Energy Dependency and Competitiveness

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Summary:

The main emphasis in the development of the EU economy over the past decade is placed on two challenges - globalization and the ageing population. The common basis for an adequate response to these challenges is the competitiveness of the European economy. On the one hand, the energy as a polyvalent resource plays an important role in the improvement of the competitiveness of each economic system. On the other hand, the provision of the economies with energy resources, i.e. their dependence on imported energy resources, is different. The possibilities of an economic system to increase its competitiveness while reducing its dependence on imported energy resources is determined by the ability to increase the efficiency with which energy resources are used. Energy efficiency is becoming a bridge between the competitiveness of an economic system and its dependence on imported energy resources.

Key words: Input Output, Economic Planning, Energy Efficiency, Energy Dependence, National Competitiveness.

JEL Classification: E160, O200, Q40

1. Introduction

The competitiveness topic is sufficiently broad in scope, which suggests its research from different positions. In most cases, it is asserted the understanding, that it (the competitiveness) can be studied only at microeconomic system level. Whether it is possible that the competitiveness can be explored at higher levels as well - national economic system or the EU economy for example, depends primarily on the meaning and content that is put in the term competitiveness.

At the very beginning of his book The Competitive Advantage of Nations Michael Porter poses the question what is understood under competitiveness of a national economy. He demonstrates that it is not correct to link the competitiveness of a national economy to interest rates, tax rates, budget deficits, debt, positive or negative trade balance, exchange rate, wealth of natural resources. According to Michael Porter (2004), *the major determinant of competitiveness is the effectiveness, with which an economic system uses its resources in connection with achieving a single unit of ultimate goal.* Therefore, the main criterion for evaluating the competitiveness of an economic system in qualitative terms appears to be efficiency.

The role and the significance of energy resources for the increase of quality of life are notorious. Without energy the implementation of whatever human or economic activity is impossible. The polyvalent nature of the energy resource determines its essential place with regard to boosting the competitiveness of an

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economic system. It is well known that an industry, national economy or integrated community will be more competitive when they have less energy costs (ceteris paribus) per production unit (gross or final) or when with the same quantity of resources they produce bigger volume of production (gross or final) from a period to period. Therefore, changes in energy[1] output ratio can be presented as an indicator of a change in the competitiveness of the given economic system and as one of the most important factors for its improvement.

Yet the separate countries (or integrated community) have different available energy resources, i.e. they differ in terms of their dependence on imported energy resources. The energy dependence of a given country or integrated community is most commonly determined by comparing the overall quantity of energy produced (production plus import) with the overall quantity of consumed energy (consumption and export). The same applies to the separate energy sources (petroleum products, solid fuels, natural gas). If the quantity of the consumed energy (total and/or per individual sources) is greater than the quantity of the produced energy (total and/or individual resources), then the respective country or community are regarded as energy dependent.

This definition of energy dependence contains one major flaw. The focus is placed on the absolute meaning of energy dependence. Energy dependence can be viewed as a relative category as well, if the performance variations[2] are taken into account, with which each energy unit is created, transmitted, distributed and consumed. An economic system can consume bigger quantity of energy compared to the generated amount of energy, i.e. according to the first criterion for energy dependence. However, if the efficiency by which each energy unit is used is higher than the efficiency with which each energy unit is produced, then that economic system will not be as dependent on energy as some other economic system in which the total production of energy exceeds the total consumption of energy, but the efficiency, the creation, transmission, and consumption of each unit of energy is very low.

The efficiency becomes a bridge between an economy's dependence on imported energy resources and its competitiveness. The increase in energy efficiency (ceteris paribus) will lead to an increase in the national competitiveness but will also decrease the dependence on energy imports and vice-verse – low energy efficiency will increase the dependence of competitiveness on the import of energy resources. Even if energy supplies are guaranteed, the low efficiency of energy resources consumption appears to be a restrictive factor for enhancing the national competitiveness.

In this sense, energy dependence appears to be a relative category that is dependent on the efficiency with which the energy resource is produced, transferred, distributed and the energy resource is consumed. ***Therefore energy resources are important for enhancing competitiveness not so much with regard to their availability or provision, but to the effectiveness***

[1] In the most general sense, under energy consumption, it is understood the consumed energy units for obtaining one unit of useful result. On national economy level, the energy-output ratio most often is calculated as the ratio between the amount of energy cover a given period in the economy and the produced GDP for the same period. In other words, the energy-output ratio indicates how many energy units are consumed for the production of a single GDP unit.

[2] In the case under efficiency it is understood the ratio between the expended resources for obtaining single unit useful result

of their use. In other words, when an economic system increases the efficiency of energy production and consumption, it also increases its competitiveness and reduces its dependence on imported energy resources. Therefore, the import of energy resources and the efficiency of energy resources consumption are among the elements used in most of the international methodologies for the evaluation of a national economy's attractiveness for foreign investors.

