

The Impact of Electricity Consumption on a Number of Economic Indicators in Iraq: An Econometric Study

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Abstract:

The research problem is to measure the value of the association of electricity consumption in Iraq with a group of important economic indicators and to show their significance. These indicators include: gross domestic product, per capita share of gross domestic product, unemployment rate, and inflation rate. In addition to these indicators, the relationship between electricity consumption and carbon emissions (environmental pollution) will be studied due to their impact on all economic activities, as well as the total population index due to its connection and direct relationship to electricity consumption.

The time period of the study is from 2000 to 2024. Pearson's correlation coefficient was used to compare two sets of data: The first group is the values of electricity consumption in Iraq, and the second group is the values of the Iraqi economic indicators referred to, and given the difference in the nature of the two sets of data in terms of the units used in measurement, standard values for the data will be used so that the degree of correlation between them can be studied and measured and its significance demonstrated.

The study showed a strong positive correlation between electricity consumption and GDP, There is a moderate positive correlation between electricity consumption and annual per capita GDP, There is a weak inverse (negative) correlation between electricity consumption and the inflation rate, There is a strong (positive) direct relationship between electricity consumption and the amount of carbon emissions, and Finally, there is a strong direct (positive) correlation between electricity consumption and the total population in Iraq in the period from 2000 to 2024. .

Keywords: Electricity consumption , correlation coefficient, economic indicators

1. INTRODUCTION :

Energy is generally the fuel of the economy and affects all aspects of modern life in one way or another. It is used to generate electricity, operate factories, vehicles, and a long list of uses. The higher the standard of living of individuals, the higher the need for energy and the greater its consumption. That is, energy is essential to living standards, and the standard of living of individuals is equal to energy needs. [1] Consumption, in general, is the total amount of energy consumed during a specific period. Electricity is the primary source for achieving economic development and sustainable growth. Therefore, its sources must be diversified and obtained on a continuous and sustainable basis. Electricity is obtained as a primary or primary energy source from natural sources such as wind, solar energy, water resources, and tidal energy. Electricity is obtained as a secondary energy source from geothermal energy, solar thermal energy, and the heat of nuclear fission generated from nuclear fuel, as well as by burning primary combustible fuel sources such as coal, oil, natural gas, and waste. Electricity is transmitted directly through transmission and distribution networks within or outside the country, and electricity consumption depends on the country's economic strength and industrial development, as well as its population size. Electricity generation in the Republic of Iraq depends mainly on fossil fuels (natural gas and oil) and a little renewable energy (hydroelectricity). The residential sector accounts for the largest part of electricity consumption in Iraq, followed by the commercial and public services sector, then industrial activities, and the agriculture and forestry sector, respectively. From this standpoint, we will conduct a study of the relationship between electricity consumption and important economic and environmental indicators in a standard quantitative manner and explain its significance. [2][3]

2. **Research problem:** A quantitative measurement of the correlation between electricity consumption in Iraq and a selected group of important economic indicators, which we have indicated in the abstract, and an interpretation of the significance of the correlation coefficient between them.
3. **The importance of research:** The research helps to clarify and explain the impact of electricity consumption on the economy and environment in the Republic of Iraq.
4. **Research objectives:**
 - A. identify Iraq's electricity consumption from 2000 to 2024.
 - B. Identifying data on a number of important economic indicators in Iraq, as well as carbon emissions and total population.
 - C. A quantitative measure of the relationship between electricity consumption in Iraq and a set of economic indicators, carbon emissions, and total population.
5. **Temporal and spatial boundaries:** The research includes archival data on Iraq's electricity consumption from 2000 to 2024, as well as some economic and environmental

indicators such as annual gross domestic product, annual per capita GDP, unemployment rate, inflation rate, carbon emissions (environmental pollution), and total population for the same period. The relationship between electricity consumption and these important economic indicators in Iraq will be studied.

6. **Research sample:** The study sample consists of 25 observations representing the actual values of electricity consumption in Iraq for the years from 2000 to 2024.
7. **Search tools:** Excel was used to calculate the standard deviation, standard deviations, and correlation coefficients between the standard deviations and graphs. Pearson's correlation coefficient was used to compare two sets of data. The first set represents electricity consumption values in Iraq, and the second set represents six important economic and environmental indicators in the Republic of Iraq.
8. **Study questions:**
 - A. What is the value of Pearson's correlation coefficient between electricity consumption and GDP
 - B. What is the value of Pearson's correlation coefficient between electricity consumption and annual per capita GDP?
 - C. What is the value of Pearson's correlation coefficient between electricity consumption and the unemployment rate?
 - D. What is the value of the Pearson coefficient of correlation between electricity consumption and the inflation rate?
 - E. What is the value of the Pearson coefficient of correlation between electricity consumption and the amount of carbon emissions?
 - F. What is the value of the Pearson coefficient of correlation between electricity consumption and total population?
9. **Research hypotheses:**
 - A. There is a strong positive correlation between electricity consumption and GDP.
 - B. The correlation between electricity consumption and annual per capita GDP is moderately positive.
 - C. There is a strong positive correlation between electricity consumption and the unemployment rate.
 - D. There is a weak inverse relationship between electricity consumption and the inflation rate.
 - E. There is a strong direct correlation between electricity consumption and the amount of carbon emissions.
 - F. The correlation between electricity consumption and total population is strongly positive.

10. The methodology used in the research: The descriptive analytical approach was used [4] where the consumption of electricity in Iraq was described in the period from 2000 to 2024, as well as the description of economic indicators data for the same period, and then that data was analyzed to measure the extent of its correlation.

11. Previous studies

The first study: A study conducted by Saad Shamsi Kazim, Abdul Karim Abdullah 2021 [5] entitled "Analysis of the gap in electrical energy consumption and the fragility of economic policy in Iraq for the period from 2004-2019", Iraqi Journal of Economic Sciences 2021, and the study showed that there is a demand gap represented by a required consumption rate (required load) of (15,322 MW), while the actual consumption rate (supplied load) was (7,356 MW), meaning there is a consumption gap of (7,966 MW) during the period (2004-2019). The reason for this is due to the crises that Iraq has gone through, the fragility of the economic policy followed, and the failure to adopt alternative or renewable energy policies.

