INCREASE OF ENERGY EFFICIENCY OF THE UKRAINIAN ECONOMY: PROBLEMS AND PRIORITIES

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Abstract. The article deals with the factors slowing down the energy efficiency processes of Ukraine's economy. To identify existing problems the structural-functional and value engineering analysis of energy consumption dependence on conditions of economic environment has been made. The priority directions and instruments to intensify energy efficiency policy in Ukraine have been suggested.

Keywords: energy efficiency, energy consume, sector of the economy, share of energy, cost of energy.

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Introduction

Modern paradigm of normal functioning of the economy determines a plenitude of demands for energy resources as one of the dominating factors for almost all the countries. The solidity of energy needs can be achieved by having sufficient and stable resource and energy base, on the one hand, and by providing efficient use of energy resources, with improvement and development of energy supply, on the other hand. The phenomenon of the world economic experience, such as the "resource curse" and "Dutch disease", shows the advantages of the second way of meeting the energy needs of the economy.

Ukraine is characterized by high unit costs of energy resources in almost all the fields of economic activities. Besides, Ukrainian economy has a significant dependence on import of energy and hydrocarbons. Despite some progress in energy efficiency, which has occurred recently, the processes of implementation of projects and activities to improve energy efficiency occur rather slowly, selectively and not systematically. Therefore, there is a need for a detailed structural analysis of complex trends of energy consumption of the Ukrainian economy. It will help to identify topical problems and suggest priorities for improving energy efficiency.

Key trends of energy efficiency in Ukraine

Research of energy efficiency requires the selection of adequate methodology for analyzing and building the relevant indicators. According to the International Energy Agency (IAE) methods, energy expenditures are measured in millions or thousands tons of oil equivalent (Mtoe, Ktoe). Major indicators of energy efficiency evaluation are the total primary energy supply (TPES) per one-dollar GDP and per one-dollar GDP at purchasing

power parity (TPES/GDP, TPES/GDP PPP). Thus, the difference of the currency rate embedded in the calculation of purchasing power parity can significantly affect the efficiency indicator. Together with the total primary energy supply, energy balance provides information about the total final consumption (TFC) that allows performing calculation of the final energy expenditures per GDP (TFC/GDP, TFC/GDP PPP).

The trends of specific indicators of energy expenditure for 2008-2014 shows a slight increase of efficiency of Ukrainian economy (fig. 1). In 2014 GDP amounted to 134.02 billion 2010 USD that is 1.15 times less than in 2008, and TPES amounted to105.68 Mtoe, or decreased compared to 2008 1.27 times. However, TFC for this period decreased by 1.35 times. Thus, the ratio of TFC/TPES decreased from 0.62 in 2008 to 0.58 in 2014, reflecting the negative impact of the effect of scale on energy efficiency *(Shevtsov, 2014)*. It should be noted, that the ratio between final consumption and primary energy supply is characterized as a conversion efficiency of energy resources, and specific types of economic activities in the country. In particular, in 2014 the ratio of TFC/TPES for individual countries wasas follows: Germany–0.71, France–0.61, Poland – 0.69, Belarus–0.73. However, in the context of a comparison of individual European countries TPES and GDP statistics are not for the benefit of Ukraine. Therefore, in 2014 TPES in Germany totaled 306.07 Mtoe, which exceeded the Ukrainian one by 2.89 times, while GDP of Germany was 3624.17 billion of 2010 USD, surpassing value of Ukraine by 27.04 times. France (2.29 and 20.37) and Poland (0.89 and 3.99), correspondingly, give a similar ratio.

Besides the above said, low energy efficiency of the economy worsens due to the weakness of the national currency *(Ukraine, 2012)*. In 2014, the divergence of energy efficiency for TPES/GDP and TPES/GDP PPP was 2.55 times for Ukraine, for Germany – 0.89 times, France – 0.9 times and Poland – 1.64 times. On the one hand, decline of hryvnia creates favorable conditions for export-oriented sectors of Ukrainian economy, but,on the other hand, leads to non-motivation energy efficiency in industry.

