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Impact of COVID-19 crisis on Energy Consumption and socio-spatial behavior of the residential sector in extreme climates. Case study Southwest of Algeria

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Abstract. The outbreak of the COVID-19 pandemic has not only affected the health sector, but has affected all aspects of people's lives, all economic, social and environmental sectors, including global energy. This article aims to study the impact of COVID 19 on the energy consumption of electricity, gas and water in the residential sector, where confinement has presented one of the associated measures taken by many countries to slow down the spread of this disease. The objective of this article is to examine both the immediate and long-term impact of Covid-19 on energy consumption and on the socio-spatial behavior of occupants. The results show that there were variations in the domestic spatial spaces and a change in the social practices of each family. There is a sharp drop in the electricity consumption of single-family homes during the pandemic year. Other households have experienced an increase in electricity consumption during the summer months, mainly due to the periods of confinement such as travel restrictions imposed on the one hand and the harshness of the climate on the other. This study is essential for policymakers to detect changing patterns of electricity consumption in the context of emergencies such as the pandemic.

Keywords. COVID 19 crisis, Spatial-social approach, consumption behavior, arid area, residential sector, electricity, lockdown

1. Introduction

The outbreak of the COVID-19 pandemic has not only affected the health sector, but has affected all aspects of life, economic, social and environmental, including global energy. This article aims to study the impact of COVID 19 on the energy consumption of electricity, gas and water in the residential sector, where confinement has presented one of the associated measures taken by many countries to slow down the spread of this disease. First, we studied the distribution of the annual electricity consumption of the city of Bechar for all sectors of the city,
during the pandemic year compared to the pre-pandemic years. Then we will carry out a comparative study on the influence of the pandemic on different accommodations (villa and apartment), in the city of Bechar.

The harsh climate and the confinement situation have caused a new spatial-temporal appearance of the house and increased electricity consumption in summer. Using data from the Algerian electricity and gas Distribution Company and spatial statistical modeling before and during the pandemic, we will compare this data before and during the pandemic. The results show variations in electricity consumption between the different housing cases studied.

The objective of this article is to examine both the immediate and long-term impact of Covid-19 on the energy consumption and the socio-spatial behavior of the occupants.

The main changes in electricity consumption during the pandemic year occur because of the confinement situation. Spatially, changes noticed in plan, some of the spaces are modified by the pandemic, where the pattern of a spatial and temporal evolution is totally changed.

To achieve, due to the significant disruptions caused by the COVID-19 pandemic, we understand that many changes in the behavior of individuals will bring adjustments to their professional and personal lives. Therefore, they may find it difficult to understand these impacts associated with a fast and exclusive process.

2. Three Contexts impact of COVID 19 crisis
2.1. First context: Changing social practices
Confinement and social distancing to fight against the covid-19 virus have generated significant disruptions in the behavior of occupants. The first is the change of the social context includes workplace, community, Neighbors and Friends. by life events such as marriage, people's daily life, going to school, going to the market, walking, etc. all these social practices change because of the confinement situation, having a move from one city to another.

Confinement and social distancing to fight the covid-19 virus have generated significant disruptions in the behavior of occupants. The first is the change in social context through life events such as marriage, having children and moving from one city to another. Social context includes workplace, community, neighbors and friends.

All consumption is related to time and place. With the flexibility of time but the rigidity of place, consumers have learned to improvise creatively and innovatively. Work-life boundaries are now blurred as people work from home, study from home, and relax at home. Since the consumer cannot come to the store, the store must come to the consumer.

As consumers adapt to house arrest for an extended period, they are likely to adopt new technologies that make work, study, and consumption more convenient. Digital adoption is likely to change existing habits. Finally, public policies will also impose new consumption habits, especially in public places such as airports, concerts and public parks.

The objective of this research paper is to examine the impact of the Covid-19 pandemic on the social and spatial behavior of occupants.

1- Have the occupants permanently changed their social and spatial habits in their accommodation due to confinement?

2- Would there be new habits that the occupants will acquire due to the new health protocol linked to the pandemic situation, such as traveling by plane, shopping in malls and attending concerts and sporting events?

