BULGARIA'S ENERGY BALANCE – A STRATEGIC ANALYSIS

Kaloyan Pargov[1]
[1]D. A. Tsenov Academy of Economics – Svishtov, Bulgaria
E-mail: *[1]d030220101@uni-svishtov.bg*

Abstract: The Energy Balance is a strategic report which is of crucial importance to national economies. The strategic analysis of the Energy Balance of the Republic of Bulgaria for the period 2006-2020 allows drawing up key trends for determining the priorities for the development of the infrastructure of production, transfer, consumption, intersystem exchange and expanding the share of renewable sources. The research consists of two parts – the first one focuses on the methodology of preparing an Energy Balance as a statistical document with the corresponding evolution characteristics and structural components; the second one includes a verbal and graphic representation of the dynamics of some major components and indicators of the Energy Balance of the Republic of Bulgaria. As a result, we have illustrated the annual rates of change for a fifteen-year period, linear regression equations and coefficients of determination. The article ends by drawing up conclusions of strategic importance for the energy system.

Key words: energy balance, energy security, energy sector, The Republic of Bulgaria.

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Energy security and energy consumption management have been among the priority issues over the last years in the Republic of Bulgaria. This is especially relevant due to the availability of high degree of energy consumption in all leading sectors of the economy directly corresponding to the limited natural resources in our country and the necessity of external support for the purposes of meeting the national energy demand. The political and economic cataclysms worldwide have a significant negative impact on the energy sector in our country. For the purposes of rational energy management, we shall analyze quantitively the elements of the Energy Balance as the main source of analytical information. In this respect, the research **object** in this article is the Energy Balance of the Republic of Bulgaria. The research **subject** is the system analysis of the Energy Balance of the Republic of Bulgaria for a fifteen-year period (from 2006 to 2020) and determining the annual rate of change of 12 key indicators. The **aim** of the research is to perform a statistical analysis of the key parameters of the Energy Balance of the Republic of Bulgaria. The **research hypotheses** which the author attempts to prove in the article is that determining the trends in the dynamics of leading indicators of the Energy Balance of the Republic of Bulgaria in the long term is the basis for drawing up analytical regression equations and correlations of strategic importance for the system.

The research is structured in two main parts; the first one focuses on the Energy Balance as a statistical report with the corresponding evolution characteristics and structural components; the second one includes a graphic representation of the dynamics of some major components and indicators of the Energy Balance of the Republic of Bulgaria for the period 2006 – 2020 by drawing up the annual rates of change, linear regression equations and coefficients of determination. The article ends by drawing up conclusions of strategic importance for the energy system.

1. Energy balance – evolution characteristics and structural components

The Energy Balance is the most detailed statistical report which reflects the reporting of energy products and their dynamics in the economy of the corresponding country (Eurostat - Statistics Explained, 2022). On the basis of this document, it is possible to trace and analyze in a quantitative aspect the energy extracted from the environment, traded, transformed, and consumed by end users. Besides from analytical point of view, it is useful for the purposes of determining the energy situation in a specific country and the strategic observation of the impact of energy policies. The main functions of the Energy Balance are systematized in Figure 1.

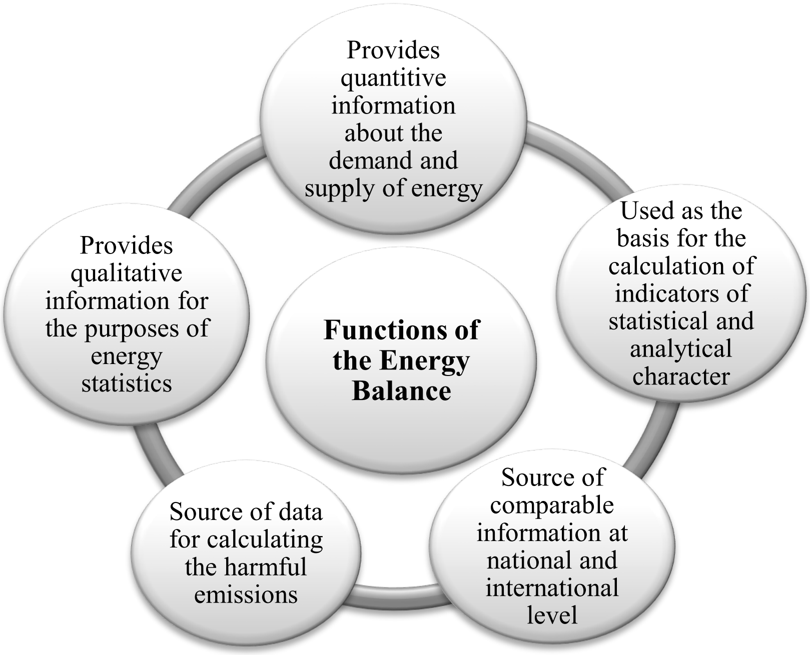

Figure 1. ***Functions of the Energy Balance***
Source: Author's adaptation on the basis of (Eurostat - Statistics Explained, 2022)

In terms of structure, the Energy Balance is a matrix which reflects the relationship between energy products and flows (United Nations, 2018). According to the Eurostat methodology, the Energy Balance can be represented as follows:

Table 1.