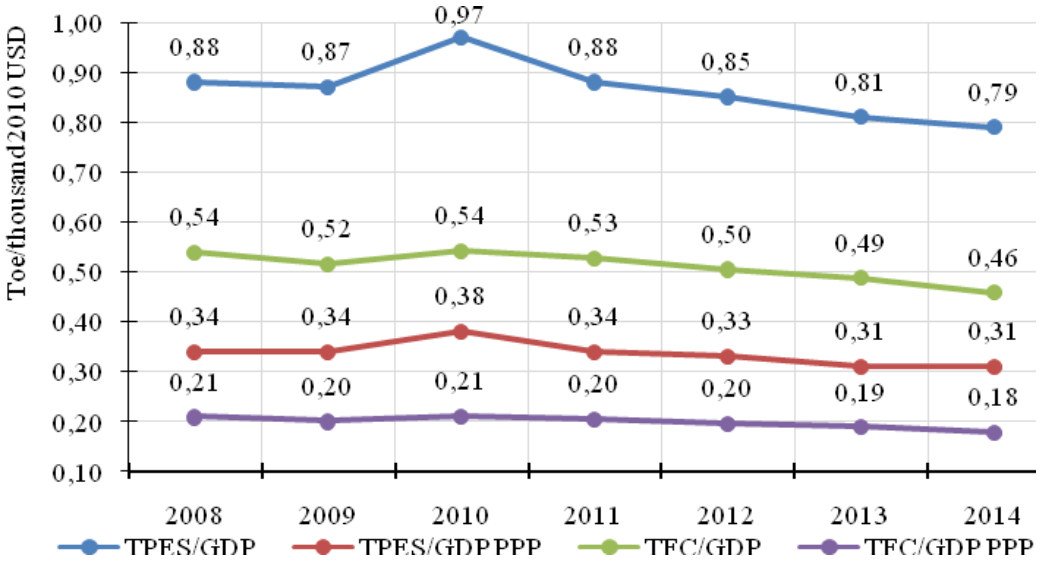

Fig. 1. Ukrainian energy efficiency in 2008-2014
(IEA statistics)

Taking into account the share of imported energy in the structure of energy supply, the following adverse implications are displayed in economic activity and welfare of the population.

The changes of energy supply and consumptionin Ukraine

The dynamics of energy efficiency essentially depends on changes in types and product structure of energy use. In 2008-2012, the basic sources of primary energy supply were coal and natural gas, which are used both for conversion to other forms of energy and for final consumption, and nuclear energy, which is converted into electricity. Against the falling trends of the energy from coal and natural gasproduction, the volume of oil products increased (table 1).

