ЕЛЕКТРИФІКАЦІЯ ТА АВТОМАТИЗАЦІЯ ГІРНИЧИХ РОБІТ

УДК 621.311
DOI: 10.20535/2079-5688.2017.32.86495

V.S. Stepashko, doctor of technical sciences, professor, **A.R. Trachuk,** postgraduate (Igor Sikorsky Kyiv Polytechnic Institute)

METHODOLOGY OF ANALYSIS AND FORECASTING OF THE ELECTRICITY CONSUMPTION IN UKRAINE BY USING THE GROUP METHOD OF DATA HANDLING

В.С. Степашко, докт. техн. наук, професор, **А.Р. Трачук,** аспірант (КПІ ім. Ігоря Сікорського)

МЕТОДОЛОГІЯ АНАЛІЗУ ТА ПОБУДОВИ ПРОГНОЗНИХ МОДЕЛЕЙ СПОЖИВАННЯ ЕЛЕКТРОЕНЕРГІЇ В УКРАЇНІ ШЛЯХОМ ВИКОРИСТАННЯ МЕТОДУ ГРУПОВОГО УРАХУВАННЯ АРГУМЕНТІВ

Considered issues of electricity consumption in Ukraine. The dynamics of energy consumption and the proposed guidelines gait efficient use of electricity. Researched and projected scenarios projected electricity consumption in general throughout Ukraine.

Keywords: *energy balance; energy conservation; energy efficiency; energy statistics.*

Розглянуті проблемні питання споживання електроенергії по Україні. Проаналізовано динаміку споживання електроенергії та запропоновані методичні рекомендації ходо ефективного використання електроенергії. Досліджені та прогнозовані прогнозні сценарії споживання електроенергії загалом по всій Україні.

Ключові слова: *енергетичний баланс; енергозбереження; енергоефективність; енергетична статистика.*

Рассмотрены проблемные вопросы потребления электроэнергии по Украине. Проанализирована динамика потребления электроэнергии и предложены методические рекомендации походкой эффективного использования электроэнергии. Исследованы и спрогнозированные прогнозные сценарии потребления электроэнергии в целом по всей Украине.

Ключевые слова: *энергетический баланс; энергосбережение; энергоэффективность; энергетическая статистика.*

Introduction. The basic foundation of the formation of the Ukraine grid construction is forecasting scenarios for different types of energy and the various criteria for effective use of energy resources. The problem of efficient use of energy resources raises crucial for sustainable economic development against the backdrop of energy saving national economy depends on energy imports, on the one hand, and rising prices for these resources. The solution to this problem is not only with

ensuring energy security, but also with the level of development of regions and the quality of life of its population.

Forecasting electricity consumption in Ukraine today is an extremely important issue of strategic importance since conducted through analysis and building predictive models will be possible to develop guidelines for the efficient production and consumption across Ukraine as a whole.

Aim of the work is development of methodical provisions for forecasting electricity consumption in Ukraine through the use of group method of data handling.

Statement of material and research results. The level of energy has a decisive impact on the economy of the state, resolving social problems and living standards of citizens. Changes in energy prices immediately reflected in all industries, and the rest, the price of the final product. Therefore, instead of quantitative objectives of energy development, which was followed by Ukraine's economy in recent decades, energy has to go to power sustainable economic development, focused on that now developed countries. The said research leads scientists to balance the energy balance of Ukraine, which determined the relevance of the work. In the traditional understanding of energy balance is the ratio between the extraction (production) and consumption of different types of energy resources.

At the heart of the development of fuel and energy balance is a set of strategic statements of economic development, the definition of forecast volumes of energy consumption, based on adopted policies to increase energy efficiency, the development of fuel and energy complex and evaluating opportunities extraction and production of fuel and energy, as well as the formation of areas of import- exporting policy and determine the volume of purchase and sale of energy.

One of the mathematical methods of forecasting is group method of data handling, which allows you to build adequate predictive models of energy consumption in the system of Ukraine's energy balance.

