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Sánchez-Gamboa, Franklin Israel; Moreno, Jordan; Caiza, Danny
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Prevalent age group in household electricity consumption in times of COVID-19 in San Agustín

Franklin Israel Sánchez-Gamboa, Jordan Moreno & Danny Caiza

*Higher Electromechanical Technology Research Department, Instituto Superior Tecnológico Cotopaxi, Cotopaxi, Ecuador.
fisanchezg@istx.edu.ec, jmmorenoi@istx.edu.ec, dacaizas@istx.edu.ec*

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Abstract

This research aims to analyze the relationship between monthly energy consumption and age of users of Barrio San Agustín in Machachi Canton in the province of Pichincha in the EEQ by its Spanish acronym, Empresa Eléctrica de Quito, before and after the curfew measures issued by the national COE (by its Spanish acronym) in response to the global COVID-19 pandemic. It is carried out taking into account a stratum distributed by the level of energy consumption, conducting age surveys of users in the area, determining its variation in relation to the years 2018, 2019 2020 and 2021, applying the curvilinear regression method to estimate the average monthly demand in relation to the average age of users, and as a result thereof, the group that reaches the peaks of power consumption in the period from March to November 2020, corresponds to an average age ranging from 27 to 33 years old and the average age groups that present the lowest average consumption are those ranging from 20 to 25 and from 40 to 45 years old.

Keywords: age; curfew; COVID-19; electric power; energy resources.

Grupo etario prevalente en consumo energético eléctrico domiciliario en tiempos de COVID-19 en San Agustín

Resumen

Esta investigación tiene como objetivo analizar la relación entre el consumo energético mensual y la edad de los usuarios pertenecientes al Barrio San Agustín en el Cantón Machachi provincia de Pichincha en la EEQ (Empresa Eléctrica Quito) antes y después de las medidas de toque de queda dictadas por el COE nacional en respuesta a la pandemia mundial por COVID-19. Se lleva a cabo tomando en cuenta un estrato distribuido por el nivel de consumo energético, levantando encuestas de edad de usuarios de la zona determinando su variación en relación al año 2018, 2019 2020 y 2021 aplicando el método de regresión curvilineal para estimar la demanda promedio mensual en relación a la edad promedio de los usuarios, resultando que el grupo que alcanza los picos de consumo de energía eléctrica en este periodo de marzo a noviembre del año 2020 pertenecen a una edad promedio de 27 a 33 años y el grupo de edades promedio que presenta el menor consumo promedio es de 20 a 25 años y de 40 a 45 años.

Palabras clave: edad; toque de queda; COVID-19; electric power; energy resources.

1. Introduction

According to [1] age was found to be closely linked to thermal comfort related behavior, and hence influences heating energy consumption. Existing research indicates a positive relationship between occupant age and heating energy consumption in most studies. Generally, older households tend to consume more energy for space heating than younger households, as older occupants prefer a warmer indoor environment and use heating for longer hours

Findings of a study [2] carried out in Mexico that found that young people use more technologically efficient devices and are more energy efficient also corroborate the results of this study.

According to 2035 National Energy Efficiency Plan, the accumulated energy consumption of the residential, commercial and public sectors is projected to be reduced by at least 88.8 MMboe, due to energy efficiency measures implemented with the main objective that proposes to establish mechanisms for monitoring and control for the implementation and enforcement of the NEC (by its Spanish acronym) (Energy Efficiency, Air Conditioning and Renewable Energy Chapters) at the level of the GADs (by its Spanish acronym, Decentralized Autonomous Government).

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According to the actual conditions it is necessary to know the relation between age of users subscribed to the EEQ and the electric energy consumption by household in the context of the curfew measures dictated by the national COE (Emergency Operation Center).

Therefore, it is proposed to analyze if the energy consumption of the Barrio San Agustín EEQ's subscribers is related to the age in the context of curfew measures in the Pichincha Province during COVID-19 times.

The analysis is based on the energy consumption data of the residential users of the Barrio San Agustín EEQ, the data was extracted from the "Empresa Eléctrica Quito" (Quito Electric Company) databases, after applying a curvilinear regression an estimated consumption by the average age users of the residential subscriptions to Barrio San Agustín was obtained, for before and after the WHO declared the COVID-19 as a global pandemic and the national COE dictated the curfew measures and the lockdown comparing the years 2018 2019 2021 with the 2020.