Table 1

Share of TPES and TFC in 2008-2014

Indica-tor	Ukraine								Germany		France		Poland	
	2008		2010		2012		2014		2014		2014		2014	
	Ktoe	%	Ktoe	%	Ktoe	%	Ktoe	%	Ktoe	%	Ktoe	%	Ktoe	%
TPES, total	**134642**	**100,0**	**132428**	**100,0**	**122512**	**100,0**	**105683**	**100,0**	**306070**	**100,0**	**242642**	**100,0**	**94018**	**100,0**
coal	41799	31,04	38251	28,88	42545	34,73	35576	33,66	79602	26,01	9288	3,83	49313	52,45
crude oil	11166	8,29	11497	8,68	5073	4,14	3043	2,88	94012	30,72	55459	22,86	24640	26,21
oil products	3202	2,38	1682	1,27	6559	5,35	7645	7,23	7000	2,29	14790	6,10	-2655	-2,82
natural gas	52805	39,22	55229	41,70	43019	35,11	33412	31,62	63356	20,70	32585	13,43	13401	14,25
nuclear	23566	17,50	23387	17,66	23653	19,31	23191	21,94	25312	8,27	113748	46,88	0	0,00
hydro	990	0,74	1131	0,85	901	0,74	729	0,69	1684	0,55	5403	2,23	188	0,20
geotherm al, solar, etc.	4	0,00	4	0,00	53	0,04	134	0,13	8842	2,89	2350	0,97	698	0,74
biofuels and waste	1689	1,25	1597	1,21	1695	1,38	1934	1,83	29179	9,53	14792	6,10	8218	8,74
electricity	-579	-0,43	-349	-0,26	-987	-0,81	-725	-0,69	-2914	-0,95	-5778	-2,38	186	0,20
heat	0	0,00	0	0,00	0	0,00	745	0,70	-3	0,00	5	0,00	29	0,03
TFC, total	**82872**	**100,0**	**73933**	**100,0**	**72548**	**100,0**	**61460**	**100,0**	**216322**	**100,0**	**147652**	**100,0**	**65271**	**100,0**
coal	10068	12,15	7987	10,80	8717	12,02	9180	14,94	6787	3,14	3158	2,14	11861	18,17
crude oil	0	0,00	10	0,01	9	0,01	8	0,01	0	0,00	0	0,00	0	0,00
oil products	13532	16,33	12548	16,97	12481	17,20	10141	16,50	92099	42,57	67305	45,58	20952	32,10
natural gas	34147	41,20	28396	38,41	26605	36,67	20955	34,10	49942	23,09	28228	19,12	10406	15,94
nuclear	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
hydro	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
geotherm al, solar, etc.	0	0,00	0	0,00	0	0,00	0	0,00	709	0,33	129	0,09	37	0,06
biofuels and waste	1207	1,46	984	1,33	1030	1,42	1201	1,95	13532	6,26	10898	7,38	5744	8,80
electricity	11612	14,01	11526	15,59	11839	16,32	11041	17,96	44104	20,39	35718	24,19	10824	16,58
heat	12306	14,85	12481	16,88	11865	16,35	8933	14,53	9148	4,23	2217	1,50	5446	8,34

(Calculations are based on IEA statistics)

The positive trend was the growth of the share of alternative sources of energy (geothermal, solar, etc.) from 4 Ktoe in 2008 to 134 Ktoe in 2014, but this share was only 0.13%in the primary balance in2014, which is inessential. At the same time the share of alternative sources in Germany amounted to 2.89%, in France to 0.97%, in Poland to 0.74%.

The differences of fractions of biofuels and waste as energy sourcesis very illustrative. In period from 2008 till 2014 this share was only 1.25-1,83% in Ukraine with relatively little change in the volume of biofuel proposals (from 2008 to 2014 growth was 15%). In 2014 in Germany the share of biofuel and waste amounted to 9.53% of primary supply, in France - 6.1%, in Poland – 8.74%. Despite the fact that the primary supply in Poland was by 1.12 times less than in Ukraine, initial supply of biofuel prevails by 4.25 times.

Structural changes for theperiod of 2008-2014, which occurred in TFC and TPES, do not show trends of optimization of energy consumption due to the impact of situational factors of economic environment. The largest share of TFC is accounted for industrial and residential sectors: 33.47% and 33.17% correspondingly, the share of transport amounted to 16.8%in 2014.In Ukraine industrial and residentialsections are identified as the sectors, which have the biggest potential for energy savings. Industry is the largest final consumer of coal (91.59%). The largest final consumers of electricity are residential section (43.62%), industry (35.73%), commercial and public services (18.26%). Natural gas in final energy consumption accounted for most on the residential section (56.04%) and industry (15.86%). In industry, the natural gas consumption dropped from 9687 Ktoe in 2008 to 5272 Ktoe in 2012, and 3324 Ktoe in 2014.This reduction is primarily associated with a decrease in the volume of industrial production and with the modernization of individual enterprises of metallurgical complex. In particular, the gross added value of industry from 2008 to 2014 in terms of comparable prices decreased by 42.5%, industrial consumption of electricity decreased by 18%, but industrial consumption of coal increased by 7%. Besides, the share of biofuels and waste used by Ukrainian industry varies on the level of 4-4.5%, while in Germany it is 27.59%, in France – 11.89%, in Poland – 31.96%.