2. Importance of "energy dependence - competitiveness" ratio for management

In the last decade a major emphasis in the EU's energy policy is placed on the security of energy supplies in two directions – the diversification of routes and the diversification of energy sources. Under the first approach efforts are mainly directed towards looking for new suppliers of conventional energy resources (oil, natural gas, coal) while under the second one, the attention is focused on the replacement of conventional with renewable energy sources [European Commission, 2011, 2014]. Under both approaches the possibilities for energy supply security are largely contingent on the geographical location and on natural and climate factors.

Therefore, the energy efficiency issue is getting more significant. Currently, public attention is focused mainly on the achievement of energy savings by the overhaul of buildings, the introduction of high energy standards for the new construction, the introduction of domestic energy-efficient electrical appliances. Relatively low attention is paid to the issue of studying the options to increase energy efficiency based on energy production, technological waste in the process of energy resources' transformation to fuels and energies, transmission and distribution of energy.

The changes in the efficiency of the entire chain - production, transmission, distribution and consumption of energy are an important benchmark for the adoption of measures in terms of diversification of energy supplies and in terms of evaluating the overall effectiveness of the energy policy. Quite often due to the lack of systematic and comprehensive studies a situation is reached when the positive effects at one point of the above mentioned chain of energy efficiency are offset, as in other points the appropriate measures are not taken. At what point of time, and at which point of this chain should the efforts and resources (mainly financial) be focused depends primarily on the objectives to achieve, on the status of energy efficiency, on the trends and issues that have emerged in the different directions, and on other factors.

For example, if we take the objective which the EU wants to achieve in the field of energy efficiency by year 2020, and namely - increasing energy efficiency by 20%, the question arises as to which of the four points of the chain, when, and what resources should be directed in order to achieve this goal with the lowest cost of resources. In other words, what variation of efficiency must be obtained in each of the four elements in the chain (production, transmission, distribution and consumption) in order to achieve this objective? The more important issue, however, is if this goal is achieved (increase of the efficiency by 20% by year 2020), will this be enough for the significant reduction of energy dependence of the EU economy?

3. Contradictory trends

In this relation it is interesting to follow what trends are outlined on the present stage in terms of the energy dependence ↔ energy efficiency relation. Examining this relationship by applying Eurostat's standard indicators for energy intensity[3] and energy dependence[4] exposes quite interesting picture. In the period between 2001 and 2012, there was a positive trend in the reduction of energy intensity of the EU-27 economy and the individual national economies. In 2001 the energy intensity in the EU-27 is 170,9 kgoe/1,000 EUR, and in year 2010 - 151,6 kgoe/1,000 EUR. For the same period, the index of total energy dependence of the economy of EU-27 increases from 47.4% in 2001 to 52.7% in 2010. The situation is similar in Denmark, for which many studies show that it is the country with highest energy efficiency of all the EU member states. The data show that during the last two decades there has been a stable tendency of increase of the energy dependence (all products) in the EU-27 economy. That tendency is particularly strong for the most developed countries in the EU – the Eurozone` countries (EU-18). Despite the structural changes that were made, the energy dependence on the import of oil products followed by natural gas and coal remains highest. For the same period the dependence on coal and natural gas was growing at the highest rate. The EU's dependence on oil products is changing at a relatively slower pace.

In other words, on the one hand, energy efficiency is increasing, while there is an increase in the overall energy dependence. For Bulgaria the picture is quite different compared to Denmark and the EU-27 in

Table 1. Energy intensity and Energy dependence

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Energy intensity of the economy - Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1,000 EUR)												
EU-27	170,9	168,2	169,2	166,9	163,9	159,2	151,9	151	148,9	151,6	144	143,2
Denmark	103,3	101,2	105	99,8	94,4	98,2	94,3	92,6	94,1	97,5	89,7	87,2
Bulgaria	1040,1	962,9	942	866,2	849,4	823,5	759,9	711,7	661,4	668,8	705,5	669,9
Energy dependence (%)												
EU-27	47,4	47,5	48,8	50,1	52,2	53,6	52,9	54,7	53,7	52,7	53,9	53,4
Denmark	-28	-41,9	-31,4	-47	-49,9	-35,5	-24,1	-21,4	-20,3	-16,1	-6,1	-3,4
Bulgaria	45,8	45,7	46,3	48,1	46,7	45,6	50,7	51,7	45,1	39,6	36	36,1

Source: Eurostat.

[3] Energy intensity of the economy - Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1 000 EUR) - This indicator is the ratio between the gross inland consumption of energy and the gross domestic product (GDP) for a given calendar year. It measures the energy consumption of an economy and its overall energy efficiency. The gross inland consumption of energy is calculated as the sum of the gross inland consumption of five energy types: coal, electricity, oil, natural gas and renewable energy sources. The energy intensity ratio is determined by dividing the gross inland consumption by the GDP. Since gross inland consumption is measured in kgoe (kilogram of oil equivalent) and GDP in 1 000 EUR, this ratio is measured in kgoe per 1 000 EUR. (Eurostat)

[4] Energy dependence (%) - Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs. The indicator is calculated as net imports divided by the sum of gross inland energy consumption plus bunkers.

general. There is a trend of reduction of the energy dependence and energy intensity. How can we explain the behavior of these conflicting trends?

