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Investigating Factors Influencing Energy Consumption: An Analysis in Kolhapur City

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Abstract:- In this study, the effects of several factors on Kolhapur city's energy consumption in 2023 will be objectively examined. Various data collected from The Kolhapur Maharashtra Electricity Board, the Census handbook to identify different factors influencing energy use. The findings validate that the following factors have positive and statistically significant effects: climate, temperature, population, time, environment and pollution, and humidity. Statistically substantial positive correlations between population growth rate and energy use have been found. Conversely, other elements, such as water and natural gas pricing, have little bearing on energy use. As a result, the study's findings have policy implications that emphasize expanding the energy supply in order to attain a higher degree of sustainable development and economic expansion.

Keywords*: Energy consumption, factors, Kolhapur.*

1. Introduction

For social welfare to improve, sustainable economic development is essential. However, One of the primary goals of sustainable development is to foster a robust economy in order to produce a large amount of resources to meet the demands of the populace collectively and enhance environmental quality in contrast. Thus, it would preserve the environment and human health even more. In order to help consumers meet their demands while using less energy through increased energy efficiency, sustainable development also aims to provide sufficient energy supply to mitigate the negative effects of energy use to favorable levels.

Sources of energy are refers to the sources of energy that are obtained from the surroundings and supplied for economic purposes (e.g., coal mine, oil well, solar, wind, or water on turbines, etc.). The several benefits of wind energy include an energy source that is renewable for all nations.

In the process of economic growth and development, energy plays a crucial role as a global commodity. Capital and human capital are similar to other elements that contribute to economic progress.etc., energy development is another important factor that determines economic development and progress [19]. Clearly, the accessibility of economic Alternative, more cost-effective, and higher-quality energy sources have played a significant part in propelling economic expansion in emerging industrialized economies and ging [13,59]. The Koutrouma study According to Nidis et al. [34], energy resources have consistently and everywhere a key role in social and economic development welfare. Thus, the importance of fuelwood and biomass in specifically, one of the most important renewable energy sources that can make a significant contribution.

However, some earlier research demonstrates the detrimental effects of excessive energy use. For instance, Neumayer [50] has demonstrated that typically, the industrial sector is examined considerably more pollutant-intensive in contrast to the services industry. In a related investigation, According to Peng and Bao [52], over use of natural resources causes an increase in industrial pollutants' emissions. The outcomes Degradation of environmental quality is caused by an increase in industrial expansion. Supposedly, the creative growth combined with quick Urbanization, the growing consumption of products and services during a rebellion rising production

patterns and the middle class lead to strong adverse outcomes, lowering the chances for economic progress for the nations [62]. According to Seiford and Zhu's research [57], unacceptable carbon emission levels are harmful.

This study's primary goal is to investigate empirically the effects of several factors on energy consumption in the setting of Kolhapur city—over the time frame between 2022 and 2023. However, there are numerous elements influencing how energy is used, however this study exclusively considers the impact of the rise of urbanization rate, population growth rate, pollution and life anticipation. This research differs from earlier studies in both in terms of the time frame it considers and in terms of group of location taken into consideration. However, many previous research have examined a number of variables influencing energy consumption function from various angles with various bands.

2. Scope of Study: Kolhapur

In "one of the top six districts in the state of Maharashtra with highest per capita income," Kolhapur is the eleventh-largest city. (TOI, March 8, 2016) is situated between latitudes 160 39" 3' to 160 45" 50' North and longitudes 740 11" 20' to 740 16" 10' East. This city is situated on the right bank of the Panchaganga River, which is a tributary of the Krishna River. The elevation of Kolhapur City is 650 meters above sea level. Kolhapur City has a temperate climate, with an average annual temperature of 1043 mm, a minimum temperature of 150 °C, and a maximum temperature of 400 °C.

In 1901, there were just 54,373 people living there; over the course of more than a century, that number rose to 5,49,236 in 2011. The city's physical layout is distinct, with a moderate slope that drops gently from south to north. Both locals and visitors to the Great Mahalax-ami temple find the renowned Rankala Tank, which is situated on the western side of the city, to be a popular destination. Kolhapur is referred to as "Dakshin Kashi" because of the magnificent and well-known Mahalaksh- mi temple. On the eastern side of the city is National Highway No. 4, which connects Pune and Bengaluru.