Matrix of the Energy Balance

(ktoe)	**Energy resources**			
Major balance entries which make up the energy balance				

Source: Author's adaptation based on (Eurostat, 2022)

The unit of measurement which is used to report the data in the Energy Balance is a kilotonne of oil equivalent - (ktoe). Converted (Armand Di Marco,

2022) to the more widespread units of measurement, 1 ktoe = 11,630,000 kWh. Generally, the Energy Balance comprises three major components of data (Millard & Quadrelli, 2017): primary energy supply, energy production and data about the end consumption. In more detailed structural aspect, the major balance entries which make up the Energy Balance vertically are: the gross available energy, the gross inland consumption, the general power supply with energy, the transformation input and output, the distribution losses, the data from the energy sector, the available quantity for final consumption, the final energy and non-energy consumption, the statistical difference, the gross energy production and the gross heat production. Horizontally, all energy resources and their quantitative contribution to the corresponding period of the specific country are placed as follows: Total amount[1], Solid fossil fuels[2], Peat and peat products[3], Oil shale and oil sand, Oil and oil products[4], Natural gas, Renewable energy sources and biofuels[5], Primary solid biofuels[6], Non-renewable waste[7], Nuclear heat, Heat, Electricity, Energy from fossil fuels, Bioenergy. A specific feature for the statistics in the sector is the methodical overcoming of the currency risk (Zahariev & Kostov, 2016), the specific characteristics of supply chains (Laktionova, Dobrovolskyi, Karpova, & Zahariev, 2019), as well as the impact of public fiscal politics (Zahariev, Radulova, Aleksandrova, & Petrova, 2021), (Zarkova & Kostadinov, 2018). For the purposes of the international comparability of energy data, preparing the balance shall be based on universally acknowledged approaches based on precision, clarity, and applicability. The whole construction of the Energy Balance requires following three key stages visualized in Figure 2. Their correct application allows

[1] This category encompasses: Anthracite, Metallurgical coal, Other bituminous coal, Sub-bituminous coal, Lignite coal, Patent fuel, Coke from coke furnaces, Gas coke, Coal tar, Brown coal briquettes

[2] Includes: Gas, Coke gas, Furnace gas, Other recovered gases.

[3] Includes: Peat, Peat products.

[4] Includes the following analytical subcategories: Crude oil, Liquid natural gases, Refinery raw materials, Additives and oxygenates (excluding biofuels), Other hydrocarbons, Gas from refineries, Ethan, Liquefied petroleum gases, Gasoline for automobiles (excluding biofuels), Aviation gasoline, Aviation fuel, Kerosene (excluding biofuels), Other kerosene, Naphtha, Gasol and diesel fuel (excluding biofuels), Fuel oil, White spirit and industrial spirits with a specific boiling point, Lubricating elements, Bitumen, Petroleum coke, Paraffin waxes, Other oil products.

[5] Includes: Hydro tidal waves/ocean, Wind, Solar photovoltaics, Solar thermal energy, Geothermal energy.

[6] Includes: Charcoal, Biogases, Renewable Възобновяеми household waste, Pure biogasoline, Blended biogasoline, Pure biodiesels, Blended biodiesels, Pure bio reactive kerosene, Blended bio jet kerosene, Other liquid biofuels, Surrounding heat (heat pumps).

[7] Includes two positions: Industrial waste (non-renewable), Non-renewable household waste.

researching it on the basis of contemporary approaches for making managerial decisions – such as analysis “costs-benefits” (Prodanov, 2009), (Stoychev, 2010) or regression and vector models (Zahariev, et al., 2020a).

