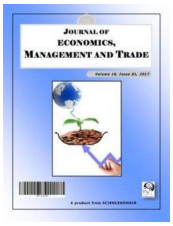

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World Energy Consumption: Regional Differences and Features of Change

Sergey Alexandrovich Surkov[1*] and Ellen Grigorjevna Trofimova[2]

[1]International Institute of Management LINK, Moscow, Russia.
[2]Russian Medical Academy of Continious Professional Education, Moscow, Russia.

Authors' contributions

This work was carried out in collaboration between both authors. Author SAS performed the statistical analysis, wrote the protocol and the first draft of manuscript. Author EGT managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Literary sources contain contradictory information about energy release. Some authors describe the trend of rapid growth of this indicator, others believe that this growth is gradually subsiding
Objective: Authors have considered a problem of worldwide consumption of energy.
Methods: The necessary parameters were determined by data of various literary sources.
Discussion: It is shown that the direct approximation of dependencies of energy release per capita, population size and inhabited territory to calculate the energy release density is inexpedient.
It is established that the energy release density first decreases with time, and then begins to grow.
Conclusion: The main sources of growth are industrialized countries.

Keywords: Energy consumption; density of consumption; damage to nature.

**Corresponding author: E-mail: context2002@yandex.ru, context2002@yahoo.com;*

1. INTRODUCTION

From the first bonfires to prototypes of fusion reactors, energy consumption by the person only grew. New sources of energy were being developed, battles for energy raw materials broke out, but growth continued and continues now. A further increase in energy consumption becomes dangerous. In this case, the nature starts to react negatively to the high levels of energy consumption. On the other hand, industrial development demands increase in consumption of energy. For this purpose, it is necessary to choose criteria for establishment of balance.

Such an approach should be stopped, otherwise the environment will not survive. But the existing patterns of change in the indices of human society suggest the need of stabilization long before this limit.

This article is devoted to this issue.

1.1 Literature Review

Tverberg G. [1] points out that there are the huge increases in world energy consumption that has taken place in roughly the last 200 years.

This rise in energy consumption is primarily from increased fossil fuel use.

On a per capita basis, there was a huge spurt of growth between World War II and 1970.

In this source indicators of level of consumption of energy per capita aren't emitted.

Koppelaar R. [2] indicates, that we are now burning 10 times as much energy as a century ago to provide the goods and services.

Energy consumption is still increasing rapidly, with an approximate 550 exajoules consumed at the primary energy level in 2010.

Consequences of use of large volumes of energy aren't specified here.

This data is useful because evaluating this information to discover trends might yield energy issues not currently being addressed, thereby encouraging the search for solutions.

International Energy Agency established a goal of limiting global warming to 2 degrees Celsius, but this goal is becoming more difficult to reach each year that the necessary action is not taken. In global energy use, fossil fuels make up a substantial portion [3].

This source is concentrated on consequences of the increased consumption of energy for ecology, but doesn't allow to estimate regularities of change of consumption of energy.

Group of authors as a part of Belotskaya G.D. etc. [4] specifies that the world enters a new stage of development of power engineering when after the continuous growth of energy consumption, economic growth for the first time began to break away from increased energy consumption. Primary energy consumption in many industrialized countries have stabilized, and in some began to gradually decline.

The authors of this study endure the trends of future development to the present day, which is incorrect.

Medvedev E.G. and Zakharov S.A. hold the same opinion [5]. They emphasize that the increase in energy consumption in industrialized countries has slowed to 2% due to the economic crisis, and the increase in total energy consumption is due to the Indian and Chinese markets.

There is practically the same problem here. The problem consists in the fact that temporary slowdowns in energy consumption are taken as long-term trends.

Opinion of Voronina N. [6] looks more realistic. She writes that the power consumption of the world economy will gradually decrease, but directly proportional dependence between a gain of GDP and increase in energy consumption will remain.

