International Journal for Quality Research 18(3) 927–938
ISSN 1800-6450

Mirza Pasic [1]
Zedina Lavic

Article info:
Received 23.10.2023.
Accepted 01.03.2024.

UDC – 351.777.6
DOI – 10.24874/IJQR18.03-20

REGRESSION ANALYSIS OF HOUSEHOLDS' ELECTRICITY CONSUMPTION BASED ON AIR POLLUTION AND METEOROLOGICAL PARAMETERS

Abstract: *This research investigates the complex relationship between households' electricity consumption and a range of environmental factors, such as air pollution and meteorological parameters. Data regarding air pollutants* PM_{10} [$\mu g/m^3$], *and* NO_2 [$\mu g/m^3$], *as well as meteorological parameters temperature* [°C], *relative humidity* [%], *and atmospheric pressure* [hPa] *were collected from the Federal Hydrometeorological Institute of Bosnia and Herzegovina, while data related to electricity consumption were obtained from the Public Enterprise Elektroprivreda BiH d.d. – Sarajevo. Measurements and data collection were done for a period of time from January 2020 until March 2022 allowing for seasonal variations to be taken into account. The research findings reveal strong negative correlation of households' electricity consumption with temperature, moderate positive correlation with* PM_{10}, *and* NO_2, *as well as weak positive correlation with relative humidity and very weak positive correlation with pressure. Linear regression model developed in this research showed that temperature, humidity and concentration of air pollutant* PM_{10} *were significant variables and had impact on households' electricity consumption. The results of this research provide valuable insights into the complex dynamics between households' electricity consumption and environmental factors, and can help policymakers, electricity providers as well as households to develop better ways to save energy and develop better electricity consumption strategies.*

Keywords: *electricity consumption, households, air pollution, meteorological parameters, regression*

1. Introduction

Households' electricity consumption affects various aspects of the society such as economic, environmental, health, and policy making and is fundamental element of sustainable living, economic stability, environmental preservation, and global energy security. Climate change is expected to impact electricity markets through both demand and supply. Higher temperatures will increase cooling demand, decrease heating demand, and reduce thermal power plant production. Also, geographical

[1] Corresponding author: Mirza Pasic
Email: mirza.pasic@mef.unsa.ba

variability in non-thermal electricity supply is evident (Mideksa & Kallbekken, 2010). As stated by Mideksa & Kallbekken (2010), more research is needed to understand the effects of climate change on the electricity market, including regional studies, extreme weather events, air conditioning adoption rates, and thermal power supply sensitivity.

Weather's impact on residential electricity consumption is a topic with limited scholarly attention. Research often examines the relationship between energy consumption and weather variables like temperature, precipitation, humidity, wind speed, cloud cover, and sun duration (Kang & Reiner, 2022). The study by Bessec and Fouquau (2008) explores the relationship between electricity demand and temperature in 15 European countries over two decades. Findings show a non-linear relationship, more prominent in warmer climates. The study also reveals a notable increase in energy demand responsiveness to temperature during the summer.

The study by Ralston Fonseca et al. (2019) looked into the effects of climate change on electricity demand and power plant dispatch (using the Tennessee Valley Authority as a case study in the United States). It uses a linear regression model to analyse the non-linear relationship between electricity demand and air temperature. Moreover, Ralston Fonseca et al. (2019) highlight the U-shape of that relationship because of the use of electricity for heating in the winter and cooling in the summer. The results suggest that climate change could significantly affect the hourly load curve's structure and seasonal variations, potentially influencing power supply costs (Ralston Fonseca et al., 2019). The work conducted by Silva, Soares, and Pinho (2020) examined the relationship between average temperatures and electricity consumption in Portugal, and the results also showed a U-shaped relationship. The study by Auffhammer & Aroonruengsawat (2011) examined the impact of human-caused climate change on California's residential electricity consumption. It used a dataset of electricity invoices from three investor-owned utilities. Results showed a significant temperature response across climate zones, suggesting a potential 55% increase in consumption by the end of the century. The study also considered higher electricity prices and population growth scenarios.

