D. A. TSENOV ACADEMY OF ECONOMICS

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AUTHOR'S SUMMARY

of a PhD dissertation in the doctoral programme in Finance, Money Turnover, Credit, and Insurance (Finance) for acquisition of the educational and scientific degree of Doctor of Philosophy (in Economics) entitled:

Energy Security and the Energy strategy of EU in Bulgaria: Financial and Economic Aspects and Challenges

Dissertation Advisor:

Prof. Stoyan Stanimirov Prodanov, PhD

Svishtov

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The dissertation thesis was was discussed and allowed to be defended on an extended session of the Department of Finance and Credit of the Department of Finance at D. A. Tsenov Academy of Economics - Svishtov.

PhD thesis statistics:

Number of pages – 217

Number of figures – 95

Number of tables – 5

Number of references – 158

Number of author's publications – 4

The defense of the doctoral thesis will be held at 1:30 pm on 24th March 2023 in the Rectorate meeting room of D. A. Tsenov Academy of Economics.

All material related to the defense are available upon request at the Department of Doctoral Studies and Academic Staff Development.

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I. General characteristics of the dissertation thesis

1. Contemporaneity of the topic

The relevance of the problem addressed in the dissertation thesis is related to the growing impact of climate change on energy systems worldwide, which has a direct impact on the European Union member states and Bulgaria in particular. Energy and the cost of energy resources have driven global and national economies into abnormal inflationary waves rocking macroeconomic accounts, interest spreads, and credit ratings. At the same time, the growing interest in renewable energy sources is a strategic choice to ensure affordable energy, economic growth and a sustainable environment. This necessitates the implementation of radical strategic financial and macroeconomic measures to improve not only on the energy sector, but also all related industries. Therefore, an expert assessment of the financial and economic aspects and challenges faced by the energy industry is essential both for its strategic long- and short-term development and for improving macroeconomic parameters and geopolitical relations.

2. Subject and object of the research

The subject of the dissertation research is the energy security of the EU and Bulgaria.

Its **object** are the financial and economic aspects and challenges of energy security and energy strategies of the EU and Bulgaria.

3. Research thesis

The main **thesis** of the dissertation thesis is that *energy security is a key component of the energy strategy of the EU and Bulgaria, which should be based*

on financial and economic analyses assessing the various aspects and challenges of the energy balance and the trend and force majeure energy mix dynamics.

4. Research goal

The main **goal of the dissertation thesis** is to discuss the evolution of energy strategies of the EU and Bulgaria as sources of energy security based on based on multi-factor financial and economic analyses, energy balance trend modeling and assessment of energy mix dynamics.

5. Research objectives and methodology

The goal, object, subject and thesis of the dissertation research define the tasks and the related structure of the dissertation thesis as follows:

First. To focus on solving the task of critical assessment of the priorities and components of the EU energy policy at the beginning of the 21st century with a definitive introduction of the concept of energy security as part of *acquis communautaire*.

Second. To develop a dynamic model of the components of the energy balance of the EU and Bulgaria with a study of price parameters and technology for electricity and LPG pricing.

Third. Prospective analysis and combinatorial modeling of Bulgaria's value-adding opportunities based on its strategic location along and in the vicinity of major gas pipelines, LNG terminals, and alternative sources, as well as the critical effects of the Day Ahead market segment of the Independent Bulgarian Energy Exchange.

The **methodology** of the dissertation research includes the following methods: descriptive statistics, tabular presentation and schematic illustration, verbal and graphical modeling, regression analysis and beta analysis.

Sources of empirical data are official websites and databases of the World Energy Council, Eurostat – an official European sources that allows comparison among various EU member states and outlining parameters for presenting the challenges to the energy sectors of the EU and Bulgaria; the Electricity Systems Operator, the Independent Bulgarian Energy Exchange, etc.

6. Research scope

The study was carried out with data from 2007 to 2021, as this is the period of the last major enlargement of the EU for which revised data are available in the official information sources. In order to achieve relevance and objectivity of the analyses the time frame includes some data for 2022 as well. The scope of the study does not include the force majeure circumstances in the energy balance and the energy mix caused by the war in Ukraine and the repeated increase in the price of stock market quotations of basic energy sources. The author believes that this force majeure phenomenon directly affects the original construct of energy security in Bulgaria and the EU. Regardless of the strong pro-inflationary effects of this price increase, excess profits were observed and reported among producers of low-carbon electricity, which in competitive conditions rebalances the energy market itself.