The area of Kolhapur City was 66.82 square kilometers when it was incorporated as a Municipal Corporation on December 15, 1972, and it has remained that way ever since. According to the Indian census, its population was less than one lakh (93,032) in 1941 and more than one lakh (136,835) in 1951. Any urban center must experience this demographic growth in order to be designated as a city and granted the status of a Municipal Corporation. This status was really given to the city in 1972. According to the 2011 census, the city's population has more than doubled, from 2,59,050 in 1971 to 5,49,236 now.

Beginning in 1989, there had been discussions about merging the approximately forty-two surrounding villages with Kolhapur city. On July 11, 2001, twenty-five of the villages were removed from the 42 total, and The state chief minister put a stop to the union of seventeen of the communities in August 2014. The KMC then issued a resolution suggesting the merging of 18 villages and two industrial zones after the urban development department rejected the idea (TOI, Jan. 23, 2016). The population of these villages will increase when they join the KMC, which will increase the amount of funding the civic body receives for development.

3. Experimental Approach

3.1. Data Sources

The Time series for the year data used in this study spans the years 2022 to 2023. The Maharashtra State Electricity Board, Kolhapur from where the data was gathered about energy consumption. The handbook of the Maharashtra Census Office in Bombay is another source of information on the Kolhapur district. Also the information about kolhapur is collected from the e-book published by the Executive editor and secretary, Gazetters department, Government of Maharshtra, Mumbai.

3.2 Results and conversation:

3.2.1 Sources of Electricity Generation in India:

With 1.2 billion people and a land area of 3.29 million km2, India is one of the seven biggest nations in the world. Its economy is still in its infancy and is reliant on infrastructure and electricity generation. Coal thermal power stations are India's primary source of electricity. Coal continues to be the nation's principal source of electricity despite efforts to diversify the alternatives, especially in the case of renewable energies.

Coal has been used to generate a steadily growing percentage of power since 2000; it was 68% at the beginning of the new millennium and 73% in 2013. All other energy sources' percentage shares, with the exception of renewables, have reduced over the period [14]. Renewable and alternative power sources that are making great progress include solar, wind, biomass, and small hydropower (less than 25 MW) projects.

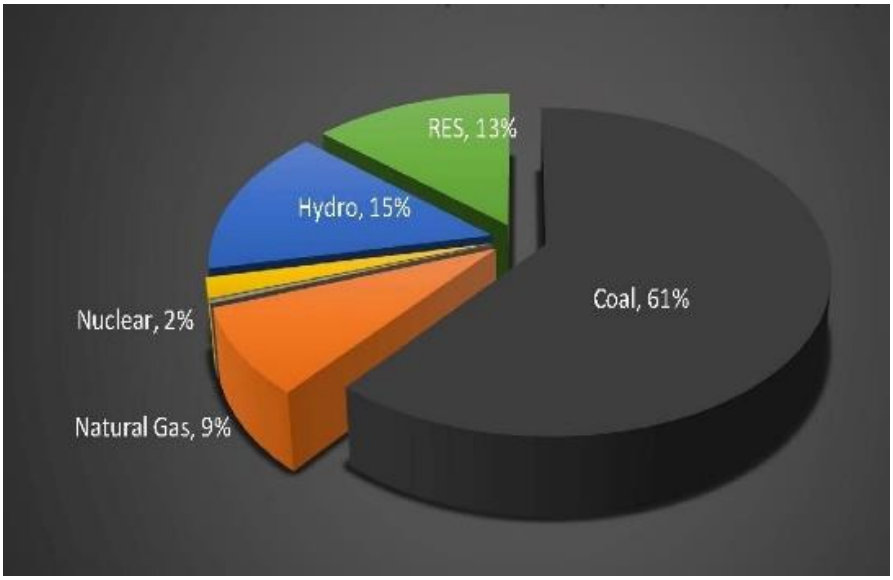

Fig 1. Sources of Energy in India

3.2.2. Kolhapur city peak power demand vs temperature and humidity change January to December 2023

The lowest and maximum temperatures, humidity, and peak electrical usage are listed in Table 1.1. The comparison analysis in Figure 2.1 indicates that peak electricity demand decreases when humidity rises. Therefore, as can be seen, the highest atmospheric humidity occurs in June, July, and August, and consequently, the need for electricity is lower. On the other hand, as the temperature rises, so does the need for electricity, as seen in the figure for March till June, albeit the biggest demand for electricity occurs in October.

