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DEVELOPMENT OF FORECASTING SCENARIOS OF THE ELECTRICITY CONSUMPTION IN UKRAINE BY USING THE GROUP METHOD OF DATA HANDLING

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РОЗРОБКА ПРОГНОЗНИХ СЦЕНАРІЙІВ СПОЖИВАННЯ ЕЛЕКТРОЕНЕРГІЇ В УКРАЇНІ ШЛЯХОМ ВИКОРИСТАННЯ МЕТОДУ ГРУПОВОГО УРАХУВАННЯ АРГУМЕНТІВ

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РАЗРАБОТКА ПРОГНОЗНЫХ СЦЕНАРИЕВ ПОТРЕБЛЕНИЯ ЭЛЕКТРОЭНЕРГИИ В УКРАИНЕ ПУТЕМ ИСПОЛЬЗОВАНИЯ МЕТОДА ГРУППОВОГО УЧЕТА АРГУМЕНТОВ

Рассмотрены проблемные вопросы потребления электроэнергии по Украине. Проанализирована динамика потребления электроэнергии и предложены методические рекомендации относительно эффективного использования электроэнергии. Исследованы прогнозные сценарии потребления электроэнергии в целом по всей Украине. Базовой основой формирования энергосистемы Украины является построение прогнозных сценариев по различным видам энергоресурсов и разнообразным критериям эффективного использования топливо-энергетических ресурсов. Проблема эффективного использования топливо-энергетических ресурсов возникает крайне важной для устойчивого экономического развития энергетики на фоне сохранения зависимости национальной экономики от импорта энергоносителей, а также роста цен на данные ресурсы. Решение данной проблемы связано не только с обеспечением энергетической безопасности страны, но также с повышением уровня развития регионов страны и качества жизни его населения.

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

Табл.: 7. Бібл.: 6.

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

Key words: energy balance; energy conservation; energy efficiency; energy statistics.

Tabl.: 7. Bibl.: 6.

Introduction. Forecasting of electricity consumption in Ukraine today is an extremely important issue of strategic importance because due to conducted analysis and build predictive models may be developed guidelines for efficient production and consumption across Ukraine as a whole.

The aim of the work is to develop a methodological provisions for forecasting electricity consumption in Ukraine through the use of Group Method of Data Handling.

Statement of main material and research results. The level of energy has a decisive influence on the development of the state economy, solving social problems and living standards of citizens. Changes in energy prices immediately displayed in all industries, and the rest, the price of the final product. Therefore, instead of quantitative objectives of energy develop-
ment, which was followed by Ukraine's economy in recent decades, energy has to go to power sustainable economic development, the targeted today 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 like the relation between extraction (production) and consumption of different types of energy resources.

The formulation of energy balance is a complex strategic statements of economic development, the definition of forecast consumption of energy based on adopted policies to increase energy efficiency, the development of the fuel and energy sector and assess options extraction and production of fuel and energy, as well as forming lines import- export policy and determine the volume of purchase and sale of energy.

One of the mathematical methods of forecasting is group method of data handling that allows you to build adequate models predicted energy consumption energy balance in the system of Ukraine.

By using the Group Method of Data Handling and by using modern software were built prediction models of energy resources in the system of energy balance of Ukraine:

1. Projected system model prediction for next year depends on the values for 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 energy consumption (FEC), t h.s. t o.e.) Depends on Y2 (-1) (last year) and Y2 (primary energy intensity (total primary energy supply, t o.e. / € 1000 GDP)) in turn by Y3 (-1) last year - that Y1 and Y2 do not include auto regressive components; This model is for purely autoregressive Y3: Y3 (final energy consumption (final energy consumption t o.e. / € 1000 GDP)) depends on its previous value Y3 (-1).

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

| Year | Final energy consumption (FEC) | 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                        | 1,324                           | 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 Table 2.

| 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 | 69,335 | 69,632 | 69,398 | 69,160 | 68,919 |
| Model | 70,237 | 67,425 | 69,335 | 69,632 | 69,398 | 69,160 |

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

Table 3

| 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 | 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 Table 4.

Table 4

| 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 | 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)):

\[
Y_1 = 39.222 + 0.2496 Y_1(-1) + 0.722 Y_2(-1) - 29.210 Y_2(-1) + 0.7087 Y_3(-1) - 354.418 Y_3(-2); \\
Y_2 = 0.0000 + 0.0000 Y_2(-1) + 0.0000 Y_3(-1) + 1.0316 Y_2(-1) + 0.6787 Y_3(-1); \\
Y_3 = 0.0000 + 0.0000 Y_1(-1) + 0.0000 Y_2(-1) + 0.6410 Y_2(-1) - 0.0590 Y_2(-2) + 1.0149 Y_3(-1) + 0.0590 Y_3(-2). \\
\]

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

\[
Y_1 = 0.3428 Y_1(-1) + 0.722 Y_2(-1) + 0.7087 Y_3(-1); \\
Y_2 = 0.3942 Y_1(-1) + 0.5874 Y_2(-1); \\
Y_3 = -11.4467 + 0.0847 Y_1(-1) + 0.6787 Y_3(-1). \\
\]

Forecasting electricity consumption (gross) by using the group method of data handling are given in 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 | 235.1 | 243.9 | 253.2 | 263.7 | 275  | 287.2 |
| Model |      |      |      |      |      |      |

**Prediction of electricity consumption (net) by using the group method 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 | 172.0 | 176.9 | 182.0 | 187.0 | 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**

| 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:**

\[
Y_1 = 88.6897 - 2.0492*Y_3(-1);
\]

\[
Y_2 = 0.0823*Y_1(-1) - 3.4666*Y_2(-1) + 7.2614*Y_3(-1);
\]

\[
Y_3 = 4.2195 - 2.2605*Y_2(-1) + 4.5343*Y_3(-1).
\]

**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.

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