The assessment of the influence of climate change on global energy consumption is crucial for the investigation of both mitigation and adaptation strategies. However, the present empirical estimates primarily focus on Western countries, particularly the United States (Li et al., 2019). In this study, the authors utilised daily household energy consumption data to investigate the potential alterations in electricity consumption within the Shanghai region, specifically concerning climate change. In cases where the temperature falls below 7 °C, it has been observed that a rise in daily temperature of 1 °C leads to a decrease in electricity use of approximately 2.8%. During days with temperatures exceeding 25 °C, it has been observed that a mere 1 °C rise in daily temperatures results in a substantial 14.5% escalation in electricity use. As household income rises, the sensitivity to weather conditions remains consistent for hotter days in the summer while it intensifies throughout the winter. The estimated behaviour is used with a set of downscaled global climate models (GCMs) to establish a correlation between future annual variations in global mean surface temperature (GMST) and annual residential electricity consumption. It has been observed that there is a positive correlation between annual electricity consumption and annual Global Mean Surface Temperature (GMST), with a 9.2% increase in electricity consumption for every one °C rise in GMST. When comparing the data, it is observed that there is a significant increase of up to 36.1% in annual peak electricity usage for every one °C rise in annual Global Mean Surface Temperature (GMST).

In different climatic areas, households' electricity demand reacts to air temperature differently. A study by Salvo (2018) showed that in Singapore, with a tropical climate, with the increase in air temperature, the consumption of electricity increases, especially in households with a better socioeconomic status. In their research, Mashhoodi, Stead, and van Timmeren (2020) examined the household energy consumption determinants in the Netherlands at both local and national levels. The study's results indicate that national determinants include the number of frost days and wind speed. In contrast, local determinants encompass income, household size, building age, surface-to-volume ratio, population density, summer days, and land surface temperature. According to this study, local determinants are crucial and should be considered when creating policies related to household energy consumption.

Humidity affects human discomfort and space cooling demands. As Earth's temperature rises, relative humidity is expected to decrease. However, the impact on electricity demand remains uncertain. Integrating humidity-based indicators into electricity consumption assessment is very important. Apparent temperature-based models show superior predictive capabilities, predicting greater demand across all regions in the southeastern United States (Rastogi et al., 2021). In the work by Beccali et al. (2008), an artificial neural network model was used to predict household electricity consumption in a region and evaluate the impact of air conditioning equipment on consumption, using data from Palermo, Italy, from June 2002 to September 2003. The dataset encompassed many variables, such as electric current intensity, temperature, relative humidity, global sun radiation, atmospheric pressure, and wind speed.

The presence of air pollution has the potential to impact individuals' involvement in outdoor activities. Suboptimal air quality may discourage individuals from engaging in outdoor activities, resulting in a higher prevalence of indoor pursuits requiring electricity. The study (He et al., 2020) reveals that particulate air pollution increases electricity consumption in residential buildings and retail industries while reducing solar panel electricity generation. Lower-income and minority ethnic groups are disproportionately affected, increasing electricity expenses. This highlights the need for environmental justice in energy policymaking and more comprehensive evaluations of environmental protection policies. The study by Salvo (2020) explores the impact of ambient particle pollution on residential energy consumption in Singapore. It reveals a positive correlation between increased $PM_{2.5}$ levels and residential electricity demand. The research compares this relationship to heat and electricity consumption, examining differences across socioeconomic groups. Implementing local pollution control measures can reduce household electricity demand and consequently electricity generation and carbon emissions. Research by Pasic et al. (2023) analysed PM_{10} and meteorological parameters in Sarajevo with and without temperature inversion, and it was showen that in January, except at 13:00 hours, the values of PM_{10} were significantly lower without temperature inversion. The study by Leffel et al. (2022) investigates the link between air pollution reduction and industrial growth in 96 major world metropolitan areas. It argues that economic growth initially increases pollution but decreases as the economy transitions from manufacturing to services. The research found that PM_{10}, $PM_{2.5}$, NO_2, and SO_2 reductions are associated with local growth in the public administration, environmental, and health services industries.

In contrast, pollution increases are associated with growth in the manufacturing and mining industries. This study by Eom et al. (2020) uses real-time smart metre data to examine households' reactions to air pollution in South Korea. Results show that a rise in $PM_{2.5}$ concentration leads to an

11.2% increase in power consumption, similar to a 3.5°C increase in summer temperature. The extent of energy-intensive adaptation positively correlates with households' lifestyles, with higher levels observed during weekends and daytime hours. The study emphasises the need for policy formulation to balance mitigation and adaptation efforts. In their work, He et al. (2020) evaluate the environmental externalities of particle air pollution using customer-level electricity data from residential and commercial consumers in Arizona. The research uses an instrumental variable panel regression methodology to examine the relationship between particulate matter air pollution and electricity consumption in residential structures and the retail and leisure service industries. The findings show a positive association between air pollution and electricity consumption. Also, it has been found that air pollution harms the overall electricity output of distributed solar panels.

