Kütahya Dumlupınar University
Institute of Graduate Studies

Journal of Scientific
Reports-A
E-ISSN: 2687-6167
Number 54, September 2023

RESEARCH ARTICLE

ENERGY-POPULATION EVALUATION AND PROJECTION OF KÜTAHYA PROVINCE

Oğuz Ozan YOLCAN[1*], Ramazan KÖSE[2]

[1*]Kütahya Dumlupınar Üniversity, Faculty of Engineering, Department of Mechanical Engineering, Kütahya, oguzozan.yolcan@dpu.edu.tr, ORCID: 0000-0002-6664-5675
[2]Kütahya Dumlupınar Üniversity, Faculty of Engineering, Department of Mechanical Engineering, Kütahya, ramazan.kose@dpu.edu.tr, ORCID: 0000-0001-6041-6591

Receive Date: 23.11.2022 *Accepted Date: 19.09.2023*

ABSTRACT

Examination of the energy situation is essential, especially for countries that are dependent on foreign Energy terms of Energy. Energy consumption, which increases indirectly with population and technology, needs to be evaluated in the short, medium, and long term. Energy projections are one of the most critical issues in the development planning of states. In this study, the population and energy status of the Kütahya province of Turkey were examined in detail, and the population and Energy projections were evaluated. While reviewing the population projection, predictions have been prepared depending on the population changes of the last five years, the last ten years, the last 15 years, and the previous 20 years, together with the projection prepared by the Turkish Statistical Institute. While preparing the electrical energy consumption projection of Kütahya province, evaluations were made according to three different scenarios prepared by the Ministry of Energy and Natural Resources of the Republic of Turkey. Accordingly, the electricity consumption of Kütahya province in 2039; has been determined as 2.71 billion kWh according to the 1st scenario, 2.96 billion kWh according to the 2nd scenario, and 3.27 billion kWh according to the 3rd scenario.

Keywords: *Energy, population, electricity projection*

1. INTRODUCTION

Energy consumption and short- and long-term energy projections are essential considerations for governments' investment and savings plans. This study examined the energy status of Kütahya province of Turkey and evaluated energy consumption projections.

According to the International Atomic Energy Agency, world electrical energy consumption will reach 104 EJ (28,889 TWh) in 2030, 127 EJ (35,278 TWh) in 2040, and 152.7 EJ (42,417 TWh) in 2050 [1]. In addition, the Ministry of Energy and Natural Resources of the Republic of Turkey has predicted Turkey's electrical energy consumption as 370 TWh for 2025 and 591 TWh for 2040 [2].

JSR A
Journal of Scientific Reports

Şişman et al. modeled Turkey's energy consumption using Artificial Neural Networks. The model created was developed for 1975-2016, and the electricity consumption for Turkey until the end of 2023 was accurately estimated with the model created [3]. Kan et al., while modeling electricity demand, also referred to techno-economic criteria. Seasonal and daily variations were considered while designing the demand model [4]. Wu et al. developed a new model for electricity demand forecasting. The developed model has been evaluated for simulating and predicting the electricity consumption of the Hubei region of China in a specific time period. It has been stated that the model has high performance [5]. Belançon evaluated Brazil's electricity needs in 2030 under four different scenarios. To determine the electricity need, Brazil's 20-year electricity load curves were examined [6]. Cekinir et al. evaluated Turkey's 2050 energy projection under four different scenarios. Turkey's electricity production values for the year 2050 are modeled with Artificial Neural Networks. In addition, it has been evaluated how much the production from Turkey's domestic resources should increase to meet the consumption in 2050 [7]. Zhang et al. evaluated the electricity consumption for the Jiangsu region of China, considering socioeconomic criteria. For the electricity consumption estimation, the period 2018-2100 has been evaluated [8]. Soummane and Ghersi have developed a model to determine Saudi Arabia's electricity needs by 2030. Considering the cost and efficiency criteria, modeling was applied under various scenarios [9]. Da Silva et al. have developed a methodology for the estimation of electricity consumption in an industrial sector. The developed method was evaluated to estimate the electricity consumption of the Brazilian paper industry until 2050 [10]. Perez-Garcia and Moral-Carcedo developed a methodology for long-term forecasting of electricity demand. The developed methodology was applied to Spain [11]. Roberts et al. have developed a model for the United States that predicts hourly electricity demand based on thermal conditions [12].

Kütahya is a province in the Aegean Region of Turkey, with 13 districts, including the central district [13]. The representation of Kütahya on the map of Turkey is given in Figure 1 [14]. The district borders of Kütahya province and the annual total solar radiation are shown in Figure 2 [14].