One possible explanation is the decrease in the energy consumption of the economic and the demographic systems, which is linked to a decrease in the import of energy resources. The data show that for the countries joined to the EU after 2004, energy consumption has generally decreased, whereas for the other countries (especially these in the Eurozone) it has increased. The other possible explanation is that the energy intensity indicator does not provide realistic picture about the changes in energy efficiency. This has been carefully examined by Assistant Professor PhD Georgi Kiranchev. According to Kiranchev (2013), a very significant disadvantage of the energy intensity indicator is that it does not reflect the complexity of the produced products and the changes in the structure of the economic system. One way to overcome this disadvantage is to move towards the use of models with multidimensional product structure that adequately reflect the complexity of the subject.

4. The study of complex processes requires adequate tools

The conventional global methodology for assessing national competitiveness is that of the World Economic Forum. The basis of this methodology is 12 criteria, along which competitiveness is measured. These are institutions, infrastructure, macroeconomic environment, health care and primary education, higher education and training, the effectiveness of stock markets, the effectiveness of labor markets, financial markets, the size of the market, technological preparedness, the degree of business development, innovation. All these factors impact competitiveness in a different way. Their influence, however, occurs mainly on the surface of the pyramid structure of the national economic system. The processes that are developing at the basis of the national economic system remain hidden.

In economic science, the capabilities of the created by Wassily Leontief (Leontief, 1976) input-output model are well known as a tool for testing the quality of a conducted development and for the design of future development. This tool makes it possible to penetrate deeper during the study of the effectiveness (i.e. the competitiveness) of the national economic system. According to Manov (2001), with the elements of the matrix of direct tangible costs and of the matrix of full tangible costs the effectiveness in several areas can be studied. The first direction is the effectiveness by which an industry utilizes the output of another industry in connection with the establishment of a single unit of its gross or final production. The second direction is the efficiency by which the industry itself operates (i.e. the so called comparative effectiveness). The third direction is the study of the efficiency by which the economic system operates as a whole.

In examining the energy efficiency – competitiveness relation, the input-output model is used to outline the main trends in the energy efficiency of the EU economy in the following areas: the effectiveness with which a single unit of energy product is created; the effectiveness with which a single unit of energy for final consumption is created; the effectiveness with which the industry functions as a whole; the effectiveness with which each single unit of energy is consumed in the economic and demographic systems. The energy sector is represented under the Electrical energy, gas, steam and hot water heading in the model. For the study of the the effectiveness for the creation of a single energy unit the vector columns from the matrices of direct material costs and complete material costs are used.[5] For the study of the effectiveness with which an energy unit is consumed, the coefficients per row vector of both matrices (i.e. the coefficients of direct cost of energy per unit gross output and complete energy consumption per unit of production for end use) are used. The alteration of the efficiency by which Electrical energy, gas, steam and hot water industry functions is examined through the alteration of the element on the main diagonal $\frac{A_{ii}}{\Delta}$.

For the period between 2000 and 2010, EUROSTAT represents data on several classifications. For the period between 2000 and 2005 the tables represent 59 industry aggregation, and for the period between 2006 and 2010 - 65 industry structure. This required additional conversion of the tables for the aggregation of 20 industries in order to ensure data comparability in carrying out the comparative analysis. EUROSTAT presents the „resources" and „use" tables in symmetric „input-output" (SIOT) only for the economy of the EU-27 and EU- 17. For the member states four transformational models have been highlighted for bringing the output data in symmetric „input-output" table (SIOT). In this case the „B" transformation model was used to obtain symmetric „input-output" table per „product - product".

5. Evaluation of energy efficiency through the "input-output" model

5.1. Evaluation of the energy efficiency through the effectivenes with which a single unit of energy is created

In order to highlight the trends in the efficiency with which a single energy unit is created, the first changes that occur in the elements in the column vector of the technological matrix (matrix A) are monitored, i.e. the changes in the direct material costs of production per unit of gross output (energy).

$$\sum_{i=1}^{20} a_{i4} = a_{14} + a_{24} + a_{34} + a_{44} + + a_{54} + \cdots + a_{20\,4} \quad (1),$$

where each a_{i4} represents an expense coefficient of materials to create an energy unit, but represents cost coefficient of energy for the creation of energy unit.

