CRITICAL ASSESSMENT OF UTILITIES UNDER CRISIS CONDITIONS

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ABSTRACT
Less than three months after the first confirmed cases of COVID-19 in Wuhan City, China, in December 2019, Europe was announced as the active center of the pandemic, with more than a quarter of a million Europeans going into lock-down. This crisis not only disrupted the everyday life but also resulted in irregular conditions in the field of building utilities management. The necessity for the development of advanced services for managing utilities under lock-down and quarantine conditions arose. This study presents an overview of the models developed during the COVID-19 pandemic with the purpose of managing utilities in the building sector. The study summarises the important findings of scientific reports in this field and extracts the critical aspects which are anticipated to prevail in the following years in this field. Research initiatives towards developing platforms that enable utilities management under crisis conditions and, in particular, the Marie Curie Initiative "Development of Utilities Management Platform for the case of Quarantine and Lockdown- eUMaP" are presented.

Keywords: Covid-19, Utilities Management, Resources, Facilities Management

1. INTRODUCTION
The COVID-19 pandemic is a crisis not only related to the health sector; it has severely affected the economic and the social sectors worldwide, whereas nearly all sectors of our societies experienced its consequences (Brosemer et al., 2020). The dramatic shift in operations has led to utility deficiencies, indicating the significance of the need of their management. A number of problems emerged, including the management of building utilities under crisis and quarantine conditions.
Building utility management is the awareness of how different energy, pollution, and water use measures affect a building. Evaluating the building and inhabitants' energy usage and immediately detecting wastage or other issues can reduce costs and charges. Although the macro implications tend to understand distinct geographic differences, the individual-micro reaction to the pandemic has also altered the overall market demand, mostly by reduced mobility and thus more time spent at home (Hoda et al., 2020). According to International Energy Agency (IEA) statistics, global energy usage was projected to be reduced by 5% in 2020 and rebound to its pre-crisis point by early 2023, although trends and timing differ from country to country (IEA Outlook, 2020). Prior to the crisis, energy demand was expected to rise by 12% between 2019 and 2030. The pandemic presented an extraordinary chance to prove the need for utilities and how they could be managed in pre - and post-COVID environments for communities to fulfill the needs for water-electricity-fuel, as well as achieve the goals for social growth (Mukherjee et al., 2020). Despite the fact that the majority of the emerging pandemic literature is oriented on virus progression and research due to the (at the time) limited information on this subject, the dynamic nature of the COVID-19 pandemic also gave rise to articles providing solution on how utilities could be managed effectively and efficiently during such crisis period. This research seeks to examine whether utility management rationale has found application in countries around the world during the situation of the COVID-19 pandemic by evaluating the scientific literature available. In Section 2, a review of the scientific works published within a year from the start of the crisis is presented, whereas Section 3 performs a critical analysis of the literature with reference to the needs for the management of such crises. In Section 4, a brief introduction to the European-funded research project eUMaP is provided, and in Section 5, some concluding points regarding the management of utilities during periods of crisis are summarized.

2. STUDIES CONDUCTED FOLLOWING THE START OF THE COVID-19 PANDEMIC RELATED TO UTILITIES MANAGEMENT UNDER CRISIS CONDITIONS

2.1 Overview of Conducted Studies

Although reducing energy usage is one prominent place to start with, it is not the only effective way to strengthen the performance of a building. Monitoring the usage of utilities and managing billing by the consumer, as well as resolving both emergency and preventive infrastructure aspects with regard to utility systems, are actions of fundamental value. In view of this reality, utility management is a significant aspect of being examined if enhancing efficiency and saving energy and money are primary goals (Chan, 2019). According to the European Commission (EC), energy usage in buildings has decreased over the last decade, most notably in the residential sector, as a result of enhancing energy efficiency, implementing different types of government policies, increasing energy prices, and economic stagnation (EC, 2020). The Energy Efficiency Directive (EED) has been set as a prerequisite for all MS to establish an energy efficiency policy scheme. This scheme has guaranteed that energy utilities met the accumulated end-use energy savings commitment of 1.5% of yearly energy sales to end-users by the end of 2020 (Lewis et al., 2013). Gas energy usage accounts for the largest proportion of energy consumption in buildings (both residential and non-residential), 36% at a EU level, as well as the highest proportion of energy consumption in many countries (EC, 2020). The second place of building energy use at the EU level is acquired by electricity (by 32%), while renewables and oil stand at 11% - 12% (EC, 2020).