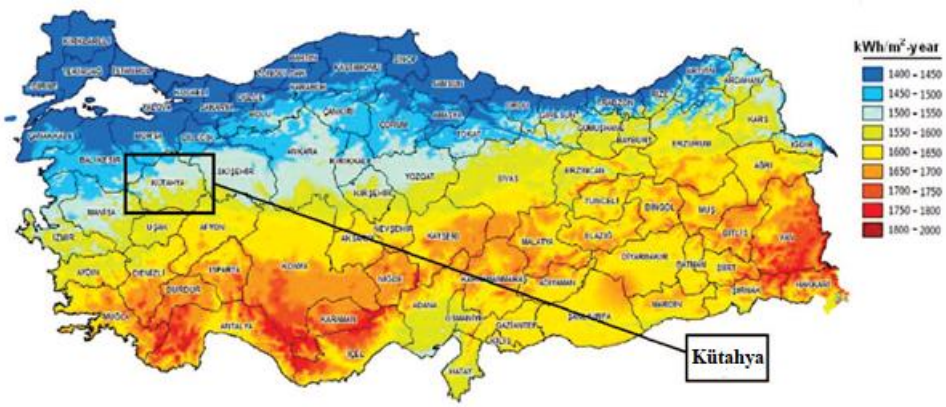

Figure 1. Location of Kütahya province in Turkey [14].

JSR A
Journal of Scientific Reports

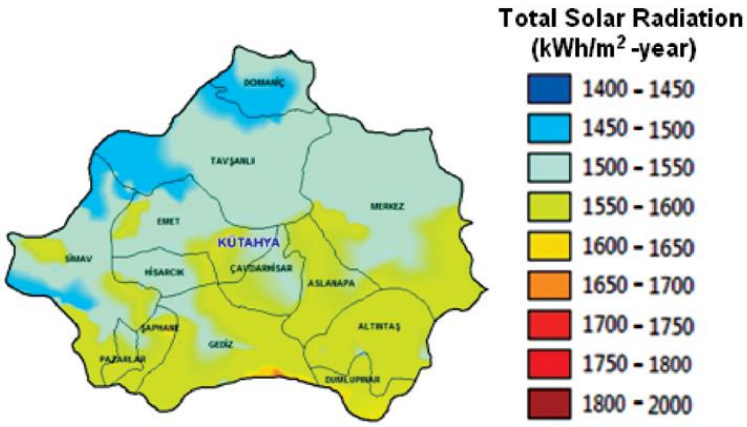

Figure 2. Kütahya district borders and annual solar radiation [14].

For district centers of Kütahya province, General information such as latitude, longitude, altitude, average daily solar radiation, average daily sunshine duration, and annual average temperature are given in Table 1 [15]–[17].

Table 1. General information of Kütahya districts [15]–[17].

	Latitude	Longitude	Altitude	Average temperature (°C)	Wind speed (m/s)
Merkez	39.4	30	960	10.50	2.79
Altıntaş	39.1	30.1	1030	10.84	2.98
Aslanapa	39.2	29.9	1030	10.61	2.92
Çavdarhisar	39.2	29.6	1010	10.96	2.87
Domaniç	39.8	29.6	880	10.49	2.74
Dumlupınar	39.9	30	1225	10.33	2.99
Emet	39.3	29.3	900	11.21	2.84
Gediz	39	29.4	750	12.57	2.77
Hisarcık	39.3	29.2	760	11.92	2.69
Pazarlar	39	29.1	925	11.69	2.63
Simav	39.1	29	820	11.78	2.68
Şaphane	39	29.2	980	11.40	2.61
Tavşanlı	39.5	29.5	845	10.83	3.01

JSR A
Journal of Scientific Reports

2. POPULATION AND ENERGY OUTLOOK OF KÜTAHYA

As of the end of 2020, the total population of Kütahya is 576 688. [18]. The population view of Kütahya by years is given in Figure 3 [18]. While the people of Kütahya was approximately 593 thousand in 2000, it decreased to 564 thousand in 2011.

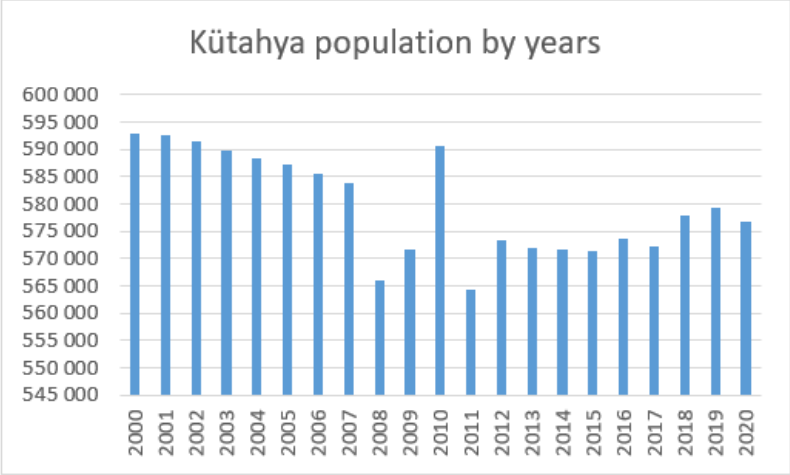

Figure 3. Kütahya population by years [18].