7. Research structure

The overall volume of the dissertation thesis is 217 standard pages and includes three chapters, an introduction and a conclusion structured as follows:

INTRODUCTION

CHAPTER ONE. HISTORICAL ANALYSIS AND ASSESSMENT OF EU's ENERGY POLICY IN THE BEGINNING OF THE 21st CENTURY

1. A review of the fundamental discussions regarding the common European policy

2. The theoretical concept and indicators for assessing energy security

2.1. The term “energy security” as an element of the energy union strategy

2.2. Indicators for assessing energy security

3. Energy policy as a responsibility of the European Commission in the 21st century

3.1. Global trends in energy consumption as a factor for the formation of a new energy policy in the European Union

3.2. Energy efficiency and low-carbon energy as EU objectives

3.3. The paradigm of the European energy security strategy

Conclusions from Chapter One

CHAPTER TWO. FINANCIAL AND ECONOMIC MEASURES AS INDICATORS FOR PREVENTION OF ENERGY CHALLENGES

1. Energy balance – an analytical source for strategic analysis of the European and national energy security

1.1. Energy balance – evolutionary characteristics and structural components

1.2. Static and dynamic energy balance of the EU

1.3. An analysis of the components of Bulgaria’s energy balance

2. A study on the trends and components of the energy mix of the EU and Bulgaria in the 21st century

3. An analysis of the price parameters and pricing of key energy sources of the EU and Bulgaria

3.1. Price parameters and pricing components of LNG and electricity for households in the EU and Bulgaria

Declaration for originality and credibility of the dissertation thesis

8. Practical applicability of the research findings

The theoretical arguments developed in the dissertation and the derived empirical results based on an econometric financial and economic analysis evaluating the many aspects and challenges of a trend and force majeure nature, aim to establish the importance of energy security for the implementation of the energy strategy of the European Union and Bulgaria. The developed analytical models focused on key energy measures can be beneficial both for the strategic long- and short-term development of the sector as well as for the improvement of economic parameters and geopolitical relations. The research is applicable for the purposes of creating a new perspective on the practical research in the energy sector. It can be a starting point for evaluating energy sector trends and developing strategic concepts to prevent force majeure and overcome challenges at national and European level.

II. Contents of the Dissertation Thesis

Chapter One. Historical Analysis and Assessment of EU's Energy Policy in the Beginning of the 21st Century

Chapter one focuses on energy security as a permanent issue in the field of economic development. The main emphasis is placed on:

First. A review of the fundamental discussions regarding the common European policy.

Second. The theoretical concept of the term "energy security" and indicators for assessing energy security.

Third. Energy policy as a responsibility of the European Commission in the 21st century.

The concept of "energy security" was first used by Winston Churchill when he made the historic decision to diversify fuel sources for the British Navy using oil in addition to coal. Traditional sources of risk such as the supply of energy carriers, the ever-increasing demand for and consumption of energy, the geopolitical paradigms and market conditions are at the heart of many discussions related to finding the best option for national economies to ensure the energy they need for their normal operation.

Since the middle of the 20th century, the coordination, joint discussion and search for approaches by the EU member states to solving energy policy problems are constantly intensifying. Free competition in the internal market of the European Union is one of the ways to influence energy policies in the community. A large number of European countries are highly dependent on the import of energy resources. On the other hand, climate change, geopolitical conflicts, and uneven recovery from the pandemic are leading to a rapid change in consumption and supply patterns. All this has made the EU start planning its energy future more seriously and define energy policy as one of its main priorities. At the end of 2019,

the European Commission set the ambitious goal to become a leader in climate-friendly industries and clean technologies through the European Green Deal, which commits the EU countries to achieving climate neutrality by 2050.

The political discourse emphasizes the extreme importance of energy security. It is one of the main goals of energy policy. However, the term is not clearly defined, making it difficult to measure and balance against other policy objectives (Winzer, 2012). Based on the large-scale theoretical review, the author has defined of the concept of energy security as *an essential element of the energy policy of any country with a direct factor impact and importance for its economic, national and ecological security, which in their integrity are achieved by securing energy needs at optimal prices that support economic growth in conditions of a global low-carbon transition.*

Based on the author's definition derived in this way, the indicators for assessing energy security are analytically systematized and classified into simple and complex energy measures. These categories include: resource estimation, reserves/production ratio, diversity indices, import dependencies, political stability indicators, energy prices, share of zero-carbon fuels, market liquidity, demand-related indicators, the Shannon–Wiener diversity index, the Herfindahl-Hirschman Index, capacity adequacy indicators, production reliability indicators, etc. Used separately or in combination, they are criteria of high information value in the process of analyzing energy security, its structural components and options for its optimization and balancing.

The importance of energy security and the implementation of an energy strategy was prioritized by the European Commission in the 2006 European Strategy for Sustainable, Competitive and Secure Energy. It, as well as a number of other strategic European documents provide an incentive and action plan to the European Council and the European Parliament, assess the progress, identify new challenges and provide solutions in all individual aspects of energy policy. Stability and sustainability of energy security are supported on national level

through the "Strategy for sustainable energy development of the Republic of Bulgaria until 2030 with a horizon up to 2050." (Министерство на енергетиката, 2022). It defines the long-term development of the national energy sector based on models and forecast base and target scenarios.

