2,7,9–11]. At the local scale, other elements, such as the features of the national electricity system and the severity of the propagation of the pandemic, have also been identified as potential contributors to changes in electricity demand and consumption [11,12]. Finally, understanding the impact of different factors and policies on electricity demand and consumption during the course of the pandemic can highlight its relevance and significance as a key economic metric moving forward [13–15].

The India is one of the countries that imposed very strict policies to slow the pandemic in the country [6,16]. The national lockdown in the country started on March 25, 2020 and continued for almost three months.

During this time, industrial and commercial During this time, industrial and commercial operations and services were reduced to the bare minimum. Employees in the as well as government employees and students in schools and higher education institutions, were instructed to remain at home. Mobility was restricted; public transportation operations stopped completely, and restrictions were imposed on international flights [16–18]. These restrictions affected the country's electricity demand and usage. Very few studies have been conducted to analyse the effect of the COVID-19 pandemic and associated measures on the power generation sector within the MP DISCOM we examined the effect of the pandemic on electricity usage across commercial, residential, industrial sectors using statistical modelling. The study compared electricity usage prior to and during the pandemic between 2018 and 2020. The results reveal variations in electricity use over space and time and across sectors. Implementation of the lockdown contributed to a reduction in electricity usage in the commercial and industrial sectors, while an increase was observed in the residential sectors.

Impact of COVID-19 on Rural Demand

The utility demand in rural areas for the years 2018-2019, 2019-2020, and 2020-2021 highlights significant differences and similarities, with the impact of COVID-19 in 2020-2021 playing a notable role.

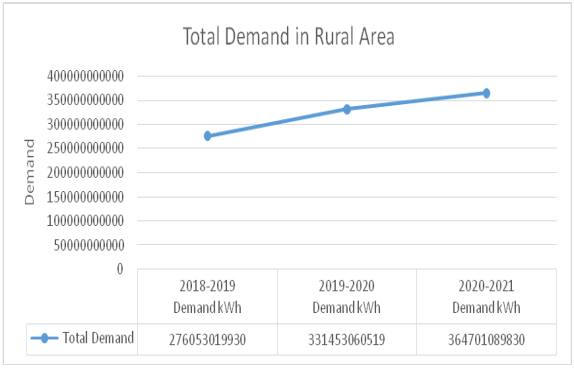

Figure 1: Graph Showing the Pattern For Deviation of Total Demand in Rural Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021

In terms of differences, there was a consistent increase in electricity demand in rural areas over the three-year period. The demand rose from 2.19189E+11 kWh in 2018 -2019 to 2.63342E+11 kWh in 2019-2020, and further increased to 2.89931E+11 kWh in 2020-2021. This upward trend can be attributed to factors such as population growth, electrification initiatives, and improved access to electricity in rural communities.

The impact of COVID-19 on rural electricity demand in 2020-2021 is also evident. While the overall demand increased, there were fluctuations in specific sectors. The domestic sector, for example, experienced a significant rise in demand, reaching 17,312,949,657 kWh in 2020-2021. This increase can be attributed to people spending more time at home during lockdown, leading to higher electricity consumption in rural households.

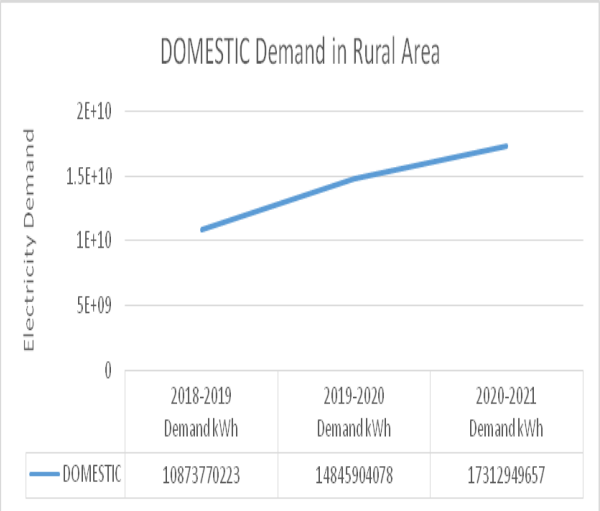

Figure 2: Graph Showing the Pattern For Deviation of Domestic Demand in Rural Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021

Similarly, the demand for electricity in the irrigation pumps sector showed a steady growth trend, reaching 36,420,544,209 kWh in 2020-2021. This indicates the continued need for electricity in agricultural activities, which are vital for rural communities.