In the next place, the changes are monitored that occur in the elements per vector-column from the matrix of the total costs $(E-A)^{-1}$ for the Electrical energy, gas, steam and hot water industry, i.e. the direct plus the indirect costs, which are made in the economic system for the creation of a single unit of energy output for final consumption.

$$\sum_{i=1}^{20} \frac{A_{i4}}{\Delta} = \frac{A_{14}}{\Delta} + \frac{A_{24}}{\Delta} + \frac{A_{34}}{\Delta} + \frac{A_{44}}{\Delta} + + \frac{A_{54}}{\Delta} + \cdots + \frac{A_{20\,4}}{\Delta} \quad (2),$$

where each $\frac{A_{i4}}{\Delta}$ represents the total cost (i.e. direct plus indirect costs from the point of view of the whole economy) of a given material resource for the creation of a unit of energy for final consumption, $\frac{A_{44}}{\Delta}$ gives

[5] Direct costs are those costs that occur in the immediate stage of manufacture of the corresponding product. Indirect costs are those that have taken place at earlier stages of the production and technological process. Total costs are the sum of direct and indirect costs.

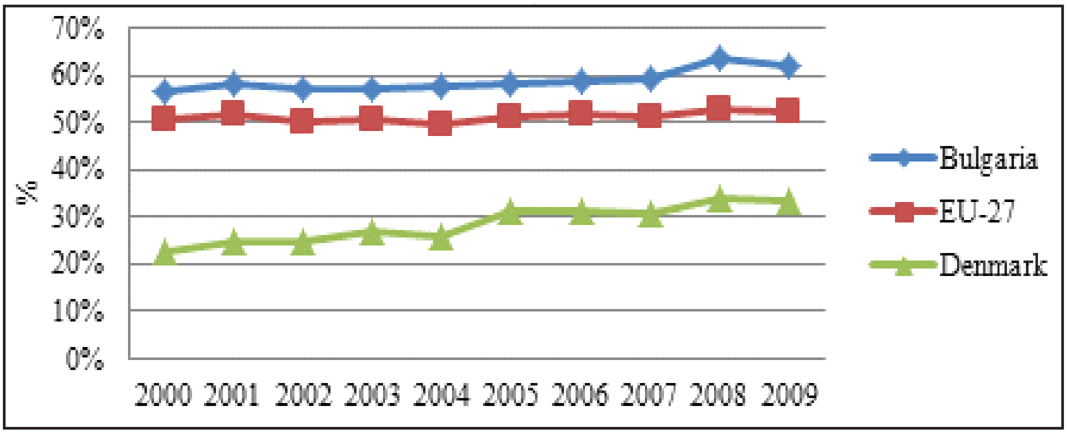

Fig. 1. Share of material costs in gross output of the Electrical energy, gas, steam and hot water sector
Source: Own calculations based on Eurostat data.

the characteristics of the energy conversion efficiency, with which the industry functions, and is the determinant of matrix (E-A).

For the period between 2000 and 2009 the following trends have been outlined:

- In terms of the efficiency with which a single unit of gross output is created - for all three surveyed economies (of Bulgaria, Denmark and the EU-27) there is a trend of increase of the share of the material costs for the creation of an energy unit, which actually means a reduction of the share of the GVA (gross value added) created in industry, i.e. the generated useful result from the operation of the industry.
- The difference between Bulgaria and Denmark in respect of the share of the material costs for the creation of an energy unit remains significant. If in Bulgaria's economy this share is 60%, in Denmark's economy it does not exceed 30%, and the economy of the EU-27 has an average share of about 50%. In other words, in Bulgaria an energy unit is created by nearly twice as many materials compared to Denmark, while compared to EU average – 1.2 times (Graphics 1).
- Significant changes occur in the structure of the material costs, including the cost of energy production for own consumption (coefficient A_{44}) and other material costs. In Bulgaria a sharp decrease of the share of the costs for energy for own production consumption is observed. In the year 2000 this share was 13%, while in 2009 it dropped to 1.3%. Denmark and the EU-27 show the opposite trend. In the year 2000 the share of the costs for energy for own production consumption in Denmark was 0.6% and for the EU-27 - 36%. In 2009 this share increased correspondingly to 2% and 49%. Despite these changes, the difference in the coefficient A_{44} between Bulgaria and Denmark remains significant - more than 3 times.
- Regarding the effectiveness of creating an energy unit for final consumption for the three compared economies, there is a trend for an increase of the direct and indirect (i.e. total) costs. The position of Bulgaria is relatively better towards the leading country and the EU average level, in terms of total costs for the creation of an energy unit for final consumption, compared with the position that it has

