Malysheva, Tatyana V.; Ishmuradova, Izida I.; Yarlychenko, Alla A.

Article

Study of trends in the formation of energy intensity of production and the structure of "energy portfolio"

Reference: Malysheva, Tatyana V./Ishmuradova, Izida I. et. al. (2020). Study of trends in the formation of energy intensity of production and the structure of "energy portfolio". In: International Journal of Energy Economics and Policy 10 (4), S. 36 - 42.
https://www.econjournals.com/index.php/ijeep/article/download/9545/5100.
doi:10.32479/ijeep.9545.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(4), 36-42.

Study of Trends in the Formation of Energy Intensity of Production and the Structure of "Energy Portfolio"

Tatyana V. Malysheva[1]*, Izida I. Ishmuradova[2], Alla A. Yarlychenko[1]

[1]Department of Logistics and Management, Kazan National Research Technological University, Kazan, Russia, [2]Department of Business Informatics and Mathematical Methods in Economics, Kazan (Volga region) Federal University, Kazan, Russia.
*Email: tv_malysheva@mail.ru

Received: 04 February 2020 **Accepted:** 05 May 2020 **DOI:** https://doi.org/10.32479/ijeep.9545

ABSTRACT

The goal of the article is to define factors that influence formation of energy intensity and structure of "energy portfolio" in petrochemical manufacture and production. One of the basic research methods applied in the article is to use the method of correlation analysis for connection detection between specific energy resource consumption, dynamic factor analysis for types of comments determination into factor formation of energy intensity in production, method of main part and criteria of "stony cree" for identification of dominant factors and tendency in energy intensity formation. The article has the analysis of dynamics and structure of specific consumption of energy resources on production of each type of petrochemical types of production. There is an interconnection between increase rate of specific electric and thermal consumption. Key factors and tendency formation of energy intensity and structures of "energy portfolio" by types petrochemical manufacture were identified. Research materials may be used to develop public documents of strategic planning, pioneering projects for introduction of resource saving technologies, monitoring performance of efficiency implementation in energy-saving programs. Identified tendencies and consistent patterns will introduce purposeful impact on certain performance types with the aim of energy intensity cause increase identification in production and decision development to organize energy-saving manufacture.

Keywords: Energy Efficiency, Product Energy Intensity, Energy Resources, Thermal Energy, Energy Portfolio, Energy Saving Technologies
JEL Classifications: O14, D24, C38

1. INTRODUCTION

Currently the problem of energy-saving in Russian industrial companies has reached special relevance. This is caused by constant non-stop growing electricity, heat and energy carriers prices. Major industrial companies consume lots of electric and thermal energy, leading to expenditure growth and this requires an adequate strategy of energy-saving. Price increase for energy resources leads to product price increase and decreases level of competitiveness both in internal and external markets. In Russia fuel and energy resource expenditure share cost price is greatly higher than analogous index in developed countries. Russia is on the third place in the scale of energy consumption in the world. In the volume of energy consumption, Russian industry uses more energy resources by the unit of gross domestic product than any of the top ten countries. By evaluation of the Centre of efficient energy use and world bank of reconstruction and development, the potential of energy-saving in Russia is at 40-45% of its real volume.

Problem of energy-saving in the industrial sector does not receive enough attention, leading to serious difficulties in companies' organization, deficit of working capital, high production costs and definite crisis in the industrial sphere. Despite the government programs that include main directions of energy efficiency development, there is no direct communication with industrial companies. Furthermore, many organizations oriented mostly on the internal market have no motivation for realization of capitalintensive projects because in the frame of Russian industry of energy-saving ecology-oriented technologies is not always a competitive advantage.

Due to this interconnection, the goals of organization of energy-saving manufacture systems need regular monitoring, tendencies' analysis, consistent pattern in energy consumption, event and principles of energy-saving development, project information support technology development for energy efficiency increase.