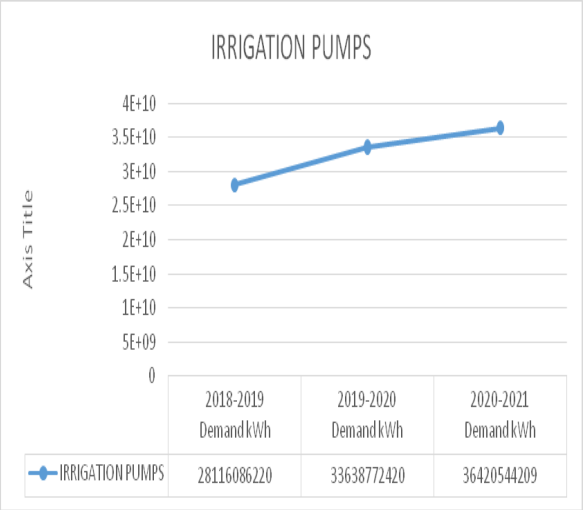

Figure 3: Graph Showing the Pattern For Deviation of Irrigation Pumps in Rural Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021

Despite the impact of COVID-19, certain sectors displayed stability in their electricity demand. The high tension (HT) industrial sector, for instance, maintained consistent demand over the three years, with 7,143,473,992 kWh consumed in 2020-2021. This suggests the resilience of rural industries and their sustained electricity requirements.

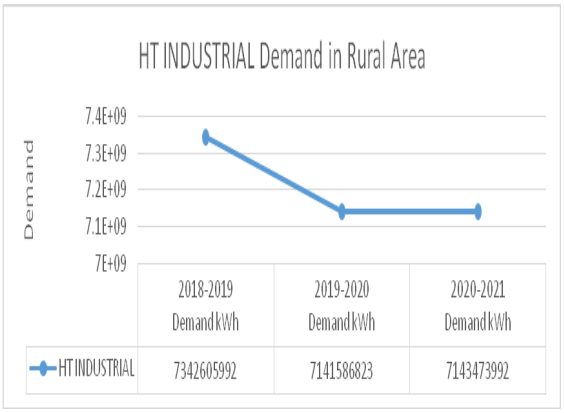

Figure 4: Graph Showing the Pattern For Deviation of HT Industrial Demand in Rural Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021

In summary, the utility demand in rural areas exhibited both differences and similarities over the three-year period, influenced by the impact of COVID-19 in 2020-2021. Overall, there was an increase in electricity demand, with specific sectors experiencing fluctuations and others displaying stability. Understanding these patterns is crucial for effective energy planning and resource allocation in rural communities, ensuring reliable and sustainable electricity supply for their development and well-being.

2. IMPACT OF COVID-19 ON URBAN DEMAND

The utility demand in urban areas for the years 2018-2019, 2019-2020, and 2020-2021 not only reflects the influence of COVID-19 but also highlights the difficulty of accurately forecasting electricity demand in uncertain times.

The impact of COVID-19 on electricity consumption introduced unpredictability and challenges to demand forecasting. The decrease in electricity demand in 2020-2021, with consumption reaching 214,890,502,919 kWh, compared to the previous year, is a testament to the unforeseen disruptions caused by the pandemic. The volatile nature of the pandemic and its ongoing effects on various sectors made it difficult to accurately predict and plan for future electricity requirements.

Specific sectors faced unique forecasting difficulties due to COVID-19. The domestic sector, which experienced a steady increase in demand, showcased the complexity of forecasting residential consumption patterns during the pandemic. Electricity demand in this sector rose from 11,932,408,439 kWh in 2018-2019 to 13,949,942,467 kWh in 2020-2021. Factors such as work-from-home arrangements, changing lifestyle habits, and economic uncertainties made it challenging to anticipate the exact energy needs of households.