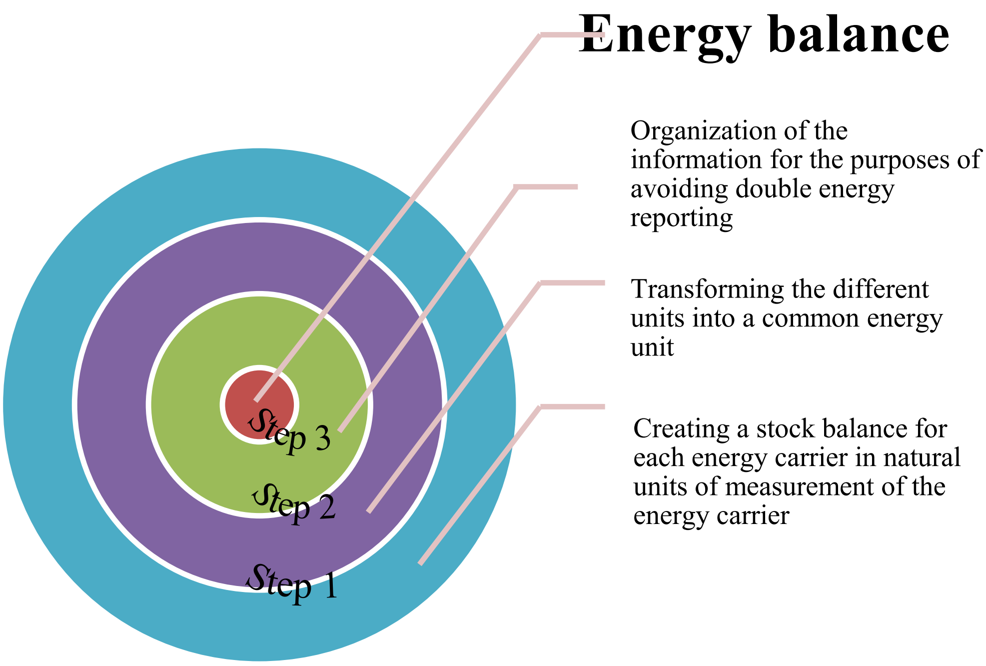

Figure 2. ***Stages in the creation of the Energy Balance***
Source: Author’s adaptation based on (Eurostat - Statistics Explained, 2022)

It is institutionally regulated by COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. The cost-benefit analysis shall at least take into account (European Commission, 2017): the technical feasibility, the economic efficiency, the impact on competition and integration of balancing markets, the costs and benefits of implementation, the impact on European and national balancing costs, the potential impact on European electricity market prices, etc.

2. Analysis of the dynamics of the components of the Energy Balance of the Republic of Bulgaria

For the purposes of the Energy Balance of the Republic of Bulgaria, we have selected twelve indicators of key systematic character (Eurostat, 2019): Gross available energy[8]; Gross inland consumption[9]; Total energy supply[10]; Transformation input[11]; Transformation output[12]; Energy sector – annual dynamics[13]; Distribution losses; Available for final consumption[14]; Final non-energy consumption; Final energy consumption[15]; Gross energy production; Gross heat production (see figures 3-14). The researched data is on annual basis in ktoe for the period 2006-2020; for each of the indicators we have drawn up the dynamics (in ktoe) and the change rate compared to the previous year (in %).

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[8] Components: Gross available energy = Primary production + Recovered & Recycled products + Imports – Export + Stock changes

[9] Components: Gross inland consumption = Gross available energy – International maritime bunkers

[10] Components: Total energy supply = Gross available energy – International maritime bunkers – International aviation

[11] Components: Transformation input = Electricity & heat generation + Coke ovens + Blast furnaces + Gas works + Refineries & petrochemical industry + Patent fuel plants + BKB & PB plants + Coal liquefaction plants + For blended natural gas + Liquid biofuels blended + Charcoal production plants + Gas-to-liquids plants + Not elsewhere specified

[12] Components: Transformation output = Electricity & Heat generation + Coke ovens + Blast furnaces + Gas works + Refineries & Petrochemical industry + Patent fuel plants + BKB & PB plants + Coal liquefaction plants + Blended in Natural gas + Liquid biofuels blended + Charcoal production plants + Gas-to-liquids plants + Not elsewhere specified

[13] Components: Energy sector = Own use in electricity & heat generation + Coal mines + Oil & natural gas extraction plants + Patent fuel plants + Coke ovens + BKB & PB plants + Gas works + Blast furnaces + Petroleum refineries (oil refineries) + Nuclear industry + Coal liquefaction plants + Liquefaction &

regasification plants (LNG) + Gasification plants for biogas + Gas-to-liquids (GTL) plants + Charcoal

production plants + Not elsewhere specified (energy)

[14] Components: Energy available for final consumption = Total energy supply – Transformation input + Transformation output – Energy sector – Distribution losses

[15] Components: Final energy consumption = Industry sector + Transport sector + Other sectors

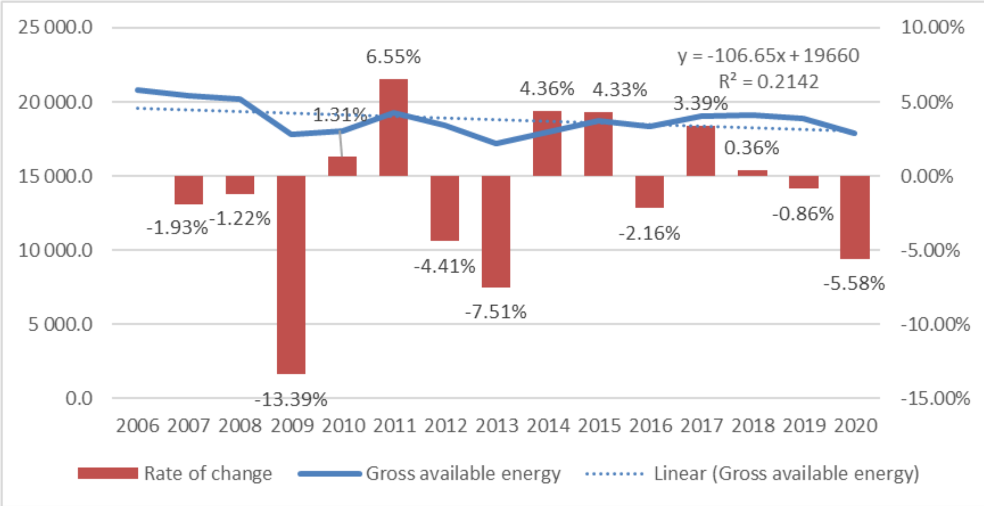

Figure 3. ***Gross available energy – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