The construction industry is Europe's most significant consumer of electricity. It is reported that approximately 75% of the currently built buildings will still exist in the year 2050 (Esser et al., 2019). The revised EED set an ambitious aim of a minimum of 32.5% enhanced energy efficiency at the EU level by 2030, indicating the way to a low-carbon economy and the fulfillment of the Paris Agreement's commitments (Esser et al., 2019). Sophisticated Information and Communications Technology systems have the capability of organizing and connecting all energy-related resources of a dwelling in an interconnected and comprehensive manner, such as to optimize their energy performance and ability. In addition, intelligent and smart sensors may control the buildings' energy usage, inform residents and enable utilities to control the residential flow of energy effectively (Santamouris, 2016).

Under these circumstances, social reassessment of everyday activities, habits, attitudes, and desires is essential. The findings of Lu et al. (2020) revealed that the reliability of the production process, power storage, and policy-making pre and post the epidemic are critical concerns for the shift to sustainable energy. At an international level, energy and electricity demand is estimated to decline by 5-6% in the developed economies, with 11% in EU countries experiencing the highest decreases (IEA, 2020, Press Release). Energy accessibility, energy management, and energy sustainability are becoming increasingly popular from a consumer's point of view, as remote employment, online purchases, streaming entertainment services, operating home appliances, and automated heating and cooling homes are an integral part of everyday life (Birol, 2020). Zhang et al. (2020) investigated the impact of three restricted measure scenarios due to the COVID-19 outbreak on the energy demand in a district in Sweden related to different occupancy schedules in residential, commercial, and office buildings. The study showed that the entire district's delivered electricity increased from 14.3% to 18.7% in the cases of different levels of containment mechanisms, with the focus on residential buildings and retail shops. The increase or decrease in the overall demand for energy of the entire district depends on the restricted level of the buildings; thus, it is regulated by the total sum of the increased consumption of energy and the reduction in other demands. Given the current situation, emissions are expected to recover by +5.8% worldwide by 2021 (IEA Review, 2020), presumably caused by suspensions in Europe's renewable development programs (Manley et al., 2020) or possible third waves of COVID-19 contagion (Gallagher, 2020).

Reductions in the overall energy usage have been observed in most countries that have imposed lock-down restrictions, whereas dwelling loads have increased, also modifying the typical demand profile. The analysis of Kylili et al. (2020) showed that by embracing remote employment procedures in the case of long traveling time from home to the office, fuel and emissions could be substantially decreased by up to 60%. The shift in the 'standard habits' of usage and availability of public utilities triggered system failures, posing various issues, such as power outages, water shortages, and inadequate internet access, concerning their accuracy and coherence. Compared to the decrease in overall power production, the percentage share of renewable energy generation has risen. In order to minimize voltage violation problems caused by decreased loads, it was required by operators to take joint measurements (Zhong et al., 2020). According to the findings of the study of Chen et al. (2020), the participants had a positive attitude towards implementing home energy management systems, with approximately 80% being willing to pay and 30% being willing to invest more than 5USD per month for its energy characteristics. The findings of this survey also indicated that there were no further morning or evening demand spikes during weekdays and a reported higher or much higher than

typical electricity consumption. Credibility in utilities is not linked to the desire for home energy management system deployment but is favorably correlated with the well-being characteristics of willingness to pay.

2.2 Critical Analysis of Review Findings

A critical analysis of the management needs of utilities identified in Section 2 is conducted under this section, considering their main purpose, i.e. to supply services to customers affected by the Covid-19 pandemic. Some of the proposals outlined in this section are endorsed by scholarly research, such as those relating to the value of adequate targeting of management utilities, while others represent the authors' thoughts.