With the help of a group of data handling and by using modern software were built predictive models of consumer energy resources in the system of energy balance of Ukraine:

1. Expected system model prediction for next year depends on the values of the previous year, offset (-1):

$$Y1 = 89{,}726 + 0*Y1(-1) - 12{,}174*Y2(-1) + 0*Y3(-1)$$
$$Y2 = 0{,}3592 + 0*Y1(-1) + 0*Y2(-1) + 1{,}3623*Y3$$
$$Y3 = 0{,}0000 + 0*Y1(-1) + 0*Y2(-1) + 1.0149*Y3(-1)$$

Comment: Y1 (final consumption of energy (FCE)) Depends on Y2 (-1) (last year) and Y2 (primary energy intensity (total primary energy supply, t.o.e. / € 1000 GDP)) in turn from Y3 (-1) last year - that Y1 and Y2 contain auto regressive components; This model is for purely autoregressive Y3: Y3 (final energy consumption (final energy consumption toe / € 1000 GDP)) depends on its previous value Y3 (-1).

Initial data for forecasting final energy consumption are presented in Table 1

Table 1

Output consumption of final energy consumption

Year	Final consumption of energy (FCE) thousand. t.o.e.	Primary energy intensity (total primary energy supply, t.o.e. / € 1000 GDP)	Final energy consumption (final energy consumption t.o.e. / € 1000 GDP)
	Y1	Y2	Y3
2006	72,948	1,518	0,822
2007	73,270	1,281	0,691
2008	73,846	1,091	0,616
2009	74,037	1,363	0,753
2010	74,238	1,429	0,796
2011	74,303	1,497	0,842
2012	74,067	1,524	0,879
2013	75,984	1,582	0,895
2014	63,266	1,620	0,921
2015	67,425	1,675	0,948

Results of approximation and forecast FCE for the next 5 years:

1. The first indicator Y1 (final energy consumption) is given in tab. 2

Table 2

Prediction of final consumption of energy (FCE) thousand t.o.e.
by using the group method of data handling

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Table	72,948	73,270	73,846	74,037	74,238	74,303	74,067	75,984	63,266
Model		71,247	71,721	71,518	71,312	71,104	70,892	70,677	70,458

Continuation of Table 2

Year	2015	2016	2017	2018	2019	2020
Table	67,425					
Model	70,237	69,335	69,632	69,398	69,160	68,919

2. The second indicator Y2 - Primary energy intensity (total primary energy supply, t.o.e. / € 1000 GDP) is given in tab. 3

Table 3

Prediction of primary energy intensity by using the group method of data handling

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Table	1,518	1,281	1,091	1,363	1,429	1,497	1,524	1,582	1,620
Model		1,48	1,50	1,51	1,53	1,55	1,56	1,58	1,60

Continuation of Table 3

Year	2015	2016	2017	2018	2019	2020
Table	1,675					
Model	1,62	1,651	1,670	1,709	1,689	1,729

3. The third indicator Y3 (final energy consumption (final energy consumption t.o.e. / € 1000 GDP) are shown in tab. 4

Table 4

Prediction of final energy intensity (final energy consumption t.o.e. / € 1000 GDP) by using the group method of data handling

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Table	0,822	0,691	0,616	0,753	0,796	0,842	0,879	0,895	0,921
Model		0,83	0,85	0,86	0,87	0,88	0,90	0,91	0,93

Continuation of Table 4

Year	2015	2016	2017	2018	2019	2020
Table	0,948					
Model	0,94	0,962	0,991	0,976	1,006	1,021

Predictive System Model of FEC forecast for next year depends on the values of the last and before last year, offset (-1) and (-2)):

$$Y1 = 39{,}222 + 0{,}2496*Y1(-1) + 0*Y1(-2) - 29{,}210*Y2(-1) + 178{,}642*Y2(-2) + 0*Y3(-1) - 354{,}418*Y3(-2)$$

$$Y2 = 0{,}0000 + 0*Y1(-1) + 0*Y1(-2) + 1{,}0316*Y2(-1) + 0*Y2(-2) + 0*Y3(-1) + 0*Y3(-2)$$

$$Y3 = 0{,}0000 + 0*Y1(-1) + 0*Y1(-2) + 0{,}6410*Y2(-1) - 0{,}0590*Y2(-2) + 1.0149*Y3(-1) + 0*Y3(-2)$$

Comment: Y1 depends on Y1 (-1), Y2 (-1), Y2 (-2) and Y3 (-2); Model is purely autoregressive Y2: Y2 depends on its previous value Y2 (-1); Y3 depends on Y2 (-1), Y2 (-2) and Y3 (-1)

