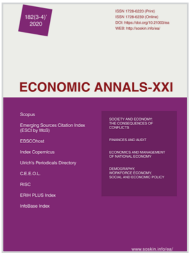

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Relation of technology and urbanization with electricity consumption in Kazakhstan

Abstract. We analyze the impact of social, economic and technical factors on power consumption in Kazakhstan. The work uses time series cointegration equation with the Granger causality test for data 1993-2019. The results show that urbanization, income levels and technology levels affect electricity consumption in the long term. Urbanization and economic growth have a strong impact on growth in electricity consumption.
In the article, the influence of growth of digital technologies use which can have bi-directional influence on the energy consumption is analyzed. In the long term, the development of digital technologies in Kazakhstan reduces the need for electricity through the use of energy-saving measures. Digitalization should stimulate the efficiency of energy systems by optimizing consumption and metering, reducing losses, generating with the lowest costs and emissions, etc.
Keywords: Electricity Market; Urbanization; Information and Telecommunication Technologies; Digitalization; Energy Consumption
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Взаємозв’язок технологій та урбанізації зі споживанням електроенергії в Казахстані
Анотація. У статті аналізується вплив соціально-економічних і технологічних факторів на споживання електроенергії в Казахстані. Відзначається тенденція зростання споживання електроенергії як населенням, так і промисловим сектором країни. Варто зазначити, що на сучасному етапі Казахстан забезпечений повною мірою електроенергією, і навіть існує певний профіцит, який планується зберігати на середньостроковий майбутній період. Відповідно до прогнозного балансу відзначається надлишок електроенергії, який, починаючи з 2020 року, варіюється від 5 млрд.кВт*год і передбачає щорічний приріст, що дозволить досягти 7,3 млрд.кВт*год. у 2025 році.
Існує кілька основних факторів, від яких в істотній мірі залежить розвиток енергетики Казахстану: скорочення споживання електроенергії за рахунок підвищення енергоефективності; модернізація наявних потужностей; конкурентоспроможність різних технологій виробництва електроенергії з точки зору собівартості; зростання урбанізації. Як показує аналіз міжнародного досвіду, реформа ринку електроенергії повинна здійснюватися цілісно. Ціноутворення залишається одним із тих аспектів, які пов’язують функціонування різних організованих секторів ринку електроенергії.

У роботі використовуються коінтеграційні співвідношення часових рядів із тестом причинності Грейнджера для даних з 1993 по 2019 рр. Результати показують, що урбанізація, рівень доходів і рівень технологій впливають на споживання електроенергії в довгостроковій перспективі. Урбанізація й економічне зростання чинять сильний вплив на зростання споживання електроенергії. У статті проаналізовано вплив зростання використання цифрових технологій, яке може мати двунаправлений вплив на споживання електроенергії.
Вплив показника ВВП на душу населення на споживання електроенергії позитивний. Значення коефіцієнта вказує на те, що збільшення змінної ВВП на душу населення на 1% приведе до збільшення споживання електроенергії на душу населення на 0,28%. У разі змінної частки населення, що використовує Інтернет, коефіцієнт є негативним (-0,043) і статистично значущим. Це означає, що збільшення користувачів Інтернету на 1% спричинить зниження споживання електроенергії на душу населення на 0,043% в довгостроковій перспективі. Найзначнішим є вплив урбанізації: збільшення частки міського населення на 1% веде до збільшення споживання електроенергії на 1,5%.
За прогнозами моделі через 5 років при збільшенні ВВП на душу населення до 13 тис. доларів США, зростанні частки міського населення до 62% і збільшенні користувачів Інтернету до 80% очікується зростання споживання на душу населення до 6800 кВт*г.
Авторами зроблений висновок про те, що в довгостроковій перспективі розвиток цифрових технологій у Казахстані скорочує потребу в енергії в результаті використання енергозберігальних заходів. Цифровізація повинна стимулювати ефективність енергосистем шляхом оптимізації споживання й обліку, скорочення втрат, генерації енергії з найменшими витратами й викидами.
Ключові слова: ринок електроенергії; енергоспоживання; енергоефективність; урбанізація; інформаційно-телекомунікаційні технології; ІКТ; Інтернет; цифровізація; Казахстан.