These factors are contradictory but the BP forecast of world energy development [7], which indicates that population and income growth represent the two most powerful drivers of energy demand, provides a clearer explanation for historical trends in energy consumption. Since 1900 the world's population has increased more than 4 times, real income - 25 times and consumption of basic energy - 22.5 times.

Mitrova T.A. [8] writes, among other things, about the high rate of growth in energy consumption and the growing tension in supplying the energy needs of transport. This is in line with the prevailing view on energy consumption, but does

not provide recommendations for reducing the effect of these factors.

The Association "IECC Center" [9] in the review article points out that world energy consumption will grow along with the development of the world economy, and by 2035 - 2040 it will increase by one third, mainly at the expense of India, China, Africa, the Middle East and South- East Asia.

Fursova I. [10] confirms this thesis. She emphasizes that by 2040 consumption of energy in the world will grow approximately by a third, first of all thanks to India, China, the countries of Southeast Asia, the Middle East and Africa. In the next year energy consumption in the world will grow in all macro-regions except for the EU where insignificant decrease will happen in connection with priority policy on development of energy efficient technologies.

TASS reports that according to the expert-analytical report of Centre for Strategic research a world electricity consumption by 2035 can grow by 40 - 50% in comparison with indicators at the moment [11].

Sources [9,10,11] indicate essential increase in energy consumption, but don't concretize dynamics of change of this indicator.

The same opinion is expressed also by Losev A. [12] noting that the energy requirements will only increase. If, according to the International Energy Agency, in 2015 world energy consumption amounted to 20,76 trillion kWh, then in 15 years 33,4 trillion kWh are predicted (a gain for 60%), and by 2050 consumption of energy can double – up to 41,3 trillion kWh.

However, according to BP's annual report [13], world primary energy consumption in 2016 increased by only 1% after rising by 0.9% in 2015 and by 1% in 2014, which is comparable to the 10-year average in 1.8% per year.

Rapier R. [14] makes an important remark that explosive growth in developing countries is the real story as far as carbon emissions go.

Nevertheless, Dimitriev O.P. [15] indicates that energy consumption is increasing faster than the population growth and the industrialized countries provide most of the growth. However, his opinion and the provided data don't give an overall picture of this phenomenon.

Hossain Kh.A. [16] is offering own vision of trends in energy consumption growth, but there aren't enough data to assess the correctness of his observations.

Klimenko V.V. and Tereshin A.G. [17] speak about influence of energetics on release of carbon dioxide, but they don't offer significant recipes on his decrease.

Okorokov R.V. [18] indicates that energy consumption increases by country and by region, but they do not indicate which features of this consumption will allow to decrease it.

Andrews R. [19] shows that schedules of energy consumption and release of carbon dioxide go in parallel, but he notes that the effort of the countries of the world doesn't affect this process yet.

In general, information about the world's energy consumption in various sources is contradictory and allows for various manipulations and speculation. This article is intended to clarify some points in the development of world energy consumption.

2. MATERIALS AND METHODS

The necessary parameters were determined by data of various literary sources. References have been checked for reliability by their comparison with each other and with other independent sources.

Most of data have been obtained from reliable sources on the Internet using search engines Yandex, Google, and Mail.

After assessing the reliability of the sources they were consolidated into a single list and are ranked according to the degree of consistency to each other. The pairs of sources were compared with each other and compared with neighboring ones in the case of data consistency. The obtained data were lined up according to the reliability of data. The list thus constructed was abbreviated by a strikeout method, beginning at the end.

Data processing was carried out by linearization of functions and construction of simple linear regression. Indeed, linear regression can be easily understood in terms of the simple ideas and does not require understanding complex abstractions.

2.1 Theory

Relative consumption of energy at first seeks for stabilization, and further there is a growth.

