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Household Water and Energy Consumption Changes during COVID-19 Pandemic Lockdowns: Cases of the Kazakhstani Cities of Almaty, Shymkent, and Atyrau

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Abstract: The COVID-19 pandemic has changed the daily behaviors of people by forcing them to spend the majority of their time in their residences, particularly during social distancing measures. The increased time spent at home is expected to influence, among other things, the daily consumption of utilities: specifically, water and energy. A prolonged presence of residents at home during COVID-19 lockdowns might increase strain on water and energy resources, which are mostly from non-renewable sources in several countries, including Kazakhstan; however, such potentially important effects have not yet been studied for the country. The present research aims to evaluate how the COVID-19 pandemic lockdowns have affected the water and energy consumption in residential housings in cities of varying sizes in Kazakhstan, providing a novel understanding of the effect of pandemic lockdowns on household energy and water consumption. Energy and water consumption data of Almaty, Shymkent, and Atyrau have been first obtained from the local service companies, and then, the usage behavior was analyzed for the periods before, during, and after the COVID-19 pandemic lockdown. After, statistical tests were conducted to check the hypotheses regarding the effect of COVID-19 pandemic lockdowns on the consumption of energy and water. The findings indicate that residential energy and water consumption increased during the lockdown periods in large and medium cities. Nevertheless, this growth is not highly significant compared to similar non-pandemic timeframes. This result could indicate a particular risk for sustainable resources consumption and put pressure on the supply companies. Moreover, in case of further lockdown measures, current building systems are at risk of increased pressure, and eventually, of failure.

Keywords: building sustainability; coronavirus; electricity demand; residential buildings; SARS-CoV-2; water supply

1. Introduction

COVID-19, which started in 2019, resulted in a series of unexpected challenges, including health [1–5], social [6–9], environmental [10–14] issues which humanity continues to face as of 2021 and must overcome to ensure a sustainable and optimistic future. As an emergency and management response, global lockdowns in cities worldwide have aimed to reduce the propagation of the virus [15]. Issues and challenges related to COVID-19 and lockdowns exist at both macroscopic (e.g., environment, economy, etc.) and microscopic (individual) levels [16]. The microscopic level influences of the pandemic include changes in people's daily habits and time spent at home, which may consequently result in macroscopic changes such as environmental resources consumption and sustainability of residential buildings [8,17,18].

The environmental impact of COVID-19 has demonstrated itself in both positive (such as increased water and air quality in urban areas) and negative directions (including waste generation due to disposal of medical consumables) [13]. The waste management of highly urbanized areas has been particularly strongly influenced by COVID-19, which influenced the waste recycling flow, reuse, and waste reduction and has led to new measures such as creating new sanitation requirements [19]. Even though most of the pandemic-related changes seem temporary, some others might remain well after the pandemic is over; indeed, some researchers argue that COVID-19 could be critical in policy-making for global sustainable energy transition [20]. On top of habit changes and environmental impact, the current pandemic highlights the importance of social and built environment, including quality of housing and living conditions for maintaining a healthy population [7]. Another social impact of the pandemic is the switch of education and certain types of work to online mode, which resulted in multiple issues and challenges related to remote education and working [21–24]. Finally, the pandemic is a transformational event that influences social responsibility and behavioral change toward environmental awareness [25].

Kazakhstan was not left uninfluenced by the current pandemic. Following 13 March 2020, the first case of coronavirus infection registered in Kazakhstan, a state of emergency was introduced on 16 March to prevent the spread of infection in the country. As a preventative measure, entry to and exit from the two largest cities (Nur-Sultan and Almaty) were prohibited on 22 March. Later, the rest of the country was also put into quarantine. The state of emergency lasted until 11 May, during which all citizens stayed home for isolation purposes [26]. Due to the pandemic, Kazakhstan's economy experienced a contraction of 3% (for the first time since the late 1990s) in 2020, while a moderate recovery of 2.5% followed it in 2021 [27]. The adverse economic conditions during the pandemic in Kazakhstan are likely to cause a wave of pandemic-related depression [28]; recent World Bank estimates for Kazakhstan show that the pandemic will reduce education quality by eight on the P.I.S.A. (Program for International Student Assessment) scale [29]. The difficulties in the transition to remote education may be held responsible for the decrease in the education quality, which is related to poor internet infrastructure, ineffective interaction with stakeholders, and biased statistical information [30]; however, the pandemic is expected to enhance the digitalization of transitional economies, such as Kazakhstan [31].

The effect of the pandemic on water consumption has been studied to an extent by researchers around the globe [6,11,15,32–34]. COVID-19 raises a question of the sufficiency of the regular water supplies in cities which is directly related to sanitation and public health, especially in regions with water shortages before the pandemic [6,32]. More specifically, Kalbush et al. [6] demonstrated that the water consumption by industrial, commercial, and public sectors decreased, whereas the consumption by the residential sector increased. Moreover, the increase in consumption was higher in apartment buildings than in single-family houses. Similarly, the demand modeling of California's urban water consumption showed a 7.9% decrease due to an 11.2% lower consumption in the industrial, commercial, and institutional sectors and a 1.4% increased consumption in the residential sector [35]. In the Iranian metropolitan area Tabriz, water consumption increased by up to 18% [36]; even water consumption peaks changed during the pandemic, resulting in a delay of morning consumption peak by 2 h [16]. Another study has also highlighted the significant increase in water consumption patterns related to the COVID-19 lockdowns in England [34]. In addition, water plays a significant role in hindering the spread of the coronavirus by washing hands, which is expected to have a significant impact on the quantity and quality of water consumption in near future [37,38]. A study conducted in Bangladesh shows that tap water was used extensively for hand washing during pandemic quarantines, reaching 13-times more compared with pre-pandemic tap water use [39]. Water consumption in Nepal during the pandemic increased; however, the payment for water decreased [11], highlighting the need to implement a proper policy to regulate water consumption. Behavioral change during lockdowns also resulted in a change in the consumptive water footprint of European thermal power plants, 16% of which is related to decreased electricity demand [40]. At the same time, water security and scarcity in Europe, which was exacerbated by the COVID-19 pandemic, was addressed by 11 out of 27 European countries in the form of policy intervention mostly related to water bills [33]. The water sector will have to adapt to the new requirements and conditions set by the current pandemic, which will have a positive impact, such as ICT upgrades, remote working load resilience, and project delivery [41].

Regarding the energy consumption during the pandemic, studies mainly show that the residential sector faced an increase which is, however, contrasted with commercial energy consumption decrease. For instance, in the United States, energy use in houses has increased by 30% during pandemic lockdowns [42]. In contrast, Wang et al. [43] compared the total (residential, commercial, etc.) energy consumption in China with a simulated COVID-19-free scenario, and showed that the actual energy consumption would be reduced by an average of 29% due to pandemics. COVID-19 related changes resulted in an increased heating energy consumption of residential buildings, e.g., in Barcelona, Spain, by 182% [17]. A study conducted on Canadian social housing showed that electricity and hot water consumption slightly increased during the first two months of the lockdown. The consumption was distributed throughout the day, rather than having a peak in the evening as before the pandemic [44]. The energy consumption in South Korea has decreased for most of the facilities; at the same time, there was an increase in consumption by residential buildings, indicating the need to develop a new energy system management [45]. The main factors affecting energy consumption were social distancing, self-quarantine, and home transformation [46]. In addition, optimal population distribution can lead to decreased energy consumption by 32%, mainly due to a lower use of HVAC systems [47], which, when used, is claimed to substantially increase energy consumption [48]. Qarnain et al. [49] suggest that governments consider domestic energy consumption as an emergency sector and healthcare due to higher consumption and importance during the COVID-19 pandemic. Three D's: Digitization, Decarbonization, and Decentralization of the energy sector should be one of the main goals of the policymakers as a lesson learned from COVID-19 [50]. ICT innovations, including Big Data analysis using artificial intelligence, could be useful for efficient energy management in near future [42,48]. Finally, it is important to research the duration of the changes brought by COVID-19, and its effect on energy consumption [51].

