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Economic growth and electricity consumption in Mongolia

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Abstract: The energy industry being one of the most important, sectors of economy has a direct impact on all the development processes of the national economy as a whole. The article provides analysis that demonstrate inter-dependence between macroeconomic indicators and the Energy Systems peak load and level of electricity consumption. Thus was developed a multi-dimensional linear regression model of peak load and the consumption level.

Keywords: economic growth, electrical power load, electricity production, mathematical model, correlation analysis, regression analysis, and planning

I. INTRODUCTION

The electric power industry ensures vital activity of all sectors of the national economy, and largely contributes tothe formation of the main financial and economic indicators of the country. Its effective management creates necessary prerequisites for bringing the country's economy to the path of sustainable development, ensures stable welfare and living standards of the population.

The planning of the power load and consumption could be regarded as an issue of primary concern in the energy sector. This can prevent from the shortage of power sources and effectively help in solving many other cardinal problems.

There are several ways and methods of planning the power consumption. Currently the probability statistical approach is regarded as the most promising one. In the scope of this paper, the power load and consumption will be analyzed in a close relationship to macroeconomic indicators, with a purpose of designing mathematical models, while planning and determining their levels of inter-dependence.

II. ECONOMY

However, the economy of Mongolia decreased by 8.7% in 1991, it grew by 6.4% in 1995. In 2000, it increased by 1.1%, in 2005 – by 7.3%, in 2010 – by 6.4% and in 2016 – by 1.2%. In 2017, Gross Domestic Product (GDP) increased by 5.1% compared to the previous year.

GDP per capita at current prices in 2017 reached 8.8 thousand tug. The World Bank Atlas method shows that GDP per capita in 2017 reached 3.8 US dollars, which is 4.6 times higher than in 2000. In 2016, the supply of goods and services amounted to 55.4% trillion tugriks.

In 1991-2018, the annual growth of the country's economy was 4.6%, and the geometric mean was 5.3%, while the error in the annual growth standard was noted at a relatively high level of 5.7% (Figure 1). The country's economy in 2011 rose to an unprecedented height reaching 17.5%, which nominated Mongolia to the 5 fastest growing countries in the world. However, by 2016 it fell down to only 1.2%.

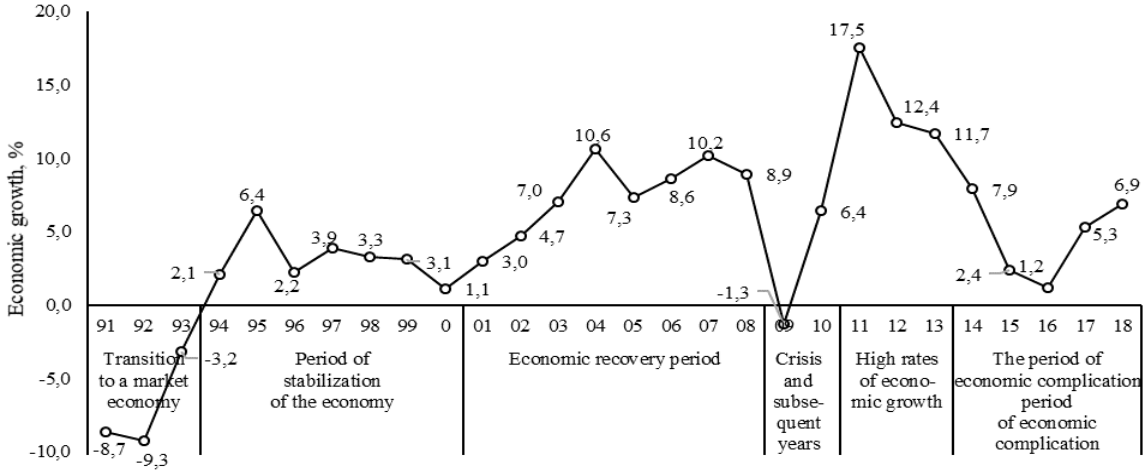

Fig. 1. A dynamic economic

III. ENERGY

In 2018, the power generation by Mongolian power plants amounted to 6535.3 million kWh [1].

The volume of domestic production fell significantly - from 94% in 2010 to 79% in 2017, while imports continued to grow due to increased demand for energy in the industrial sectors (including the Oyutolgoi copper and gold deposits), at the transport and by population.

In 2018, gross domestic product increased by 16.2% compared to 2017 (Figure 2).Electricity production in 2018 compared with the previous 2017, increased by 8.4%, including:

- Thermal power plants – 6062.8.0 million kWh (1.0%);
- Diesel power stations – 3.7 million kWh (0.1%);
- Solar sources – 51.1 million kWh (0.8%);
- Hydroelectric Power Stations – 78.7 million kWh (1.2%);
- Wind power stations – 339.0 (5.2%);