Forecasted balance of Electricity

$$Y1 = 0.3428*Y1(-1) + 0.722*Y2(-1) + 0.7087*Y3(-1);$$

$$Y2 = 0.3942*Y1(-1) + 0.5874*Y2(-1);$$

$$Y3 = -11.4467 + 0.0847*Y1(-1) + 0.6787*Y3(-1);$$

Forecasting electricity consumption (gross) by using the group method of data handling are given in tab. 5

Table 5

Prediction of electricity consumption (gross) by using the group method of data handling:

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Table	177.9	183.7	193.7	198.8	204.7	209.5	216.9	226.9	231
Model		181.6	186.8	192.3	198.2	204.6	211.4	218.7	226.6

Continuation of Table 5

Year	2015	2016	2017	2018	2019	2020
Table						
Model	235.1	243.9	253.2	263.7	275	287.2

Prediction of electricity consumption (net) by using the group method of data handling are given in tab. 6

Table 6

Prediction of electricity consumption (net) by using the group method of of data handling:

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Table	158.6	162.6	167.4	172.8	175.6	181.5	184.2	189.4	198.5
Model		163.3	167.5	172.	176.9	182	187	193.5	199.9

Continuation of Table 6

Year	2015	2016	2017	2018	2019	2020
Table	208.5					
Model	206.7	213.5	221.6	230	239	248.8

Prediction of electricity export by the group method of data handling are given in tab. 6

Table 7

Prediction of electricity export by the group method of data handling:

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Table	8.56	9.35	10.47	10.86	11.35	13.65	15.33	17.37	19.23
Model		9.43	10.33	11.39	12.57	13.88	15.3	16.84	18.51

Continuation of Table 7

Year	2015	2016	2017	2018	2019	2020
Table	20					
Model	20.31	21.69	23.94	26.24	28.7	31.33

Prediction of energy consumption by using the group method of data handling:

$$Y1 = 88.6897 – 2.0492*Y3(–1);$$
$$Y2 = 0.0823*Y1(–1) – 3.4666*Y2(– 1) + 7.2614*Y3(–1);$$
$$Y3 = 4.2195 – 2.2605*Y2(–1) + 4.5343*Y3(–1);$$

Conclusions

Through analysis of the dynamics of electricity consumption in Ukraine and analysis of such important indicators as the final energy consumption, primary energy consumption, the export of electricity consumption (net) electricity consumption

(gross) final consumption of energy - were built predictive models in the energy sector through the use group method of data handling for the above indicators and made the following results:

- predicted the increase of final energy intensity from 8.22 t.n.e. / € 1000 of GDP in 2005 to 9,52 t.n.e. / € 1000 of GDP in 2020;
- predicted the increase of primary energy intensity from 15,18 t.n.e. / € 1000 of GDP in 2005 to 16.74 t.n.e. / € 1,000 of GDP in 2020;
- predicted the increase electricity exports from 8,56 in 2005 to 31,33 in 2020;
- predicted the growth of electricity consumption (net) from 158,6 in 2005 to 258,8 in 2020;
- predicted the growth of electricity consumption (gross) from 177,9 in 2005 to 287,2 in 2020;
- predicted the reduction of final consumption of electricity (FCE) from 72.95 thousand t.o.e. in 2005 to 68,91 thousand t.o.e. in 2020.

References

1. Yvahnenko, A.G. Adoption decisions based on self-organization [Text] / A.G. Yvahnenko, Y.P. Zaichenko, V.D. Dimitrov. - M.: "Soviet Radio", 1976. - 280 p.

2. Kravets, I.O. Research methods of statistical and predictive analysis for autoregressive models [Text] / I.A. Kravets, G.A. Afanasyeva; Scientific Papers: Scientific-methodical journal. - Mykolaiv: CSU named after Petro Mohyla, 2009. - Vol. 93.

3. Tatarkyn, A.I. The economic security of the region: the unity of theory, research methodology and practice [Text] / Tatarkyn A.I., Kuklin A.A., Romanov A.A., Chukanov V.N., Yakovlev V.I., Kozytsyn A.A. - Ekaterinburg: Publisher Ural. 2007. - 240 p.

4. Savenko, J.N. Energy balance [Text] / Y.N. Savenko, E.O. Steinways; Some questions of theory and practice. - M.: Energy, 2011. – 184 p.

5. Egorov, A.L. Method of analysis and energy balances of industrial enterprises [Text] / A.L. Egorov - St. Petersburg, 2012. - 134 p.

Стаття надійшла до редакції 16.12.2016 р.