There is no comprehensive study related to water and energy residential consumption in Kazakhstan during the COVID-19 pandemic. One study reported on the country's total energy situation [52] and stated that electricity production in Kazakhstan for the first quarter of 2020 increased by 3.6% compared to the same period in 2019. Due to the introduced quarantine, demand was expected to decrease by 12% in the second quarter of 2020. In such a case, the direct revenues of energy companies would be significantly reduced, possibly forcing energy companies to ask for state support or to lay off staff. The current energy sector situation in the country shows the need for radical reforms and expects upcoming changes in the global and Kazakhstani energy sector under the influence of the COVID-19 crisis [52].

Moreover, the energy sector of Kazakhstan is currently highly dependent on coal and oil as energy fuels, only with a small number of renewables in the presence [53]. Regarding the situation for water, Kazakhstan is soon expected to face a water crisis, which makes the development of sustainable water consumption strategies critical for the environment and population wellness [54]. If the COVID-19 pandemic has indeed led to a surge of water and energy use in the country, the pressure on the supply companies and the environmental situation in the country can rapidly become critical.

The present study aims to assess how the lockdown caused by the COVID-19 pandemic has affected household water and energy consumption in residential housings in Kazakhstan's cities. First, water consumption and wastewater generation trends were analyzed for periods defined as pre-pandemic, during the lockdown, and post-lockdown.

Then, the electricity consumption was investigated by surveying city residents and analyzing electricity bills.

1.1. Study Area

1.1.1. Shymkent City

Shymkent is the third most populated city in Kazakhstan, with 1,093,084 people as of 2021 [55]. Located in South Kazakhstan, bordering Uzbekistan, it is a major industrial and commercial activity center. L.L.P. "Vodnye Resursy-Marketing" provides water supply to Shymkent. There are 45 wells in operation, which provide the city with 90% of its water. The underground water obtained with the help of pumping stations is fed into the main water conduit. The water extracted from the wells and then disinfected is delivered through three main water pipelines; further, it is transported through the quarterly distribution networks. For the operational management of the water supply and sewerage system, eight operational sites have been created where outsourcing companies operate [56]. Shymkent has a humid continental climate with hot and dry summers and cold winters [55]: The precipitation decreases through the spring-summer period, becoming the lowest in August and the highest is in March (approx. 33 mm) (Figure 1), and the average temperatures in summer and winter are 35 °C and −4 °C, respectively.

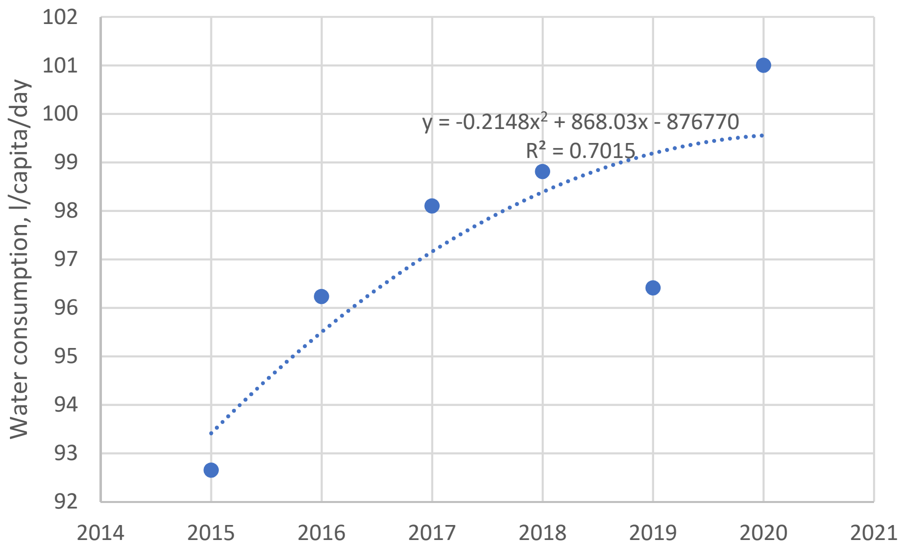

Figure 1. Water consumption (liter per capita per day) during 2011–2020.

1.1.2. Almaty City and Almaty Region

Almaty city, the former capital of the country, is the largest city in Kazakhstan, with 1,996,700 people [57]. Almaty city was the regional center of the Almaty region until 2001, after which it has, due to its large population, become a city of republic importance, and is also considered a cultural, financial, and historical center of the country [58]. Almaty region contains three cities and seventeen districts, with 2,092,400 people [59]. The energy in Almaty city and region is provided by three combined heat and power stations; two of them are working on coal and oil byproducts, while another one recently converted to natural gas [60,61]. It is important to note that electricity is not used for heating in the city. Therefore, it is not a seasonal-dependent utility.

1.1.3. Atyrau City

Atyrau city is located both in Europe and Asia in the west region of Kazakhstan, at the delta of the Ural River that flows to the Caspian Sea. The city is well known as the leading oil and gas industry region in Kazakhstan and worldwide. It is a medium-sized city that experienced a 22.5% growth with 290,700 people in 2020 compared to 2018 [62].

This intense population growth of the city puts it in an important position for the efficient consumption of energy resources.

The Atyrau Combined Heat and Power Plant (C.H.P.P.) is the third power plant in Western Kazakhstan in terms of installed capacity and one of the important electricity suppliers in Atyrau since 1963. As of 2014, the installed electric capacity was 314 MW, the estimated electric capacity was 283 MW, and electricity generation was 1.75 billion kWh. In 2015, after installing the new turbine unit, the power plant's capacity increased to 414 MW [63]. The main type of fuel is natural gas; also, fuel oil is used as a backup. However, Atyrau city is one of the most polluted cities in Kazakhstan in terms of air and water contamination because of the abundance of manufactories. The Atyrau C.H.P.P. is not an exception, as, in the winter of 2018, it was involved in a catastrophic environmental occasion, where more than 110 tons of fish, including sturgeon, were killed in the Ural River by the discharge of contaminated water from the combined heat and power plant [64].