The population growth rate of Kütahya by years is shown in Figure 4 [18]. In the given date range, the highest increase in the population of Kütahya was realized in 2009 – 2010 with 3.2%. The highest population decline occurred in 2010 – 2011, with 4.5%.

JSR A
Journal of Scientific Reports

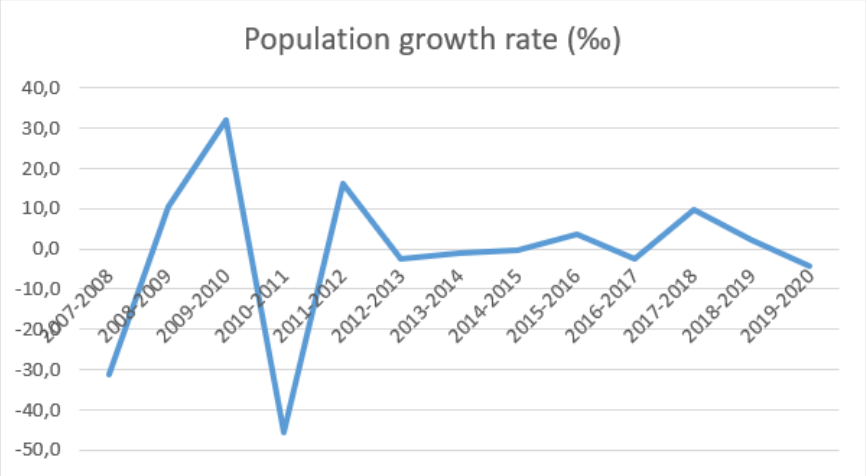

Figure 4. Kütahya population growth rate by years [18].

As of the end of March 2022, the licensed electrical Energy installed power in Kütahya is 1067.82 MW, and the unlicensed electrical energy installed power is 118.93 MW [19]. The unlicensed installed power consists of 2.61 MW of biomass and 116.32 MW of solar Energy. The development of unlicensed installed capacity by years is given in Figure 5 [19]. While unlicensed solar installed power was 1 MW in January 2016, this value increased to 116.32 MW by the end of March 2022.

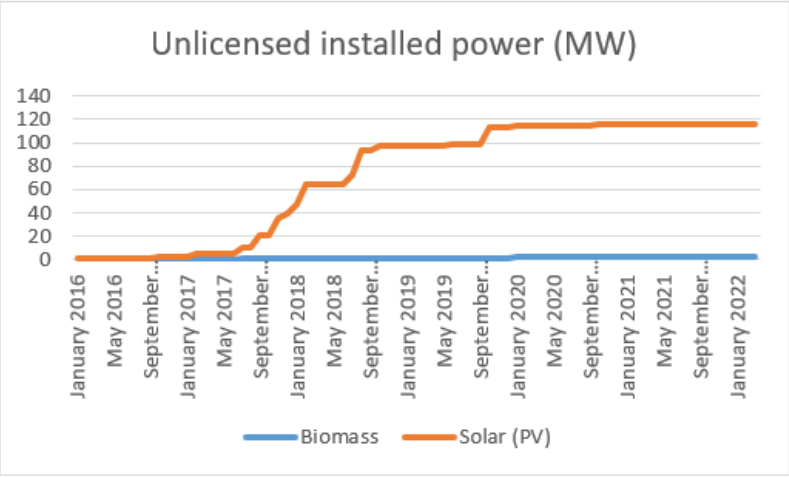

Figure 5. Kütahya unlicensed electrical energy installed capacity [19].

JSR A
Journal of Scientific Reports

The licensed electricity generation of Kütahya province was 384 million kWh in March 2022. Licensed electricity production of Kütahya by years is shown in Figure 6 [19]. The highest generation was realized in February 2018 with 633.6 million kWh in the given date range.

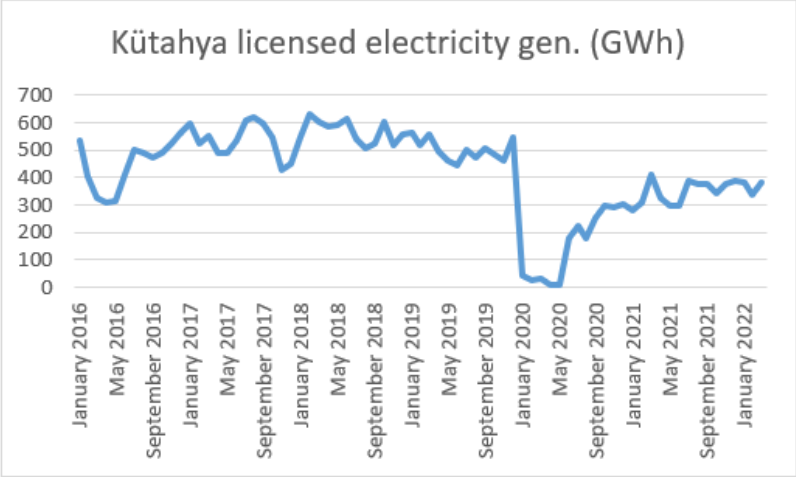

Figure 6. Kütahya licensed electricity generation [19].