Volumes and dynamics of the vertical structure of TPES and TFC indicate that the potential for energy efficiency is being implemented slowly, despite all efforts of the government, public and support of international organizations *(Uglublennyy, 2013)*. State Energy Efficiency Program for 2010-2015, developed with the support of international organizations, intended to achieve a number of objectives, including:

- reduction of the energy capacity of GDP by 20% compared to 2008;
- increase of the share of renewable energy up to 10%;
- reduction of the cost of natural gas for the production of heat by 60%;
- reduction of energy costs for government agencies by 50%;
- increase of the annual replacement of imported natural gas from other sources by 12.2 Mtoe.

However, the efficiency of the economy depends on technical and technological characteristics of the consumption and the cost of energy. Thus, according to analytical estimates the cost of 1 toe of imported energy resource in 2008 amounted to 349.8 USD, in 2012 – to 563.0 USD, in 2013-2014 there was reduction to 21.8%. These trends have a negative impact on the overall value of the imported energy supplies, such as leveling the physical reduction of import (*Melnyk, 2016*). Correspondingly, the capacityof energy policy is not only a necessity for technical optimization of energy use, but also an opportunity to change the comparative value of energy in terms of potential consumer. Activation of energy efficiency is to create conditions of economic interest to businesses in maximizing the useful

output from each unit of energy resource.

Specific character of energy use in different sectors of the economy

The level of energy consumption by individual sectors of the economy depends on a number of technical and economic factors. The combination of key parameters, such as availability, price, quality, interchangeability, direction and flexibility of the applicationform the demand for energy resources and specific characterof their use. From a consumer perspective the entity role of each resource (including energy) is determined through the complex of a particular set of characteristics. Therefore, the improvement of energy efficiency in terms of a business entity is not the goal but strategy or means of achieving economic interests and benefits.Extensive strategy, as a rule, is carried out at the expense of expanding involvement of energy resources in production process. These resourceshave less absolute and/or specific value according to the source of technical and economic characteristics. The substituteresources have related or identical properties for the economic relevance of the economic process, the purpose of the economic activities, using as a factor of production or the nature of consumption in economic activity (fig. 2). In contrast, intense strategy is carried out by increasing the efficiency of energy use by introducing innovations and achievements of scientific and technological progress, enhancing existing and establishing new production and business operations, processes and forms of organization of economic activity.

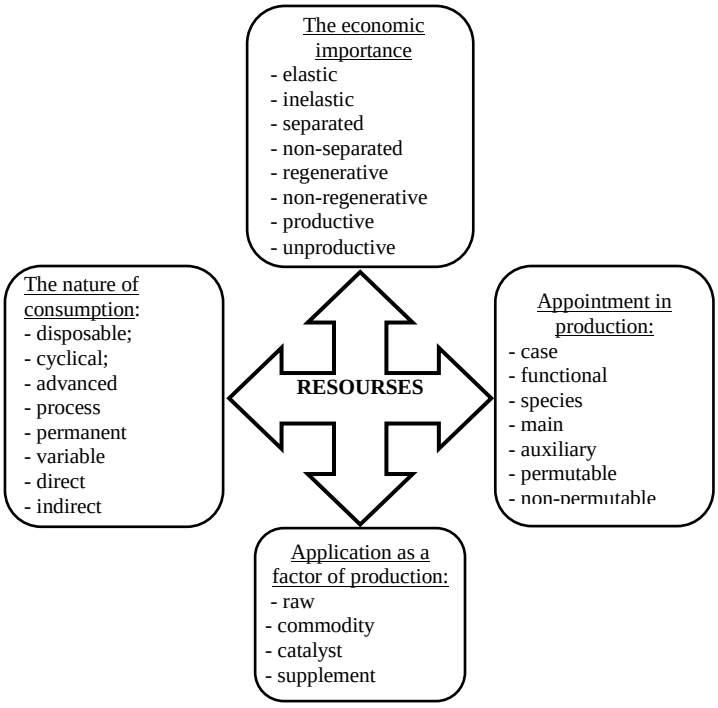

Fig. 2. Resources systematization according to their value in economic activity (developed by the authors)