2. Materials and Methods

To analyze the household water and energy consumption in residential houses in Almaty and Shymkent (the largest cities in Kazakhstan), the water consumption data have been obtained from the water utility company "L.L.P. Vodnye resursy-Marketing." These data comprise water consumption and wastewater generation of the residents of Shymkent from January 2011 to April 2021 for different residential building types (e.g., single houses, multi-residential complexes) throughout all the regions of the city. The data have been analyzed to receive consumption patterns of periods of pre-lockdown, during the lockdown, and post-lockdown. The variation in energy consumption data has been obtained (1) during a pilot study—from volunteering householders of Almaty (n = 60, survey on behavior patterns related to cooking, entertainment, and lighting use); from (2) official statistics for 2019–2021 from "AlmatyEnergoSbyt," the energy providing company for Almaty city and Almaty region; and (3) from official statistics from "AtyrauZharyk" for 2018–2021 for March, April, and May. For the analyses, the pre-lockdown and post-lockdown periods have been considered as well as the lockdown period itself (consists of the last two weeks of March, April, and until May 11: corresponding to the period during which the Kazakhstani government officially enforced a lockdown, and the entire population was forced to stay home most of their time).

3. Results and Discussion

3.1. Water Consumption and Wastewater Generation: The Case of Shymkent

According to the population and water demand changes for Shymkent through 2011–2020 (Table 1 and Figure 1), the average exponential rate of increase for the population was calculated as 5.88%, while water consumption was 6.55%. Specifically, in 2020, covering the outbreak of COVID-19 in Kazakhstan, the yearly increase for water demand (7.61%) was higher than previous pre-pandemic years 2016–2019, whereas the population increase in 2020 was 2.88%, which is lower than the pre-pandemic years.

These data support that the increase in water use may be explained more due to other factors (in the present case, assumed to have changes in daily habits of water consumption tied to the effects of pandemic lockdown) than the population increase.

The domestic water consumption values in liter per capita per day (lpcd) are calculated and illustrated in Figure 1. During the study period, the average water consumption value is 97 lpcd, and the increase over the average value is 3.8% in 2020. Figure 1 represents the time period between 2015 and 2020, as information up to 2015 was considered unreliable due to the use of old metering devices across the city. New regulations regarding updating metering devices with expired verification period was signed in 2012, and by 2015 the water meters were finally updated across the majority of city residents [65].

Table 1. Dynamics of population and water consumption change through 2011–2020 in Shymkent.

Year	Population	Population% Variation (A)	Water Consumption, m^3	Water Consumption % Variation (B)
2011	642,700	n/a	20,111	n/a
2012	662,300	+3.05	23,310	+15.91
2013	683,300	+3.17	24,313	+4.30
2014	711,873	+4.18	26,490	+8.95
2015	858,147	+20.55	28,622	+8.05
2016	885,799	+3.22	30,687	+7.21
2017	912,300	+2.99	32,225	+5.01
2018	951,605	+4.31	33,802	+4.89
2019	1,009,086	+6.04	35,023	+3.61
2020	1,038,152	+2.88	37,689	+7.61

Table 2 and Figure 2 represent the statistical test to check the hypotheses regarding the effect of the COVID-19 pandemic lockdown on water consumption. We set the following hypotheses, H0 (The mean is equal to 0.035) and Ha (The mean is different from 0.035). As the computed *p*-value is greater than the significance level alpha = 0.05, one cannot reject the null hypothesis H0. That means there is no difference between the value of ater consumption overpopulation from 2011 to 2020, which shows that there was some increase during the COVID-19 pandemic lockdown, but it was not that significant to link it with the pandemic lockdown.

Table 2. Model parameters (Water consumption, m^3).

Source	Value	Standard Error	t	Pr > |t|	Lower Bound (95%)	Upper Bound (95%)
Intercept	−850.382	2297.823	−0.805	0.444	−7149.171	3448.408
Population	0.037	0.003	13.716	<0.0001	0.031	0.043
Equation of the model (Water consumption, m^3):						
Water consumption, $m^3 = -1850.38 + 0.0371 * \text{Population}$						
Standardized coefficients (Water consumption, m^3): **Correlation**						
Source	**Value**	**Standard error**	**t**	**Pr > |t|**	**Lower bound (95%)**	**Upper bound (95%)**
Population	**0.979**	0.071	13.716	**<0.0001**	0.815	1.144

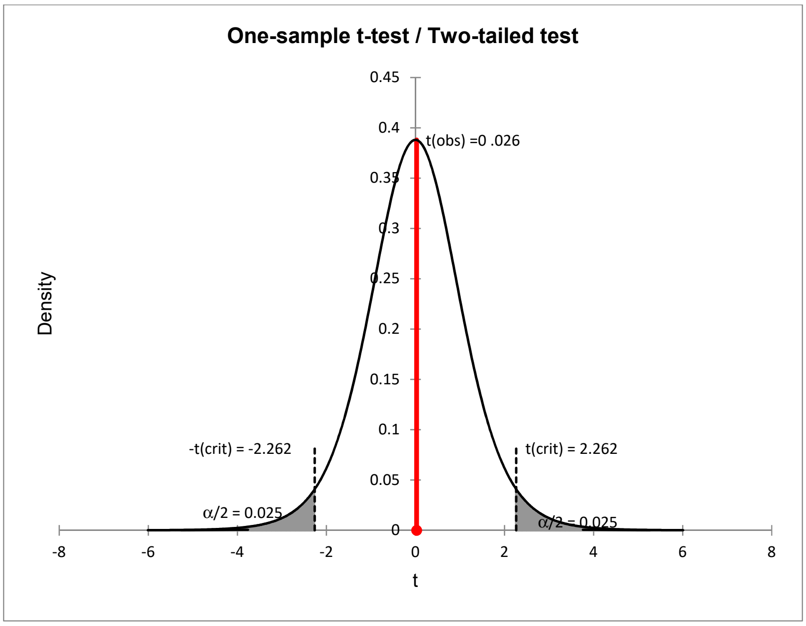

Figure 2. One-sample *t*-test/Two-tailed test for water consumption during COVID-19.

Figure 3 presents water consumption and wastewater generation comparison between multi-residential and single houses. In both building types, water consumption has increased during the pandemic period (2020), where multi-residential complexes faced a higher increase than single houses (2.93% and less than 0.1% increase for 2020 compared with 2019 correspondingly). This difference could be attributed to population densities in different housing types. Multi-residential buildings occupy more people per building, and consequently, their consumption experienced a higher increase. The main reason for the rise in water demand during lockdown is the residents' increased time spent at home. It could be also linked to various hygienic practices, including the popularization of frequent hand washing via different campaigns such as the ones from the WHO and the government [66], more frequent sanitation of residences, and more frequent laundry practices.