Table 1. Kolhapur City peak power demand with temperature and humidity

Sr. No	Month	Peak Demand (in MUS)	Min Temperature (in ^{0}C)	Maximum Temperature (in ^{0}C)	Humidity
1	January	64.55983	14.2	30.92	45
2	February	65.58295	15.5	34.77	41
3	March	72.57671	19.62	34.61	40
4	April	73.01285	24.67	39.59	49
5	May	76.96687	23.73	37.24	62
6	June	74.07304	25.84	36.69	83
7	July	71.23935	24.3	29.5	89

Sr. No	Month	Peak Demand (in MUS)	Min Temperature (in ^{0}C)	Maximum Temperature (in ^{0}C)	Humidity
8	August	69.87016	21.4	25.3	89
9	September	67.80365	21.2	26.9	85
10	October	72.53676	20.8	29.1	72
11	November	63.99293	19.3	29.0	54
12	December	65.91544	17.6	29.6	46

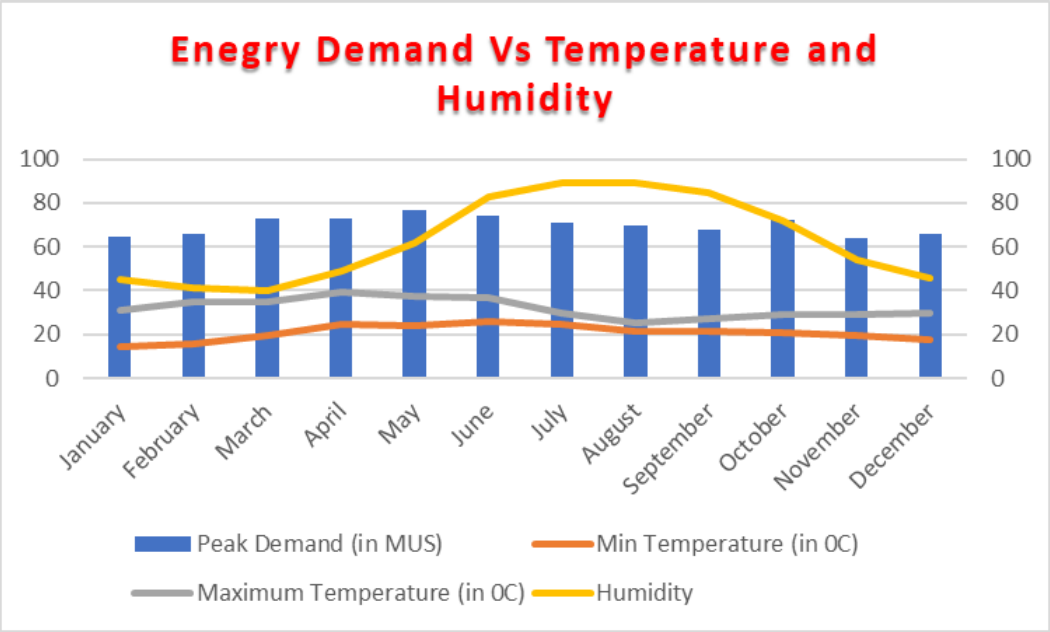

Fig 2. Comparison of Energy Demand with temperature and humidity

3.2.3. Population Distribution of the City:

The distribution of the city's municipal wards is the first notable aspect. Since their creation several years ago, these wards have not been updated since 2001. The E ward, which occupies over 60% of the city's total territory, is the largest and most expansive of the city's five historic wards. With only 2% of the total, ward C is the smallest and most crowded.

Database:

Secondary sources form the basis of the current investigation. The secondary data was gathered from the Kolhapur District Gazetteer, the District Census Handbooks for the years 1961 to 2011, the Kolhapur Municipal Corporation publications, journals, etc. The population growth rate has been expressed as a percentage.

Ward-wise Density of Population

Kolhapur's ward system was altered in 2001. There A, B, C, D, and E were the five wards until 2001. In 2001, all five of these wards were converted into seventy-two new ones. Kolhapur City had 77 wards as of 2011. In other words, five wards were added in 2011. The 77 wards' total area is calculated in hectares (ha) to determine their density. Owing to their tiny size, we discovered that the population density is higher than the ward's actual population when we converted the wards' area from square kilometers to hectares. Consequently, the ward area in hectares has been taken into account while calculating the population density.