Unlicensed electricity generation in Kütahya province was realized as 15.1 million kWh in March 2022. The unlicensed electricity production of Kütahya by years is shown in Figure 7 [19]. The highest generation was realized in July 2020 with 26.4 million kWh in the given date range.

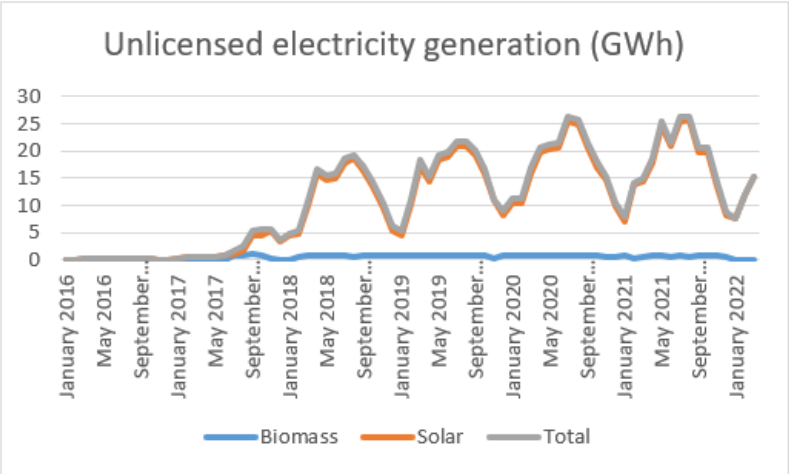

Figure 7. Kütahya unlicensed electricity generation [19].

The total electricity generation (licensed and unlicensed) of Kütahya province was realized as 399.1 million kWh in March 2022 [19]. The graph of total electrical energy production of Kütahya province by years is given in Figure 8.

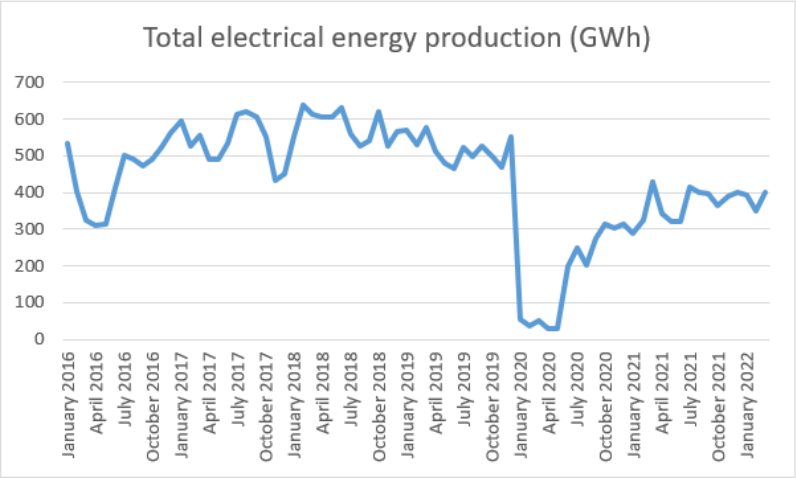

Figure 8. Total electrical energy production of Kütahya province [19].

The number of electricity consumers in the province of Kütahya is 421,762 as of the end of March 2022 [19]. The change in the number of electricity consumers in Kütahya province by years is given in Figure 9.

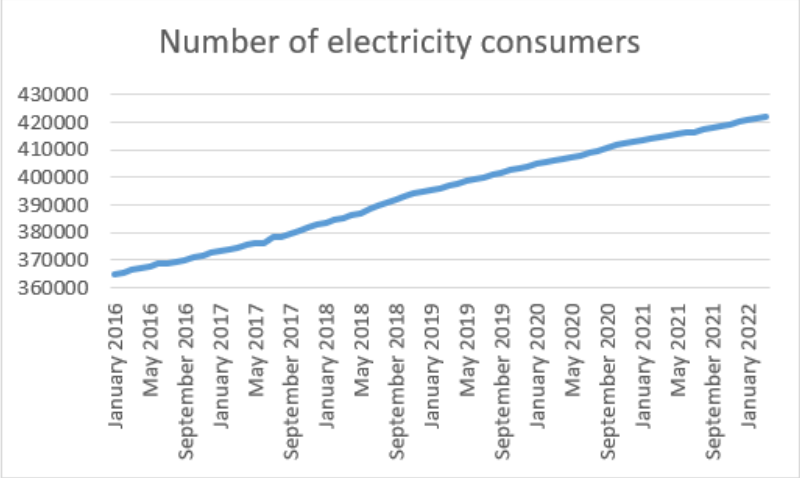

Figure 9. The number of electricity consumers in the province of Kütahya [19].