All this makes it possible to identify and evaluate the possibilities and the consistency of the implementation of alternative policies undertaken in Europe to overcome energy poverty in the member states, the implementation of low-carbon sources in production; an emphasis on preparation of adequate action for implementation of energy security and efficiency; improvement of the Bulgarian electricity market through changes in the market model and amendments of laws and regulations for their harmonization with *acquis communautaire*. These arguments are supported with environmental considerations in the context of global efforts to limit global climate changes.

Chapter Two. Financial and Economic Measures as Indicators for Prevention of Energy Challenges

Chapter Two presents a detailed analysis of the financial and economic measures as indicators for preventing energy challenges. Structurally, the chapter focuses on:

First. Energy balance – an analytical source for strategic analyses of the European and national energy security.

Second. A study on the trends and components of the energy mix of the EU and Bulgaria in the 21st century.

Third. An analysis of the price parameters and pricing of key energy sources of the EU and Bulgaria.

The theoretical and analytical findings presented in Chapter Two are based on a detailed analysis of the energy balance which reflects the mix of energy products and their dynamics. The structural matrix and main functions of the energy balance are presented.

Table 1. Energy balance matrix

(ktoe)	**Energy sources** →			
Main items defining the energy balance structure ↓				

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

Considering the structural components of the energy balance of the European Union and the Republic of Bulgaria and the strategic beta analysis of its main indicators, the more important conclusions that can be drawn are that within the framework of the EU energy balance, the beta coefficients of all considered components have negative values.

This shows that the studied energy balance items will probably not be able to respond to the market changes in the energy sector of the European Union and will require a substantial and expedient consideration of optimization plans and political and economic decisions for implementation of new management solutions for some of the components. The impact of the change in the Distribution Losses indicator is positive for a distribution which, by its economic nature, has a positive impact on the system of -224.88 ktoe per year. The significant analytical indicators and the estimated beta coefficients are seriously affected in terms of their dynamics and coefficient values in the analyses for 2021

and 2022 data due to the presence of significant force majeure circumstances in the sector.

Table 2. Strategic beta analysis of the main components of EU's energy balance (2006-2020)

No.	Item in ktoe units	Linear regression
1	Gross available energy	**y = -14588x + 2E+06 R^2 = 0.7323**
2	Gross internal consumption	**y = -13781x + 2E+06 R^2 = 0.728**
3	Total energy supply	**y = -13846x + 2E+06 R^2 = 0.7692**
4	Transformation input	**y = -11454x + 1E+06 R^2 = 0.6254**
5	Transformation output	**y = -4307.7x + 1E+06 R^2 = 0.2767**
6	Energy sector	**y = -802.62x + 76154 R^2 = 0.8062**
7	Distribution losses	**y = -224.88x + 25483 R^2 = 0.7268**
8	Available for final consumption	**y = -5671.5x + 1E+06 R^2 = 0.4848**
9	Final consumption – non-energy use	**y = -1021.8x + 102479 R^2 = 0.6342**
10	Final consumption – energy use	**y = -4735.3x + 976810 R^2 = 0.4885**
11	Gross electricity production	**y = -596.67x + 255903 R^2 = 0.2854**
12	Gross heat production	**y = -382.72x + 59194 R^2 = 0.4656**

Source: Author's calculations based on data from (Eurostat, Energy balance sheets, 2022)

The strategic beta analysis of the twelve indicators in the Republic of Bulgaria's energy balance shows that the beta coefficient of only one indicator (Final consumption – energy use) has a positive value of 16.9 ktoe, which is comparable to the requirements for energy supply that supports GDP growth. To it we add the distribution losses indicator, which by its economic nature has a positive effect for the system with a value of -12.9 ktoe per year. All the other ten indicators have a negative beta and reflect parallel processes of improving

efficiency in the system, decreasing production capacity, expanding the capacity of RES and trends to reduce energy consumption of heat during the winter months due to the sustained increase in average annual temperatures. Naturally, when we add the data for 2021 and 2022, the analysis results will be adjusted due to the exceptional dynamics in the ad valorem component for the system given the conservative characteristics of its technologies.

Table 3. Strategic beta analysis of the main components of Bulgaria's energy balance (2006-2020)

No.	Item in ktoe units	Linear regression
1	Gross available energy	**y = -106.65x + 19660** **R^2 = 0.2142**
2	Gross internal 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	**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 consumption – non-energy use	**y = -24.827x + 770.29** **R^2 = 0.4408**
10	Final consumption – energy use	**y = 16.9x + 9197.4** **R^2 = 0.0255**
11	Gross electricity 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 calculations based on data from (Eurostat, Energy balance sheets, 2022)

In addition to the logical sequence of Chapter Two, a comprehensive study of trends in the components of the energy mix in the European Union and Bulgaria was carried out. The results obtained in the course of this analytical study and the

evaluation of the energy mix components show the crucial importance of developing energy security systems and undertaking an energy strategy aimed at generating clean energy for the energy transition as well confirm the importance of applying these technologies during global health, economic, political and social crises. In years of challenges (pandemic crises, socio-economic upheavals, political paradoxes), it is necessary to create a complex management model based on the triple helix of cooperation of the political sector, the industrial sector and academia to build innovations to overcome challenges and shape the future of the European and the national energy sectors. A clear proof of the need for energy policy and strategy coherence between Bulgaria and the EU is 2021, when the price of gas for households in Bulgaria is higher than the price in the EU-27 by more than 25%.