The second study: presented by Batahir Samir and Bin Muammar Abdul Basit [6] entitled "The relationship between electricity consumption and economic growth in Algeria, an econometric study for the period (1980-2012)". The study aims to measure the relationship between electricity consumption, economic growth, and oil price in Algeria during the period (1980-2012) using the simultaneous integration model, and to estimate the relationship in the long run using the method of fully corrected least squares, where the results showed that there is a simultaneous integration relationship between the variables in the long run, as well as the presence of a unidirectional causal relationship from the per capita share of electricity consumption to the per capita share of the gross domestic product, as well as the presence of a unidirectional causal relationship from the price of oil to the per capita share of the gross domestic product in Algeria.

The third study: presented by (Mona Muhammad Gharib 2022) [7] entitled "Predicting solar photovoltaic energy consumption in China using a combined application of specific and random models." The study presented a complete section on studying the correlation between solar photovoltaic energy consumption and a number of Chinese economic indicators, through the use of Pearson's correlation coefficient, Zagazig University, Egypt, March 2022, and it was found that there is a strong direct correlation between solar energy consumption and the gross domestic product. It was also found that there is a strong direct correlation between solar energy consumption and the average per capita income. It was also found that there is a strong inverse correlation between solar energy consumption and the unemployment rate.

The fourth study: presented by Ahmed Abu Al-Yazid Al-Rasoul and Ibrahim bin Saleh Al-Omar (2012) [8] entitled "The Causal Relationship between Electricity Consumption and

Economic Growth in the Kingdom of Saudi Arabia." This study aimed to determine the causal relationship between electricity consumption and economic growth in the Kingdom of Saudi Arabia during the period 1980-2009 AD, using the cointegration test and bounds test approach proposed by Pesaran et al. (2001). The main results of this study revealed the existence of a cointegration relationship between the time series data under study, namely electricity consumption, GDP, and investment. The results of the Granger causality test showed that in the long run, there is a unidirectional causal relationship extending from real GDP and investment to electricity consumption. In the short run, there is a two-way causal relationship between electricity consumption and investment, real GDP and investment, while there is a one-way causal relationship between real GDP and electricity consumption. This has significant implications for energy conservation policies, especially since the Kingdom, through the Electricity Regulatory Authority, has developed future plans to regulate the electricity industry in the Kingdom. The findings in this paper indicate that electricity conservation policies, through efficiency improvement measures and demand management policies designed to reduce waste and reduce electricity consumption, can be implemented without negatively impacting investment or real GDP in the Kingdom.

The fifth study: presented by Marwa Salah El-Din Fahmy and Mona Mohamed Gharib [9] titled "A study of the Correlation of Renewable Egypt with Specific Economic and Environmental Indicators", Arab Journal of Management, August 2022. The study concluded that there is a moderate direct correlation between renewable energy consumption and gross domestic product in Egypt, amounting to 0.638, a moderate direct correlation between renewable energy consumption and average annual per capita income, amounting to 0.565, a weak inverse correlation of -0.227 between renewable energy consumption and the unemployment rate, a weak direct correlation of 0.380 between renewable energy consumption and the inflation rate, and finally, a weak inverse correlation of -0.191 between renewable energy consumption and carbon emissions. These results largely confirm the validity of the study's hypotheses.

The sixth study: presented by Ahmed Abu Al-Fotouh Al-Naqa and others [10] entitled "The Relationship between Energy Consumption, Economic Growth and the Environment in Egypt during the Period (1980-2017): An Analytical Econometric Study", the study aimed to analyze and measure the quantitative and causal relationship between energy consumption, environmental degradation and economic growth in the Egyptian economy during the period (1980-2017). The study relied on the use of the Vector Error Correction Model (VECM) to estimate the quantitative relationships between the study variables and to determine the directions of the causal relationships between them. The study concluded that there is a relationship of mutual influence and impact between each of the energy consumption, environmental degradation and economic growth in the Egyptian economy.

The seventh study: conducted by Eyup Dogan (2015) [11] entitled "A Study of the

Relationship between Economic Growth and Electricity Consumption from Renewable and Non-Renewable Energy Sources in Turkey”, with the aim of analyzing the relationship in the long and short term and the causal relationship between economic growth and electricity consumption from renewable and non-renewable energy sources, labor, and capital for Turkey during the period (1990-2012) using the autoregressive model of distributed lags, the Johanson cointegration test, and it was found that there is a cointegration relationship between the variables, as well as the presence of a direct relationship in the long term from electricity consumption from non-renewable energy sources to economic growth, and the presence of an insignificant inverse relationship at 5% between electricity consumption from renewable energy sources and economic growth, the presence of a unidirectional causal relationship in the short term from labor, capital, renewable, and non-renewable to economic growth, as well as the presence of a relationship Long-run causality of capital, labor, renewables, and economic growth to non-renewables.

12. Research items:

Item 1: Introduction, Item 2: Research Problem, Item 3: Research Importance, Item 4: Research Objectives, Item 5: Temporal and spatial boundaries, Item 6: Research sample, Item 7: Research tools, Item 8: Study questions, Item 9: Research hypotheses, Item 10: Methodology used, Item 11: Previous studies, Item 12: Research items, Item 13: Theoretical framework of the research, Item 14: Application to the data, Item 15: Research results and recommendations, Item 16: References.

13. The theoretical framework of the research

In this study, Pearson's correlation coefficient was used to measure the correlation between two sets of data: the first set represents electricity consumption in Iraq, and the second set represents a set of Iraqi economic indicators from 2000 to 2024. The selected Iraqi economic indicators are gross domestic product (GDP), average annual per capita income, unemployment rate, inflation rate, carbon emissions, and total population. Given the different nature of the two sets in terms of the units used for measurement, standard values were used for the data to study the correlation between them.