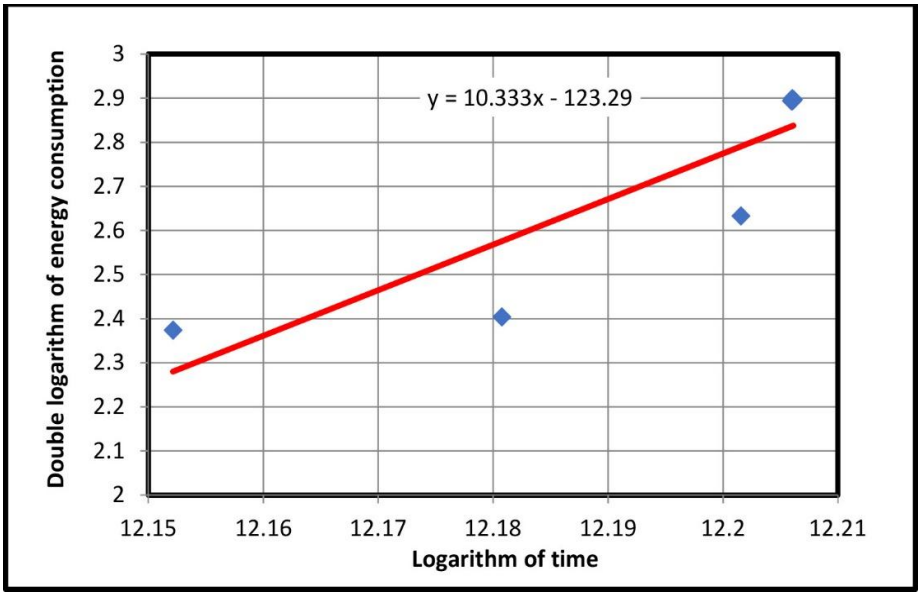
The relative energy consumption was calculated from formula. The formula is derived proceeding by sense and definition of indicators.

$$E_{Rel} = EN/S, \quad (1)$$

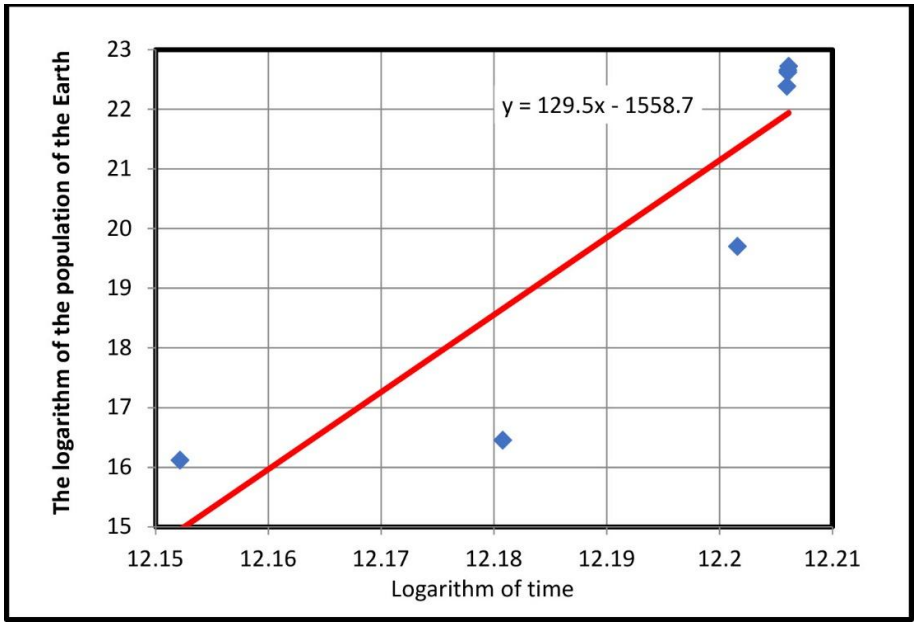
E_{Rel} – specific energy consumption per capita per unit area
N – population size,
S - area of habitable territory.

The linearization of the parameters entering into formula (1) is presented in Fig. 1 a), b) and c), and in Tabl.1.