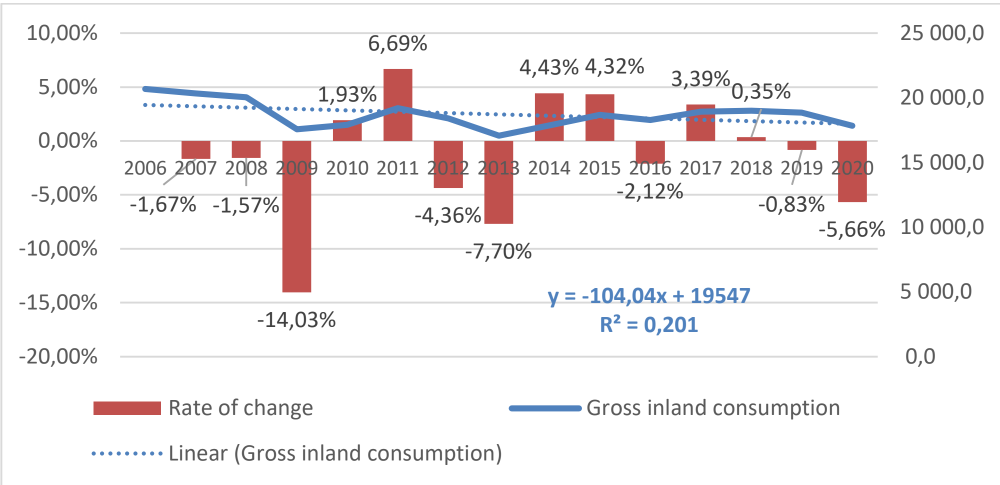

Figure 4. ***Gross inland consumption – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

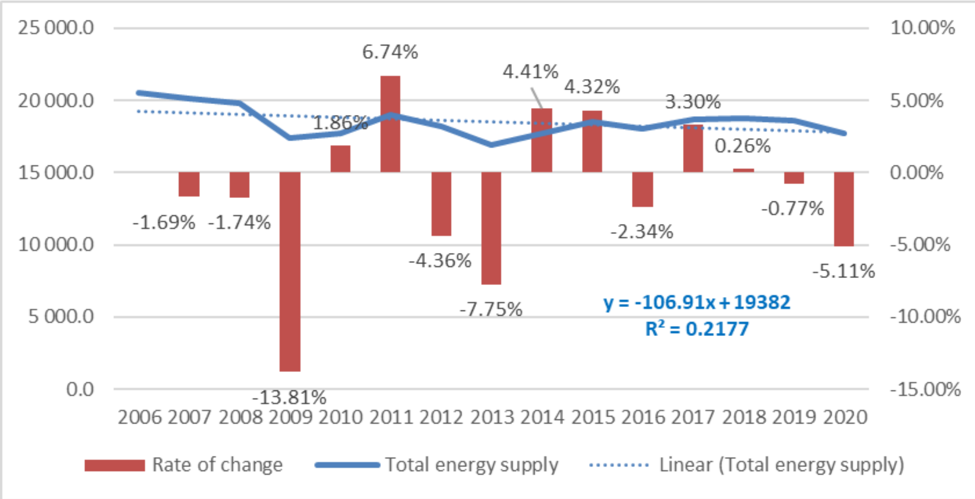

Figure 5. ***Total energy supply – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

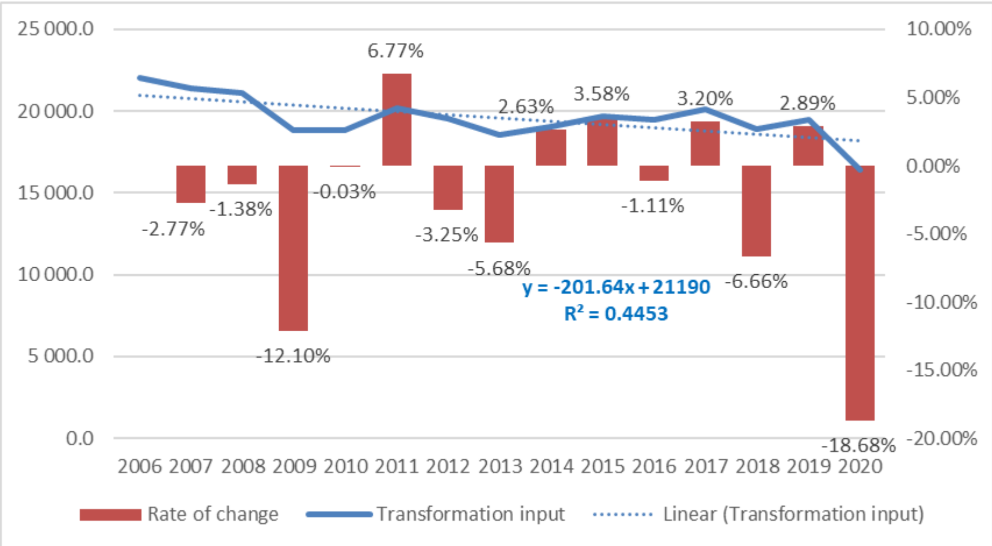

Figure 6. ***Transformation input – dynamics (in ktoe) and rate of change*** *compared to the previous year (in %)*