As stated by Costa et al. (2014), the primary air pollutants in Europe are particulate matter (PM) and nitrogen dioxide (NO_2). The analysis (WHO Regional Office for Europe, 2011) used particulate matter (PM_{10}) data collected from 357 cities, comprising 33 countries, from 2004 to 2009. In 2009, the average levels of PM_{10} exposure exhibited a range of 10–14 µg/m3 in countries such as Iceland, Estonia, Finland, and Ireland, whereas in Turkey and Bosnia and Herzegovina, the range was higher, precisely 58–61 µg/m3. In the context of Bosnia and Herzegovina, the data exclusively relates to only one city included in the analysis. European Environment Agency (EEA) obtained data on PM_{10} levels for 2018. Moreover, 3,015 stations were analysed concerning the annual limit value. The stations were located in all 37 reporting countries in 2018. The annual mean value for PM_{10}, as set by the World Health Organisation Air Quality Guidelines (AQG), was found to be surpassed in 53% (1,594) of the monitoring stations. This was observed in all reporting countries except Estonia, Iceland, and Ireland. Nitrogen dioxide concentrations exceeding the annual limit and corresponding World Health Organisation (AQG) values were observed in sixteen member states and three additional reporting countries. For Bosnia and Herzegovina, the NO_2 concentration was below both mentioned annual limit values (EEA, 2020). In 2021, there were recorded amounts of PM_{10} in 11 reporting countries, with 6 of them being European Union (EU) Member States. These concentrations exceeded the EU annual limit value of 40 µg/m3. Except for Iceland, all reporting countries recorded readings above the World Health Organisation's annually recommended 15 µg/m3 threshold. Also, 11 countries, comprising nine member states of the European Union, have reported nitrogen dioxide (NO_2) concentrations that exceed the annual limit value of 40 µg/m3 set by the European Union. Concentrations exceeding the World Health Organisation's yearly recommended level of 10 µg/m3 were recorded in all 37 nations that provided data (EEA, 2023).

Sarajevo Canton is considered one of the most polluted regions in Bosnia and Herzegovina (Federal Hydrometeorological Institute of Bosnia and Herzegovina, 2023). The research question addressed in this study relates to how meteorological parameters and air pollution in Canton Sarajevo influence household electricity consumption. The meteorological parameters examined in this study include temperature, relative humidity, and atmospheric pressure, while the pollutants considered include PM_{10} and NO_2.

2. Research methodology

The meteorological data for this research were gathered from the Federal Hydrometeorological Institute of Bosnia and Herzegovina, which is located in the part of the city of Sarajevo, the capital of Bosnia and Herzegovina, called Bjelave, at an altitude of 630 m as depicted in Figure 1. The institute is situated at the location where, 122 years ago, the foundations for the first meteorological station in Bosnia and Herzegovina were established. Today, it serves as the central institution for monitoring all weather-related phenomena. Data collected at this meteorological station included the concentration of air pollutants PM_{10} $[\mu g/m^3]$, NO_2 $[\mu g/m^3]$, temperature $[°C]$, relative humidity [%], pressure $[hPa]$. The data related to electricity consumption were obtained from the Public Enterprise Elektroprivreda BiH d.d. – Sarajevo.

Figure 1. Sarajevo Meteorological Station (Bjelave).

Data were analyzed using descriptive statistics and the linear regression as depicted by equation 1.

$$\hat{y} = b_0 + \sum_{i=1}^{i=5} b_i x_i \qquad (1)$$

where:

$\hat{y}$ – expected value of households' electricity consumption as dependent variable,

x_i – concertation of air pollutants PM_{10} and NO_2, temperature, humidity and pressure as independent variables ($i = 1, \dots, 5$),

b_i – regression coefficients ($i = 1, \dots, 5$),

b_0 – regression intercept.