According to data from the 2011 census, the city had six wards with a population density of more than 600 people per hectare. These Wards are Sukrawar Gate, Padmaraje Udyan, Yadav Nagar, Kholkhandoba, Vicharemal, and

Daulat Nagar. There were four wards with 450–600 people per hectare of population. These wards are Chandreswar, Commerce College, Bazar Gate, and Natha Gole Talim. There were twelve wards with a population density of 300–450 people per hectare. Shahu Bank, Khari Corner, Panjarpol, Sadar Bazar,

Panchganga Talim, Kasaba Bawada, Rajarampuri, Phirangai, Dudhali Pavelean, and Bindu Chowk are some of these wards. The population density in sixteen wards of the city has been recorded to range from 150 to 300 people per hectare. These wards are called Syke's Extension, Shidarth Nagar, Kanan Nagar, Mangeshkar Nagar, Neharu Nagar, Line Bazar, Vikram Nagar, Subhash Nagar, Pratibhanagar, Shahupuri Kumbhar Vasahat, Treasury Office, Tararani Vidyapeeth, Mahalaxmi Mandir, and Vikram Nagar. The population density in the remaining thirty-nine wards of the city was less than 150 people per hectare.

Table 2: Ward wise Population, Area and Energy Consumption of Kolhapur City in year 2016

Sr. No	Ward	Name of the Ward	Area	Population	Energy Consumption (MW)
1	Ward No – 1	Sugar Mill	777.89	7140	15876
2	Ward No – 2	Kasaba Bawada, Ra. Shahu Mar. School	256.26	7742	16109
3	Ward No – 3	Kasaba Bawada	16.67	6287	15600
4	Ward No – 4	Kasaba Bawada Hanu- man Talav	75.81	7201	16002
5	Ward No – 5	Raman Mala	404.05	6809	15529
6	Ward No – 6	Line Bazar	58.10	8779	16565
7	Ward No – 7	Bhosalewadi, Kadam- wadi	134.96	9229	16700
8	Ward No – 8	Police Line	161.36	9082	16595
9	Ward No – 9	Nagala Park	78.46	6120	15640
10	Ward No - 10	Tarabai Park	49.53	6919	15813
11	Ward No – 11	Sadar Bazar	20.45	6613	15730
12	Ward No - 12	Vichare Mal	5.46	6069	15512
13	Ward No - 13	PatoleWadi	90.16	8062	16499
14	Ward No - 14	Sant Gora Kumbhar Vasahat	229.01	6822	16064
15	Ward No - 15	Shahu Market Yard	112.08	6894	15749
16	Ward No - 16	Ruikar Colony	66.80	6619	15779
17	Ward No - 17	Shivaji Park	65.08	6410	15332
18	Ward No - 18	Kanan Nagar	37.54	7152	16202
19	Ward No - 19	Shahupuri North	61.20	6529	15768
20	Ward No - 20	Shidharth Nagar	25.47	5240	15824
21	Ward No - 21	Toraskar Chowk	26.91	6291	15532
22	Ward No - 22	Panchaganga Talim	18.81	6812	15323
23	Ward No - 23	Mira Bagh	235.61	7657	14962
24	Ward No - 24	Laxathirth Vasahat	243.04	9890	14409
25	Ward No - 25	Phulewadi	61.13	5815	13609