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Взаимосвязь технологий и урбанизации с потреблением электроэнергии в Казахстане

Аннотация. В данной статье анализируется влияние социально-экономических и технологических факторов на потребление электроэнергии в Казахстане. Отмечается тенденция роста потребления электроэнергии как населением, так и промышленным сектором страны. Стоит отметить, что на современном этапе Казахстан обеспечен в полной мере электроэнергией, и даже существует определенный профицит, который планируется сохранять на среднесрочный будущий период. В соответствии с прогнозным балансом отмечается избыток электроэнергии, который, начиная с 2020 года, варьируется от 5 млрд.кВт*ч и предполагает ежегодный прирост, что позволит достигнуть 7,3 млрд. кВт*ч в 2025 году.
Существует несколько основных факторов, от которых в существенной мере зависит развитие энергетического сектора Казахстана: сокращение потребления электроэнергии за счет принятия мер по повышению энергоэффективности; модернизация существующих мощностей; конкурентоспособность различных технологий производства электроэнергии с точки зрения себестоимости; рост урбанизации. Как показывает анализ международного опыта, реформа рынка электроэнергии должна осуществляться целостным образом. Ценообразование остается одним из тех аспектов, которые связывают функционирование различных организованных секторов рынка электроэнергии.
В работе используются коинтеграционные соотношения временных рядов с тестом причинности Грейнджера для данных с 1993 по 2019 гг. Результаты показывают, что урбанизация, уровень доходов и уровень технологий влияет на потребление электроэнергии в долгосрочной перспективе. Урбанизация и экономический рост оказывают сильное влияние на рост потребления электроэнергии. В статье проанализировано влияние роста использования цифровых технологий, которое может иметь двунаправленное влияние, на потребление электроэнергии.
Влияние показателя ВВП на душу населения на потребление электроэнергии положительное. Значение коэффициента указывает на то, что увеличение переменной ВВП на душу населения на 1% приведет к увеличению потребления электроэнергии на душу населения на 0,28%. В случае переменной – доли населения, использующего Интернет, коэффициент является отрицательным (-0,043) и статистически значимым. Это означает, что увеличение пользователей интернета на 1% приведет к снижению потребления электроэнергии на душу населения на 0,043% в долгосрочной перспективе. Наиболее значительно влияние урбанизации, увеличение доли городского населения на 1% ведет к увеличению потребления электроэнергии на 1,5%.
По прогнозам модели через 5 лет при увеличении ВВП на душу населения до 13 тыс. долларов США, росте доли городского населения до 62% и увеличении пользователей интернета до 80% ожидается рост потребления на душу населения до 6800 кВт*ч.

Авторами сделан вывод о том, что в долгосрочной перспективе развитие цифровых технологий в Казахстане сокращает потребность в энергии в результате использования энергосберегающих мер. Цифровизация должна стимулировать эффективность энергосистем путем оптимизации потребления и учета, сокращения потерь, генерации с наименьшими затратами и выбросами.
Ключевые слова: рынок электроэнергии; энергопотребление; энергоэффективность; урбанизация; информационно-телекоммуникационные технологии; ИКТ; Интернет; цифровизация; Казахстан.

1. Introduction

According to the International Energy Agency, electricity is an important source of greenhouse gas emissions, and urban growth has a strong influence on energy consumption. Cities are the driving force behind economic growth and, according to forecasts, 66% of the world's population will live in cities in 2050 (UNCCD, 2017). Urbanization creates challenges, such as increasing inequality and imbalanced development of territories. For example, the largest agglomerations of Kazakhstan, the cities of Nur-Sultan (Astana) and Almaty, are characterized by high primary energy consumption per capita (90-91 GJ) in comparison with other similar cities. Theoretical potential for energy conservation in both cities of Kazakhstan is 30-40% (World Bank, 2018). Thus, urban growth requires digital technologies and a transition to a new generation of urban energy.

In Kazakhstan, 138 power stations of different forms of properties produce electricity. The total capacity of power plants in Kazakhstan is 21 GW, and the available capacity is 18 GW.

Figure 1 shows data on heat and electricity production dynamics according to the data of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan in thousand Gcal and million kWh, respectively. It can be seen in Figure 1 that during the 90s there was a decrease in electricity production practically in two times, the minimum value is noted in 1999 - 47497.1 million kWh, in comparison with 1990 - 87379.2 million kWh. This is followed by gradual levelling and stable annual growth, which allowed reaching the level of 107459 million kWh in 2019. It should be noted that despite the stable dynamics in production, it was possible to approach the level of 1991 only by 2011, when electricity production amounted to 86585.5 million kWh.

As for heat energy, up to the current year the Republic has not managed to achieve the indicators of 1990 - 125969 thousand Gcal, with the maximum indicator being noted in 2012. - 103350.3 thousand Gcal, after that to the present stage there is a gradual decrease of the indicator and a slight increase in 2018 to 88351.4 thousand Gcal.