Finally, it is considered that the estimate of the age group that has the highest monthly power consumption will allow to address awareness campaigns on saving and conscious power consumption with better results, and this will serve as a tool to EEQ and MERNNR (by its Spanish acronym) (Ministry of Energy and Non-Renewable Natural Resources) to plan actions and meet energy efficiency goals.

2. Literature revision

2.1. Electric power demand in Ecuador

According to the National Energy Balance 2019, power consumption per person between 2009 and 2019 showed an increase of 39.4%, from 1,088 kWh per inhabitant to 1,517 kWh per inhabitant. In this document prepared by the Ministry of Energy and Non-Renewable Natural Resources (MERNNR) and the Institute of Geological and Energetic Research (IGE, by its Spanish acronym), it can be seen that power consumption per inhabitant increased by 2% between 2018 and 2019, from 1,488 kWh per inhabitant to 1,517 kWh per inhabitant. [4]

2.2. E.E.Q. concession area

According to its foundation documents, E.E.Q. has as a fundamental objective to provide electric services to the designated concession area the Pichincha Province as you can see in Fig. 1. Following the Legal Regime Law for the Electric Sector. [5]

The concession area of the "Empresa Eléctrica Quito" covers the cantons: Quito, Pedro Moncayo, Cayambe, Rumiñahui, San Miguel De los Bancos, Pedro Vicente Maldonado, Puerto Quito, the concession area is shown in Fig 1. [5]

2.3. Age of Barrio San Agustín subscribers

As a result of the survey conducted for each family that has an electricity meter in the San Agustín neighborhood, Table 1 shows the percentage of subscribers according to the proposed age range.



Figure 1 Empresa Eléctrica Quito concession area
Source: S. Franklin, 2016

Table 1
Population percentage by age range for the Barrio San Agustín

Age range	Population percentage (%)
5-10	16
11-15	14
16-20	10
21-30	7
31-40	11
41-50	19
51-60	7
61-90	17

Source: The author

2.4. Responsive measures dictated by the National COE due to COVID-19 health emergency

On 03-11-2020 the WHO declared the COVID-19 as a pandemic, following this, through the Ministerial Mandate Letter No 00126-2020 issued in the same date by the Health Minister, a Public Health Emergency is declared nationwide.

The national government designed a strategy to prevent a community spread in the country which represents the main risk. These measures have as their purpose to incentivize the consciousness and responsibility in the citizens, in order to prevent a wider and faster spread of the virus and contain its impact. [6]

Between all the mobility restrictive measures that the National COE dictated involving the Pichincha province, for this study there are ten main months from March The cancelation of academic activities, remote jobs no presencial academic activities and remote labor are emphasizes until the month of November.

3. Electric energy consumption on the Cotopaxi province during COVID-19 times

The Pichincha province is one of the 24 provinces that make up the Republic of Ecuador, located in the central north of the country, in the geographical area known as the inter-Andean region or mountain range, mainly on the

Guayllabamba basin in the east and sub-Andean ramifications in the northwest. Its administrative capital is the city of Quito. The Pichincha territory is inhabited by 3,228,233 people, according to INEC's (by its Spanish acronym) demographic projection for 2020, making it the second most populated province in the country after Guayas. The Pichincha province is made up of 8 cantons, with their respective urban and rural parishes. [7]

The Mejia canton is located at the south of the Pichincha province. Its municipal capital is the city of Machachi, place inhabited by 36,740 people. San Agustin La Libertad is a neighborhood located in the province of Pichincha, north of the city of Machachi [7].

As can be seen in Fig. 2, there is a high power consumption demanded by the concession area of the E.E.Q.

The behavior of consumption of electrical energy before and after the pandemic of Barrio San Agustin subscribers is described next.

3.1. Electric Energy Consumption for Barrio San Agustin subscribers before COVID-19

Fig. 3 shows the electric energy consumption tendency for the Barrio San Agustin users in Pichincha from the month of March to November for the years 2018 and 2019. After analyzing this data and average monthly consumption was calculated for every user, 96.13 KWh for 2018 and 103.32 KWh for 2019.

In Table 2, consumption is assigned to a consumption stratum of 50 to 120 KWh per month to delimit subscribers with similar consumption behavior.

