COVID-19 IMPACT ON ENERGY USES AND THE NEED FOR AN ENERGY TRANSITION

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Abstract

The COVID-19 pandemic profoundly changed our life. Mitigation actions have been undertaken worldwide, including restriction policies, deeply impacting on society and lifestyle. Energy uses underwent notable changes. Stay-at-home and telework initiatives brought about an increase in residential energy use. Public mobility, domestic and international travels decreased. Studies pointed out changes in energy use by sector and in mobility patterns by means of transport. Together with the incommensurable suffering and the economic crisis, some consideration on energy impact would help redesigning the present and the future in the field, via opportunities such as, e.g., renewable generation, energy storage, and electric vehicles. This article aims at summarizing changes following mitigating actions and highlighting opportunities for the energy system and society, towards sustainability targets.

Riassunto

La pandemia COVID-19 ha cambiato profondamente la nostra vita. Azioni sono state intraprese in tutto il mondo, con un profondo impatto sulla società e lo stile di vita. Le misure restrittive e di telelavoro hanno dato luogo a un aumento del consumo di energia residenziale. La mobilità pubblica e gli spostamenti nazionali e internazionali sono diminuiti. Gli studi hanno mostrato variazioni negli usi di energia per settore e nelle dinamiche di mobilità. Assieme alla incommensurabile sofferenza e alla crisi economica, considerazioni sull'impatto energetico aiuterebbero a ridisegnare il presente e il futuro, attraverso opportunità come, ad esempio, la generazione rinnovabile, l'accumulo di energia e i veicoli elettrici. Questo articolo si propone di sintetizzare i cambiamenti conseguenti alle azioni di mitigazione e di evidenziare le opportunità per il sistema energetico e la società, verso obiettivi di sostenibilità.

Keywords: *Energy Transition, Pandemic, COVID-19, Sustainability, Energy Use, Renewables.*

Parole chiave: *Transazione energetica, Pandemia, COVID-19, Sostenibilità, Usi energetici, Energie rinnovabili.*

Introduction

Measures to control COVID-19 contagion deeply impacted on human activities, including energy uses and mobility. These countermeasures completely disrupted the usual energy use patterns, not just at the residential level, as obvious, but also from the energy system perspective: Despite smart working being a widely used form of work, time, and type of working activities changed, moving peaks and valleys in the energy use profiles. Mobility, industry, and economy were affected. In this work, we recap main findings about the impact on energy, mobility, and economy and possibilities to re-emerge stronger from the crisis.

Residential energy uses

Studies reported changes in residential load patterns in many countries. Cheshmehzangi [1] explored the impact of COVID-19 on household energy use in China, in November 2019-January 2020 (pre-lockdown), January-March 2020 (lockdown), and April-June 2020 (post-lockdown). Household cooking increased by 40% during lockdown and afterwards did not return to normal but lower than before. A similar pattern was seen for household entertainment. Heating and cooling increased by about 60% and lighting increased by about 40% during lockdown. Energy bills increased 67% in February, 95% in March, 35% in April, and 22% in May (2020 compared to 2019). Other household energy uses are unchanged. In conclusion, high and potential long-term impact on transportation, heating, and cooling, potential long-term impact on lighting and entertainment, and short-term impact on cooking and other uses are remarked.

Santiago et al. [2] observed a reduction in the total daily electricity use in Spain in March 14-April 30, 2020. Total electricity use was approximately 25 TWh (13%) lower compared to the same period 2015-2019. In a household in South-East Spain, the morning peak load was reduced (2.8 to 2 kW) and diluted (from 8

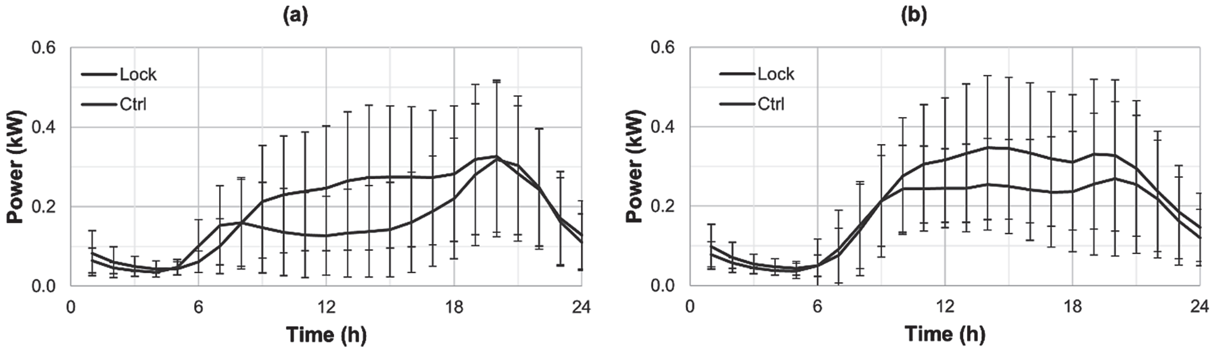

Fig. 1. Average profile of daily active power of Polish residential users on a workday (a) and in the weekend (b) in the 2020 lockdown period (red) and in the analogous 2018 period, used as control period (blue), elaborated from [3]. One can note the increased daytime energy use and similarity between workday and weekend.