As shown in Figure 2, which presents data for the period from 1991 to 2019, from 1991 to 1999 there is a decrease in domestic consumption from 5641 kWh to almost 2561 kWh in 1999 of electricity consumption per inhabitant per year. Starting from 1999, consumption has been growing at a steady pace, with an average annual growth of 90 kWh per inhabitant for the period 2001-2019. However, it should be noted that despite stable growth, domestic consumption has never reached the level of 1991.

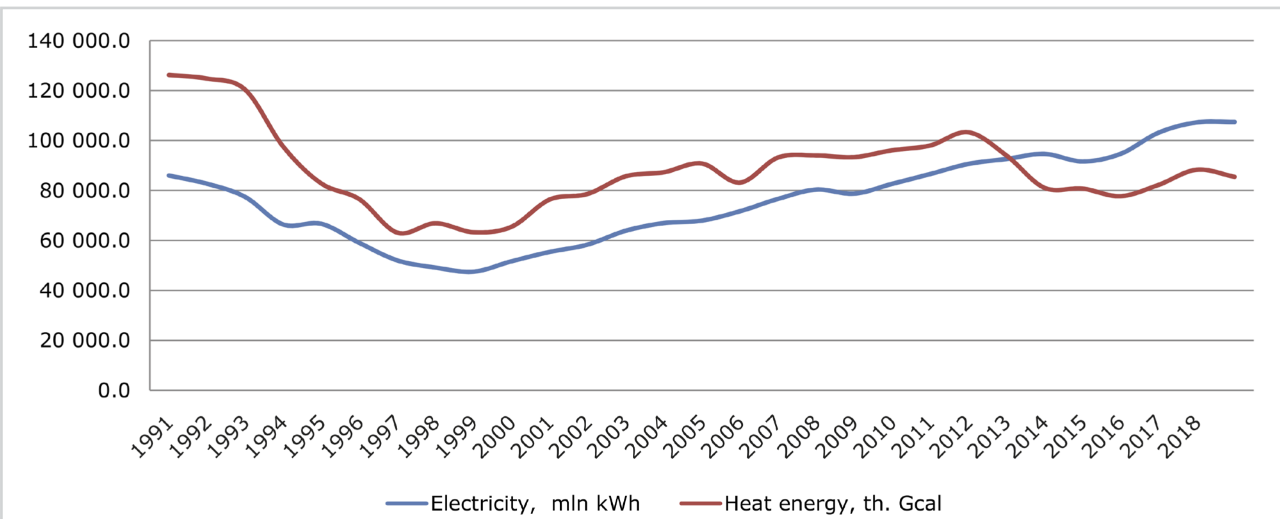

Figure 1:
Dynamics of industrial production in the section of power supply, gas, steam and air conditioning in the Republic of Kazakhstan for the period 1991-2019
Source: Compiled by the authors based on data from the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan (2020)

Kazakhstan market trends are similar for all Central Asian countries according to the UNESCAP study (2018), which describes the development of the energy sector in the region. Researches (Nazarov et al., 2018; OECD, 2015) provide an analysis of the electric power market for 2010 years and the tariff policy of Kazakhstan. The 2019 national report on achieving the sustainable development goals notes the need for the development of renewable energy sources, improving the efficiency and modernization of production technologies; implementation of energy saving and energy efficiency measures; the introduction of incentive tariff methods (Ministry of National Economy of the Republic of Kazakhstan, 2019).

In comparison with other countries the cost of utilities in Kazakhstan looks as follows (according to the Ministry of National Economy of the RK): the cost of electricity in Kazakhstan is 0.03 US cents (kWh), while in Belarus - 0.06 US cents, in England - 0.17 US cents, in Germany - 0.35 US cents (Zhumangarin S., 2018; KUS, 2018). Prices affect the energy efficiency investments, as energy prices have a significant impact on the use of the latter for space heating and water heating, as well as on the share of electricity used for the needs of other types of energy.

Another factor affecting electricity consumption is the growth of utility consumers. Electricity consumption is also affected by the growth of the share of urban population, which, like electricity consumption per resident, has been growing at a steady pace since 1999 and until now. Analyzing the data, it can be noted that the growth has been observed since 1994, but it is not as evident as in the subsequent period (Figure 3).