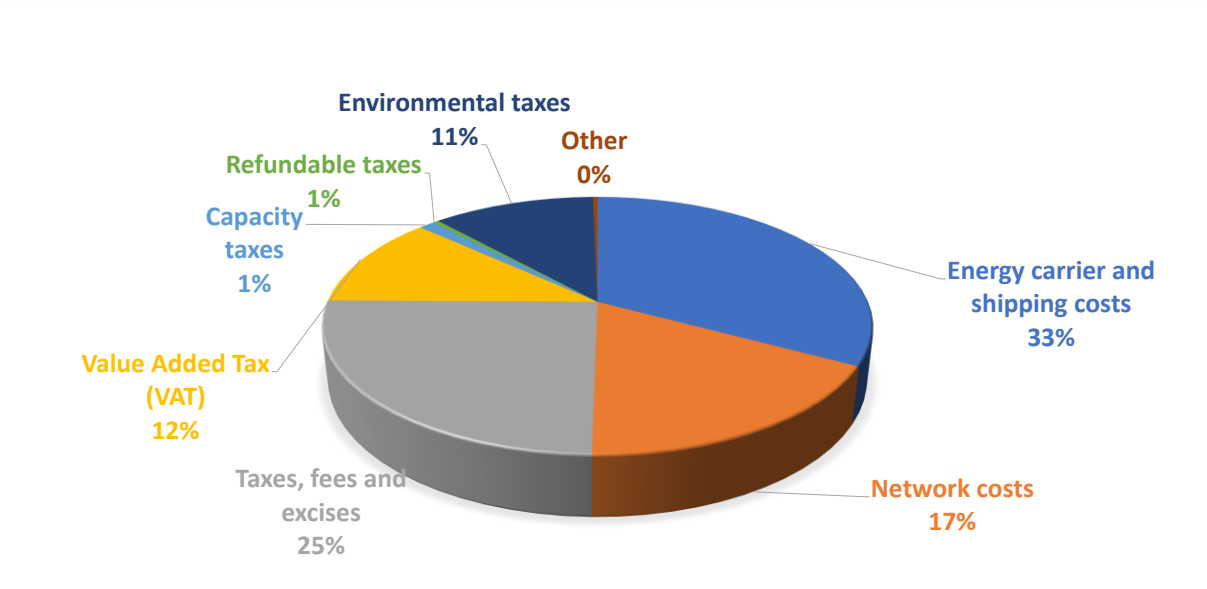

Figure 1. Household gas price components in the EU in 2021

Therefore, to achieve energy security we must take into account the fundamental characteristics of conventional centralized and fossil fuel-based systems. The future energy systems, in terms of their strategic framework and development direction, should be cleaner, sustainable, intelligent, reliable, flexible and affordable.