The COVID-19 pandemic significantly affected healthy behaviors. Hence, health policies should promote more strategies to mitigate the long-term health effects of the pandemic on Chilean parents.[2]
2.2. Second context: Socio-spatial and temporal change of spaces

The behaviors of the inhabitants learn to improvise and acquire new habits through new spaces. For example, the inhabitants cannot go to the public garden, or cafeteria, so the cafeteria comes to the house, through a new “coffee corner” space arranged in the kitchen or the courtyard.

While the inhabitants have just offered new spaces by the same old habits. Despite new regulations and procedures, demands to stay at home, occupants will be modified by the way residents change their indoor spaces according to their outdoor needs.

New habits will also emerge thanks to advances in technology, changing demographics and the innovative ways consumers have learned to cope with the blurring boundaries between work, play and education. Occupants per week/ covid19 week [1].

All of the strategies aims to reduce the spread of coronavirus disease 2019 (COVID-19) resulted in different behavioral changes in all populations. One developed by Hernández-Jaña et al., 2022, aimed to determine changes in active travel, physical activity and sedentary time during the COVID-19 pandemic among Chilean parents. Most participants stayed home during the pandemic, while active and passive travel decreased significantly among fathers and mothers. The COVID-19 pandemic has significantly affected healthy behaviors. Therefore, health policies should promote more strategies to mitigate the long-term effects of the pandemic on the health of Chilean parents.[2]

Regarding physical activity, with walking being linked to many positive physical and mental health benefits. This pre-post study was conducted by a survey to collect self-reported milestones, productivity (HWQ), perceived stress (Cohen Perceived Stress Scale) and work engagement (UWES). Process data suggests low study participation and low compliance between survey time points [3]

Nevertheless, the extent of the containment put in place during the COVID-19 pandemic has gone through published studies, linked to psychological problems in order to examine the implications of known consequences such as boredom, social isolation, stress or sleep deprivation. More of the effects of confinement are described, but the emergence mechanisms of these disorders and their interrelationships remain to be studied. Diagnostic and therapeutic approaches are offered such as telemedicine, which is experiencing rapid development during the COVID-19 crisis.[4]

Social support studied according to multidimensional according to five distinct functions: emotional support, social integration, personal development support, tangible help (instrumental and material) and informative support. It is possible to classify the instruments that operationalize it into three types of measurement: the perception of the support received (received), the perception of its availability (availability) and finally the satisfaction of the support (adequacy). Most epidemiological studies show that measures of availability of support are those that best predict the positive effects of social support on health.

Wills and Shinar (2000) recommend their use, when a choice of measures is constrained by administration time, because support satisfaction measures have not always been consistent.[5]

The EMSA is the only national-level measure of mental health available from health surveys currently conducted by Statistics Canada. By helping to understand what EMSA represents, this study facilitates the use of this measure in routine surveys and as an indicator of health.[6]
2.3. Third context: Environment impact and emission CO₂

The Covid-19 outbreak has positive impacts, too, on the environment. Studies initiated during the outbreak in the home community increased Home Office applications. This will minimize emissions of carbon dioxide by limiting people’s mobility in their outer environment [7], [8]

The study of Amirreza Naderipour and al., 2022, aims to show the potential positive effects of COVID-19 on the environment and the increase of renewable energy generation in Malaysia. To prevent the spread of this disease, Malaysia enacted the Movement Control Order (MCO) law in March 2020. The reduction of GHG emission and pollutant gases allowed more sunlight to reach photovoltaic panels, hence increasing the renewable energy generation.[9]

2.3. Four context: Impact of COVID-19 on Energy consumption in Algeria

The literature survey shows that, so far, very few studies have been focused on the effects of the Covid-19 outbreak on the energy sector and the environment. Therefore, this study aims to filling in this sector. The main focus of this work is to make comparison among the performed designs and investigate how the spread of COVID-19 could reduce energy consumption and emissions CO₂, notably in terms of the amount of clean energy generated by the residential sector.