JSR A
Journal of Scientific Reports

Electricity consumption in Kütahya province was 169.2 million kWh in March 2022. [19]. The electricity consumption of Kütahya province by year is given in Figure 10. The lowest electricity consumption in the given date range was 107.7 million kWh in February 2016, and the highest was 171.4 million kWh in December 2021.

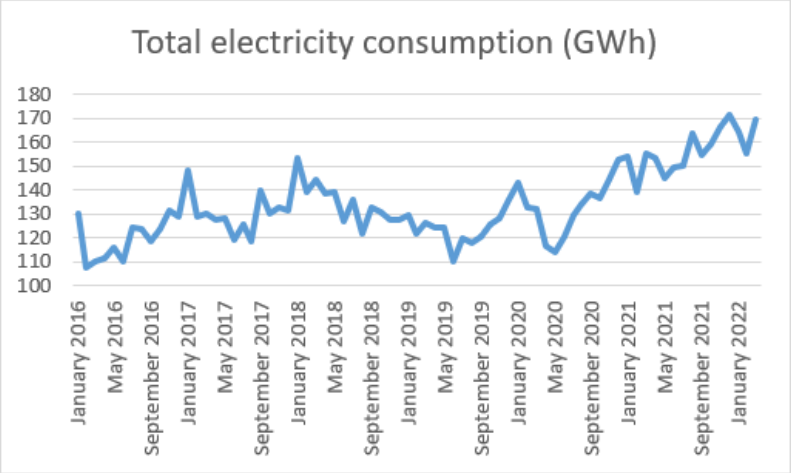

Figure 10. Electricity consumption in Kütahya [19].

The electricity consumption graph of Kütahya province according to sectors is given in Figure 11 [19]. When the electricity consumption graph of Kütahya province is analyzed, it is seen that the highest share in consumption belongs to the Industry sector, followed by Residential and Commercial consumption.

JSR A
Journal of Scientific Reports

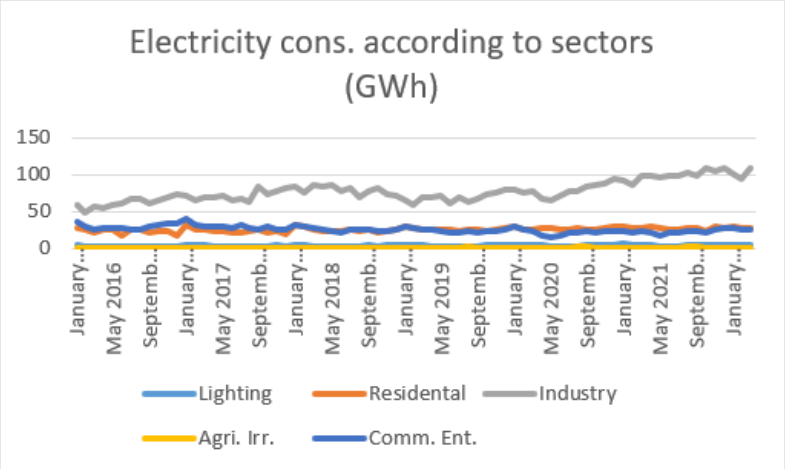

Figure 11. Electricity consumption according to sectors [19].

The average electricity consumption rates of Kütahya province in the given date range are shared in Figure 12. In the averages within the given date range, the highest share belongs to the Industry sector with 58%. The percentage of lighting is 3%, the share of residences is 19.2%, the share of agricultural irrigation is 0.5%, and the share of commercial enterprises is 19.3%.

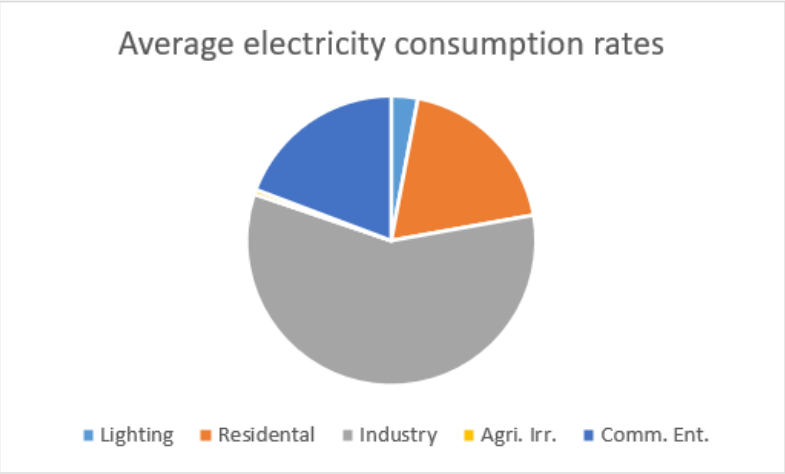

Figure 12. Average electricity consumption rates of Kütahya [19].