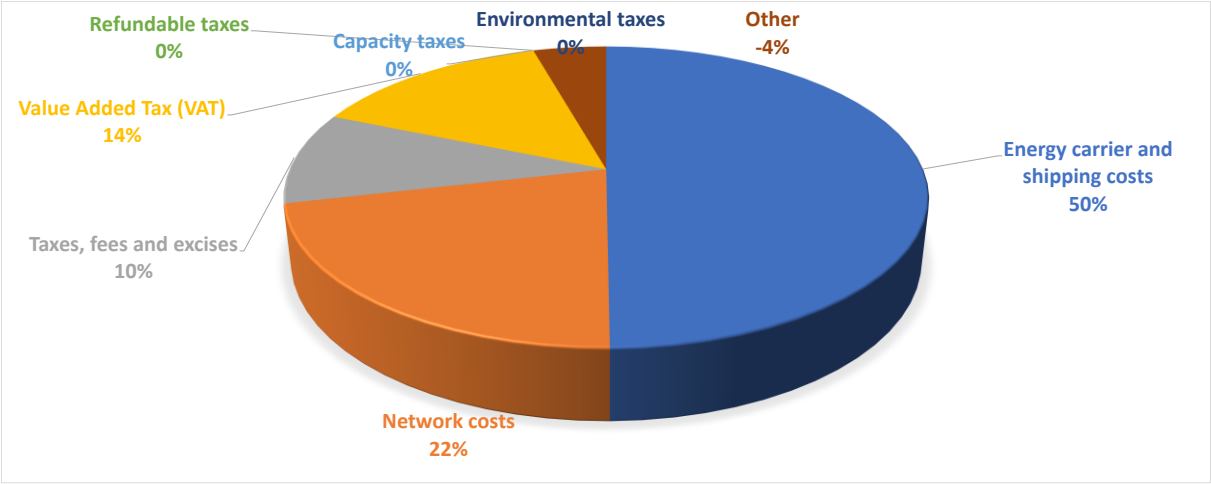

Figure 2. Household gas price components in Bulgaria in 2021

Source of the data in Figure 1 and Figure 2: Eurostat

The results from the analysis of electricity and gas prices and their pricing components reveal the necessity of adequate measures to regulate and stabilize these prices. Such a measure is the recommendation given by the Association of Industrial Capital in Bulgaria "that Bulgaria should adequately use the leverage it has to negotiate with all possible suppliers of LPG in order to maximize the benefits for our economy and society without compromising its pan-European values and affiliation." (Асоциация на индустриалния капитал в България, 2022). For the purposes of alternative regulation of electricity consumption and supply with stable price parameters, regulators should take into account not only the standard pricing methods based on economic, financial and geopolitical circumstances, but also the implementation of digitization of electricity production and distribution processes. The implementation of smart meters makes real-time pricing technologically feasible on a larger scale. On the other hand, this can be used by consumers, allowing them to react to price changes by adjusting consumption in real time and limiting consumption through various switching devices in or outside electrical appliances.

Chapter Three. Challenges and Prospects for the Energy Sector of the EU and Bulgaria

Chapter Three presents the challenges and prospects for the energy sector of the European Union and Bulgaria in analytical form. Specifically, the main aspects covered in the chapter are divided as follows:

First. The context of the European energy security debate.

Second. Resource deposits in the Caspian region and the Black Sea as alternatives of energy supplies from Russia.

Third. Energy security and energy strategy of the European Union and Bulgaria.

Chapter Three examines in detail the context of the European debate on energy security since 1994, when the Energy Charter Treaty was signed. The overall conclusion from the study on the resource deposits in the Caspian region and the Black Sea as alternatives to Russian energy carrier supplies are that the Caspian region will continue to be an important source of energy resources for the foreseeable future, especially if estimates of the available oil and gas reserves are accurate. At the same time, the "Balkan" gas hub is evaluated as an opportunity to turn Bulgaria not only into a transit, but also a regional factor in the supply of gas to South-Eastern Europe. In the long term, the Nord Stream 2, the Turkish Stream and the Balkan Stream projects should be seen as Europe's answer to securing its economy with a horizon of up to 2050, when coal power plants will be long gone. However, the decarbonisation of the EU energy sector creates a growing demand for LPG, which, even through the prism of diversification with sources in the Caspian Sea, will continue to rely on gas imports for decades to come.

Table 3-1. Energy and economic potential of the European countries in 2021.

	Energy security	Energy sustainability	Energy equity	Energy tri-component rank	Population (mln.)	GDP per capita (US $)	GDP growth (%)	Area	Industrial sector (% of GDP)	Regional economic potential rank
Belgium	61.2	74.9	95.1	11.0	11.5	46,421	1.7	30.3	19.1	28.0
Bulgaria	73.1	71.4	78.6	22.0	7	9,828	3.7	108.6	21.6	12.0
Czech Rep.	72.8	68.9	83.2	19.0	10.7	23,495	2.3	77.2	31.4	16.0
Denmark	71.2	82.9	96.4	2.0	5.8	60,17	2.8	42	21.1	26.0
Germany	71.9	75.9	95	6.0	83.1	46,445	0.6	349.4	26.7	5.0
Estonia	68.7	68.4	84.6	23.0	1.3	23,723	5	43.5	22	25.0
Ireland	56	76.3	98.4	12.0	4.9	78,661	5.5	68.9	35.2	18.0
Greece	54.7	72.9	81.1	25.0	10.7	19,583	1.9	128.9	15.3	11.0
Spain	65.6	76.1	92.3	8.0	47.1	29,6	2	499.6	20.5	4.0
France	69.1	82.7	94.9	4.0	67.1	40,494	1.5	547.6	17.1	3.0
Croatia	69	75.2	80.8	18.0	4.1	14,936	2.9	56	20.3	23.0
Italy	66.6	73.5	91.4	10.0	60.3	32,228	0.3	294.1	21.4	8.0
Latvia	74.9	70.9	78.1	20.0	1.9	17,829	2.1	62.2	18.6	21.0
Lithuania	59.6	78.2	91.2	14.0	2.8	19,602	4.3	62.6	25.3	20.0
Luxembourg	55.7	77.6	99	9.0	0.6	114,705	2.3	2.4	11.3	32.0
Hungary	70.6	72	91.8	7.0	9.8	16,732	4.6	90.5	25	13.0
Netherlands	59.5	70.2	95.7	17.0	17.3	52,331	1.7	33.7	17.7	27.0
Austria	69.4	79.4	96.4	5.0	8.9	50,138	1.4	82.5	25.5	17.0
Poland	64.2	61.6	87.6	24.0	38	15,693	4.5	306.2	28.6	7.0