Final annual electricity consumption in Algeria has seen an average increase over the years under review and was recorded at around 5.18 million tonnes of oil equivalent in 2019. This amount represents an increase of more than two million tonnes of oil equivalent in consumption since 2014 when it was estimated at around four million tonnes of oil equivalent. Table 1.

Table 1. Coronavirus Cases Deaths Recovered
258 478 6,654 172 081

The originality of this paper lies in the study of the impact of COVID-19 on energy consumption especially residential building, with Behavioral patterns and behaviors changes of occupants. It is necessary to be assess and potential demand to address the key question of this research paper. In This topic, it is interesting since it discusses a recent and evolving global problem arising due to the COVID-19 pandemic.

Figure 1. Total des cas de coronavirus en Algérie [10]
Figure 2. Active Cases in Algeria [10]

Figure 3. Total Coronavirus Deaths in Algeria
As of February 6, 2022, Seychelles was the African country with the highest coronavirus (COVID-19) vaccination rate. There, in North Africa, the most affected country on the continent, the vaccination rate reached around 50 per 100 population. Algeria had a vaccination rate of approximately 29 doses per 100 people, registering the last number of inoculations, in Africa.


The degree of the COVID-19 global crisis is exceptional; thus, the consequent impacts are unparalleled. Energy demand has risen in Algeria over the last few decades to sustain the economic growth of the nation. This demand is expected to increase in the coming years, where GHG emissions will increase as long as fossil fuels remain as the main source for generating energy. Malaysia depends on fossil fuels, mainly natural gas, coal, and petroleum, to generate energy.
In 2020, the consumption of primary energy in Algeria stood at 2.3 exajoules, which was a decrease in COVID 19 crisis, compared to the previous year.[13]

4. Case study
4.1. Climate data of arid region
In this research, current data of Bechar city is according to the Algerian National Center of Studies and Researches Integrees of the Building and the thermal regulation (DTR C3- 2), for residential buildings [15], [16].

Algeria has six distinguished climatic zones:
- Zone (A): in the north of Algeria, including the coastal zone;
- Zone (B): in the south of zone (A), including the plain behind the seashore;
- Zone (C): in the south of zone (B), including the highlands;
- Zone (D): in the south of Algeria, including the desert; and the climate zones (B’) and (D’), representing subzones within the main zones (B) and (D), respectively. [17]
Figure 5. Location map of Bechar city (SW Algeria) and sampling network. [17]

A total energy consumption of four case of existing houses in 2020 and 2021

**Table 1.** A total energy consumption Electricity and GAZ of Two cases studies of existing houses in 2020 and 2021

<table>
<thead>
<tr>
<th>Case study A: house familial</th>
<th>Case study B: Single family</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case A</td>
</tr>
<tr>
<td></td>
<td>T4 2020 T12021 T2 2021 T3 2021 T4 2021</td>
</tr>
<tr>
<td>Electric consumption (KWh)</td>
<td>1963 740 1022 4278.00 1989.00</td>
</tr>
<tr>
<td>GAZ (Th)</td>
<td>0 12257 132.28 554.60 3769.40</td>
</tr>
<tr>
<td>Facture (DA)</td>
<td>7852 2960 4088 12559.64 7032.15</td>
</tr>
</tbody>
</table>

Cost consumption DA/day 132.28DA/day
5. Changes practices and spaces by socio-spatial approach

Table 1 lists the spaces and practices mentioned changed in COVID 19 crisis for two existing house familial, and single, located in Bechar city.

Occupancy information in buildings has a great impact on energy consumption as well as indoor environment quality. Many studies showed that approximately 10%−40% of the energy consumption in buildings can be saved with occupancy information [13].

Table 1. Practices changes in COVID 19 crisis period and spaces

<table>
<thead>
<tr>
<th>Practices</th>
<th>Example and use</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>Changes in exterior kitchen summer’s</td>
<td>Change</td>
</tr>
<tr>
<td>Living room</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Rooms</td>
<td>Terrace spaces</td>
<td>Change</td>
</tr>
<tr>
<td>Bedroom</td>
<td>Same place</td>
<td>No change</td>
</tr>
<tr>
<td>Courtyard</td>
<td>After evening</td>
<td>No change [11]</td>
</tr>
</tbody>
</table>

6. Results and discussion

As mentioned earlier, all consumption and all user behaviors are rooted in time and place. Since the COVID 19 pandemic, the volume of working hours for workers has been reduced and working women, who have children under 4, stay at home, which leads to an increase in free time.