To calculate the standard values $\{z_i, i=1, 2, \dots, n\}$ for a set of data $\{x_i, i=1, 2, \dots, n\}$ with a mean $\bar{x}$ and a standard deviation s , we use the relationship [12].

$$z_i = \frac{x_i - \bar{x}}{s}$$

Whereas:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2}$$

n is the number of data.

The correlation coefficient r between two sets of data {xi}, {yi} is calculated from the following relationship:

$$r = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\sqrt{[n \sum x_i^2 - (\sum x_i)^2][n \sum y_i^2 - (\sum y_i)^2]}}$$

The correlation coefficient is a quantitative criterion whose value lies between -1 and 1, where the calculated value of the correlation coefficient indicates the strength of the relationship between the two variables, and the sign indicates its direction and whether the relationship is direct (positive values) or inverse (negative values).

Table (1): Significance of Pearson's correlation coefficient value

Negative correlation		positive correlation	
Its significance	Correlation coefficient value	Its significance	Correlation coefficient value
negative perfect correlation	1-	perfect positive correlation	1
Strong negative correlation	-0.8 to -1	strong positive correlation	0.8 to 1
Medium negative correlation	-0.5 to -0.8	moderate positive correlation	0.5 to 0.8
Weak negative correlation	0 to -0.5	Weak positive correlation	0 to 0.5

Data source: [12][13]

14. Application to data

A. Electricity consumption in Iraq and measuring its relationship to the gross domestic product (GDP)

Gross domestic product (GDP) is the total value of final goods and services produced by a country during a specific period, usually a year. It is the sum of the current domestic output of final goods and services, expressed at market prices, over a specific period, usually a year.

$GDP = \text{Private consumption} + \text{Gross investment} + \text{Government spending} + (\text{Exports} - \text{Imports})$. [14][15]

Table (2) shows the electricity consumption and the gross domestic product in Iraq from 2000 to 2024. This data has been calibrated so that the correlation between them can be measured. Figure (1) shows the curves of the standard numbers for electricity consumption and the gross domestic product of Iraq for the same period.

Table (2): Calculating the standard figures for electricity consumption and the gross domestic product of Iraq

years	Electricity consumption TWh	Gross Domestic Product GDP (Billion \$)	Standard figures for electricity energy	Standard figures for GDP
2000	27.19	48.364	-0.986821745	-1.222985666
2001	31.72	36.176	-0.876869597	-1.364794352
2002	35.42	32.928	-0.787063207	-1.402585181
2003	26.61	21.922	-1.000899504	-1.53064117
2004	30.70	36.634	-0.901627034	-1.359465473
2005	28.34	50.065	-0.958908948	-1.203194348
2006	30.59	65.147	-0.904296954	-1.027713661
2007	32.35	88.837	-0.861578239	-0.752077972
2008	35.31	131.614	-0.789733126	-0.254362991

2009	41.29	111.658	-0.644586582	-0.48655319
2010	41.70	138.517	-0.634635063	-0.174045845
2011	42.22	185.750	-0.622013624	0.375515173
2012	47.77	218.002	-0.487304038	0.750770651
2013	62.11	234.638	-0.139243595	0.944332294
2014	71.17	228.416	0.080660702	0.871938657
2015	75.32	166.774	0.181389491	0.154727379
2016	86.32	166.744	0.448381463	0.154378326
2017	93.57	187.218	0.624353445	0.392595511
2018	100.24	227.367	0.786247667	0.85973343
2019	106.01	233.636	0.926297093	0.932673917
2020	105.54	180.899	0.914889254	0.319073268
2021	110.84	209.692	1.04353084	0.65408291
2022	117.24	287.372	1.198871624	1.557898038
2023	147.1	268.881	1.923633467	1.342753271
2024	169.5	279.641	2.46732621	1.467947024
Total	1696.17	3836.892	Correlation coefficient	
Average	67.8468	153.47568		
standard deviation	41.19974067	85.94678004		
			0.82875443	

Primary raw data source : [15][16][17]

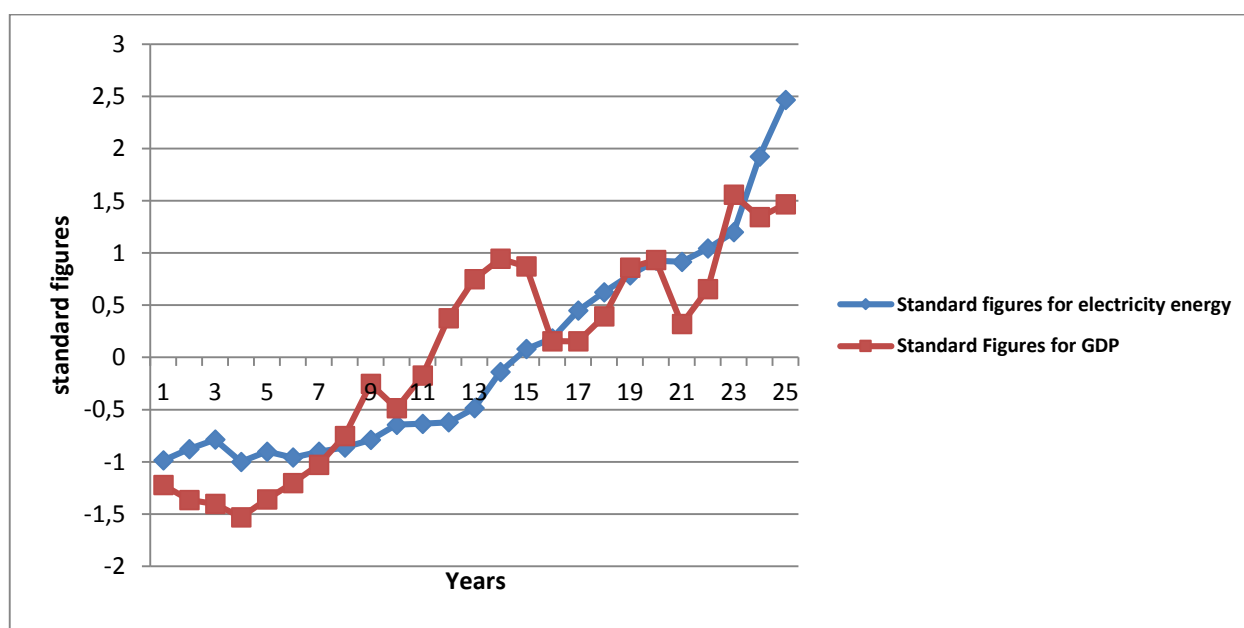


Figure (1): Standard curves of electricity consumption and gross domestic product in Iraq