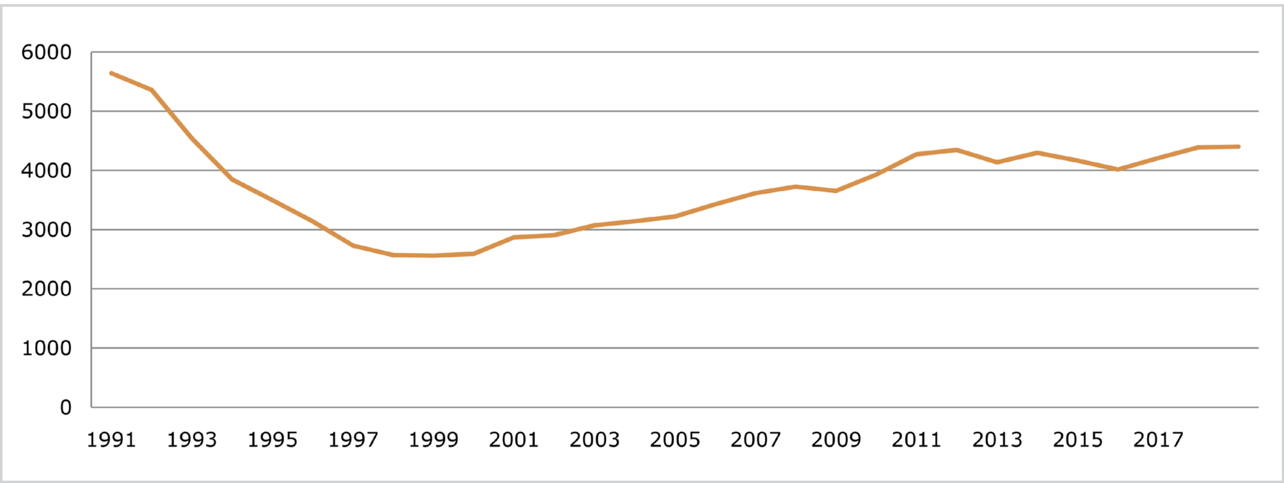

Figure 2:
Dynamics of electricity consumption per capita (kWh)
Source: Compiled by the authors based on data Enerdata and Committee on Statistics MNE RK (2020)

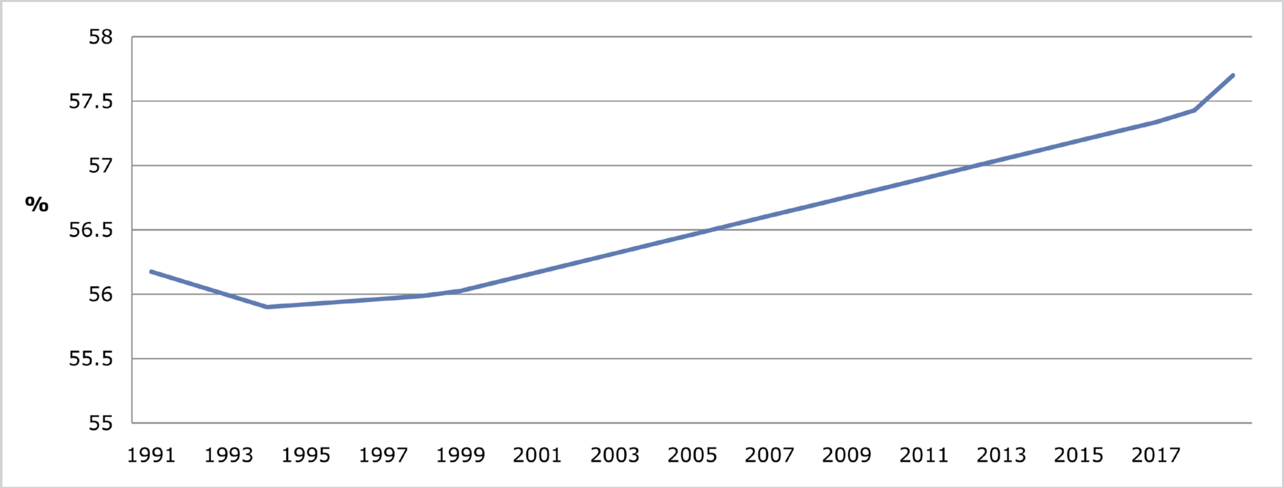

Figure 3:
Dynamics of the share of urban population (%) of Kazakhstan for 1991-2019
Source: Compiled by the authors based on data of the World Bank (2020)
and Committee on Statistics MNE RK (2020)

As noted above, there is an increasing trend of electricity consumption by both the population and the industrial sector of the country, which is covered by annual increasing production. It should be noted that at the present stage Kazakhstan is fully supplied with electricity and there is even a certain surplus, which is planned to be maintained for the medium term future period, as can be seen from the data in Table 1.

According to the forecast balance (Table 1), there is an excess of electricity (surplus), which starting from 2020 varies from 5 billion kWh and assumes an annual increase, which will reach 7.3 billion kWh in 2025. At the same time, it should be taken into account that there is a deficit of electricity in the Southern zone, with an excess in the Northern zone. The deficit is due to the fact that in the southern zone the population density is several times higher than in the northern zone due to the location of large cities and settlements.