Portugal	64.2	75.3	90.3	13.0	10.3	23,252	2.2	91.6	18.9	15.0
Romania	75.1	75.3	75.9	16.0	19.4	12,92	4.2	230.1	28.2	10.0
Slovenia	68.8	73.5	84.5	15.0	2.1	25,946	3.2	20.1	28.9	30.0
Slovakia	69.4	75.1	79.3	21.0	5.5	19,266	2.3	48.1	28.7	22.0
Sweden	74.5	86.3	93.2	1.0	10.3	51,615	1.3	407.3	22.2	6.0
Great Britain	68.8	81.3	96.8	3.0	66.8	42,33	1.5	241.9	17.4	9.0
North Macedonia	51	64.2	71.7	31.0	2.1	6,022	3.2	25.2	23.5	31.0
Serbia	62.3	58.4	69.4	29.0	6.9	7,412	4.2	87.5	25.6	14.0
Turkey	60.1	66.8	75.9	27.0	83.4	9,127	0.9	769.6	27.2	1.0
Bosnia and Herzegovina	60.3	56.6	70.4	30.0	3.3	6,109	2.7	51.2	23.9	24.0
Moldova	47.9	56.3	67.9	32.0	2.7	4,504	3.6	32.9	22.8	29.0
Ukraine	69.7	67.3	70.2	26.0	44.4	3,659	3.2	579.3	22.6	2.0
Georgia	55	72	72.9	28.0	3.7	4,698	5	69.5	20.3	19.0

Source: Author's adaptation using data from (World Energy Council, 2022) and own calculations

The energy three-component rank and the rank of the regional economic potential outline the countries with good energy discipline and socio-economic conditions. Given these ranks, for the purpose of improving energy security, an energy security alliance could be formed between Sweden, Denmark, Great Britain, France, Austria, Germany, Hungary, and Spain, which represent good practices in the energy sector. These EU member states (except the UK) have met a number of EU targets for increasing energy efficiency and developing low-carbon and renewable sources.

For the purposes of the quantitative analysis of the relationships among the prices of the main energy resources in Europe as a strategic element for ensuring the energy security of the EU countries the relationships among all European countries were subjected to a correlation analysis. Moreover, for the purposes of statistical analysis, hourly data was extracted from 01 Jan. 2021 to 26 Oct. 2022 - a total of 31870 observations, of which 15935 observations of spot prices in Euro/MWh. Within the framework of the research of market anomalies in the "Day Ahead" segment in the case of the market merger between Bulgaria and Greece from 12 May 2021, cross-border capacity is allocated between the two countries using the Euphemia algorithm or Separate Virtual Broker (SVB) analysis.

The conducted research has two main parts. The first presents and visualizes from the point of view of an open economy the operational capacity of Bulgaria's energy system to produce electricity from renewable sources and its interconnectivity. The second part examines market anomalies in the Day Ahead segment from the beginning of 2021 until 30 Sept. 2022 using econometric methods on an hourly basis with data on prices in EUR/MWh and traded volumes in MW.