3.2. Electric Energy Consumption for Barrio San Agustin subscribers after COVID-19

Fig. 4 details the consumption tendency from the month of March to November for the years 2020 and 2021 for the Barrio San Agustin users. After analyzing this data, the average consumption per user is 112.14 KWh for 2020 and 100.57 for 2021.

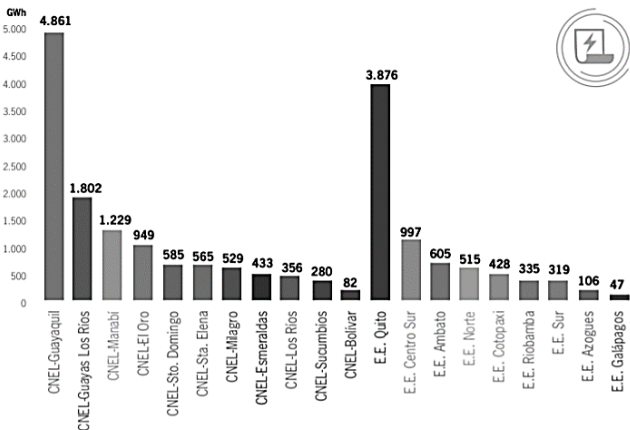


Figure 2 Energy consumption by Electric Company of Ecuador. Source: A. de regulación y control de Electricidad, 2018.

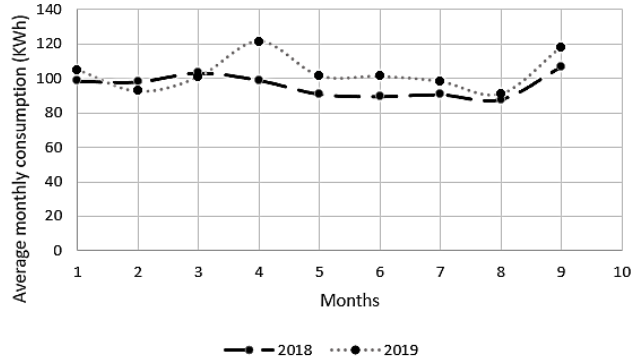


Figure 3. Electricity consumption trend 2018-2019 Barrio San Agustin subscribers. Source: The author.

Table 2. Average monthly consumption KWh of Barrio San Agustin subscribers by strata.

Strata	Average monthly consumption KWh 2018	Average monthly consumption KWh 2019
D	96,130	103,325

Source: The author

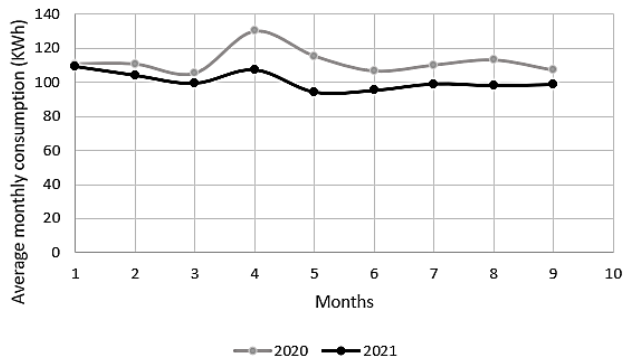


Figure 4. Electricity consumption trend in COVID-19 of Barrio San Agustin subscribers. Source: The author.

In Table 3, consumption is assigned to a consumption stratum of 50 to 100 KWh per month to delimit subscribers with similar consumption behavior.

Table 3. Average monthly energy consumption KWh in COVID-19 from Barrio San Agustin subscribers by strata.

Strata	Average monthly consumption KWh 2020	Average monthly consumption KWh 2021
D	112,145	100,576

Source: The author

4. Methodology

In order to analyze the variation of power consumption of the users of San Agustin neighborhood, the data collected from the EEQ database is tabulated.

Subsequently, on-site surveys of the ages of the subscribers of each electricity meter are carried out.

Thereafter, a study stratum is considered to group common subscribers according to the amount of power consumed and to discard inactive subscribers with a limit of 50 to 120 KWh. To apply this consumption limit, the year of study 2020 is taken as a reference, the average age is calculated for each electricity meter, then an independent (average age of subscribers for each electricity meter) and dependent (monthly KWh consumption of subscribers of stratum D of the San Agustín neighborhood) correlation model is used between the variables studied. The correlation model used in this study, according to the conditions of the relationship between the variables, is curvilinear regression, taking Spearman's value as a significance reference.