Data source: Author's own calculations based on data from (Eurostat, 2022)

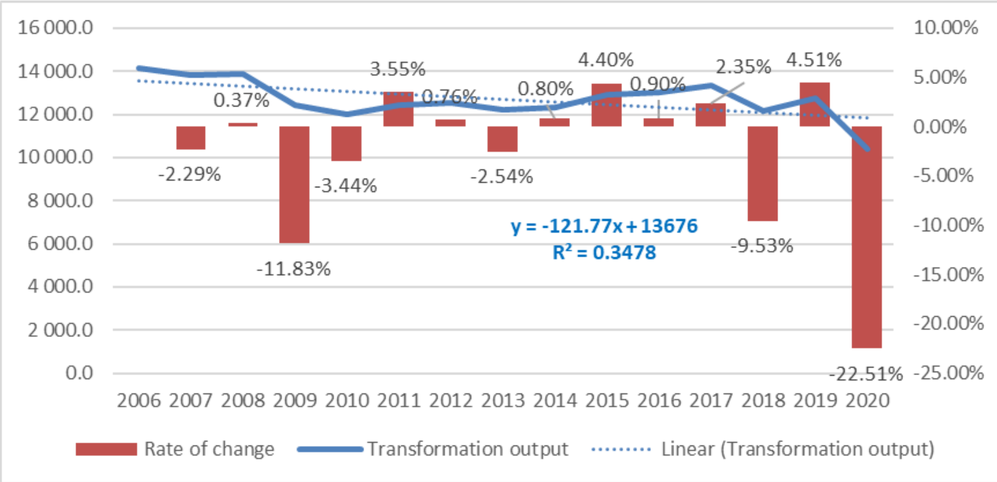

Figure 7. ***Transformation output – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

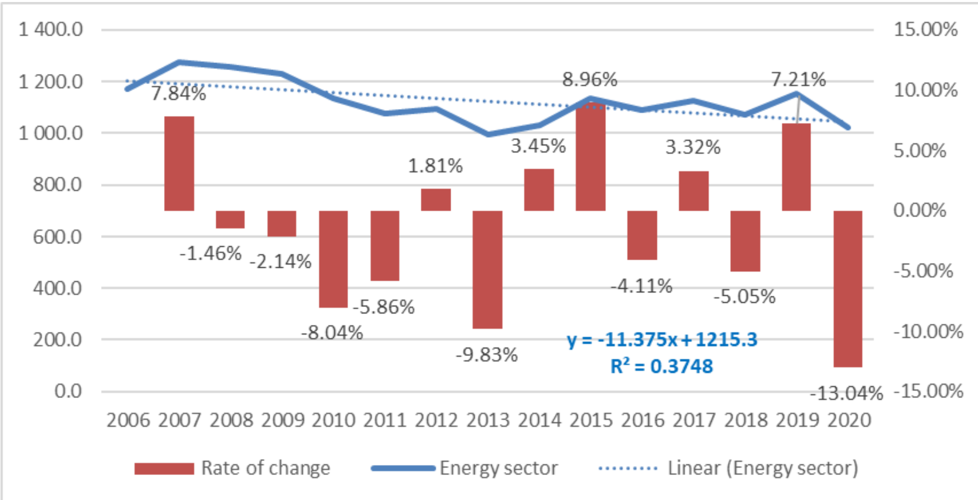

Figure 8. ***Energy sector – annual dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