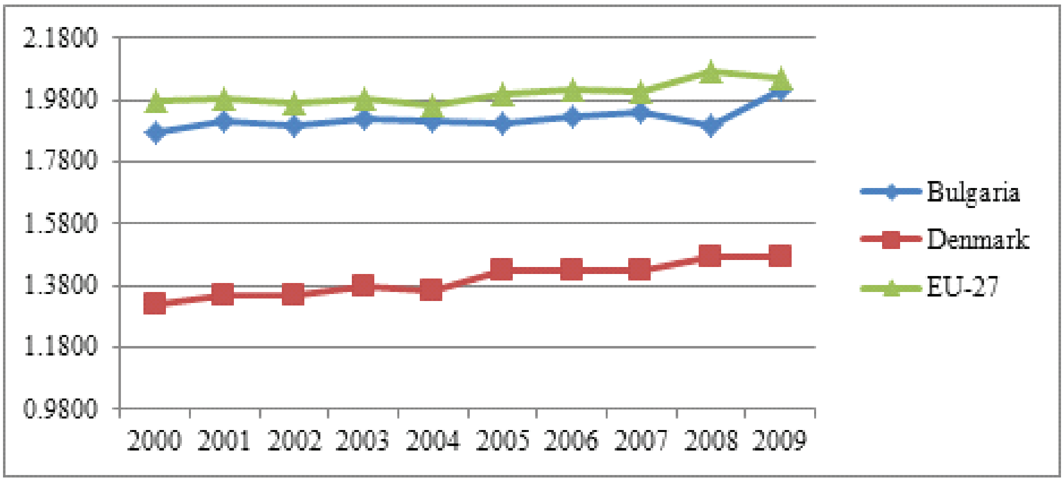

Fig. 2. Total costs for the creation of an energy unit for final consumption

Source: Own calculations based on Eurostat data.

in terms of the direct costs for creating the energy unit. For the whole period, the total costs for the creation of an energy unit for final consumption remain below the EU average level, and compared with Denmark, the difference is 1,4 times (Graphics 2).

5.2. Assessment of energy efficiency through the efficiency with which "Electrical energy, gas, steam and hot water" industry operates

Significantly higher rank of performance analysis can be performed by tracking the changes in the values of the elements on the main diagonal $\frac{A_{ii}}{\Delta}$ of (E-A)$^{-1}$ matrix. Higher rank analysis in the sense of disclosing processes and trends that can not be traced through the ordinary scalars $\left(\frac{A_{ij}}{\Delta}\right)$. According to Mateev (1987), each element on the main diagonal shows the coefficient of Energy conversion efficiency (ECE), with which a given industry functions. If you add and subtract 1 to $\frac{A_{4\,4}}{\Delta}$ and decompose the numerator and denominator, we will get the following equation:

$$\frac{A_{4\,4}}{\Delta} = 1 + \frac{(a_{41}\,A_{14} + a_{42}\,A_{24} + a_{43}\,A_{34} + a_{44}\,A_{44} + a_{54}\,A_{45} + \cdots + a_{20\,4}\,A_{4\,20})X_4}{(A_{41}Y_1 + A_{42}Y_2 + A_{43}Y_3\; Y_3 + A_{44}Y_4 + A_{45}Y_{45} + \cdots + A_{4\,20})} \quad (3),$$

where $a_{4j}A_{i4}$ shows the direct cost of energy for the creation of a single output in the j-th industry, which shall be directly and indirectly spent as materials for the creation of an energy unit, X_4 is the created gross output in the industry, and Y_i is the production for the corresponding industry for final consumption.

In such case, the numerator will show how much energy the industry will provide directly and indirectly to other sectors, in order to ensure its own reproduction, and the denominator will show how much energy the industry will provide to the other sectors to create their products for final consumption. From this position, one industry will operate with greater efficiency when allocating a smaller portion of its production for its reproduction, while the majority of its production goes to create the final output of other industries (i.e. for the useful result from the operation of the economic system as a whole).

In practice, quite often, the performance indicators are used incorrectly when making comparisons between sectors. For example, many times the achieved level of labor productivity in the manufacturing industry is compared with the agriculture industry. It is not correct to say that labor productivity in the manufacturing industry is higher than the labor productivity in agriculture, as the compared two results are achieved in incomparable conditions. Completely different thing it is to say, which industry with what efficiency functions (in terms of Energy conversion efficiency) and then to compare the industries.

The elements on the main diagonal of $(E\text{-}A)^{-1}$ matrix make it possible that the separate industries in the economy can be compared according to the Energy conversion efficiency level with which they function. Due to this, very often they are called coefficients of comparative effectiveness. For example, in year 2000 "Electrical energy, gas, steam and hot water" industry compared to the other 20 industries is ranked 14th place in Bulgaria, in Denmark - in 4th place, and in the EU-27 – in 16th place. In year 2009, the industry takes in Bulgaria the 11th place, in Denmark the 5th place, and in the EU-27 the 18th place. This means that in Bulgaria "Electrical energy, gas, steam and hot water" industry increases the efficiency with which it functions, while in Denmark and the EU-27 the efficiency with which the industry operates, decreases compared to the efficiency with which the other industries operate. From this perspective, Bulgaria occupies a relatively good position towards the average EU level.

This good position of Bulgaria is confirmed when comparing the industry through the share of the production, which it sets aside for its own reproduction, with the share of the production, which it sets aside for the final production of the other sectors. In Bulgaria, for the studied period, there is a steady tendency for reduction of the share of the production of the industry for own reproduction and an increase of the share, which the industry sets aside for the final production of the other sectors.