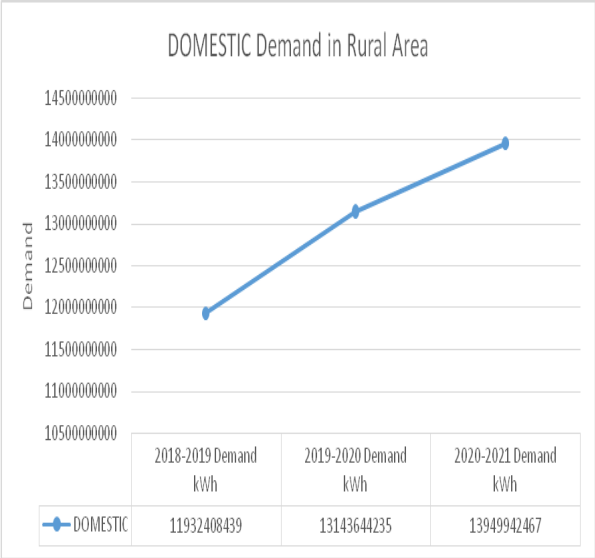

Figure 4: Graph Showing the Pattern For Deviation of Domestic Demand in Rural Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021

Similarly, the HT industrial and LT industry sectors encountered forecasting difficulties as the pandemic disrupted production schedules, supply chains, and business operations. The HT industrial sector consumed 8,937,888,160 kWh in 2020-2021, showing a slight decrease compared to the previous year's consumption of 10,314,249,570 kWh. Similarly, the LT industry sector experienced a marginal increase in demand, with 1,612,784,434 kWh consumed in 2020-2021, up from 1,584,354,464 kWh in 2019-2020. These fluctuations highlight the uncertainties faced by energy planners and forecasters in anticipating future consumption trends.

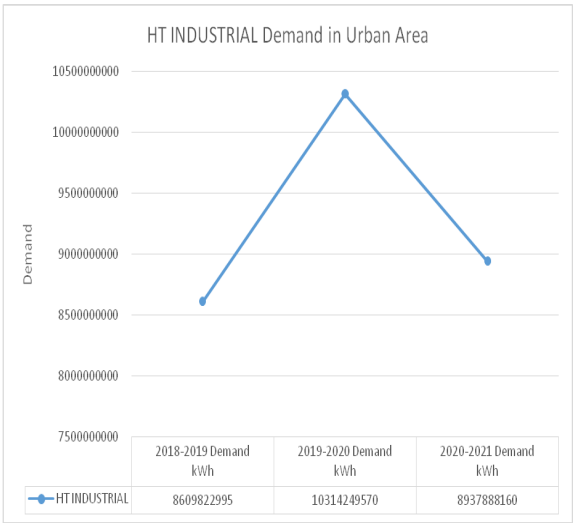

Figure 5: Graph Showing the Pattern For HT Industrial Demand in Urban Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021HT Industrial Demand in Urban Area

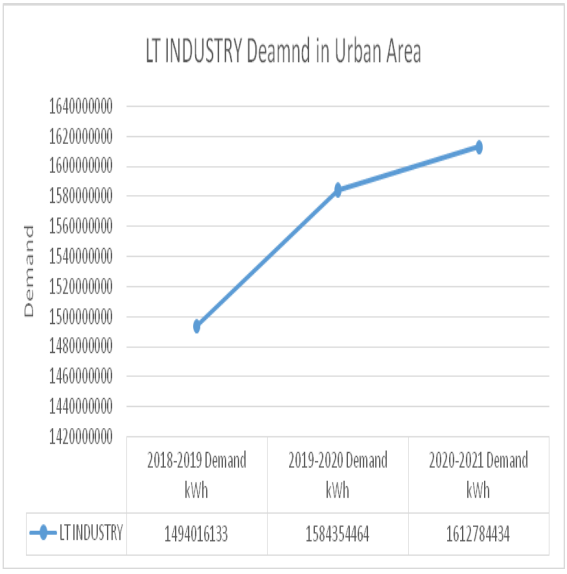

Figure 6: Graph Showing the Pattern For LT Industrial Demand in Urban Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021

In the non-industrial/shopping mall sector, which includes commercial establishments like shopping malls and retail outlets, the electricity demand displayed a fluctuating pattern. Consumption stood at 1,778,128,172 kWh in 2018-2019, increased to 1,799,920,961 kWh in 2019-2020, and then decreased to 1,480,069,430 kWh in 2020-2021. The varying demand can be attributed to the impact of the COVID-19 pandemic on the retail sector.