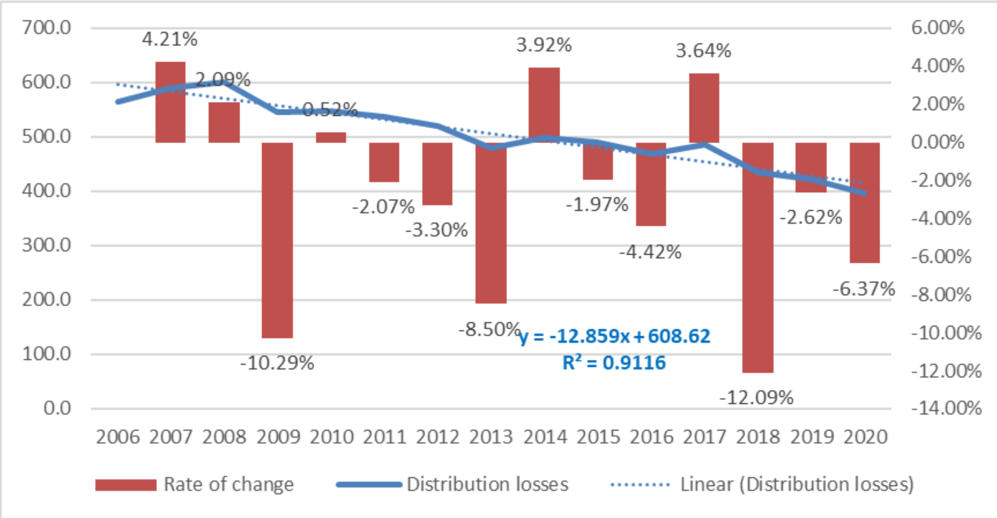

Figure 9. ***Distribution losses – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

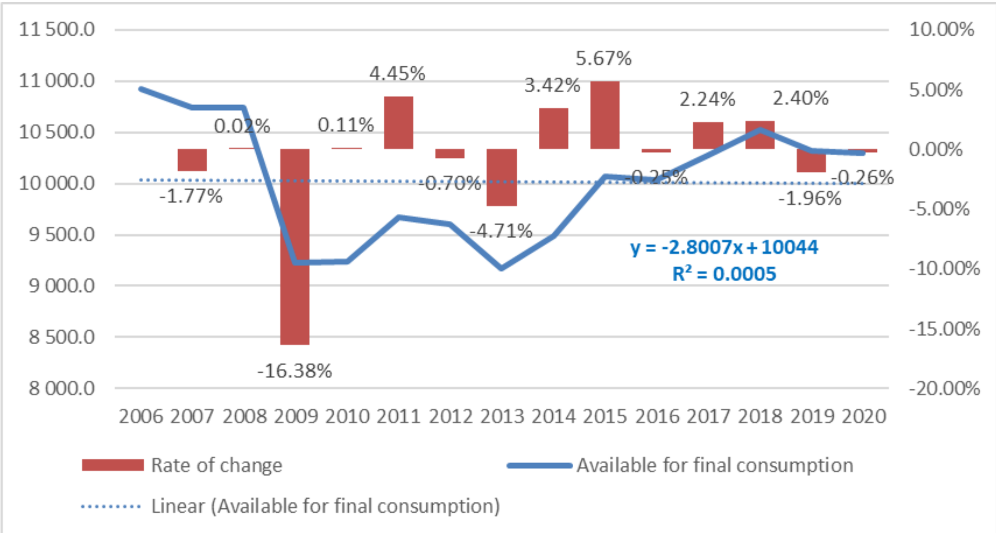

Figure 10. ***Available for final consumption – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

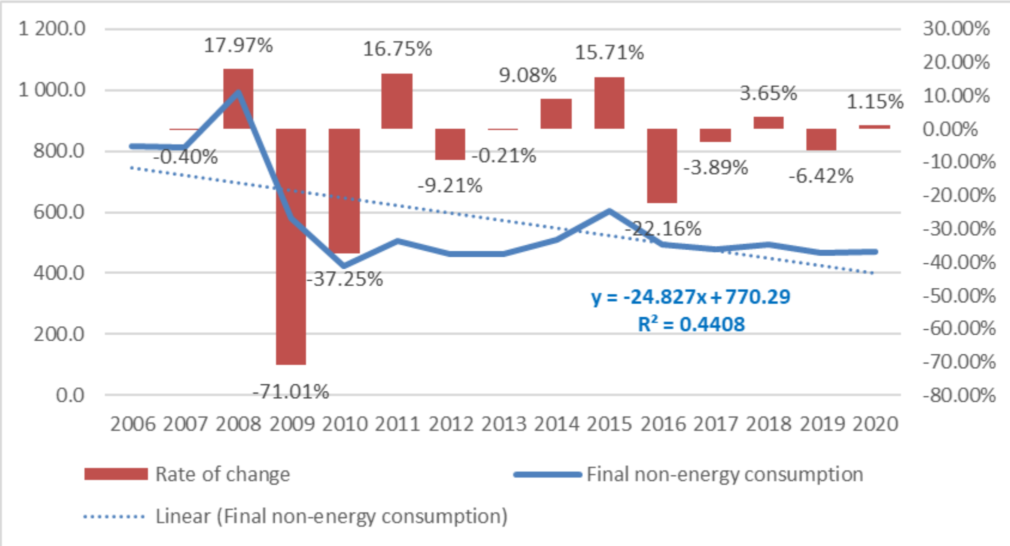

Figure 11. ***Final non-energy consumption – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