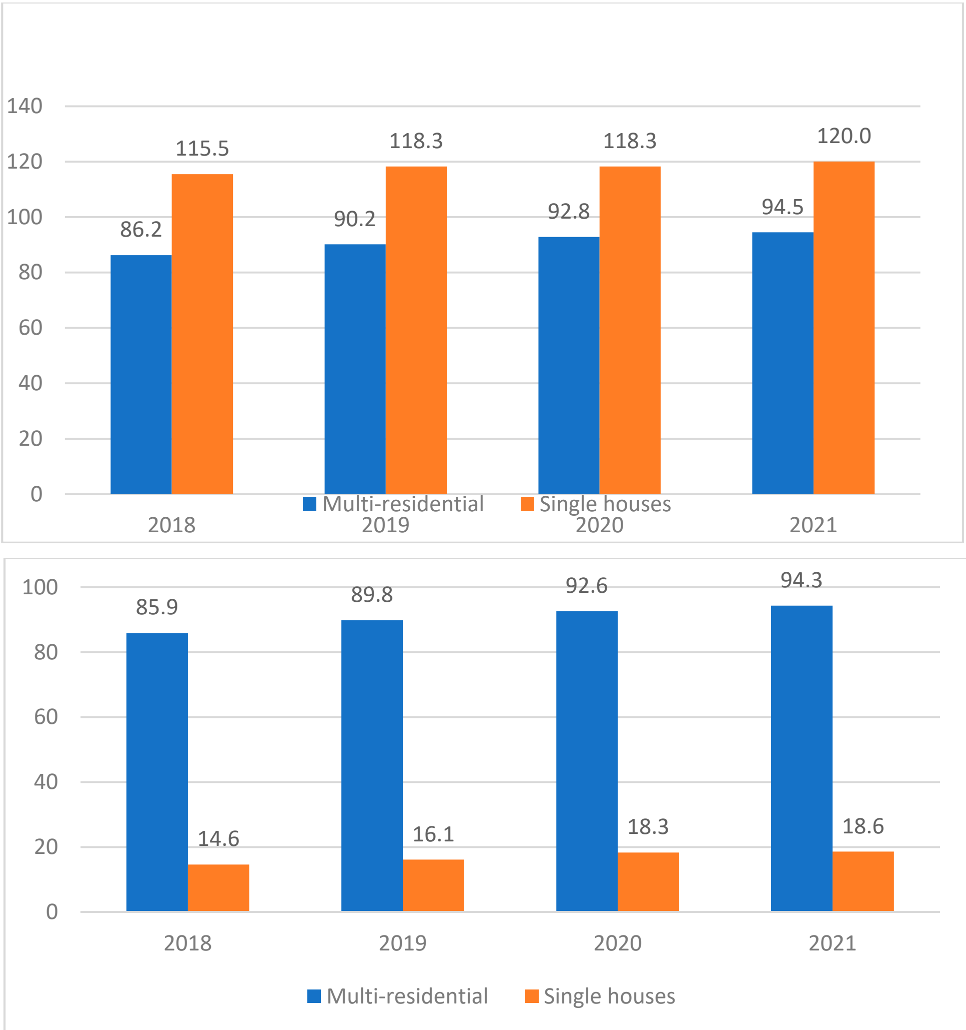

Figure 3. (**upper figure**) Water usage in April in thousands m^3; (**lower figure**) Total charged amount of wastewater for April month in thousands m^3.

Other regions of Kazakhstan also noticed an increase in water consumption during the lockdown, which continued to stay high in the post-lockdown period. For example, in Uralsk (Western Kazakhstan), due to increased water consumption, the water supply company developed a particular schedule to provide water for the residents: at night, the pressure was reduced by 70%, and in the morning by 50% [67]. The schedule was developed at the end of June 2020, showing that even after the lockdown in May, the water consumption was still at a high level. Uninterrupted supply was no longer possible because the water consumption in residential housings had doubled. Moreover, this initiated the development of the projects for six new wells drilling. Nevertheless, other issues also affected water supply—a huge need for main pipe renovation. Increased water surge also leads to faster wearing out of the pipes and numerous accidents. Thus, the pipes need to be in a proper state more robust to allow increased water surge flow.

One interesting point to note is that the water use trends keep growing during the lockdown and do not return to the pre-lockdown condition. It might be linked to (1) public and personal behavioral change and (2) still, the risk of infection was inevitable in 2021, even though there was no strict lockdown as it was experienced in 2020 in Kazakhstan. Although the main lockdown was finished in mid-May, the partial lockdowns are still taking place in different cities, explicitly depending on the situation of COVID-19 cases.

A rapid and continuous increase in water consumption demand driven by a pandemic addresses a clear need to develop sustainable residential water services. Thus, planning for a pandemic is not an option but a new set of requirements for water resource planners. Since the COVID-19 pandemic is not finished yet, it was also experienced that all these sanitation measures are still relevant even after the lockdown was finished more than a year ago. Therefore, considering the long period of COVID-19 pandemic rise, constant new strains development, and the possibility of further pandemics in the future, it is crucial to develop and implement sustainability strategies for water consumption in households as soon as possible.

Similar to household water use, residential wastewater generation also is proven to grow in accordance with COVID-19 pandemic lockdown (see Figures 3b and 4b).

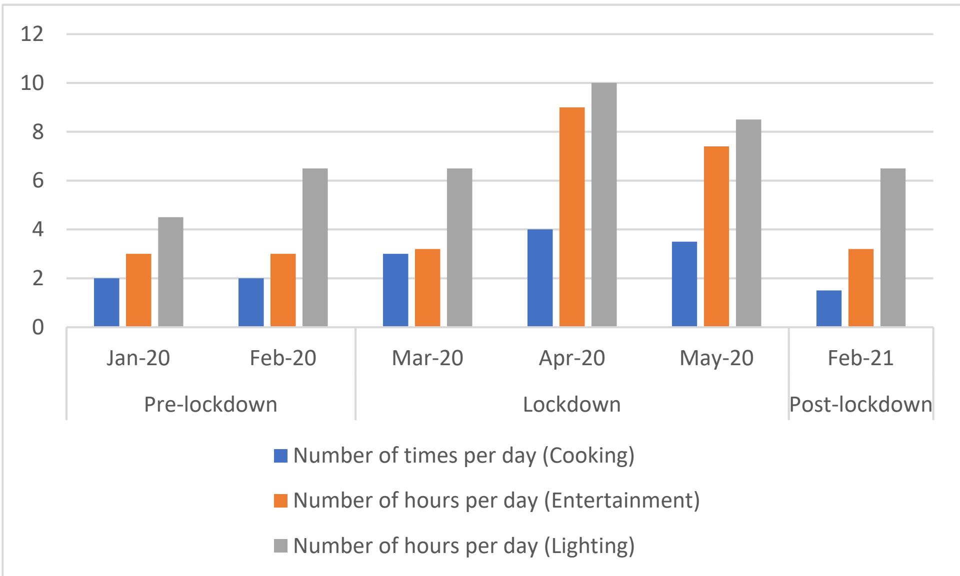

Figure 4. Results of a pilot study from January-May 2020 and February 2021 for cooking, entertainment, and lighting behavior patterns for pre-lockdown, lockdown, and post-lockdown periods.

Nevertheless, if we compare the wastewater generated in multi-residential with the wastewater from single housings, it is seen that multi-residences generate six times larger amounts of wastewater. Thus, resilient wastewater policies are prioritized for implementation in multi-residential housings rather than in detached households. Similar to one of the "water" policies, in the shed of wastewater generation increase during COVID-19 pandemic lockdown (and continued high level in the post-lockdown), the piping system should be qualitatively maintained to exclude accidental wearing out.

3.2. Energy Consumption

3.2.1. The Case of Almaty

Based on the data available for the energy consumption for Almaty, the pre-lockdown period was defined as January, February, and the first two weeks of March 2020 (before

COVID-19 reported in Kazakhstan in 2020, a period representing regular living conditions); the lockdown period continued from mid-March 2020 to 11 May 2020 (the period of application of strict regulations of social distancing, with a direct impact of lockdown), and the post-lockdown period (the month of February 2021, encompassing enduring effects of lockdown and changes due to post-lockdown lifestyle after roughly a year). The analyses indicated that consumption behavior remained changed almost a year after the strict lockdown.