The graph of the ratio of total electricity generation (licensed and unlicensed) to consumption of Kütahya is shown in Figure 13. [19]. Except for the January 2020 – May 2020 date range, it is seen

JSR A
Journal of Scientific Reports

that the electricity production of Kütahya province is higher than the electricity consumption. The average electricity generation to consumption ratio in the given date range is 328.8%. The main reason why production values are so high compared to consumption values is the thermal power plants located in the province of Kütahya.

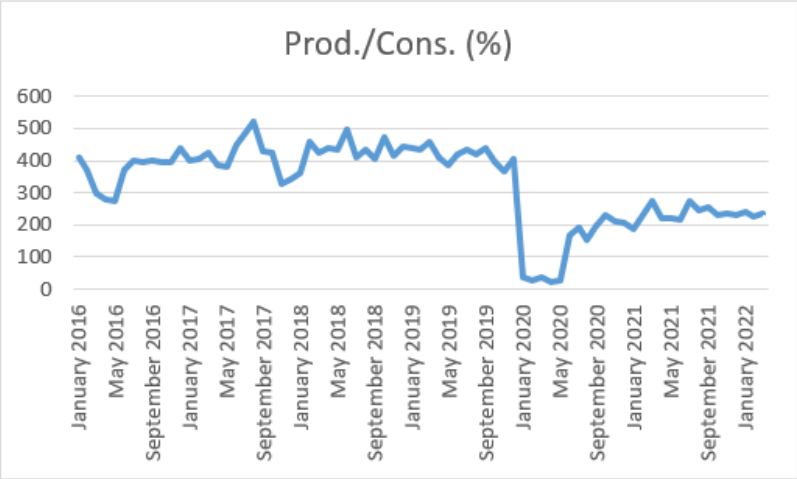

Figure 13. The ratio of total electricity generation to consumption of Kütahya [19].

The ratio of unlicensed solar power generation to total consumption in Kütahya is shown in Figure 14. [19]. Unlicensed solar power generation in July 2020 corresponds to 19.7% of total consumption. The average ratio of unlicensed solar energy generation to consumption in the given date range is 8%.

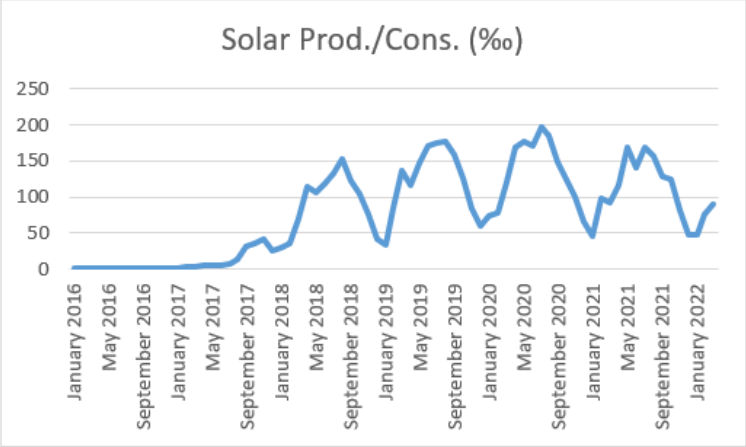

Figure 14. the ratio of unlicensed solar power generation to total consumption in Kütahya [19].

JSR A
Journal of Scientific Reports

3. KÜTAHYA POPULATION AND ENERGY PROJECTIONS

Population projections by provinces from the end of 2017 to 2025 were shared by the Turkish Statistical Institute [20]. The population projection for the province of Kütahya until 2025 is shown in Figure 15. According to this projection, the population of Kütahya province in 2023 is estimated to be 577 125, and in 2025 the population of Kütahya province is expected to be 576 830.

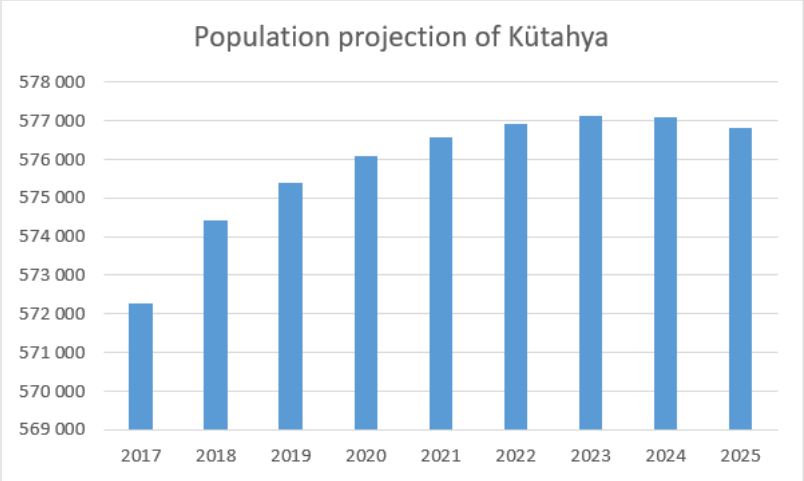

Figure 15. Kütahya province population projection prepared by TUIK [20].