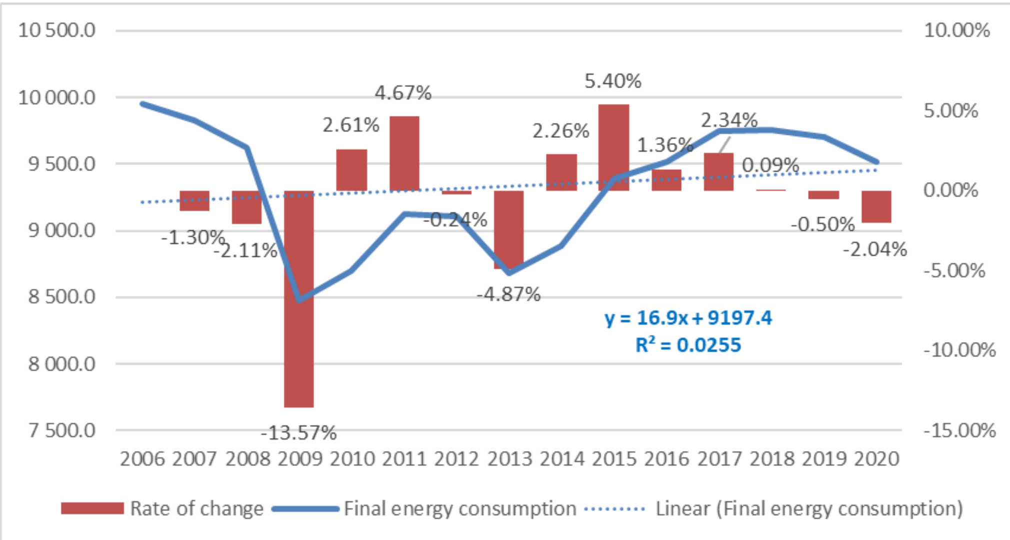

Figure 12. ***Final energy consumption – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

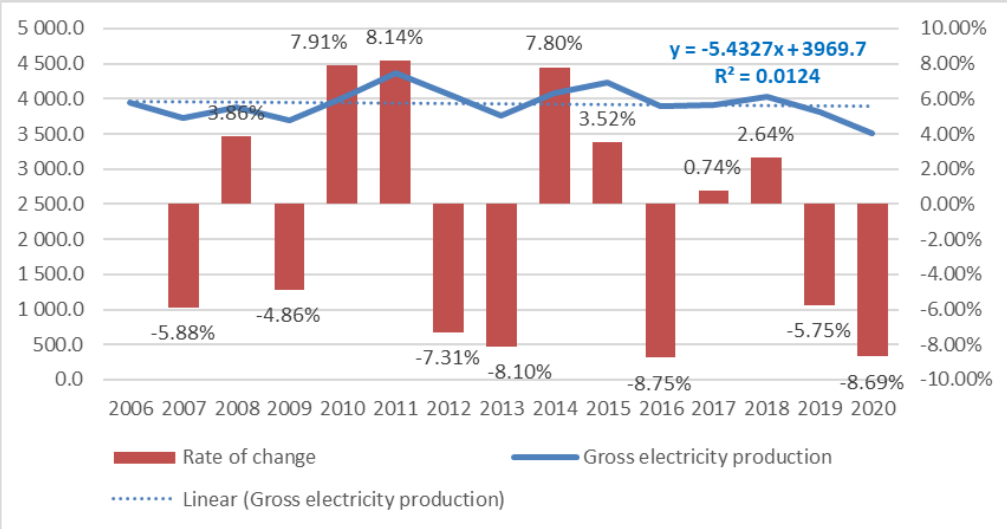

Figure 13. ***Gross electricity production – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

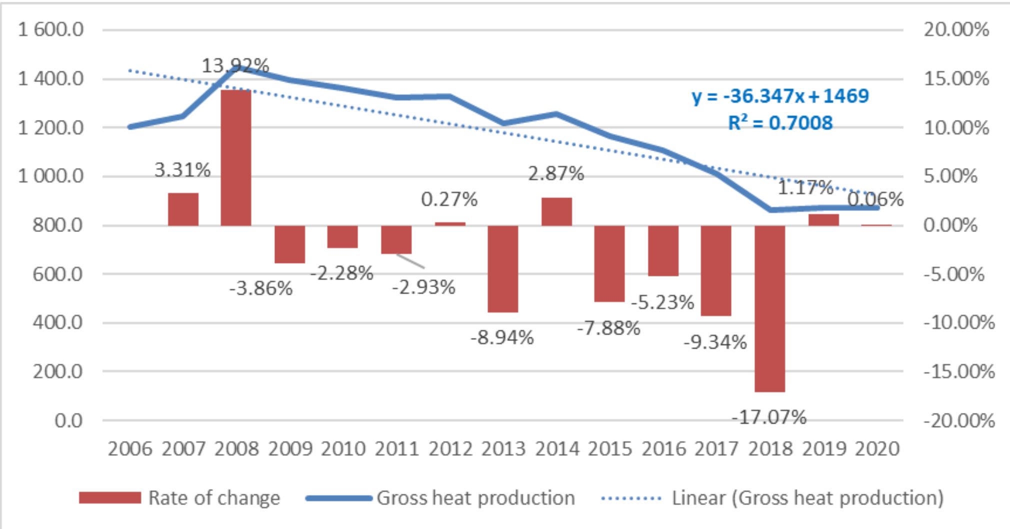

Figure 14. ***Gross heat production – dynamics (in ktoe) and rate of change compared to the previous year (in %)***

Data source: Author's own calculations based on data from (Eurostat, 2022)

In summary of the drawn-up verbal and graphical models of the dynamics of the major indicators of the Energy Balance of the Republic of Bulgaria, we present the following table which contains a beta strategic analysis for the period 2006-2020 (see Table 2).