2. LITERATURE REVIEW

Questions of organization of energy-saving production systems in petrochemical complex are raised by many foreign and domestic scientists. An improvement of technological and economic indicators in the work of petrochemical manufacture requires an outrunning efficiency increase in the use of energy resources provision of which is possible only based on study of consistent pattern formation and management of power mode. Main focus of studies in concept area and principle of energy-saving manufacture organization are defined in the works of Fotis and Polemis (2018) who conducted research in area of sustainable development, ecological politics and the use of renewable energy; Irandoust (2019) has studied causal relationship between energy efficiency and technological innovations; Yildirim et al. (2019) researched energy use and economic growth for Brics T. countries; Naidoo and Gasparatos (2018) investigated drivers and strategies of corporate environmental sustainability; Wiese and Baldini (2018) founded conceptual model of industrial sector within energy system model; Akadiri et al. (2019) reflected on interaction between energy use, economic growth and environmental sustainability; Mednikova et al. (2019) defined features of law development in heat power industry in Russia, De Almeida et al. (2019) revealed new technological tendencies and political needs in energy-efficient systems naming primary potential for saving energy and carbon; Chaabouni and Khemakhem (2018) worked out a strategy of energy management in cloud calculations; Alqahtani and Patino-Echeverri (2019) defined combined impact of politics for increase of energy efficiency and distributed solar generation; Lin and Wang (2019) looked at potential of isolated development of energy use from economic growth; Trotta (2019) assessed of energy efficiency increase, energy dependency and carbon emissions in European Union. However, mentioned above studies do not cover functioning specifications of petrochemical manufacture to the extent of personal approach in organization and management of energy-saving processes, which is required since by nature petrochemical manufacture is high energy-consuming. Questions of competitiveness in petrochemical industry and energy efficiency of chemical and technological systems are also brought up in the studies of the following authors: Rajskaya et al. (2019), Shinkevich et al. (2019), Shinkevich et al. (2018), Malysheva et al. (2017), Malysheva et al. (2016), Shinkevich et al. (2016).

Despite the availability of extensive theoretical and methodological data arrays and practical solutions there is still a lack in research that solves the problem of energy efficiency increase on all levels of petrochemical manufacture. This brings us to tentative realization of complex questions in energy-saving, mostly subjective and poorly connected with specifics.

3. DESCRIPTION OF RESEARCH STATISTICAL BASE

Income growth based on unit cost reduction of production of goods is an important direction of technical progress and competitiveness growth in Russian industry. Energy intensity of productive power also reflects on export potential of manufacturer, that depend both on external economic conditions and on the balance of fuel and energy resources at the internal market. Due to this link energy-saving becomes the primary cause for successful highly profitable business.

Currently planners of industrial installations are faced with an objective to give low waste in new production. This objective is solved by the use of highly effective, economic systems of power and heat supplies that provide critical resource consumption reduction. Modern industrial technological complexes presume secondary use of water, fuel gas, fuel vapor. Substitution of traditional kinds of energy with secondary resources and waste production provides both economic and ecological effect.

All that is mentioned above may be fully related to the petrochemical industry. It is important to take into consideration that fuel and energy unit costs in Russia are 1.5-2 times higher than in developed countries. For instance, part of energy costs in the expenses of sector production "Chemistry and Petrochemistry" in Russia reaches 9.9% (4.9% in developed countries, 10.0% in BRICS countries), sectors of "Rubber and Plastic" - 4.1% (3.4% in developed countries, 7.8% in BRICS countries). In addition, fuel and energy unit costs in numbers of petrochemical manufactures increase dynamically due to moral and physical depreciation of equipment and great losses during energy resource transportation.

Typical processes of chemical technology are realized in specific productions with the use of various types of energy. Energy is also required for management implementation of all chemical and technological systems. Factual use of energy resources per unit of production in various types of petrochemical manufacture complex in Russian Federation greatly varies due to manufacture specifics and resource consumption standards (Table 1). Maximum energy intensity is defined by electrical and heat energy costs, may be seen at the production of 1 ton of synthetic rubber (2027, 1 kw-h and accordingly 11693,0 thousand kilocalories), chiotic thread and fiber (2218,6 kw-h and accordingly 2401,3 thousand kilocalories), synthetic resin and plastic masses (560,0 kw-h and accordingly 2129,5 thousand kilocalories).

In dynamics during 2012-2018 years energy resource growth per unit of production in most types of fuel and energy may be seen in production of paint and varnish materials (average growth rate 296%), truck tires (124%), sulfur (124%), soda ash (107%) and also in oil production and refining (104%). unit cost reduction in fuel and energy resources up to 20% during 6 years research frame may be noticed in production of rubber (reduction rate 80%), synthetic resin and plastic masses (77%), phosphate fertilizer (70%) (Rosstat, 2020).