The dependency characteristics are presented in Table.1.



a)



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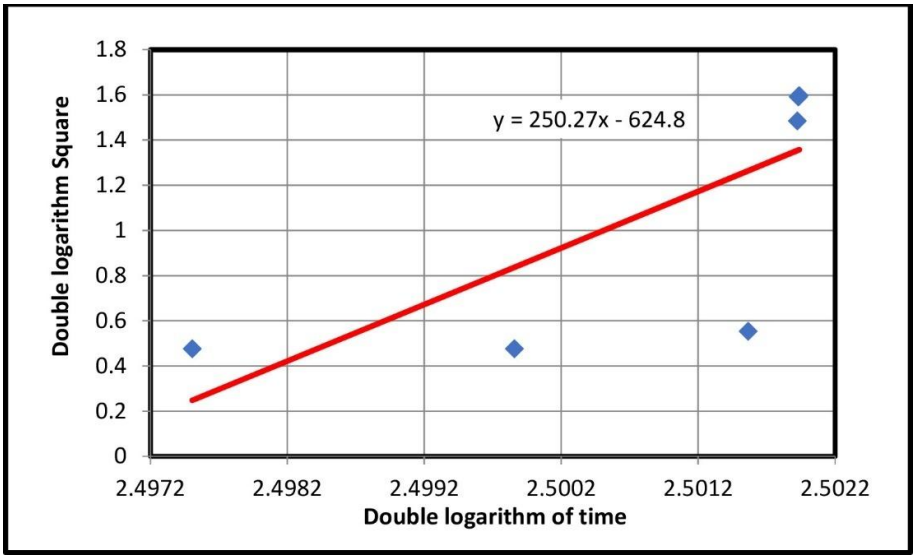

c)

Fig. 1. Dependences on time: a) - energy consumption per capita; b) - population size; c) - habitable territory

Table 1. The dependencies parameters on Fig. 1

Parameter	Regression equation	Correlation coefficient
Energy consumption per capita	Ln Ln E=10,3Lnt-123,3	0,883
Population size	Ln N=195,5 Ln t- 1558,7	0,894
Inhabited territory	LnLnS = 250,3LnLnt - 624,8	0,744

Parameters of the linearization of the dependences are rather conventional, they are given for orientation.

Calculations using formula (1) does not make sense to produce by the linearization formulas, since there is a contradiction between the different units.

Real data in a relative form are used by authors in a tabular form for calculations on cumulative dependence (1).

3. RESULTS

It is widely known that any attempts of the description of any process by means of formulas risk to encounter features of the used functions.

That can lead to errors or difficulties.

Therefore, it is expedient to use for the calculation according to formula (1) dimensionless parameters, normalized to the maximum value.

The result of the calculations for determining the normalized energy consumption, carried out taking into account the above reasoning, is presented in Fig. 2.

The current time on this chart is normalized on the value of 100,000 years.

High values of specific energy consumption in the descending branch of the graph due to the fact that the energy consumption is carried out at small habitable territories.

It is easy to see that in the historical context, for many millennia, the density of energy release has fallen, but over time the rate of decline has been decreasing, and by now the fall has practically ceased.

In the subsequent the specified indicator shows a tendency to increase.

This is due to the fact that the expansion of the area of residence has almost ceased, and energy consumption is increasing.

Fig. 3 shows the change of final energy consumption in different countries in time.

Part of the data in the literature is given in tons of oil equivalent per capita, so we had to take into account the current population of the countries and using a conversion factor of oil equivalent to kilowatt per hours.

The received results are presented in Fig. 3.

As can be seen from Fig. 3, the main energy consumption is accounted for by the "world workshop" - China which is at an industrial stage, and the countries close to the transition to the postindustrial stage, like the United States and the EU countries.

In order to more clearly identify the impact of energy consumption in different countries on the overall situation, we introduce the integrated indicator of energy consumption for the period.