Thus, there are several main factors on which the development of energy sector in Kazakhstan depends to a significant extent: reduction of electricity consumption through energy efficiency measures; modernization of existing facilities; competitiveness of various energy generation technologies in terms of cost, and increased urbanization of the population. As the analysis of international experience shows, electricity market reform should be carried out in a holistic manner. Pricing remains one of the aspects that connects the functioning of different organized sectors of the electricity markets.

Table 1:
Forecast balance of electric energy of the Unified Electric Power System of the Republic of Kazakhstan (bln. kWh)

Name	Forecast					
	2020	**2021**	**2022**	**2023**	**2024**	**2025**
Power Consumption	108.8	110.7	112.7	114.5	118	120.8
Electricity generation	113.8	113.5	116.1	120.9	123.5	128.1
Deficit (+) surplus(-)	**-5.0**	**-2.8**	**-3.4**	**-6.3**	**-5.5**	**-7.3**

Source: Compiled by the authors based on data of the Ministry of Energy of the Republic of Kazakhstan (2020)

2. Brief Literature Review

Urbanization is considered by many authors in relation to changing energy consumption. However, it is important to understand the meaning of the word «urbanization» itself in the context of this study. For example, Morikawa (1989) defines urbanization as the transformation of the lifestyle of rural populations combined with the expansion of urban development, and Pachauari & Jiang (2008) argues that urbanization is accompanied by an increase in the urban population associated with urban growth.

Wang & Yang (2018) define the level of urbanization as an indicator that is measured by the percentage of urban population to the total population. Franko et al. (2017) believe that the degree of urbanization can be measured using the percentages of urban and rural populations. The urban-rural population ratio is an indicator to estimate the number of urban population per each rural inhabitant within a geographical area (Franco et al., 2017).

Ayinde et al (2019) define urbanization as the gradual growth of people living in urban areas. They note that urbanization has an impact on energy consumption because urbanization involves increasing transport units, electricity and hot water consumption. Nevertheless, growth of energy consumption encourages the development of energy-saving technologies that can reduce or eliminate the growing effect of energy consumption due to urbanization. However, it was noted in Nigeria that there were no short-term causal links between energy consumption, economic growth, industrial growth and urban growth. One of the possible reasons for this interrelation is that energy consumption has been at a very low level for many years and therefore there is a low correlation between economic growth, urbanization and industrialization (Ayinde et al, 2019).

Wang et al. (2015) noted that in China, urban population consume about three times as much energy as rural population and rapid urbanization has led to huge energy demand. The authors have concluded that the impact of urbanization on the growth of electricity consumption in the residential sector depends on the level of income and the degree of urbanization (Wang et al., 2015).

Su (2020) assessed the impact of urbanization on energy poverty rates in relation to electricity demand among Taiwanese people. This study attempted to assess the impact of the number of people moving from rural to urban areas (urbanization) on energy demand. It was concluded that, given the overwhelming cost of replacing high energy efficiency appliances, low-income households could continue to use their old and inefficient technologies. This indicates that the growth in the number of households with low income has a positive impact on electricity consumption, and when making such calculations it is worth paying attention to the significant income gap between urban and rural populations (Su, 2020).

Franco et al. (2017), the case of India, notes that income levels have a significant impact on energy consumption and emissions from urbanization and industrialization. In India, energy consumption and emissions are growing much faster than urbanization.

Summing up the authors' research, it is necessary to note that the growth of urbanization and income tends to increase energy consumption. But the degree of influence also depends on population density and income gap, and may also depend on the specific conditions of each country.

Koliesnichenko & Yuryeva (2019) noted the importance of tariff formation in the electricity market. Pricing remains one of the aspects that link the functioning of the various organized sectors in the electricity markets. Thus, reforming the tariff formation system at one of these markets, to a certain extent, causes a reaction at another or several other markets (Koliesnichenko and Yuryeva, 2019).

Another factor with a dual impact on electricity consumption is the increasing use of information and communication technologies and household appliances. Over the past two decades, the ICT industry has grown very rapidly with the Internet, mobile phones and digital computers, online services and entertainment, increasing demand for electricity.

Walker (1985) noted that as the economy moves towards greater use of information technologies, the overall demand for energy will tend to decrease, but greater use of information technologies will increase the consumption of electricity in the economy.

Houghton (2010) notes that ICT has a positive impact on dematerialization of transport and travel substitutes, online delivery, energy efficiency in production and use, product management and recycling, and on many applications for process monitoring and management.