It is estimated that today more than 75% of all women with children at home work full time. This has resulted in lack of time and jet lag in family and personal consumption.

From Monday to Friday, the whole family is at home, all day, except the man stays outside between 8 a.m. and 1 p.m. for work to ensure all the necessary needs.

With lockdown and social distancing, this has resulted in location constraint and location scarcity. We have mobility change and mobility scarcity. Work, school and shopping have all moved and localized to home. At the same time, there is more time flexibility because consumers do not have to follow scheduled times to go to work or school or to shop or consume.

Lack of space at home creates new dilemmas and conflicts about who does what and where in the space at home. As homo sapiens we are generally more territorial and everyone needs their space, we all struggle with our intimacy and consumer convenience.

In view of this situation, the occupants learn to improvise existing habits are abandoned, new ways of consuming are invented or modified to adapt to this new situation.

➢ Confinement, reduction of social contacts and potential psychotic symptoms

The literature on the links between mental health and the situation of confinement linked to the COVID-19 epidemic ignores the question of psychotic disorders or symptoms. At
present, no data has been collected or reported in the literature on this subject, whereas a large number of studies report the psychological effects, in terms of psychotic symptoms, of social isolation, and this in very varied from loneliness, extreme conditions of prison detention, polar or submarine expeditions, space travel, certain military situations, or even the isolation of patients in intensive care units.

The impact of containment on occupant behavior may be further increased in large case A families, especially the elderly. Women could be another subgroup at home. They are generally more likely to find practices all morning, especially during pregnancy and also if they have young children. The current period of confinement can be all the more stressful for parents or caregivers who must ensure both the stewardship of the house, their own work and the support of school work and activities. Free time for their children must be controlled at home. In adolescents, sleep disorders are correlated with emotional and behavioral disorders.

It is therefore particularly important to monitor the need and the practice in a situation of confinement. In arid and dry climate, expert advice with concrete recommendations to maintain the rhythms and adopt good behaviors related to habits.

The coronavirus has given some freedom of creativity and resilience of users for its tradition-related activities such as weddings and funeral services.

- **The marriages**
  Weddings are cancelled in party halls, so people are returning to the tradition on the terraces of individual houses or in sidewalk tents.

- **Funeral services**
  Because of COVID-19, people have always stopped pitching tents outside the house to give a sign of death. These traditional events centred on religious services, especially on Fridays at the mosque

- **Prayer at the mosque**
  The mosques are partially or totally closed, so the men made their prayers at home even the Friday prayer, aid Adha and Aid Elfitr and Tarawih of Ramadan

- **Immediate impact of Covid-19 on consumer behavior**
  Consumers stockpile essential goods for daily consumption, leading to temporary stock-outs and shortages. This includes table oil, flour, milk, bread. This common reaction is a common practice manages an uncertainty of the future supply of commodities for basic needs. There remains a mentality to meet a temporary additional or mandatory demand.

7. **Conclusion**

The impact of covid 19 on energy consumption due to the socio-spatial changes of the inhabitants and their behavior remains a very multidisciplinary field and a major phenomenon for academic research. It is considered a new field of research and the Covid-19 crisis has surfaced from it as a tremendous research opportunity. For example, are there different changes in societal behaviors, depending on the cultural, social and energy context

This research is a first step to understand the situation of a global and serious crisis and affects different sectors, such as the behavior of individuals and its impact on the energy stage. It is necessary to develop the different techniques used by occupants around the world to isolate themselves from infection.

8. While confinement and social distancing have disrupted the entire behavior of the inhabitants, it has generated several new research opportunities grounded in the real world. These areas of empirical research with some theoretical proposals on socio-spatial approaches, and a positive or negative impact on the energy level. Personal life, is different from one to another, according to the way of life to enrich the discipline of the behavior of the inhabitants.
Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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