In total consumption of fuel and energy resources at petrochemical manufactures thermal energy receives 66,6%, electric

Table 1: Actual consumption of energy resources per unit of certain types of manufactured products of the petrochemical complex of the Russian Federation in 2012, 2018

Type of production	Unit	Electric Energy, KW/hour		Heat energy, thousands, kilocalories		Fuel, kgf. equivalent	
		2018	Growth rate 2018/2012 %	2018	Growth rate 2018/2012 %	2018	Growth rate 2018/2012, %
Oil production	Tons	145,1	108,2	17,9	201,1	2,3	127,8
Oil refining	Tons	49,0	105,6	148,1	110,1	57,8	97,5
Sulfur	Tons	88,5	140,5	652,1	137,0	82,6	95,5
Ammonia	Tons	112,4	92,8	104,5	85,3	114,5	400,3
Soda ash	Tons	197,1	111,1	2009,3	100,7	83,5	109,7
Potash fertilizer	Tons	265,4	96,9	540,9	112,4	24,1	99,2
Phosphate fertilizer	Tons	376,7	64,2	1517,5	65,3	46,8	81,3
Ammonium nitrate	Tons	55,3	94,4	302,1	76,7	1,9	61,3
Chemical fibers and threads	Tons	2218,6	95,2	2401,3	88,9	39,6	68,8
Synthetic resins and plastic	Tons	560,0	76,3	2129,5	75,3	113,3	78,8
Synthetic rubber	Tons	2027,2	78,0	11693,0	76,1	652,7	96,1
Paints and varnishes	Tons	172,6	88,2	259,6	66,3	12,4	120,3
Ethylene and propylene	Tons	412,3	85,6	2322,5	89,9	302,5	96,4
Tires for trucks	Piece	74,2	142,7	248,7	130,0	0,1	100,0
Tires for cars	Piece	18,7	144,6	61,1	308,4	1,2	434,7

energy - 26.4%, fuel - 7,0%. Fuel energy structure substantially varies depending on manufacture (Table 2). More than 30% of electric energy is used during oil production, chemical threads and fiber, ammonia, potash fertilizer. Maximum specific weight of heat energy use (more than 80%) is present in soda ash, ammonium nitrate, synthetic rubber production. Consumption of various types of energy is distributed between processes of chemical production in the following pattern: in chemical reactions - 5-35%, in mass transfer processes - 35-80%, in heat transfer processes - 55-85% (Rosstat, 2020).

4. METHODS AND MODELS

We will use the method of principal component and factor analysis in order to study dynamics and structure of energy resources and to determine factors that influence overall energy intensity of petrochemical manufacture. Dynamic factor analysis allows us to explore data's cause and effect relationship in dynamics and perform its reduction.

The goal of principal components analysis (PCA) method (PCA) is to determine the least several factors (principal part) that bring the greatest value into data dispersion. In our case we have the matrix X of variables dimension of which is I×J, where I – number of types of petrochemical production, and J – number of independent variables (energy resources) under condition that J >1. The method allows to receive new formal variables ta (a=1, …A), that present a linear combination of first variables xj (j=1, …J):

With new variables matrix X becomes a product of two matrices T and P, where matrix T is a matrix of counts with dimensions (I×A), matrix P is a matrix with capacity dimensions (J×A), matrix E is a matrix of remainders with dimensions матрица E (I×J):

New variables ta are called principal components, number of columns – ta in matrix T, and pa in matrix P, are equal A, that is a number of Principal Components. Wherein the number of Principal Components is less than the number of variables J (energy resources) and number I (types of petrochemical products). An important feature of PCA is its orthogonality or indepence of principal components.