Because variables were measured in different scales data were normalized before regression model was developed. Level of significance in this research was α= 0.05. Multicollinearity between independent variables was examined by calculating Variance Inflation Factor (VIF) as shown by equation 2. VIF less than five indicates that there is no multicollinearity between independent variables.

$$VIF = \frac{1}{1 - R_i^2} \qquad (2)$$

where:

R_i^2 – coefficient of determination when the i^{th} independent variable is regressed against the all other remaining independent variables.

3. Results and discussion

Monthly electricity consumptions of the households [kWh] in Canton Sarajevo are depicted in Figure 2. From Figure 2 it can be seen that the highest electricity consumptions were during January of years 2020, 2021, and 2022 with the values of 66,709,422.86 [kWh], 66,585,666.88 [kWh], and 66,802,379.77 [kWh] respectively. The lowest electricity consumptions during year 2020 were measured during August and September with the values of 43,483,303.17 [kWh], and 43,048,416.04 [kWh] respectively. During year 2021 the lowest electricity consumptions were measured again during August and September with the values of 44,004,882.48 [kWh] and 44,122,168.24 [kWh] respectively.

Average monthly temperatures [°C] in Canton Sarajevo are depicted in Figure 3. From Figure 3 it can be seen that the lowest average temperatures were during each January of 2020, 2021, and 2022 with the values of -0.75 [°C], 1.30 [°C], and -0.71 [°C]. The highest average temperature values of 21.36 [°C] and 22.95 [°C] were in August 2020, and July 2021 respectively. From Figure 2 and Figure 3 it can be seen that there is inverse relationship between monthly electricity consumptions of the households and average monthly temperatures.