Figure 4 indicates the result of the Pilot study—the daily cooking frequency has doubled, entertainment tripled, while lighting hours increased around 1.5 times during the lockdown period in April 2020. Nevertheless, in the post-pandemic period, all the cooking, entertainment, and lighting patterns have returned to pre-pandemic behavior, evidencing that the effect of the energy consumption would increase during lockdown is temporary. Cooking and laundry activities, lighting use, and use of I.C.T.s are proven to be increased during lockdowns, which is consistent with the other countries in the literature [68–70].

As the pilot study results have shown the trend of electricity consumption increase during the pandemic, electricity consumption statistics from the energy-providing company were also analyzed for 2019–2021. Tables 3 and 4 show how Almaty city and region's population and energy demand have changed through 2019–2021.

Table 3. Population dynamics and energy consumption change through 2019–2021 in Almaty city.

Year	Population	Population % Variation	Electric Energy Consumption, kWh	Electric Energy Consumption % Variation
2019	1,854,656	n/a	1,230,190	n/a
2020	1,916,822	+3.35%	1,278,444	+3.92%
2021	1,996,700	+4.17%	1,346,268	+5.31%

Table 4. Population dynamics and energy consumption change through 2019–2021 in the Almaty region.

Year	Population	Population % Variation	Electric Energy Consumption, kWh	Electric Energy Consumption % Variation
2019	2,038,935	n/a	816,477	n/a
2020	2,055,724	+0.82%	870,756	+6.65%
2021	2,092,400	+1.78%	915,855	+5.18%

It indicates that the electricity consumption increase is higher than the increase in population. Thus, the reason for energy consumption rise could be linked to other reasons, rather than an increase in population. Figure 5 shows electric energy consumption per population in Almaty and Almaty region, and the increase in 2021 is apparent.

3.2.2. The Case of Atyrau

The electricity consumption and number of electricity consumers in Atyrau in March-May for 2018–2021 years are given in Table 5.

Table 5. Electricity consumption and the number of electricity consumers in Atyrau in March, April, and May for 2018–2021 in kWh.

	Electricity Consumption			Number of Consumers		
	March	**April**	**May**	**March**	**April**	**May**
2018	25,812,172	23,542,181	21,848,953	97,198	97,479	97,802
2019	26,384,106	24,677,799	23,944,992	101,381	101,599	101,879
2020	27,051,863	26,822,609	25,714,753	105,227	105,221	105,504
2021	30,957,504	28,436,423	27,582,400	107,031	107,469	107,469

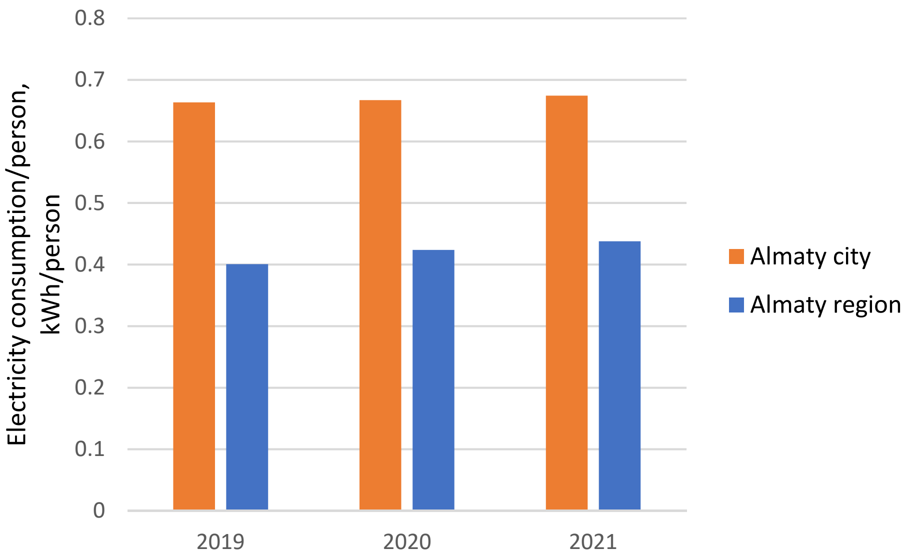

Figure 5. Electricity consumption by population (kWh/person) of Almaty city and Almaty region for 2019–2020–2021.

Figure 6 shows the same data adapted by electricity consumption per consumer for the same period. Thus, it is seen that the electricity consumption increased during the pandemic lockdown period—in April and May 2020, the consumption per person is higher compared to the same months in 2018 and 2019 years. Interesting to note that in 2021 (when the lockdown was over, but the pandemic is not over yet), the energy consumption has continued increasing—in March, April, and May 2021, the energy consumption per person is the highest compared to 2018–2020.

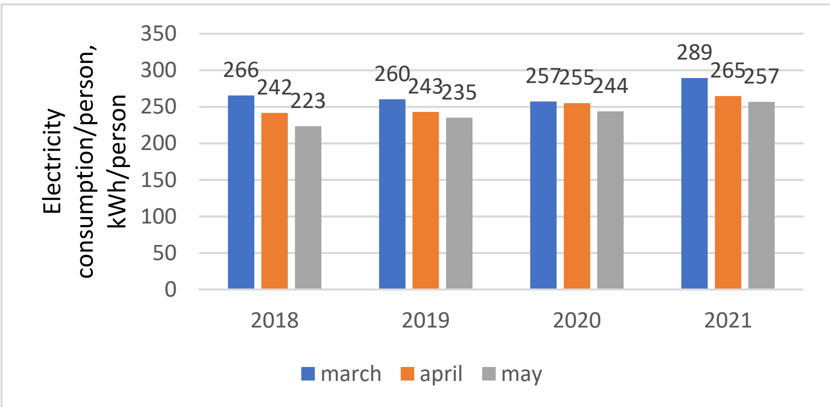

Figure 6. Electricity consumption per consumer (kWh/person) in Atyrau for 2018–2021 years.

Table 6 and Figure 7 represent the statistical test to check the hypotheses regarding the effect of the COVID-19 pandemic lockdown on energy consumption. We set the following hypotheses: H0 (The mean is equal to 252.91) and Ha (The mean is different from 252.91). As the computed *p*-value is greater than the significance level alpha = 0.05, one cannot reject the null hypothesis H0. That means there is no difference between the value of energy consumption overpopulation from 2018 till 2021, which shows that there was some increase during the COVID-19 pandemic lockdown, but it was not that significant to link it with the pandemic lockdown.

Table 6. Model parameters.