Sr. No	Ward	Name of the Ward	Area	Population	Energy Consumption (MW)
26	Ward No - 26	Rankala Talav	2112.07	6465	19118
27	Ward No - 27	Dudhali Pavelean	22.08	6743	18769
28	Ward No - 28	Sukrawar Gate	9.09	5754	18698
29	Ward No - 29	Kholkhandoba	7.59	5890	18698
30	Ward No - 30	Bazar Gate	9.52	5018	18792
31	Ward No - 31	Treasury Office	20.24	5321	19387
32	Ward No - 32	Shahupuri Kumbhar Vasahat	22.28	5411	20486
33	Ward No - 33	Shahpuri Talim	42.34	5973	21194
34	Ward No - 34	Syke's Extension	30.32	6279	20899
35	Ward No - 35	Takala- Mali Colony	73.17	6315	20706
36	Ward No - 36	Tembalai Mandir	46.83	6760	20602
37	Ward No - 37	Vikram Nagar	27.32	6000	20307
38	Ward No - 38	Tembalaiwadi	202.72	7718	19852
39	Ward No - 39	Shivaji Vidyapeeth	468.33	7073	19553
40	Ward No - 40	Rajarampuri Extension	45.44	6826	13859
41	Ward No - 41	Tararani Vidyapeeth	27.90	7601	13678
42	Ward No - 42	Rajarampuri	18.50	5818	13637
43	Ward No - 43	Shivaji Udyamnagar	61.33	5863	13779
44	Ward No - 44	Commerce College	13.26	6942	14444
45	Ward No - 45	BinduChowk	18.05	5448	15736
46	Ward No - 46	Mahalaxmi Mandir	20.62	5214	16464
47	Ward No - 47	TatakadilTalim	17.16	6912	16493
48	Ward No - 48	Chandreshwar	11.82	5876	16551
49	Ward No - 49	Padmaraje Udyan	9.39	6813	16553
50	Ward No - 50	Phirangai	20.11	6259	16511
51	Ward No - 51	Khari Corner	15.84	6555	16346
52	Ward No - 52	Shahu Maidan	19.18	6097	16209
53	Ward No - 53	Mangeshkar Nagar	47.53	8279	15957
54	Ward No - 54	Jawahar Nagar	61.32	7232	15817
55	Ward No - 55	Yadav Nagar	9.51	6810	16220
56	Ward No - 56	Panjarpol	19.46	6603	17110
57	Ward No - 57	Pratibhanagar	21.63	5252	17563
58	Ward No - 58	Daulat Nagar	8.44	6559	17525
59	Ward No - 59	Sagar Mal	68.24	8856	17415

Sr. No	Ward	Name of the Ward	Area	Population	Energy Consumption (MW)
60	Ward No - 60	Subhash Nagar	31.43	6887	16948
61	Ward No - 61	Neharu Nagar	49.91	7806	16308
62	Ward No - 62	Sambhaji Nagar	67.19	8138	15493
63	Ward No - 63	Shahu Bank	12.95	5741	15451
64	Ward No - 64	Natha Gole Talim	11.66	6561	15104
65	Ward No - 65	Ganji Mal	21.75	5990	14921
66	Ward No - 66	Sambhaji Nagar Bus Stand	32.42	7066	14921
67	Ward No - 67	Rajlaxmi Nagar	68.44	8961	14989
68	Ward No - 68	Sane GurujiVasahat	93.84	8953	15211
69	Ward No - 69	Vishal Nagar	355.27	14787	15542
70	Ward No - 70	Surve Nagar	134.55	10683	16097
71	Ward No - 71	Salokhe Nagar	108.18	10227	16465
72	Ward No - 72	Tapovan	57.15	8115	16433
73	Ward No - 73	Kalamba Filter House	80.62	9213	16185
74	Ward No - 74	ZilaKaragruha	121.26	7848	15885
75	Ward No - 75	Baba Jarag Nagar	186.04	8209	15665
76	Ward No - 76	Swatantrya Sainik Vasahat	128.08	7734	15456
77	Ward No - 77	Rajendra Nagar	85.79	9599	15406
		Total Kolhapur City	6682	549236	

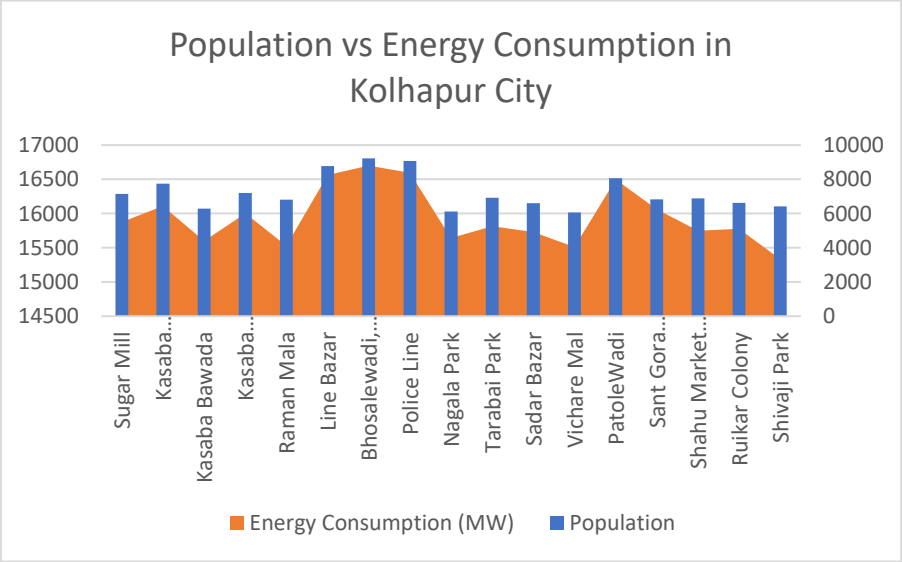

Fig 3: Population vs Energy Consumption in Kolhapur city

According to the above graph, which displays Kolhapur City's energy use by ward, the wards with the largest populations use more electricity.