Together with the quantitative and structural differences in energy consumption between Ukraine and Europe, there is also substantial difference in prices for energy resources. Studies point to the issue of thefunctioning of the market mechanisms for stimulation, namely, excessivegovernment regulation of the energy market. Therefore, in Ukraine tariffs for industrial consumers are significantly above the market price and tariffs for the population does not cover a half of the costs, while in the EU the alignment is opposite: in France the average price of electricity for households is by 1.85 times higher than price for industrial sector, in Germany the figure amounts to2.24 times. The average EU household pays for electricity 2.16 times more than an industrial entity. The average cost of natural gas for households (at the exchange rate on November 2015) in Europe is 2.52 times higher than in Ukraine. In particular, in Germany it is 2.57 times, in France – 2.66 times, in Sweden – 4.29 times. Price of gas for industry is almost the same in EU and exceedsthe Ukrainian price only by 4%/ (Yevropeyskiy, 2015).

This price disparity reflects the strategy of European countries to stimulate the productive use of energy resources and optimize non-productive consumption. The level of economic development and the welfare of its citizens corresponds to energy needs. The rising cost of energy would promote more dynamic transformations and increase energy efficiency of the Ukrainian economy.

The analysts of the German Advisory Group (Mayssner, 2012) highlights the main issues that are to be be resolved at the government level:

– administrative pricing, subsidies and cross-subsidies which distort prices of energy resources;

– lack of competition and inefficient use of energy as a result of existence of state property and vertically integrated monopolies;

– lack of proper legislative framework governing legal relations in the residential sector and other energy-related areas.

Along with the above factors, there are general conditions of business activity, trends, specific economic terms and conditions of significant influence. They are reflected on the horizontal structure of energy consumption (table 2). By approximate calculations cost of 1 toe of electricity (scaled according to the NBU exchange rate and to the established prices and tariffs) in Ukraine amounted to the following figures: in 2012 – 185.54 USD for residential section and 577.78 USD for the industry; in 2014 – USD 143.54 for residential section and 465.69 USD for the industry. Cost of 1 toe of natural gas in 2012 was 169.19 USD for residential section and 611.39 USD for the industry; in 2014 – USD 134.69for residential section and 416.81 USD for the industry. It caused the growth of the prices on energy resources in hryvnia equivalent.

For export-oriented enterprises, which receive currency earnings, such a situation does not stimulate the implementation of comprehensive and systematic measures of energy efficiency. Correspondingly, actual cost of energy for residential section and domestic businessfalls.The latest trends in energy price increase occurred with the growth of the rate of USD.

Thus, the cost of energy for 1 toe in 2016 was as follows: 160.07 USD for electricity in the residential section and326.90 USD for the industry; USD 336.96 for natural gas in the residential section and 321.12 USD for the industry. More accurate and probable calculations require taking into account all the scenarios of energy consumption, market dynamics, and the economic efficiency of production and the welfare of the population. It will allow getting adequate evaluation and forecast of energy efficiency. Therefore, along with exceeding

Ukraine on GDP, the EU has the highest standards of life of the population, which is reflected in the greater energy consumption per capita in the sector of commercial and public services. That is why the increase of electricity consumption can revealnot reducing of energy efficiency, buta greater level of residential section needs.