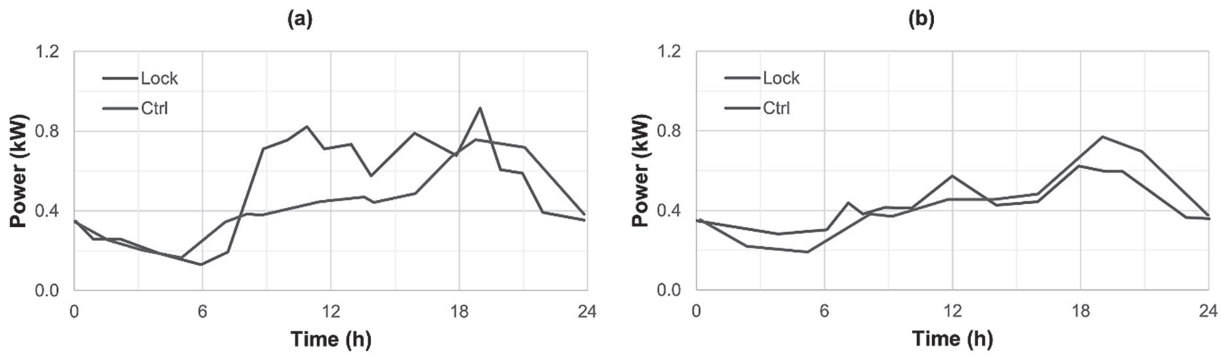

Fig. 2. Average profile of daily active power of Quebecker residential users in April (a) and July (b) during lockdown (red) and in the control period (blue), elaborated from [5].

AM to 11 AM-2 PM) and the evening peak load was also reduced (2.7 to 1.5 kW) and postponed (8 PM to 9 PM) compared to 2019.

Bielecki et al. [3] observed (from almost 7000 households in Poland over 800 hours in the same period of 2020 and 2019) that peak load was almost unchanged, but the distribution of peak load duration was broader. The load profile was unchanged 8 PM-8 AM, but it increased 8 AM-8 PM (Fig. 1). The increased daytime energy use was notable.

Snow et al. [4] noted an almost unchanged load profile in weekdays and an increased evening peak load in Australia. Rouleau and Gosselin [5] detected major changes in April-May 2020 and minor changes in June-July 2020 with respect to the control period in a social housing building in Québec, Canada (Fig. 2).

Mustapa et al. [6] studied the impact on household electrical appliance consumption level and on the household conduct concerning energy saving and energy-efficient equipment. The consumption level during measures was greater than before and subsequently decreased but it remained higher than before. Results are available for a variety of appliances. Also, the impact of energy efficient appliances on energy behavior across income groups of users was studied.

In general, daytime energy use increased. A scarcity of measured data was remarked [3]. Increased energy awareness in users [3] and also in service providers and governments [4] is desirable. Low-income users proved more sensitive to energy saving and efficiency with respect to medium- and high-income users [6].

The pandemic has exacerbated energy poverty, in a two-fold effect: Confinement causes energy expenditure increase and, at the same time, market contraction and income decline. Energy poverty was studied in Italy and Spain, two countries strongly affected by COVID and having a comprehensive pre-existing legislation on energy poverty [7].

Relief measures were taken worldwide to support household electricity and gas supply. The ENGAGER network has mapped such responses [8]. Affiliated scientists and activists also issued a call for action for the right of energy and against energy disconnections

[9]. An analysis on the U.S. case is reported as an example [10].

Other than energy consumption, indoor comfort was investigated, e.g. by Cuerdo-Vilches et al. [11], concluding that energy-poor households were more exposed to discomfort and resorted to saving strategies (e.g. thermal adaptation via clothing).

Mobility

Restrictive measures and health concerns also impacted on mobility patterns [12, 13]. Correlation between mobility and SARS-CoV-2 transmission is studied [12, 14-16]. Datasets are available on pandemic-altered mobility [17, 18]. Health has become a priority when choosing transport mode, at the detriment, e.g., of timing and price [19].

Katrakazas et al. [20] studied changes in driving behavior and road safety, evidencing a more aggressive driving following lesser traffic volumes (higher speeds, more numerous speed violations, more frequent harsh acceleration or braking) and higher usage of mobile phone when driving and yet less incidents (following shorter trips, less frequent trips in nighttime, and reduced traffic). Li et al. [21] studied altered traffic patterns in Shanghai. Luan et al. [22] explored the impact on travel choices and car purchasing. Other studies deal with electric vehicle charging dynamics [23, 24]. Mobility and transports, especially public transports, declined in general, while the use of cars, bicycles, and micro mobility increased. The impact on industry is also analyzed, e.g., concerning electric vehicles [25].