Romm (2002) talks about two different effects underlying the relationship between energy consumption and economic growth. First, the ICT sector consumes less energy than the productive sector. Second, the Internet is becoming a key factor for improving efficiency in every sector of the U.S. economy. Romm (2002) also noted that the Internet seems to contribute to energy efficiency, not to the increase in demand for electricity.

Takase and Murota (2004) note that increasing information technology reduces the energy intensity of the economy. Collard et al. (2005) noted the relationship between ICT and energy consumption. Their results show that the impact of communication technologies is greater than that of information technologies on energy use. Cho et al. (2007) showed that investment in ICT in manufacturing industries, which typically consume more energy, increases the replacement of production factors to electricity. The results also show that investment in ICT in the small production and service sectors affects the increase in consumption of electricity, while investment in ICT in some industries helps to reduce electricity consumption. They noted that electricity prices significantly affect the consumption of electricity in the industrial sector in South Korea (Cho et al., 2007).

In the case of Denmark, Ropke et al. (2010) states that the integration of ICT into everyday practice leads to increased electricity consumption. Muhammad Shahbaz et al. (2014) examined the relationship between information and communication technology (ICT), economic growth and electricity consumption using UAE data for the period of 1975-2011. They have found that ICT increase the demand for electricity, but electricity prices reduce it. Saidi et al. (2015) studied the impact of ICT and economic growth (GDP) on electricity consumption (EU) for a global group of 67 countries using the dynamic panel data model. This study concludes that there is a positive and statistically significant impact of ICT on electricity consumption.

Salahuddin and Alam (2016) investigated the short and long-term effects of ICT use and economic growth on electricity consumption using OECD panel data for the period of 1985-2012. The results confirm that both use of ICT and economic growth stimulate electricity consumption, and growth of electricity consumption causes intensification of economic growth.

Rahimi M. at al. (2017) examined the short and long-term impacts of Internet use and economic growth on electricity consumption, using group data for developing 8 (D-8) countries for the period of 1990-2013. They believe that Internet use only affects electricity consumption in the long term. However, economic growth affects electricity consumption both in the short and long term.

Thus, the ICT industry, through the spread of computer and software technologies, can lead to increased energy consumption. However, the spread of communication technologies has an impact on reducing energy consumption at the sector level. According Global e-Sustainability Initiative (2008), the ICT industry could generate approximately 7.8 GtCO2 emissions savings by 2020. This represents a significant reduction below the levels of 1990, which will bypass dangerous climate change by 2020 according to scientists and economists.

3. Purpose

The purpose of this work is to determine the influence of factors on electricity consumption. In accordance with the experience gained, the following functional form of the model is proposed:

$$ELUSE = f(GDP, INT, URBAN)\ . \quad (1)$$

Assuming a log-linear form of both sides of equation (1), we obtain the following equation:

$$lnELUSE = \beta_0 + \beta_1\, lnGDP + \beta_2\, lnINT + \beta_2\, lnURBAN + \varepsilon_{it}\ , \quad (2)$$

where:

ln stands for natural logarithm;

parameters β_1, β_2 represent long-term elasticity of electricity consumption relative to GDP per capita, persons using the Internet (% of population);

$lnELUSE$ - logarithmic electricity consumption per capita;

$lnGDP$ - logarithmic value of GDP per capita;

$lnINT$ - logarithmic use of Internet;

$lnURBAN$ - logarithmic urbanization level.

Annual electricity consumption data are measured in kWh per capita and GDP per capita is measured in current US dollars. The ICT variables in this study include people using the Internet (% of population) as the only quantifiable factor for the influence of digital technologies in Kazakhstan statistics. All data was obtained from the World Bank database.

The following main hypotheses were tested during the research process:

- increased use of digital technologies has a bi-directional effect on electricity consumption: increased use of digital technology increases consumption, but its development on the other hand leads to the replacement of technologies with energy-saving ones;
- variable of GDP per capita through income growth and urbanization through consumer growth are positively related to electricity consumption.

Empirical testing of hypotheses in our case is reduced to a test for the presence and direction of the long-term relationship between the variables.

4. Results

The authors use Granger causality test to study the causal relationships. The idea of the test is that the values (changes) of X_t time series, which is the cause of changes in Y_t time series, should precede the changes of this time series, and should also make a significant contribution to the forecast of its values (Granger and Clive, 1969).

In Granger test two null hypotheses are consistently tested: «x is not the cause of y by Granger» and «y is not the cause of x by Granger». To test these hypotheses, two regressions are built: in each regression the dependent variable is one of the variables tested for causality, and fixed variables are lags of both variables (actually, it is a vector autoregression).