The correlation coefficient between electricity consumption and GDP in Iraq from 2000 to 2024 was calculated at **0.83**, indicating a strong direct correlation between them; that is, a strong positive correlation. This means that the higher the electricity consumption, the stronger the GDP of goods and services. The explanation for the increase in electricity consumption is the result of the natural population increase and the return of immigrants who immigrated during the period of political unrest in 2003 and after. The increase in GDP may be due to the improvement in projects in the various sectors of agriculture, construction, industry, and trade, and the return of the economy to its normal path, especially since energy is the main catalyst for production and growth.

B. Electricity consumption in Iraq and measuring its relationship to the per capita share of the gross domestic product (in dollars) in Iraq

Gross Domestic Product (GDP per capita) is the average value of what each person in a country produces. It is calculated by dividing a country's GDP by its total population. It is used as an indicator of a country's average standard of living and the strength of its economy, as the per capita value of the economic product reflects. $\text{GDP per capita} = \text{GDP} \div \text{Population}$ [14][16] The following will study the relationship between it and electricity consumption.

Table (3) shows the electricity consumption and per capita share of the gross domestic product in Iraq from 2000 to 2024, and Figure (2) shows the curves of the standard numbers for electricity consumption and per capita share of the gross domestic product in Iraq for the same period. The data were calibrated so that the correlation between them and the significance of that value could be measured:

Table No. (3): Calculating the standard figures for electricity consumption and per capita share of the gross domestic product in Iraq

Years	Electricity consumption TWh	Annual GDP per capita (\$)	Standard figures for electricity energy	Standard figures for Annual GDP per capita
2000	27.19	1980.19	- 0.986821745	-1.15389779
2001	31.72	1435.70	- 0.876869597	-1.439796581
2002	35.42	1266.16	- 0.787063207	-1.528818016
2003	26.61	817.89	- 1.000899504	-1.764193965
2004	30.70	1328.37	- 0.901627034	-1.496153019
2005	28.34	1762.39	- 0.958908948	-1.268259407

2006	30.59	2276.55	- 0.904296954	-0.99828618
2007	32.35	3128.99	- 0.861578239	-0.550690145
2008	35.31	4542.97	- 0.789733126	0.191757232
2009	41.29	3714.71	- 0.644586582	-0.243142458
2010	41.70	4461.75	- 0.634635063	0.149110536
2011	42.22	5775.54	- 0.622013624	0.838950519
2012	47.77	6477.60	- 0.487304038	1.207585581
2013	62.11	6650.35	- 0.139243595	1.29829251
2014	71.17	6249.39	0.080660702	1.08775792
2015	75.32	4440.14	0.181389491	0.137763637
2016	86.32	4334.42	0.448381463	0.082252571
2017	93.57	4759.28	0.624353445	0.305336485
2018	100.24	5646.69	0.786247667	0.771294438
2019	106.01	5671.86	0.926297093	0.784510609
2020	105.54	4295.19	0.914889254	0.061653828
2021	110.84	4868.49	1.04353084	0.362680067
2022	117.24	6520.73	1.198871624	1.230232121
2023	147.1	5965.32	1.923633467	0.938599497
2024	169.5	6073.61	2.46732621	0.995460009
Total	1696.17	104444.28	Correlation coefficient	
Average	67.8468	4177.7712		
standard deviation	41.19974067	1904.485145		
			0.657372704	

Primary raw data source : [15][16][17]

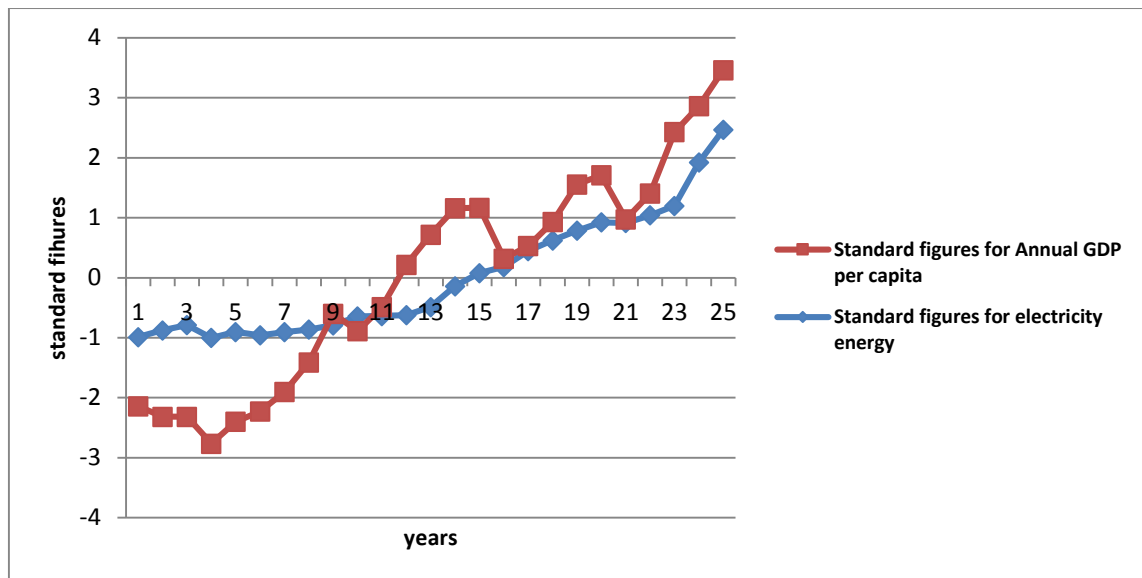


Figure (2): Standard curves of electricity consumption and per capita share of GDP in Iraq

The correlation coefficient between electricity consumption and per capita GDP in Iraq was calculated from 2000 to 2024 and reached a value of **0.66**, which means a medium direct (positive) correlation between them; that is, the more average electricity consumption is, the more average GDP is produced by each individual, as energy is the primary driver of GDP growth and development, and the more energy is consumed, the more positively it is reflected in improving the standard of living and well-being of individuals.