Name	Value
Difference	−0.004
t (Observed value)	−0.001
∣t∣ (Critical value)	2.201
DF	11
p-value (Two-tailed)	0.999
alpha	0.05

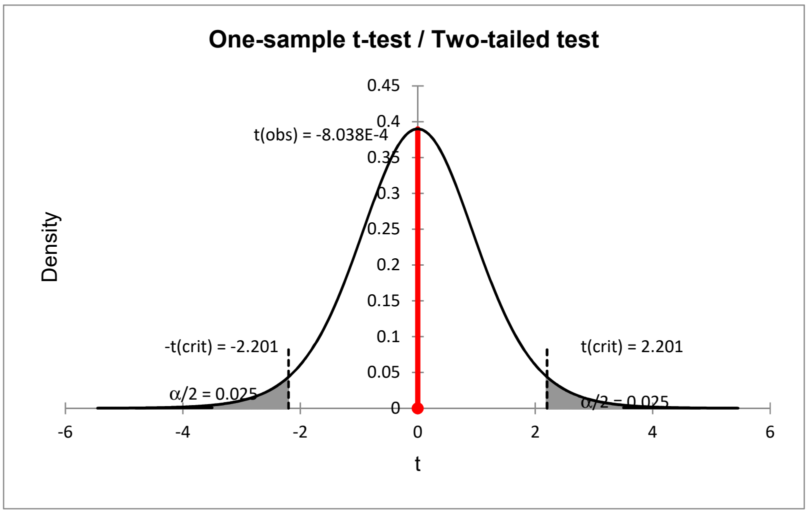

Figure 7. One-sample *t*-test/Two-tailed test for energy consumption during COVID-19.

4. Conclusions

The COVID-19 pandemic has astonished the world with its scale, rapid transfer, and fast development of new strains. Resultingly, strict lockdowns have occurred globally, forcing billions of people to stay at home for long periods to improve social distancing and prevent virus transmission. Around 1.5 years after the first outbreak, the coronavirus still kept raging around the world, negatively affecting the health of millions of people. Therefore, as new lockdowns are possible to occur during COVID-19 or possible future pandemics, it is essential to study how the pandemic affects residential buildings—the main shelter and new working, studying, and even leisure space during the pandemic. The novelty of this research lies in the study of the unprecedented COVID-19 pandemic on household water and electricity consumption in Kazakhstani cities, Almaty, Shymkent, and Atyrau. It was found that both energy and water usage increased during lockdown periods. Thus, the pandemic measures have led to an increase in water/energy consumption; however, the increase was not significant compared to similar timeframes without pandemic measures. These results are somewhat different from the results of other countries, which have noted energy and water consumption increase over the pandemic period. Nevertheless, the results are limited to the three cities in Kazakhstan.

For future works: the change in waste behaviors during the lockdown and/or pandemic is suggested to be analyzed for improvement of waste management plans towards not only more sustainable but also safe, as the recent COVID-19 pandemic has led to increased use of medical personal protective equipment by ordinary users, whereas the knowledge and experience on treating the resulting waste after use are limited.

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References

1. Haider, A.S.; Al-Salman, S. Dataset of Jordanian university students' psychological health impacted by using e-learning tools during COVID-19. *Data Br.* **2020**, *32*, 106104. [CrossRef]
2. Chinn, R.Y.W.; Sehulster, L. *Guidelines for Environmental Infection Control in Health-Care Facilities: Recommendations of CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC)*; CDC: Atlanta, GA, USA, 2003.
3. Dzhambov, A.M.; Lercher, P.; Browning, M.H.E.M.; Stoyanov, D.; Petrova, N.; Novakov, S.; Dimitrova, D.D. Does greenery experienced indoors and outdoors provide an escape and support mental health during the COVID-19 quarantine? *Environ. Res.* **2020**, *196*, 110420. [CrossRef]
4. Balocco, C.; Leoncini, L. Energy cost for effective ventilation and air quality for healthy buildings: Plant proposals for a historic building school reopening in the covid-19 era. *Sustainability* **2020**, *12*, 8737. [CrossRef]
5. Moreno, C.; Wykes, T.; Galderisi, S.; Nordentoft, M.; Crossley, N.; Jones, N.; Cannon, M.; Correll, C.U.; Byrne, L.; Carr, S.; et al. How mental health care should change as a consequence of the COVID-19 pandemic. *Lancet Psychiatry* **2020**, *7*, 813–824. [CrossRef]
6. Kalbusch, A.; Henning, E.; Brikalski, M.P.; de Luca, F.V.; Konrath, A.C. Impact of coronavirus (COVID-19) spread-prevention actions on urban water consumption. *Resour. Conserv. Recycl.* **2020**, *163*, 105098. [CrossRef] [PubMed]
7. Hu, M.; Roberts, J.D.; Azevedo, G.P.; Milner, D. The role of built and social environmental factors in Covid-19 transmission: A look at America's capital city. *Sustain. Cities Soc.* **2021**, *65*, 102580. [CrossRef]
8. Tokazhanov, G.; Tleuken, A.; Guney, M.; Turkyilmaz, A. How is COVID-19 Experience Transforming Sustainability Requirements of Residential Buildings? A Review. *Sustainability* **2020**, *12*, 8732. [CrossRef]
9. Nicola, M.; Alsafi, Z.; Sohrabi, C.; Kerwan, A.; Al-Jabir, A.; Iosifidis, C.; Agha, M.; Agha, R. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *Int. J. Surg.* **2020**, *78*, 185–193. [CrossRef]
10. Realyvásquez-Vargas, A.; Maldonado-Macías, A.A.; Arredondo-Soto, K.C.; Baez-Lopez, Y.; Carrillo-Gutiérrez, T.; Hernández-Escobedo, G. The impact of environmental factors on academic performance of university students taking online classes during the COVID-19 pandemic in Mexico. *Sustainability* **2020**, *12*, 9194. [CrossRef]
11. Shrestha, A.; Kazama, S.; Takizawa, S. Influence of service levels and covid-19 on water supply inequalities of community-managed service providers in Nepal. *Water* **2021**, *13*, 1349. [CrossRef]
12. Amankwah-Amoah, J. Stepping up and stepping out of COVID-19: New challenges for environmental sustainability policies in the global airline industry. *J. Clean. Prod.* **2020**, *271*, 123000. [CrossRef]
13. Cheval, S.; Adamescu, C.M.; Georgiadis, T.; Herrnegger, M.; Piticar, A.; Legates, D.R. Observed and potential impacts of the covid-19 pandemic on the environment. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4140. [CrossRef]
14. Rume, T.; Islam, S.M.D.U. Environmental effects of COVID-19 pandemic and potential strategies of sustainability. *Heliyon* **2020**, *6*, e04965. [CrossRef] [PubMed]
15. Elsaid, K.; Olabi, V.; Sayed, E.T.; Wilberforce, T.; Abdelkareem, M.A. Effects of COVID-19 on the environment: An overview on air, water, wastewater, and solid waste. *J. Environ. Manage.* **2021**, *292*, 112694. [CrossRef]
16. Balacco, G.; Totaro, V.; Iacobellis, V.; Manni, A.; Spagnoletta, M.; Piccinni, A.F. Influence of COVID-19 spread on water drinking demand: The case of Puglia Region (Southern Italy). *Sustainability* **2020**, *12*, 5919. [CrossRef]
17. Monzón-Chavarrías, M.; Guillén-Lambea, S.; García-Pérez, S.; Montealegre-Gracia, A.L.; Sierra-Pérez, J. Heating energy consumption and environmental implications due to the change in daily habits in residential buildings derived from COVID-19 crisis: The case of Barcelona, Spain. *Sustainability* **2021**, *13*, 918. [CrossRef]
18. Tleuken, A.; Tokazhanov, G.; Guney, M.; Turkyilmaz, A.; Karaca, F. Readiness Assessment of Green Building Certification Systems for Residential Buildings during Pandemics. *Sustainability* **2021**, *13*, 460. [CrossRef]