To avoid the problem of false regression in the analysis of data with an obvious upward trend, the procedure of time series stationarity estimation is used. The stationarity of a time series is assessed by means of a unit root test. Dickey and Fuller unit root test was used in this study (Dickey and Fuller, 1979; 1981). Augmented Dickey-Fuller test is based on a regression of the following type:

$$\Delta y_t = \delta + \beta_t + (\rho - 1)\, y_{t-1} + \sum\nolimits_{i=1}^{k} \Delta y_{t-i} + \varepsilon_t\ . \quad (3)$$

The null hypothesis is that the row is nonstationary ($\rho = 1$, row is stationary in differences). If the hypothesis is rejected, the time series variable is stationary. Conclusions on the adoption of a particular hypothesis are made on the basis of McKinnon one-sided distribution.

The null hypothesis of non-stationarity must be rejected if the absolute value of t-statistics is less than the critical value, which always has a negative value, at the set level of significance. Cointegration methods for empirical estimation of model parameters were used. This is due to the fact that the vast majority of macroeconomic indicators of the economy are nonstationary variables, which makes it impossible to apply traditional methodology due to the danger of obtaining the phenomenon of «false regression».

Cointegration refers to a stationary combination of nonstationary economic variables. In contrast to stationary time series, non-stationary series is not characterized by a tendency to return to its stationary value or some trend. If the stationarity test is successful, the economic dependence is considered statistically proven. Through cointegration, for example, dependencies between inflation, GDP, money supply, consumption, income levels and many other economic dependencies with noise variables are confirmed.

The concept of cointegration is based on the idea that in some cases the absence of stationarity in a multidimensional process is caused by a general stochastic trend, which can be eliminated by taking a certain linear combination of process components, resulting in a stationary linear combination (Engle and Granger, 1987; Johansen, 1991).

The results of Granger causality test are presented in Table 2. The criterion for accepting the hypothesis is the so-called P-value. If the P-value is less than 0.05, the null hypothesis is rejected. At the same time, the presence of the opposite causal relationship is also checked.

The presented data show that direct causal dependence of electricity consumption per capita on variables: persons using the Internet (%), level of urbanization (percentage of urban population) and GDP per capita affects electricity consumption rather than vice versa according to the test results (Table 2).

The stationarity of the time series is analyzed firstly. In accordance with the basic idea of cointegration, it is necessary to determine the order of integration of each variable before switching to cointegration methods. The results in Table 2 indicate that the hypothesis of nonstationarity of time series is accepted at 1% of the significance level. When these tests are applied to the first differences of these variables, the unit root hypothesis is rejected.

The level results show that all variables are nonstationary at 5% of significance level (Table 3). The test results show that the first difference between these variables is stationary. This implies that energy consumption, GDP per capita, the indicator of persons using the Internet (%) are integrated in the first-order.

Johansen cointegration test was used to evaluate long-term relationships between nonstationary variables. The results of the calculations are shown at the bottom of Table 3. OLS method is not suitable for determining cointegration vectors in nonstationary variables. A more suitable test for the components of cointegration vectors is Johansen probability relationship, or Trace test, which attracts an error correction model to determine independent cointegration vectors and to check their stationarity. Statistics of Maximum Eigenvalue is used to test the hypothesis that the rank is equal to r against the hypothesis that the rank is equal to $r + 1$.

Table 2:
Granger Causality Test

Null hypothesis	F-statistics	P value
lnINT is not Granger cause of lnELPOWER	7.122	0.0053
lnURBAN is not Granger cause of lnELPOWER	9.620	0.0014
lnGDP is not Granger cause of lnELPOWER	4.041	0.0355

Source: Compiled by the authors

Table 3:
Unit root test

	Augmented Dickey-Fuller test (ADF)		Integration procedure
	Row	First-order difference	
lnINT	0.402	-6.021	I(1)
lnGDP	1.198	-2.721	I(1)
lnELPOWER	0.423	-2.681	I(1)

Source: Compiled by the authors

According to trace statistic (61.155 and P = 0.0018) and eigenvalue statistic (40.556 and P = 0.0018) of Eviews econometric software, we have only one cointegration equation at 5% of significance level, that can be interpreted as a long-term equilibrium between these variables. In this case, we can interpret the results as opposed to a possible case in several cointegrating vectors, where it is difficult to identify the combination that interprets the economic equilibrium.

Thus, the study concludes that there is a long-term relationship between electricity consumption, economic growth, urbanization and ICT use.