C. Electricity consumption and measuring its relationship to the unemployment rate in Iraq

The unemployment rate is one of the economic indicators that has important significance in formulating economic policies and evaluating their effectiveness. Countries calculate unemployment rates periodically and regularly using the sampling method; meaning that a representative sample is taken from the active segment of the population and the number of unemployed is estimated from it, and then the unemployment rate is determined. The unemployment rate is measured as the ratio of the number of unemployed people to the labor force in society or the active group at a specific point in time; that is, the unemployment rate = (number of unemployed people / total members of the labor force) * 100. [14][16][18]

Table (4) shows the electricity consumption and unemployment rate in Iraq from 2000 to 2024. This data has been calibrated so that the correlation between them can be measured. Figure (3) shows the curves of the standard numbers for electricity consumption and unemployment rate in Iraq from 2000 to 2024.

Table (4): Calculating the standard figures for electricity consumption and the unemployment rate in Iraq from 2000-2024

years	Electricity consumption TWh	Unemployment rate %	Standard figures for electricity energy	Standard figures for Unemployment rate
2000	27.19	8.1	- 0.986821745	-0.896183458
2001	31.72	8.3	- 0.876869597	-0.829897699
2002	35.42	8.6	- 0.787063207	-0.730469061
2003	26.61	9.0	- 1.000899504	-0.597897544
2004	30.70	8.7	- 0.901627034	-0.697326182
2005	28.34	8.6	- 0.958908948	-0.730469061
2006	30.59	8.4	- 0.904296954	-0.79675482
2007	32.35	8.6	- 0.861578239	-0.730469061
2008	35.31	8.5	- 0.789733126	-0.763611941
2009	41.29	8.4	- 0.644586582	-0.79675482
2010	41.70	8.3	- 0.634635063	-0.829897699
2011	42.22	8.2	- 0.622013624	-0.863040579
2012	47.77	8.0	- 0.487304038	-0.929326337
2013	62.11	9.2	- 0.139243595	-0.531611785
2014	71.17	10.6	0.080660702	-0.067611474
2015	75.32	10.8	0.181389491	-0.001325715
2016	86.32	10.8	0.448381463	-0.001325715
2017	93.57	13.0	0.624353445	0.727817631
2018	100.24	13.5	0.786247667	0.893532028
2019	106.01	14.1	0.926297093	1.092389304
2020	105.54	15.8	0.914889254	1.655818253
2021	110.84	16.2	1.04353084	1.788389771
2022	117.24	15.5	1.198871624	1.556389615

2023	147.1	15.4	1.923633467	1.523246736
2024	169.5	15.5	2.46732621	1.556389615
Total	1696.17	270.1	Correlation coefficient	
Average	67.8468	10.804		
standard deviation	41.19974067	3.017239356	0.931307472	

Primary raw data source : [15][16][17]

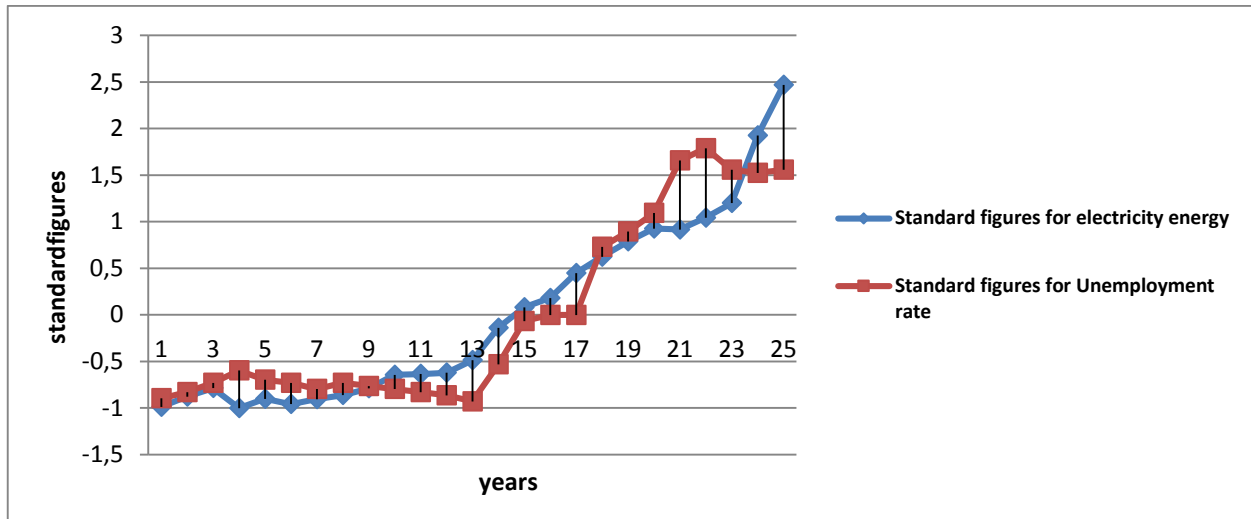


Figure (3): Standard curves of electricity consumption and unemployment rate in Iraq

The correlation coefficient was calculated and its value was 0.93, which is a strong (positive) direct correlation between them. This means that an increase in electricity consumption leads to a strong decrease in the unemployment rate due to the improvement in living standards on the one hand and industrial and service projects in particular on the other hand, which lead to the creation of job opportunities and thus a reduction in the unemployment rate. The opposite is true; meaning that a decrease in electricity consumption or interruption leads to a decrease in production in energy-intensive industries, which in turn results in a reduction in the workforce and a decrease in job opportunities (i.e. a negative impact on the unemployment rate)

D. Electricity consumption in Iraq and measuring its relationship to the inflation rate in Iraq:

The inflation rate is the rate of change in prices in the economy as a whole (the continuous increase in the general level of prices of goods and services in a particular economy) [14], and it is an important economic indicator that will be measured in relation to electricity consumption in Iraq.