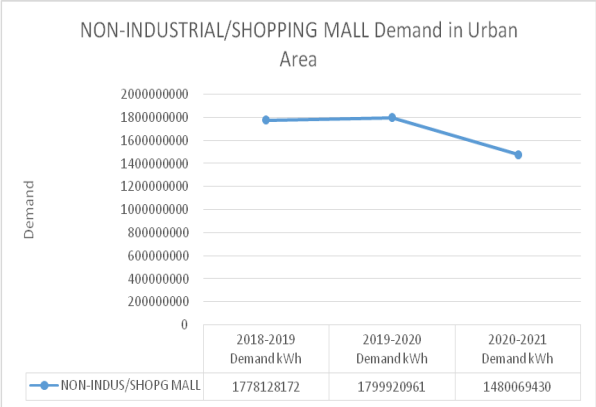

Figure 7: Graph Showing the Pattern For Non Industrial / Shopping Demand in Urban Area in FY 2018-2019 FY 2019-2020 and FY 2020-2021HT Industrial Demand in Urban Area

The challenges of forecasting were not limited to the impact of COVID-19 on specific sectors but extended to the overall unpredictability in energy consumption patterns. The pandemic's unprecedented nature, evolving regulations, and shifting consumer behaviors made it difficult to accurately project future electricity demands in urban areas.

Overall, the utility demand in urban areas, influenced by the COVID-19 pandemic, underscored the difficulties faced in accurately forecasting electricity consumption. The uncertainties and disruptions experienced in various sectors emphasized the need for agile and data-driven forecasting methods to ensure reliable and resilient energy systems in the face of evolving circumstances.

Impact of COVID-19 on Consumer Electricity Demand

Improving the Paragraph Summary Report: Average Load in MWh (2018-2020) with Forecasted Load for 2020:The analysis of average load in Megawatt-hours (MWh) from 2018 to 2020 reveals both similarities and significant differences. While 2018 and 2019 followed relatively consistent patterns, 2020 stood out due to the unprecedented impact of the COVID-19 pandemic.

In 2018, the average load exhibited a normal fluctuation throughout the year, with monthly values ranging from 2,263.88 MWh in April to a peak of 3,084.31 MWh in November. Although there were minor variations between months, the overall pattern remained within expected levels, reflecting a stable energy consumption trend.

However, 2020 presented a unique scenario due to the global pandemic. The average load displayed distinct trends compared to previous years, reflecting the profound influence of COVID-19. The initial months of the pandemic, such as March (2,296.7 MWh) and April (2,254.79 MWh), witnessed lower average loads as the world grappled with lockdown measures and reduced economic activity.

As the year progressed and restrictions were gradually lifted, the average load began to recover. Notably, December marked the highest average load of the analyzed period, soaring to 3,352.25 MWh. This resurgence in energy consumption could be attributed to the gradual resumption of economic activities and the increased demand for power.

Furthermore, comparing the forecasted load for 2020 with the actual data, we can observe deviations throughout the year. The forecasted load for January was projected to be 2040.68 MWh, but the actual load turned out to be 2,296.7 MWh, indicating a variance of -254.98 MWh. Similarly, in February, the forecasted load was estimated at 2093.42 MWh, but the actual load measured 2,254.79 MWh, resulting in a deviation of -161.37 MWh.

Taking into consideration the later months of 2020, the forecasted load for March was 1831.08 MWh, while the actual load recorded was 2,297.0 MWh, reflecting a variance of +465.92 MWh. In April, the forecasted load was 2997.06 MWh, but the actual load measured 2,254.79 MWh, resulting in a deviation of -742.27 MWh. These discrepancies further emphasize the challenges of accurately forecasting energy consumption during times of extreme uncertainty.

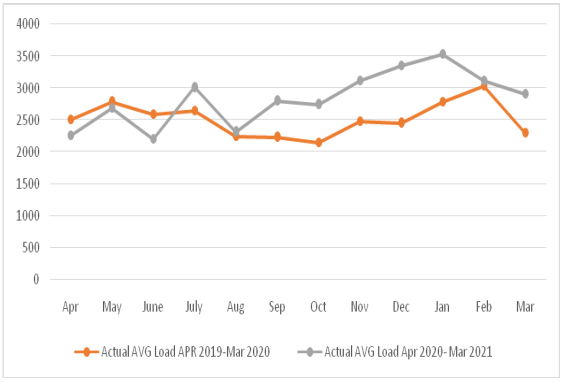

Figure 8: Graph Showing the Pattern For Deviation of Load Between Average Load in FY 2019-2020 and FY 2020-2021