The result was an equation:

$$LnELUSE = 0.285\ LnGDP - 0.0428\ LnINT + 1.488\ LnURBAN \quad (4)$$

$$t \qquad 5.495 \qquad -2.315 \qquad 14.570$$

$$R^2 = 0.90\ .$$

All coefficients are significant at least at 5% of significance level. All variables in the model have been pre-tested for stationarity and the validity of the selected econometric model evaluation method has been established.

The impact of GDP per capita on electricity consumption is positive. The value of the coefficient indicates that an increase in the GDP per capita variable by 1% will increase electricity consumption per capita by 0.28%. The coefficient for the variable is statistically significant, as t statistic value is 5.5. In case of a variable of population using the Internet, the coefficient is negative (-0.043) and statistically significant. This means that a 1% increase in internet users will lead to a decrease in per capita electricity consumption by 0.043% in the long term. The most significant impact of urbanization, the increase in the share of urban population by 1% leads to an increase in electricity consumption by 1.5%.

According to the model forecasts in 5 years with GDP per capita increase up to USD 13 thousand, growth of the share of urban population up to 62% and increase of internet users up to 80% the growth of consumption per capita up to 6800 kWh is expected (as compared to the forecast of the Electrical Balance of 6500 kWh).

5. Conclusion

In this study the factors influencing consumption of the electric power in Kazakhstan since 1993 are considered. Despite previous studies, estimating the demand for electricity in a particular country is important, as impact factors, such as resource endowments, socio-economic and climatic conditions, are different in countries. We use a different of econometric methods, such as Granger causality test, cointegration methods. Unit root test confirms that all series in the study are stationary in first-order difference.

Following the trend of reducing greenhouse gas emissions around the world, Kazakhstan is obliged to reduce the use of electricity, and this article discusses the factors that influence electricity consumption. The authors applied a model of relation between electricity consumption and urbanization, GDP, growth of Internet users. The results of cointegration methods confirm the interrelationship between variables and show a positive relationship between electricity consumption, urbanization and economic growth in both the short and long term. The results show that the growth of Internet users as a parameter of digital technology development has a negative impact on energy consumption in the long run, which may be due to the replacement of modern energy-saving equipment. But the coefficients show that user growth has no greater impact on GDP per capita, reflecting the impact of economic growth and increasing urbanization. Economic growth has a positive and statistically significant impact on energy intensity through increased incomes and an urbanized population.

We assume that the effect of reducing energy intensity benefits mainly from the following channels of the ICT industry, which is closely linked to the growth of digital users:

- optimization of industry and networks structure;
- due to lower operating and maintenance costs.

The presented measures correspond to the current trends in energy management. Thus, the energy approach assumes transformation of the electric power industry based on distributed architectures. This approach assumes significant use of distributed renewable energy with attraction of private investments. It is the private investment that makes it possible to form decentralized markets. The active involvement of the private sector in the energy sector implies the use of intelligent management systems and the increased contribution of consumers with renewable energy sources, which in this case can act as electricity suppliers.

For example, in Estonia, the large energy holding Eesti Energia and the operator of electricity networks Elering are actively implementing digital technologies and digital services, allowing users to analyze online their electricity consumption and set the tariff package, sell electricity from their own solar panels (EnergyNet, 2018).

Another possible factor is an increase in reduced electricity tariffs, but this factor was not statistically significant in model under selection variables. It is important to help consumers to replace their old devices with more efficient ones, which will also create additional energy savings in the context of increasing population density in cities and changing consumer behavior.

It should also be borne in mind that, based on calculations and research, despite the impact of ICT use on energy efficiency, the effects presented may not be justified against the background of increasing urbanization. Urbanization has a greater impact on the growth of energy consumption, which probably determines the need to implement measures aimed at energy conservation as well as the development of renewable energy sources.

Based on the study, we can forecast an increase in electricity consumption as a result of urbanization growth (increase in per capita consumption up to 6800 kWh), which is confirmed by previous studies (Ayinde, et al, 2019; Su, 2020; Nazarov et al., 2018). However, investments and other consistent support of the digital technology and renewable energy industries can reduce energy consumption and optimize peak loads in networks in cities (confirms the conclusions of Takase and Murota, 2004), which requires the development of blockchain technologies that actively use small energy companies: LO3 Energy in the USA, Power Ledger in Australia, Verv and Piclo in the UK, EnerPort in Ireland (EnergyNet, 2018).

This is particularly true in the southern zone, where population density is several times higher than in the northern zone. In the southern zone there are two large cities and a belt of settlements around them, which form pole of attraction of rural population. For future studies, it is assumed that the proposed analysis can be expanded by including the assessment of the impact of other ICT indicators, the development of renewable energy sources, especially in hard-to-reach areas in the southern Kazakhstan, where there is a potential for their development.

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