Table 2: The structure of the "energy portfolio" of petrochemical production (percent)

Types of production	Electric energy	Heat energy	Fuel
Oil production	87,8	10,8	1,4
Chemical fibers and threads	47,6	51,5	0,8
Ammonia	33,9	31,5	34,6
Potash fertilizer	32,0	65,1	2,9
Tires for cars	28,4	69,6	2,1
Tires for trucks	23,0	77,0	0,0
Paints and varnishes	22,6	72,5	4,9
Synthetic resins and plastic	20,0	76,0	4,0
Phosphate fertilizer	19,4	78,2	2,4
Oil refining	19,2	58,1	22,7
Ammonium nitrate	15,4	84,1	0,5
Synthetic rubber	14,1	81,4	4,5
Ethylene and propylene	13,6	76,5	10,0
Sulfur	10,8	79,2	10,0
Soda ash	8,6	87,7	3,6

For graphic determination of optimal numbers of principal components the graph of "stone cree" is applied. The core of the method is to find own value of correlations matrices, where the decrease of own values from left to right slows down to it maximum. It is supposed that to the right from point of change of curve direction there is only "factorial scree" and those factors drop out.

For the realization of Principal Components Method and factorial analysis program complex Statistica is applied.

5. RESULTS AND DISCUSSIONS

Analysis of database in energy resource use of petrochemical production in 2012-2018 has shown positive interconnection between electric and heat energy consumption growth (coefficient 0, 7). Correlation between fuel consumption growth and types of energy has not been found (Table 3). In types of petrochemical production during 2012-2018 high fuel consumption growth rate has been up to 18% in natural units. This situation significantly varies from dynamics of electric and heat energy use: growth rate of 100,3% and 103,4% accordingly. Multidirectional dynamics of variables demonstrates lack of effectiveness in government and corporate energy efficiency politics in the means of individual manufactures.

With the use of factor analysis tools, the contribution of product types to the formation of the energy intensity of the petrochemical industry was determined based on the correlations and dynamics of variables in 2016-2018 (Table 4). According to the first factor, "Reducing energy intensity," the largest contribution to increasing the energy efficiency of the industry may be seen in the production of paints and varnishes (55%), where the specific energy consumption decreased in all of the studied items. This industry is developing quite actively, and innovative "Paint Technologies" that are directly related to "critical technologies" at the federal level, are being introduced. Among other things these technologies consider the solution of energy-saving problems within the framework of creating a low-waste, closed-loop production. In addition, phosphate fertilizers contribute 11.6% to factor 1 "Reducing energy intensity." Due to the export of over 45% of these products Russian manufacturers increase their competitiveness, also by the means of energy-saving technologies. "Increasing energy intensity" is a second factor, and it contributes 51% to car tires production, 26% to ammonia production. This factor is negative, and it indicates a decrease in energy efficiency production facilities use. In Russia tire manufacturers during 2012-2018 had a difficult economic situation due to increased competition, reduction of sales markets, and financial instability in this segment. The following conditions did not allow Russian tire manufacturers to modernize production and to change their approach to the use of energy resources accordingly.

In contrast to tire manufacturers, ammonia production has positive trends in its development, and export expansion of Russian market share in the world now reaches 10%. Important to note that this type of product is involved in factor 2 "increasing energy intensity" formation as a result of a four-fold increase in specific fuel consumption. At the same time during 2012-2016 the electric and thermal energy consumption in the production of ammonia does not increase. Due to the nature of production fuel source (natural gas) share accounts for more than half of the energy consumed by the petrochemical industry. This is a very energy-intensive production cause the costs of ammonia production consist of 68% energy resources as a whole. Factor 3 "sustainability of the energy resources structure" is distinguished by less contribution variations in the product type. The highest values may be seen in truck tire production (23.6%) and paints and varnishes (20.2%). According to these numbers, energy resources structure for product manufacture is the most stable, displacement by types of resources is insignificant.

Measurement of the relative contribution to overall dispersion of the variables allows to determine the main components of the energy intensity in petrochemical industries (Table 5). So, the first

Table 3: Matrix of correlation coefficients between indicators of energy resources use for the production of petrochemical products

Indicator	The average growth rate of electric energy per unit of output, %	The average growth rate of heat energy per unit of output	The average growth rate of fuel energy per unit of output
The average growth rate of electricity per unit of output, %	1	0,741	0,086
Average heat energy growth rate per unit of production, %	0,741	1	0,181
Average fuel growth rate per unit of production, %	0,086	0,181	1