Considering the fact that the devices, techniques, and technical know-how to appropriately and effectively operate critical public service systems are available, their full potential is, in fact, not being exploited (Kylili et al., 2020). Recording of building utility needs in crisis services will relate to both quantitative and time-consuming profiles. Thus, the employment of adequate devices in order to extract this kind of information through the buildings is a critical measure that needs to be addressed. Accordingly, the development of the required knowledge and framework that will enable the efficient data management of public utilities can drive the implementation of the various solutions. Energy conservation should be of high priority within all EU MS; thus, through relevant directives and regulations, the establishment of an energy efficiency policy scheme should be launched. This work signifies the urgent need for cities to comprehend the large variety of established technology, legislation, and funding sources, in order to enhance energy quality and maximize cost-effective energy conservation in buildings.

3. THE EUMAP PROJECT

The research initiative "Development of Utilities Management Platform for the case of Quarantine and Lockdown – eUMaP" is a project that directly addresses the challenges in relation to the completeness, integrity, and sustainability of public utilities' systems that emerge under crisis conditions, including power outages, water shortages, and insufficient telecommunication connections, by enabling the efficient management of the resources based on real-time data that is introduced into an integrated open building utilities management platform. The main output of the project will thereby support the utility operators to maintain balanced and reliable systems under any circumstances. In addition, the innovative technologies and methodologies to be tested under the project and for the development of the platform will form the basis of a range of applications towards the provision of secure and sustainable services systems beyond the scope of this project. In particular, the eUMaP project proposes:

(i) development of an innovative holistic framework for the design of sustainable services platforms and
(ii) contribution to the development of integrated platforms, based on Building Information Modeling (BIM), Geographic Information System (GIS), and Internet-of-Things (IoT) and the transition of this practice from the research level to the market.

The platform will be developed through a Research and Innovation Staff Exchange (RISE) program and will be adopted by the industry after the end of the project, as well as exploited for application in other fields. Potential end-users of the eUMaP platform include government agencies, public and private building services providers and managers, transmission and telecommunication systems operators, local authorities and bodies related to the provision of building utilities, energy service companies (ESCOs), developers, academia, and research institutes active in the specific fields and advanced building owners. The eUMaP platform will be based on the rationale of earth observation and the recording of the required network information in open BIM platforms of five European capital cities (Rome, Berlin, Athens, Vilnius, and Nicosia). The platform will be piloted in study areas with the aim of optimizing it and delivering it as an open platform upon project completion. The development of this integrated, reliable, and sustainable platform will lead to the increased employment of intelligent tools for the delivery of reliable, efficient, and sustainable management systems.

4. CONCLUSIONS

While the magnitude, harshness, and length of the pandemic, as well as the long-standing consequences of COVID-19 regarding the energy-water-fuel sector still remain unclear, this work concludes that adjusting to the "as-usual" successful development of the industry that has existed without significant modifications will be demanding. The results conducted by these early studies presented in this work will help minimize the effects of a crisis situation in the energy sector by opening new pathways for updated policy frameworks and policy reforms that will be able to cope with coming shocks in the future. The study findings will enable policy-makers to comprehend the impact of a crisis situation in energy generation, supply, transmission, and consumption and identify the challenges that come along with such disruptions in the energy system. For extreme emergencies, such as lighting/ equipment power density, ventilation rate, and structural design direction, it is then feasible to provide a baseline for new construction requirements. In addition, local or regional-level policy-making can be assisted in planning restricted measures, the preparation of the energy supply system/infrastructure, and the evolving function of the energy system to ensure an adequate supply of energy to the various buildings. A more

precise forecast of power consumption would serve a far more essential part in assuring that all regions have a stable energy supply under any crisis situation. While several electricity-predicting analyses have been conducted, the outbreak was not acknowledged, and several studies just addressed the forecasting precision and neglected consistency. There is a need for the establishment of energy demand forecast models, which can be effectively implemented throughout this pandemic or any other future crisis situation.