19. Ikiz, E.; Maclaren, V.W.; Alfred, E.; Sivanesan, S. Impact of COVID-19 on household waste flows, diversion and reuse: The case of multi-residential buildings in Toronto, Canada. *Resour. Conserv. Recycl.* **2021**, *164*, 105111. [CrossRef]
20. Kuzemko, C.; Bradshaw, M.; Bridge, G.; Goldthau, A.; Jewell, J.; Overland, I.; Scholten, D.; Van de Graaf, T.; Westphal, K. Covid-19 and the politics of sustainable energy transitions. *Energy Res. Soc. Sci.* **2020**, *68*, 101685. [CrossRef] [PubMed]
21. Samueli, B.; Sror, N.; Jotkowitz, A.; Taragin, B. Remote pathology education during the COVID-19 era: Crisis converted to opportunity. *Ann. Diagn. Pathol.* **2020**, *49*, 151612. [CrossRef]
22. Rotas, E.; Cahapay, M. Difficulties in Remote Learning: Voices of Philippine University Students in the Wake of COVID-19 *Crisis*. *Asian J. Distance Educ.* **2020**, *15*, 147–158.
23. Becker, S.P.; Breaux, R.; Cusick, C.N.; Dvorsky, M.R.; Marsh, N.P.; Sciberras, E.; Langberg, J.M. Remote Learning During COVID-19: Examining School Practices, Service Continuation, and Difficulties for Adolescents with and without Attention-Deficit/Hyperactivity Disorder. *J. Adolesc. Heal.* **2020**, *67*, 769–777. [CrossRef] [PubMed]
24. Mohmmed, A.O.; Khidhir, B.A.; Nazeer, A.; Vijayan, V.J. Emergency remote teaching during Coronavirus pandemic: The current trend and future directive at Middle East College Oman. *Innov. Infrastruct. Solut.* **2020**, *5*, 1–11. [CrossRef]
25. Severo, E.A.; De Guimarães, J.C.F.; Dellarmelin, M.L. Impact of the COVID-19 pandemic on environmental awareness, sustainable consumption and social responsibility: Evidence from generations in Brazil and Portugal. *J. Clean. Prod.* **2021**, *286*, 124947. [CrossRef]
26. Markova, A. Kak God Pandemii Povliyal na Kazakhstan. Kursiv 2021. Available online: https://kursiv.kz/news/obschestvo/2021-03/kak-god-pandemii-povliyal-na-kazakhstan (accessed on 3 August 2021).
27. Agaidarov, A.; Izvorski, I.V.; Rahardja, S. *Kazakhstan Economic Update: Navigating the Crisis*; World Bank Group: Washington, DC, USA, 2020.
28. Crape, B.L.; Rakshit, A.; Yakhiyayeva, T. Depression Associated with Pandemic Economic Duress, Knowing Someone with COVID-19, But Not with COVID-19 Deaths in Kazakhstan: A Two-City Randomized Baseline Survey for a Longitudinal Panel Study. *SSRN Electron. J.* **2021**. Preprint. [CrossRef]
29. Marteau, J.-F. Post-COVID Education in Kazakhstan: Heavy Losses and Deepening Inequality. 2020. Available online: https://blogs.worldbank.org/europeandcentralasia/post-covid-education-kazakhstan-heavy-losses-and-deepening-inequality (accessed on 8 August 2021).
30. Bokayev, B.; Torebekova, Z.; Abdykalikova, M.; Davletbayeva, Z. Exposing policy gaps: The experience of Kazakhstan in implementing distance learning during the COVID-19 pandemic. Transform. *Gov. People Process Policy* **2021**, *15*, 275–290. [CrossRef]
31. Shaikholla, S.; Dikhanbayeva, D.; Suleiman, Z.; Shehab, E.; Turkyilmaz, A. Impact of COVID-19 on Industry 4.0 Implementation: Kazakhstan Industry Case. In Proceedings of the 2021 IEEE International Conference on Smart Information Systems and Technologies (SIST), Nur-Sultan, Kazakhstan, 28–30 April 2021; pp. 1–6.
32. Van der Voorn, T.; van den Berg, C.; Bhattacharya, P.; Quist, J. Never Waste a Crisis: Drawing First Lessons from the COVID-19 Pandemic to Tackle the Water Crisis. *ACS ES&T Water* **2021**, *1*, 8–10. [CrossRef]
33. Antwi, S.H.; Getty, D.; Linnane, S.; Rolston, A. COVID-19 water sector responses in Europe: A scoping review of preliminary governmental interventions. *Sci. Total Environ.* **2021**, *762*, 143068. [CrossRef]
34. Abu-Bakar, H.; Williams, L.; Hallett, S.H. Quantifying the impact of the COVID-19 lockdown on household water consumption patterns in England. *Clean Water* **2021**, *4*, 1–9. [CrossRef]
35. Li, D.; Engel, R.A.; Ma, X.; Porse, E.; Kaplan, J.D.; Margulis, S.A.; Lettenmaier, D.P. Stay-at-home orders during the COVID-19 pandemic reduced urban water use. *Environ. Sci. Technol. Lett.* **2021**, *8*, 431–436. [CrossRef]
36. Feizizadeh, B.; Omarzadeh, D.; Ronagh, Z.; Sharifi, A.; Blaschke, T.; Lakes, T. A scenario-based approach for urban water management in the context of the COVID-19 pandemic and a case study for the Tabriz metropolitan area, Iran. *Sci. Total Environ.* **2021**, *790*, 148272. [CrossRef]
37. Sivakumar, B. COVID-19 and water. *Stoch. Environ. Res. Risk Assess.* **2021**, *35*, 531–534. [CrossRef]
38. Amuakwa-Mensah, F.; Klege, R.A.; Adom, P.K.; Köhlin, G. COVID-19 and handwashing: Implications for water use in Sub-Saharan Africa. *Water Resour. Econ.* **2021**, *36*, 100189. [CrossRef] [PubMed]
39. Sayeed, A.; Rahman, M.H.; Bundschuh, J.; Herath, I.; Ahmed, F.; Bhattacharya, P.; Tariq, M.R.; Rahman, F.; Joy, M.T.I.; Abid, M.T.; et al. Handwashing with soap: A concern for overuse of water amidst the COVID-19 pandemic in Bangladesh. *Groundw. Sustain. Dev.* **2021**, *13*, 100561. [CrossRef] [PubMed]
40. Roidt, M.; Chini, C.M.; Stillwell, A.S.; Cominola, A. Unlocking the Impacts of COVID-19 Lockdowns: Changes in Thermal Electricity Generation Water Footprint and Virtual Water Trade in Europe. *Environ. Sci. Technol. Lett.* **2020**, *7*, 683–689. [CrossRef]
41. Renukappa, S.; Kamunda, A.; Suresh, S. Impact of COVID-19 on water sector projects and practices. *Util. Policy* **2021**, *70*, 101194. [CrossRef]
42. Krarti, M.; Aldubyan, M. Review analysis of COVID-19 impact on electricity demand for residential buildings. *Renew. Sustain. Energy Rev.* **2021**, *143*, 110888. [CrossRef]
43. Wang, Q.; Li, S.; Jiang, F. Uncovering the impact of the COVID-19 pandemic on energy consumption: New insight from difference between pandemic-free scenario and actual electricity consumption in China. *J. Clean. Prod.* **2021**, *313*, 127897. [CrossRef]
44. Rouleau, J.; Gosselin, L. Impacts of the COVID-19 lockdown on energy consumption in a Canadian social housing building. *Appl. Energy* **2021**, *287*, 116565. [CrossRef]