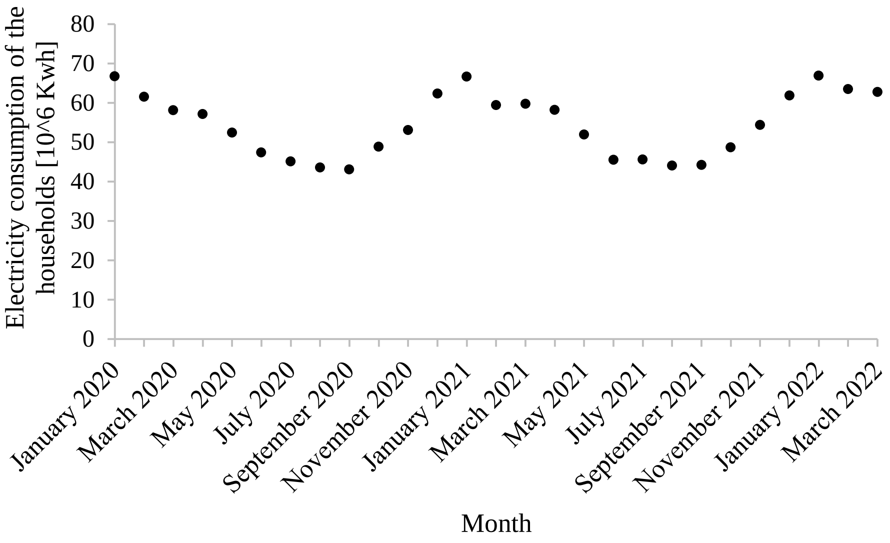

Figure 2. Monthly electricity consumption of the households

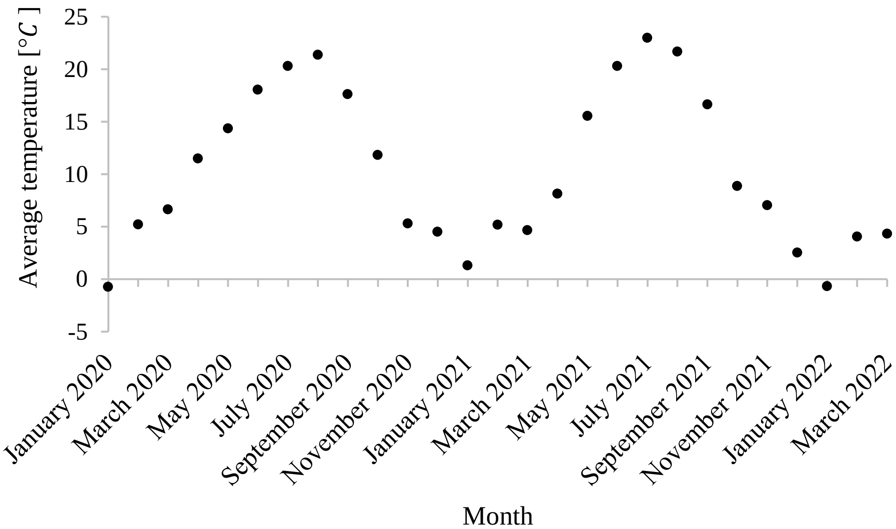

Figure 3. Average monthly temperature

Average monthly relative humidity values [%] in Canton Sarajevo are depicted in Figure 4. From Figure 4 it can be seen that the lowest relative humidity values were during April 2020, and May 2021 with the values of 48.15 [%] and 55.48 [%] respectively. The highest average relative humidity values were 80.82 [%] and 85.55 [%] in December 2020 and December 2021 respectively.

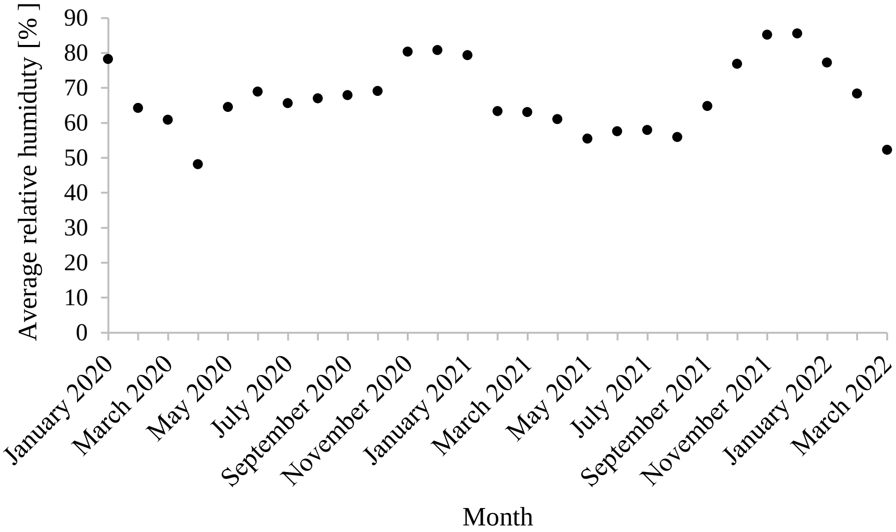

Figure 4. Average monthly relative humidity

Average monthly pressure values [hPa] in Canton Sarajevo are depicted in Figure 5. From Figure 5 it can be seen that the lowest pressure value was 936.94 [hPa] during January 2021, while the highest value was 949.84 [hPa] in November 2020.

Correlation matrix of dependent variable and independent variables is presented in Table 1.

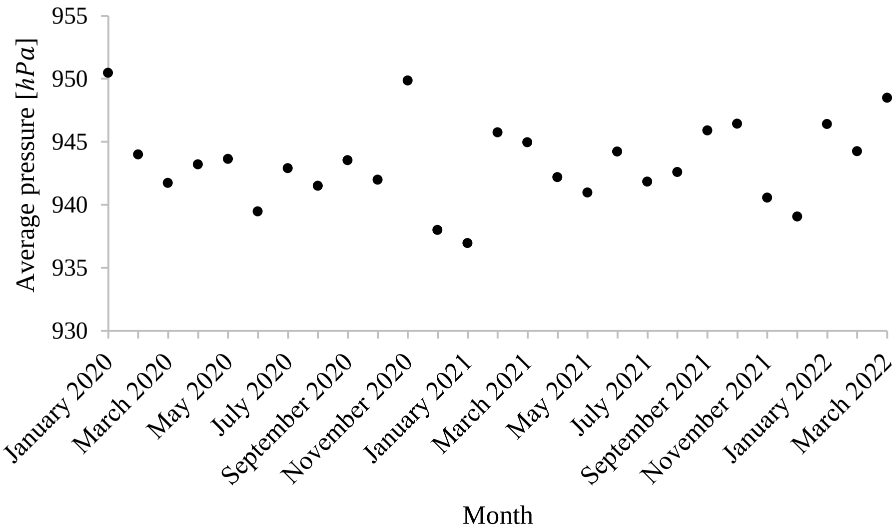

Figure 5. Average monthly pressure

Table 1. Correlation coefficients matrix

	HEC	T	H	P	PM_{10}	NO_2
HEC	1					
T	-0.93	1				
H	0.30	-0.50	1			
P	0.09	-0.22	-0.12	1		
PM_{10}	0.55	-0.59	0.53	0.39	1	
NO_2	0.60	-0.63	0.38	0.32	0.50	1