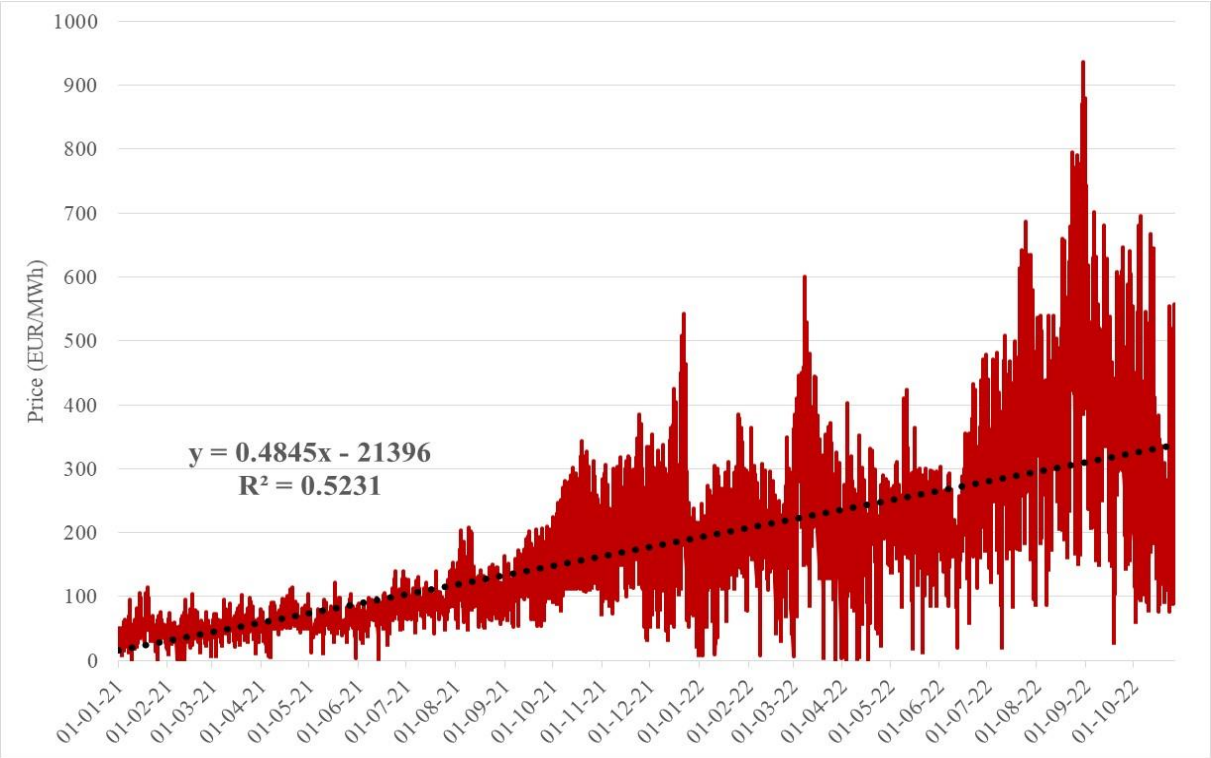

Figure 3. Hourly spot prices in the Day Ahead market segment of the Independent Bulgarian Energy Exchange in the period 01 Jan. 2021 – 26 Oct. 2022.

Source: https://ibex.bg/dam-history.php

The regression model confirms the presence of statistical significance in the regression equation between the volume of electricity traded in the Day Ahead segment as a factor variable and the price as an output variable (both for the model itself at Signif. F=0.00<0.99 and for alpha with P-value =0.006<0.99 and for beta with P-value=0.00<0.99). The price of 936.33 EUR/MWh reached on 30 Sept. 2022 in the time range 7-8 pm is a historical record for the segment in conditions of summer energy consumption, which confirms that the regulation of the energy market is yet to be expected.

The conclusion from the analyses in Chapter Three is that the Day Ahead market segment generates market price anomalies two national exchanges with different seasonal pace and rhythm of demand and supply of electricity are interconnected. The demand for electricity from Greece at high prices on the

connected Bulgarian energy market in the Day Ahead segment forms a situation of international transfer of economic shocks, which results in observations of a record annual consumer price inflation index of 20% for the whole period of Bulgaria's EU membership.

Conclusion

The presented research on the energy security and energy strategy of the EU and Bulgaria has a particular relevance and significance as of the end of 2022 and the beginning of 2023. Energy and the prices of energy resources caused abnormal inflationary waves in the world and national economies that changed macroeconomic balances, interest rate spreads and credit ratings. Combined with the military actions on the territory of Ukraine (which ceased the supply of Russian gas and oil to Europe) and the post-pandemic social and economic recovery, we had to review objectively the indicators and target parameters imposed by the European Green Deal and the Paris Climate Agreement. Modeling the components in the energy balance of the EU and Bulgaria combined with studying the price parameters and the technology for electricity and gas pricing bring out the dynamics in the political and economic conditions at national and global level. It requires that the strategically important components that make up the energy balance should be identified and maintained at optimal levels that are consistent with the ongoing trends.

The prospective analysis and combinatorial modeling of value-adding opportunities for Bulgaria based on its strategic location along and in the vicinity of major gas pipelines, regasification terminals and alternative production sources as well as the critical effects of the Day Ahead market segment of the Bulgarian Independent Energy Exchange generates price market anomalies when two

national exchanges with different seasonal pace and rhythm of demand and supply of electricity are interconnected.

In order to implement new strategic decisions to improve energy security and add energy benefits for the European Union and Bulgaria as a result of the collected empirical data and the applied analyses, it is necessary to review the energy relationships between individual countries. As a direct result of the analysis of the populations of data regarding the energy system, main results are derived, which, at the time of completion of the dissertation, are scientifically significant and analytically relevant and which are summarized at the end of each chapter.

This gives us reason to conclude that the stated research thesis has been proven. All aspects considered show that the topic of the energy strategy and energy security of Bulgaria and the EU is of permanent relevance and has a direct impact on the well-being of the main economic agents: governments, companies and households. That is why the dissertation does not conclude the topic but is a modest contribution to the scientific understanding of energy accessibility as a symbol of modern civilization.