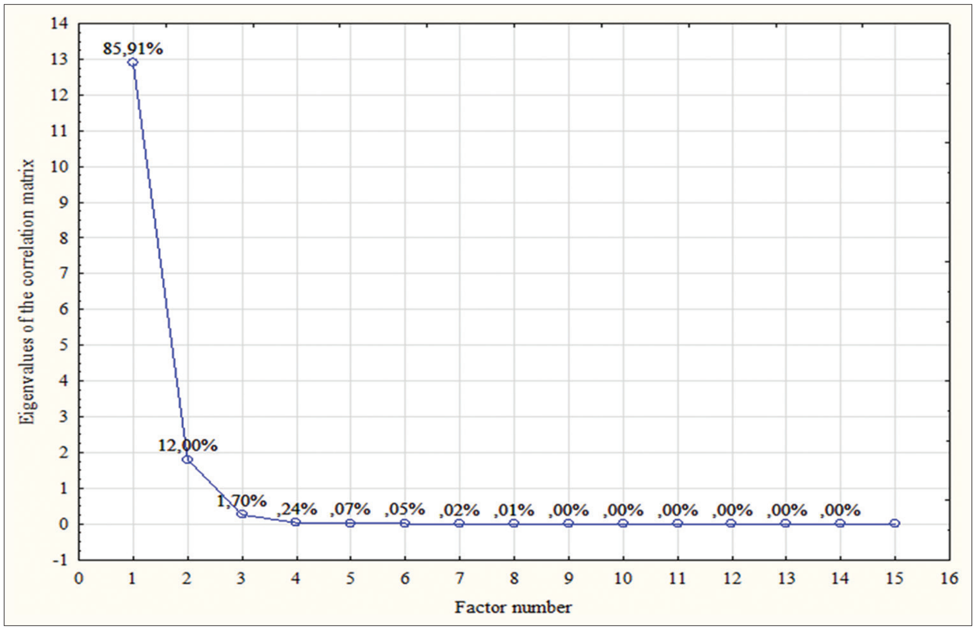
Table 4: Contribution of product types to the formation of energy intensity factors in petrochemical industries (dynamic factor analysis)

Types of production	Factor 1 "reducing energy intensity"	Factor 2 "increasing energy intensity"	Factor 3 "sustainability of the structure of energy resources"
Phosphate fertilizer	11,64	0,06	8,17
Synthetic resins and plastic	6,36	0,27	5,09
Synthetic rubber	5,95	0,15	2,63
Ethylene and propylene	2,57	0,26	1,43
Tires for cars	0,48	51,13	5,68
Ammonia	0,07	26,22	1,74
Ammonium nitrate	2,44	2,09	0,80
Chemical fibers and threads	1,32	2,04	0,06
Potash fertilizer	0,13	1,12	0,63
Oil refining	0,00	1,68	0,57
Oil production	3,08	1,34	9,78
Soda ash	0,03	1,46	3,57
Sulfur	4,94	4,95	16,03
Tires for trucks	5,82	5,09	23,61
Paints and varnishes	55,15	2,14	20,21

Table 5: Determination of the main components of the energy intensity of petrochemical industries

Main components	Eigen value	The relative contribution to the total dispersion,%	Total relative contribution to the total dispersion,%
1 component "reducing energy intensity"	1,78	59,51	59,54
2 components "increasing energy intensity"	0,96	32,02	91,56

Figure 1: Energy resource curve affecting the energy intensity of Russian petrochemical industries ("stone cree" method)



main component with a contribution to the total dispersion of 59.5% is the "reduction of energy intensity." According to the results of the study as a whole, in the Russian petrochemical industries, the positive trend of increasing energy efficiency slightly prevails over the trend of increasing energy intensity (2 components, "increasing energy intensity"). At the same time, the contribution of the second component is still quite significant, indicating the presence of problems in the implementation of energy efficiency programs in the petrochemical sectors. Overall, components 1 and 2 show a relative contribution to the total dispersion of 91.5%. With the use of graphical "stone scree" method a deeper study of energy resource structure, including electric and thermal energy, and the use of fuels such as combustible natural gas, fuel oil, coal, gasoline, diesel fuel and others in the production has been conducted. The analysis helped to identify the main types of energy resources that today determine the "energy portfolio" of petrochemical industries and the energy intensity of products (Figure 1).