Table (5) shows the electricity consumption and inflation rate in Iraq in the period from 2000-2023, as well as their standard values for the same period.

Table (5): Calculating the standard figures for electricity consumption and the inflation rate in Iraq 2000-2023

years	Electricity consumption TWh	Inflation rate %	Standard figures for electricity energy	Standard figures for inflation rate
2000	27.19	4.98	-1.008894064	-0.340414318
2001	31.72	16.37	-0.8834099	0.444666741
2002	35.42	19.32	-0.780917316	0.648002047
2003	26.61	33.62	-1.024960469	1.633661322
2004	30.70	26.96	-0.911664612	1.174606023
2005	28.34	36.96	-0.977038261	1.863878244
2006	30.59	.5323	-0.914711689	2.985324148
2007	32.35	-10.07	-0.86595846	-1.37776901
2008	35.31	12.66	-0.783964393	0.188946748
2009	41.29	6.87	-0.618314216	-0.210141868
2010	41.70	2.88	-0.606956929	-0.485161484
2011	42.22	5.80	-0.592552566	-0.283893996
2012	47.77	6.09	-0.43881369	-0.263905102
2013	62.11	1.88	-0.041585674	-0.554088707
2014	71.17	2.24	0.209382655	-0.529274907
2015	75.32	1.39	0.324340553	-0.587863045
2016	86.32	0.56	0.629048236	-0.64507264
2017	93.57	.018	0.8298783	-0.671264984
2018	100.24	0.37	1.014641959	-0.658168812
2019	106.01	-0.20	1.174474989	-0.697457328
2020	105.54	0.57	1.161455661	-0.644383367
2021	110.84	6.04	1.308269363	-0.267351463
2022	117.24	4.99	1.485553833	-0.339725046
2023	147.1	4.36	2.312696689	-0.383149196
Total	1526.67	238.05	Correlation coefficient	
Average	63.61125	9.91875		
standard deviation	36.10017275	14.50805603		
			-0.492014075	

Primary raw data source : [15][16][17]

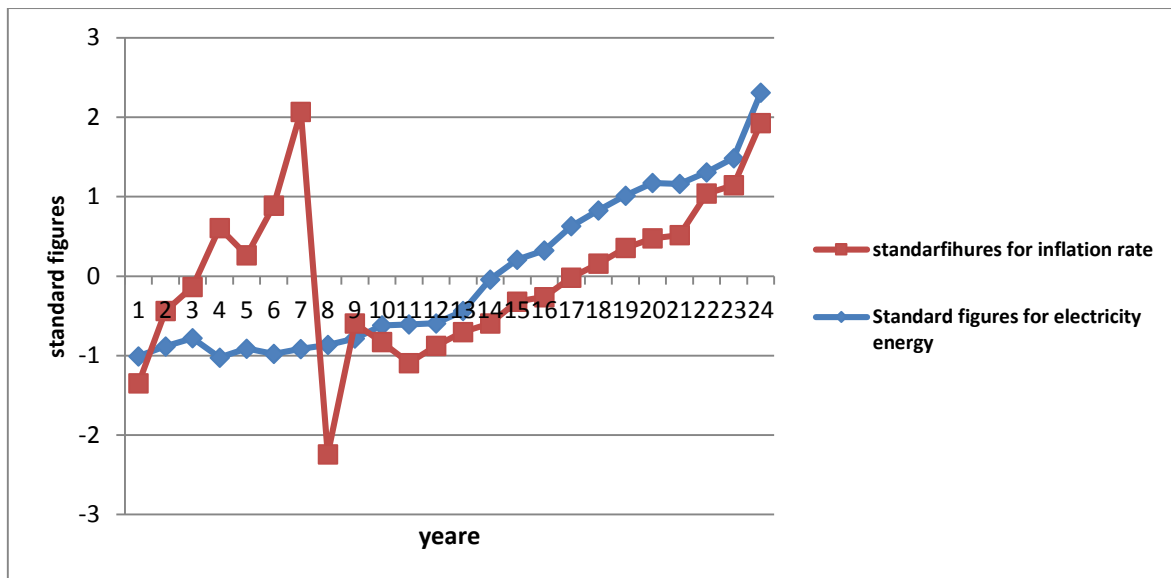


Figure (4): Standard curves of electricity consumption and inflation rate in Iraq 2000-2023

The correlation coefficient between electricity consumption and inflation rate was calculated for the period 2000-2023 and its value was **(-0.49)**, meaning that there is a weak (negative) inverse correlation between them. This means that when electricity consumption increases, the inflation rate will be low and vice versa. By observing Figure (4), we find that during the period 2000-2002, inflation increased strongly and electricity consumption increased significantly. In 2003, electricity consumption decreased and inflation rate increased. This can be explained by the fact that no new power plants or energy sources were added, and the increase in inflation was due to the unavailability of goods as a result of the political unrest during that period, as the supply of goods was low and the demand for them was high. From 2004-2006 we find that electricity consumption was almost constant while inflation was increasing due to the fact that electricity consumption was in the household sector and not the manufacturing sector. From 2007-2023 we find a sharp decline in inflation and an increase in electricity consumption. This decline resulted from the provision of goods through imports. In general, the correlation coefficient between electricity energy consumption and the inflation rate was calculated for the period as a whole and it was proven that there is a weak inverse correlation between them.

E. The relationship between electricity consumption and carbon emissions (environmental pollution)

Carbon dioxide emissions are those resulting from the combustion of fuels and include carbon dioxide produced during the consumption of solid, liquid and gaseous fuels [9] [19]. Table (6) shows the electricity consumption and total carbon emissions in Iraq from 2000 to 2023, and Figure (5) shows the curves of standard numbers for electricity consumption and the amount of carbon emissions in Iraq from 2000 to 2023.