III. Directions for future research in the field of the dissertation thesis

As a result of the proved analytical relevance and scientific novelty of the energy security and energy strategy of the European Union and Bulgaria from a financial and economic point of view and given the wide scope of research opportunities in this field, the present research determines the following aspects for further research in this field:

First. The impact of large-scale investments in RES and the Chaira PSHPP on the balance of Bulgaria's electricity generation mix.

Second. The strategic effects of the Day Ahead segment of the Independent Bulgarian Energy Exchange on inflation and the financial position of electricity consumers.

Third. Bulgaria's nuclear energy prospects in two aspects - new reactors at the Kozloduy NPP site, a new nuclear power plant (Belene NPP), or a combination of both.

Fourth. The impact of the European Green Deal on the future of the Maritsa East complex and Bulgaria's significant coal deposits.

Fifth. The requirements for implementation of a program for financial recovery of Toplofikatsia Sofia as a systemic consumer of LPG.

IV. List of the scientific contributions of the dissertation thesis

First. The author's definitive interpretation of the "energy security" concept is derived as an essential element of the energy policy of every country with a direct factor impact and importance for economic, national and ecological security, which in their integral entirety are achieved by meeting energy needs at optimal prices that maintain economic growth in conditions of a global low-carbon transition.

Second. The model of the components of energy balance of the European Union and Bulgaria reveals the need for an in-depth study of energy processes and their trends for taking effective measures to prevent potential negative consequences from disruption of technological processes in the energy sector.

Third. On the grounds of evaluation of the energy three-component rank and the rank of the regional economic potential of the European countries the author put forward a substantiated proposal for establishing a strategic energy security alliance among Sweden, Denmark, Great Britain, France, Austria, Germany, Hungary and Spain.

Fourth. A correlation analysis was carried out to identify the quantitative relationships among the prices of the main energy resources in the European countries and hence the geopolitical possibilities for adjusting the financial parameters of the main energy resources in Europe and the options for potential cooperation between these countries were defined**.**

Fifth. The practical opportunities to add value for Bulgaria have been identified taking into account its strategic location along and in the vicinity of major gas pipelines and the opportunities for gas supplies from regasification terminals to establish competitive alternatives to traditional sources. The applied prospects analysis and combinatorial modeling based on the Euphemia algorithm or Separate Virtual Broker (SVB) were used for a critical assessment of the effects on the Day Ahead market segment of the Independent Bulgarian Energy

Exchange considering the price market anomalies in 2022 resulting from interconnecting two national exchanges with a different seasonal peak patterns of electricity supply and demand.

V. Author's publications related to the topic of the dissertation thesis

Studies:

1. Pargov, K. (2022). A Historical Analysis and Evaluation of the Energy Policy of the European Union in the Beginning of the 21st Century. Annual Almanac "Doctoral Scientific Research", 30 pages (approved for publication/in print).

Articles:

1. Pargov, K. (2022). Bulgaria's Energy Balance – a Strategic Analysis, Economic Archive, Vol. 3, ISSN: 2367-9301, pp. 19-34.

Scientific papers:

1. Pargov, K. (2021). Resource Deposits in the Caspian region and the Black Sea as an Alternative to Russian Energy Supplies. Collection of papers from the scientific conference "Logistics and public systems", V. Tarnovo, February 25 - 27, 2021, Publishing complex of NMU Vasil Levski, pp., 1096-1095, ISSN 2738-8042.

2. Zahariev, A., Pargov, K. (2022). Market anomalies in the "Day ahead" segment of the Independent Energy Exchange - Bulgaria's experience in the transition to the "European green deal". Works of the International scientific and practical conference "Sustainable development of the Republic of Kazakhstan in the context of the transition to "Green economy": application of the experience of the countries of the European Union", 28.10.2022, Kazahstan, Astana: NAO "L.N.Gumilyov Eurasian National University", pp. 210-216, ISBN 978-601-307-777-3

VI. Reference for compliance with the national requirements under the Regulations on the Implementation of the Development of Academic Staff in the Republic of Bulgaria Act

National requirement: **30,00 points**

Number of **studies** published in non-referenced peer-reviewed journals or reviewed collections: 1
Score: 15 points

Number of **articles** published in non-referenced peer-reviewed journals or reviewed collections: 1
Score: 10 points

Number of **papers** published in non-referenced peer-reviewed journals or reviewed collections: 2
Score: 15 points

Total score: 40.00 points with a minimum requirement of 30.00 points

VII. Statement of originality of the dissertation thesis

The dissertation thesis entitled *Energy Security and the Energy strategy of EU in Bulgaria: Financial and Economic Aspects and Challenges* comprising 217 pages and the author's summary thereof are authentic scientific works of the author. They are based on their author's ideas, texts and visualization in terms of graphs, schemes, tables and formulas, and comply with all the requirements of the Law on copyright and its related rights for proper citing and referencing of other author's publications and data, including:

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Date: 10 Jan. 2023 **Doctoral Student**: ……

/Kaloyan Pargov/