3.3.4 Impact of Pollution and Environment on energy consumption:

Poor indoor or outdoor air quality is a contributing factor in one out of every nine fatalities globally, making air pollution one of the biggest environmental hazards to human health. The World Health Organization (WHO) estimates that 92% of people on Earth live in places with local air pollution levels above WHO standards.

Cardiff university, located in Cardiff, Wales, is a public research institution. Originally called the University institution of South Wales and Monmouthshire, it was founded in 1883 and joined the University of Wales as a foundation institution in 1893.

According to news released by this university on September 24, 2024, increased pollution levels have been linked to increasing electricity usage in residential buildings, with daytime rises accounting for the majority of these increases. Commercial buildings used more electricity as a result of increasing pollution levels. According to Dr. Pan He of Cardiff University's School of Earth and Environmental Sciences, when air pollution levels are high, people tend to stay indoors and travel less. This results in a general increase in electricity consumption from lighting, heating, and cooling as well as from using appliances more.

Following Table shows the air quality index and consumption of energy. It indicated that if AQI is highest than energy consumption is increased by default. For the AQI, there are six groups. All of these categories imply various kinds of health concern. Additionally, each group has a unique color. Because of the color, people can immediately and readily determine whether the air conditions in their neighborhoods is approaching dangerous levels. From 0 to 50The condition of the air is sufficient, and the possibility of air pollution is little to nonexistent. 51 to 100 The air is of a suitable quality. Some individuals, however, may be at risk, more those who are especially allergic to air pollution and other variables.

Table 3: Energy consumption and air quality

Sr. No.	Month	AQI	Energy consumption
1	January 23	53.875	64.55983
2	February 23	52.75	65.58295
3	March 23	52.75	72.57671
4	April 23	47.88	73.01285
5	May 23	50.5	76.96687
6	June 23	48.375	74.07304
7	July 23	37	71.23935
8	August 23	49	69.87016
9	September 23	51.44	67.80365
10	October 23	54.12	72.53676
11	November 23	57.63	63.99293
12	December 23	54.875	65.91544

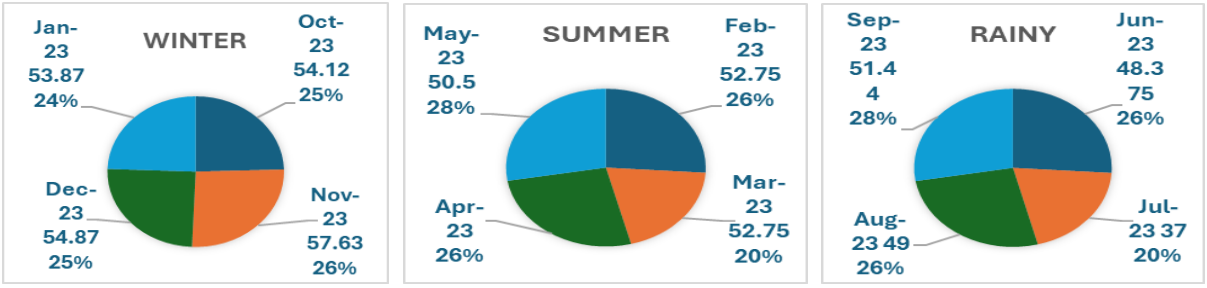

Fig. 4 The relationship between energy consumption and air quality

The aforementioned investigation indicates that, in contrast to winter and summer, air pollution is higher in the summer and lower during the rainy season. Consequently, just as air pollution fluctuates, so does energy use.

4. Summary and Conclusion

Examining the variables influencing the utilization of electric energy was the aim of this study. The main factors influencing Kolhapur city's electricity consumption were identified by this study. Seasons, population growth, and air quality were found to have an equal impact on power use as the external environment (geography, temperature, and humidity). Additionally, this study discovered that the city's energy usage is most affected by temperature and time characteristics. We came to the overall conclusion that time, temperature, population, and environment are the most effective factors in city energy use.

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