Table (6) Electricity energy consumption and total carbon emissions in Iraq from 2000 to 2023

years	Electricity consumption TWh	Carbon emissions MT	Standard figures for electricity energy	Standard figures for Carbon emissions
2000	27.19	88.8104	- 1.008894064	-1.001024633
2001	31.72	100.6519	-0.8834099	-0.705956347
2002	35.42	95.0515	- 0.780917316	-0.84550796
2003	26.61	82.8875	- 1.024960469	-1.14861235
2004	30.70	90.321	- 0.911664612	-0.963383274
2005	28.34	87.2354	- 0.977038261	-1.040270721
2006	30.59	84.8631	- 0.914711689	-1.099384051
2007	32.35	78.4289	-0.86595846	-1.259712419
2008	35.31	90.6703	- 0.783964393	-0.954679364
2009	41.29	96.8494	- 0.618314216	-0.800707616
2010	41.70	111.4927	- 0.606956929	-0.435823654
2011	42.22	115.9058	- 0.592552566	-0.325857361
2012	47.77	133.0442	-0.43881369	0.10119988
2013	62.11	144.4097	- 0.041585674	0.384407127
2014	71.17	138.2875	0.209382655	0.231853222
2015	75.32	137.9039	0.324340553	0.222294619
2016	86.32	152.3036	0.629048236	0.58110852
2017	93.57	165.6795	0.8298783	0.914411218
2018	100.24	178.471	1.014641959	1.233151748
2019	106.01	193.6559	1.174474989	1.611531381
2020	105.54	170.4465	1.161455661	1.033196044
2021	110.84	174.8366	1.308269363	1.14258922
2022	117.24	190.4753	1.485553833	1.53227671
2023	147.1	192.9082	2.312696689	1.59290008

Total	1526.67	3095.5898	Correlation coefficient
Average	63.61125	128.9829083	
standard deviation	36.10017275	40.13138835	0.962911764

Primary raw data source : [15][16][17]

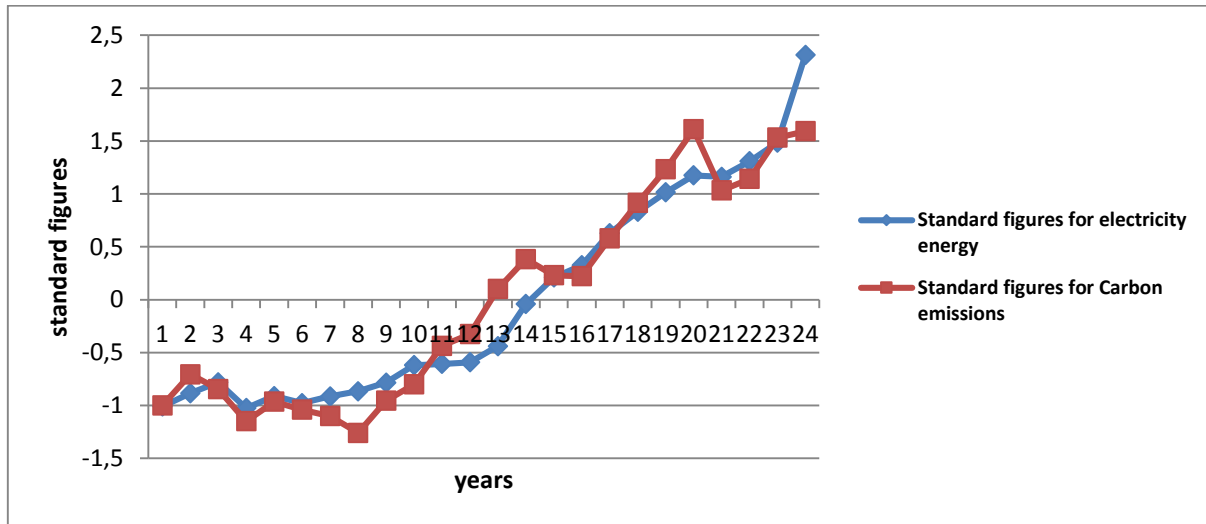


Figure (5): Standard curves of electricity consumption and carbon emissions in Iraq

The correlation coefficient was calculated for the period from 2000 to 2023 and its value was **0.96**. Its significance is that there is a strong (positive) direct correlation between them, which means that the more electricity consumption increases, the more carbon emissions increase to a large extent and vice versa. This means that there is a reliance on traditional (fossil) energy that pollutes the environment greatly in Iraq. Therefore, it is necessary to plan to introduce clean renewable energy and invest in it more to reduce environmental pollution on the one hand and to achieve sustainable energy security on the other hand.

F. The relationship between electricity consumption and the total population in Iraq

Population is considered one of the most important indicators, as it represents a quantitative numerical indicator that is used as a means of measuring the population of a part of a region or the population of entire countries. It is customary to attribute the population size indicator or “absolute number” to a specific moment in time, because the measurement of that indicator has a dynamic, time-changing nature. The census or population census was defined as the expression of population numbers collected by means of enumeration and is concerned with facts and figures [20][21].

Table (7) shows the consumption of electricity and the total population in Iraq from 2000 to 2024, and Figure (6) shows the curves of standard numbers for electricity consumption and the total population in Iraq for the same period referred to.