Table 2.

Beta strategic analysis of the major indicators of the Energy Balance of the Republic of Bulgaria (2006-2020)

#	Indicator in ktoe	Linear regression
1	Gross available energy	**y = -106.65x + 19660** **R^2 = 0.2142**
2	Gross inland consumption	**y = -104.04x + 19547** **R^2 = 0.201**
3	Total energy supply	**y = -106.91x + 19382** **R^2 = 0.2177**
4	Transformation input	**y = -201.64x + 21190** **R^2 = 0.4453**
5	Transformation output	**y = -121.77x + 13676** **R^2 = 0.3478**
6	Energy sector – annual dynamics	**y = -11.375x + 1215.3** **R^2 = 0.3748**
7	Distribution losses	**y = -12.859x + 608.62** **R^2 = 0.9116**
8	Available for final consumption	**y = -2.8007x + 10044** **R^2 = 0.0005**
9	Final non-energy consumption	**y = -24.827x + 770.29** **R^2 = 0.4408**
10	Final energy consumption	**y = 16.9x + 9197.4** **R^2 = 0.0255**
11	Gross energy production	**y = -5.4327x + 3969.7** **R^2 = 0.0124**
12	Gross heat production	**y = -36.347x + 1469** **R^2 = 0.7008**

Source: Author's own calculations based on data from (Eurostat, 2022)

The beta strategic analysis of twelve indicators of the Energy Balance of the Republic of Bulgaria shows that the beta coefficient of only one of the indicators has a positive value of 16.9 ktoe (final energy consumption), which is commensurate with the requirements for energy security of the growth of the GDP. We add to it the indicator of distribution losses, which in its economic essence has a positive impact on the system of minus 12.9 ktoe per annum. All other ten indicators have a negative beta and reflect parallel processes of improvement of the efficiency of the system, bringing out power capacities, expanding the capacity of the renewable energy sources and trends for reducing the energy consumption during the winter months for heating purposes due to the sustainable increase of the average annual temperatures. Naturally, when adding the data from the years 2021 and 2022, the presented analysis will undergo corrections owing to the specific dynamics of the ad valorem component for the system which is conservative in its technological part.

Conclusion

On the basis of the conducted strategic research and having represented the dynamics of the major components and indicators of the Energy Balance of the Republic of Bulgaria for the period 2006 – 2020, by drawing up the annual rates of change, linear regression equations and coefficients of determination, we could reach the following important conclusions:

Firstly, we observe significant changes in a downward trend in the following indicators: Gross available energy – 2009 (-13.39%); gross inland consumption – 2009 (-14.03%); general energy supply – (13.81%); transformation input – 2020 (18.68%); transformation output – 2020 (-22.51%); energy sector – 2020 (-13.04%); distribution losses – 2018 (-12.09%); available for final consumption – 2009 (-16.38%); final non-energy consumption – 2009 (-71.01%); final energy consumption – 2009 (-13.57%); gross energy production – 2016 (-8.75%) and 2020 (-8.69%); gross heat production – 2018 (-17.07%). The dominating trends related to the decrease in the values of the components of the Energy Balance in 2009 are due to the negative impacts of the global financial and economic crisis accompanied by a partial exhaustion of the raw materials and the poor production activity which is also characteristic of 2020.

Secondly, we observe significant upward trends in the components of the Energy Balance in: gross available energy – 2011 (6.55%); gross inland consumption – 2011 (6.69%); general energy supply – 2011 (6.74%); transformation input – 2011 (6.77%); transformation output – 2019 (4.51%); energy sector – 2015 (8.96%); distribution losses – 2007 (4.21%); available for end consumption – 2015 (5.67%); final non-energy consumption – 2008 (17.97%); final energy consumption – 2015 (5.40%); gross energy production – 2011 (8.14%); gross heat production – 2008 (13.92%). The recovery processes in the economy, the industry and the demographic trends are clearly visible, as they have their sustainable impact on the energy sector during the analyzed period.

Thirdly, the dynamic political and economic conditions on a national level and worldwide impose seeking and maintaining the strategically important components which make up the Energy Balance at optimal levels in compliance with the deepening analytical results and trends. We shall therefore take effective measures for the prevention of potential negative consequences of hampering the technological processes in the energy sector and adopt mechanisms for timely coordinated measures based on in-depth research of the energy processes and their trends.

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Kaloyan Pargov is a PhD student at the Department of Finance and Credit, the D. A. Tsenov Academy of Economics – Svishtov, Bulgaria. His **research interests** are in the field of energy economics, energy security, investments in renewable energy sources.

ORCID ID: 0000-0002-2259-5477

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