A period of time where the national COE announced mobility restrictions, academic activities were cancelled and teleworking was emphasized from March to November is considered for the study, and subsequently compared with previous years and a year after the same period where these measures did not exist.

5. Results and analysis

The first result obtained in the analysis of power consumption behavior is shown in Fig. 5. The average consumption from March through November in the curve for 2020 exceeds those in the curves for 2018 and 2109, before curfew measures were enacted, and is also higher than that for 2021, when we continued under pandemic conditions, but no restrictive mobility and confinement measures were put in place.

The percentage increase rate of stratum D for the period between March and November 2019 and 2020 has a value of 8.54% and it is shown in Table 4.

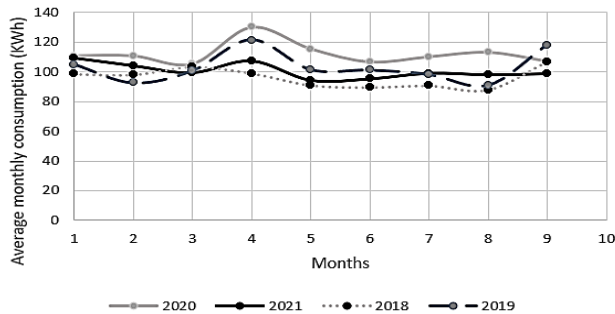


Figure 5. Consumption trend comparison 2018 2019 and 2020 in COVID-19 PEC subscribers . Source: The author.

Table 4. Electricity consumption increase rate March-November 2019 and 2020 in COVID-19 of Barrio San Agustín subscribers by strata.

Strata	Average monthly energy consumption KWh march-november 2019	Average monthly energy consumption KWh march-november 2020	Rate of increase (%)
D	103.32	112,145	8.54%

Source: The author

Table 5. Electricity consumption increase rate March-November 2020 and 2021 in COVID-19 of Barrio San Agustín subscribers by strata.

Strata	Average monthly energy consumption KWh march-november 2020	Average monthly energy consumption KWh march-november 2021	Rate of increase (%)
D	112.145	100.576	-10.31%

Source: The author

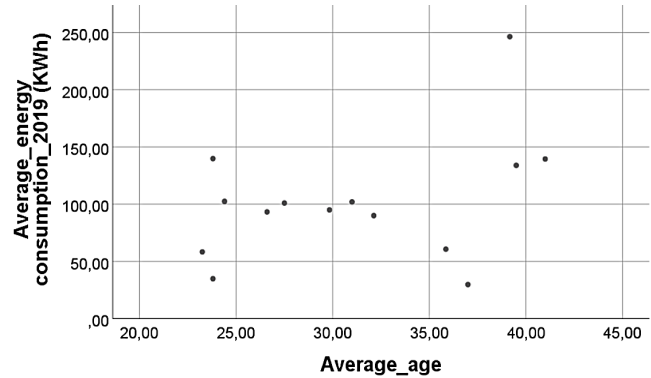


Figure 6 Average age vs Average monthly energy consumption KWh stratum D 2019.

Source: The author.

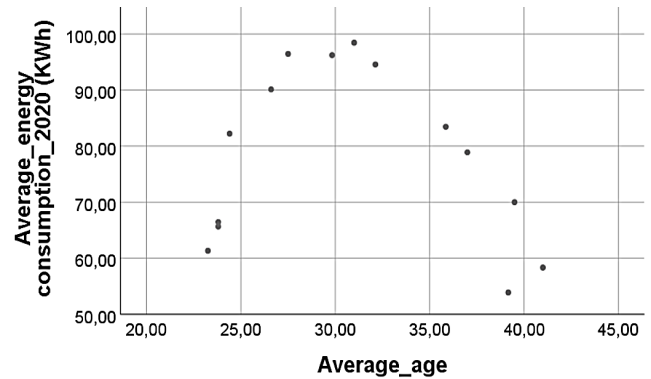


Figure 7 Average age vs Average monthly energy consumption KWh stratum D 2020.

Source: The author.

The percentage increase rate of stratum D for the period between March and November 2020 and 2021 has a value of -11.5% and it is shown in Table 5.