From Table 1 it can be seen that there is high negative correlation between households' electricity consumption (HEC) and temperature (T) with the correlation coefficient value of -0.93. That means as the the temperature increases the households' electricity consumption decreases. It can be seen that there is moderate positive correlation between households' electricity consumption and concentration of air pollutants PM_{10} and NO_2 with the correlation coefficient values of 0.55 and 0.60 respectively. That means as the concentration of air pollutants PM_{10} and NO_2 increases the households' electricity consumption increases.

Also, from Table 1 it can be seen that there is weak positive correlation between households' electricity consumption and relative humidity with the coefficient of correlation 0.30, and very weak positive correlation between households' electricity consumption and pressure with the coefficient of correlation 0.09.

Developed regression model is given by equation 3.

$$HEC = 1.36 - 1.11\,T - 0.48\,H - 0.39\,P + 0.42\,PM_{10} \quad (2)$$

From equation (3) it can be seen that coefficients of regression associated with temperature (T), relative humidity (H), and pressure (P) are with negative sign, while PM_{10} coefficient of regression is positive. All independent variables (temperature, relative humidity, pressure and PM_{10}), except NO_2, were significant and showed that households' electricity consumption depends on these variables.

Standard errors of the coefficients (SE Coef), 95% confidence intervals of the coefficients (95% CI), t – values and p – values are depicted in Table 2.

From Table 2 it can be seen that VIF value of each regression coefficient is less than five which means that there is no multicollinearity between independent variables.

Table 2. Regression coefficients

Term	Coef	SE Coef	95% CI	t −value	p-value	VIF
Constant	1.36	0.07	(1.21; 1.51)	18.59	0.000	
T	-1.11	0.06	(-1.24; -0.98)	-17.81	0.000	1.67
H	-0.48	0.08	(-0.63; -0.32)	-6.27	0.000	1.83
P	-0.39	0.07	(-0.54; -0.23)	-5.21	0.000	1.44
PM_{10}	0.42	0.11	(0.19; 0.65)	3.84	0.001	2.20

Calculated p – values show that all regression coefficients presented in Table 2 are significant since all p – values are lower than level of significance $\alpha = 0.05$.

From Table 2 it can be seen that the standard error of the estimate is small, while both coefficients of determination for the training set and the test set are high with the values of 95.61% and 92.29% respectively. Calculated coefficient of determination shows that 95.61% variability in households' electricity consumption is explained by temperature, relative humidity, pressure, and the concertation of air pollutant PM_{10}. Table 3 shows standard error of the estimate (SE), coefficient of determination (R^2) for the training set and the test set.

Table 3. Coefficients of determination (R^2) of training and test sets, and standard error (SE)

SE	R^2 training set	R^2 test test
0.08	95.61%	92.29%

Contribution of each independent variable in explaining variability of dependent variable is shown in Table 4. From Table 4 it can be seen that the highest contribution, 86.19%, in explaining variability of households' electricity consumption comes from temperature (T), followed by relative humidity (H) with 3.48%, pressure (P) with 3.00%, and concentration of air pollutant PM_{10} $with$ 2.94%.

From Table 4 it can be concluded that the most important variable in the regression model is temperature, followed by relative humidity, pressure and concetratin of air pollutant PM_{10}.

Table 4. Contribution to R^2

Source	Contribution
Regression	95.61%
T	86.19%
H	3.48%
P	3.00%
PM_{10}	2.94%
Error	4.39%
Total	100.00%

Figure 6 shows the line of equality and the scatter plot of the points of households' electricity consumption fitted values versus actual values. From Figure 6 it can be seen that the points in the scatter plot are clustered closely around the line of equality, and there is no evidence of any tendency for the points to deviate from the line, indicating that the developed regression model's predictions are very close to the actual values and that the model provides a good fit to the data.