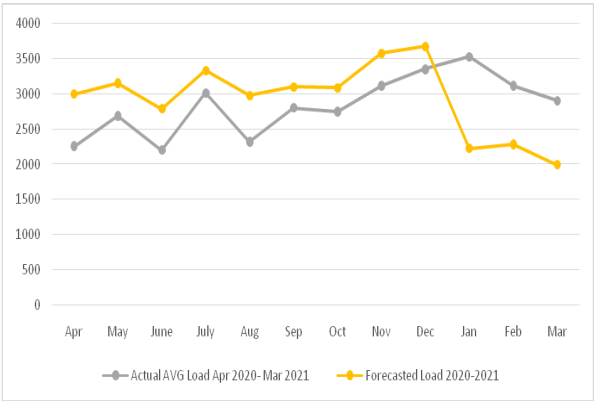

Figure 9: Graph Showing the Pattern For Deviation of Load Between Average Load in FY 2020-2021 and Forecasted Load FY 2020-2021

These differences between the forecasted and actual load highlight the challenges of accurately predicting energy consumption, especially in the face of unforeseen events like the COVID-19 pandemic. As the pandemic unfolded, the energy landscape experienced significant shifts, causing the forecasted load to deviate from the actual values. The global lockdown measures and reduced economic activity resulted in lower energy demand during the initial months of the pandemic.

The contrasting patterns observed between the forecasted and actual load in 2020 underscore the unpredictable nature of energy consumption dynamics during unprecedented events like the COVID-19 pandemic. These variations highlight the need for continuous monitoring, timely data analysis, and adaptive forecasting techniques to improve the accuracy of load projections and inform decision-making in the energy sector.

Understanding and addressing the challenges faced in predicting energy consumption accurately allows for improved resilience and better preparation for future unforeseen events. By incorporating real-time data and adjusting forecasting models to account for dynamic circumstances, energy systems can become more adaptable, enabling effective resource allocation and mitigating potential disruptions in the face of uncertainties

3. CONCLUSION

In conclusion, the COVID-19 pandemic has revealed the challenges and failures of forecasting electricity demand accurately in both rural and urban areas. The unprecedented nature of the pandemic and its impact on various sectors have made it difficult to predict and plan for future energy requirements.

In rural areas, while there was an overall increase in electricity demand over the three-year period, the fluctuations caused by the pandemic highlighted the limitations of forecasting. The surge in demand in the domestic sector, as people spent more time at home during lockdown, was unforeseen and difficult to anticipate. Similarly, the steady growth in electricity demand in the irrigation pumps sector demonstrated the ongoing need for electricity in agricultural activities, but the extent of the increase was hard to predict.

In urban areas, the pandemic introduced a high level of unpredictability and disrupted traditional forecasting methods. The decrease in electricity demand in 2020-2021 compared to the previous year was a clear indication of the forecasting failures. Sectors such as the domestic sector and non-industrial/shopping mall sector experienced fluctuations in demand due to changing consumer behaviors and economic uncertainties, making it challenging to accurately project future energy needs.

The discrepancies between the forecasted load and actual data in 2020 further underscored the failure of forecasting during times of extreme uncertainty. The initial months of the pandemic witnessed lower average loads, but as restrictions were gradually lifted, energy consumption patterns shifted, leading to deviations from projected values. These variations highlighted the limitations of traditional forecasting models in capturing dynamic circumstances and adapting to unforeseen events.

The failures of forecasting during the COVID-19 pandemic emphasize the need for more agile and data-driven approaches in energy planning. Continuous monitoring, timely data analysis, and adaptive forecasting techniques are essential to improve the accuracy of load projections and inform decision-making in the energy sector. By incorporating real-time data, leveraging advanced analytics, and adjusting forecasting models to account for dynamic circumstances, energy systems can become more resilient and better prepared to mitigate potential disruptions in the face of uncertainties.

Overall, the failures of forecasting in the context of the COVID-19 pandemic underscore the importance of reevaluating and improving forecasting methodologies to enhance the resilience and reliability of energy systems in the future.

REFERENCES:

[1] S. Mansour, A. Abulibdeh, M. Alahmadi, E. Ramadan, Spatial Assessment of COVID-19 First-Wave Mortality Risk in the Global South (2022) 1–19, https://doi.org/10.1080/00330124.2021.200988, 10.1080/00330124.2021.2009888.

[2] A. Abulibdeh, S. Mansour, Assessment of the Effects of Human Mobility Restrictions on COVID-19 Prevalence in the Global South (2021) 1–15, https://doi.org/10.1080/00330124.2021.197059. Oct.10.1080/00330124.2021.197059.