Figs. 6-8 show the relationship between average age and monthly power consumption of subscribers in San Agustín neighborhood in 2019, 2020 and 2021. The results of the graphs show the relationship between the aforementioned variables in 2020 with a significance of 0.097 after applying the regression method with the Spearman's coefficient for curvilinear regression; however, for 2019 and 2021 the correlation coefficients have a significance of 0.295 and 0.117, respectively, and in 2019 there is no relationship between the variables studied.

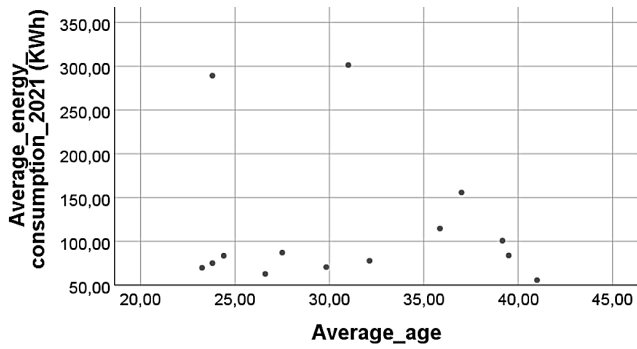


Figure 8 Average age vs Average monthly energy consumption KWh stratum D 2021
Source: The author.

6. Conclusions

It is found that there is a relationship between the average age and monthly power consumption in users of San Agustín neighborhood in 2020 in conditions of confinement and teleworking decreed by the national COE, reaching a significance of 0.097. According to the results, the group that reaches the peaks of power consumption from March to November 2020, corresponds to an average age of 27 to 33 years old and the average age groups that show the lowest average consumption are those ranging from 20 to 25 and 40 to 45 years old. However, for 2021, although the pandemic continues, the 27 to 33 age group shows a drastic reduction. This may be due to the fact that the restrictive mobility and confinement measures for 2021 were mostly eliminated and most of the subscribers returned to their on-site jobs.

It is concluded that in 2020, the average residential power consumption of San Agustín neighborhood from March to November in relation to the same period in 2019, increased at a rate of 8.54%. Also, that the average residential power consumption of San Agustín neighborhood from March to November in 2021 compared to 2020, was reduced at a rate of -10.31%.

For future work, it is suggested that an analysis be made to take into account more variables related to the power consumption behavior of subscribers, considering the activities to which each age group is dedicated, this would explain why in 2021 there is a violent reduction in consumption in the age groups that show peaks in 2020. This could be due to the fact that this group is dedicated to working outside their homes most of the day and in conditions of confinement, as established in 2020, this group shows peaks and a less efficient use of electricity.

It is suggested to carry out an analysis in the other provinces to obtain data in the most populated areas of the country and to go up to a study at the national level that will be very useful for the national COE to consider the incidence in home electricity consumption in restrictive measures of curfew.

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F.I. Sánchez-Gamboa, received the BSc. Eng. in Electromechanical Engineering in 2016, from the Universidad de las Fuerzas Armadas ESPE of Latacunga, Cotopaxi, Ecuador. From 2009 to 2016, he worked as a transformer design engineer for electricity companies within the power sector and since 2019 for the Instituto Superior Tecnológico Cotopaxi. Currently, he is a full professor in the Electromechanical Department and research department, Instituto Superior Tecnológico Cotopaxi. His research interests include design, modeling and analysis of data in electromechanical markets.
ORCID: 0000-0001-8390-6200

J.M. Moreno-Tipan, is graduated in Electromechanical Technology in 2021, from the Cotopaxi Higher Technological Institute of Latacunga, Cotopaxi, Ecuador. He began his career in 2019 and finished in 2021. He is currently a graduate of the Electromechanical Technology career at the Cotopaxi Higher Technological Institute. His research interests include design, modeling, and data analysis in electromechanical markets.
ORCID: 0000-0001-5361-0599

D.A. Caiza-Sambachi, is graduated in Electromechanical Technology in 2021, from the Cotopaxi Higher Technological Institute of Latacunga, Cotopaxi, Ecuador. He began his career in 2019 and finished in 2021. He is currently a graduate of the Electromechanical Technology career at the Cotopaxi Higher Technological Institute. His research interests include design, modeling, and data analysis in electromechanical markets.
ORCID: 0000-0003-2983-1820