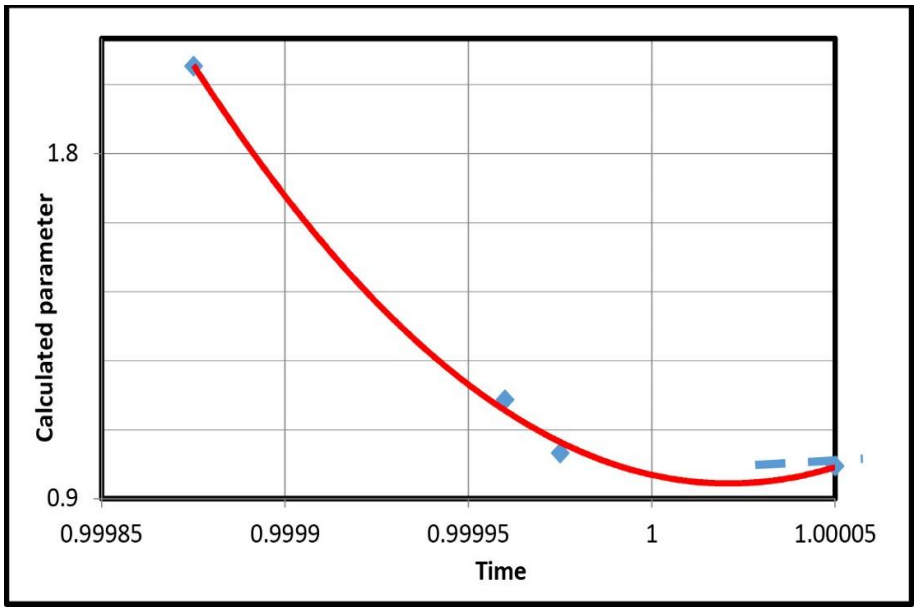

Fig. 2. Dependence of the specific energy release (use) on time

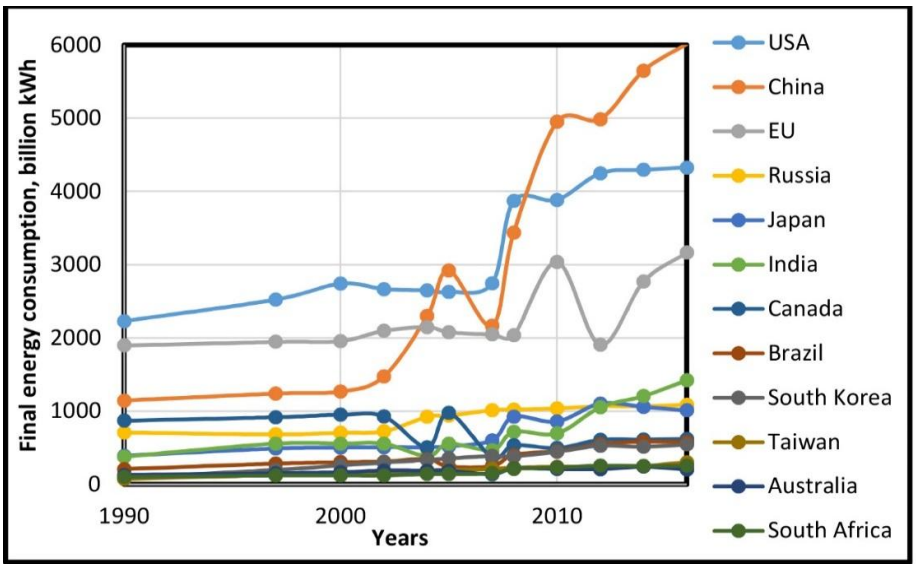

Fig. 3. Change in energy consumption by years for the leading world powers

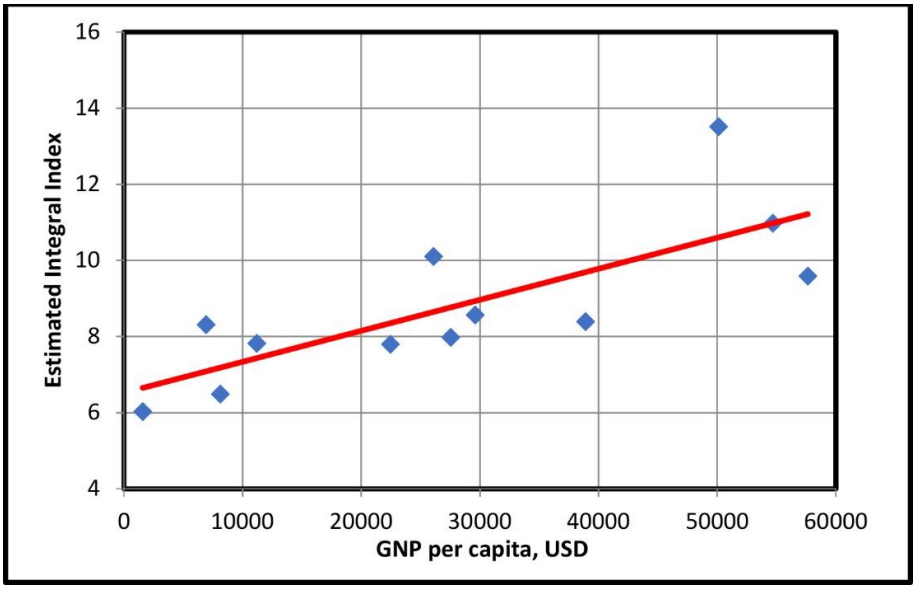

Fig. 4. Interrelation of the integral indicator of energy consumption and average GNP per capita

This indicator is equal to the sum of all values of energy consumption of a given country, normalized using the maximum value of the energy consumption for it.

We have compared these data with size of the average level of GNP per capita for the same countries.

Results are presented in Fig. 4.

For the dependence in Fig. 4, the correlation coefficient 0.77 is significant for all significance levels exceeding the level of 0.01.

But he is not very high in the first place because of the scatter of the values of integral index of energy consumption.

Various factors of internal life of the different countries, and not just level of industrial development which characterizes GNP per capita can serve as the reasons of such fluctuations.

4. DISCUSSION

Automatic approximation predicts a small rise in specific energy consumption beyond the reporting period.

This is consistent with the empirical data on the growth of energy consumption.

The direct observations and data consolidated in Fig. 3 show that growth of energy consumption will continue and further.

China carries out actions which can be regarded as attempts to begin transition to a post-industrial stage, and it means that energy consumption will even more increase.

On graphics of Fig. 4 it is visible that some countries consume more, than it would be necessary for their level of industrial development, and some – it is less.

Such circumstances can serve as a starting point for framing of the relation to the Kyoto Protocol and for making strategic decisions on the directions of industrial development in each of the countries.

5. CONCLUSION

The density of energy release per unit area after stabilization begins to grow again.

Since the habitable territories practically does not increase, the specific energy consumption will increase further.

It won't give to the nature the chance to adapt to the changed conditions and doesn't lead to decrease in damage to natural educations.

State and supranational entities should more consciously choose development strategy, including, and based on their integral power consumption.