New drivers shaping future mobility are health, policies and regulations, hyper-locality, industry consolidation, and a rethinking of innovations. A strong global uptake of electric vehicles is expected, albeit with local slowdowns [19]. Post-pandemic mobility scenarios are explored [13, 26]. The impact on mobility also propagates to related aspects, namely energy and the environment: As an example, perceived health risk influenced carsharing and, in turn, emissions and traffic [27].

Power system, industry, and climate

The impact on the power system and the energy market is also investigated [28-31]. A review on the matter is by Navon et al. [28], discussing present challenges, which include irregular load distribution and inaccurate load forecasting. The effect on energy demand is studied, e.g., in the case of Italy [30]. Other studies focus, e.g., on increased photovoltaic generation due to clearer skies following lockdown [32], modeling of energy generation and consumption during criticalities [33], or the impact on small power systems [34].

Electricity demands dropped in many countries following lockdown orders, only partially compensated by increased residential energy use, and recovered following eased measures [35]. The energy industry was affected [36], resulting in reduction of oil and gas prices [37]. The effect on renewable energy industry in particular is studied [38]. In addition to a decreased energy consumption, an increased share of renewable generation is found in a pandemic scenario [34]. This is explained by dispatch priority and the significant capacity installed in 2019. On the other hand, new investments were delayed [39], as a consequence of slowdowns in shipments and restrictions to personnel [40].

The impact of the pandemic and on mitigation measures on other sectors is also explored. It is noted that increased reliance on ICT (driven by telework, distance learning, gaming, entertainment, and internet shopping) boosted the demand for devices [41] and the related energy uses [42]. The COVID-19 pandemic is regarded as the main cause of the current global chip shortage, as increased demand and factory shutdowns depleted inventories. After a noted glut in DRAM memory in 2019, the industry growth in 2020 could not keep up. Demand for semiconductors keeps increasing and so is price. Filling the shortage is expected to take a couple of years. The automotive industry was especially affected: Vehicle sales dropped at the beginning of lockdowns and semiconductor manufacturers redirected to consumer electronics, exposing the automotive industry when car sales rose again [41].

Unfortunately, the COVID-19 pandemic broke out within an ongoing climate crisis, both unprecedentedly disruptive [43]. Health measures impacted positively on the environment, by reducing emissions [44]. While countries are deploying economic recovery programs, it is advised not to neglect the environment [43].

Possibilities

The altered context can be a fertile environment for local renewable generation, energy storage, and electrical mobility [45]. Although newer studies incorporate the pandemic context, specific studies on the impact on local generation and storage are scarce. As an example, we investigated the impact of the altered

Tab. 1. Comparison of results on average daily energy exchanged and yearly energy cost and saving for an Italian household based on the presence of a renewable energy system, an electric vehicle, and lockdown measures, elaborated from [46]. The results show that lockdown-altered energy use pushes for increased use of renewable energy systems and electric vehicle charging.

Photovoltaic and storage	Electric vehicle	Lockdown	Daily energy (kWh)		Annual cost (€)	Annual saving (€)
			from grid	to grid		
No	No	No	13	0	1.094	–
No	No	Yes	19	0	1.458	–
No	Yes	No	25	0	1.860	–
No	Yes	Yes	30	0	2.225	–
Yes	No	No	6	20	448	645
Yes	No	Yes	7	18	552	906
Yes	Yes	No	16	19	1.155	706
Yes	Yes	Yes	17	17	1.264	961

context and possibilities of exploitation [46] based on a model of residential renewable generation and storage [47], concluding that pandemic-induced loads increase savings from a local photovoltaic-storage system, also considering a home-charged electric vehicle (Tab. 1). COVID-19 also motivated research works on stand-alone energy systems for medical facilities [48] or rural communities [49] or on cold vaccine storage and distribution [50].

Technology can provide an extensive contribution. In addition to bioinformatics [51] or digital and telehealth [52, 53], examples exist of technology repurposing. Some examples are smart building applications [54], robotic nasopharyngeal swab sampling [55], or the control of mechanical ventilation in buildings [56]. A review on robotics and artificial intelligence in healthcare against COVID-19 is by Sarker et al. [57].

Studies advise to accelerate the energy transition in this time of health and climate crises, as the way to emerge stronger, via disruptive technologies, including clean energy, storage, and electric mobility [58]. Although one can be tempted to promote sustainable energy in the short term, it is advised to minimize economic damage for businesses and devise long-term plans for a transition to low-carbon energy, along with a stronger economy and a more responsive health care. A comprehensive exploration on the matter is by Hoang et al. [59]. Renewable energy communities, for instance, are regarded as a key element [60].

Conclusions

The COVID-19 pandemic exposed weaknesses in the energy system and economy. Also, it happened within an ongoing climate change. Residential energy uses increased but other uses and overall consumption decreased. Power generation and emissions also decreased, but the share of renewable generation increased. Mobility declined and new transportation modalities are taking over. We can learn from this and take advantage of recovery actions. Contributions are coming from many technologies. Renewable generation, energy storage, and new mobility systems are among key elements. A cleaner and more sustainable energy system can be built, along with better economy and healthcare.

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