45. Kang, H.; An, J.; Kim, H.; Ji, C.; Hong, T.; Lee, S. Changes in energy consumption according to building use type under COVID-19 pandemic in South Korea. Renew. *Sustain. Energy Rev.* **2021**, *148*, 111294. [CrossRef]
46. Qarnain, S.S.; Sattanathan, M.; Sankaranarayanan, B.; Ali, S.M. Analyzing energy consumption factors during coronavirus (COVID-19) pandemic outbreak: A case study of residential society. Energy Sources, Part A Recover. *Util. Environ. Eff.* **2020**, 1–20. [CrossRef]
47. Mokhtari, R.; Jahangir, M.H. The effect of occupant distribution on energy consumption and COVID-19 infection in buildings: A case study of university building. *Build. Environ.* **2021**, *190*, 107561. [CrossRef]
48. Zheng, W.; Hu, J.; Wang, Z.; Li, J.; Fu, Z.; Li, H.; Jurasz, J.; Chou, S.K.; Yan, J. COVID-19 Impact on Operation and Energy Consumption of Heating, Ventilation and Air-Conditioning (HVAC) Systems. *Adv. Appl. Energy* **2021**, *3*, 100040. [CrossRef]
49. Qarnain, S.S.; Muthuvel, S.; Bathrinath, S. Review on government action plans to reduce energy consumption in buildings amid COVID-19 pandemic outbreak. *Mater. Today Proc.* **2021**, *45*, 1264–1268. [CrossRef]
50. Madurai Elavarasan, R.; Shafiullah, G.M.; Raju, K.; Mudgal, V.; Arif, M.T.; Jamal, T.; Subramanian, S.; Sriraja Balaguru, V.S.; Reddy, K.S.; Subramaniam, U. COVID-19: Impact analysis and recommendations for power sector operation. *Appl. Energy* **2020**, *279*, 115739. [CrossRef] [PubMed]
51. Carvalho, M.; Bandeira de Mello Delgado, D.; de Lima, K.M.; de Camargo Cancela, M.; dos Siqueira, C.A.; de Souza, D.L.B. Effects of the COVID-19 pandemic on the Brazilian electricity consumption patterns. *Int. J. Energy Res.* **2021**, *45*, 3358–3364. [CrossRef]
52. Sabekov, S. Kak Pandemiya Povliyala na Energeticheskuu Otrasl v Kazakhstane i Mire—Mnenie Experta. Kazinform 2020. Available online: https://www.inform.kz/ru/kak-pandemiya-povliyala-na-energeticheskuyu-otrasl-v-kazahstane-i-mire-mnenie-eksperta_a3656209 (accessed on 3 August 2021).
53. UNDP. *Fourth Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change*; UNDP: New York, NY, USA, 2019.
54. Gadimova, N. Kazakhstan May Run Out of Drinking Water By 2038. Available online: https://caspiannews.com/news-detail/kazakhstan-may-run-out-of-drinking-water-by-2038-2018-8-27-22/ (accessed on 28 July 2021).
55. Info Shymkent. Available online: https://www.shymkent.info/ (accessed on 30 July 2021).
56. LLP Water Resources-Marketing. Vizitnaya Kartochka. Available online: https://www.wrm.kz/rus/visit-card.html (accessed on 16 July 2021).
57. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan Almaty. Available online: https://stat.gov.kz/region/268020 (accessed on 23 August 2021).
58. Almaty—A city profile. Available online: https://www.eyeonasia.gov.sg/other-asian-countries/central-asia/almaty-a-city-profile/ (accessed on 15 September 2021).
59. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan Almaty region. Available online: https://stat.gov.kz/region/250502 (accessed on 23 August 2021).
60. Vidyanova, A. Kak Gazifikaciya TEC-1 Povliyala na Ekologiu Almaty? Available online: https://kapital.kz/economic/91440/kak-gazifikatsiya-t-ets-1-povliyala-na-ekologiyu-almaty.html (accessed on 5 August 2021).
61. Domnin, S. Pyat' Krupneishih Electrostancii Kazakhstana v 2020 Godu Uvelichili Vyrabotku na 2.5%. Available online: https://kursiv.kz/news/otraslevye-temy/2021-03/pyat-krupneyshikh-elektrostanciy-kazakhstana-v-2020-godu-uvelichili (accessed on 10 August 2021).
62. Statistical Committee of National Economy Ministry of the Republic of Kazakhstan. The Population of the Republic of Kazakhstan in the Context of Regions and the Capital, Cities, Districts, District Centers and Villages. 2021. Available online: https://stat.gov.kz/api/getFile/?docId=ESTAT354434 (accessed on 17 August 2021).
63. Tasbulatova, S. Na TEC Vvedena v Stroi Novaya Gazoturbinaya Stanciya. Available online: https://azh.kz/ru/news/view/33262 (accessed on 4 September 2021).
64. Mostovoy, Z. Atyrauskaya TEC Priznala Vinu v Massovoi Gibeli Ryby. Available online: https://365info.kz/2019/06/atyrauskaya-tets-priznala-vinu-v-massovoj-gibeli-ryby (accessed on 1 September 2021).
65. Вопросы-ответы. Водные Ресурсы Маркетинг(ВРМ). Available online: https://www.wrm.kz/rus/faq/23-5.html (accessed on 4 October 2021).
66. UNICEF. Everything You Need to Know about Washing Your Hands to Protect against Coronavirus (COVID-19) | UNICEF Kazakhstan. Available online: https://www.unicef.org/kazakhstan/en/stories/everything-you-need-know-about-washing-your-hands-protect-against-coronavirus-covid-19 (accessed on 16 September 2020).
67. Vodu Budut Podavat po Grafiku v Uralske. Available online: https://24.kz/ru/news/social/item/405350-vodu-budut-podavat-po-grafiku-v-uralske (accessed on 28 July 2021).
68. Cheshmehzangi, A. COVID-19 and household energy implications: What are the main impacts on energy use? *Heliyon* **2020**, *6*, e05202. [CrossRef]
69. Edomah, N.; Ndulue, G. Energy transition in a lockdown: An analysis of the impact of COVID-19 on changes in electricity demand in Lagos Nigeria. *Glob. Transit.* **2020**, *2*, 127–137. [CrossRef]
70. Bielecki, S.; Dukat, P.; Skoczkowski, T.; Sobczak, L.; Buchoski, J.; Maciag, Ł. Impact of the lockdown during the covid-19 pandemic on electricity use by residential users. *Energies* **2021**, *14*, 980. [CrossRef]