The only looked-through opportunity in this case is using of innovative energy saving technologies by the countries which are at a development stage, post-industrial stage or close to it. Because it is clear that these countries are the main consumers of world energy resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tverberg G. World Energy Consumption Since 1820 in Charts. (03.12.2012). Available:https://ourfiniteworld.com/2012/03/12/world-energy-consumption-since-1820-in-charts/
2. Koppelaar R. World energy consumption – beyond 500 exajoules The Oil Drum. (02.16.2012) Available:http://www.resilience.org/stories/2012-02-16/world-energy-consumption-beyond-500-exajoules/
3. Boundless. World energy use. Boundless Physics Boundless; 2016. (01.24.2017) Available:https://www.boundless.com/physics/textbooks/boundless-physics-textbook/work-and-energy-6/case-study-world-energy-use-66/world-energy-use-288-10950/
4. Belotskaya GD, Veselov FV, Galkin YuV etc. Forecast of the development of the world and Russian energy industry, INEI RAS - Analytical Center under the Government of the Russian Federation, 2016:200. Available:http://www.forsage.org/mediafiles/u/files/pre-reading/Prognoz_razvitiya_energetiki_Rossii_i_mira_2016.pdf
5. Medvedev EG, Zakharov SA. Modern problems of power: Methodical instructions to a practical training. Kemerovo, KUZGUTU, 2014,19. Avialable:https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwj97rqUz8nXAhUijFQKHTyvArAQFggmMAA&url=https%3A%2F%2Flibrary.kuzstu.ru%2Fmeto.php%3Fn%3D3715&usg=AOvVaw0QrMeT0uPMfMnGPWWs5RMf.
6. Voronina N. The world markets of energy resources - problems and prospects. Practical marketing. 2004;2. Available:http://www.cfin.ru/press/practical/2004-02/03.shtml
7. British Petroleum Company. The World Energy Outlook to 2030. BP 2011;80. Available:https://www.bp.com/content/dam/bp-country/ru_ru/folder/Energy_outlook_2030_rus_2011.pdf
8. Mitrova TA. Trends and risks of global energy development. ESCO, Electronic Journal of Energy Service Company "Ecological Systems", №6, June 2011, Available:http://esco.co.ua/journal/2011_6/art067.htm
9. Association "Center of IESCR". Development of the world energy market until 2035. International scientific and public magazine "The World of Change". (08.08.2016) Available:http://mirperemen.net/2016/08/razvitie-mirovogo-energeticheskogo-rynka-do-2035-goda/
10. Fursova I. Will throw in the furnace. Energy consumption in the world will grow. Rossiyskaya Gazeta - Special Issue No. 6860 (289), 12.22.2015. Available:https://rg.ru/2015/12/22/prognoz.html.
11. World energy consumption could increase by 50% by 2035. According to the research of the Center for Strategic Research, the new consumers who does not have access to electricity yet to this point will be around 1.3 billion people. Available:http://tass.ru/ekonomika/4557505.09.13.2017
12. Losev A. It is too early to put a cross on fossil fuels. The world economy is structured and developed in such a way that no renewable sources can provide an ever-increasing need for energy. The energy needs increase by an order of magnitude faster than the population growth. Vedomosti. (01.09.2016) Available:https://www.vedomosti.ru/economics/blogs/2016/09/01/655312-krest-iskopaemom-toplive-rano
13. The review of the market of world power following the results of 2016. On materials

of the annual report of BP. Website World Trade Center Moscow.
Available:https://wtcmoscow.ru/services/international-partnership/analitycs/obzor-rynka-mirovoy-energetiki-po-itogam-2016-goda/, 06.27.2017

14. Rapier R. World energy consumption facts, figures, and shockers. Website Energy Trends Insider.
Available:http://www.energytrendsinsider.com/2012/06/28/world-energy-consumption-facts-figures-and-shockers/. 06.28.2012.
15. Dimitriev OP. Global energy consumption rates: Where is the Limit? Sustainable Energy. 2013;1(1)1-6.
16. Hossain Kh A. Global energy consumption pattern and GDP. International Journal of Renewable Energy Technology Research. 2012;1(1):23-29.
17. Klimenko VV, Tereshin AG. World energy and climate in twenty-first century in the context of historical trends: Clear constraints to the future growth. Journal of Globalization Studies. 2010;1(2):27–40.
18. Okorokov R.V. Trends and consequences of the global fuel and energy complex development. Vestnik IGEU. 2018;1:75-86.
19. Andrews R. Global CO2 emissions forecast to 2100. Oil Production Vital Statistics; 2018.

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