One of the methods used to calculate population projections is the exponential increase method. This method can be calculated by the formula [21];

$$P = P_0 x e^{r.t} \tag{1}$$

In this formula, P represents the projective population, P_0 represents the initial population, r represents the population growth rate, and t represents the time. Using the exponential increase method, the population projection of Kütahya province until 2025 was created. While creating the population projection, Population growth rates of the last five years, the last ten years, the last 15 years, and the last 20 years are used. The projection obtained is shared in Figure 16.

According to this graph, the population of Kütahya province in 2025; It reaches 576,830 in the TUIK projection, 588,750 in the calculation made according to the population growth rate of the last five years, 572,617 in the calculation made according to the population growth rate of the last ten years, 576,152 in the calculation made according to the population growth rate of the last 15 years, and 575,220 in the calculation made according to the population growth rate of the last 20 years.

JSR A
Journal of Scientific Reports

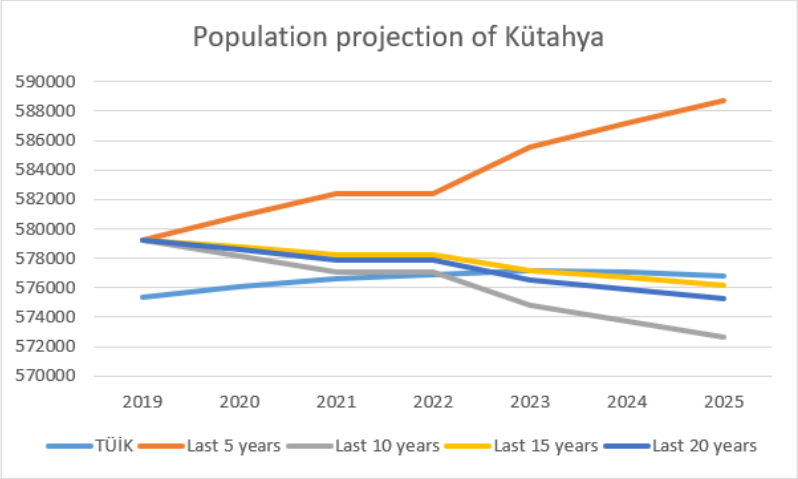

Figure 16. Population projection of Kütahya [20].

Three different scenarios have been prepared by the Ministry of Energy and Natural Resources of the Republic of Turkey for Turkey's 20-year electrical energy projection. [22]. These are the Low Scenario (Scenario 1), Reference Scenario (Scenario 2), and High Scenario (Scenario 3). These scenarios are adapted to the electrical energy consumption of Kütahya province and are shared in Figure 17.

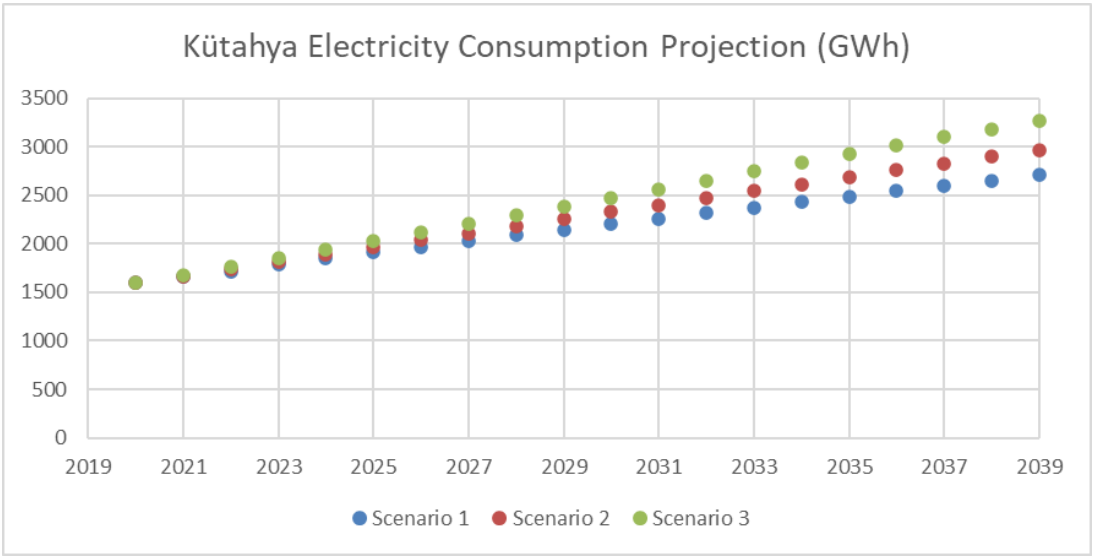

Figure 17. Electric energy consumption projection of Kütahya province [22].