Table (6) Electricity consumption and total population in Iraq from 2000 to 2024

years	Electricity consumption TWh	Total population (Millions)	Standard figures for electricity energy	Standard figures for total population
2000	27.19	23636527	- 0.986821745	-1.427203485
2001	31.72	24424056	- 0.876869597	-1.315234333
2002	35.42	25197840	- 0.787063207	-1.205219416
2003	26.61	26006559	- 1.000899504	-1.090237516
2004	30.70	26802659	- 0.901627034	-0.977049759
2005	28.34	27577878	- 0.958908948	-0.866830816
2006	30.59	28407448	- 0.904296954	-0.748884367
2007	32.35	28616515	- 0.861578239	-0.719159678
2008	35.31	28391607	- 0.789733126	-0.751136606
2009	41.29	28971036	- 0.644586582	-0.668754657
2010	41.70	30058206	- 0.634635063	-0.514183203
2011	42.22	31045366	- 0.622013624	-0.373830953
2012	47.77	32161424	- 0.487304038	-0.215152266
2013	62.11	33654842	- 0.139243595	-0.002821359
2014	71.17	35281989	0.080660702	0.228522844
2015	75.32	36550059	0.181389491	0.408814264
2016	86.32	37560535	0.448381463	0.552481533
2017	93.57	38469627	0.624353445	0.681734246
2018	100.24	39337353	0.786247667	0.805105632
2019	106.01	40265624	0.926297093	0.937085173
2020	105.54	41192171	0.914889254	1.0688196
2021	110.84	43071211	1.04353084	1.3359774
2022	117.24	44070551	1.198871624	1.478061376

2023	147.1	45074049	1.923633467	1.620736528
2024	169.5	46042015	2.46732621	1.758359818
Total	1696.17	841867147	Correlation coefficient	
Average	67.8468	33674685.88		
standard deviation	41.19974067	7033446.166		
			0.965247367	

Primary raw data source : [15][16][17]

The correlation coefficient was calculated for the period from 2000 to 2024 and its value was 0.96. This indicates that there is a strong (positive) direct correlation between them, which means that the more the total population increases, the more electricity consumption increases strongly and to a large extent. This is a natural thing, as the more the population increases, the greater the demand for energy. This is due to many reasons, including, but not limited to: the improvement in the standard of living in general, the increased use of electrical appliances and modern technology, as well as the increase in industrial expansion and development, which requires energy to operate equipment and machines, and thus the increase in electricity consumption.

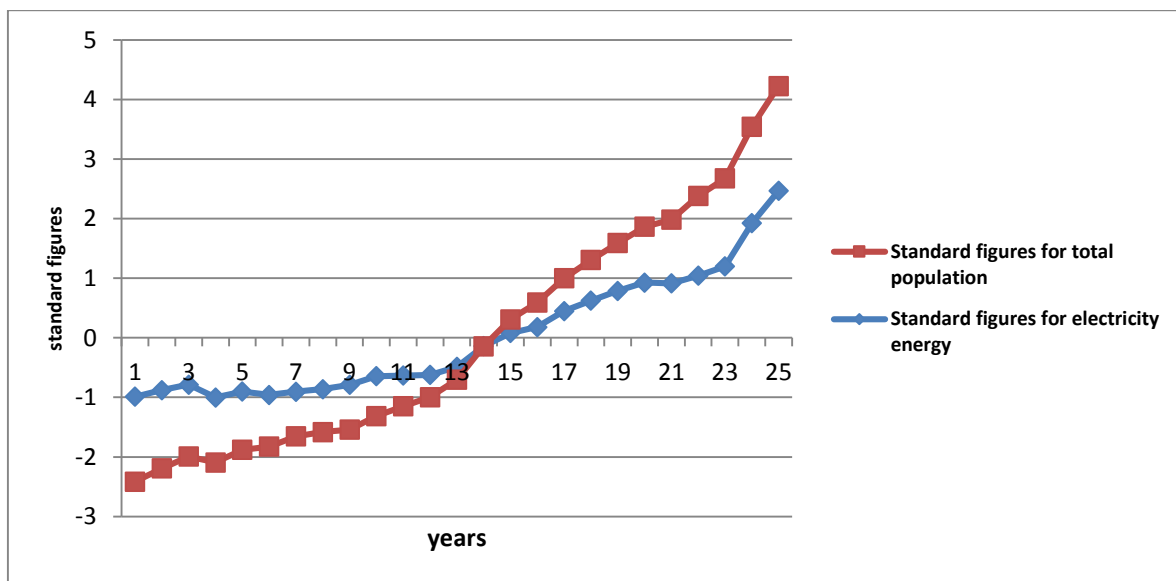


Figure (6): Standard curves of electricity consumption and total population in Iraq

15. Research results and recommendations

The research problem is to measure the relationship between electricity consumption in Iraq and a number of economic and environmental growth indicators represented by six important indicators: gross domestic product, per capita share of gross domestic product, unemployment rate, inflation rate, carbon emissions (environmental pollution), and total population in the period from 2000 to 2024, due to the utmost importance of these indicators as a basis for planning and making economic decisions, as well as their impact on the balance of payments and the trade balance, which show the state's economy and its strength. Pearson's coefficient was used to measure the correlation between two sets of data:

The first group: electricity consumption values, and the second group: selected Iraqi economic indicators, which are six indicators: gross domestic product, per capita share of gross domestic product, unemployment rate, inflation rate, carbon emissions (environmental pollution), as well as the total population indicator.

Due to the difference in the units of measurement in the two groups mentioned, the data in them were calibrated so that the value of the correlation coefficient between them could be measured and its significance interpreted.

The study concluded that there is a strong (strong positive) direct correlation between electricity consumption and the gross domestic product in Iraq, with a value of **0.83**, and a medium (medium positive) direct correlation between electricity consumption and the per capita share of the annual gross domestic product, with a value of **0.66**. It also showed a strong (strong positive) direct correlation between electricity consumption and the unemployment rate, with a value of **0.93**, and a weak (negative) inverse correlation between electricity consumption and the inflation rate for the period, with a value of **(-0.49)**, and a strong (positive) direct correlation between electricity consumption and the amount of carbon emissions, with a value of **0.96**. Finally, it was shown that there is a strong (positive) direct correlation between electricity consumption and the total population, with a value of **0.96**. These values were interpreted economically in the research above.

The research recommends increasing production in all areas of the country, whether agricultural, construction, industrial or commercial, which in turn leads to the creation of job opportunities and the subsequent improvement in the standard of living in general for individuals or citizens. This is on the one hand, and on the other hand, by increasing production and providing the supply of goods to citizens, the level of inflation will decrease. The research also recommends focusing on creating an optimal energy combination (optimum energy mix) that combines fossil fuels and clean renewable energy to reduce environmental pollution.

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