The largest contribution to energy intensity formation in petrochemical industries is made by thermal energy (85.9%). Earlier it was noted that in 2018, the share of thermal energy in the industry's "energy portfolio" was 66%. Taking into account the dynamics of changes in energy consumption in 2012-2016 and types of resources the correlation matrix, the contribution of thermal energy to the formation of the energy intensity of the industry is set at 85.9%.

The second significant most factor is electric energy with a contribution to energy intensity formation of 12%, the third is natural gas with a share of 1.7%. According to the concept of "stone cree," the point of significance of the factors will be the point of 1.7% "natural gas." To the right of this point, the decrease in eigenvalues from left to right slows down to its minimum point. Thus, to the right of the 1.7% point "natural gas" is a "factorial cree" and these factors may not be considered.

It should be noted that the allocation of main components - types of energy resources in 2012 and 2018, shows a slight increase of electric energy role in energy intensity formation in petrochemical industries. In 2012 the contribution of electric energy to the total dispersion was 10.9%, then by 2018 this indicator increased up to 14.8%. At the same time, accordingly, the role of thermal energy decreases from 87.8% in 2012 to 83.8% in 2018. Possibly this situation occurred due to modernization of production lines at petrochemical enterprises aimed at increase of the isolation of technological processes and the use of secondary thermal energy.

The energy potential of secondary resources is quite high and may be achieved through the release of thermal energy from by-products and intermediate products, that may later be used to power related processes.

6. CONCLUSION

The study of energy intensity dynamics and structure of petrochemical industries allows us to draw the following conclusions:

1. The specificity of technological processes and norms of energy consumption in the production of petrochemical products

affect the structure and dynamics of production energy intensity. The most energy-intensive products in the Russian industry are synthetic rubber, ammonia, chemical threads and fibers. A negative growth trend in energy resources per unit of production for the period 2012-2018 is observed in car and truck tires production, sulfur, soda ash, and also in the extraction and processing of oil. In total consumption of fuel and energy resources at petrochemical enterprises, thermal energy accounts for 66.6%, electric energy - 26.4%, fuel - 7.0%. The maximum specific weight of the use of thermal energy (more than 80%) is observed in the production of soda ash, ammonium nitrate, and synthetic rubber
2. There is a close positive relationship between an increase in specific consumption of electric and thermal energy in the production of petrochemical products. At the same time, there is no correlation between changes in fuel consumption and types of energy. The multidirectional dynamics of the variables indicates the lack of effectiveness of state and corporate energy efficiency policies in relation to individual industries
3. The following factors and types of industries that influence formation of trends in energy intensity of the petrochemical industry are identified: a decrease in energy intensity, an increase in energy intensity and stability of the structure of energy resources. It may be seen that formation of a positive factor "reduction in energy intensity" is influenced by the production of paints and varnishes, and phosphate fertilizers. The negative factor "Increasing energy intensity" is formed to a greater extent under the influence of trends in the development of tire production for passenger cars and ammonia production
4. A positive factor is the prevalence of decreasing energy intensity of petrochemical industries (the first major component with a contribution to the total dispersion of 59.5%) over the trend of increasing energy intensity (the second component with a contribution to the total dispersion of 32%). However, the contribution of the second component is still quite significant, indicating the presence of problems in energy efficiency implementation programs in the petrochemical sectors
5. The largest contribution to level and structure of energy intensity formation in the "energy portfolio" of petrochemical industries is made by thermal energy (85.9%). The second most significant factor is electric energy with its contribution to formation of energy intensity of 12%, the third is natural gas with a share of 1.7%. At the same time, in the 6 years study period, the role of electric energy in energy intensity formation in petrochemical industries has increased against the background of a decrease in the role of thermal energy. This may be due to increased closure of technological processes and an increase in share use of secondary energy resources

The research materials may be used in the development of government strategic planning documents, innovative projects for the introduction of resource-saving technologies, monitoring the effectiveness of energy efficiency programs. Identified trends and patterns allow to purposefully influence certain types of activities in order to identify the reasons for the increase in products energy intensity and develop solutions for the organization of energy-saving industries.

7. ACKNOWLEDGMENTS

The research was carried out within the framework of the grant of the President of the Russian Federation for state support of leading scientific schools of the Russian Federation, project number NSH-2600.2020.6.