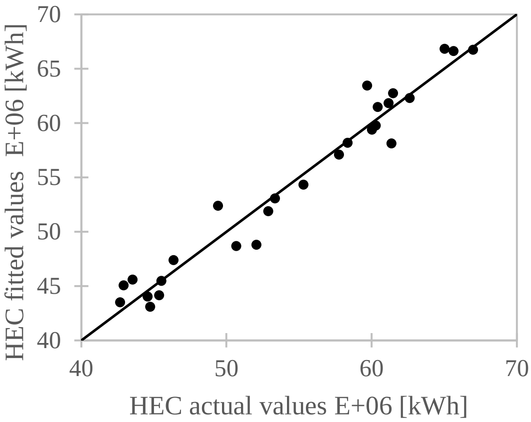

Figure 6. HEC fitted values vs HEC actual values

Scatter plot of standardized residuals versus fitted values is depicted in Figure 7. From Figure 7 it can be seen that standardized residuals have equal variance along fitted values with no pattern, and that all standardized residuls are within ± 3 standard deviations.

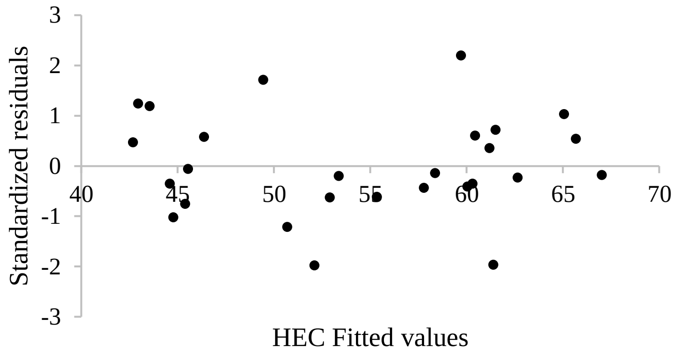

Figure 7. Standardized residuals vs HEC fitted values

4. Conclusion

In this research, a comprehensive analysis was performed to investigate the complex relationship between households' electricity consumption and environmental factors, including concertation of air pollutants PM_{10}, and NO_2, as well as meteorological parameters temperature, relative humidity, and pressure. Measurements and data collection allowed inclusion of seasonal variations of all variables.

The highest households' electricity consumption was in each January of 2020, 2021, and 2022, while the lowest values were during August and September of 2020, and 2021. The lowest average temperatures were during each January of 2020, 2021, and 2022, while the highest average temperature values were in August 2020, and July 2021. Similar pattern in monthly electricity consumptions of the households and average monthly temperatures was revealed.

Regression analysis showed that temperature, relative humidity, pressure, and concertation of air pollutant PM_{10}, were significant predictor variables of households' electricity consumption. The highest contribution in explaining variability of households' electricity consumption came from temperature, followed by relative humidity, pressure, and concentration of air pollutant. With respect to air pollution the results of this research support conclusion in Salvo, A. (2020) where it was stated that residential electricity demand grows when $PM_{2.5}$ rises.

The findings of this research offer important insights into the complex and dynamic relationship between households' electricity consumption and environmental factors. These findings have the potential to assist policymakers, electricity providers, and households in improving energy-saving strategies and enhancing electricity consumption strategies in general.

Acknowledgment: The authors would like to thank Federal Hydrometeorological Institute of Bosnia and Herzegovina and Public Enterprise Elektroprivreda BiH d.d. – Sarajevo for allowing to collect data for this research.

References:

Auffhammer, M., & Aroonruengsawat, A. (2011). Simulating the impacts of climate change, prices and population on California's residential electricity consumption. *Climatic change*, *109*, 191-210. doi: 10.1007/s10584-011-0299-y

Beccali, M., Cellura, M., Brano, V. L., & Marvuglia, A. (2008). Short-term prediction of household electricity consumption: Assessing weather sensitivity in a Mediterranean area. *Renewable and Sustainable Energy Reviews, 12*(8), 2040-2065. doi: 10.1016/j.rser.2007.04.010

Bessec, M., & Fouquau, J. (2008). The non-linear link between electricity consumption and temperature in Europe: A threshold panel approach. *Energy Economics*, *30*(5), 2705-2721. doi: 10.1016/j.eneco.2008.02.003

Costa, S., Ferreira, J., Silveira, C., Costa, C., Lopes, D., Relvas, H., ... & Paulo Teixeira, J. (2014). Integrating health on air quality assessment—review report on health risks of two major European outdoor air pollutants: PM and NO2. *Journal of Toxicology and Environmental Health, Part B*, *17*(6), 307-340. doi: 10.1080/10937404.2014.946164

Eom, J., Hyun, M., Lee, J., & Lee, H. (2020). Increase in household energy consumption due to ambient air pollution. *Nature Energy*, *5*(12), 976-984. doi: 10.1038/s41560-020-00698-1

European Environment Agency. (2020). *Air quality in Europe – 2020 report*. Retrived from https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report.