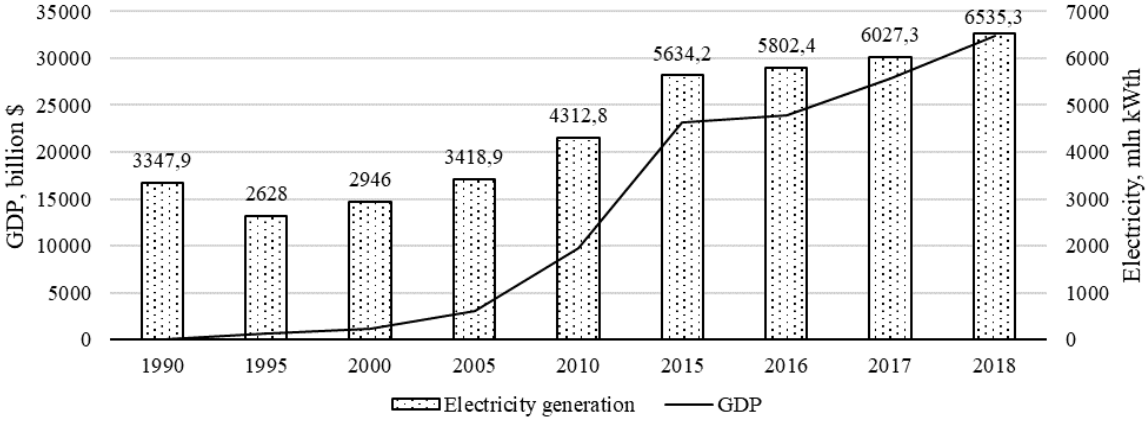

Fig. 2. GDP and electricity growth

IV. THEORETICAL PART

The level of energy consumption as regards the time factor, raises with a high rate and this trend continues for a relatively normal growth. In addition, the consumption level stays in a close correlation dependence with the macroeconomic indicators of the country.

Here was used a methodology of multi-dimensional linear regression. When analyzing the economic situation of Mongolia the following two indicators were taken into account:

1. The gross domestic product(GDP);
2. Gross national income(GNI);

GDP is a market value of all officially recognized final goods and services produced within the country in a year or over a given period. GNI is a measure of income produced by a nation. Here is a CES peak load multi-regression linear model analyses is used. This is one of the important issues. In other words, these are the model variable selection and the determination of the time interval of model variables. Here is an often-used correlation analysis methodology and the purpose is to determine what variable is related to the dependent parameter for establishing correlation between independent parameters.

A model of planning the produced electricity

$$P_{\max}(GDP, GNI, t) = a_0 + a_1 GDP + a_2 GNI \quad (1)$$

The above (1) model is worked out with the use of dependent variables based on the initial observation, which were summarized in the Table I.

Table I. Macroeconomic and energy system indicators of Mongolia in 2004-2018 (at current prices)

№	Year	Macroeconomic indicators		Energy System	
		GDP	GNI	Peak load	Produced electricity
		Billions of tug.		*MW*	*Million kWh*
1	2004	2152.1	2312.3	550	3297.0
2	2005	2779.6	2878.4	576	3450.5
3	2006	3715.0	3755.5	585	3558.5

4	2007	4599.5	4583.6	638	3724.1
5	2008	6555.6	6353.6	673	4006.5
6	2009	6590.6	6309.1	695	4033.9
7	2010	8414.5	7654.4	729	4312.7
8	2011	11087.7	10020.5	782	4522.8
9	2012	14012.9	12724.1	863	4856.3
10	2013	17550.2	16384.4	910	5132.2
11	2014	22227,1	20420,1	969	5391,9
12	2015	23150,4	21251,4	965	5634,2
13	2016	23942,8	21971,1	975	5802,4
14	2017	27876,2	23951,3	1100	6027,3
15	2018	32411,2	28564,1	1117	6535.3

V. SURVEY RESULTS

When summing up the above data, the correlation method was used for the analysis of the country's economic situation in 2001-2012. In this way, the time interval was determined. Due to the sudden transition to the market economy system in 1990, the major macroeconomic indicators, energy system power load and consumption showed reduction till 1994. The growth started from 1996 and since 2001, the economy has been developing in a faster way.

Table II shows the results of correlation coefficient of strong and weak sides of dependence between macroeconomic indicators, the power load and consumption level. The results prove that these findings are closely related to the correlation.

Table II. Macroeconomic indicators and the power peak load and consumption level

	GDP	***GNI***	**Peak load**	**Produced electricity**
GDP	*1.000*			
GNI	*0.994*	*1.000*		
Peak load	*0.993*	*0.987*	1.000	
Power production	*0.994*	*0.986*	0.993	1.000

Multi-dimensional linear regression model was designed based on the relevant year's peak load and produced electricity. The following models were used as testers and suggested for planning the load and consumption level.Table III shows the multi-dimensional linear regression model and degree of accuracy.

TableIII. Multi-dimensional linear regression model and degree of accuracy

№	**Power load and multi-dimensional linear regression models of consumption**	**Fischer criterion, F_{cal}**	**Correlation coefficient, R**
1	$P_{max}(t)=539.55+0.018GDP-0.0005GNI$	438.4	0.99
2	$E_{prod}(t)=2883.55+0.146GDP-0.03GNI$	610.5	0.99

The degree of accuracy of these models could be tested with the use of the method developed by Fisher as well as by the multi-dimensional correlation analysis. These methods are proven to be possible to improve the planning of Mongolian energy sector. Table IV shows the possibility of planning the electricity production and the power load till 2025.

TableIV. Planning results of energy system peak load and the production of electricity

№	**Year**	**Macroeconomic indicators**		**Energy System**	
		GDP	GNI	Peak load	Produced electricity
		Billion tug.		*MW*	*Million Wh*
1	2019	35384,27	31827,55	1185,75	6971,21
2	2020	38885,61	35210,53	1249,57	7367,74

3	2021	42542,13	38766,57	1316,21	7781,07
4	2022	46353,85	42495,66	1385,67	8211,18
5	2023	50320,75	46397,80	1457,95	8658,08
6	2024	54442,85	50473,00	1533,04	9121,78
7	2025	58720,13	54721,25	1610,95	9602,26

VI. CONCLUSION

In the scope of this report, the following issues were resolved:

Analyzed was dependence between macroeconomic indicators (GDP and GNI) and the energy system, thus proving their close correlation dependence.

High peak load and consumption models were developed with the help of using multi-step regression analysis.

Peak load and the electricity production were planned until 2025 based on the above models. In case if GDP grows on average by 1.2% annually, the research results showed that the peak load in 2025 could be around 1610.95 MW and the electricity production may reach 9602.26 million kWh.

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