REFERENCES

Akadiri, S.S., Bekun, F., Sarkodie, S.A. (2019), Contemporaneous interaction between energy consumption, economic growth and environmental sustainability in South Africa: What drives what? Science of the Total Environment, 686, 468-475.

Alqahtani, B.J., Patino-Echeverri, D. (2019), Combined effects of policies to increase energy efficiency and distributed solar generation: A case study of the Carolinas. Energy Policy, 134, 110936.

Chaabouni, T., Khemakhem, M. (2018), Energy management strategy in cloud computing: A perspective study. Journal of Supercomputing, 74(12), 6569-6597.

De Almeida, A., Fong, J., Brunner, C.U., Werle, R, Van Werkhoven, M. (2019), New technology trends and policy needs in energy efficient motor systems-a major opportunity for energy and carbon savings. Renewable and Sustainable Energy Reviews, 115, 109384.

Fotis, P., Polemis, M. (2018), Sustainable development, environmental policy and renewable energy use: A dynamic panel data approach. Sustainable Development, 26(6), 726-740.

Irandoust, M. (2019), On the causality between energy efficiency and technological innovations: Limitations and implications. International Journal of Green Energy, 16(15), 1665-1675.

Lin, B., Wang, M. (2019), Possibilities of decoupling for China's energy consumption from economic growth: A temporal-spatial analysis. Energy, 185, 951-960.

Malysheva, T.V., Shinkevich, A.I., Ostanina, S.S., Vodolazhskaya, E.L., Moiseyev, V.O. (2016), Perspective directions of improving energy efficiency on the meso and micro levels of the economy. Journal of Advanced Research in Law and Economics, 1(15), 75-83.

Malysheva, T.V., Shinkevich, A.I., Zelenkina, E.V., Dmitrieva, O.A., Kurdyumov, V.I. (2017), Development and concentration efficiency study of enterprises innovation activity in real sector of economy. Eurasian Journal of Analytical Chemistry, 12(7B), 1347-1356.

Mednikova, E., Siennikov, V., Postnikov, I., Penkovskii, A. (2019), Development features of heat power industry legislation in Russia. Environmental and Climate Technologies, 23(2), 22-35.

Naidoo, M., Gasparatos, A. (2018), Corporate environmental sustainability in the retail sector: Drivers, strategies and performance measurement. Journal of Cleaner Production, 203, 125-142.

Rajskaya, M.V., Sagdeeva, A.A., Panteleeva, Yu.V., Malysheva, T.V., Ershova, I.G. (2019), Differentiated approach problems to innovative development management in Russian regions. Humanities and Social Sciences Reviews, 7(4), 1262-1268.

Rosstat. (2020), Available from: http://www.gks.ru.

Shinkevich, A.I., Malysheva, T.V., Ostanin, L.M., Muzhzhavleva, T.V., Kandrashina, E.A. (2018), Organization challenges of competitive petrochemical products production. Espacios, 39(9), 28-41.

Shinkevich, A.I., Malysheva, T.V., Ryabinina, E.N., Morozova, N.V., Sokolova, G.N., Vasileva, I.A., Ishmuradova, I.I. (2016), Formation of network model of value added chain based on integration of competitive enterprises in innovation-oriented cross-sectorial clusters. International Journal of Environmental and Science Education, 17, 10347-10364.

Shinkevich, A.I., Malysheva, T.V., Zaraichenko, I.A., Lubnina, A.A., Garipova, G.R., Sharafutdinova, M.M. (2019), Investigation of energy consumption trends in petrochemical plants for the management of resource saving. E3S Web of Conferences, 124, 04005.

Trotta, G. (2019), Assessing energy efficiency improvements, energy dependence, and CO_2 emissions in the European union using a decomposition method. Energy Efficiency, 12(7), 1873-1890.

Wiese, F., Baldini, M. (2018), Conceptual model of the industry sector in an energy system model: A case study for Denmark. Journal of Cleaner Production, 203, 427-443.

Yildirim, D.C., Yildirim, S., Demirtas, I. (2019), Investigating energy consumption and economic growth for BRICS-T countries. World Journal of Science Technology and Sustainable Development, 16(4), 184-195.