Table 2

Share of energy consumption by sectors of the economy in the period from 2008 to 2014

Indicator	Ukraine				Germany	France	Poland
	2008	2010	2012	2014	2014	2014	2014
Industry	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
coal	26,01	27,29	31,08	40,88	10,54	10,69	26,27
oil products	4,68	5,46	5,19	4,48	5,14	8,75	5,03
natural gas	32,08	25,81	21,98	16,16	34,09	38,54	22,57
biofuels and waste	0,18	0,16	0,19	0,23	6,80	5,01	12,96
electricity	19,12	22,73	22,62	22,74	35,85	37,01	29,18
heat	17,94	18,55	18,94	15,52	7,58	0,00	4,00
Transport	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
coal	0,22	0,21	0,10	0,07	0,00	0,00	0,00
oil products	61,65	68,24	75,74	70,80	92,30	90,65	91,53
natural gas	32,19	25,57	17,39	22,01	0,82	0,21	2,31
biofuels and waste	0,00	0,00	0,00	0,40	5,07	6,67	4,51
electricity	5,95	5,98	6,77	6,72	1,81	2,46	1,66
heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ResidentialSection	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
coal	3,31	2,00	3,04	1,42	1,12	0,40	33,47
oil products	0,42	0,34	0,24	0,16	23,62	16,61	3,22
natural gas	60,51	59,00	58,68	57,61	35,67	28,88	16,58
geothermal, solar, etc.	0,00	0,00	0,00	0,00	1,19	0,23	0,14
biofuels and waste	4,76	3,83	3,99	5,25	9,54	16,31	13,29
electricity	11,75	13,26	14,08	16,44	21,73	34,44	12,75
heat	19,25	21,56	19,97	19,12	7,14	3,13	20,54
Commercial and public services	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
coal	4,64	3,81	2,62	1,57	0,16	0,51	8,60
oil products	1,23	1,59	1,56	2,29	21,45	10,89	5,58
natural gas	10,82	7,50	9,25	17,93	30,29	29,07	20,65
geothermal, solar, etc.	0,00	0,00	0,00	0,00	0,30	0,14	0,13
biofuels and waste	0,87	0,26	0,54	0,60	6,44	2,25	2,77
electricity	39,50	35,41	39,54	43,23	37,34	53,85	49,88
heat	42,91	51,41	46,49	34,40	4,03	3,30	12,39

(Calculations are based on IEA statistics)

Analysis of the horizontal structure of the TFC in industry shows that during the period from 2008 to 2014the shares of coal and natural gaschanged significantly. In 2008 the share of

natural gas was 32.08% and coal amounted to 26.01% in energy consumption. In 2014, it changed to 16.16% and 40.88% respectively. On the contrary, theshare of electricity increased from 19.12% to 22.74%.

In Germany and France, the share of coal does not exceed 11%, but in Poland it is up to 27%. For the residential section the main source of energy is natural gas (60.51-57.61%), heat energy (about 20%) and electricity (11.75-16.44%). Despite the higher relative cost of 1 toe of electricity to natural gas, households are inherent to the substitute of natural gas byelectricity. The substitution process caused by the rising cost of energy in UAH in 2012-2014: it was 14.97% for electricity and 18.31% for gas. It resulted in saving energy and changing the structure of energy needs. In 2014-2016, the price for the electricity in residential section increased on average by 2.36 times, fornatural gas –by 5.3 times. Therefore, the costs changes lead to further structural shifts in energy consumption.

Thus, the indicators of the energy efficiency should be built and corrected taking into account technical, economic, organizational, financial and market features of the functioning of certain sectors of the economy. Application of this methodological approach will accurately delineate the impact of intensive and extensive factors of energy consumption.

Conclusions and suggestions

The Ukrainian energy policy needs to improve the coordination of interaction in the kind of “energy resource is a sector of consumption”. The determinationof the tools of effective cooperation is possible byusing the functional approach, which based on the intersectoral connectionof economic activity. The process of social production is represented as a technological chain, applying a functional approach which proves the key directions of efficiency growth both in the field of generation and in the creation of tangible and intangible benefits.

The main factors of energy efficiency growth are to improve the quality features of the economic environment such as competition, business climate, investment attractiveness, innovation activity. It will create the proper level of motivation for entrepreneurial initiatives in energy efficiency, prevent ineffective government intervention and excessive administrative influence in the energy sector, and, eventually, ensure the gradual performance of Ukraine at the best practices of effective energy consumption.

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