European Environment Agency. (2023). Europes Air Quality Status 2023 – briefing. Retrived from https://www.eea.europa.eu/publications/europes-air-quality-status-2023#:~:text= Concentrations%20of%20PM2.5%20above,46%20air%20quality%20zones%2C%20respectively.

Federal Hydrometeorological Institute of Bosnia and Herzegovina. (2023). Annual Report on Air Quality in Federation of Bosnia and Herzegovina for 2022. Retrieved from http://www.fhmzbih.gov.ba/latinica/ZRAK/izvjestaji.php.

He, P., Liang, J., Qiu, Y., Li, Q., & Xing, B. (2020). Increase in domestic electricity consumption from particulate air pollution. *Nature Energy*, *5*(12), 985-995. doi: 10.1038/s41560-020-00699-0

Kang, J., & Reiner, D. M. (2022). What is the effect of weather on household electricity consumption? Empirical evidence from Ireland. *Energy Economics*, *111*, 106023. doi: 10.1016/j.eneco.2022.106023

Leffel, B., Tavasoli, N., Liddle, B., Henderson, K., & Kiernan, S. (2022). Metropolitan air pollution abatement and industrial growth: Global urban panel analysis of PM10, PM2. 5, NO2 and SO2. *Environmental Sociology*, *8*(1), 94-107. doi: 10.1080/23251042.2021.1975349

Li, Y., Pizer, W. A., & Wu, L. (2019). Climate change and residential electricity consumption in the Yangtze River Delta, China. *Proceedings of the National Academy of Sciences*, *116*(2), 472-477. doi: 10.1073/pnas.1804667115

Mashhoodi, B., Stead, D., & van Timmeren, A. (2020). Local and national determinants of household energy consumption in the Netherlands. *GeoJournal*, *85*(2), 393-406. doi:10.1007/s10708-018-09967-9

Mideksa, T. K., & Kallbekken, S. (2010). The impact of climate change on the electricity market: A review. *Energy policy*, *38*(7), 3579-3585. doi: 10.1016/j.enpol.2010.02.035

Pasic, M., Hadziahmetovic, H., Ahmovic, I., & Pasic, M. (2023). Principal Component Regression Modeling and Analysis of PM 10 and Meteorological Parameters in Sarajevo with and without Temperature Inversion. *Sustainability,* 15(14), 11230. doi: 10.3390/su151411230

Ralston Fonseca, F., Jaramillo, P., Bergés, M., & Severnini, E. (2019). Seasonal effects of climate change on intra-day electricity demand patterns. *Climatic Change*, *154*, 435-451. doi: 10.1007/s10584-019-02413-w

Rastogi, D., Lehner, F., Kuruganti, T., Evans, K. J., Kurte, K., & Sanyal, J. (2021). The role of humidity in determining future electricity demand in the southeastern United States. *Environmental Research Letters*, *16*(11), 114017. doi: 10.1088/1748-9326/ac2fdf

Salvo, A. (2018). Electrical appliances moderate households' water demand response to heat. *Nature communications*, *9*(1), 5408. doi: 10.1038/s41467-018-07833-3

Salvo, A. (2020). Local pollution as a determinant of residential electricity demand. *Journal of the Association of Environmental and Resource Economists*, *7*(5), 837-872. doi: 10.1086/709533

Silva, S., Soares, I., & Pinho, C. (2020). Climate change impacts on electricity demand: The case of a Southern European country. Utilities Policy, 67, 101115. doi: 10.1016/j.jup.2020.101115

World Health Organization, WHO (2011). Exposure to air pollution (particulate matter) in outdoor air: fact sheet 3.3. Retrived from https://apps.who.int/iris/handle/10665/366475?show=full.

Mirza Pasic
Faculty of Mechanical Engineering, University of Sarajevo,
Sarajevo,
Bosnia and Herzegovina
mirza.pasic@mef.unsa.ba
ORCID 0000-0002-0901-0913

Zedina Lavic
Faculty of Mechanical Engineering, University of Sarajevo,
Sarajevo,
Bosnia and Herzegovina
lavic@mef.unsa.ba
ORCID 0000-0002-6216-5295