In EU-27 there is observed exactly the opposite trend - the share of the industry's production for its own reproduction increases and the share of the production, which the industry sets aside for the final production of the sectors decreases. Moreover, the difference between Bulgaria and the average EU level remains significant. During year 2009 3,2% of the industry's output in Bulgaria was necessary to ensure its own reproduction and the average share for the EU-27 was 26,3%.

The leading position of Denmark in the field of energy efficiency is demonstrated at this point as well. For the entire period, the share of the production which the industry sets aside in order to ensure its own reproduction remains below 1%. Detailed information for the alteration of the element $\frac{A_{4\,4}}{\Delta}$ per years in Bulgaria, Denmark and EU-27 is represented in table 2 and graphics 3.

5.3. *Evaluation of the energy efficiency through the effectiveness, with which the product energy is used in the economy*

For the evaluation of the effectiveness with which each energy unit is used in the economy, there are used the coefficients of *direct energy consumption* a_4j (the cost of energy to create one unit of gross output)

Table 2. Efficiency with which the Energy sector is functioning

Comparative efficiency	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bulgaria										
Main diagonal value	1,1020	1,1079	1,0945	1,0999	1,0861	1,0793	1,0757	1,0726	1,0744	1,0326
Allocation of sector production:										
For its own reproduction (in %)	9,6%	9,6%	8,6%	9,1%	7,9%	7,3%	7,0%	6,6%	6,9%	3,2%
For the final production of the other sectors (in %)	90,4%	90,4%	91,4%	90,9%	92,1%	92,7%	93,0%	93,4%	93,1%	96,8%
Denmark										
Main diagonal value	1,0024	1,0036	1,0040	1,0043	1,0041	1,0044	1,0044	1,0048	1,0053	1,0091
Allocation of sector production:										
For its own reproduction (in %)	0,3%	0,4%	0,4%	0,4%	0,4%	0,4%	0,4%	0,5%	0,5%	0,9%
For the final production of the other sectors (in %)	99,7%	99,6%	99,6%	99,6%	99,6%	99,6%	99,6%	99,5%	99,5%	99,1%
EU-27										
Main diagonal value	1,2372	1,1230	1,2362	1,2459	1,2454	1,2703	1,2821	1,2866	1,3619	1,3565
Allocation of sector production:										
For its own reproduction (in %)	19,2%	11,0%	19,1%	19,7%	19,7%	21,3%	22,0%	22,3%	26,6%	26,3%
For the final production of the other sectors (in %)	80,8%	89,0%	80,9%	80,3%	80,3%	78,7%	78,0%	77,7%	73,4%	73,7%

Source: Own calculations based on Eurostat data.

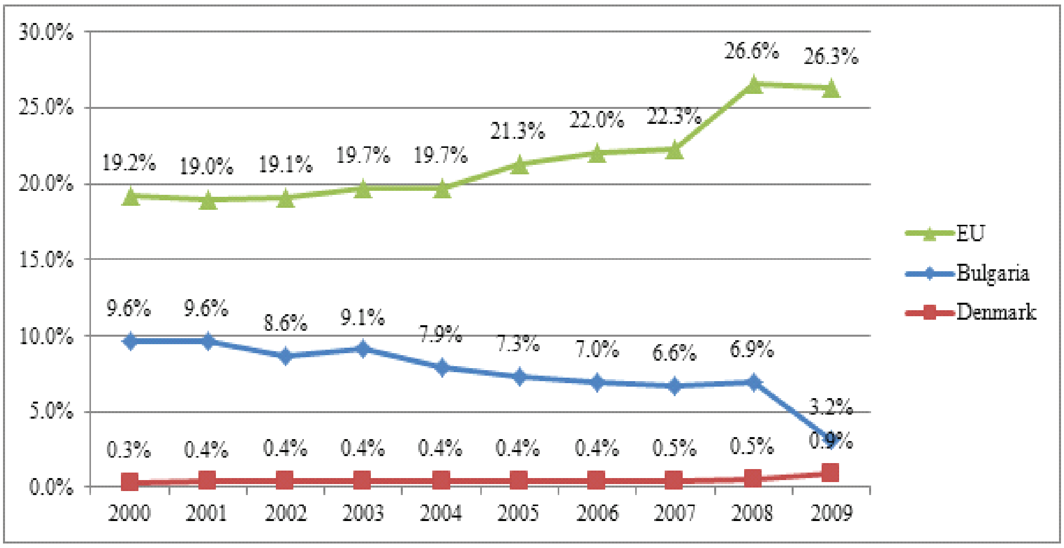

Fig. 3. Share of the production used for Electrical energy, gas, steam and hot water sector own reproduction
Source: Own calculations based on Eurostat data.

and *total energy consumption* $\frac{A_{4j}}{\Delta}$ (direct plus indirect costs of energy to create a single output unit for end use).

$$\sum_{j=1}^{20} a_{4j} = a_{41} + a_{42} + a_{43} + a_{44} + + a_{45} + \cdots + a_{420} \quad (4)$$

$$\sum_{j=1}^{20} \frac{A_{4j}}{\Delta} = \frac{A_{41}}{\Delta} + \frac{A_{42}}{\Delta} + \frac{A_{43}}{\Delta} + \frac{A_{44}}{\Delta} + + \frac{A_{45}}{\Delta} + \cdots + \frac{A_{4\,20}}{\Delta} \quad (5),$$

where each a_{4j} represents the cost of energy to manufacture one unit of gross output and each ordinary scalar represents the total energy costs to manufacture one output unit for final consumption.