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REFERENCES

1. Brosemer, K., Schelly, C., Gagnon, V., Arola, K. L., Pearce, J. M., Bessette, D., & Olabisi, L. S. (2020). The energy crises revealed by COVID: Intersections of Indigeneity, inequity, and health. Energy Research & Social Science, 68, 101661.
2. Hoda, S., Singh, A., Rao, A., Ural, R., & Hodson, N. (2020). Consumer Demand Modeling During COVID-19 Pandemic. In 2020 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2282-2289.
3. IEA (2020), World Energy Outlook 2020, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2020, Accessed on May 7, 2021.
4. Mukherjee, A., Babu, S. S., & Ghosh, S. (2020). Thinking about water and air to attain Sustainable Development Goals during times of COVID-19 pandemic. Journal of Earth System Science, 129(1), 1-8.
5. Chan R. (2019), What is utility management and how can property managers reduce costs?, [Online]. Available:https://www.onupkeep.com/answers/property-management/utility-management-and-property-costs, Accessed on May 7, 2021.
6. Energy use in buildings. (2020). European Commission. [Online]. Available:https://ec.europa.eu/energy/eu-buildings-factsheets-topics-tree/energy-use-buildings_en, Accessed on May 7, 2021.
7. Lewis, J. O., Hógáin, S. N., &Borghi, A. (2013). Building Energy Efficiency in European Cities-URBACT II Capitalisation. Urbact Ii, 1-52.
8. Esser, A., Dunne, A., Meeusen, T., Quaschning, S., Wegge, D., Hermelink, A., & Reiser, M. (2019). Comprehensive Study of Building Energy Renovation Activities and the Uptake of Nearly Zero-Energy Buildings in the EU. Final Report.
9. Santamouris, M. (2016). Innovating to zero the building sector in Europe: Minimising the energy consumption, eradication of the energy poverty and mitigating the local climate change. Solar Energy, 128, 61-94.
10. Lu, H., Ma, X., & Ma, M. (2020). What happened and will happen in the energy sector under the impact of COVID-19? A review.
11. Global energy demand to plunge this year as a result of the biggest shock since the Second World War, International Energy Agency. (2020). Press Release. [Online]. Available: https://www.iea.org/news/global-energy-demand-to-plunge-this-year-as-a-result-of-the-biggest-shock-since-the-second-world-war, Accessed on May 7, 2021.
12. Birol F. (2020). The coronavirus crisis reminds us that electricity is more indispensable than ever, IEA, Paris. [Online]. Available: https://www.iea.org/commentaries/the-coronavirus-crisis-reminds-us-that-electricity-is-more-indispensable-than-ever, Accessed on May 7, 2021.
13. Zhang, X., Pellegrino, F., Shen, J., Copertaro, B., Huang, P., Saini, P. K., &Lovati, M. (2020). A preliminary simulation study about the impact of COVID-19 crisis on energy demand of a building mix at a district in Sweden. Applied Energy, 280, 115954.
14. IEA (2020). Global Energy Review 2020, IEA, Paris. [Online]. Available:https://www.iea.org/reports/global-energy-review-2020, Accessed on May 7, 2021.
15. Manley M., Muschal T., Annunziato F., &Herrenschmidt J-C., Letter to the President of the European Commission. (2020). [Online]. Available:https://www.acea.be/uploads/news_documents/COVID19_auto_sector_letter_Von_der_Leyen.pdf, Accessed on May 7, 2021.
16. Gallagher J., Coronavirus: What is a second wave and is one coming?, BBC, 2020. [Online]. Available: https://www.bbc.com/news/health-53113785, Accessed on May 7, 2021.
17. Kylili, A., Afxentiou, N., Georgiou, L., Panteli, C., Morsink-Georgali, P. Z., Panayidou, A., & Fokaides, P. A. (2020). The role of Remote Working in smart cities: lessons learnt from COVID-19 pandemic. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 1-16.
18. Zhong, H., Tan, Z., He, Y., Xie, L., & Kang, C. (2020). Implications of COVID-19 for the electricity industry: A comprehensive review. CSEE Journal of Power and Energy Systems, 6(3), 489-495.
19. Chen, C. F., de Rubens, G. Z., Xu, X., & Li, J. (2020). Coronavirus comeshome?Energy use, home energy management, and the social-psychological factors of COVID-19. Energy research & social science, 68, 101688.