JSR A
Journal of Scientific Reports

According to these prepared scenarios, the electrical energy consumption of Kütahya province in 2039;

According to scenario 1, 2.71 billion kWh (70% more than 2020),

According to scenario 2, 2.96 billion kWh (86% more than 2020)

According to scenario 3, it will be 3.27 billion kWh (105% more than 2020).

4. ASSESSMENTS

Energy efficiency, reducing foreign dependency on Energy by utilizing domestic resources, and increasing the rate of utilization of renewable energy resources are critical issues in terms of the development plans of states. In terms of the evaluation and planning of energy resources, energy projections need to be evaluated.

In this study, the population and energy status of the Kütahya province of Turkey were examined in detail, and the population and Energy projections were evaluated. While examining the population projection, projections have been prepared depending on the population changes of the last five years, the last ten years, the last 15 years, and the last 20 years, together with the projection prepared by the Turkish Statistical Institute. While preparing the electrical energy consumption projection of Kütahya province, evaluations were made according to three different scenarios prepared by the Ministry of Energy and Natural Resources of the Republic of Turkey. Accordingly, the electricity consumption of Kütahya province in 2039; has been determined as 2.71 billion kWh according to the 1st scenario, 2.96 billion kWh according to the 2nd scenario, and 3.27 billion kWh according to the 3rd scenario.

ACKNOWLEDGMENT

There is no conflict of interest with any person/institution in the paper.

REFERENCES

[1] International Atomic Energy Agency. (2019). Energy, electricity and nuclear power estimates for the period up to 2050, reference data series no. 1.

[2] Republic of Turkey Ministry of Energy and Natural Resources. (2022). Republic of Turkey Ministry of Energy and Natural Resources – electricity.

[3] Şişman, N., Sofuoğlu, M. A., Aras, N. and Aras, H. (2022). Modelling of Turkey's energy consumption using artificial neural networks. Advanced Engineering Forum, 44 (1), 73-86.

[4] Kan, X., Reichenberg, L. and Hedenus, F. (2021). The impacts of the electricity demand pattern on electricity system cost and the electricity supply mix: A comprehensive modeling analysis for Europe. Energy, 235 (1), 121239.

[5] Wu, W. Z., Pang, H., Zheng, C., Xie, W. and Liu, C. (2021). Predictive analysis of quarterly electricity consumption via a novel seasonal fractional nonhomogeneous discrete grey model: a case of Hubei in China. Energy, vol. 229 (1), 120714.

[6] Belançon, M. P. (2021). Brazil electricity needs in 2030: trends and challenges. Renewable Energy Focus, 36 (1), 89–95.

[7] Cekinir, S., Ozgener, O. and Ozgener, L. (2022). Türkiye's energy projection for 2050. Renewable Energy Focus, 43 (1), 93–116.

[8] Zhang, M., Cheng, C. H. and Ma, H. Y. (2020). Projection of residential and commercial electricity consumption under SSPs in Jiangsu province, China. Advances in Climate Change Research, 11 (2), 131–140.

[9] Soummane, S. and Ghersi, F. (2022). Projecting Saudi sectoral electricity demand in 2030 using a computable general equilibrium model. Energy Strategy Reviews, 39 (1), 100787.

[10] da Silva, F. L. C., Cyrino Oliveira, F. L. and Souza, R. C. (2019). A bottom-up bayesian extension for long term electricity consumption forecasting. Energy, 167 (1), 198–210.

[11] Pérez-García J, Moral-Carcedo J (2016) Analysis and long term forecasting of electricity demand trough a decomposition model: A case study for Spain. Energy 97:127–143.

[12] Roberts, M. J., Zhang, S., Yuan, E., Jones, J., and Fripp, M. (2022). Using temperature sensitivity to estimate shiftable electricity demand. iScience 25 (9), 104940.

[13] Republic of Türkiye Kutahya Governorship. (2021). Information about Kütahya.

[14] Ozgur, M. A. and Köse, G. (2013). A technoeconomic analysis of solar photovoltaic power systems: Kütahya case study. Energy Sources, Part A: Recovery, Utilization and Environmental Effects, 35 (1), 42–57.

[15] Ministry of Energy and Natural Resources of the Republic of Turkey. (2020). Solar Energy Potential Atlas.

[16] European Commission. (2017). JRC photovoltaic geographical information system (PVGIS).

[17] Climate-data.org. (2021). İklim: Türkiye.

[18] Turkish Statistical Institute. (2021). Population results based on address.

[19] Republic of Türkiye Energy Market Regulatory Authority EPDK. (2021). Electricity market monthly sector reports.

[20] Turkish Statistical Institute. (2021). Türkiye population and demography.

[21] Suddhendu, B. (1988). Stochastic Processes in Demography and Applications, John Wiley & Sons.

[22] Republic of Türkiye Energy Market Regulatory Authority EPDK. (2021). General Directorate of Energy Affairs reports.