There are two trends that can be outlined for the Bulgarian economy. One trend is of growth of the direct energy consumption in the sectors of agriculture, mining and manufacturing industries. The other trend is of significant reduction of the direct energy consumption in the branches in the services sphere - Accommodation and food services, Financial services, except insurance and pension funding; Scientific research and development services, Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services, Public administration and defense services; compulsory social security services, Education services, Human health services, Creative, arts and entertainment services; Sporting services. The situation is analogous with the total energy costs for final production unit.

For the EU-27 economy there is a trend of an increase of the direct and indirect energy consumption. For the research period, only in Financial and insurance activities sector there is observed a decrease in the direct energy consumption while the total energy consumption grows in all 20 sectors during year 2009 compared to year 2000. For the economy of Denmark in 7 out of 20 branches the direct energy consumption decreases (Manufacturing, Electrical energy, gas, steam and hot water, Accommodation and food services, Financial services, except insurance and pension funding, Real estate services, Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services, Education services) while the total energy consumption decreased only in three of them (Accommodation and food services, Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services, Education services).

Despite the outlined positive trend exposing the reduction of direct and total energy consumption in most industries of Bulgaria's economy, the difference towards the average for the EU level and the leading country Denmark remains quite significant. In other words, in the Bulgarian economy one unit is produced with several times higher energy costs (in some cases the difference reaches 8-9 times) compared to the leading EU countries. Detailed information on the difference in the direct and final energy consumption of the products manufactured in the Bulgarian economy compared with similar products in Denmark's economy and the economy of EU-27 is presented in Table 3.

5.4. Evaluation of energy efficiency through technological losses in the conversion/transformation of the energy resources in fuel and energy

The existing information does not allow for the examination and comparison of the effectiveness with which the product energy is transferred and distributed. The existing information, however, allowed for the

Table 3. Products comparison in terms of direct and total energy consumption between the Bulgarian economy and the Denmark economy and the economy of the EU-27

.	Sectors:	Difference in terms of direct energy consumption in comparison to				Difference in terms of total energy consumption in comparison to			
		-		2009 г.		2000 г.		2009 г.	
		Denmark (in times)	the EU (in times)	Denmark (in times)	the EU (in times)	Denmark (in times)	the EU (in times)	Denmark (in times)	the EU (in times)
1	Agriculture, forestry and fishing	0,66	0,46	0,95	0,42	1,37	0,46	1,42	0,53
2	Mining and quarrying	34,65	1,26	38,58	0,73	25,33	1,26	9,98	0,50
3	Manufacturing	4,95	1,34	8,18	1,64	5,79	1,34	8,03	0,94
4	Electrical energy, gas, steam and hot water	53,53	0,41	6,43	0,04	1,09	0,41	1,03	0,77
5	Water supply; sewerage, waste management and recovery	2,41	2,54	3,40	3,23	2,82	2,54	3,32	1,91
6	Constructions and construction works	10,62	1,71	10,30	1,05	6,94	1,71	5,39	0,89
7	Retail trade services, except of motor vehicles and motorcycles	1,28	1,11	3,13	1,57	1,82	1,11	4,00	1,31
8	Transport services, Postal and courier services	5,83	2,85	6,25	2,16	6,05	2,85	5,96	1,61
9	Accommodation and food services	2,05	1,93	4,16	3,00	2,67	1,93	3,48	1,79
10	Financial services, except insurance and pension funding	5,97	7,41	0,10	0,13	5,69	7,41	1,10	0,57
11	Real estate services	5,61	1,38	8,46	2,29	4,26	1,38	5,06	1,25
12	Scientific research and development services	7,82	7,02	1,17	0,67	7,92	7,02	2,67	0,93
13	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services	5,04	2,51	2,67	1,17	4,28	2,51	3,20	1,16
14	Public administration and defense services; compulsory social security services	3,11	2,67	0,00	0,00	4,11	2,67	1,34	0,41
15	Education services	2,08	3,94	0,25	0,40	2,40	3,94	0,56	0,62
16	Human health services	2,95	5,30	1,90	2,43	3,75	5,30	3,15	1,95
17	Creative, arts and entertainment services; Sporting services	3,07	6,00	0,61	0,55	3,86	6,00	1,68	1,19
18	Other personal services	7,69	3,41	1,98	0,64	9,03	3,41	2,91	0,78
19	Services of households as employers; undifferentiated goods and services produced by households for own use		…	…	…	…	…	…	…
20	Services provided by extraterritorial organizations and bodies	…	…	…	…	…	…	…	…

Source: Own calculations based on Eurostat data.

examination of another aspect of energy efficiency and namely - technological losses during conversion/transformation of the energy resources in fuels and energy. For key measure of the technological losses during conversion of the energy resources into fuels and energy there is used the ratio between the final energy consumption (FEC)[6] and primary energy consumption (PEC)[7]. According to a paper of the Energy Efficiency Agency (2005), the greater $\left(\frac{FEC}{PEC}\right)$ this ratio is, the higher the efficiency of the resources conversion in a useful result (in the present case of fuels and energy).