[3] A. Abulibdeh, Can COVID -19 mitigation measures promote telework practices? J. Labor Soc. 23 (4) (2020) 551–576, https://doi.org/10.1111/wusa.12498.

[4] S. Mansour, et al., Spatial Associations between COVID-19 Incidence Rates and Work Sectors: Geospatial Modeling of Infection Patterns among Migrants in Oman (2022) 1–20, https://doi.org/10.1080/24694452.2021.2015281, 10.1080/ 24694452.2021.2015281.

[5] S. Halbrügge, P. Schott, M. Weibelzahl, H.U. Buhl, G. Fridgen, M. Schopf, How did the German and other European electricity systems react to the COVID-19 pandemic? Appl. Energy 285 (2021), 116370 https://doi.org/10.1016/J.APENERGY.2020.116370.

[6] A. Abulibdeh, Modeling electricity consumption patterns during the COVID-19 pandemic across six socioeconomic sectors in the State of Qatar, Energy Strategy Rev. 38 (2021), 100733, https://doi.org/10.1016/J.ESR.2021.100733.

[7] H. Kang, J. An, H. Kim, C. Ji, T. Hong, S. Lee, Changes in energy consumption according to building use type under COVID-19 pandemic in South Korea, Renew. Sustain. Energy Rev. 148 (2021), 111294, https://doi.org/10.1016/J.RSER.2021.111294.

[8] G. Morva, I. Diahovchenko, Effects of COVID-19 on the electricity sectors of Ukraine and Hungary: challenges of energy demand and renewables integration, CANDO-EPE 2020 - Proceedings, IEEE 3rd Int. Conf. Work. Obuda Electr. Power

Eng. (Nov. 2020) 41, https://doi.org/10.1109/CANDO-EPE51100.2020.9337785. –46.

[9] E. Buechler, S. Powell, T. Sun, N. Astier, C.Z. Iscience, undefined, Global Changes in Electricity Consumption during COVID-19, Elsevier, 2022. Accessed: May 09, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/ S2589004221015388.

[10] J. Lopez Prol, S O, Impact of COVID -19 measures on short-term electricity consumption in the most affected EU countries and USA states, iScience 23 (10) (2020), 101639, https://doi.org/10.1016/J.ISCI.2020.101639.

[11] G. Ruan, et al., A cross-domain approach to analyzing the short-run impact of COVID-19 on the US electricity sector, Joule 4 (11) (2020) 2322–2337, Nov, https://doi.org/10.1016/J.JOULE.2020.08.017.

[12] A. Leach, N. Rivers, B. S.-C. P., Policy, and undefined 2020, "Canadian electricity markets during the COVID-19 pandemic: an initial assessment, utpjournals 46 (2020) S145–S159, https://doi.org/10.3138/cpp.2020-060, press.

[13] G. Soava, A. Mehedintu, M. Sterpu, E. Grecu, The impact of the COVID-19 pandemic on electricity consumption and economic growth in Romania, Energies 14 (9) (2021), 2394, https://doi.org/10.3390/EN14092394. Page 2394.

[14] A. Khurshid, K. Khan, How COVID-19 shock will drive the economy and climate? A data-driven approach to model and forecast, Environ. Sci. Pollut. Res. 28 (3) (2021), https://doi.org/10.1007/S11356-020-09734-9/FIGURES/7, 2948–2958, Jan.

[15] Q. Wang, F. Zhang, What does the China's economic recovery after COVID-19 pandemic mean for the economic growth and energy consumption of other countries? J. Clean. Prod. 295 (2021), 126265 https://doi.org/10.1016/J.JCLEPRO.2021.126265.

[16] A. Abulibdeh, Spatiotemporal analysis of water-electricity consumption in the context of the COVID-19 pandemic across six socioeconomic sectors in Doha City, Qatar, Appl. Energy 304 (2021), 117864, https://doi.org/10.1016/J.APENERGY.2021.117864.

[17] D. Muley, M.S. Ghanim, A. Mohammad, M. Kharbeche, Quantifying the impact of COVID–19 preventive measures on traffic in the State of Qatar, Transport Pol. 103 (2021) 45–59, https://doi.org/10.1016/J.TRANPOL.2021.01.018.

[18] S. Reagu, et al., Psychological impact of the COVID-19 pandemic within institutional quarantine and isolation centres and its sociodemographic correlates in Qatar: a cross-sectional study, BMJ Open 11 (1) (2021), e045794, https://doi. org/10.1136/BMJOPEN-2020-045794. z