From all points of view from which the energy efficiency was viewed, the most minor changes were observed in the efficiency with which the energy resources are converted/transformed into fuels and energy. In year 2000, the ratio $\left(\frac{FEC}{PEC}\right)$ for Bulgaria is 0.47, for Denmark – 0.86, and for the EU-27 – 0.67. In year 2010, these figures are respectively 0.51; 0.88 and 0.68. The fact that these coefficients remain constant for such a long period of time should not lead to complacency that things at this point of the energy efficiency chain are looking good or that the preservation of this trend in the future will be able to compensate for the deterioration of performance in the other two points. Mostly this applies to Bulgaria. Maintaining the technological losses during the transformation of energy resources in fuels and energy at such a high level shows that the overall policy for energy development has not led to a change in the production and processing conditions, which would lead to a sharp increase in the efficiency at this point of the chain.

Conclusion

The analysis of the Energy dependency – competitiveness ratio through the changes in the energy efficiency exposed how important for the quality of management decisions is the utilization of adequate tools during the examination of complex processes in the economy. In other words, the complexity of a process poses significant demands on the complexity of the tools by which this process is examined, analyzed and evaluated. The study of the energy dependence - competitiveness through the input-output model revealed the true picture of energy efficiency and showed how it is possible for one country to reduce its dependence on imported energy resources and at the same time to increase its competitiveness.

Furthermore, the model revealed the directions in which efforts and resources in the future should be focused in order to obtain the desired effect. For Bulgaria, this is related most of all to the provision of such mode of functioning of the economy, in which the increase of the efficiency with which the product energy is consumed, should grow faster than the growth in efficiency with which energy unit is manufactured. Pursuing policies for energy efficiency directed at compensating the retardation at one point of the chain by maintaining the good positions at another point will hardly achieve the same effects with regard to the country's competitiveness and energy dependence.

[6] Final energy consumption (FEC) includes all energy delivered to the final consumer's door (in the industry, transport, households and other sectors) for all energy uses. It excludes deliveries for transformation and/or own use of the energy producing industries, as well as network losses.

[7] Primary energy consumption (PEC) refers to the direct use at the source, or supply to users without transformation, of crude energy, that is, energy that has not been subjected to any conversion or transformation process.

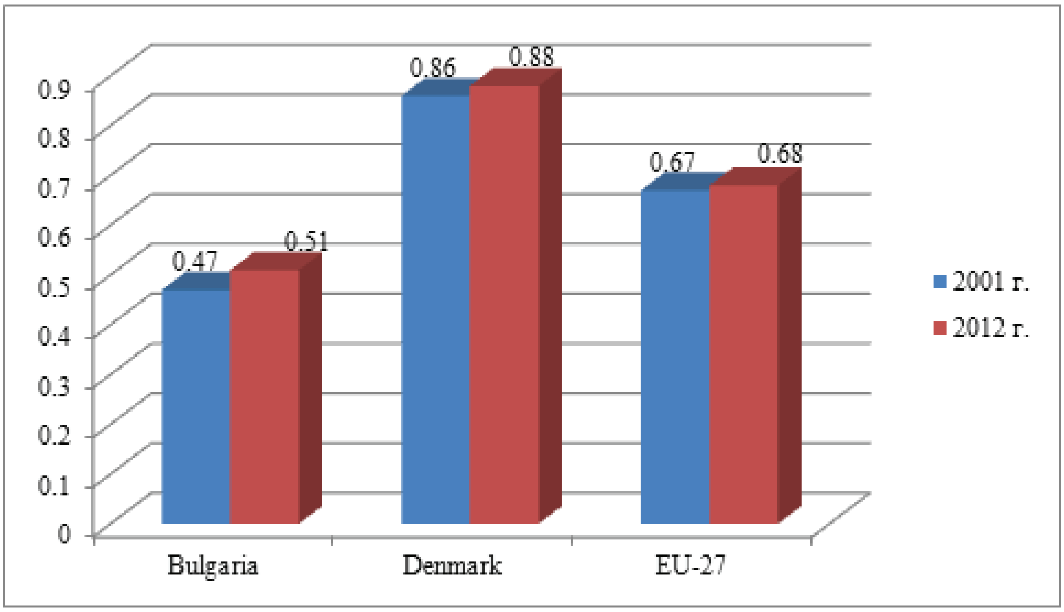

Fig. 4. Coefficient of transformation of energy resources in fuels and energies

Source: Own calculations based on Eurostat data.

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